A framework for energy storage in the Spanish power market

Public report

A note from AFRY Management Consulting

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AFRY Management Consulting provides leading-edge consulting and advisory services covering the whole value chain in energy, forest and bio-based industries. Our energy practice is the leading provider of strategic, commercial, regulatory and policy advice to European energy markets. Our energy team of over 250 specialists offers unparalleled expertise in the rapidly changing energy markets across Europe, the Middle East, Asia, Africa and the Americas.

This study has been conducted as a Multiclient project entitled 'Development of a storage framework in the Spanish power market', led by AFRY Management Consulting and with cooperation of the Gold Members of the project. It has been sponsored by 11 founding members, including Gold and Silver Members. Project members are owners of the report, and as such can use it at their discretion, under the conditions agreed in the Multiclient project.

This public report presents the main findings and proposals of the study. All analysis have been conducted by AFRY Management Consulting with proprietary models, and a combination of own assumptions and assumptions discussed specifically for this study. Independent interpretation of results has been led by AFRY, incorporating views of all Gold Members, and does not necessarily represent the views of any of the study members.

This report is published for dissemination and discussion with wider stakeholders of the energy sector. Gold Members (by alphabetical order): Atalaya Generación, Energia de Portugal, Endesa Generación, Galp, Iberdrola, Magtel, Plenium Partners, Repsol, Total Energies. Silver Members (by alphabetical order): Canadian Solar, RWE

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1. Executive summary

This public report summarises the analysis and proposals developed in the multiclient study on the 'Development of a framework for energy storage in the Spanish market'. This study has assessed the expected storage that might be attracted by the existing energy market and the latest proposal of a Capacity Market. It has then evaluated the cost-effective volumes of new storage that seem to make economic sense from a Social Welfare perspective. Finally, the study assesses potential regulatory mechanisms that could be designed to attract said cost-effective storage levels to the Spanish power market

1.1 Overview of the project

The Spanish energy sector aims at contributing to the Paris Agreement, and the European decarbonisation targets as they have evolved over time, particularly in the latest months since energy prices started skyrocketing in Spring 2021. Ambitious Renewable Energy Sources (RES) penetration targets have been set in a range of regulatory documents such as the Climate Change and Energy Transition Law, the Spanish National Energy and Climate Plan 2030 (NECP 2030) or the 'Storage Roadmap 2030'. Spanish targets are likely to also evolve in line with rising ambition of Europe's energy policy both in terms of the decarbonisation targets and in terms of speed of deployment of decarbonised sources.

Developing storage technologies that can use abundant renewable energy to be deployed during this decade and beyond, is seen as one of the key enablers of the Iberian and European Energy Transition, as a vector capable of storing some renewable surpluses and replacing utilisation of fossil fuels in hours of lower renewable resource. However, sole merchant revenues based on an energy-only market will struggle to enable relevant volumes of new storage capacity.

In this context AFRY designed an independent study seeking to design potential regulatory mechanisms capable of attracting sufficient new storage capacity to the power market, in turn enabling the decarbonisation targets of the sector. The study has been sponsored by a total of 11 founding members, including large utilities and other sector stakeholders with interests in deployment of renewables and/or storage solutions. Project sponsors have contributed with own ideas, and assessment of all proposals for an efficient and effective implementation. All methodologies and models have been designed and executed by AFRY's team, whilst all required assumptions and discussions have been discussed together with project members, with the spirit of making of this study a useful and constructive analysis of challenges and solutions for storage and renewable deployment.

1.2 Main findings

This study finds that the storage volumes set in the Spanish NECP 2030, in terms of capacity and duration, are reasonable from a cost and benefit perspective to the economy. These storage targets could even be exceeded and still result in a positive Socio-Economic Welfare for consumers. However, the study also finds that the existing and foreseen revenue streams are unlikely to be sufficient to attract the target storage volumes, given the asymmetry between the investors' returns and the wider benefits to the electricity consumers and the wider economy. Furthermore, the proposed Capacity Market, if finally developed as per the 2021 document published for consultation, whilst positive in attracting some capacity shortly, seems potentially suboptimal in awarding the specific storage projects that maximise the ratio of the wider value for consumers to the cost of the incentive.

In order to bridge the gap between the cost-effective storage volumes that could be envisaged in the Spanish power market, and the volumes likely to be attracted by the current energy market and the proposed Capacity Market (still in consultation phase), the study has assessed many conceivable new regulatory mechanisms. A short list of proposals has been selected, based on their expected effectiveness (i.e., how much additional storage is enabled by the mechanism) and their regulatory difficulty for implementation (i.e., how likely is the proposal to overcome European and Spanish regulatory hurdles).

Whilst no regulatory proposal scores the highest in all dimensions, as all have positive aspects and drawbacks, the study highlights the following proposals:

- Proposal A: an adaptation of the current proposal for a Capacity Market with a more sophisticated award process to attract short duration and long duration technologies, with two variants A.1 (based in quotas) and A.2 (based in 'scaling factors'); and

— Proposal B: a two-round Capacity Market based on the National Energy and Climate Plan which values both security of supply and renewable energy integration.

The longer list of proposals assessed is provided in Annex A, some of which, also with positive elements, should not necessarily be discarded.

The study also proposes different settlement schemes: the standard capacity payment, a 'strike spread' mechanism, or a cap & floor mechanism. These options are explored in Annex B.

1.3 Summary of project Tasks

Task 1 has replicated the expected security of supply analysis that the Spanish Transmission System Operator (TSO) shall conduct as per the new European regulation on Capacity Markets. A sophisticated model to assess Security of Supply has been used, based in a Montecarlo analysis to produce LOLE and EENS indexes. The study finds that little new firm capacity is likely to be required, unless CCGTs (gas fired power plants) close for economic reasons before 2030. Furthermore, even if additional storage capacity is deployed through other drivers, such as European Next Generation Funds, the political target of developing +12GW of new storage by 2030 seems highly unlikely to reach.

Task 2 has assessed the cost-beneficial level of new storage, through the design of potential Capacity Mixes with +7GW (NECP minus 5GW), +12GW (NECP targets) and +17GW (NECP plus 5GW) of new storage capacity; the breakdown of technologies, which is uncertain and shall result from a competitive mechanism (mainly batteries and pumped storage hydro) is taken as an assumption, yet different alternatives are explored by further splitting the +12GW Capacity Mix in two variants with changing share of batteries and pumped hydro. For each of these Capacity Mixes, total system costs for consumers have been projected in the long run, in order to assess the Social Welfare of each mix compared to the Counterfactual one.

The analysis is framed in a Base macroeconomic Scenario 1 (including projected demand, commodity prices etc.) and a second Scenario 2 with higher commodity prices to confirm resilience of economic findings. The study finds that even the most ambitious Capacity Mix, with +17GW of new storage, has a positive ratio of modelled benefits to cost of the required incentives. Benefits are modelled considering the impacts on the wholesale pool price and each of the other regulated system costs, and other socio-economic benefits are assessed such as impact on investments, employment, CO2 reductions, or reduced gas consumption for power generation. It is worth mentioning that the Social Welfare is considered positive when the NPV of projected benefits is higher than the NPV of projected costs of the mechanism for

consumers. All Capacity Mix alternatives considered provide greater benefits in the medium and long-term than the cost it implies for the consumer, as the corresponding additional storage enables much more efficient renewable integration and a decrease in the wholesale electricity price.

In Task 3, the study aims at bridging the gap between the findings of Task 1 (how much storage capacity the current regulation might bring) and Task 2 (how much storage capacity make economic sense for electricity consumers). Bridging this gap requires developing new (and novel) regulatory mechanisms, capable of ensuring sufficient returns to investors, particularly having in mind that the higher the storage target, the lower the price spreads for revenues from arbitrage, and therefore the higher the missing money. A total of 10 new mechanisms have been assessed, including the justification mechanism for the tendered volume of storage, and the award and remuneration mechanism. Additionally, some thoughts on potential settlement schemes are discussed, such as an innovative 'strike spread' settlement or optional Cap & Floor complements.

All proposals were assessed in the dimensions of efficiency (attracting high storage capacity and energy) and facility of implementation (high likelihood of solving regulatory hurdles in short timeframes). Whilst no option is strictly discarded, this task highlights the three mechanisms put forward for discussion with the sector stakeholders. They bring innovations to the Capacity Market proposal, or new mechanisms ad-hoc for storage as a complement of said Capacity Market proposal.

1.4 Recommendations and next steps

The study is disseminated through this public report, and through different actions led by AFRY and by project members as per their specific interests, and specific focus on the regulatory proposals that each entity is most comfortable with.

The project members and AFRY aim at increasing awareness of the urgency of accelerating the development of a positive regulatory framework for storage to overcome the challenges that developing this technology entails. AFRY aims to be proactive and constructive in providing innovative solutions to the Spanish regulatory authorities and to other sector stakeholders, by improving some aspects of the proposed Capacity Market. Therefore, this study is not the end of the challenging work, but rather the beginning of a much-required discussion among many more parties than those who contributed to this work.

AFRY and the project members are further open to discuss and refine the most promising regulations to progress towards the decarbonisation targets.

2. Introduction

This section describes the context, the motivation and the objectives of the study, together with some conventions on the report.

2.1 Situation of storage and targets in the Spanish system

2.1.1 Current context

The Spanish energy sector aims at contributing to the Paris Agreement on limiting Earth's average temperature increase to 2°C by end of the century and ideally 1.5°C, and to the European decarbonisation targets as they have evolved over time, particularly in the latest months with the publication of the 'Fit-for-55' and the 'REPowerEU' packages. Ambitious renewable penetration targets have been set in a range of regulatory documents such as the Climate Change and Energy Transition Law, the Spanish National Energy and Climate Plan 2030 (NECP 2030) or the 'Storage Roadmap 2030'. Spanish targets are likely to also evolve in line with rising ambition of Europe's energy policy both in terms of the decarbonisation targets and in terms of speed of deployment of decarbonised sources.

Deploying storage technologies that can use abundant renewable energy to be deployed during this decade and beyond, is seen as one of the key enablers of the Iberian and European Energy Transition, as a vector capable of storing some renewable surpluses and replacing utilisation of fossil fuels in hours of lower renewable resource. Ambitious storage targets have been set to integrate the upcoming new renewable deployment, however market signals seem insufficient to make those storage targets happen.

The Government also issued a proposal of a Capacity Market for consultation in 2021, as one of the potential drivers for attracting new storage capacity with an additional revenue stream. A number of uncertainties are still present, such as pending details of said mechanism, and the results of the security of supply studies that shall support the requirement for capacity auctions.

2.1.2 Political targets for renewables and storage

The Spanish NECP 2030 aims at reaching 42% of renewable penetration over final energy by 2030, and 74% renewable penetration over the Electricity sector. This is a significant increase from 20% and 40% respectively by 2020.

The current NECP and Storage Roadmap consider an illustrative capacity mix with:

- 3.5GW of new pumped storage hydro;
- 2.5GW of generic short duration storage (i.e. batteries or any technology with an equivalent service);
- 5GW of Concentrating Solar Power with thermal storage; and
- <1GW of storage Behind-the-Meter.

Whilst none of these targets are binding, and a review NECP 2030 will be submitted in 2023 by all Member States (presumably with more ambitious renewable penetration targets, in line with the latest European agreements), reaching those targets will require additional revenue streams through new services or new support schemes additional to the current opportunities in wholesale or retail energy markets.

2.2 Motivation and Objectives of the study

2.2.1 Motivation

This report summarises the analyses and the recommendations of an independent multiclient study on the 'Development of a framework for energy storage in the Spanish market'. The motivation is to raise awareness of the challenges for developing new storage in the Spanish power market, and to proactively propose innovative regulatory solutions that could enable the deployment of efficient storage capacity in line with the ambitious decarbonisation targets.

2.2.2 Objectives

In this context, AFRY has designed a study to analyse the challenges of storage and to give solutions to enable its deployment. The objectives of the study have been divided in three tasks.

Task 1 aims at shedding light on the potential backup capacity that might be required in the Spanish power system, complying with the Security of Supply standards and the new European methodologies. This further feeds into the expected volumes of storage that could be attracted by the Capacity Market proposed by the Spanish Government for consultation.

Task 2 aims at assessing the volumes of new storage that make economic sense for electricity consumers and for the wider economy.

Task 3 aims at bridging the gap between the market incentives and the cost-effective volumes that should theoretically be developed for an efficient decarbonisation of the power sector, by proposing innovative regulations compliant with the spirit of European and national regulations.

This public report seeks to be a useful tool to discuss innovative regulatory proposals with regulatory authorities and with the wider stakeholders of the sector.

2.3 Conventions

- All models and methodologies are AFRY's propriety. All assumptions use a combination of AFRY's own assessment, public information, and assumptions agreed with the project members.
- No statement or opinion of this report necessarily reflects the opinion of any of the project members.

3. Task 1: Security of Supply

This study assesses the Security of Supply replicating the European probabilistic methodology and the impact of the currently proposed Capacity Market on the levels of storage in the Iberian power market. Whilst the proposed Capacity Market (still in consultation phase) could attract some new storage, subject to demand evolution and the uncertain thermal closures, it does not seem to be the right regulatory tool to attract the volume of new storage capacity described in Spain's political targets, namely the Storage Roadmap and the National Energy and Climate Plan 2030.

3.1 Introduction

Analysis of market revenues and regulated capacity payments for the CCGT capacity (most CCGT capacity has lost the Investment Incentive, and the 'Availability incentive' was fully suspended for all thermal plants) suggests that most of the Spanish CCGT fleet is suffering or will soon suffer negative margins. Also, new additional storage is required to meet the NECP and the Storage Roadmap targets. However, in AFRY's view, price arbitrage on an energy-only market as well as ancillary services revenues will not be sufficient to justify investment in any storage technology, and the revenues for CCGTs seem insufficient to keep the whole fleet in service until 2030 and beyond. Both new storage and existing thermal plants are waiting for a proposed Capacity Market that will guarantee a sufficient return.

The Spanish Government presented the April 2021 draft proposal for the creation of a Capacity Market to address these issues. However, at European level, one of the main constraints is the need of a Security of Supply analysis that will justify Capacity Market volumes. It is such an analysis, which has never been fully performed yet for the Spanish market, that will determine how much firm capacity can be granted a capacity payment.

The purpose of the analysis described along this section is to build a view on whether the currently proposed Capacity Market can be the right regulatory tool to enable the target levels of storage in the Iberian power market.

3.2 Methodology

To assess the security of supply in the Spanish system, the analysis has used a proprietary model with a probabilistic methodology which replicates AFRY's view of potential outcomes of the official ERAA to be conducted by the European TSOs.

The model tests the probabilistic capability of future supply to meet hourly system demand through a Monte Carlo analysis. It produces LOLE (Loss of Load Expectation) and EENS (Expected Energy not Served) indexes of Security of Supply, which describe the probabilistic energy not supplied and the frequency of hours with unserved load. These indexes are then used to find the cost-effective backup capacity by minimising total costs of probabilistic demand not served and cost of incremental backup capacity.

The analysis shows that average available generation is substantially higher than demand for all years and still, the system needs additional firm capacity to comply with the security of supply criteria. This need is heavily influenced by random failures in the hours of tightest reserve margin; it is not the average availability that drives EENS and backup requirements, but the most unfavourable random Montecarlo samples where many unplanned unavailabilities coincide. Technologies with variable generation such as wind see much lower than average load factors in some Montecarlo samples during tight hours.

This study was conducted for different scenarios with various input capacity assumptions to assess security of supply under different future outlooks. Similar conclusions were reached: the need of firm capacity at the end of the decade could be covered by the existing CCGT fleet, and new storage would only come by 2030 if some CCGTs close in the 2025-2030 period. After 2030, more storage is likely to be attracted by the Capacity Market, once the missing money of storage for new build beats the missing money of CCGTs for extension, even if sufficient CCGT capacity has remained in the system (presumably some of which without secured capacity payments).

3.3 Conclusion

The security of supply assessment conducted by AFRY's modelling suggests that additional firm capacity beyond CCGTs that can potentially remain operational in absence of capacity payments is needed in the system. This firm capacity need rises over time, as critical demand increases whilst some thermal capacity (from coal and nuclear) decommissions. The exact volume of new storage that the Capacity Market might bring will therefore be highly impacted by how much CCGT capacity, if any, closes before 2030. In turn, this is likely to be impacted by how much CCGT capacity secures annual capacity payments from 2025 onwards, or decides to mothball in expectation of future 'de-mothballing'. Significant new storage triggered by the proposed Capacity Market only seems likely if some CCGTs do decide to close before 2030, or if the official Security of Supply analysis have significantly more conservative assumptions (for instance on interconnector availability, critical demand projections or statistical contribution of wind power) or a substantially different methodology.

It seems clear that a Capacity Market is required shortly, at least to ensure the extension of a relevant share of the current capacity of CCGTs. Whether this Capacity Market will be 'successful' in attracting new storage capacity will greatly depend on methodological aspects and assumptions of the official Security of Supply study, as well as on closure decisions of some CCGTs. Whilst all in all, some new storage capacity might be attracted by the proposed Capacity Market before 2030, the total volume will likely be small, and very likely much smaller than the political target of the NECP and the Storage Roadmap.

Considering all the previous, the current draft Capacity Market does not seem to be the right regulatory instrument to enable the target levels of storage in the Iberian power market; AFRY considers it is more designed as an 'anti-blackout' mechanism, rather than a renewable integration tool.

4. Task 2: Techno-economic analysis of storage

Task 2 has assessed the cost-beneficial level of new storage, through the design of potential Capacity Mix cases with +7GW (NECP minus 5GW), +12GW (NECP targets) and +17GW (NECP plus 5GW) of new storage capacity. This study confirms that incentivising storage up to an additional 17GW of capacity still brings a positive Socio-Economic Welfare, as well as benefits to GDP, employment and emissions. It should be noted that this study has not aimed at assessing the optimal capacity mix, and the optimal breakdown of storage technologies; it has seeked to prove that a ‘market failure’ will not attract sufficient storage versus cost-effective levels, and start the discussion of potential solutions.

4.1 Introduction

The situation that storage is facing is that the expected market revenues are insufficient to guarantee investors an adequate return on their investment and in this context, government incentives or new market mechanisms are key. The justification for providing these incentives is the benefits that storage can bring to the electricity consumers and to the wider economy. As long as these benefits outweigh the cost of the incentive, it is a positive investment for society and therefore it should be implemented. This performance evaluation is carried out through the so-called **Cost Benefit Analysis (CBA)** methodology, applied in our study. Note that Europe has much to say in any national incentive mechanism, and the ‘State Aid Guidelines’ (CEEAG, for Guidelines on State Aid for Climate, Environmental Protection and Energy) set the framework under which governments can provide incentives complementary to the energy market. Also note that a CBA methodology already exists in the energy sector for assessment of Projects of Regional Interest (mainly interconnections and storage) at European level within ENTSO-E’s Ten-Year Network Development Plan.

The CBA assessed in this project evaluates the impact of **different levels of storage on the electricity system’s costs** comparing the results against a counterfactual Base Capacity Mix[3] .

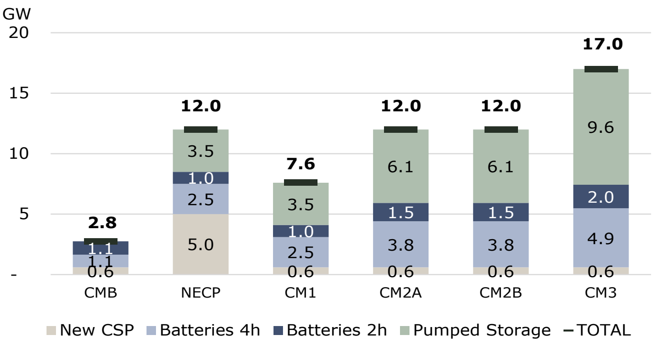
The Base case and the alternative capacity mix analysed are presented in Exhibit 4.1, in which additional pumping capacity and batteries are added until 2030 on top of the currently existing 6GW of pumped storage. This macroeconomic scenario also includes AFRY projections on demand, commodity prices etc.

3 A counterfactual scenario refers to the scenario that would take place if the aid is not given.

The same analysis has also been carried out on a second Scenario 2 with higher commodity prices to confirm resilience of economic findings. Given that the outcome of Scenario 1 and Scenario 2 lead to the same conclusion, this report will focus on the first scenario’s results.

EXHIBIT 4.1 – TOTAL ADDITIONAL STORAGE CAPACITY 2022-2030 (GW)

The additional storage capacity mix analysed are CM1 (Capacity Mix 1), CM2A, CM2B and CM3, which are compared against the Base case (CMB) which is the counterfactual.



Scenario	Storage 2030 (GW)	Comment
CMB (Base)	2.8	Storage that comes thanks to other sources: market driven, PRTR, etc.
NECP	12.0	NECP target
CM1	7.0	-5GW from NECP target
CM2A	12.0	NECP target, PSP High-duration
CM2B	12.0	NECP target, PSP Low-duration
CM3	17.0	+5GW from NECP target

Notes: PSP refers to Pumped Storage Plants

To carry out a holistic assessment, the study has also provided a wider view of the implications of storage on the economy, not just linked to the electricity system itself, by evaluating the macroeconomic, employment and emissions perspective. Note that this wider impact on the economy is interesting information for Governments, but it is generally excluded by European CBA methodologies.

Overall, the main goal of this task is to analyse whether the development of new storage capacity should be trusted to the market mechanisms alone; or whether it is justified that the Regulator develops new mechanisms to incentivise and attract additional volumes of storage than the market alone would.

4.2 Results

4.2.1 Total system costs

Storage effect in the day-ahead market is the better integration of the most competitive technology (lower LCOE), which under AFRY Central assumptions is solar PV technology in the long-term. This enables to reduce curtailments and to displace more expensive generation during peak hours. Therefore, storage manages to **reduce electricity production costs** (wholesale market costs).

However, integrating storage implies **higher regulated costs**[4] mainly driven by the incentives given to storage in the short term[5] (by default the incentive is given in 5 years, but this could be spread over a larger period considering the participation of long-duration technologies). The regulated cost increase as more storage capacity is incentivised, mainly because as more storage capacity is targeted, revenues from price arbitrage are cannibalized, and hence a higher incentive per installed capacity is needed to reach the required rate of return. Therefore, Capacity Mix cases with more storage imply higher incentive payments ('Capacity Payments' or whichever name is assigned to a generic incentive mechanism for storage), however greater economic benefits generally come in subsequent years.

All in all, the total costs of the electricity system (including unregulated wholesale energy and regulated costs) increase in the short term and across scenarios due to the incentive payments to storage. However, this trend reverts in the early 2030s and until the end of the period for all Capacity Mix cases, as the reduction in the wholesale price and incentives to renewable outweighs the higher regulated costs **resulting in savings to the system for the entire period**.

4.2.2 Cost-Benefit analysis

The CBA has been performed considering:

- Cost: the additional cost incentive to attract storage through the draft Capacity Market published.
- Benefit: the difference of the total cost of the electricity system (Section 4.2.1) with respect to the Base scenario.

The results of the CBA show that the system incurs a cost associated to the capacity payment incentives to storage. However, positive benefits start as soon as the first storage facilities start operation, partly offsetting the cost of incentives from the beginning. The net impact becomes positive in subsequent years and rise to high values over time. Note that annual cost figures and therefore net benefits depend on the assumption of annual capacity new build (this could be spread over more years), and also on the chosen period for the capacity payment (by default 5 years, but this could also be spread over more years, reducing the annual amount and extending the duration).

4.3 Conclusions

The CBA study leads to the conclusion that according to a long-term analysis, **the value of the incentive cost to additional storage is lower than the value of the benefit to consumers**, even for the most extreme case studied in which +17GW of additional storage is installed, going beyond the political target of the National Energy and Climate Plan 2030 and the Storage Roadmap.

Storage does not only entail an economic benefit but it also allows for higher renewable integration, reducing curtailments in hours of high renewable resource. **It also reduces the need for thermal emitting technologies during hours of system stress, which helps accelerate decarbonisation**, reduces CO2 emissions and international gas dependency.

When comparing the impact of storage under a scenario with higher commodity prices, the CBA shows that the benefits of storage are enlarged, with storage providing an 'insurance' against high commodity prices. Additionally, the payment of the incentive in this scenario is reduced as the storage facilities will have lower missing money due to higher revenues captured in the market. This means that storage appears as an **efficient solution to mitigate price volatility and a 'cheap insurance' to stabilise electricity costs**, which is particularly beneficial in turbulent times for commodities such as the period the world faces today.

The installation of storage has also **a positive impact on the economy**, which translate into positive employment effects.

All in all, **incentivising storage implies more efficient electricity costs for consumers and a 'national hedge' against commodity fluctuations**. In AFRY's view, the regulator should assess the incentives to storage capacity with a long-term CBA perspective, which is modelled by this study as clearly positive. Note that the duration of incentives, and consequently their annual value, is a discretionary decision of regulatory bodies, and is key for the annual net impact of costs and benefits. The potential forms of the incentive schemes compatible with European and national regulations are discussed in Task 3.

4 The regulated costs are destined to cover the payment of infrastructures and generation subsidies costs (RECORE, capacity payments, transmission and distribution costs...). System costs are covered mainly by the end-user through the retail tariff.
5 The 'short term' definition depends on the chosen duration of the incentive scheme, which is by default 5 years as per the proposed Capacity Market rules.

5. Task 3: Regulatory proposals

The Capacity Market proposed in the Draft Order published in April 2021 is considered an insufficient tool to promote the development of a level of storage volume equivalent to the one set in the Spanish NECP 2030. Therefore, some improvements to the current proposed Capacity Market as well as other regulatory mechanisms are proposed, explored and assessed. It is important to note that no proposal is perfect in all dimensions of effectiveness and ease of regulatory developments required; no single proposal can be highlighted as the perfect and easy solution.

Nonetheless, the chosen best are deemed to bring considerable improvements versus the current proposal of a fairly simple Capacity Market. Therefore, this study does not aim at providing regulatory bodies a single regulatory proposal and recommendation that stands out in all dimensions, but rather to assess those mechanisms that could bring more or more efficient storage in line with cost-effective levels, which the market will otherwise very likely underdeliver.

5.1 Introduction

Given the political plan of gradually decommissioning coal and nuclear capacity, and the low utilisation of the fleet of CCGTs, a Draft proposal was published in April 2021 with the aim of creating a Capacity Market to ensure the availability of enough firm capacity in the Spanish system. This measure is clearly an important step forward, however, it seems suboptimal to promote the development of political target and economically viable storage in Spain, as it only values the 'anti-blackout' aspect of energy storage and no other positive externalities that storage entails (as concluded in Section 3.3).

In addition to the Capacity market presented in the Draft proposal, the Spanish government is establishing the regulatory bases for the granting of public aids[6] with funds from the Recovery, Transformation and Resilience Plan, on a competitive basis, for promoting the technological development of energy storage technologies. However, although the implementation time will be short, AFRY considers that grants may play a key role in innovation (encouraging to invest in research and development projects) but will be also insufficient to attract a significant volume of storage[7].

With the aim of enabling the storage targets and consequently, the achievement of the whole renewable penetration targets of the NECP, the Multi-client project aims to complement the current proposed capacity mechanism with different regulatory proposals which AFRY considers are more effective or easier to implement.

5.1.1 Proposed Capacity Market

The Spanish Capacity Market is based on Regulation (EU) 2019/943 of the European Parliament and the Council of the 5th of June 2019 on the internal electricity market, adopted in the European Union's Clean Energy Package.

This Draft Capacity Market defines medium-term auctions – known as main auctions – to secure the targeted volume of firm capacity needed by the system and attract new build in non-emitting firm capacity; and short-term auctions – known as adjustment auctions – to procure remaining needs of firm capacity identified one-year ahead.

6 Up to date, the Spanish government has announced three aid programs in order to incentivize energy storage, under the component 8: "Electric infrastructures, promotion of smart grids and deployment of flexibility and storage" of the PRTR, in particular from its Investment (I1) "Deployment of energy storage".
7 Analysis of capacity additions derived from the grants are carried out under proposal 'Direct Capex support' of Task 3; See Annex A

Although the Draft Capacity Market is seen as a promising starting point, it is considered to be insufficient to attract significant volume of storage, since it is designed to guarantee minimum Security of Supply volumes, and not to promote flexibility, integration of renewables, reduction of curtailments, reduction of gas dependency, etc. Hence, the volume attracted by this scheme will be the firm capacity with the lowest missing money, namely existing CCGTs, at least in the short term.

In addition, if new storage is allocated in the main auctions – awarded based exclusively on the minimum cost adjusted with the 'derating factor' (i.e., contribution as firm capacity available in the hours with the tightest reserve margin) – it might attract technologies with short-duration that do not necessarily provide the best value for their holistic services beyond their contribution to Security of Supply.

5.2 Regulatory proposals

In order to propose potential improvements to the current Draft Capacity Market proposal, ensuring sufficient investment in storage and the best value for money to consumers, this study has evaluated several regulatory mechanisms according to their effectiveness to attract efficient storage and their regulatory facility to be approved. From a long list of conceivable mechanisms (detailed in Annex A), or proposals discussed in the public domain, the study emphasizes the most promising innovative designs and settlement mechanisms.

Whilst no proposal scores the highest in all dimensions, and no proposal can be highlighted as the single preferred option by all market participants or by AFRY, very positive improvements exceeding potential drawbacks are broadly accepted for two proposals. 'Proposal A' brings a relevant modification to the Draft Capacity Market without altering the total tendered capacity. 'Proposal B' adds additional criteria to the proposed Capacity Market such as renewable energy integration which significantly alter the total tendered capacity and the awarding principles.

Additionally, Task 3 has discussed the potential implementation of different settlement mechanisms: a capacity payment in €/MW/year, one based in a financial 'strike spread' and other in a Cap&Floor. This is not a holistic regulatory mechanism that considers the volumes of storage to be tendered, but rather alternatives in the settlement. This section is detailed in Annex B.

5.2.1 Proposal A: Capacity Market adapted for long-duration and short-duration storage

This proposal, with two variants, is an adapted version of the current proposed capacity mechanism. It does not alter the security of supply study which drives the total tendered capacity requirement, yet it provides opportunities to more costly storage bids that bring additional value beyond their single contribution to security of supply through their derating factor. In this proposal, additional values of storage projects are recognised with two variants: either **(A.1)**[8] **by defining specific quotas for short and long-duration storage**, where each block has its own derating factors and lead times, or **(A.2)** by **applying scaling factors** to the corresponding bids, quantifying other benefits of storage which enable being awarded despite higher bids when they bring more value.

Although it is a simple adaptation, ergo it shouldn't entail major regulatory barriers, A.1 can imply technological splitting (disregarding the principle of technology neutrality[9]). On the other hand, the calculation of the scaling factor in A.2 through measurable parameters, which is a flexible solution for adapting the mechanism to the system needs, could end up in a very complex process if flexibility is taken to the extreme.

Furthermore, this capacity mechanism should include the demand-side response (DSR) participation and the cross-border competition, which is not defined yet in the draft Order. Regarding the applicability of the capacity payment, the 5-year timeframe of the main auctions should be expanded in order to give revenue visibility to projects with a longer lifetime, namely pumped storage, and this could be done with variant A.1 and a 'bucket' of capacity for long duration through higher duration for a maximum derating factor.

In conclusion, Proposal A improves the type of storage projects awarded by the Capacity Market mechanism, however, it is important to bear in mind that this design is hardly going to meet the NECP target storage. The volume would still rely on the contribution of storage to assure the capacity adequacy of the system and there is no relation between the decarbonization targets and the Security of Supply needs.

8 The idea is to carry out a security of supply analysis under the scenario that the government projects (e.g. NECP capacity mix) in order to determine the volume to be auctioned in each block (SD and LD), promoting the entrance of different types of storage.

9 The justification of the aid for a not-technology neutral design is more difficult at European level which consequently could imply a longer approval timeframe.

5.2.2 Proposal B: Two-round Capacity Market (RES integration and System Adequacy)

This proposal complements the current Draft Capacity Market by celebrating a **two-round auction**:

— the first one focused on technologies that **promote renewable integration** (helps reducing renewable curtailments) based on a cost-benefit analysis (CBA) of the 12GW NECP targets; and
— the second one open to all technologies that help guarantee the **Security of Supply** of the system.

The main contribution of this proposal over the Draft Capacity Market is that the tendered capacity in the first round of the mechanism would use the NECP target storage as a reference, which currently exceeds greatly the expected levels required for SoS purposes alone. Consequently, the NECP storage figures shall be complemented by a CBA study to include all additional analyses necessary to obtain clearance of the European CEEAG guidelines[10] .

The award process of the first 'renewable integration round' can be done through economic bids and 'renewable integration scaling factors' per technology, as discussed in Proposal A.2. Similarly to Proposal A.2, the main challenges are related to the calculation of adequate scaling factors (demonstrating transparency in the process), the design for DSR participation and cross-border competition, and the extension of the 5-year main auctions.

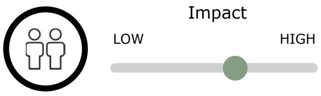
In the second round on Security of Supply, additional capacity would be tendered to reach the SoS requirements and therefore, it would ensure that existing plants have an incentive to remain in operation.

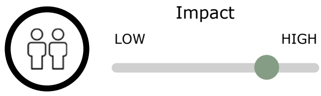
In conclusion, **Proposal B would bring more storage capacity than Proposal A, up to the cost-effective level** modelled in the NECP through a complementary CBA study. This level of storage is presumably the most efficient to reach decarbonization targets, and probably higher than the level justified by SoS reasons. All in all, this mechanism proposes an integrated solution were assuring the security of supply of the system and the achievement of the decarbonization targets are taken into consideration. Whilst all this is a novel concept in the design of Capacity Market, it relies in a CBA study based in the NECP which demonstrates compliance with CEEAG in two coupled dimensions: reduction of greenhouse emissions through support of renewable energy and security of electricity supply.

5.2.3 Proposal comparison: advantages and disadvantages

Exhibit 5.1 presents a summary of the main advantages and challenges of the selected proposals to boost the deployment of storage in Spain, considering both effectiveness to attract the desired volume and regulatory facility to implement the measure. **Proposal A and B are the preferred proposals** by the study members.

EXHIBIT 5.1 – KEY CHALLENGES AND BENEFITS OF THE HIGHER-RECORD PROPOSALS





	PROPOSAL A – LONG AND SHORT DURATION STORAGE	**PROPOSAL B –** TWO -ROUND CAP.MARKET
+	– No major regulatory changes, based on Draft Order published. – Introduces scaling factors to reflect storage benefits. – Enables competition across storage technologies.	– Integrated solution, volume beyond SoS needs. – No major regulatory changes, based on Draft Order. – Introduces scaling factors to reflect storage benefits. – Enables competition across storage technologies.
–	– Insufficient volume, related to security of supply needs. – The calculation of the scaling factors should follow a clear and transparent methodology. – DSR and cross-border integration pending to be developed, as Draft Order.	– Aid justification for the volume associated to the first round of the capacity payment (CEEAG). – The calculation of the scaling factors should follow a clear and transparent methodology. – DSR and cross-border integration pending, as Draft Order.

10 The revised CEEAG provide the framework for public authorities to support State aids with minimum distortions of competition. There are 6 aid categories related to storage, where Proposal B is explicitly supported by two of them: '4.1 Reduction of GHG emissions including through support for renewable energy and energy efficiency' and the category linked to capacity remuneration mechanisms, '4.8 Security of electricity supply'.

5.3 Summary of design aspects

Although no proposal is perfect in all dimensions of effectiveness and feasibility to be approved at regulatory level, this study has identified three critical design aspects, which could potentially improve the current Draft Capacity Market, and have a tangible impact in the deployment of storage in Spain.

The first aspect is related with the **justification of the volume in terms of capacity**, whilst complying with the CEEAG. Proposals B suggests complementing the volume from the SoS needs based on additional attributes. This proposal takes as reference the Spanish NECP (which shall be updated in 2023), that should enhance the justification of the volume of storage needed with some in-depth calculations of social welfare against required incentive requested.

The second aspect is the **duration of the incentive and the horizon of the study period**. The duration of the contract and the lead time, both currently fixed at 5 years in the Draft Capacity Market, might be problematic for long duration storage with long development times such as Pumped Storage Hydro. Extending both 5-year periods would enable participation to projects with longer lead times and lower annual payments. Also, long study horizons in the NECP process give opportunities of award to technologies with longer lifetimes. In this sense, both proposals A and B could offer longer contracts and increase the planning timeframe. One possibility could be to publish a calendar of possible auctions (or incentives in place) which would bring a clearer path to investors.

The third aspect considers an award process based on wider criteria than a simple 'lowest price bid'. The core of the preferred proposals is based on adding 'scaling factors' or specific quotas to value other positive benefits of storage, and award higher bids if they also provide more value to consumers. To calculate the scaling factors or quotas or to include a new driver on the Capacity Market (such as renewable integration), some 'back-office' calculations are required by the Regulator, or an appointed entity. For instance, a 'duration scaling factor' might award a certain project whose bid is 20% higher than another project, if its duration of storage at full load is +100%. Furthermore, a binary 'inertia scaling factor' might award a storage project that is +10% more expensive if it comes with real or emulated inertia with e.g., more expensive grid forming batteries.

All in all, the main advantage of mechanism B is its **effectiveness**, since it could attract significant and optimal cost-effective volumes of storage, presumably at the levels of the NECP targets (+12GW by 2030) or as calculated in the techno-economic analysis of Task 2 of this study.

Regarding **regulatory feasibility**, innovations of proposal A and B seem the simplest among the long list, since they are 'evolutions' of the current Draft Capacity Market and use some existing tools such as the NECP and the CEEAG guidelines methodology. However, proposal B could have a longer implementation timeframe when compared to proposal A as it should be justified under two CEEAG categories[11] .

In conclusion, Proposal A and Proposal B are found to improve the current draft Capacity Market proposed by the Government for consultation. The Spanish sector as a whole, and in particular regulatory authorities, shall weigh between speed of implementation and volume of storage attracted to the system. AFRY would put a strong emphasis on ambitious mechanisms capable of attracting high volumes of storage seeking an efficient decarbonisation; yet speed and simplicity of implementation definitely have merits for a much-needed early deployment of new storage in the Iberian market.

11 Proposal B should be supported by two CEEAG categories: '4.1 Reduction of GHG emissions including through support for renewable energy and energy efficiency' and the category linked to capacity remuneration mechanisms, '4.8 Security of electricity supply'.

6. Conclusions and recommendations

This study aims to bridge the gap between the cost-effective storage volumes, and the volumes likely to be attracted by the proposed Capacity Market. The goal is to be proactive and constructive in providing innovative regulatory mechanisms. This study is not the end of the challenging work, but rather the beginning of a much-required discussion among the sector's stakeholders.

This study finds that the storage **volumes set in the Spanish NECP 2030, in terms of capacity and duration, are reasonable from a cost and benefit perspective** to the economy. These storage targets could even be exceeded and still result in a positive Socio-Economic Welfare for consumers in the long-term.

However, the study also finds that the **existing and foreseen revenue streams are unlikely to be sufficient to attract the target storage volumes**, given the asymmetry between the investors' returns and the benefits to the electricity consumers. Furthermore, the proposed Capacity Market, if finally developed as per the 2021 document published for consultation, does not consider wider benefits of storage beyond firm availability in the hours with tightest margin. This may potentially fail to award the best 'value for money' to consumers.

In order to bridge the gap between the cost-effective storage volumes that could be envisaged in the Spanish power market, and the volumes likely to be attracted by the current energy market and the proposed Capacity Market, the study has assessed many conceivable new regulatory mechanisms. A short list of proposals has been selected, based on their expected effectiveness (i.e., how much additional storage is enabled by the mechanism) and their regulatory difficulty for implementation (i.e., how likely is the proposal to overcome European and Spanish regulatory hurdles).

Whilst no regulatory proposal scores the highest in all dimensions, as all have positive aspects and drawbacks, the study highlights the following proposals:

— Proposal A: an adaptation of the current proposal for a Capacity Market with a more sophisticated award process to attract short duration and long duration technologies, with two variants A.1 (based in quotas) and A.2 (based in 'scaling factors'); and
— Proposal B: a two-round Capacity Market based on the National Energy and Climate Plan, which values both security of supply and integration of renewable energy.

Whilst Proposal A and Proposal B also bring some challenges and require further detail, they seem to bring the best compromises and are generally considered to be fully implementable in reasonable timeframes towards achieving the 2030 targets.

The project members and AFRY aim at increasing awareness of the urgency of accelerating the development of a positive regulatory framework for storage to overcome the challenges that developing this technology entails. We aim to be proactive and constructive in providing innovative solutions to the Spanish regulatory authorities and to other sector stakeholders. Therefore, this study is not the end of the challenging work, but rather the beginning of a much-required discussion among many more parties than those who contributed to this work.

Annex A – List of additional regulatory proposals

AFRY, with the support of the gold members of this project, have defined different regulatory proposals that could replace or complement the Capacity Market that has been proposed by the Spanish Government. Each proposal was evaluated according to its **effectiveness** to attract storage as well as its **regulatory facility** to be approved.

For the sake of clarity, only the proposals with a highest score in both criteria (effectiveness and regulatory facility) have been described and analysed in depth, which are the ones presented in Section 5.2. However, we have included all the proposals considered in the study in Exhibit A.1, being divided into those that respond to market needs and those that aim to solve technical issues of the grid. This classification is not relevant for the project but it helps understand at a first glance the main motivation of each regulatory mechanism.

Also, a brief description of the proposals analysed is included in Exhibit A.2.

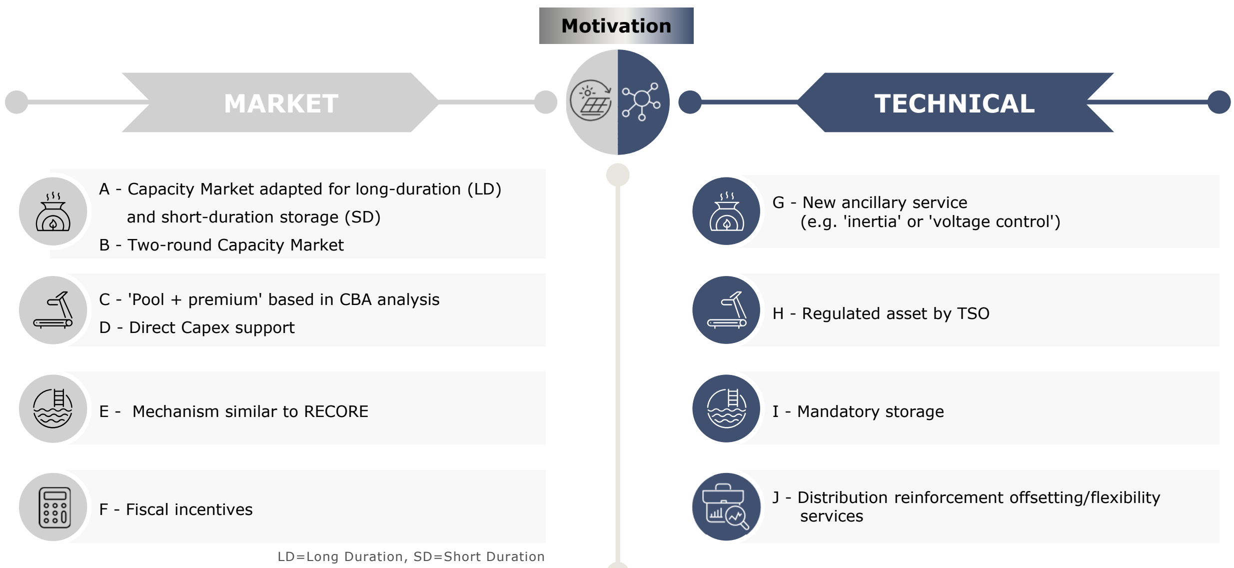
EXHIBIT A.2 – BRIEF DESCRIPTION OF THE REGULATORY PROPOSALS[12]

	Name proposal	Description
A	Capacity Market adapted for LD and SD storage	Based on the Draft Capacity Market, adapting the main auctions to either have specific blocks for SD and LD storage (variant A.1) or to add scaling factors to quantify other benefits of storage when compared to other technologies (variant A.2).
B	Two-round Capacity Market	The first round of the Capacity Market values two attributes: firm capacity and renewable integration capabilities. The second round complements the firm capacity needs with adjustment auctions.
C	'Pool + premium' based in CBA analysis	The study backing the storage capacity would be based in a 'Cost Benefit Analysis' of Social Welfare, with a similar philosophy that ENTSO-e's Ten-Year Network Development Plan for interconnections.
D	Direct Capex support	Based on an incentive program for the implementation of storage facilities under European funds and their rules. The volume and Capex percentage to be subsidised would be set in the regulatory basis of the aid.
E	Mechanism similar to RECORE	Design a RAB remuneration mechanism, like the RECORE (Rinv, Ro). Auction competition would be established through Capex-discount. The facilities may receive, during their regulatory useful life, a specific remuneration in addition to the remuneration for the sale of energy in the market.
F	Fiscal incentives	Incentivize storage through exemptions or reductions of taxes and other levies. These exemptions or reductions can be specific per storage technology or application.
G	New ancillary service (e.g., 'inertia' or 'voltage control')	Create a new remunerated service which pays for a (requested) system need that new storage can provide in a technological neutrality context. The new service should obviously address a problem, or a 'missing market' that leads to an inefficient generation schedule or underinvestment in efficient providers of the new service. The most frequently discussed potential markets are Inertia (real or synthetic/emulated), voltage control, black start capability.
H	Regulated asset by TSO	For a stand-alone asset, the system operator (REE) operates the project to optimize the system efficiency whilst maximising system security. Its revenues should be regulated with a target regulated return, complementing (or reducing) market revenues that would be neutral to the TSO.
I	Mandatory storage	The energy storage deployed will by driven by national legislation, setting an energy storage procurement mandate based in wind/solar installed capacity.
J	Distribution reinforcement offsetting/flexibility services	The reduction in network investment needs is monetized in the form of a competitive mechanism. Storage could participate in this service solving transmission congestion.

Source: AFRY Management Consulting

EXHIBIT A.1 – LIST OF REGULATORY PROPOSALS

There are two types of proposals, the ones whose aim is to solve the grid needs (technical) and the ones based on market needs (RES integration…)



12 The order of the proposals is not based in the order of preference.

Annex B – Settlement mechanisms

In addition to the eight regulatory proposals, different settlement mechanisms have been explored. They are not considered a holistic regulatory proposal as these do not address the economically viable volume to be auctioned.

In this study, different options for settling the incentive payment to storage without distorting the market have been analyzed. One simple option is a capacity payment in €/MW/year complementary to market revenues. This capacity payment could also be complemented with a Cap & Floor regime. Another option is a 'Contract for Difference' (CfD) applied to a price spread on selected hours, which can be described as a 'strike spread' settlement. Finally, we explore a Cap&Floor mechanism where storage merchant revenues are clamped to decrease their overall volatility.

A.1 €/MW

The most common remuneration for a capacity mechanism is a fixed payment based on the capacity available, meaning in €/MW/year. The project is committed to be available during a time slot, and the system remunerates the project according to its derating factor. This remuneration mechanism ensures a stable and predictable flow of income to cover fixed costs, although total annual revenues including market arbitrage are volatile based on annual hourly spreads.

An incentive payment in €/MW does not affect the operation of the plant and does not distort the market's supply curve. Conversely, if a payment in €/MWh is introduced for storage technologies there is a clear potential distortion in the market, with inefficient charge/discharge cycles affected by the premium. There is wide consensus that the incentive cannot distort efficient market operations, and therefore variable incentives are discarded.

A.2 Contract for Difference on a 'strike spread'

The purpose of the Contract-for-Difference (CfD) settlement against price spreads, or a 'strike spread' is to incentivize investments by providing stability and predictability to future revenues streams. The regulatory CfD is based on the price spread of each settlement period (e.g., one day one week). This idea is supported by the fact that required margins of storage can be brought down to a daily or weekly spread, and should those spreads for price arbitrage be insufficient then the CfD will complement market outcomes on the same daily or weekly basis. Given that this is proposed as a financial settlement, with real plant operation fully decided by the owner/operator, no market distortion is introduced.

The CfD requires five design parameters:

1. **Number of hours** (Nh) for the calculation of the spread, defined by the regulator.
2. **Price spread** of each day/week (S), defined as the difference between the average day-ahead market price between the Nh most expensive hours and the Nh cheapest hours .
3. **Volume** (V) in MWh/day of the contract, which should not be larger than the physical capacity of the facility times the numbers of hours of the daily contract already defined (Nh). It is important to highlight that the volume of the contract is independent from the effective energy injected in the grid.
4. **Strike spread** (K) of the contract in €/MWh, which will reflect different risk strategies of the participants.
5. **Settlement period**, that is, the period along which the price spread is computed and the CfD settled.

Developers submit consistent bids providing the strike spread and the volume of the contract (K,V). Award would be done based on the lowest strike spreads until a target capacity or energy volume is reached. Pay-as-bid or Pay-as-clear (marginal) variants could be explored, with pay-as-clear being more likely in line with European preference for remunerating services. However, the extent to which different storage technologies provide a same service is questionable (given different efficiencies, degradation, duration etc.), hence pay-as-bid rules might be considered.

This awarded CfD consist of a settlement each period and for Z years made in favour or against the storage facility equals to: **V*(K-S)**. It can be demonstrated that if the CfD volume is equal to the storage physical volume, then the addition of the CfD revenues and the day-ahead market revenues is a constant amount, irrespective of the day-ahead price. This settlement can only apply to storage assets that are able to do price-arbitrage. Therefore, other generation technologies like CCGTs would not be compatible with this remuneration.

Also, this settlement mechanism covers the risk on the price spreads at daily level (or whichever settlement period is chosen), and on a yearly horizon it provides higher visibility on the total revenues from the market and from the settlement of the 'strike spread' combined. Therefore, total revenues are mostly fixed, with the possibility of additional upside in ancillary services markets, and the incentive of an efficient operation in the wholesale market.

13 This is a calculation based on market prices, independent of the plant operation and their remuneration parameters, hence, it does not cause market distortions itself.

A.3 Cap & Floor

An additional settlement mechanism is the Cap & Floor design, where storage merchant revenues are limited above (Cap) and below (Floor) in order to decrease their overall volatility. Less volatility in revenues implies the possibility for lower project hurdle rates, and therefore lower Capacity Payment needs.

AFRY has modelled various Cap&Floor options and concluded that a simple Cap&Floor can decrease storage revenue volatility by 37% compared to merchant unclamped revenues. More complex Cap&Floor designs that include intermediate revenue bands can decrease storage revenue volatility by 40%.

Overall, the modelling shows that a Cap&Floor mechanism reduces revenue volatility considerably, and that this implies lower Capacity Payment needs. This, in turn, entails a reduction of Capacity Mechanism incentives which are ultimately paid by retail electricity consumers.

TABLE OF EXHIBITS

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