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Solarspitzengesetz: Potentials for Energy Optimization of Multi-Use Battery Storages

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Abstract. This paper analyses the operational and economic impacts of the MiSpeL regulation (status 10/2025) on residential PV battery systems. This paper models and compares the two new accounting options introduced by §19 EEG: the Abgrenzungsoption (differentiation option) and the Pauschaloption (flat-rate option). A MILP approach is used to represent the regulatory rules and to optimize arbitrage and self-consumption strategies. The two options create distinct operational incentives. The Abgrenzungsoption increases storage-grid-interaction that may produce distinct power peaks. In contrast, the Pauschaloption decouples storage dispatch from local generation and reacts primarily to national price signals. Economic outcomes depend strongly on storage size; small storages favour the Pauschaloption, while very large storages may benefit more from the Abgrenzungsoption. In all simulations the new accounting options outrun the already existing exclusivity option. The complex structure of the new regulation however emphasizes that simulation tools are recommended to support regulatory design.

Keywords: MISPEL; PV STORAGE; ARBITRAGE; MARKET INTEGRATION

1. Introduction

The ongoing decentralization of the energy system increasingly leads to congestion in distribution networks [1], [2], [3]. With §14a of the Energy Industry Act (EnWG), the legislator addresses controllable consumption devices such as heat pumps, charging points, and battery storages for the first time. Distribution system operators may limit their power draw to 4.2 kW in case of local network constraints to avoid congestion [4]. Due to high technical and organizational requirements and standards that still need to be defined, it remains uncertain whether this mechanism can be used in the short term [5]. Furthermore the grid operator is not able to enforce consumption in times of high energy production. Complementary control approaches therefore remain relevant.

On the generation side, the Solar Peak Law (Solarspitzengesetz) introduces, among other measures, a zero remuneration for negative electricity prices [6], [7]. Dynamic electricity tariffs are intended to pass price signals to photovoltaic (PV) storage systems that have so far been optimized predominantly for self-consumption. This enables solar electricity to be stored deliberately during low-price periods and thus relieve the subsidy account. To this end, §19 of the Renewable Energy Sources Act (EEG) expands the market integration of storages and charging infrastructure by enabling their active participation in electricity trading. The new framework increases the complexity of accounting and metering. Thus, the Federal Network Agency (Bundesnetzagentur) defines the metering and billing requirements by its MiSpeL process.

MiSpeL defines the metering and accounting rules for the market integration of storage and bidirectional charging (german: Marktintegration von Speichern und Ladepunkten). The abbreviation MiSpeL is used throughout this manuscript. According to the Grid Agency’s proposal, storages should charge fully at night, discharge in the morning to support the grid, and only then switch to self-consumption mode which would be both economic and grid oriented [8]. Direct marketing would then be mandatory.

Billing must continue to ensure a distinction between subsidized “green” electricity (for example PV) and intermediate “grey” grid electricity that may be purchased cheaply and resold profitably through temporal shifting (arbitrage). A central prerequisite is the compensation of network charges on intermediate stored electricity. At the same time, billing should be transparent and as simple as possible, for example by orienting on annual accounting intervals as proposed for the market premium. Where a storage was previously qualified exclusively for PV or grid electricity (§19 para. 3a EEG), the legislator creates two new options for storage operation with the Abgrenzungsoption (§19 para. 3b EEG) and the Pauschaloption (§19 para. 3c EEG). This raises two central questions: Which option is economically most beneficial for operators? And to what extent can the regulation support stable grid operation? The central accounting logic of both concepts is important for the further analysis and is therefore sketched below following the Federal Network Agency. Figure 1 shows a schematic comparison of the metering approaches for the Abgrenzungsoption and the Pauschaloption.

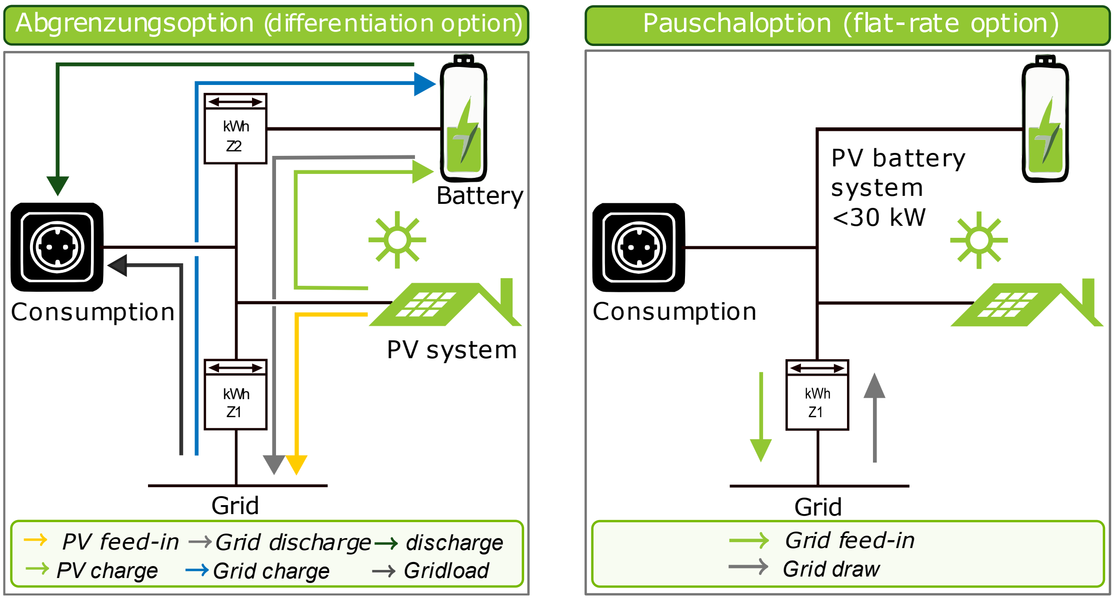

Figure 1. *Comparison of metering approaches for the Abgrenzungsoption and the Pauschaloption*

Abgrenzungsoption (A-Opt - differentiation option) [9]**:** Two networked bidirectional meters—one at the grid connection and one at the storage—balance all energy flows by reconciling 15-minute values. Example given: If the storage charges while grid electricity is drawn in the same interval, the charged energy is classified as grid electricity. If only the battery meter records the energy, it is counted as PV electricity charging the storage and thus increases the “green share” of storage usage. The same logic applies to storage discharging. Nevertheless, the A-Opt is applicable for all plant sizes but only with AC-coupled storages. This excludes hybrid converter PV battery systems from participation, also see comments on [8].

A key concept: The annual green share of stored energy. The PV market premium subsidy and the exempt of the network charge are linked to the green share stored in the battery multiplied with the storage exports. This should prevent cheaply purchased grid electricity from incorrectly receiving EEG support and to get exemptions for PV-storage-feed-in. The following example illustrates the mechanism of the A-Opt.

Example: If a storage buffers 2000 kWh from the grid and 1000 kWh from the PV system, the green share is 30%. Exports from the storage are then 30% eligible for the market premium. While 70% of the storage feed-in leads to an accounting of the grid fees to get an exemption.

Pauschaloption (P-Opt - flat-rate option) [10]**:** For systems up to 30 kWp, the second meter may be omitted. A flat rule defines all exports up to 500 kWh per kWp installed as “green” and eligible for the market premium. Energy amounts beyond that do not receive the market premium but lead to an exemption of network charges on grid imports—the main benefit of the P-Opt. If this surplus suffices for an accounting-based self-supply, consumption is priced at the spot market price. Additional exported energy receives the spot market price remuneration. The following example illustrates this mechanism.

Example: In a household with a 5-kW PV-storage system that exports 5000 kWh and imports 5000 kWh, it is assumed that 2500 kWh are eligible for support and 2500 kWh are exempt from network charges as arbitrage. Since network charges are usually higher than the feed-in tariff, this is an economically attractive assumption

Research questions: This paper investigates the effects of the MiSpeL regulation (status 10/2025) on typical PV storage systems in the single-family house segment. Two central research questions are addressed:

(1) How does the MiSpeL regulation influence the operation of solar battery storages?

(2) What is the economic added value of the Pauschaloption and the Abgrenzungsoption?

An earlier extended-abstract version of this contribution appeared in the printed conference volume in german language [11]. This submission presents the full and substantially expanded version, including additional methodological detail, extended results and a more comprehensive discussion.

2. Model description

To reliably answer the research questions an optimization problem was formulated representing. The model represents combined self-consumption and market participation. The objective is to derive an operational strategy that maximizes revenue while respecting the constraints imposed by the MiSpeL. The mathematical model follows the MiSpeL proposal [8](status 10/2025). The P-Opt and A-Opt rules were translated into a Mixed-Integer Linear Programming (MILP) optimization problem for the simulations [9], [10].

Even through, the regulation represents a complete new approach, there is limited literature on the energy-economic assessment of the MiSpeL regulation. Wagner et al. already analyzed the framework for residential PV battery systems using a multi-use optimization approach that combines self-consumption, frequency control and arbitrage within a rolling-horizon scheme. In their study, only the immediately applicable components of MiSpeL are considered during the optimization, while the annual accountment is performed ex post [12]. While this approach neglects the structural impact of the annual green share requirement on the optimal dispatch it is capable of actual implementation. The novelty of this contribution lies in a full-year optimization that endogenously incorporates all relevant elements of the MiSpeL framework. The methodological approach seems to be appropriate since it reveals unbalanced incentives. A drawback: it may not be practical implemented.

A central parameter in the calculation of the A-Opt are the green and grid share of the stored energy. Due to their non-linearity, they are modelled as exogenous parameter, e.g. solve the optimization problem with a PV share of 60%. By successively parameterizing the green share in multiple optimizations runs, the global revenue maximum under constraints is approximated. Even though the optimal result may diverge in a few Euros.

A similar approach of fragmentation was used for the P-Opt. This option was represented by using linearized min-max operators. Hence the optimization could be solved in three scenarios. (1) PV feed-in is below the flat rate, (2). PV feed-in is above the flate rate but the surplus is below total consumption and (3) same as the second but with surplus above the consumption. Each scenario has a different optimized battery dispatch schedule, costs and revenues. Therefore, the most economic scenario was chosen ex-post.

Auxiliary variables and disjunctions were introduced to preserve convexity in the MILP. For example, this prevents the battery from charging and discharging at the same time. While this may not be necessary, it seems reasonable to prevent the battery from simply increasing revenues through energy efficiency losses. The MILP was solved using Gurobi’s branch-and-bound (branch-and-cut) algorithm (Version 13.0.0). The solver iteratively tightens a global lower bound obtained from linear programming relaxations and a global upper bound derived from feasible integer solutions, thereby reducing the optimality gap. The optimization terminates when the absolute gap falls below €5 or the relative gap is below 1%. The MATLAB simulation code is published on GitHub in the repository [13]. Further details are described in the underlying thesis [14].

The optimization uses hourly day-ahead prices [15] without a margin from 2024. It is assumed that the margin is covered by the basic fee. After the hourly linear optimization, a minute-resolution simulation is performed to respect technical limits. Further input data and assumptions are as follows. Weather data from Lindenberg (2024) [16] and household load profile 46 (7900 kWh/a) were used [17]. The reference system comprises a 10 kW PV array, a 10 kWh battery and a round-trip efficiency of 83%. Charge/discharge power was set to 0.5 kW/kWh. Network charges and levies were simplified to a net value of 15 ct/kWh. The grid concession fee of 1.7 ct/kWh according to the KAV must still be paid, even though other network charges, taxes and levies can be offset through the MiSpeL saldierungs mechanism. Although it is still debated whether exemption of the the electricity tax also applies to low-voltage prosumers [12], it is assumed here that electricity taxes under the StromStG can also be offset in all simulations. The treatment of value-added tax (VAT) for residential prosumers remains unclear: VAT is likely due when electricity is drawn from the grid, but no mechanism exists to recover it for arbitrage. This aspect is not considered further, as it is assumed to reflect the regulator’s intention. For PV feed-in actual applicable values from February 2026 were assumed [18] . This leads to a yearly market premium of 2.1 ct/kWh for a 10 kW PV system and corresponding lower values to larger PV systems. It has to be pointed out, that the annual market premium is newly introduced in the MiSpeL process and may lead to economic distortion as storage operation in winter would be different to summer operation. Direct marketing costs were neglected in first approximation.

To test the findings a further analysis reveals the behavior of a 60-kW PV battery system. Therefore the “School 5”- profile from the sciber data set [19] was selected with 53 MWh annual consumption, referred as *commercial* in Table 1. A medium voltage connection with reduced grid fees of 13 ct/kWh and 86% round tip efficiency is assumed. In difference to the residential system nether concession fee nor VAT are paid. Table 1 summarizes the assumptions.

***Table 1**. Summary of simulation assumptions (ct = euro cents).*

Parameter	Value
Network charges and levies (residential / commercial)	15 ct/kWh / 13,2 ct/kWh
Concession fee (residential / commercial)	1.7 ct/kWh / 0 ct /kWh
VAT	19%
Market premium (annua residential / commercial)	3,67 ct/kWh / 2,79 ct/kWh
Installed PV power (residential / commercial)	10 kW / 60 kW
Storage capacity (residential / commercial))	10 kWh / 60 kWh
Charge and discharge power	0.5 C
Round-trip-efficiency (residential / commercial)	83% / 86%

3. Results

This section presents the optimization results for the different EEG options. First, storage usage over time are shown in section 3.1 and second, the annual economic balance is analyzed in section 3.2. Here the results are presented for a residential prosumer in the first section (3.2.1) and a commercial prosumer in the second section (3.2.2).

3.1 Time-series analysis

Figure 2 shows the optimized storage power and the day-ahead price for three representative days for the residential prosumer applying the A-Opt. The price profile typically exhibits two peaks (morning and evening) and a midday minimum. A rule-based controller would exploit this spread for arbitrage.

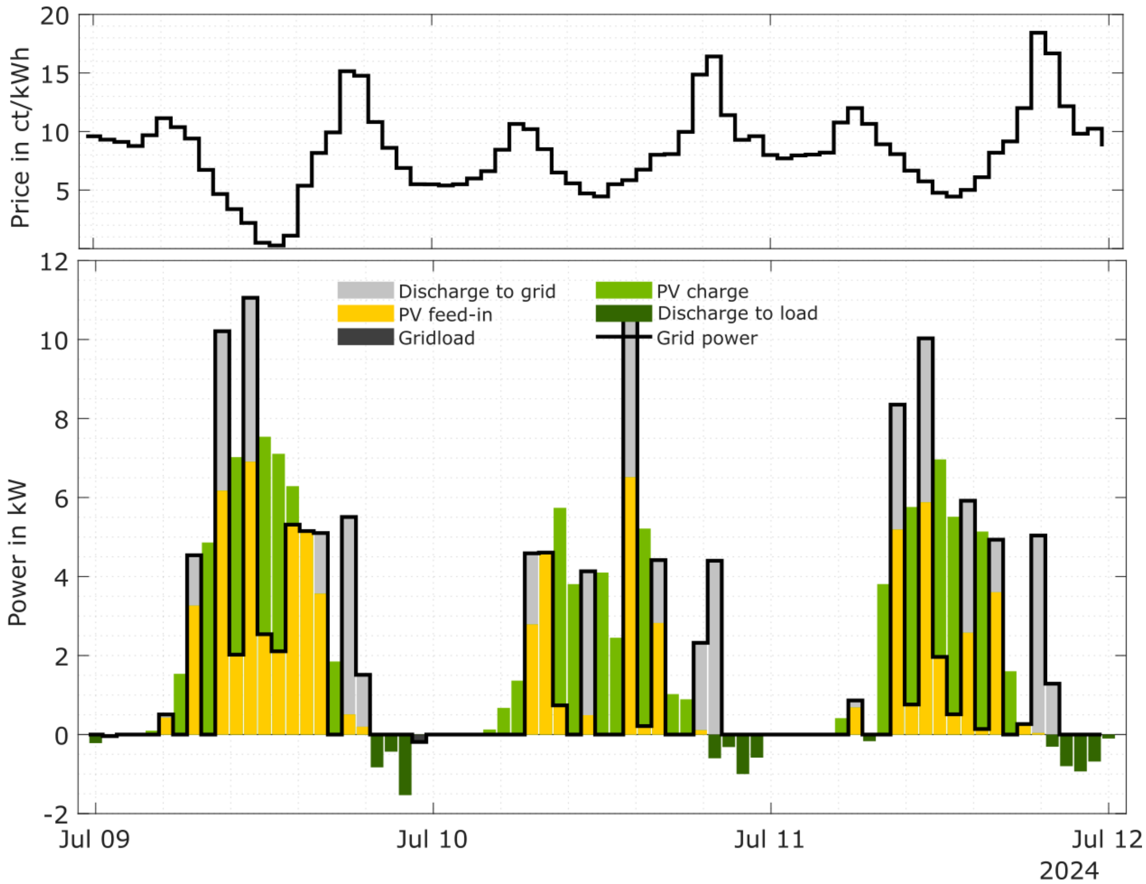

Figure 2. *Optimization result for the Abgrenzungsoption (A-Opt): top — day-ahead price; bottom — optimized storage power and resulting grid power for a 10 kW PV system and a and 10 kWh storage.*

For small price differences, the optimized schedule can produce counterintuitive behavior: The storage may charge from PV in one interval (green) and discharge in the next (light grey) instead of feeding PV directly into the grid (yellow). This produces pronounced export peaks followed by intervals with no exports (black line). The optimization result seems to be surprising because charging and discharging are lossy and therefore less efficient than direct feed-in. However, from an MiSpeL economic perspective this also increases storage exports. Whereas storage exports multiplied by the grid share determines the energy applicable for offsetting. If the grid share is however be specified; with increasing storage exports more imports, also through the storage, are exempt from network charges. Thus, creating an economic incentive for this behavior. The regulatory dynamics are described in detail in the underlying thesis [14].

While the charging of PV energy increases the PV share of the stored energy, the same behavior could be observed in winter with grid energy to increase the grid share. Here energy is drawn from the grid to the battery, with exemption of most grid fees and discharged to the prosumer in the next timestep. This could be utilized to optimize the accounting relevant green share. When the storage capacity significantly exceeds the PV system size, the effect becomes almost negligible. Nevertheless, in the physical interpretation this leads to storage losses in the first place but may also affect the grid capacity in the second. If storage actions are stochastic the effects remain small but could increase whenever oscillations are synchronized with market intervals.

Figure 3 shows the same time series for the P-Opt. The storage operation is largely decoupled from local PV generation and load and reacts primarily to the spot price. The primary driver of the optimization is, to get feed-in above the specific flat rate, since unpaid grid fees are much more valuable than the market premium. The greater the amount of energy exported, the larger the volume of imports exempt from charges. However, this results primarily in an arbitrage-driven operation: the battery discharges at maximum power during high-price periods and charges at maximum power during low-price periods. Since low prices often coincide with PV generation, the battery charges PV energy in many cases. In winter, however, a partial prioritization of self-sufficiency can be observed. When low-cost energy—whether from PV generation or from the grid—is scarce, the battery supplies only the load, while discharging is still limited to periods with high electricity prices.

A necessary condition for profitable storage arbitrage under the P-Opt is that the price spread compensates storage losses, since losses are not explicitly exempt from network charges in this option. Thus, the P-Opt creates a strong incentive for neglecting local generation in the storage dispatch. Furthermore, synchronization to a national price signal may exacerbate local network congestion [20], [21].

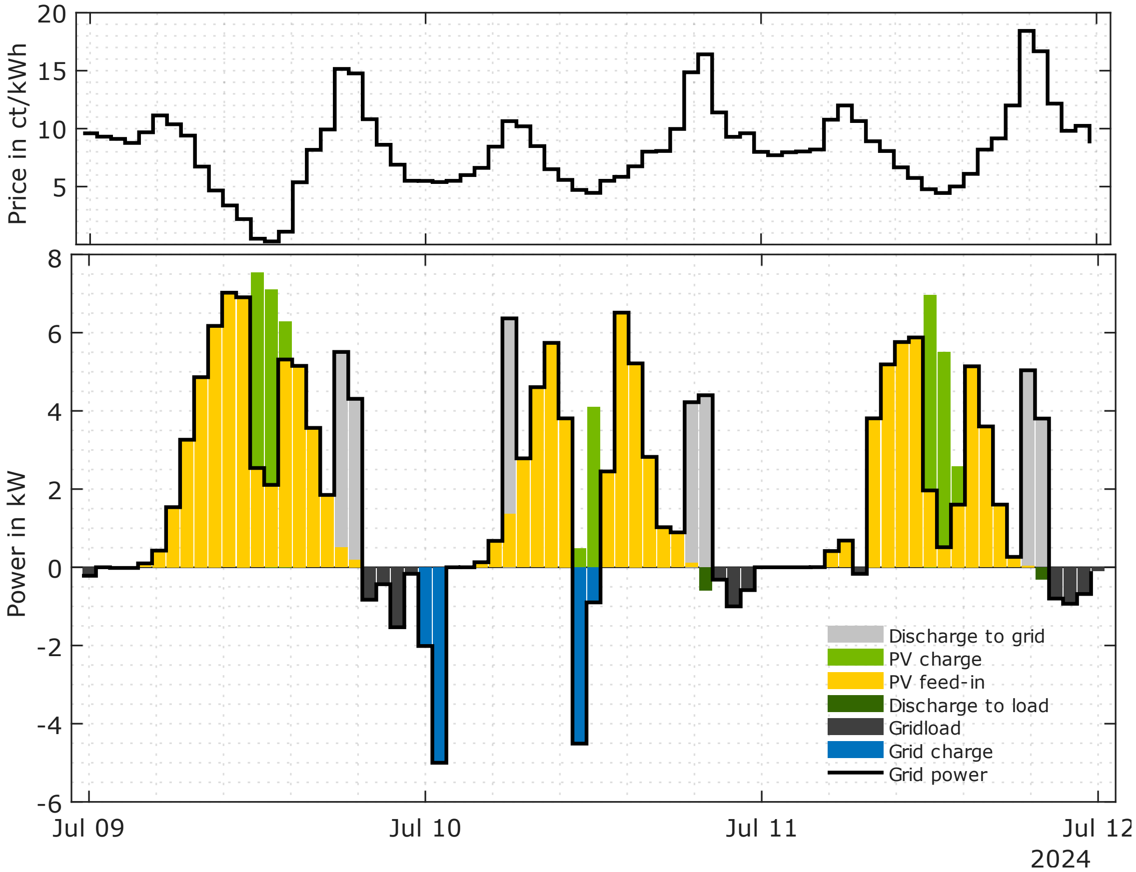

Figure 3. *Optimization result for the Pauschaloption (P-Opt): top — day-ahead price; bottom — optimized storage power and resulting grid power for a 10 kW PV system and a and 10 kWh storage.*

3.2 Annual balance and storage sizing

Annual balances for 2024 were computed by summing revenues (day ahead sales, market premium) and costs (purchases, network charges). Negative values indicate net costs; positive values indicate net revenues. Differences of up to 25 €/a between hourly optimization and minute simulation were observed, but close to optimization.

3.2.1 Residential Prosumer

For the residential prosumer with a 10 kW PV system Tables 2–4 present annual balances for different storage capacities and different accounting options. In general, the existing exclusivity option results in the highest costs. The A-Opt reduces costs through additional trading and by avoiding grid fee to some extent. The P-Opt, as proposed, is therefore most advantageous.

Table 2. *Annual balance — Exclusivity option for a residential prosumer. Assumptions: purchase price 30 ct/kWh; zero remuneration for negative spot prices; feed in tariff around 7.8 ct/kWh.*

Storage capacity in kWh	0	5	10	20	40
Annual balance (minute simulation) €/a	-1157	-930	-855	-814	-794
Savings due to storage €/a	-	227	302	343	363
Specific saving €/kWh·a	-	45	30	17	9

Table 3*. Annual balance — Abgrenzungsoption (A-Opt) for a residential prosumer,*

Storage capacity in kWh	0	5	10	20	40
Annual balance (minute simulation) €/a	-1191	-815	-546	-100	+519
Savings due to storage €/a	-	376	645	1091	1710
Specific saving €/kWh·a	-	75	65	55	42

Table 4*. Annual balance — Pauschaloption (P-Opt) for a residential prosumer.*

Storage capacity in kWh	0	5	10	20	40
Annual balance (minute simulation) €/a	-871	-613	-390	+3	+614
Savings due to storage €/a	-	258	481	874	1512
Specific saving €/kWh·a	-	52	48	44	38

Nevertheless, the various options result in different economic outcomes, even without a storage. For the 10-kW PV system annual cost amount to 1157 €/a under the exclusivity option. Applying the A-Opt, increases the annual cost 1191 €/a, since a dynamic tariff and market premium feed-in is utilized. This is 320 €/a higher than under the P-Opt, which results in 871 €/a, with same parameters. Hence, the household already benefits from the flat threshold and offsets network charges once exports exceed this threshold.

Installing a 10-kWh storage system reduces annual costs under the exclusively option by approximately 302 €/a to total 855 €/a, primarily due to increased self-sufficiency. Under the A-Opt, the specific economic benefit of the storage could be more than doubled to 546 €/a, corresponding to 45% of the initial costs. A similar relative reduction of about 45% is achieved under the P-Op; however, due to lower initial costs and different operational strategies, net costs decrease to 390 €/a. This indicates that the storage is utilized more efficiently from an economic perspective, as spare capacity is exploited for arbitrage in addition to enhancing self-sufficiency.

Doubling the storage capacity emphasizes this tendency. The additional arbitrage potential, particularly for hedging against high price periods, leads to a further reduction in net costs. While annual energy costs under the exclusivity option remain nearly unchanged, the application of the A-Opt reduces them to approximately 100 €/a. This approaches the net revenue level achieved under the P-Opt, which remains the most economically advantageous option. The comparison to the exclusivity option impressively shows how arbitrage under the P-Opt and the A-Opt could be an economic driver towards larger storage capacities.

To better understand the underlying mechanisms, Figure 4 illustrates the specific charged and discharged energy under the A-Opt (left) and the P-Opt (right) for the 10 kW PV system across different battery capacities. Three main observations can be made:

1. The total energy throughput under the A-Opt is significantly higher for all simulated capacities except for the largest 40 kWh storage. This is consistent with the behavior shown in Figure 2, where throughput is used to control the green share.
2. The share of PV energy in the storages changes only marginally across capacities, again with the exception of the 40 kWh system. In this case, the grid share under the P-Opt increases disproportionately, whereas under the A-Opt it rises approximately linearly.
3. The purpose of the battery discharge differs depending on the accounting model. Under the P-Opt, a larger share of discharged energy is fed into the grid, whereas under the A-Opt the battery supplies a greater portion of the household demand. Nevertheless, total discharged energy is hig her under the A-Opt – see point 1.

The second point, in particular, must be highlighted: The A-Opt makes it difficult to engage in grid arbitrage because it only compensates a portion of grid fees and losses. In the presented optimization, the economic optimum of the grid share remains below 60% when solar energy is included. In contrast, under the P-Opt, the storage only needs to offset conversion losses. Hence, the exemption mechanism covers 83% of the charging grid fees.

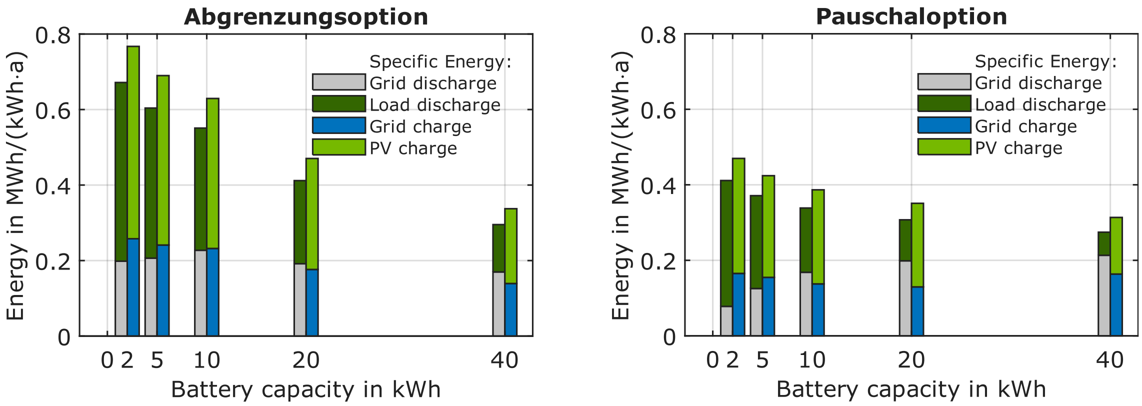

Figure 4. *Specific charged and discharged energy sorted by source and sink for the Abgrenzungsoption (A-Opt, left) and the Pauschaloption (P-Opt, right).*

3.2.2 Large prosumer

For a School with a 60 kW PV system Table 5 presents annual balances for different storage capacities and the exclusivity option while Table 6 depicts the A-Opt. As the P-Opt is restricted to 30 kW PV systems, the simulation was conducted for the A-Opt only.

Similar to the residential case, structural economic benefits arise from the combination of a dynamic tariff and direct marketing. Under a flat-rate tariff, the 60-kW PV system results in annual energy costs of approximately 5290 €/a. In contrast, dynamic procurement and market-based feed-in reduce costs to 4,628 €/a. Adding a storage increases this discrepancy. Therefore, a 45 kWh-storage system would almost halve the energy costs of the assumed school under the A-Opt. In contrast a storage system operated solely to increase self-sufficiency reduces the costs by less than one third. For a 100-kWh storage system, annual energy costs under the exclusivity option are approximately three times higher than under the A-Opt.

Table 5. *Annual balance — Exclusivity option for a larger prosumer. Assumptions: purchase price 23 ct/kWh; zero remuneration for negative spot prices; feed in tariff 6.5 ct/kWh.*

Storage capacity in kWh	0	30	45	60	100
Annual balance (minute simulation) €/a	-5290	-4105	-3769	-3545	-3368
Savings due to storage €/a		1185	1521	1745	1922
Specific saving €/kWh·a		40	34	29	24

Table 6. *Annual balance — Abgrenzungsoption (A-Opt) for a larger prosumer.*

Storage capacity in kWh	0	30	45	60	100
Annual balance (minute simulation) €/a	-4628	-3049	-2412	-1813	-1042
Savings due to storage €/a		1579	2216	2815	3586
Specific saving €/kWh·a		53	49	47	45

4. Summary and Discussion

The simulation-based analysis of the MiSpeL regulation (status 10/2025) shows that regulatory changes substantially alter storage operation and revenue streams. In particular, the rules for offsetting network charges create strong economic incentives to operate storages differently than before.

Under the Abgrenzungsoption, exemption of storage losses from network charges increases trading volume with the grid. This does not necessarily generate new energy flows; rather, the battery is often used as an intermediate stage for grid consumption and grid feed-in to save grid fees. Besides that, the battery is indeed used for optimizing the tariff for consumption, by charging when market prices are low.

The Pauschaloption largely decouples storage operation from local generation and load; the storage reacts primarily to market price signals, which can neglect local network conditions. Furthermore, the Pauschaloption has structural economical advantages, resulting in reduced costs for the single end consumer without generating any benefit. So far, the current design of the Pauschaloption appears unbalanced, as even the installation of an EV charging point (wallbox) would get substantially stronger support than before. This on the other hand will very likely increase the costs for others.

Besides that, some mechanisms in the Abgrenzungsoption appear counterproductive, e.g. avoidable power flows though the storage or the proportional offsetting of grid fees based on annual energy shares of stored energy which makes arbitrage less attractive. It is likely that the Federal Network Agency will need to refine the rules and to better balance incentives. Therefore, simulation tools like the one presented here can be a useful complement in the regulatory design process.

With the Pauschaloption a strong incentive for market integration was identified. In the example simulation, a financial advantage of 300–800 €/a compared to fixed feed-in remuneration for typical system sizes in the residential showcase was found. This revenue stream makes it likely that cooperation with a direct marketer could be profitable. For the Abgrenzungsoption, this is not certain for small storage sizes because self-consumption dominates. Nevertheless, for very large storages the Abgrenzungsoption could become also economic attractive. For larger prosumers the acquisition of a direct marketeer might be no challenge as the installed power and amount of energy are generally larger.

Furthermore, a critical view on the methodological approach itself is necessary. As mentioned above the optimization uses one hour historical data from 2024. This data does not fully feature actual tendencies in the energy market. First, since October 2025 the day ahead energy market in Germany works on a 15 minute scale [22]. Since there is no available one year dataset of 15 minute data this might be acceptable but has to be addressed in future investigations. Second the number of negative prices relevant for EEG market premium increased from 2024 to 2025 [23]. It is likely that this tendency may continue to increase for the next years and decrease with larger installed storage capacity. This increases the uncertainty regarding the validity of this study. Nevertheless, these uncertainties seem to be acceptable, as this study provides insight into the underlying mechanisms in the MiSpeL regulation and does not aim to present universally valid findings. A more crucial point is, that the costs of battery ageing were neglected in the optimization. Under the assumption of 2000–8000 cycles and investment costs of 120–180 €/kWh capacity, this corresponds to cyclic degradation costs on the order of 2–8 ct/kWh of energy throughput when calendar ageing is properly accounted for [24], [25], [26]. These values remain comparable to typical electricity price spreads used for arbitrage. Hence, explicitly incorporating degradation costs into the objective function would materially change optimal dispatch decisions. This might make arbitrage even more unattractive and should be accounted in future, more detailed investigations.

Nevertheless, this paper presents an optimization approach to inspect incentives given by the new regulatory framework. Overall, the MiSpeL regulation changes storage behavior and creates new economic incentives.

Future work will test and validate proposed regulatory amendments using the developed simulation and will develop approaches to better balance regulatory incentives.

Data availability statement

The simulation code used for the results in this paper are available on [13]. The repository contains the exact commit hash used for the presented results.

Underlying and related material

Model code and supplementary material (additional sensitivity runs) are provided in the repository referenced in the Data availability statement.

Author contributions

Gregor Conzelmann: conceptualization, methodology, modelling, simulation. Joseph Bergner: conceptualization, methodology, writing — original draft, supervision, review & editing.

Competing interests

The authors declare that they have no competing interests.

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