A Dutch Market Design on Congestion Management: The Role of (Fully) Independent Aggregators

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***Abstract*—The Dutch power system is experiencing congestion challenges due to the rapid expansion of renewable energy sources, increasing electrification, and European regulation on cross-border capacity. This paper proposes a market design for congestion management that enables Dutch Congestion Service Providers to offer (aggregated) congestion products independently from energy suppliers and Balancing Responsible Parties. A key element of this design is the obligation for customers to submit accurate forecasts for grid security analysis. To ensure reliability, the quality of these forecasts is systematically measured, and corrective actions are taken when necessary. Activating congestion products impacts multiple stakeholders. It impacts a Balancing Responsible Party's balance position and an energy supplier's procurement strategy and its energy settlements with active customers. The proposed market design effectively solves these issues, including the *Transfer of Energy* problem. Moreover, the model supports aggregation. It allows active customers to collectively participate in congestion management, including mechanisms for topology-based group formation, the establishment of group baselines, and validation processes. By adopting this market design, all active customers have the right to participate in congestion management via a Congestion Service Provider.**

***Index Terms*—congestion management, forecast, independent aggregator, aggregation model, transfer of energy**

I. The Dutch Congestion Challenge

The Netherlands faces insufficient transmission capacity on the power grid. Substantial investments are required to expand grid capacity, but behavioural adaptations from power producers and consumers also become essential. Transmission and distribution capacity is no longer unlimited, which requires congestion management (CM) to mitigate peak loads in overloaded networks. Customers are requested to temporarily increase supply or decrease power consumption, when the transmission capacity reaches its limit [1]. The Dutch Grid Code [2] distinguishes four phases in the CM process and marks the starting point of this paper:

- Phase 0 (no measure): Grid security analysis identifies no congestion. Expansion of existing and new connection points is possible, and no CM is necessary.
- Phase 1 (voluntary, market-based): There is insufficient grid capacity to accommodate all electricity demand, but voluntary flexible consumption can mitigate congestion.
- Phase 2a (mandatory, market-based): Measures are required to meet the growing electricity demand due to lack of grid capacity. CM participation becomes mandatory for customers larger than 1 MW. Prices are determined by the market party.
- Phase 2b (mandatory, regulated): When market-based CM results in excessively high prices of flexible offerings, the price of mandatory congestion products is regulated.

In the Netherlands, a Congestion Service Provider (CSP) is a market party that offers CM products [3] to the Transmission System Operator (TSO) or Distribution System Operators (DSOs). In 2022 alone, the Dutch TSO TenneT has spent up to 388 million EUR on redispatch [4], whereas around 100 CSPs are *prequalified* [5] to offer at least one congestion product. After prequalification, a CSP is allowed to offer CM products on behalf of active customers [6]. The Dutch Grid Code specifies two CM products:

- *Capacity Restriction Contract (CRC)*. The DSO or TSO contracts active customers—optionally via a CSP—to resolve physical congestion, by temporarily or permanently (partially) waiving their right to transport capacity [7]. It is activated *before* the day-ahead market closure.
- *Redispatch*. It allows a CSP engaged by the active customer to submit upward or downward bids at a specific location [8]. Such bids are activated *after* the day-ahead market closure but 45 minutes before real-time operation.

To solve this congestion challenge, the Dutch power system should further exploit the flexibility potential of small market parties, rather than rely only on large-scale CSP. According to Directive (EU) 2019/944, a CSP may be an *independent aggregator* [9]—a market participant aggregating congestion products, independent of the active customer's energy supplier (ES) or Balance Responsible Party (BRP). This paper proposes such a market design for CM, enabling Dutch Congestion Service Providers to offer congestion products independently using aggregation.

II. High-Quality Power Forecasts and General Efforts to Improve Congestion Management

Accurate analysis of grid security is essential for efficient CM. To perform day-ahead and intraday security analysis, each European TSO must prepare individual grid models [9]. These models must include up-to-date load and generation forecasts based on the input from DSOs and Significant Grid Users (SGUs) [10]. In the Netherlands, these requirements are implemented in the Dutch Grid Code [11].

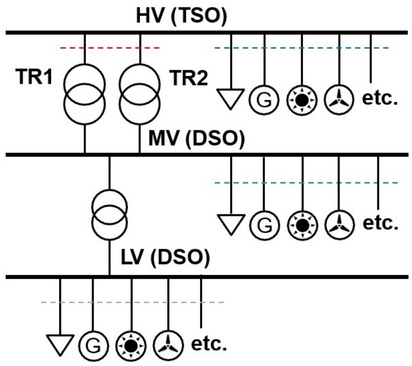

Fig. 1. Generation and consumption forecasting at different voltage levels of the Dutch electricity grid.

Figure 1 depicts the forecasting at different voltage levels of the Dutch electricity grid. All power facilities connected to the high-voltage (HV) grid must submit forecasts at the connection point (blue). Such forecasts should include active power and, if applicable, the primary fuel type and reactive power. Forecasts should consider all relevant parameters such as expected demand/production, market behaviour, weather, planned outages, and storage potential, among others. Likewise, DSOs must also submit forecasts at the connection point (red), detailing the expected load and generation per fuel type. To help DSOs generate accurate forecasts, SGUs with a capacity of 1 MW or above must submit forecasts to their DSOs (green). However, DSO-connected parties below 1 MW (grey) are currently not required to submit individual forecasts; their forecasts are provided by DSOs in aggregation. To improve CM, several forecast improvements have been agreed on in the Dutch power sector [12].

- Previously, connected parties could only submit forecasts directly or through their BRP. A proposed change to the Dutch Grid Code allows them to outsource forecasting to qualified service providers [13].
- DSOs are developing a simplified access portal for SGUs to manually update forecasts without advanced IT tools.
- Recently, a roadmap has been established to standardise forecast monitoring across the DSOs and the TSO, with the potential for an incentive scheme [12]:

Phase 1: Monitoring (6 months) & Evaluation (1 month). DSOs and the TSO monitor forecast accuracy using mean absolute error (MAE) and relative MAE (rMAE):

$$\mathrm{MAE} = \frac{1}{n}\sum_{t=1}^{n} |A_t - F_t| \tag{1}$$

where A_t is the measured value at period t (market time unit, MTU), F_t is the forecasted value at period t, and n is the total number of periods per month.

$$\mathrm{rMAE} = \frac{\mathrm{MAE}}{P_{\max}} \cdot 100\% \tag{2}$$

where $P_{\max}$ is the measured (absolute) maximum power during the month, $P_{\max} = \max(|A_t|)$.

Phase 2: Benchmark (6 months) & Evaluation (1 month). The rMAE benchmarks an SGU's forecasting performance into five categories (from bad to excellent) and communicates it transparently to encourage continuous improvement.

Phase 3: Incentive Scheme (optional). If Phase 2 does not yield significant accuracy improvements, an incentive scheme may be introduced. Under this scheme, poor performance incurs penalties, while excellent performance is rewarded in a financially neutral manner for DSOs and the TSO. A "poor" performance is automatically awarded if no forecast is provided.

In addition to these improvements, the DSOs and the TSO also continue to develop their own forecasting and grid security processes. An example is to compare aggregated individual forecasts with the dedicated forecast for the aggregated area.

III. Transfer of Energy: How Does the Activation of Congestion Products Impact Market Parties?

The further development of the CM process took place in an open and transparent forum [14], including the information exchange for CRC and redispatch. Representatives of active customers and all market parties involved in CM have participated in the market design and unanimously adopted it.

The market design facilitates both regulated and non-regulated domains, while adhering to competition regulations [15]. The contract between the active customer and the regulated DSO or TSO includes participation in (non-)market-based CM. Additionally, the active customer selects an ES and an associated BRP and may contract a separate CSP and/or Balance Service Provider (BSP). The non-regulated domain represents the commercial electricity market, where contracts and tariffs are determined by market parties, without direct government regulation.

Each delivery of a congestion product results in deviations from the energy demanded by the DSO or the TSO, ranging from zero to the maximum capacity of the connection point. Activating congestion products affects multiple market parties at a given connection point. To ensure complete, accurate, and timely settlement for each Imbalance Settlement Period (ISP), it must always be clear which market party is responsible for the energy and imbalance. Each market party involved instantly receives the activation for CRC or redispatch to:

- ES: Use information in portfolio procurement processes; if desired, adapt the contract with the active customer.
- BSP: Account for transport limitations during delivery.
- BRP: Avoid corrective actions, as imbalances are automatically adjusted; settle with ESs.

Every month, all market parties receive a comprehensive overview of activated CRCs and redispatch events. ESs can offer customised contracts to active customers participating in CM via an independent CSP or aggregator. These contracts help facilitate flexibility while mitigating risks typically handled by ESs in static contracts. ESs may settle the transferred energy or apply a risk premium within legal constraints.

The activation of a CRC occurs before the day-ahead market closure and can be incorporated into the BRP's daily nomination process. By contrast, activating redispatch impacts the BRP's balance position, and the TSO will apply imbalance adjustments. When redispatch occurs via a power exchange (using locational intraday bids), the BRP must grant an independent CSP the permission for imbalance adjustments through Priority Nomination. If all required information exchanges are implemented as agreed, the BRP has no valid reason to deny consent [16]. This ensures that CSPs can operate fully independently from BRPs.

IV. Design Principles for Dutch Congestion Management

The following design principles constitute the foundation of Dutch CM processes, ensuring that the CSP, or aggregator, remains entirely independent from all other non-regulated market parties. These principles aim to uphold market transparency, maintain fair competition, and facilitate an efficient CM framework.

- *Formal National Agreement and Representation*. The design is ratified formally and unanimously in the General Assembly of the Market Facilitation Forum (MFF) [14]. It is established through an open dialogue with representatives of all relevant market parties such as active customers, BRPs, ESs, CSPs, BSPs, DSOs and the TSO.
- *Active Customer Responsibility*. An active customer has the freedom to contract multiple entities, while maintaining primary responsibility for all imbalances resulting from the actions of those entities or market parties.
- *Complete Settlement in ISPs*. For each ISP, it must be explicit who is responsible for the corresponding energy and the imbalance.
- *Facilitation of Independent CSPs*. The independence of the CSP is ensured by preventing direct interactions between the CSP and other non-regulated market parties.
- *Transparency and Non-Discrimination*. All market parties must have equal and complete access to relevant information to operate in a transparent and verifiable process. This includes insights into all CRC and redispatch activations, imbalance corrections executed by the TSO and priority nominations by a power exchange [17].
- *Separation of Regulated Activities from Non-Regulated*. There must be a strict separation between regulated and non-regulated activities. No agreements can be made within the non-regulated or commercial domain regarding matters such as contractual adjustments by an ES in response to the presence of an independent CSP [18].

All of the above principles were developed for active customers with a grid capacity of 1 MW and above. To unlock maximum flexibility for CM, it is also necessary to leverage the potential of active customers with connection points below a capacity of 1 MW. For this purpose, we have developed an aggregation model based on the model for individual customers.

V. An Aggregation Model for the Dutch Congestion Management

Figure 2 presents a simplified overview of the CM process and illustrates the interaction between market parties, focussing on the role of the CSP, while maintaining independence from non-regulated market entities such as BRPs and ESs. The model enables active customers to participate in CM by offering CRC and Redispatch through an independent CSP. The CSP provides (group)forecasts, coordinates bids on behalf of active customers, updates (group)forecasts after activation, and delivers activated products. The DSO or the TSO receives group-based forecasts from the CSP and uses these data for grid security analysis and validation purposes. The process flow for individual products is shown (blue), supplemented with the additional steps that enable aggregation (orange).

A. Group Formation

The DSO shares information on all active customers contracted with the CSPs in relation to bottlenecks in the grid, based on topology and effectiveness. This way, the CSP can determine which customers to aggregate to relieve bottlenecks and whether upward or downward action is needed. Subsequently, the CSP provides the TSO and the DSO with the insight into which customers are part of which aggregation. The DSO and the TSO can use this information to activate group-CRCs, balanced group-redispatch, and validate delivery.

B. Group Baseline

For aggregations including connection points of 1 MW or larger, the forecast information used for grid security analysis, can be employed for validation of delivery by summing the individual forecasts of all the participating active customers.

For aggregations that contain connection points with a capacity below 1 MW, a *group forecast* [19] must be submitted to the DSO. These group forecasts serve as a baseline for delivery validation and need to be updated after activation. A group forecast for connection points with a capacity below 1 MW can only include connection points with the same DSO.

After activation of an aggregated redispatch bid, the CSP provides an updated group-forecast to the DSO. This ensures that the DSO can verify whether the activated measure effectively mitigated congestion. In case the TSO activated the group-redispatch, the DSO includes the activation in its updated forecast towards the TSO.

C. Imbalance Correction & Transfer of Energy

After delivering an aggregated redispatch bid, the CSP provides the DSO or the TSO the volume that contributed to the delivery for each participating connection point. The sum of these volumes must match the activated volume of the aggregated redispatch bid. The BRP and the ES responsible for each connection point receive this information via the DSO and the TSO before 10:00 AM on the following day—This allows them to integrate this information to optimise their daily forecasting, nomination, and procurement processes. Activating aggregated redispatch impacts the BRP's balance position. For all group redispatch bids delivered by the CSP to the DSO or TSO, the TSO sums up individual volumes per BRP and applies an ex-post imbalance adjustment.

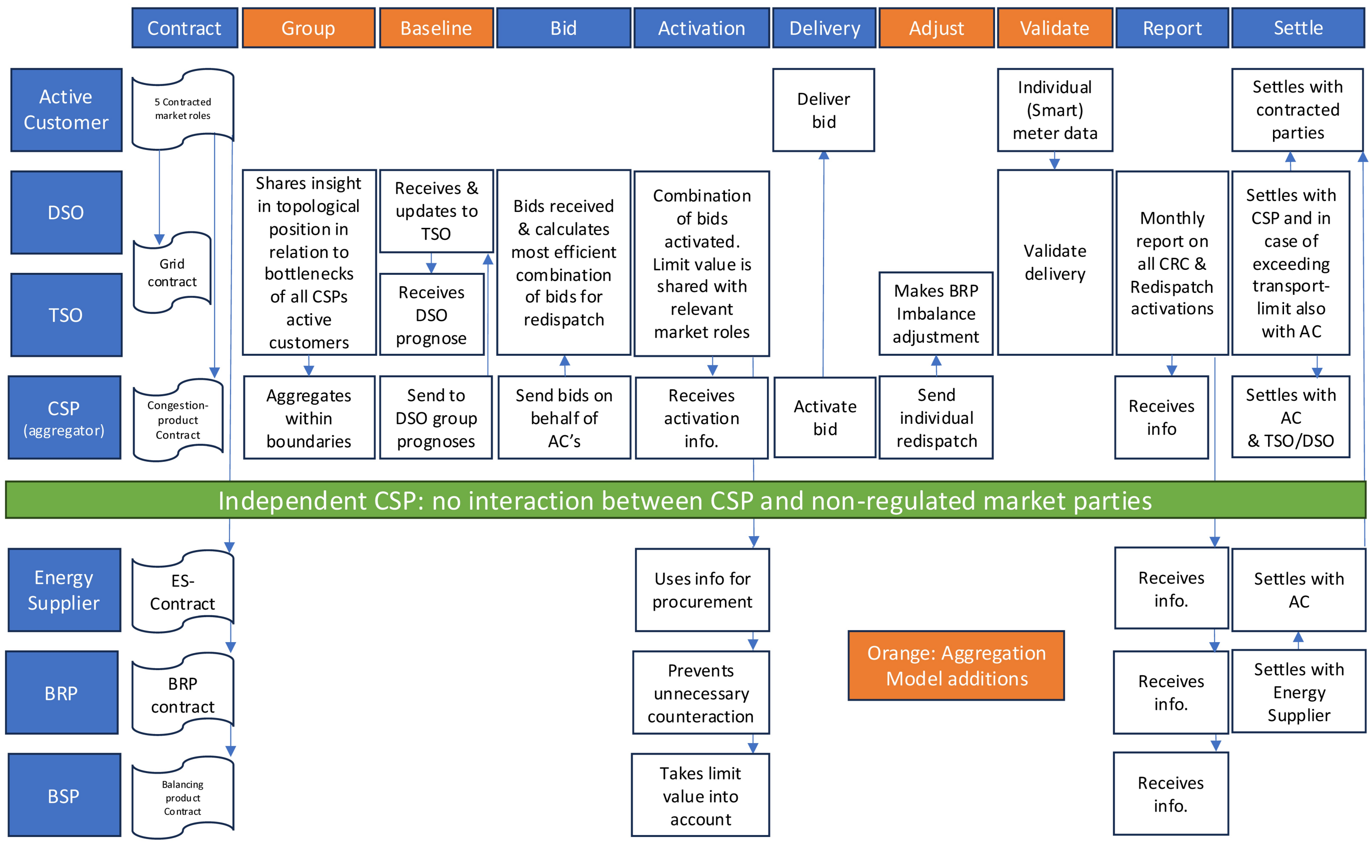

Fig. 2. Generation and consumption forecasting at different voltage levels of the Dutch electricity grid.

D. *Validation of Group Congestion Products*

Activating a group congestion product results in the establishment of a temporary group limit by the system operators at the participating connection points for the duration of the activation period. Namely, the total generation or consumption of the group must remain within the defined upper or lower group limit. The group limit represents a temporary constraint on the total transport capacity of all participating connection points. The system operators perform the validation by comparing the sum of all individual ISP measurements (via smart meters and telemetry) against the group limit during the activation period.

It is the aggregated delivery of the group that matters, not the contribution per individual active customer. If the sum of measured values exceeds the group limit, the DSO or the TSO will apply a non-delivery price per MW for the deviation in each ISP to the CSP. This non-delivery price serves as an incentive to prevent connected parties from taking actions that breach the group limit.

Finally, the DSO and the TSO provide timely insights to the CSP and relevant market parties regarding temporary group limits imposed on active customers during delivery.

VI. Discussion

The proposed market design for Dutch CM introduces several innovative mechanisms and a well-structured framework that balances national regulatory requirements and market-driven flexibility. The solution consists of non-mainstream components, including the role of active customers, transfer of energy, and aggregation. The stakeholders involved acknowledge that the flexibility is already available in day-ahead, intraday and balancing markets, and they see the solution as a way to unlock this flexibility also for CM at all levels of the grid.

Active Customers. Active customers play a central role in the CM framework. Whereas the legal obligation for active customers to submit accurate forecasts has existed for years, compliance has been inconsistent. Introducing options like selecting a forecasting service provider or using a simplified access portal invites broader participation. By monetising flexibility through contracts with market parties, active customers will experience the direct financial consequences of their participation, such as imbalance settlements in cases of non-delivery. This creates a tangible incentive for active customers to improve forecast accuracy and actively engage in CM.

Transfer of Energy. A critical strength of the Dutch market design is that it eliminates the need for a centralised and complex settlement process or national settlement price agreements. Instead, existing contractual relationships between energy suppliers (ESs) and active customers are made suitable for CM with an independent CSP. The consequences of non-delivery or under-delivery will be passed through to the primary responsible market role: the active customer. This model ensures that all market parties receive the information necessary to adjust their operations accordingly. However, active customers will inevitably experience the impact of this design, particularly in terms of their contractual obligations and financial liabilities in the event of non-compliance. This reinforces the importance of clear and transparent information exchange among stakeholders.

Aggregation. Aggregation offers a pathway for smaller customers to participate in CM, but its implementation requires careful considerations. First, with a large number of participants, automation is crucial to maintaining a feasible process and a viable business case. Second, reliance on multiple parties and IT systems introduces security and operational challenges. Data integrity, protection of sensitive market information, and alignment of aggregation with existing CM processes are the key to success. Third, the ability to effectively validate group congestion products will determine the trustworthiness and reliability of aggregation mechanisms in the broader context.

VII. Conclusion

Congestion management (CM) is essential to maintain security of supply and ensure efficient utilisation of power networks, before grid reinforcements render it unnecessary. Our proposed CM market design places active customers at the centre, holding them accountable for all contractual rights and obligations in both regulated and non-regulated domains, including forecast submissions [9], CM participation, and imbalance responsibilities. A fully independent CSP ensures the fulfilment of these obligations while creating new market opportunities. By sharing relevant information with affected market parties and leveraging existing contractual relationships in the non-regulated domain, CM is integrated in an efficient way, ensuring transparent and controllable processes for all market parties.

Facilitation of independent CSPs reduces market entry barriers and stimulates flexibility. Such CSPs operate outside traditional ES and BRP relationships: they coordinate aggregated bids, optimise demand-response portfolios, and offer location-specific CRCs and/or redispatch bids to DSOs and the TSO. The use of group forecasts ensures system reliability while unlocking small-scale flexibility—without complex central settlement processes. Such an aggregation further enhances market inclusivity, but demands robust automation and security measures.

Standardised CM processes, improved forecasting, and expanded market participation will contribute to grid stability in the Dutch energy transition. As coal phase-out and electrification advance, flexible CM mechanisms based on this independent aggregation model will be crucial to maintaining a secure and efficient electricity system. The proposed market design creates full market access and fully unlocks the available flexibility for CM. Such flexibility, already proven on a large scale in day-ahead, intraday and passive imbalance markets, can also find its way to the application of CM. At the same time, active customers will be able to improve their performance with artificial intelligence and data-driven capabilities.

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