BMViewGB: an Interactive Web Based Tool for Visualising the Operations of the Balancing Mechanism in Great Britain

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Abstract

The Balancing Mechanism (BM) is the main tool for keeping electricity supply and demand balanced in Great Britain, while respecting network constraints. Between April 2022 and March 2025, its costs were £2–3 billion per year, prompting participants to call for more efficient dispatch and greater transparency. To help meet these needs, the article presents BMViewGB, an open-source, map-based visualisation tool that displays the spatial distribution of BM costs and volumes. The straightforward map layout is designed for users with varied professional backgrounds and can also act as a foundation for further research, such as the development of digital simulators of the Balancing Mechanism.

Introduction

Since October 1, 2024, Great Britain has an independent system planner and operator, the National Energy System Operator (NESO) [1]. 'Operating the National Electricity Transmission System (NETS) in a safe, reliable, and efficient way is a core function of NESO' [2]. NESO is also expected to facilitate competitive, market-based procurement of balancing services. The balancing role of NESO encompasses all the functions that NESO performs to ensure that the electricity supply meets demand second by second while managing the physical constraints of the network [3]. Currently, NESO performs this role by operating the electricity Balancing Mechanism (BM) and procuring a number of additional balancing services.

The Balancing Mechanism is a specialised electricity market that operates continuously in real time. NESO serves as the sole counterparty, taking actions to correct system imbalances and manage operational constraints. NESO does this by instructing Balancing Mechanism Units (BMUs) to adjust their output: it accepts offers to increase generation (or reduce consumption) and bids to decrease generation (or increase demand).

Historically, the Balancing Mechanism was designed to take 'residual' actions. However, the growing integration of Variable Renewable Energy (VRE) resources and emerging technologies such as batteries has resulted in an increase in the number of balancing actions and volumes for multiple reasons. VRE generation depends on weather, requiring adjustment of generation schedules closer to real time as more accurate information on VRE actual production, demand, and availability of assets becomes available [4]. VRE capacity factors depend on location, which has resulted in high capacities of high-quality wind resources that are geographically far from the majority of demand and often connected to demand through frequently congested or unavailable transmission lines [5].

This increase in volume compounded by an increase in prices, especially during the energy crisis, has led to an increase in costs, with costs consistently exceeding £1 billion since 2020/2021 [3]. Published analysis, conducted by NESO, suggests that the management of network constraints drives over 50% of the balancing costs. In case the delivery of transmission infrastructure is not accelerated, it is projected that the balancing costs for the management of network constraints will peak at £7.2bn in 2030. To understand how to effectively participate in this growing and sizeable market, BMUs, in particular batteries, have been calling for transparent, fair, clean, and effective dispatch solutions [6].

A wide range of solutions have been proposed to improve operational efficiency. In the literature, a novel optimization platform that captures participant constraints is proposed [7]. In practice, the arrangements of the Balancing Mechanism were also reviewed by the UK government, and several proposals, such as lower participation thresholds, are being evaluated [8]. Since December 2023, NESO has had a new platform with advanced capabilities for dispatching smaller units. The capabilities of the platform will continue to expand, and will eventually replace the platform underpinning the Balancing Mechanism by 2027 [9].

In parallel with operational efficiency enhancements, NESO has made substantial efforts to improve transparency, by providing more clarity on the rationale behind the decisions in the Balancing Mechanism [10]. More recently, NESO also published two dashboards that summarize costs and volumes for balancing activities [11] and skip rates [12]. Skip rate is the frequency with which NESO's dispatch actions are considered non-economic—that is, when a more cost-effective alternative bid or offer was available but not accepted. These dashboards make publicly available data more accessible, providing figures

that stakeholders can review to gain insights on the BM performance. In particular, the NESO Monthly Balancing Services Dashboard includes figures on the temporal evolution of balancing costs and attributes them to different causes. The NESO skip rate dashboard includes figures on the temporal evolution of skip rates and shows skip rates per BMU and sets of BMUs that have the same technology.

This article expands the visualization toolkit in Great Britain by introducing BMViewGB, an open-source, map-based application that displays accepted bids and offers. Unlike existing tools, our implementation is publicly available on GitHub [13], enabling full traceability, from raw Elexon data to the rendered map, and inviting others to extend it. The map-based visualization of balancing actions makes differences across Great Britain clear, even for audiences without power-systems experience. The tool can also serve as ground truth for validating simplified GB representations, commonly used in academic studies [14]. The source code could also be used to visualize results of future power system simulations in Great Britain. To the best of our knowledge, the only comparable visualisation tool is Enact, developed by LCP Delta [15]. As Enact is a commercial product and not publicly accessible, we were unable to conduct a like-for-like comparison with BMViewGB. PVLive is another map-based application, developed by the University of Sheffield, but it focuses on visualizing PV generation in Great Britain [16].

The remainder of the article is organized as follows. Section 1 presents the application architecture, data sources and preprocessing pipeline, and user interface. Section 2 validates data ingestion by benchmarking against historical datasets and highlights regional and technology-specific patterns in balancing actions. Section 3 summarizes the key takeaways and outlines potential extensions.

1 Methodology

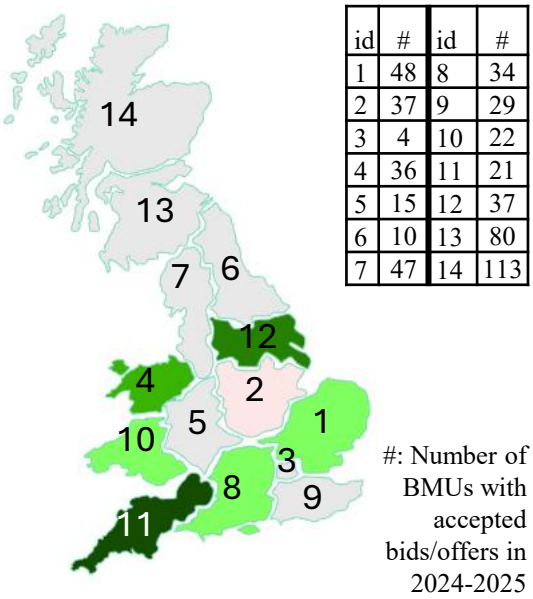
1.1 Architecture of the application

The BMViewGB platform is constructed as a modern full-stack web application. We employ a decoupled client-server architecture, where the server (back-end) is responsible for data processing and storage, and the client (front-end) is responsible for receiving requests and visualising information. The modular design allows development, testing, and maintenance of the back-end and front-end layers independently of each other. This client-server model is also scalable and flexible. It contains the data processing complexity within the back-end, allowing the front-end to remain lightweight and focus on providing a responsive user experience.

The back-end is constructed using the Django web framework [17], which provides readily available tools for all functions that our application performs. The front-end is developed using React [18]. The two layers communicate through a RESTful API [19]. In detail, the responsibilities of the back-end include fetching raw data from external sources, processing and structuring these data into a useful format, saving them in a database, and serving them to the front-end when requested via a set of well-defined endpoints. The front-end is responsible for all user-facing elements, consuming data from the back-end API and rendering the interactive map visualisation, control panels, and analytical charts.

1.2 Data sources and processing within BMViewGB

The map has fourteen distinct regions for Great Britain. The fourteen regions correspond to the fourteen Distribution Network Operator Licence Areas in GB. The regions are commonly used for regional modelling of the GB electricity transmission network, and are electrically connected [20]. To provide visual insights, the BMViewGB platform combines both relatively static metadata and time series. BMU-level metadata include region and fuel/technology classification. Regions and fuel types are assigned using the 2023–2024 Transmission Loss Factor Agent and Skip Rate datasets [21].



id	#	id	#
1	48	8	34
2	37	9	29
3	4	10	22
4	36	11	21
5	15	12	37
6	10	13	80
7	47	14	113

Fig. 1 Map of Great Britain in BMViewGB. The region identifiers (id) from 1 to 14 correspond to Eastern, East Midlands, London, Merseyside & North Wales, Midlands, Northern, North Western, Southern, South Eastern, South Wales, South Western, Yorkshire, South of Scotland, North of Scotland.

The time-series data capture accepted bids and offers in the Balancing Mechanism. By constructing a composite identifier—date, settlement period, BMU ID and acceptance ID—we link Elexon's Bid-Offer Acceptance Volumes (BOAV) to the Indicative Settlement bid–offer stacks by settlement period (ISPSTACK). The submitted bid/offer curves include up to 6 segments, and as a result the accepted bid/offers could have up to 6 so-called pairs of volumes and prices. Given that the Balancing Mechanism follows pay-as-bid settlement principles, we calculate the balancing cost for each accepted bid/offer as follows:

$$\sum_{pair} P_{pair,id} \cdot V_{pair,id} \tag{1}$$

where $P_{pair,id}$ and $V_{pair,id}$ correspond to prices and volumes per pair of an accepted bid/offer with unique identifier id. The volume $V_{pair,id}$ takes positive and negative values when the action accepts an offer or a bid, respectively. The price $P_{pair,id}$ also takes both positive and negative values. Negative values for $P_{pair,id}$ are only observed for accepted bids from wind power plants. In this case, the negative price indicates that the wind power plant will forego production-linked payments.
For each unique action in BOAV, we retrieve the corresponding price from ISPSTACK. Table 1 below reports the number of BOAV actions for which no accepted price could be found in ISPSTACK. The missing rate is lower than 0.5%, which is acceptable for the first version of BMViewGB.

Table 1 Missing rate for price data in BMViewGB

Period	Actions with missing price	Missing rate
2024-2025	715	0.03%
2023-2024	3004	0.23%
2022-2023	2534	0.25%
2021-2022	3300	0.34%

For each region r and settlement period t, we calculate the net volume NV accepted as follows:

$$NV_{r,t} = \sum_{pair,id} V_{pair,id} \cdot I_{id,r,t} \quad (2)$$

where $I_{id,r,t}$ takes the value 1 when the BMU associated with this id is in region r and the settlement period associated with this id is t and the value 0 otherwise.

1.3 User interface

The user interface is designed for clarity, responsiveness, and usability, adhering to established User Interface/User eXperience principles. The application has a persistent horizontal navigation bar at the top of the page. The navigation bar provides convenient access to three sections. The main section is the Main Map View. Two additional sections are under development: Time-Series Analysis and Regional Asset Benchmark. In the Main Map View (see Fig. 2), the user can specify the day they would like to visualize. For each day, the user has the option of either seeing a static view for a particular settlement period or pressing a button 'play' that shows in succession consecutive settlement periods in the same day. In the map, a region is colored red, grey, or green when its net volume is negative, zero, or positive, respectively. The playback functionality helps users to appreciate how dynamically the spatial patterns of balancing actions are. More than 50% of the days between April 2024 and March 2025 have more than 39 distinct maps in terms of the color of each region (green, grey, red)!
The default Main Map View also provides key statistics in terms of the number of offers and bids accepted, the net imbalance volume, and the volume attributed to system vs. energy actions. The user can customize the view by using several buttons that make information on balancing costs, system demand, and the technology mix visible. Users can also choose to see a table with numerics instead of the map on the left, and can move from a single view to a split screen view where they can see side-by-side two different settlement periods.

2 Results

2.1 Validation

To validate our approach, we compare the volumes of bids and offers accepted in the Balancing Mechanism, as calculated in the BMViewGB back-end, with the volumes reported in the 2025 Annual Balancing Cost Report Data Workbook [22]. The volumes we report do not include actions related to interconnectors and aggregated resources. As Fig. 3 shows, the bid volumes match almost perfectly, and the offer volumes in BMViewGB are between 90 and 95% of the NESO volumes.
Fig. 4 contrasts the costs of the Balancing Mechanism, as calculated in BMViewGB, with those reported in the NESO Monthly Balancing Services Summary Dashboard. The match is close to 94% between February 2024 and June 2025. We focus the rest of the analysis on the 12-month period starting in April 2024. In future versions of the BMViewGB, we plan to address the discrepancy in the Balancing Mechanism costs calculations for other periods.

2.2 Spatial patterns

We observe that spatial patterns vary throughout the year (see Fig. 5). In theory, 3^{14} spatial patterns are possible, as in each region, net volume could be positive, negative, or zero. Nevertheless, certain patterns are much more frequent than others. For example, the top 9 and 874 patterns are observed in 15% and 47% of the settlement periods, respectively. Approximately 7,353 patterns occur only once in the 12-month period we analyse (April 2024- March 2025).
The maps with the top 9 spatial pattens in Fig. 6 systematically show actions that curtail electricity generation in Scotland and increase generation in Southern GB. In addition to the maps, we summarize the pattern per region in Table 2. London has zero net volume 73% of the time. In the north of Scotland, 81% of the time, the net volume is negative, suggesting a reduction in the generation. Note that 27% of the entries per settlement period and region have both positive and negative volumes, likely due to efficiency-driven re-dispatch, intrazonal congestion, or other network issues.

2.3 Patterns by technology

Table 3 summarizes the net revenue, volumes of accepted bids and offers, and number of actions per technology for the 12-month period starting in April 2024. Over 70% of the Balancing Mechanism costs reward CCGT units, mostly to increase their generation for balancing purposes. The second most rewarded technology is wind, which is paid to curtail its output. Last but not least, batteries have the highest number

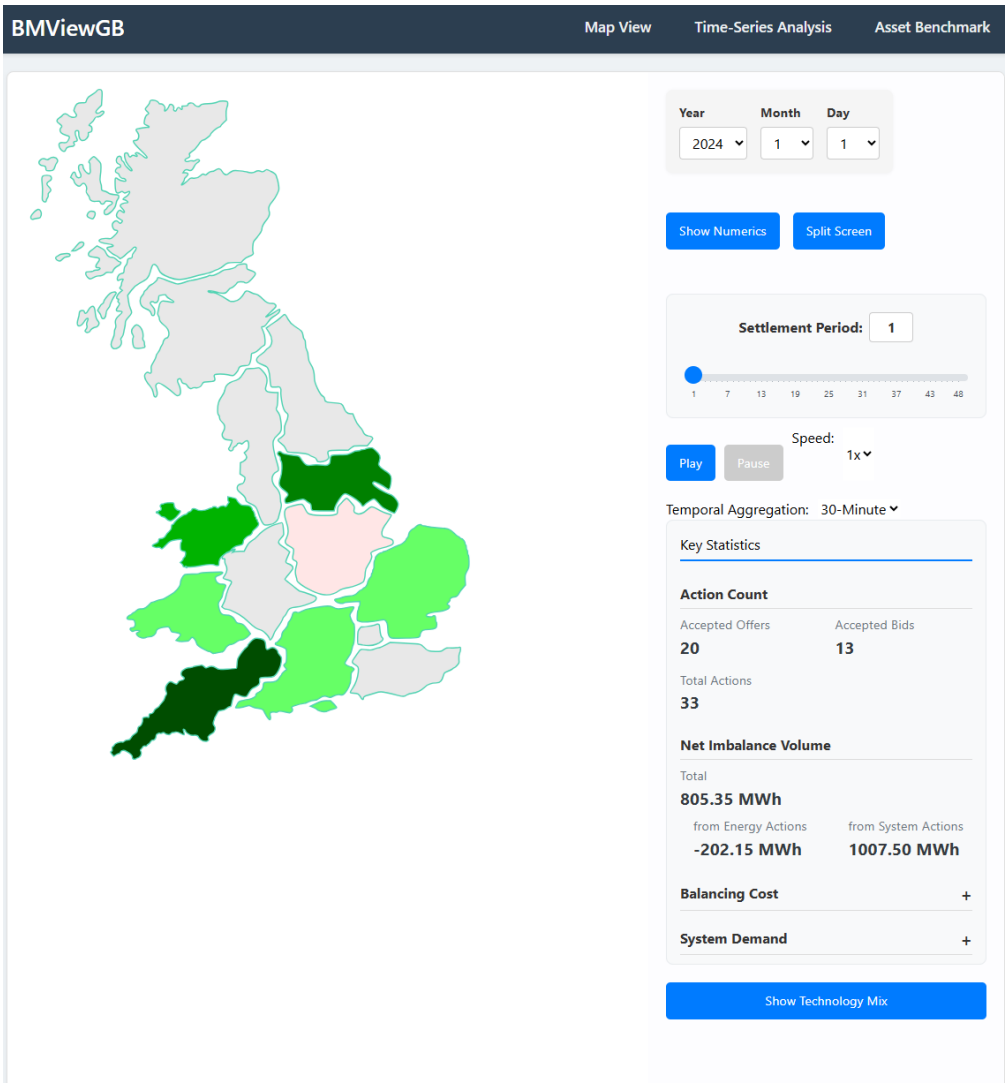


Fig. 2. The main map view in the user interface of BMViewGB.

Table 2 Percentage of settlement periods with net volume negative, zero, positive per region (April 2024 - March 2025).

Region	Negative	Zero	Positive
Eastern	30	13	**57**
East Midlands	31	7	**62**
London	16	**73**	12
Merseyside & North Wales	23	9	**68**
Midlands	23	37	41
Northern	28	40	32
North Western	36	18	46
Southern	33	7	**60**
South Eastern	36	7	**57**
South Wales	20	33	47
South Western	15	20	**65**
Yorkshire	36	5	**59**
South of Scotland	**53**	16	31
North of Scotland	**81**	7	12

Table 3 Performance summary per technology (April 2024 - March 2025)

Type	Net revenue	Offer	Bid	Actions
	£ million	TWh	TWh	number
CCGT	**1,281**	**11.80**	-2.95	416,782
Wind	351	0.03	**-9.38**	499,786
Pumped Hydro	47	0.56	-1.38	98,000
Battery	36	0.58	-0.54	**1,054,136**
Biomass	19	0.25	-0.32	21,478
Other	61	0.53	-0.08	194,233
Hydro	-6	0.07	-0.55	84,206

of accepted bids/offers, which is more than a million for the 12-month period starting in April 2024. The number of actions for batteries is in stark contrast with the volume in MW, which accounts for less than 5% of the total volume in either direction, indicating relatively small bids/offers.

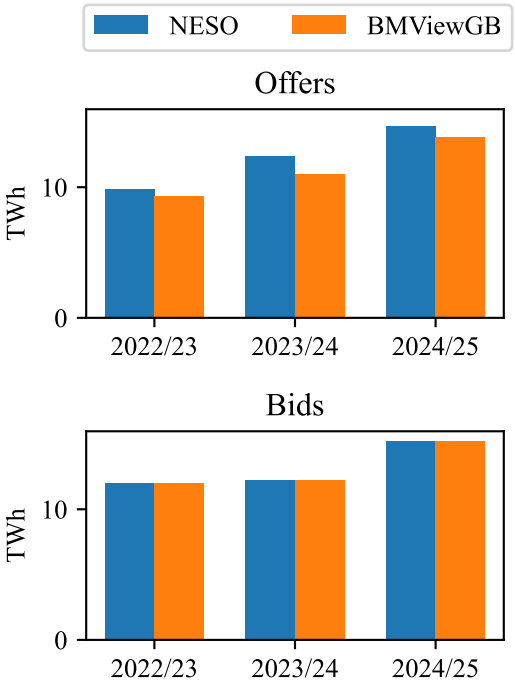


Fig. 3. Volumes for accepted bids and offers.

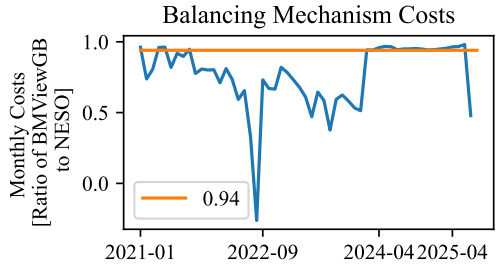


Fig. 4 Ratio of BMViewGB to NESO balancing mechanism costs.

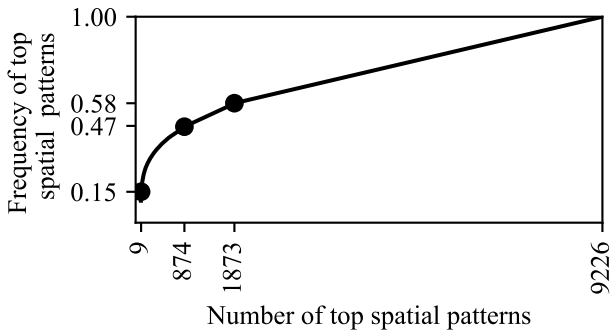


Fig. 5 Frequency of top spatial patterns between April 2024 and March 2025.

3 Conclusion

As the balancing costs in Great Britain increase, there is a growing need for improved dispatch methods and enhanced transparency. This article contributes an open-source map-based visualisation tool that clearly shows the spatial differences in balancing actions in Great Britain. The simplicity of the tool could make it useful for stakeholders with diverse professional expertise. Its open-source nature allows extensions by any interested party and the compiled dataset in its backend could be used for validation of transmission network models, used in academic studies.

Validating the data against published numbers indicates high accuracy in terms of balancing volumes. The accuracy in terms of costs is high for the period between February 2024 and June 2025. Part of the differences in costs could be explained by the fact that BMViewGB does not include actions related to interconnectors. In the future, we plan to investigate the differences in cost and release an updated version after discussions with relevant stakeholders. Further work could extend the tool to visualise balancing actions in Continental Europe and Ireland along with interconnectors. Other potential extensions could increase the spatial resolution, moving from Grid Supply Point Groups to Grid Supply Points. Last but not least, the tool could be developed to support the needs of stakeholders, especially stakeholder groups without budgets for purchasing commercial tools. In this way, the tool could eliminate informational barriers for small participants and could enable data-informed consumer advocacy.

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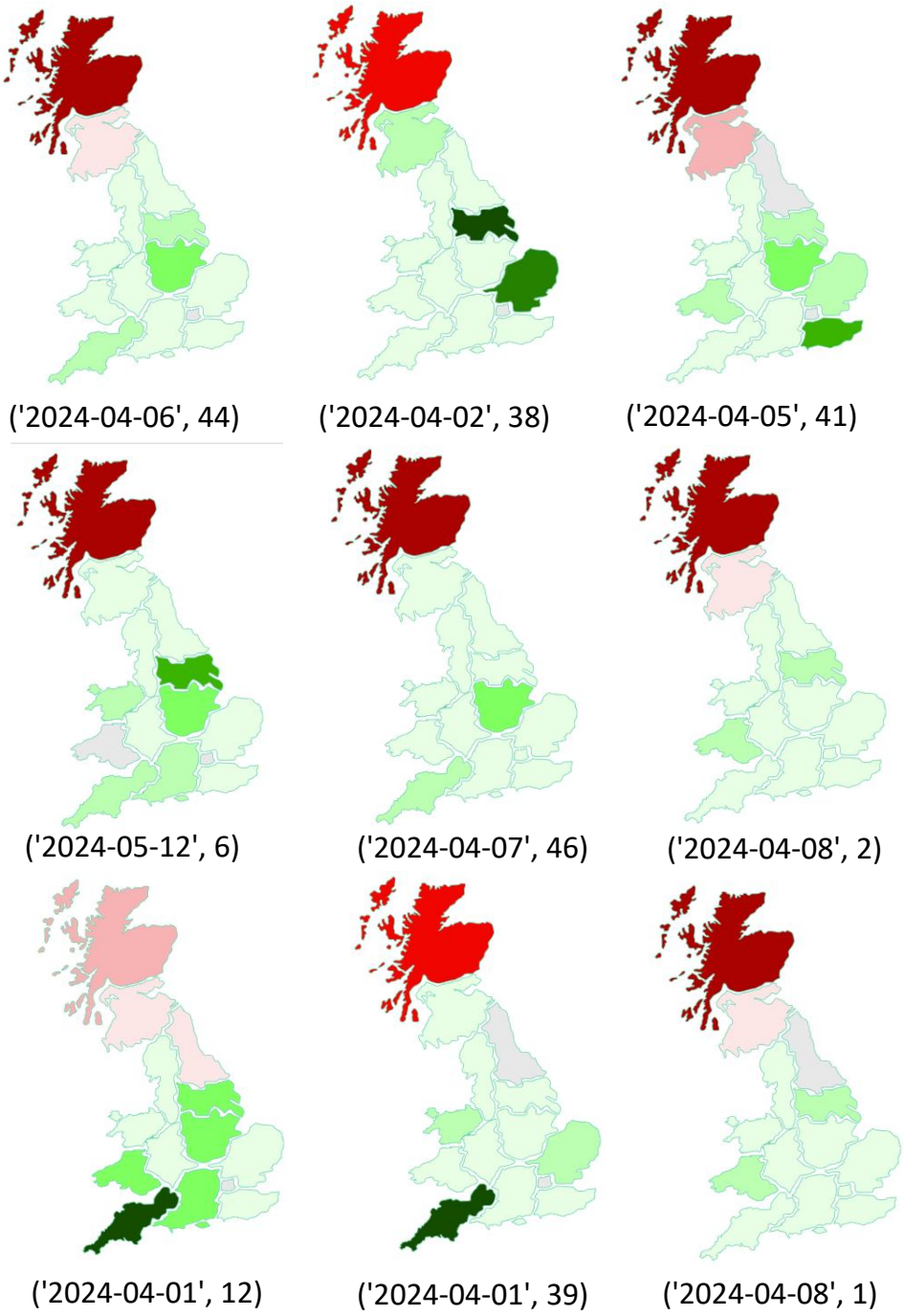


Fig. 6 Maps with the top nine spatial patterns between April 2024 and March 2025. When a region is colored red, green, or grey, the net volume is negative, positive, or zero, respectively. Below each map, we provide one of the settlement periods for which we observe this color pattern.