ACER Decision on ERAA 2024: Annex II

DECISION No 07/2025

OF THE EUROPEAN UNION AGENCY

FOR THE COOPERATION OF ENERGY REGULATORS

on the European Resource Adequacy Assessment for 2024

Amendments to ERAA 2024 Report

11 August 2025

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This Annex outlines amendments to annexes of the proposal for European resource adequacy assessment 2024 (ERAA 2024) included in this Decision in annexes I.a to I.g. Annexes I.a to I.g should be read together with this Annex.

Each amendment indicates relevant annexes (and sections), referring to their original title in ENTSO-E submission (e.g. Annex 2: Methodology) and the annex number assigned in this Decision (e.g. Annex I.c to this Decision).

Amendment 1a. Curtailment sharing (methodology)

In ERAA 2024 ***Annex 2: Methodology (Annex I.c to this Decision)****, Section 11.7 Local matching and curtailment sharing* is amended as follows:

11.7. Local matching and curtailment sharing

Local matching (LM) and curtailment sharing are implemented in the adequacy models in ERAA 2024 as described in the EUPHEMIA algorithm (PCR Market Coupling Algorithm). The curtailment rules are used in the operational FB market coupling algorithm to mitigate the effect of flow factor competition. These rules intervene when one or more countries experiences scarcity, i.e. there is ENS in the system. The solution implemented in EUPHEMIA within FBMC follows the curtailment sharing principles that already existed under the NTC. Two different rules are introduced, namely curtailment minimisation and curtailment sharing. Their main function involves minimising the ENS and equalising the curtailment ratios between the different study zones as much as possible. Moving away from the optimal solution – which is solely the minimisation of ENS towards a solidarity solution of ENS distribution – will result in a sub-optimal solution from the total welfare perspective.

The curtailment rules (curtailment sharing and curtailment minimisation) explained below follow the market behaviour expected in (simultaneous) scarcity situations. In the ERAA, the ‘curtailment of ^price-taking orders of demand’ is referred to as a shortage or ENS.

11.7.1. Implementation in the SDAC

Flow factor competition

If two possible market transactions generate the same welfare, the one with the lowest impact on the scarce transmission capacity will be selected first within FBMC. This also means that some buy (demand) bids with higher prices than other buy (demand) bids located in other study zones might not be selected within the FB allocation to optimise the use of the grid and to maximise the total market welfare. This is a well-known and intrinsic property of FB referred to as ‘flow factor competition’.

Under normal FBMC circumstances, ‘flow factor competition’ is accepted as it leads to maximal overall welfare. However, for the special case where the situation is exceptionally stressed – e.g. due to scarcity in one or several study zones – ‘flow factor competition’ could lead to a situation where order curtailment takes place non-intuitively or non-fairly. For example, this could mean that some buyers (order in the market) that are ready to pay any price to import energy would be rejected whereas lower buy bids in other study areas are selected instead due to ‘flow factor competition’. These ‘pay any-price’ orders are also referred to as ‘price taking orders’ (PTOs), which are valued at the market price cap in the market coupling.

Curtailment rules are introduced to correct market simulation results after implementing the FBMC constraints.

Local matching

Local Matching is achieved in EUPHEMIA through the LM constraint. EUPHEMIA enforces the LM of price-taking (buy) hourly orders with hourly orders from the opposite sense (sell) in the same study zone as a counterpart. That means that local PTOs are prioritized and matched with local supply, whenever the curtailment of PTOs can be avoided locally on an hourly basis.

Curtailment sharing

To address the issues of ‘flow factor competition’ concerning PTOs, EUPHEMIA implements the curtailment sharing principle. Curtailment sharing aims to equalise the curtailment ratios between those study areas that are simultaneously in a curtailment situation and those that are configured to share curtailment as much as possible. In other words, curtailment sharing aims to ‘fairly’ distribute the curtailment (rejection of PTOs) across the involved market zones by equalising the curtailment ratios of each zone, defined as curtailed PTOs divided by the total volume of local PTOs.

Adequacy patch steps

The SDAC adequacy patch is implemented in several steps that are summarized in Figure (X).

Figure (X): Steps of the adequacy patch in SDAC

The first phase are steps applied at the start of the SDAC Market Clearing Algorithm. First. local matching constraints aim at avoiding unnecessary domestic curtailment, by enforcing that simple divisible bids match in priority with local price taking orders. Second, a penalty is introduced in the welfare maximization objective function that prioritize the minimize curtailment in bidding zones with the highest curtailment ratios being defined as: $CurtailmentRatio = 1 - \frac{accepted\ price\ taking\ orders\ volume}{submitted\ price\ taking\ orders\ volume}$

The curtailment ratios are used in the 'max penalty term' added to the welfare maximization objective function as such:

$$-M \sum_{h} MaxCurtailmentRatio_h$$

$MaxCurtailmentRatio$ being the largest curtailment ratio across the modelled bidding zones. Provided that the value of M is sufficiently large, EUPHEMIA will effectively prioritize the minimization of this ratio over welfare maximization.

Hence, the first phase of the SDAC adequacy patch equalizes curtailment ratio between bidding zones under the constraints of local matching rules. It can lead to an increase or decrease of curtailment in each bidding zones, but also in the total level of curtailment.

The second phase of the SDAC adequacy patch consists of post-processing the main welfare optimization run. A post-process curtailment minimization tends to further minimize curtailment, expressed as:

$$Min \sum_{z,h} (accepted\ price\ taking\ orders\ volume)\ (1 - x)^2$$

x being the ratio between the accepted and submitted price taking orders volume.

In that step, even if the total welfare would remain fully unchanged, the total curtailment can still vary. This requires the existence of alternative solutions with identical system costs but different total ENS values. This occurs when the increased costs due to an increase of the ENS are exactly offset by savings in generation costs, resulting in no net change in overall system costs.

The last step is a post-processing curtailment sharing like the third step except that local matching constraints are relaxed of countries willing to share curtailment (i.e. a parameter in EUPEMIA).

Example of the functioning of adequacy patch steps

Considering the four steps described in Figure (X), the following Figure (Y) provides an example on the functioning of the adequacy patch steps.

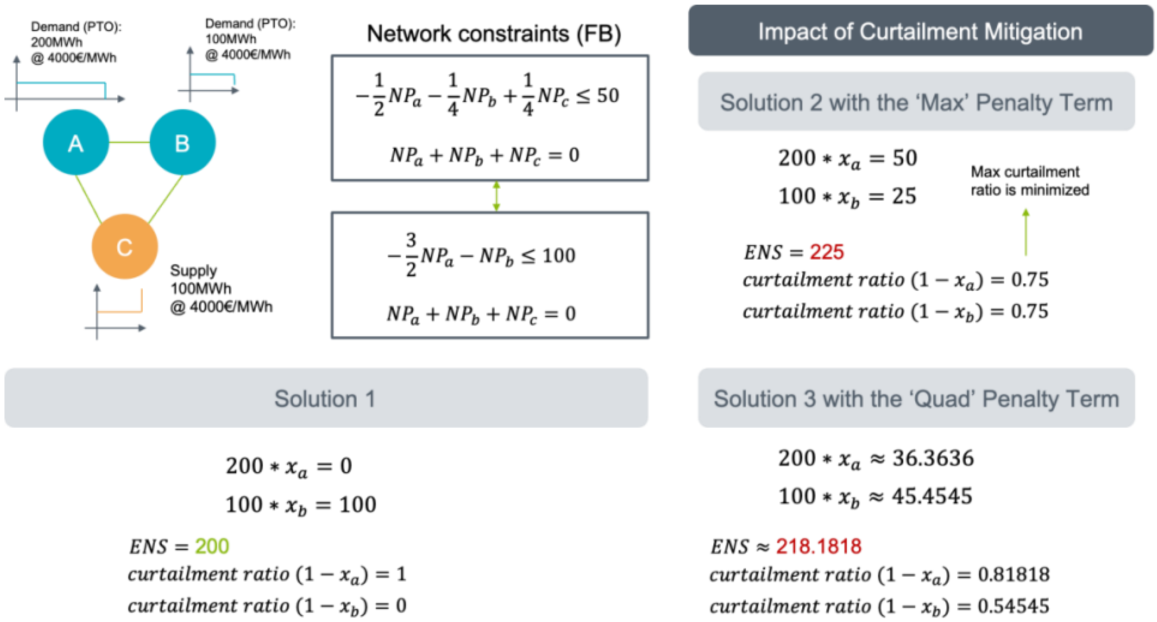


Figure (Y): Example illustrating the functioning of the SDAC adequacy patch

Solution 1 minimizes the ENS (bottom-left of Figure (Y)). In this example, all solutions lead to the same system cost, because the marginal costs of not meeting the demand are exactly equal to the marginal generation costs. This enables to focus on some specific impacts of Step 2 and Step 3, while parking the question of the detailed degrees of freedom allowed in the postprocessing Phase 2 composed of Steps 3 and 4. Step 2 (Curtailment Mitigation) of the adequacy patch, corresponding to the penalty terms in the welfare objective function, will first lead to Solution 2, where the total ENS is increased compared to Solution 1 without the application of the penalty term. Step 3 (Curtailment

Minimization) ultimately lead to Solution 3. Step 4 (Curtailment Sharing) which differs from Step 3 only by having local matching constraints relaxed is here not considered, since it would not make any difference in this example. In this example, Solution 2 leads to an increase of the ENS of 25 MW (12.5%) compared to Solution 1, while in Solution 3, the ENS is increased by 18.18181MW (9%).

11.7.4. Implementation in ERAA

To replicate the EUPHEMIA adequacy patch, curtailment sharing is implemented as an integrated post-processing mechanism. Therefore, ENTSO-E performs the adequacy run and the post-processing run. Additionally, for the purpose of ERAA 2024, “sanity checks” were added the curtailment sharing feature, to ensure proper sharing of adequacy risks.

Economic dispatch run

Local matching constraint:

In the ERAA, the LM constraint is implemented in the economic dispatch run as a conditional constraint following two different rules:

1. Each study zone is allowed to export only the share of generation capacity exceeding its internal demand, hence, preventing net exporters study zones from having ENS.

2. Net importing countries should primarily use internal resources to cover internal demand, avoiding exports to countries driven by better flow factor competition.

The LM constraint should be enforced for all study zones in the welfare maximisation problem, the condition of activation the surplus of generation in a study zone compared to the demand of the study zone for a specific hour.

Mathematically, the condition is written as:

$$If\ NetPosition_{Region} - ENS_{Region} \geq 0\ or \sum Line_{Flows} - ENS \geq 0$$

Mathematically, the constraint is written as:

$$\begin{aligned} NetPosition_{Region} + Load_{Region} - Generation_{Region} \\ \leq 0\ or \sum Line_{Flows} + Load_{Region} - Generation_{Region} \leq 0 \end{aligned}$$

Flow-factor competition conditional constraint:

In addition to the LM constraint, a flow-factor competition (FFC) constraint is implemented in the economic dispatch run to ensure that the unserved energy for a specific country does not exceed the allowed unserved energy defined by the so called 'domestic energy not served' (DENS), i.e. the difference between domestic load and generation, due to FBMC.

Two situations tend to occur due to the implementation of the FBMC constraints:

1. ENS can be created for net exporting countries to find the lowest ENS for the FB area as a whole; and

2. countries with low 'flow-factors' are penalised with ENS to the benefit of countries with high 'flow factors', even if all these countries are simultaneously at the maximum market price cap.

Mathematically, the condition is written as:

$$If\ NetPosition_{Region} - ENS_{REgion} < 0\ or \sum Line_{Flows} - ENS\ < 0$$

Mathematically, the constraint is written as:

$$NetPosition_{Region} \leq 0\ or \sum Line_{Flows} \leq 0$$

Post-processing

The post-processing run is designed to take the solution of the economic dispatch run and ensure the equalization and minimisation of curtailment ratios (CS distribution) while ensuring that all grid constraints and local matching are respected.

The LM and FFC constraints in the post-processing run are based on the domestic energy not served (DENS) inherited from the economic dispatch run. The DENS can be simply defined demand minus generation. Therefore, the LM is active if the DENS ≤ 0 and the FFC constraint will ensure that ENS ≤ DENS. The use of DENS as KPI is sound, not only as a proxy to PTO, but also in itself, since it captures the following important feature of EUPHEMIA. The 'adequacy patch' rules are activated in EUPHEMIA when there are unmatched PTOs. In ERAA, these situations are captured by the fact that the 'Price Cap' in the model is reached in a study zone if the EU market modelled in the ED simulation is not adequate. The choice of the 'Price Cap' as the SDAC Maximum Harmonised Clearing Price safeguards the coherence between the ED and EVA revenues. This choice does not affect in any way the discussion here on the application of CS after the ED simulations.

As the proxy for the PTO volume equals to the DENS, to share the ENS within the different study zones, a penalty involving a quadratic function is added to the objective function, defined similarly to EUPHEMIA as follows:

$$\boldsymbol{DENS} * \left(\frac{\boldsymbol{ENS}}{\boldsymbol{DENS}}\right)^{2}$$

The penalty grows more quickly with increased curtailment, and hence equilibrium can be expected where curtailment ratios are equalized, while perfect equalization of curtailment is limited due to the existing grid constraints, similarly to the EUPHEMIA adequacy patch.

Sanity checks

As the application of the curtailment sharing feature in the ED occurs in all hours and weather scenarios performed with ENS pre-curtailment sharing, thousands of hours need to be analysed for robustness and quality. In that sense, automatic sanity checks have been implemented in ERAA 2024.

These sanity checks monitor pre- and post-curtailment sharing values of electric demand, generation, net positions, DENS, and ENS. For zones with positive DENS, the KPI $(1-\mathrm{x})$ can be computed to use in the proxy of EUPHEMIA's quadratic penalty term, with x being the ratio between the DENS pre-curtailment sharing and the imports pre- or post-curtailment sharing.

Given that the EUPHEMIA adequacy patch minimizes and equalizes $(1-\mathrm{x})$ ratios, monitoring $(1-\mathrm{x})$ ratios pre- and post-curtailment sharing increase robustness of the feature as sanity checks verify:

1. The achievement or not of the full equalization of $(1-\mathrm{x})$ across bidding zones with positive DENS.
2. The effect of the FB active constraints on the redistribution of ENS, It assesses whether equalization of limited by active FB constraints.
3. The corresponding increase of the total ENS in relation to the impact of active FB constraints mentioned above.

Amendment 1b. Curtailment sharing (interim results)

ERAA 2024 ***Annex 3: Detailed results (Annex I.d to this Decision)*** is amended by adding the following section after *section 3. EVA comparisons related to CONE for gas investments*:

4. Curtailment sharing impact on adequacy results

The purpose of this section is to highlight the impact of the curtailment sharing feature on adequacy results. The overview of the impact of curtailment sharing on average LOLE results is provided in Figure X. For all target years of ERAA 2024, the curtailment sharing increases perceived adequacy risks, nearly doubling adequacy results.

The curtailment sharing step is currently implemented as a sequential process following economic dispatch and it remains an integral element of the overall optimisation structure. Therefore, pre-curtailment sharing data do not constitute complete results of the economic dispatch simulations yet might support the interpretation of ERAA 2024 outcomes.

Table X presents the interim adequacy metrics pre-curtailment sharing for each bidding zone of ERAA 2024.

Table X: LOLE interim results for each bidding zone for the ED module before application of curtailment sharing

LOLE (h/year)	Interim results (before the application of curtailment sharing)			
	Target year 2026	Target year 2028	Target year 2030	Target year 2035
AL00	0	0	0	0
AT00	0.07	0.49	0.07	0.67
BA00	0.04	0	0	0
BE00	0.73	0.76	0.06	2.00
BG00	0.01	0	0	0
CH00	0.01	0.01	0	0
CZ00	3.56	15.69	9.49	3.36
DE00	6.33	8.39	1.86	2.74
DK00	0	0	0	0
DKE1	5.52	12.00	5.29	6.65
DKW1	7.25	12.05	2.89	6.14
EE00	2.16	14.19	3.76	4.08
ES00	3.55	3.96	0.06	0.08
FI00	0.03	0.43	3.91	4.56

FR00	1.09	0.38	0.17	0.79
GR00	0.01	0.03	0.03	0
GR03	0.52	0.11	0.04	0
HR00	0	0	0	0
HU00	1.64	0.61	0.66	1.04
IE00	18.17	0.38	0.21	1.29
ISEM	0	0	0	0
IT00	0	0	0	0
ITCA	0	0	0	0
ITCN	0.88	0.54	0	0
ITCS	0.55	0.31	0	0
ITN1	0.13	0.01	0	0
ITS1	0.08	0.01	0	0
ITSA	0.11	0.01	0	0
ITSI	0.33	0.07	0	0
LT00	16.65	6.13	5.70	1.70
LU00	0	0	0	0
LUG1	6.33	8.39	1.86	2.74
LUV1	0	0	0	0
LV00	0	0	0	0.02
ME00	0	0	0	0
MK00	0.02	0	0	0
MT00	619.56	122.06	26.26	47.52
NL00	0.37	0.18	0.06	0.80
NO00	0	0	0	0
NOM1	0	0.06	0	0
NON1	0	0	0	0
NOS1	0.02	0.21	0	0
NOS2	0	0	0	0
NOS3	0	0	0	0
PL00	6.16	7.84	5.07	7.53
PT00	0.09	0.06	0	0
RO00	0	0	0	0
RS00	1.04	0.14	0	0
SE00	0	0	0	0
SE01	0	0	0	0.04
SE02	0	0	0	0
SE03	0.48	1.38	1.03	3.00
SE04	0.01	0.23	0.85	3.96

SI00	0	0	0	0
SK00	0.07	0.07	0.81	1.56
TR00	0.28	0	0	7.20
UK00	0	0	0	0.46
UKNI	0.39	0.09	0.02	0.26

Amendment 2. Reasons for risks

1. In ERAA 2024 ***Executive Report (Annex I.a to this Decision),*** the following footnote is added in section 2.3:

2.3 Adequacy risks appear in several European countries and margins are tight

Figure 5 to Figure 8 illustrates the Loss of Load Expectation (LOLE) per region in TYs 2026, 2028, 2030 and 2035.[4]

[4] The results presented below reflect the inclusion of out-of-market measures, where their presence was reported by the TSOs.

2. ERAA 2024 ***Annex 3: Detailed results (Annex I.d to this Decision)*** is amended by adding the following sections after *section 2.2.2. Convergence of results*:

2.2.3. Sources of scarcity

The purpose of this section is to identify and gain insight on the main drivers/sources of scarcity. The “balance constraint” expressing the ENS during a scarcity event is described in mathematical terms as follows:

$$ENS_{h,z} = Load_{h,z} - Generation_{h,z} - Imports_{h,z} + Exports_{h,z}$$

Where: h stands for hours and z for bidding zone.

This equation is valid for any MC run (for any TY, CY and FO pattern). As such the Load, Generation and the balance of Imports and Exports during scarcity can be drivers of scarcity.

As the values of Load, Generation and the balance of Imports and Exports can vary drastically from one bidding zone to another, calculated ratios are reported in the figures below to allow for comparison across bidding zones. The ratios are described below:

- Native Load[1] percentile during scarcity

The native load during scarcity is reported hourly, for each bidding zone and TY. To make values from different bidding zones comparable, values are reported as the percentile rank (e.g., 98th percentile) with respect to a single distribution of all hourly load values for all CY. These percentile ranks of hourly load during scarcity are computed repeatedly for each TY and bidding zone, each time comparing with the corresponding distribution of hourly values for all CY.

The percentile is used in order to assess whether scarcity events occur mostly during events of unusually high load (high load percentile).

- Generation is reported as Generation availability

$$Generation\ availability_{hs,z} = \frac{Generation_{hs,z}}{Installed\ Capacity_{z}}$$

where hs stands for hours with scarcity and z for bidding zones.

- The balance of imports and exports as the *Share of imports/exports relative to load*:

$$Share\ of\ imports/exports\ relative\ to\ load_{hs,z} = \frac{Net\ Position_{hs,z}}{Load_{hs,z}}$$

where hs represents each hour with scarcity and z represents each bidding zone. For $Net\ Position_{hs,z}$, a positive value means an exporting position, while a negative means an importing position.

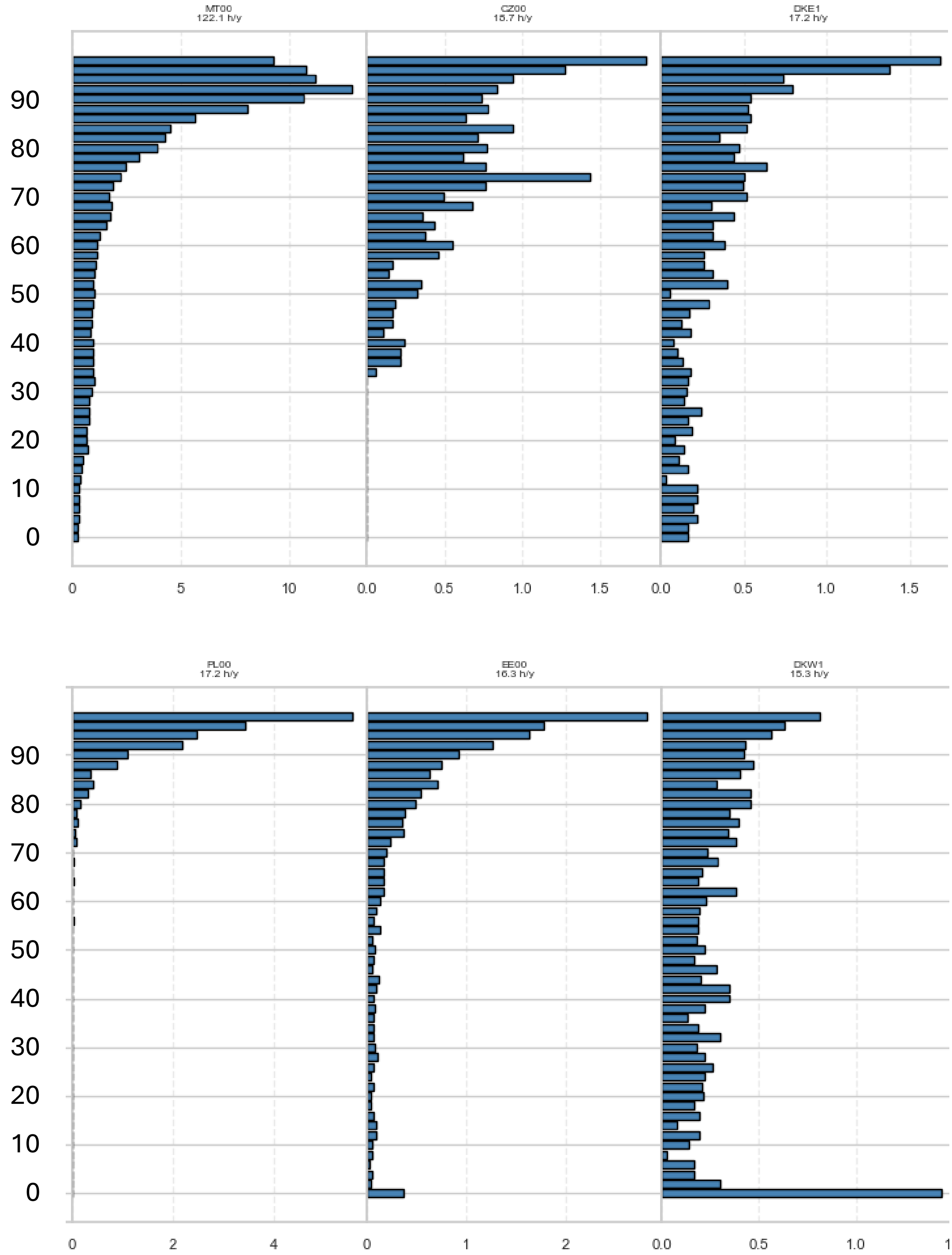
In the figures below, Native Load percentile during scarcity is reported in the shape of a histogram. The X-axis is defined as the “Contribution to LOLE” of each Exogenous load percentile. The contribution to LOLE is simply the count of scarcity hours in each bin (represented by the histogram), but divided by number of Monte Carlo realisations. In this way, the total LOLE value shown above can be analysed as being composed of the LOLE contribution per exogenous load percentile.

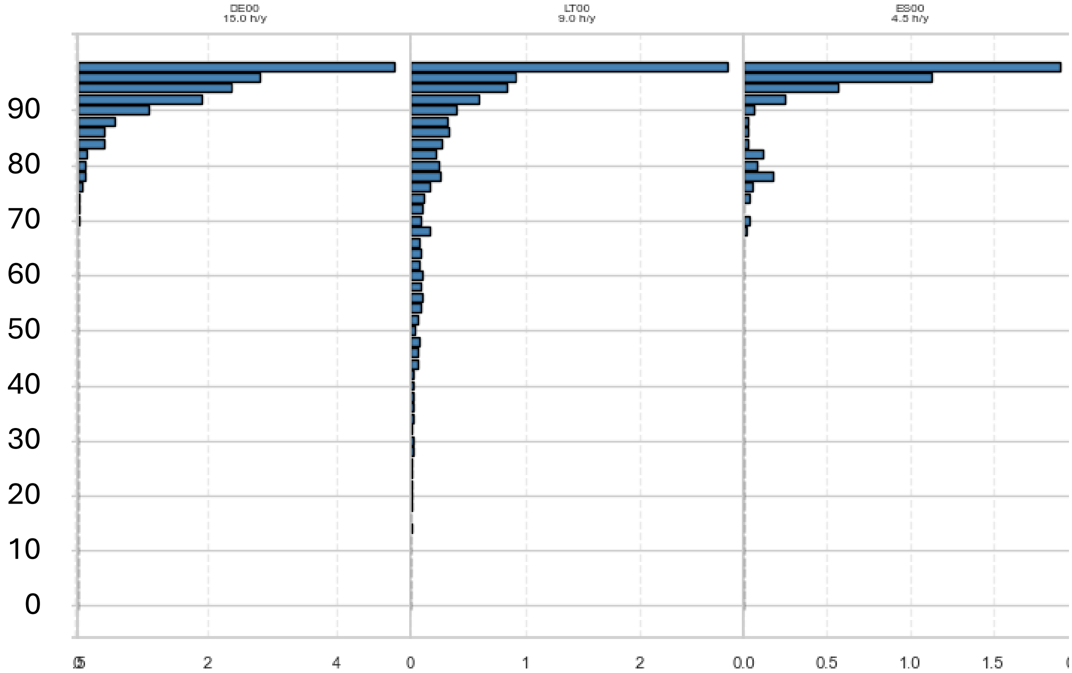
For both *Generation availability* and *Share of imports/exports relative to load*, the boxplots in the figures are built per bidding zone z, based on the distribution of data points for all hours in scarcity hs of each bidding zone. In the figures, *Share of imports/exports relative to load* is referred to as *Net Position* relative to *Load*.

[1] Native (exogenous) Load refers to the load as provided by TSOs during the data collection process.

2.2.3.1. Native Load during times of scarcities

Native load percentile at which LOLE occurs: TY2028

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9.0 h/y
ES00
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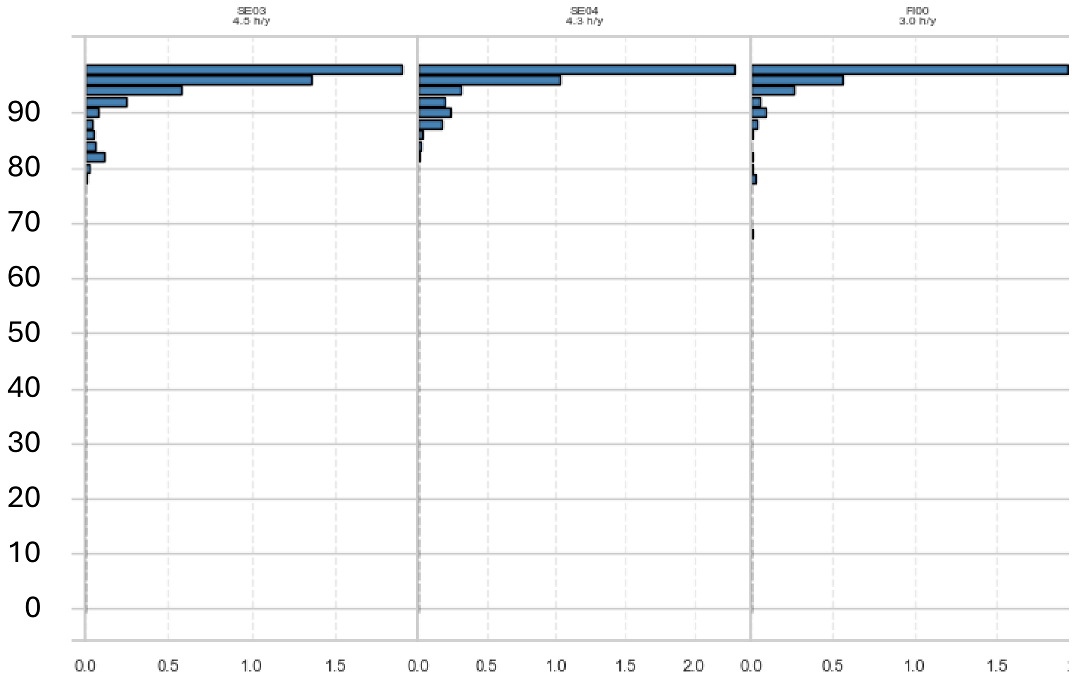
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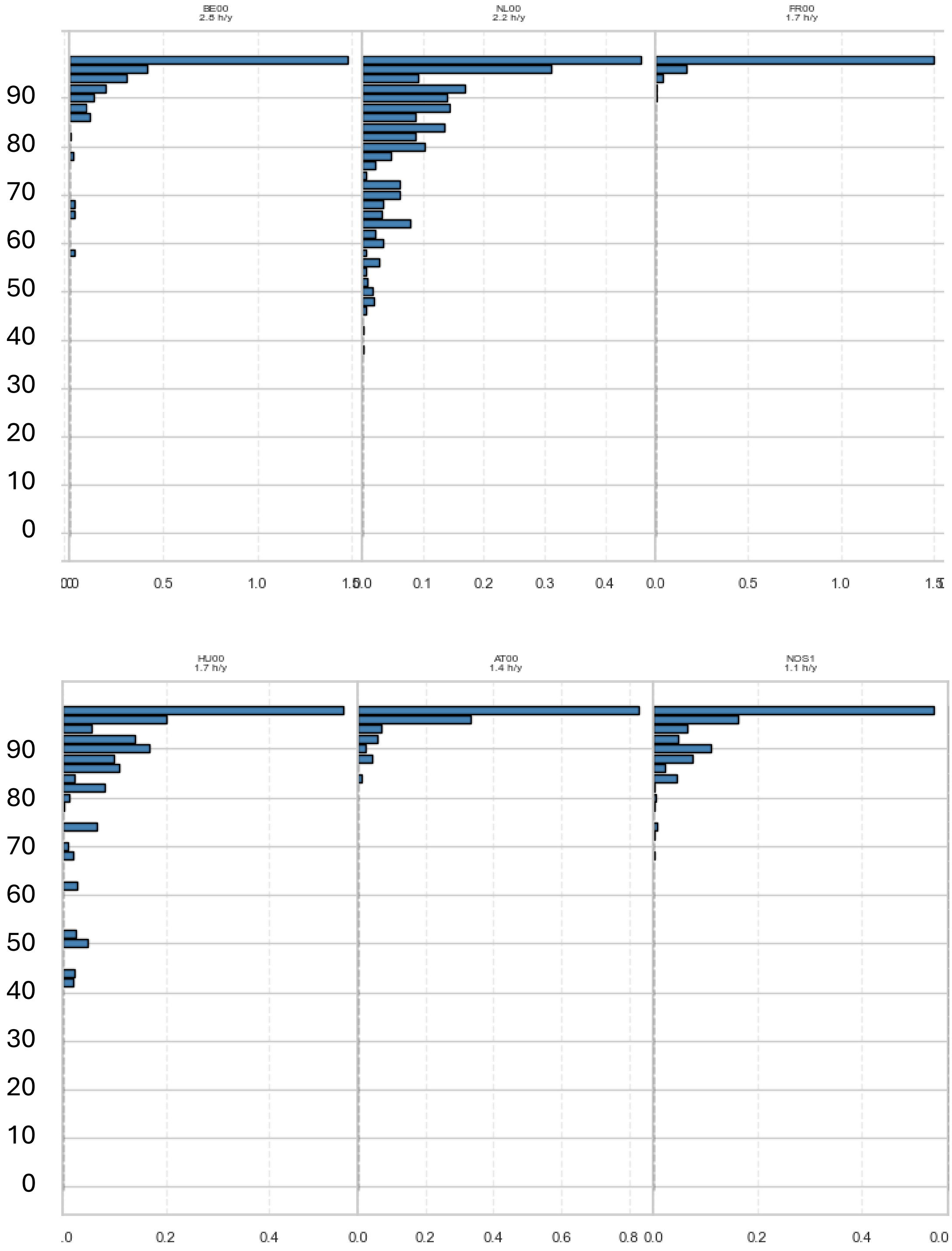
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AT00
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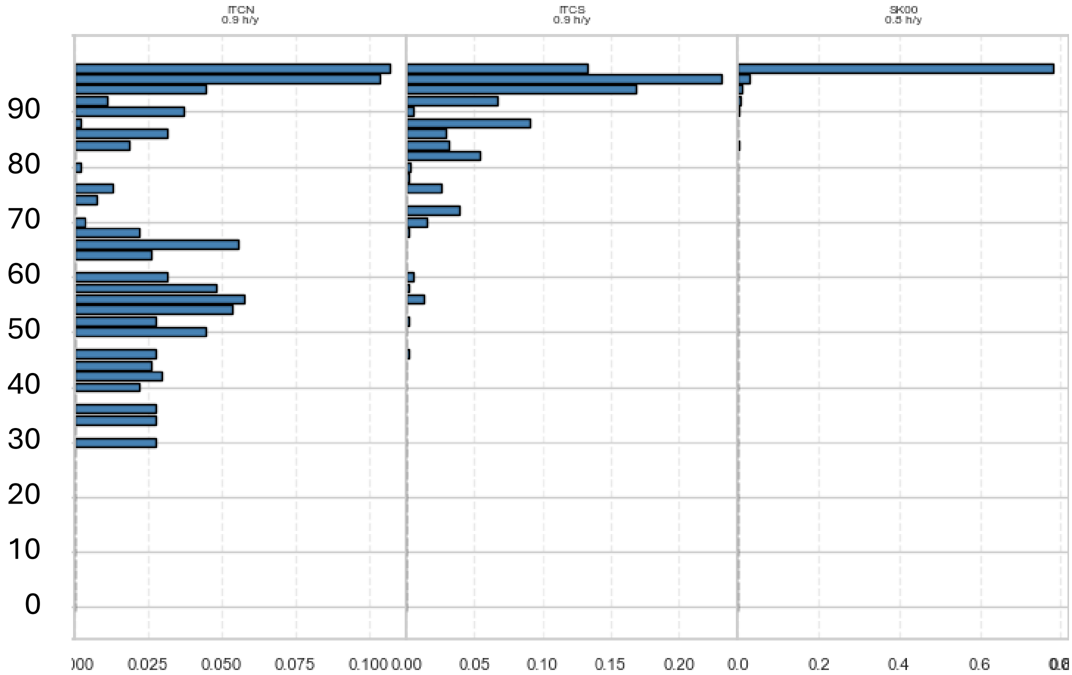
NOS1
1.1 h/y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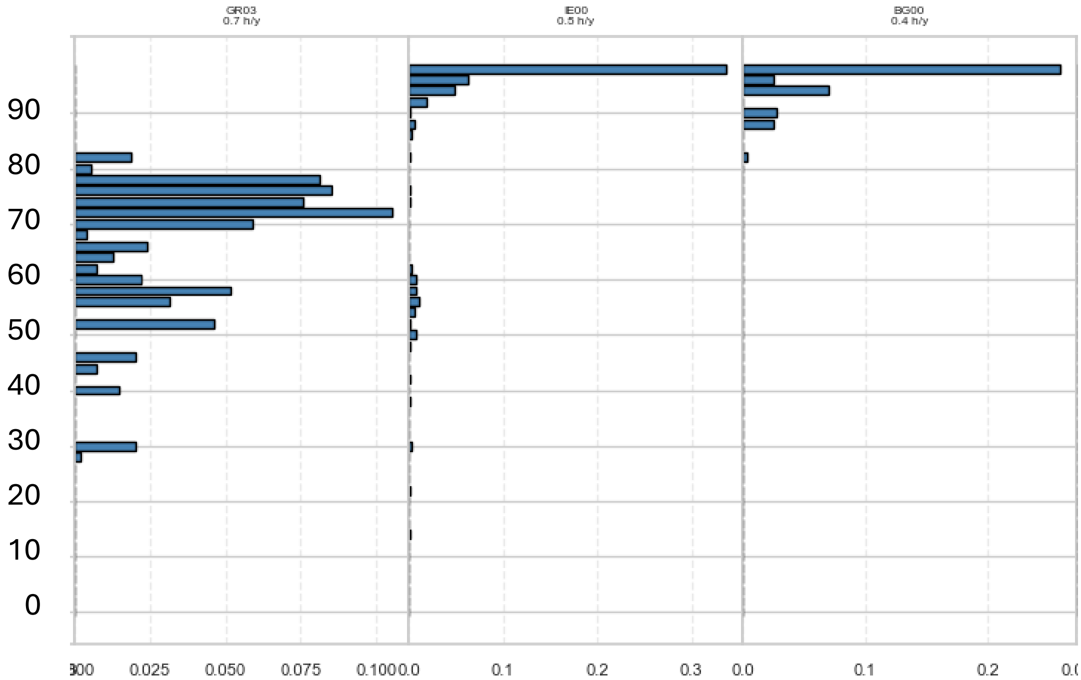
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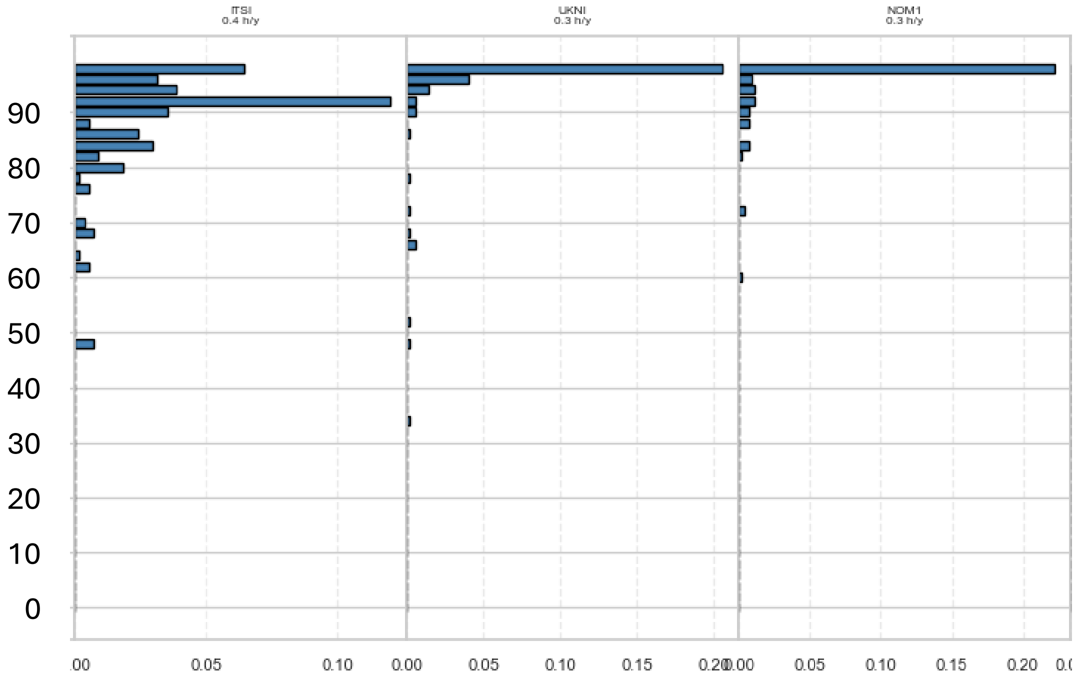
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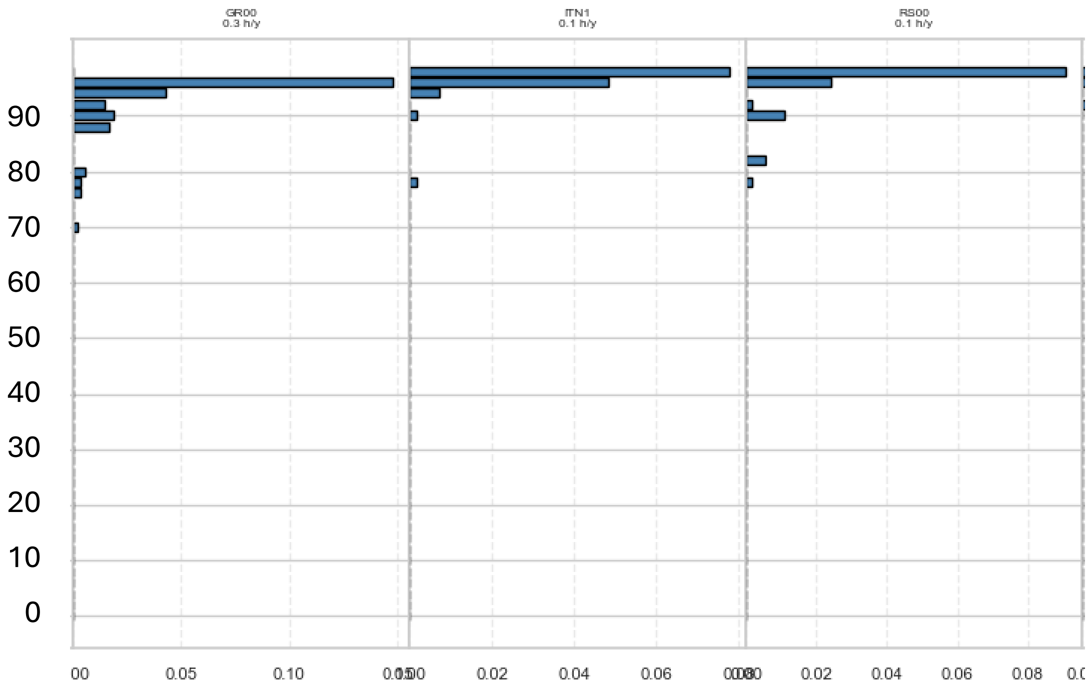
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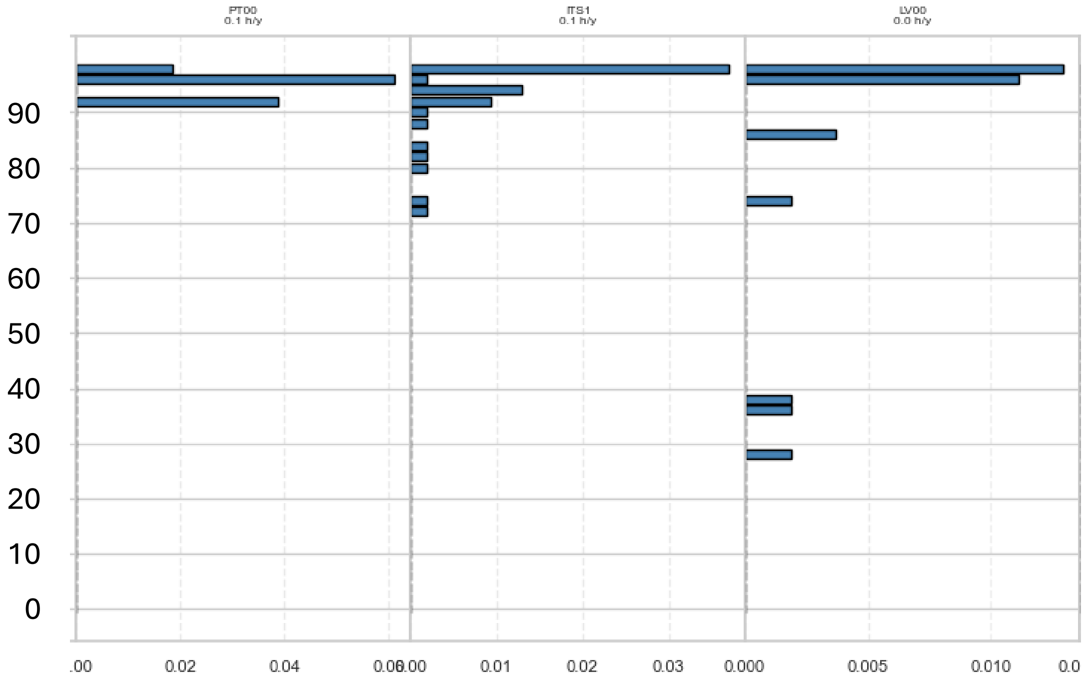
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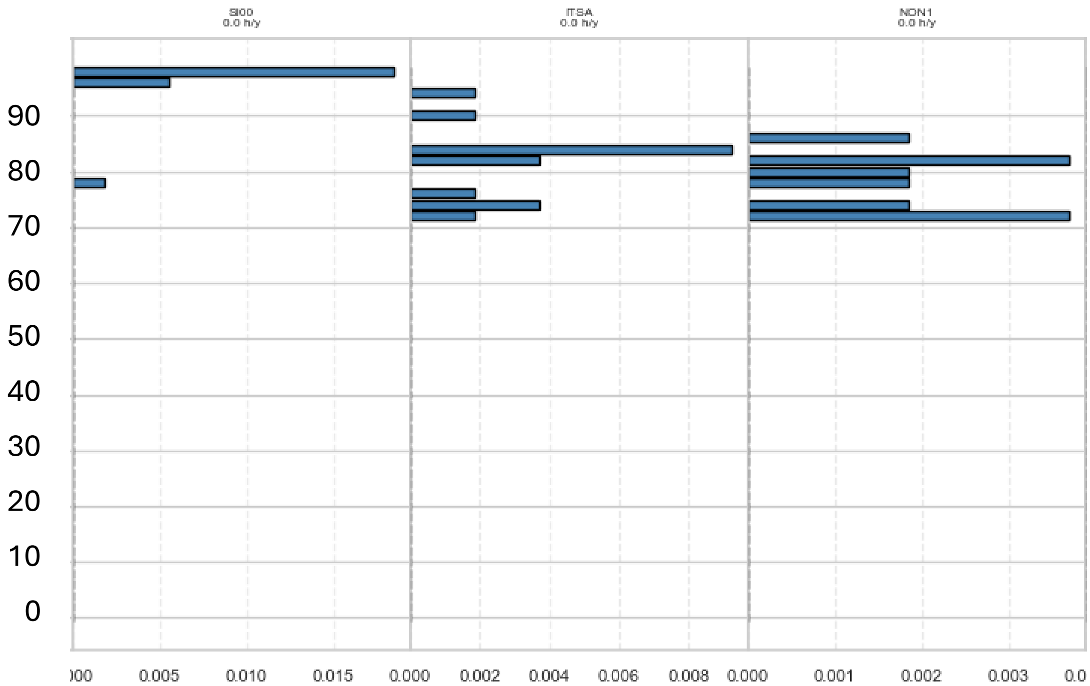
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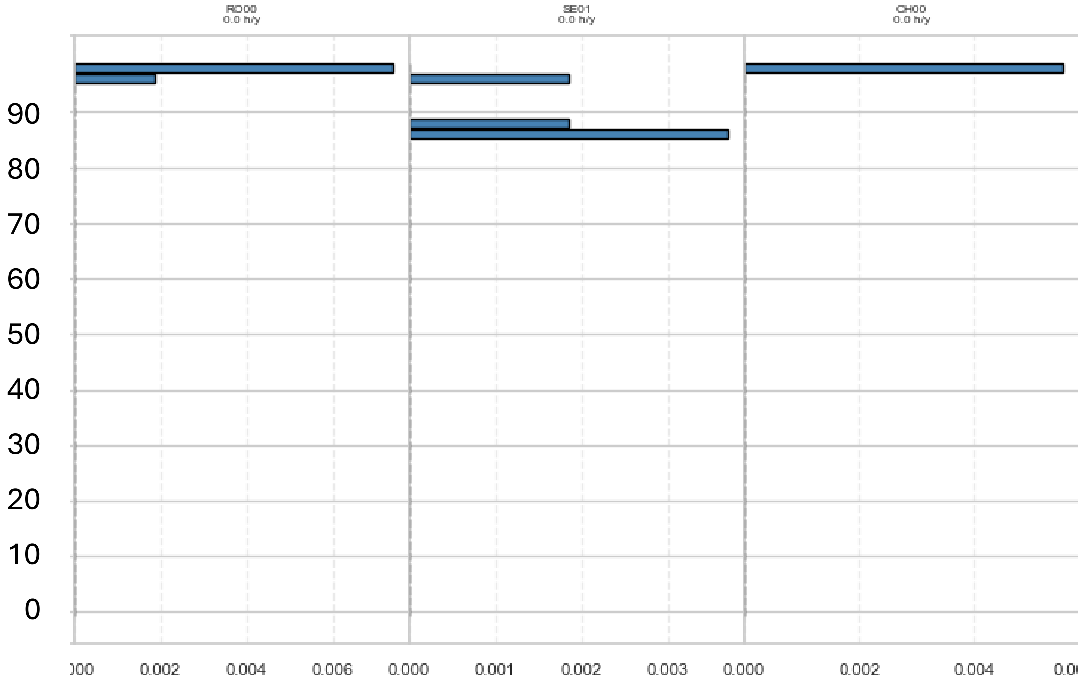

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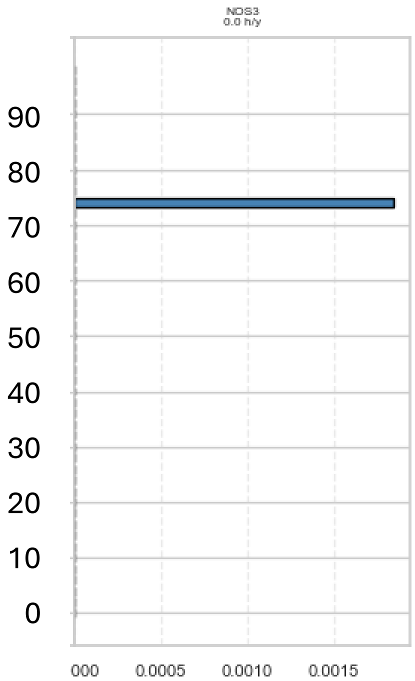
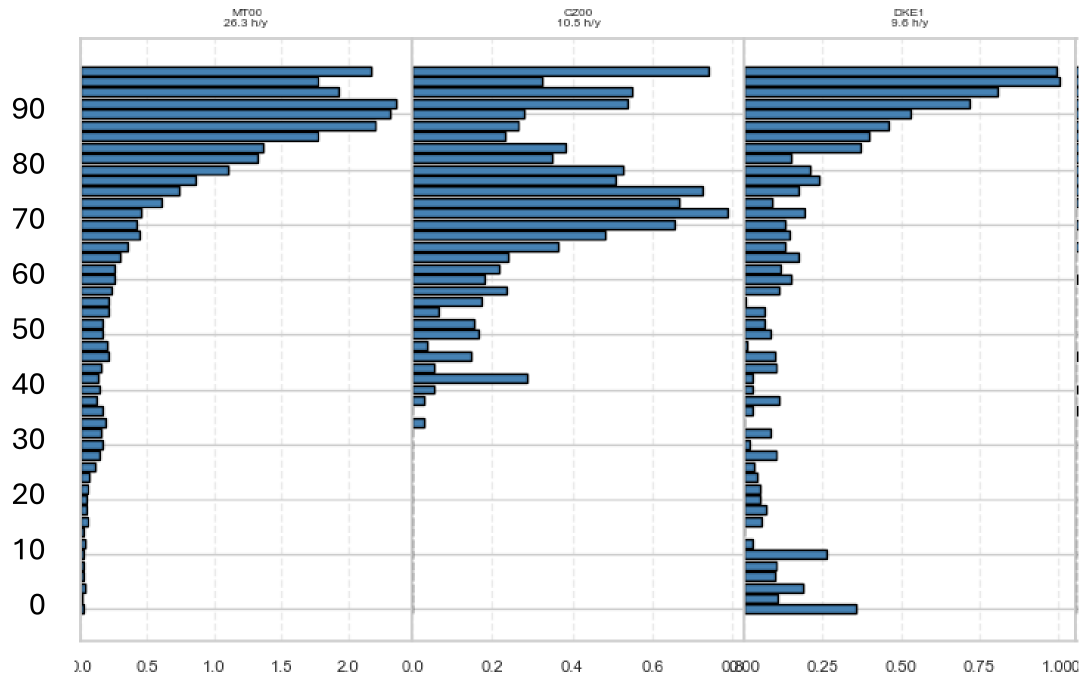
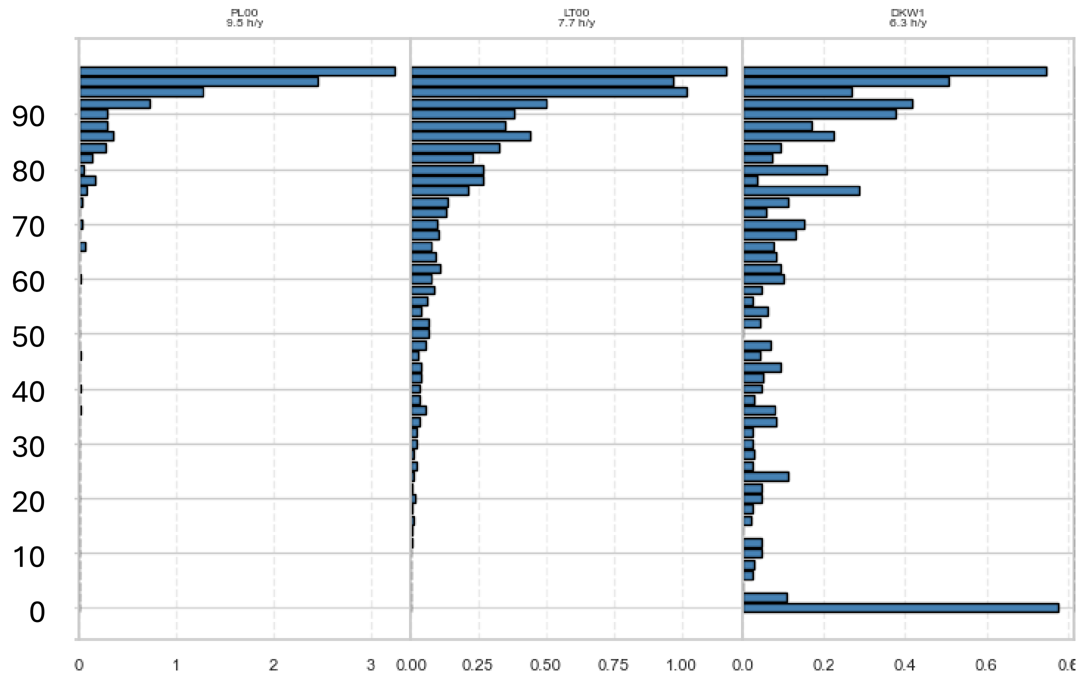
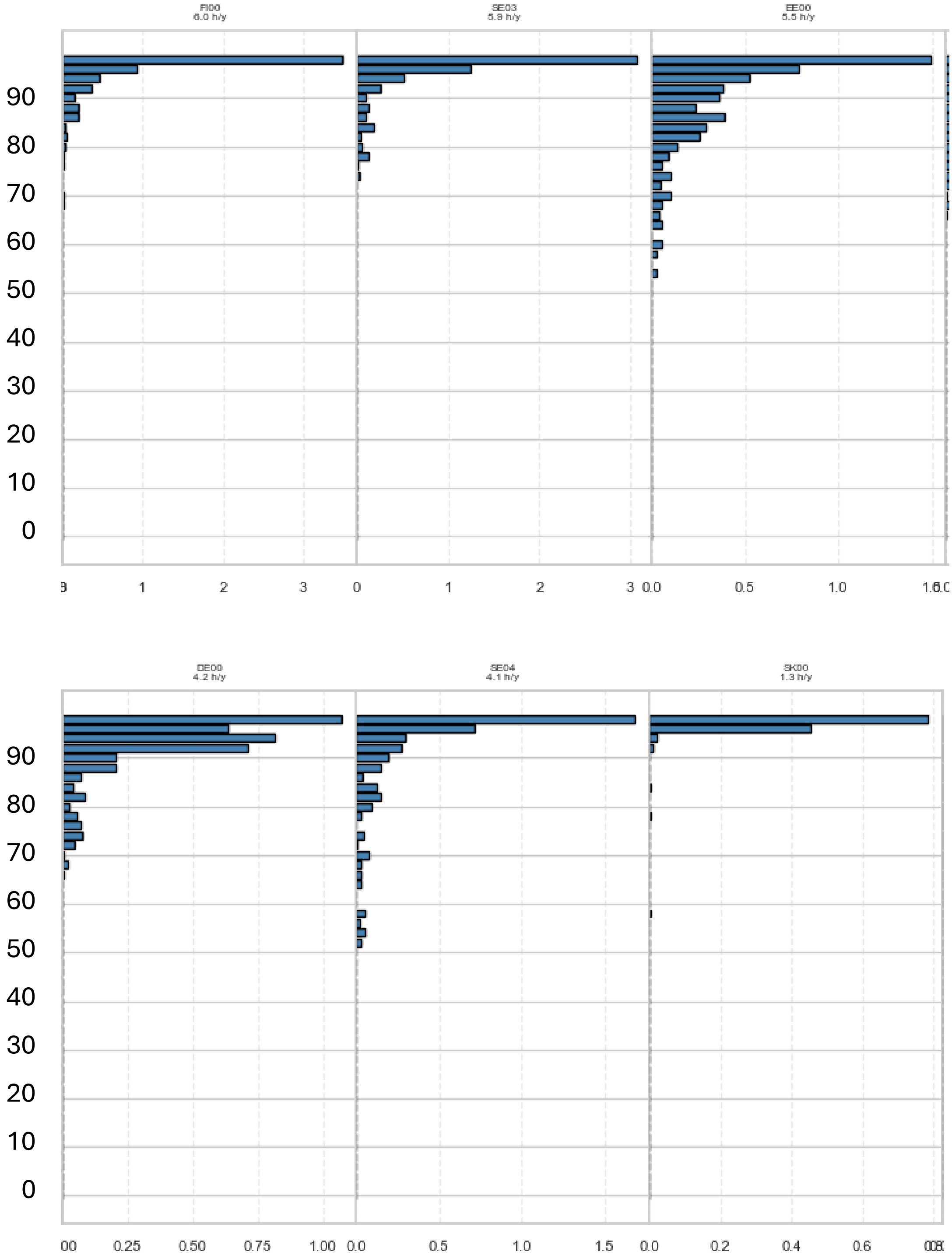


NOS3
0.0 h/y

Native load percentile at which LOLE occurs: TY2030



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SE03
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SK00
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80
70
60
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40
30
20
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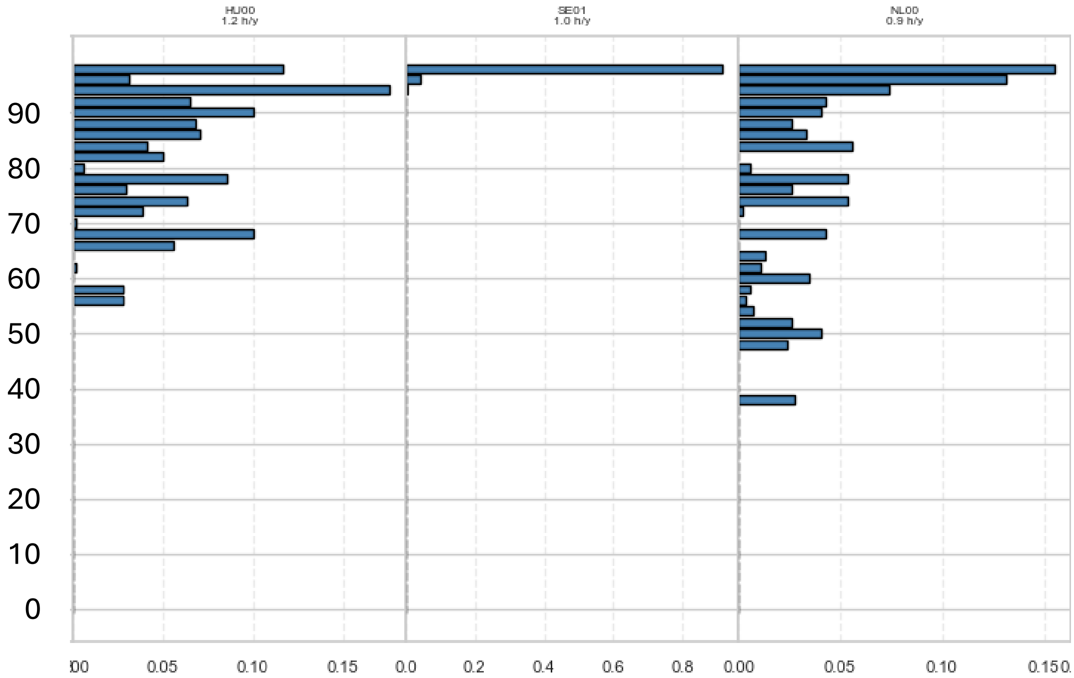
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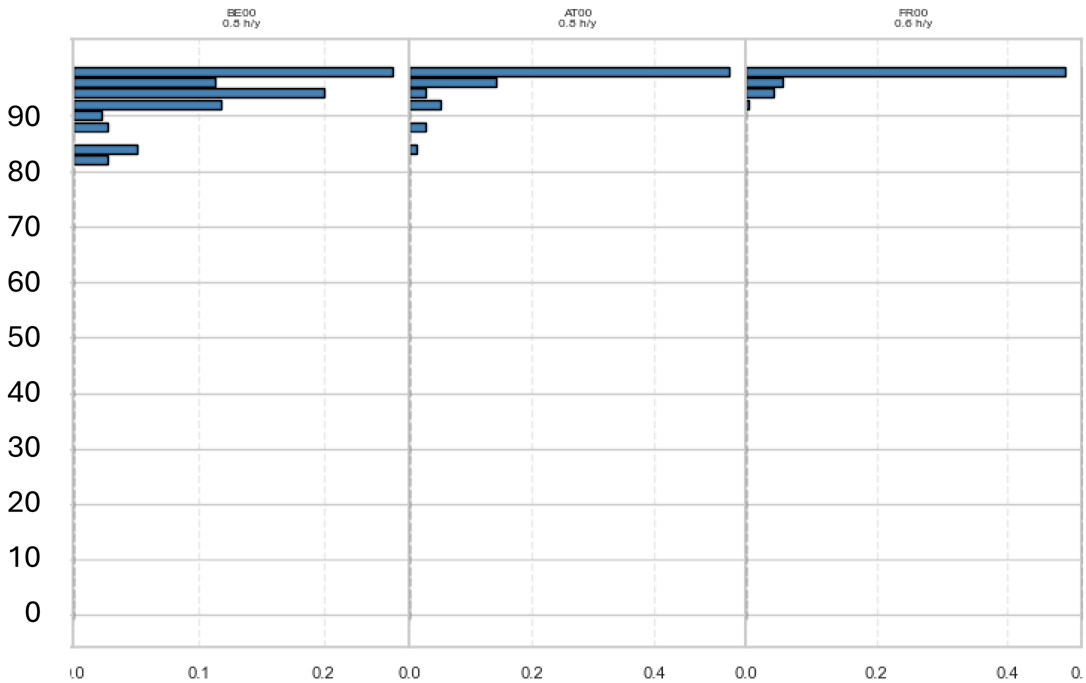
1.2 h/y
SE01
1.0 h/y
NL00
0.9 h/y
90
80
70
60
50
40
30
20
10
0
0.05
0.10
0.15
0.0
0.2
0.4
0.6
0.8
0.00
0.05
0.10
0.15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AT00
0.5 h/y
FR00
0.6 h/y
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0.2
0.4
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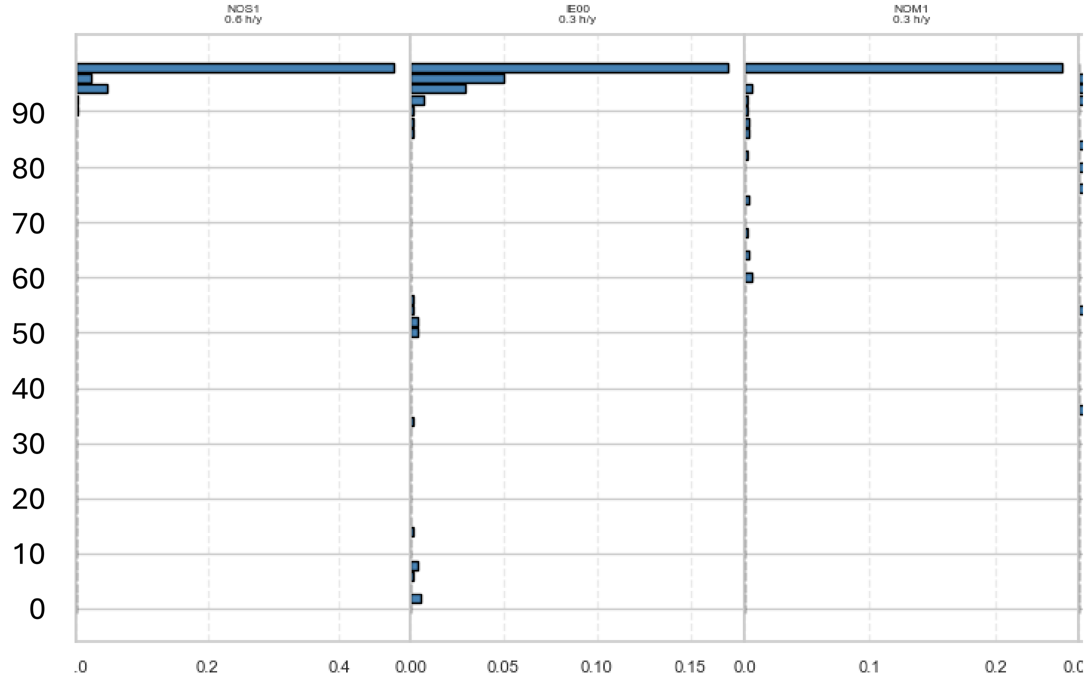
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IE00
0.3 h/y
NOM1
0.3 h/y
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60
50
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0.00
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0.10
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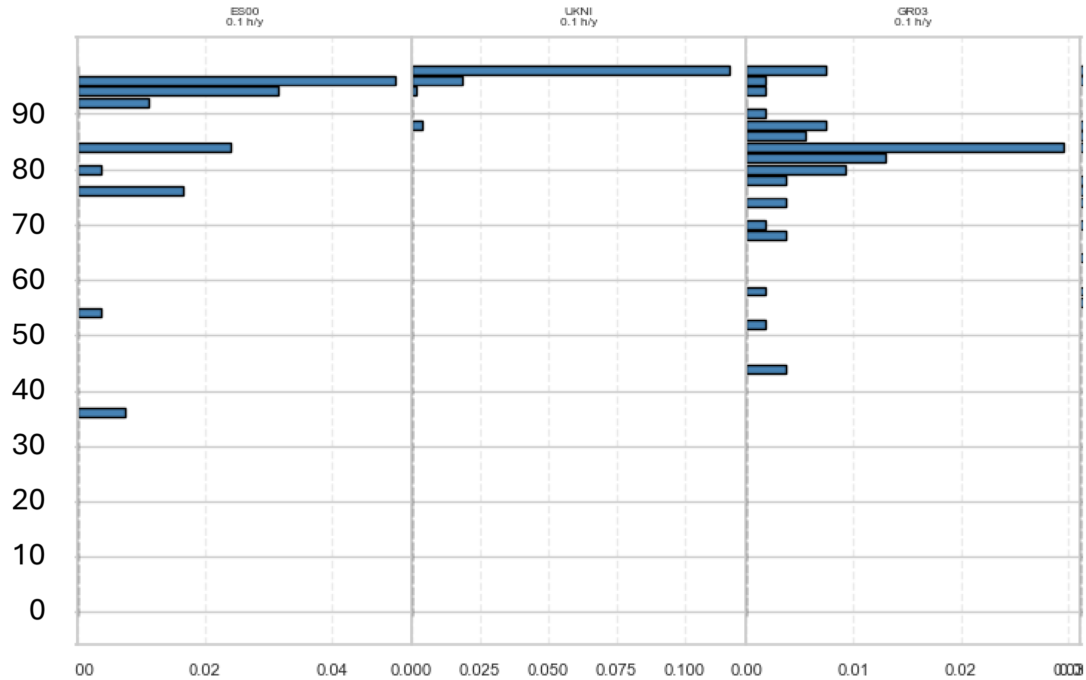
0.2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UKNI
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GR03
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80
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60
50
40
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0
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0.04
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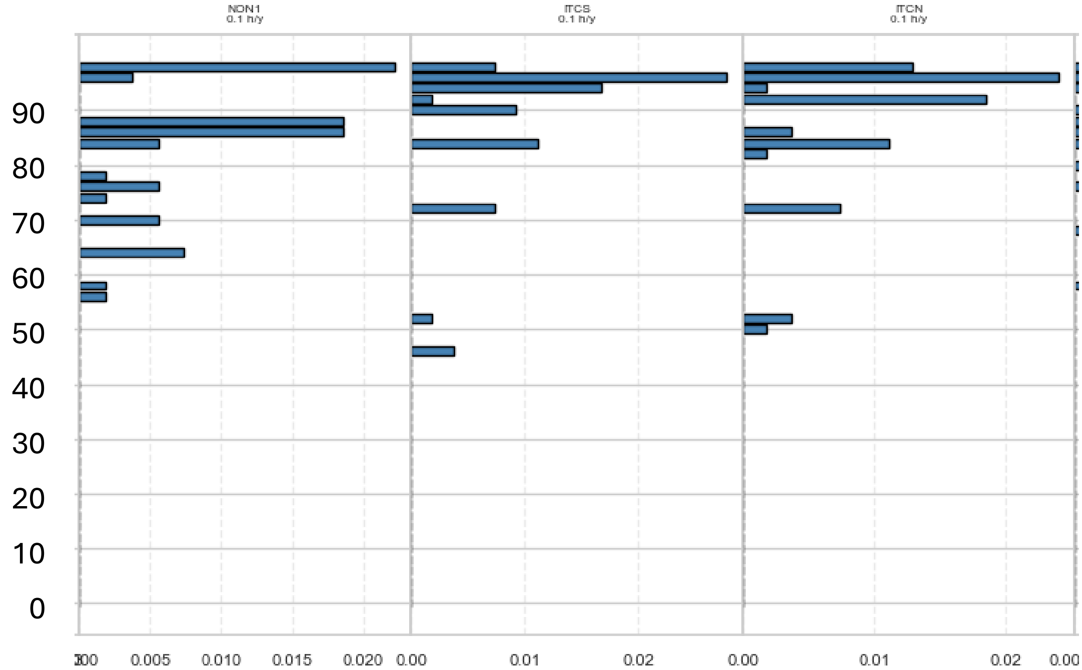
0.02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ITCS
0.1 h/y
ITCN
0.1 h/y
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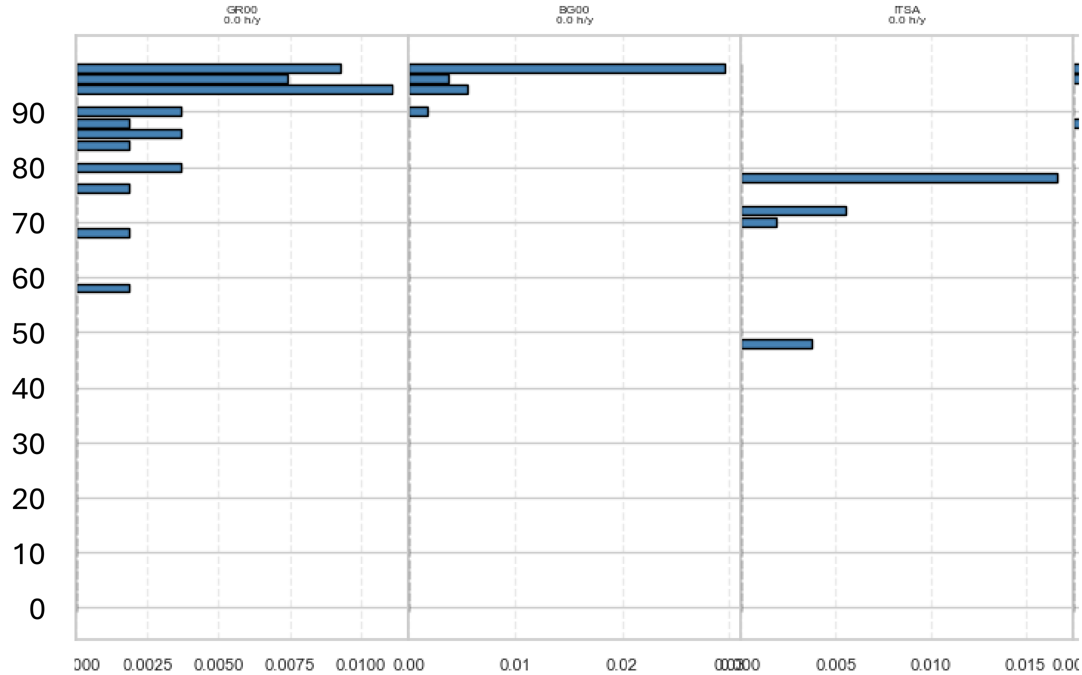
10
0
0.000 0.005 0.010 0.015 0.020
0.00 0.01 0.02
0.00 0.01 0.02 0.00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BG00
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ITSA
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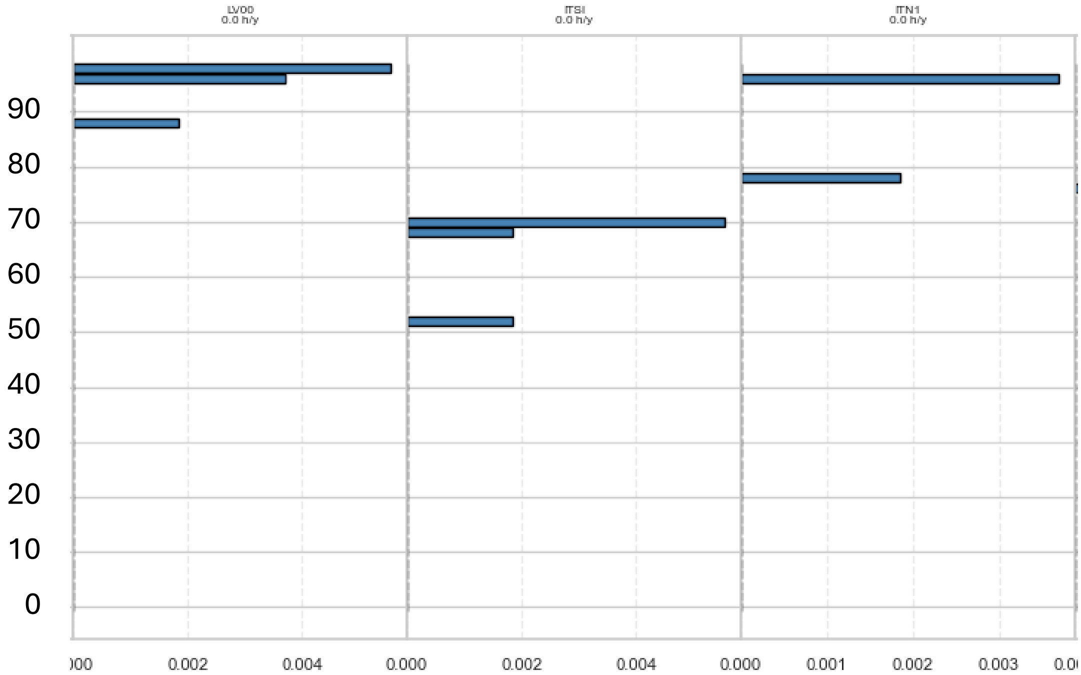
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ITSI
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ITN1
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0.000
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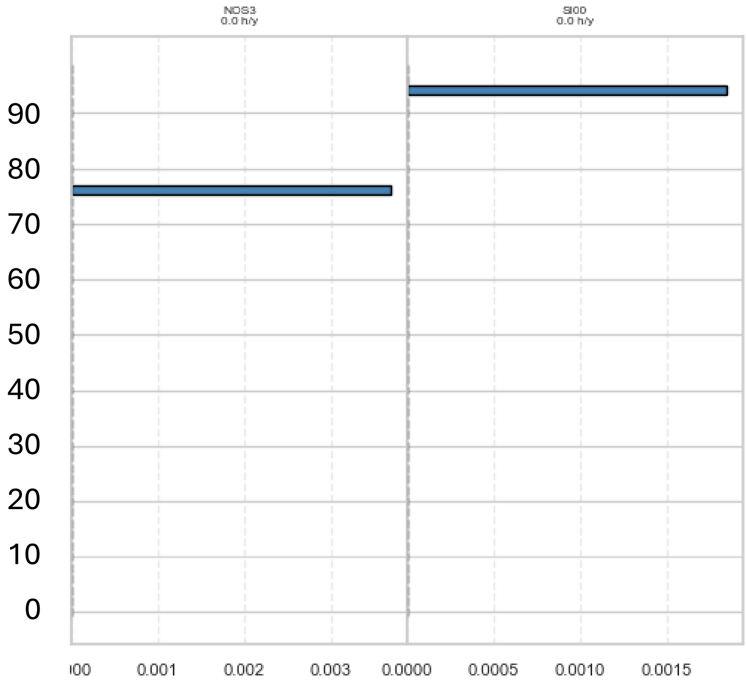
0.004
0.000
0.001
0.002
0.003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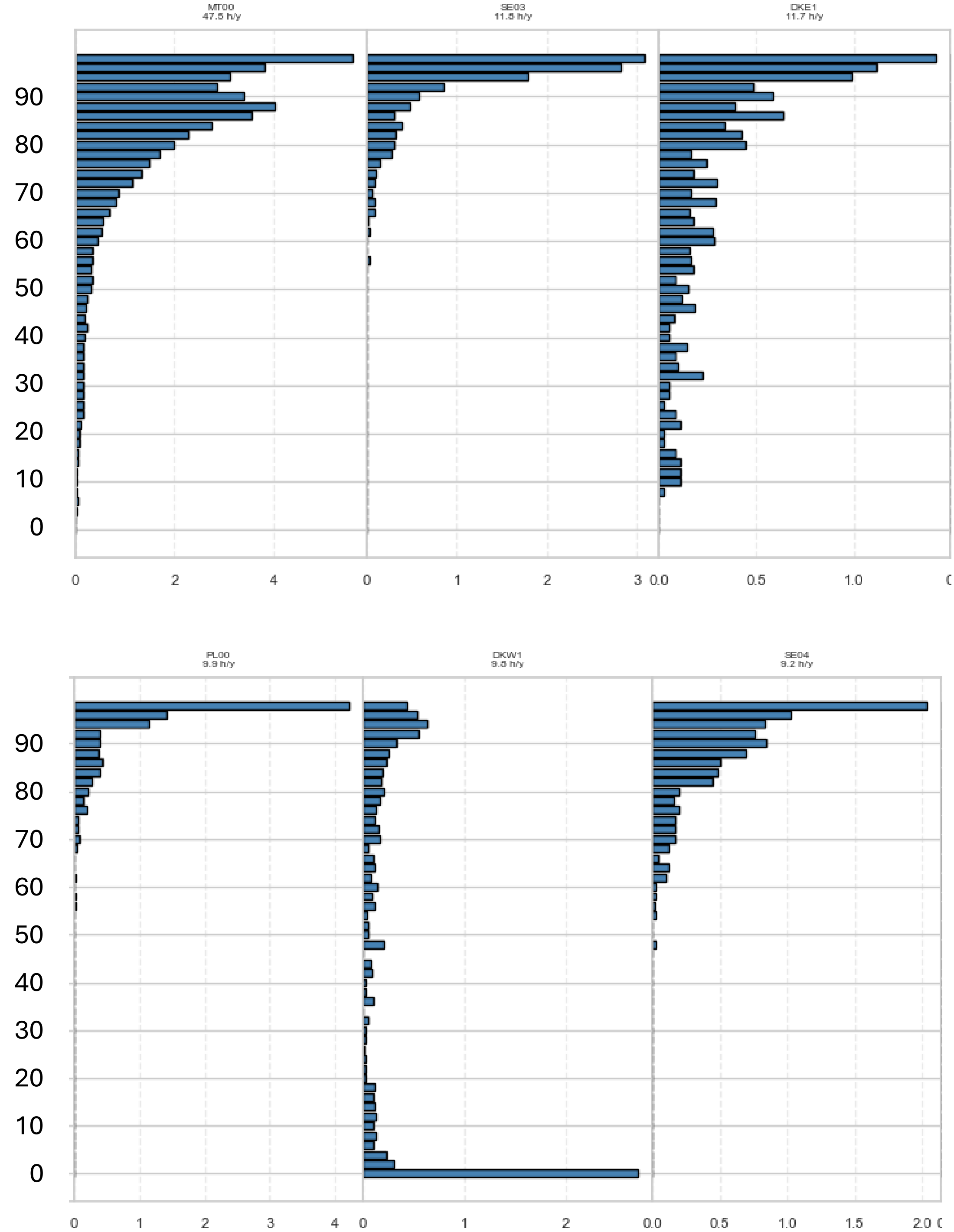
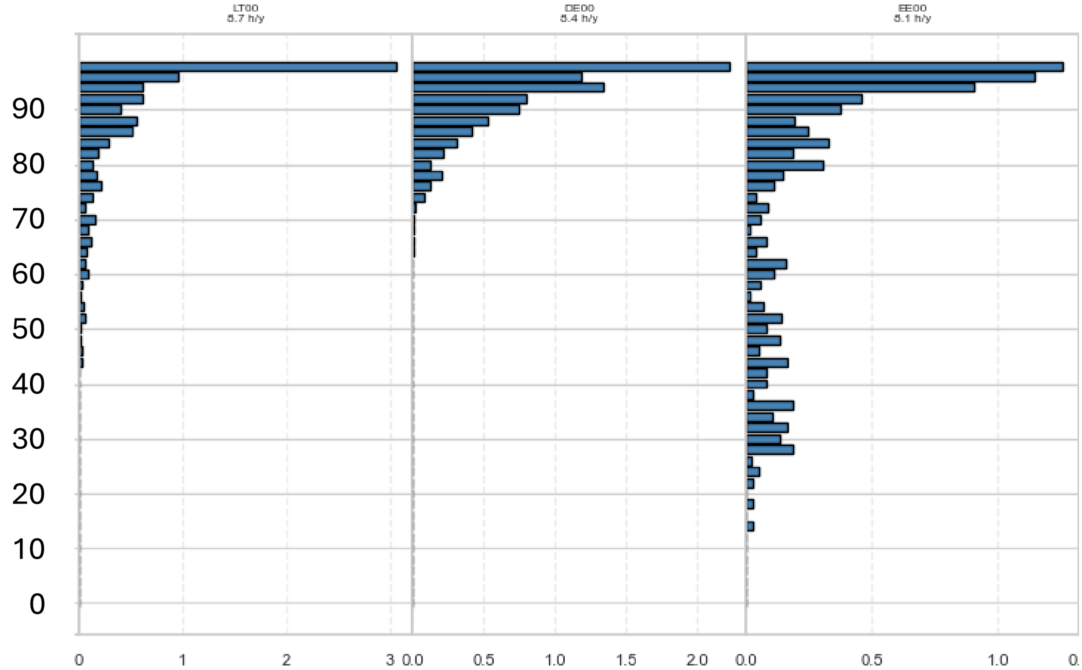
0.001
0.002
0.003
0.0000
0.0005
0.0010
0.0015

Native load percentile at which LOLE occurs: TY2035

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DE00
5.4 h/y
EE00
5.1 h/y
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30
20
10
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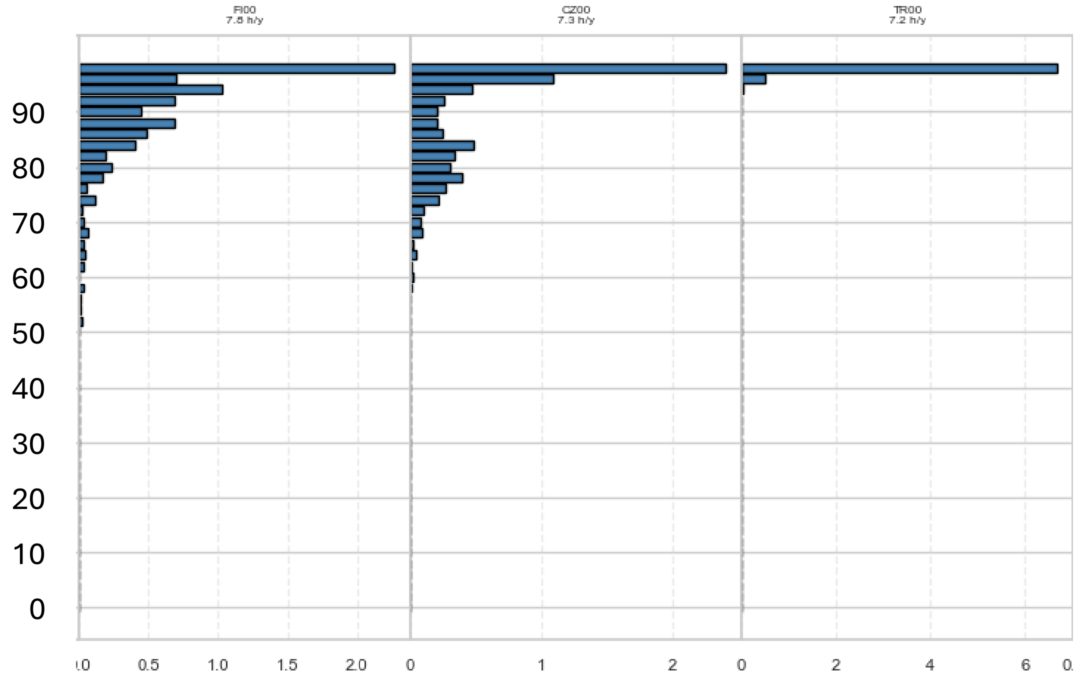
0.0 0.5 1.0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CZ00
7.3 h/y
TR00
7.2 h/y
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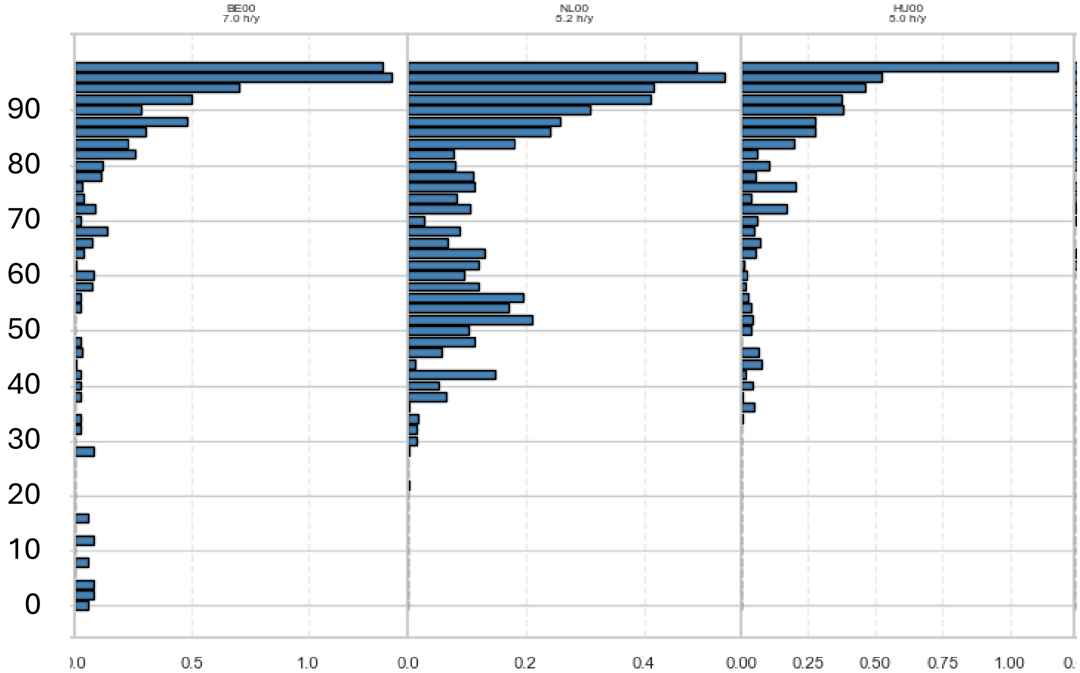
70
60
50
40
30
20
10
0
0.5 1.0 1.5 2.0
0 1 2
0 2 4 6



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7.0 h/y
NL00
5.2 h/y
HU00
5.0 h/y
90
80
70
60
50
40
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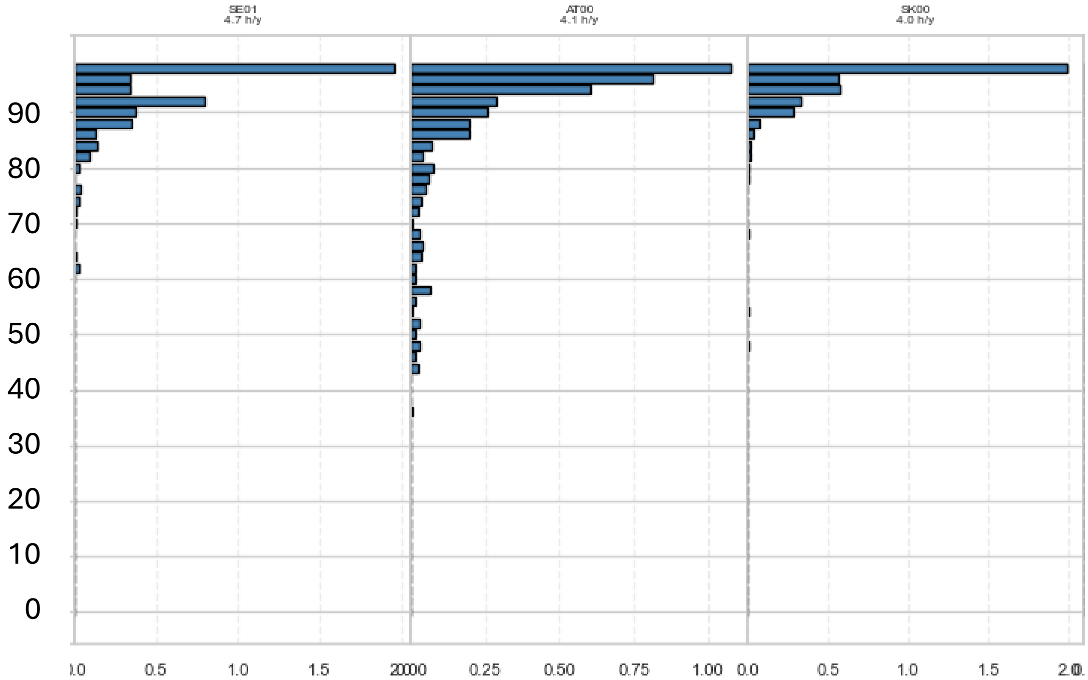
1.0
0.0
0.2
0.4
0.00
0.25
0.50
0.75
1.00



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AT00
4.1 h/y
SK00
4.0 h/y
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60
50
40
30
20
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1.5
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1.00
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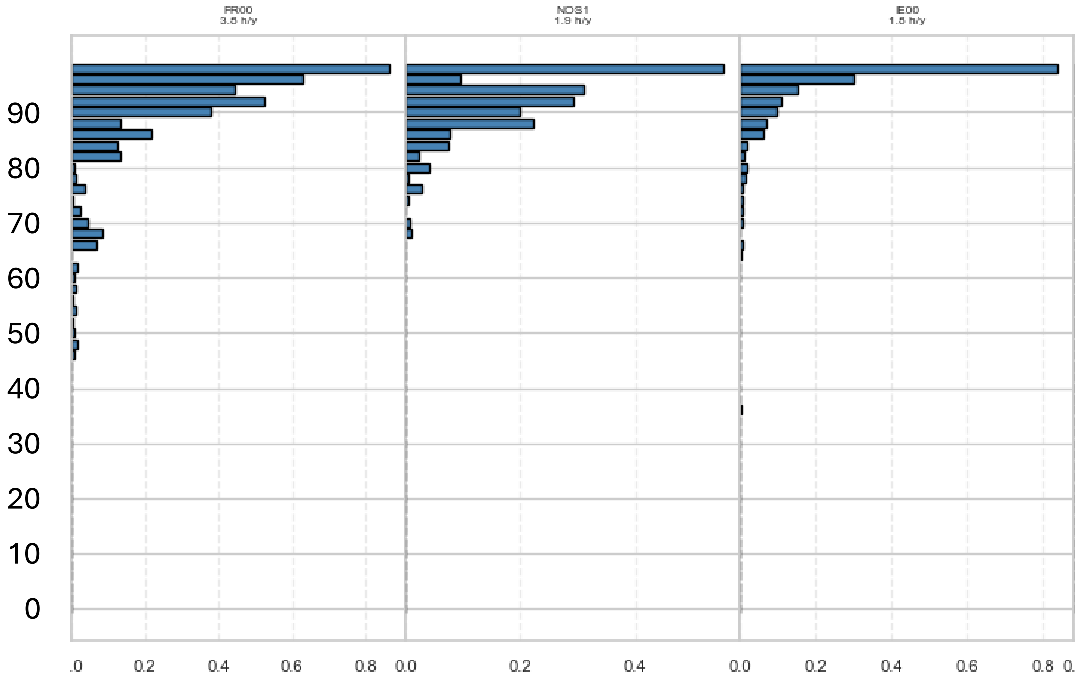
0.5
1.0
1.5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IE00
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0.4
0.6
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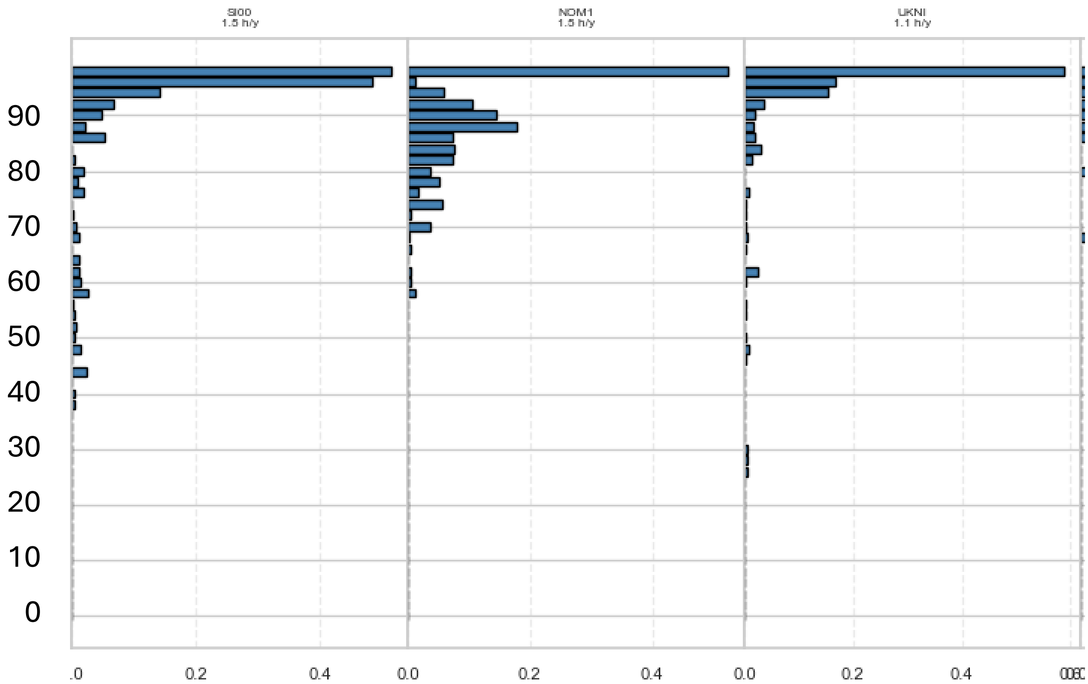
SI00
1.5 h/y
NOM1
1.5 h/y
UKNI
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60
50
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20
10
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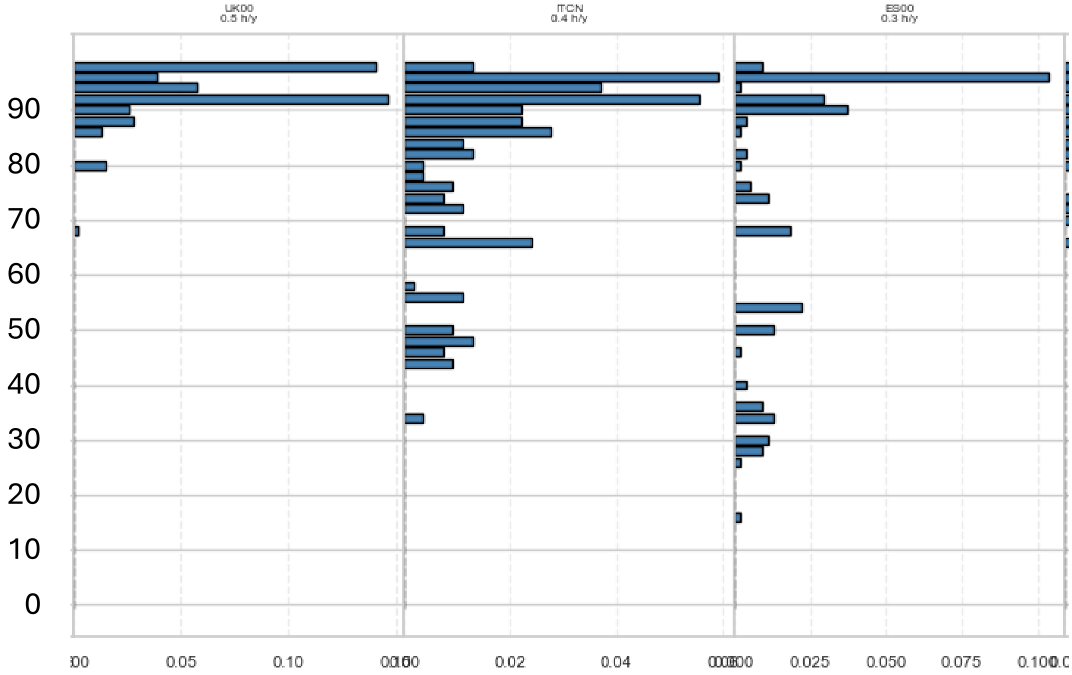
0.2
0.4
0.0


UK00
0.5 h/y
ITCN
0.4 h/y
ES00
0.3 h/y
90
80
70
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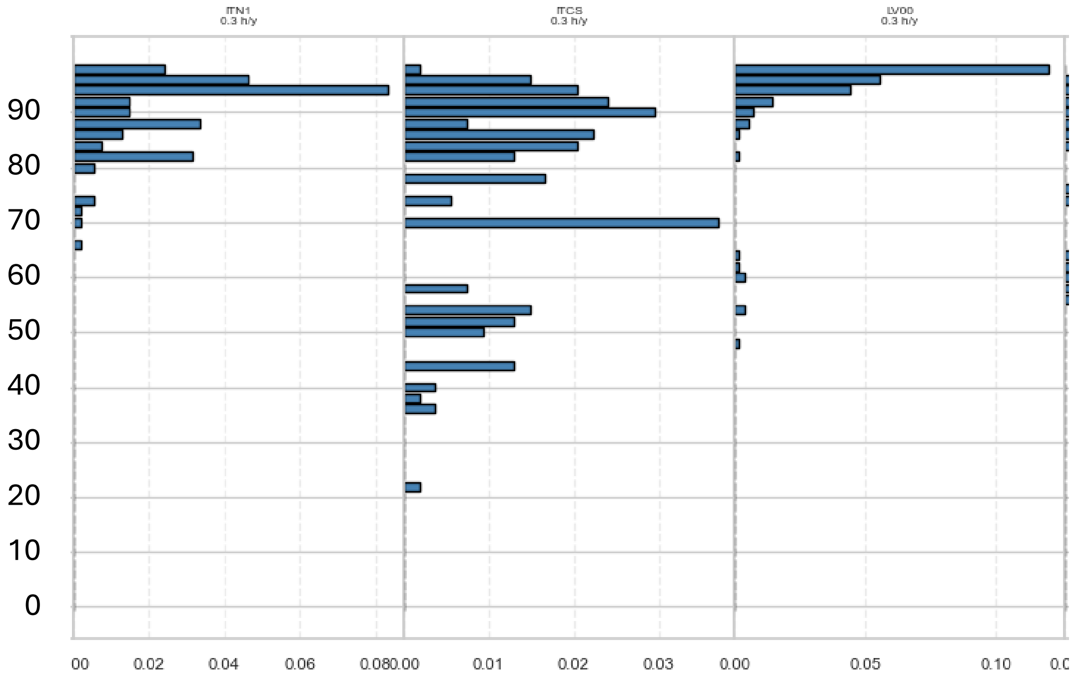
ITN1
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ITCS
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LV00
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90
80
70
60
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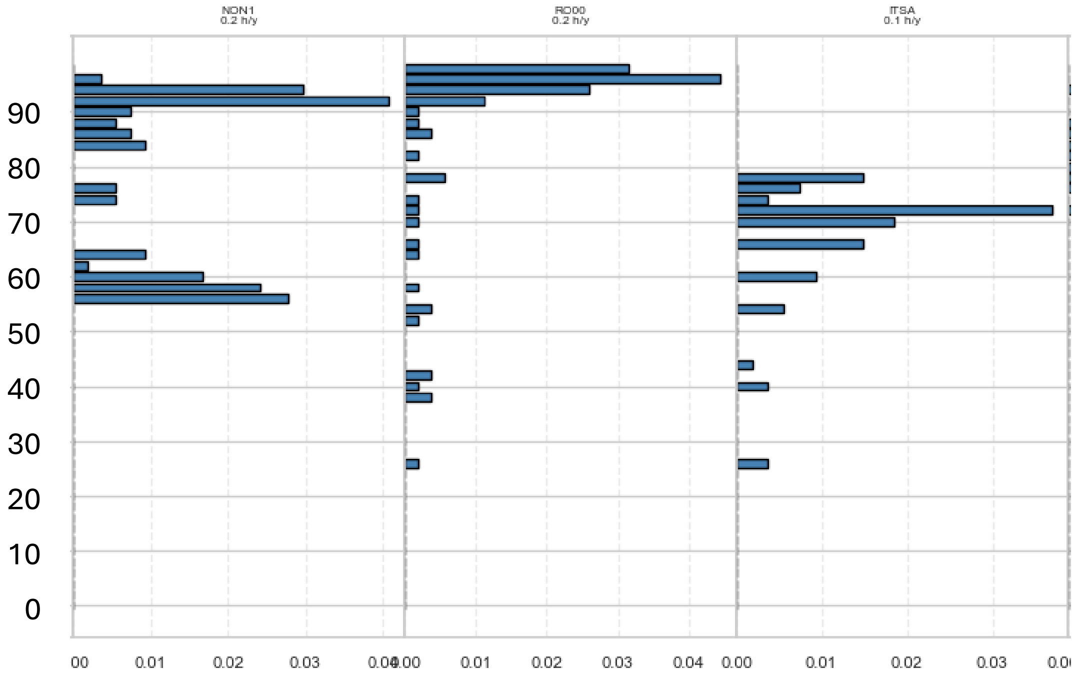
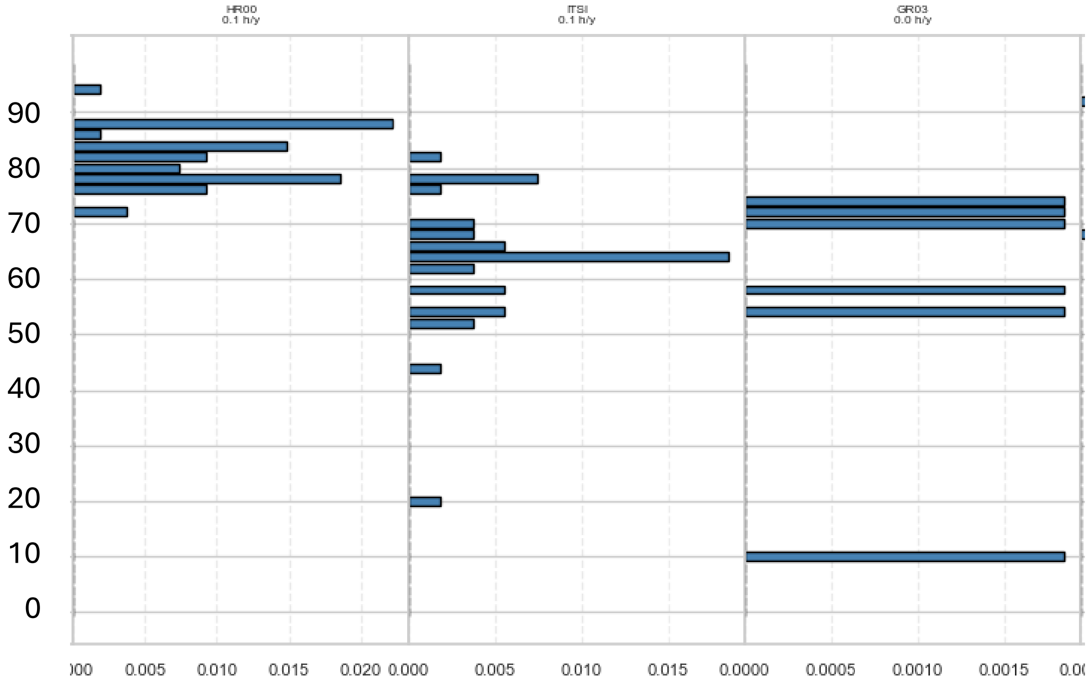
0.10


NON1
0.2 h/y
RO00
0.2 h/y
ITSA
0.1 h/y


HR00
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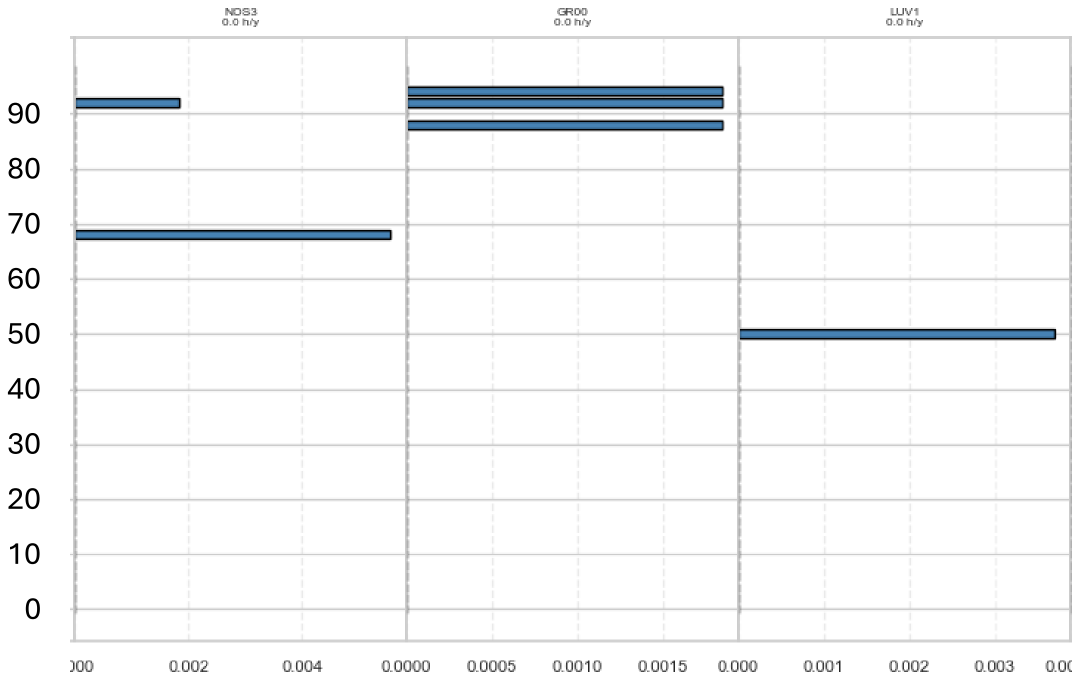
ITSI
0.1 h/y
GR03
0.0 h/y


NOS3
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GR00
0.0 h/y
LUV1
0.0 h/y
90
80
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60
50
40
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10
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0.004
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0.0005
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0.0015
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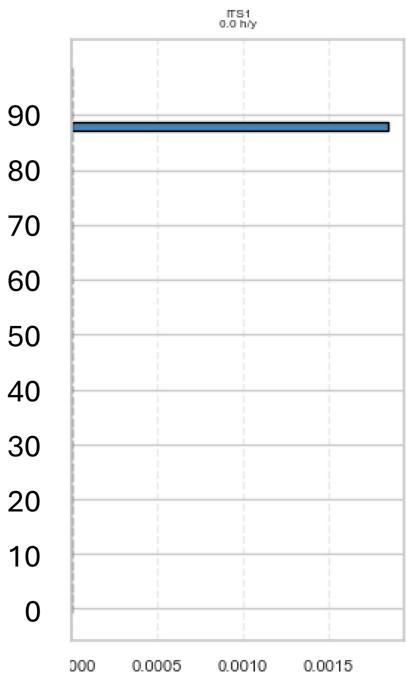
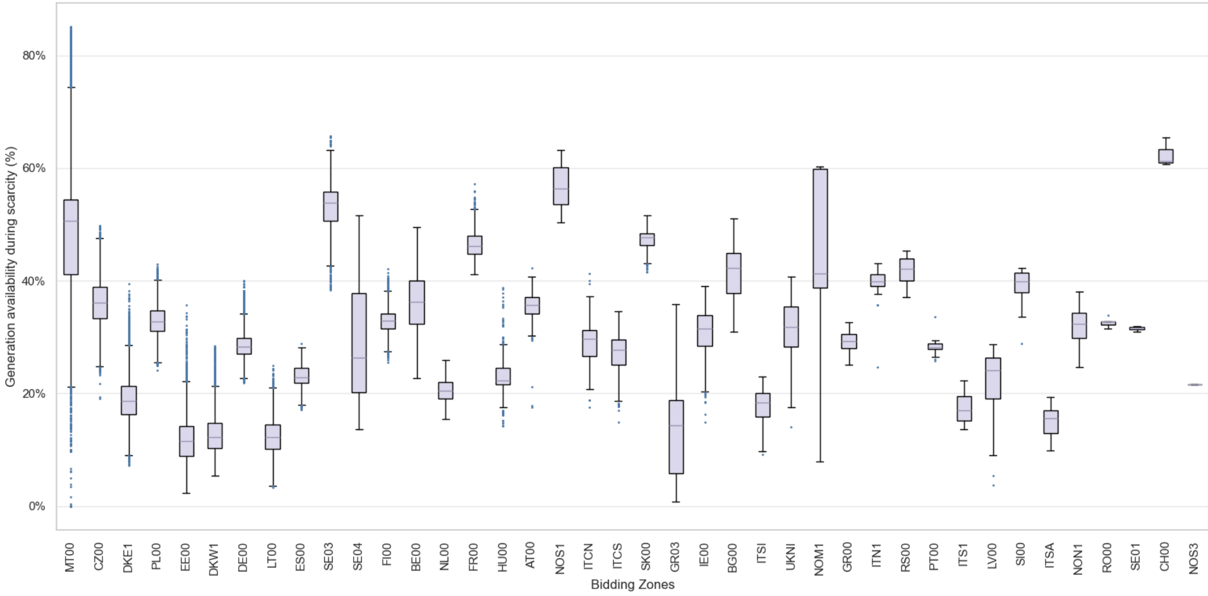
0.001
0.002
0.003

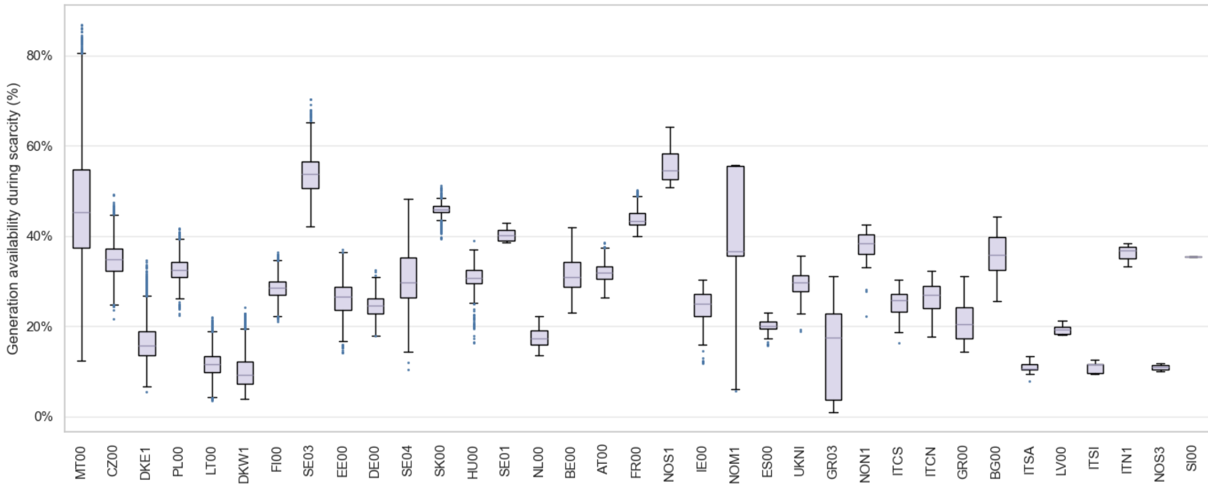

ITS1
0.0 h/y
90
80
70
60
50
40
30
20
10
0
0.0005
0.0010
0.0015

2.2.3.2. Generation availability during times of scarcity

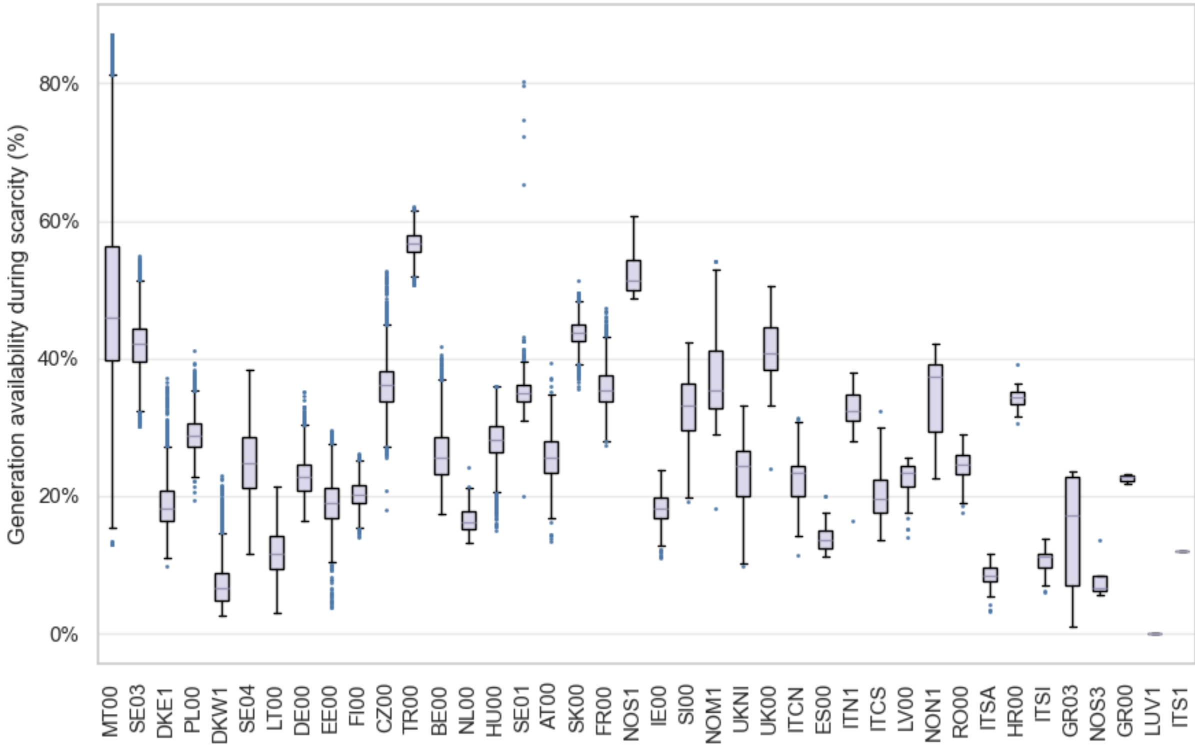
Generation availability during scarcity: TY2028



Generation availability during scarcity: TY2030

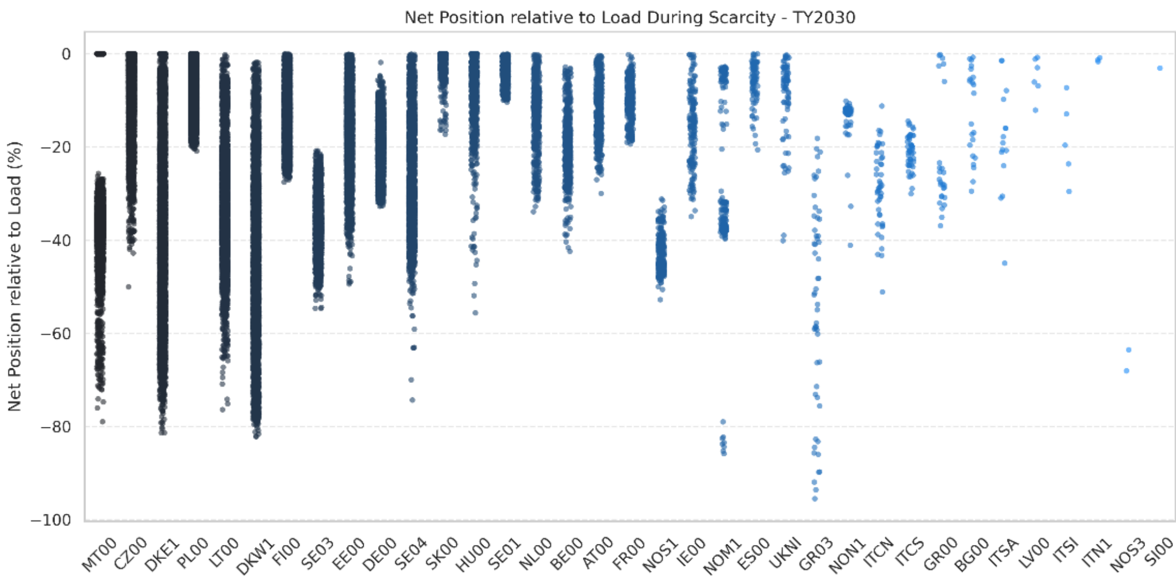


Generation availability during scarcity: TY2035

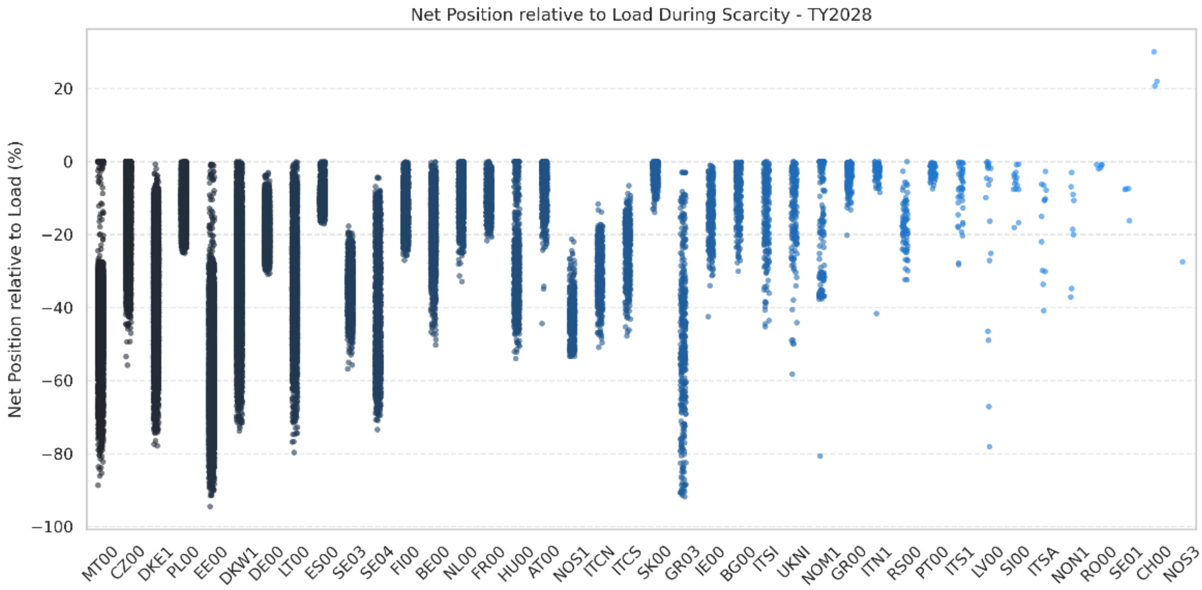


2.2.3.3. Net positions during times of scarcity

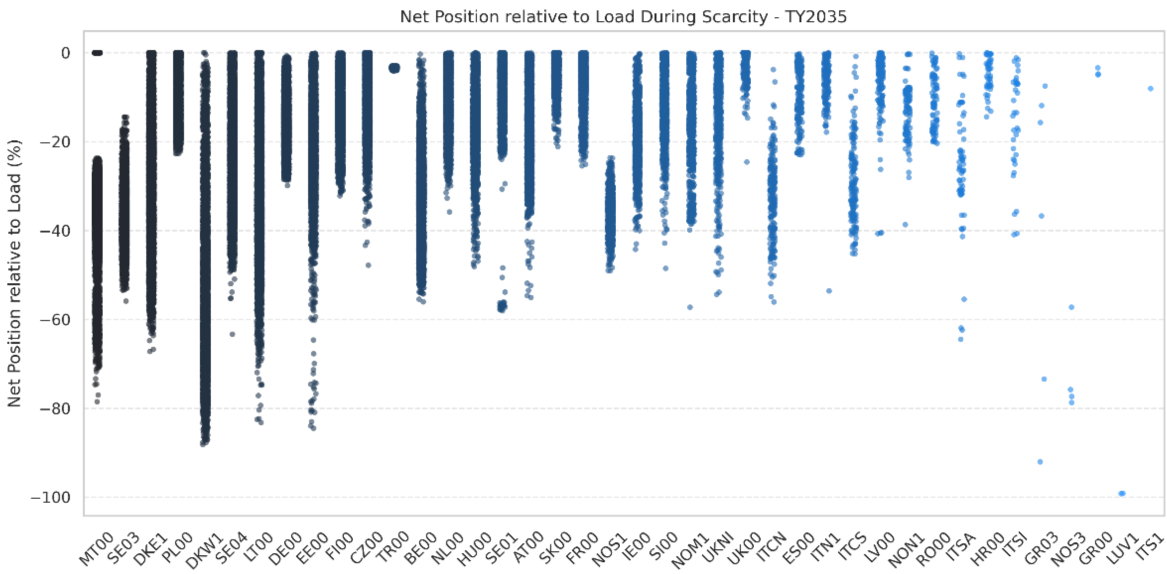
Net position relative to the domestic load during scarcity: 2028



Net position relative to the domestic load during scarcity: 2030



Net position relative to the domestic load during scarcity: 2035



2.2.4. Scarcity events description

This section aims to describe the likelihood of simultaneous scarcity events for a given target year.

Scarcity events are defined as those hours of the simulation in which, for any BZ, the ENS is higher than 0. It occurs when a BZ is unable to meet its own demand after maximising its generation and imports.

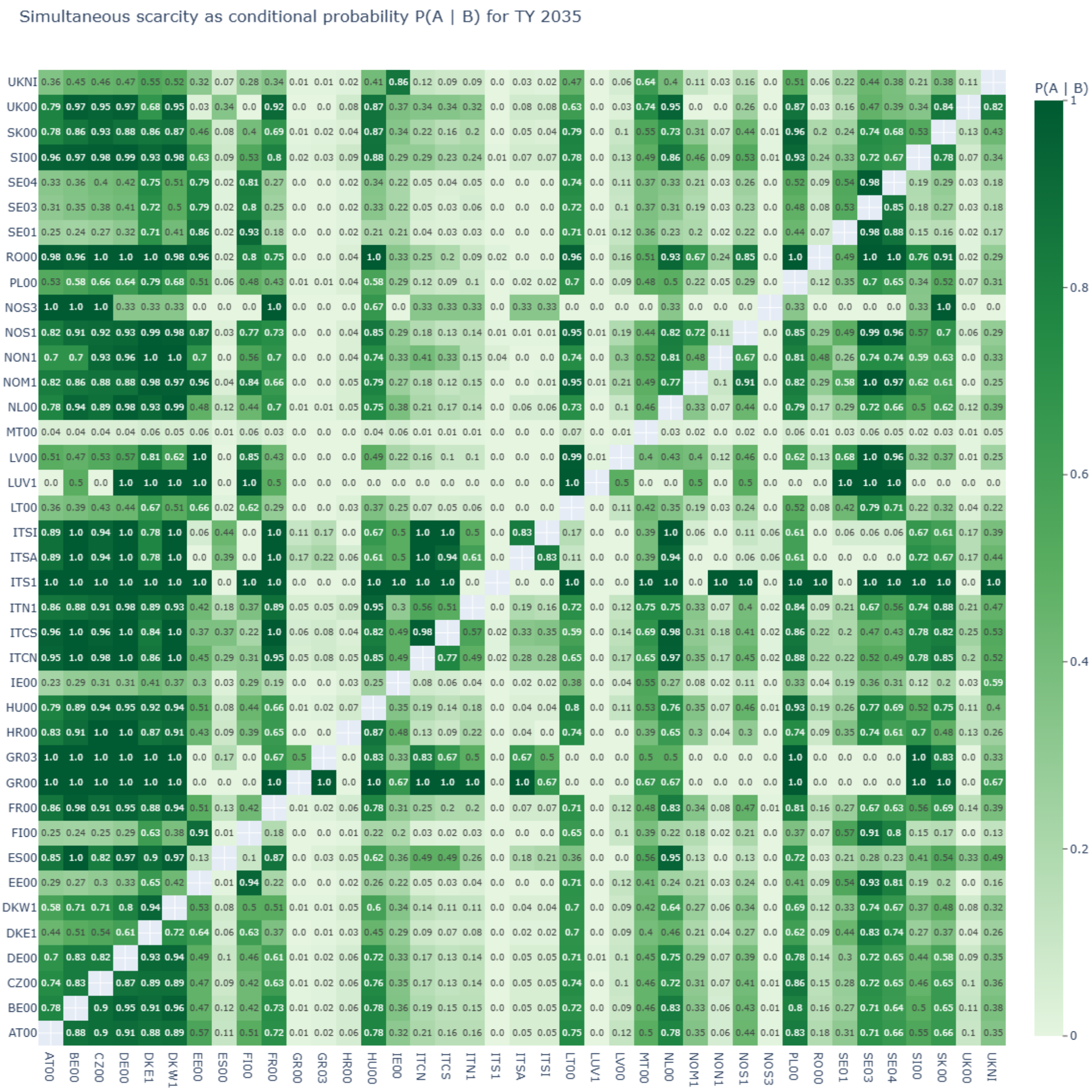
The tables below are interpreted by selecting a reference bidding zone in the rows (bidding zone A) and then a target bidding zone in the columns (bidding zone B). The value given expresses the probability of target bidding zone B experiencing a scarcity event given a scarcity event in reference bidding zone A. In mathematical terms, simultaneous scarcity probability is estimated as in the equation below, where A and B are Bidding Zones, while A_S and B_S are scarcity situations.

$$P(B = B_s \mid A = A_s) = \frac{P(B = B_s, A = A_s)}{P(A = A_s)}$$

2.2.4.1. Scarcity correlation among BZs: TY2028

2.2.4.2. Scarcity correlation among BZs: TY2030

2.2.4.3. Scarcity correlation among BZs: TY2035



2.2.5. Changes in number and distribution of scarcity events from ERAA 2023 to ERAA 2024

ERAA 2024 shows a noticeable difference in the number of scarcity events compared to ERAA 2023, along with a shift in their geographical distribution. While the past edition identified more risks in the outer regions of the continent, recent ERAA indicates a concentration of scarcity events in the CORE region and the southern Nordic bidding zones. Some driving factors of this change can be identified by analysing the input data of ERAA 2024 in comparison with ERAA 2023.[2] Some key points to consider, focusing particularly on the CORE region, are:

- An increase is observed in the demand targets for several countries, and specifically in the CORE region. Demand growth is observed steadily beyond 2030, with ERAA 2024 reaching 2035 as last analysed target year. Additionally, the demand growth is not evenly distributed in the year but rather concentrated in winter months for several MS and especially in the CORE region, driven by the increasing penetration of outdoor temperature dependent load such as heat pumps.
- New Flow-Based domains have been prepared and used in ERAA 2024 for the CORE region, delivering a more robust and accurate estimate of the future available cross-border exchanges in the region. ERAA 2023 CORE FB domains were obtained by “inflating” 2025 domains of ERAA 2022 based on the NTC expected evolution, as a simplified approach to consider future grid expansion projects. ERAA 2024 CORE FB domains were obtained instead from individual CGMES models, in line with the latest TYNDP, thus properly reflecting expected grid expansion projects and relevant CNECs per each target year. Additionally, the number of representative domains has also been increased from 4 to 6.

Other general remarks when assessing the differences between ERAA 2023 and ERAA 2024:

- Every ERAA edition includes a fully updated data collection, reflecting new developments and targets in both generation and demand side, in line with latest NECPs from member states.
- A full new set of climate data (PECD) has been used in ERAA 2024, leveraging 3 different climate projection models, for a total of 36 WS projections. The underlying complexity and differences with the PECD data used in ERAA 2023 (re-analysis of 35 historical climate data between 1982 and 2016) is rather extensive and was presented during the public webinar on the input data of ERAA 2024[3].

[2] https://www.entsoe.eu/eraa/2024/downloads/
[3] https://www.entsoe.eu/events/2024/03/14/eraa-2024-stakeholder-webinar-preliminary-input-data/

Flow-Based market coupling was also introduced in the Nordic Region, thus better representing simultaneous feasibility of cross-border exchanges in the region and the underlying limiting CNECs, especially during scarcity hours.

Additional national-specific information can be consulted in Annex 5, "Country Comments" to support understanding and interpreting the ERAA 2024 results.

Amendment 3a. Additional nuclear patters (methodology)

1. In ERAA 2024 ***Executive Report (Annex I.a to this Decision)***, section 4.2, point 7 is amended as follows:

Compared to ERAA 2023, which does not explore the probabilistic representation of nuclear availability in sufficient detail to capture the observed variability, ERAA 2024's proof of concept includes two additional nuclear availability profiles for France in the economic dispatch studies for 2030 and 2035, where this variability is more pronounced. This approach more comprehensively captures the effects of nuclear availability, which has been consistently shown, especially in 2022, to have a potentially detrimental effect on security of supply across Europe.

2. In ERAA 2024 ***Annex 1: Input Data & Assumptions (Annex I.b to this Decision)***, section 4.4.2 is amended as follows*:*

4.4.2. Proof of concept: French nuclear availability insights

Compared to the ERAA 2023 report, ERAA 2024 features a proof of concept, where the reference availability time series of the French nuclear generation have been complemented with two additional cases representing a lower and a higher availability profile. This has been deemed necessary as the observed in the past, dispersion of the nuclear generation in France is gravely underestimated otherwise. As an example, comparing the actual dispersion in available capacity in the ERAA studies against the French NRAA (Figure 6) reveals that the amplitude of the dispersion in 2030 can be up to 10 times higher in the latter. In terms of annual production, the French NRAA, corroborated by actual observations, demonstrates up to 6 times higher dispersion.

The two additional availability profiles that have been incorporated in the proof of concept are based on the following principles:

- Achieving a production level of 345TWh for the low and 375TWh for the high availability case;
- Ensure more capacity in the winter months for the high availability compared to the reference case;
- Represent low nuclear presence in the winter months for the low availability compared to the reference case;

Figure 7 and Figure 8 show the comparison of the additional cases of French nuclear generation availability (consideration of all sources of unavailability – planned maintenance, forced outages and any thermal deratings) against the reference case (consideration of planned maintenance with minimum and maximum forced outages and thermal deratings). The additional French nuclear availability cases were pre-determined taking into account all possible sources of unavailabilities already and therefore single French nuclear availability profile was defined. In the model the generation availability is composed of all aforementioned unavailability components. Sampling of forced outages probabilistically was considered when reference French nuclear availability was assumed. Hence French nuclear availability is represented as a range 6 in the reference case. However, when the low and high availability cases of French nuclear capacity were assessed, full probabilistic modelling (like for the reference case) was performed, except for pre-determined profiles for French nuclear capacity. The adequacy indicators of the proof of concept are averaged for the three cases for France and Belgium where the impact is considerable.

Amendment 3b. Additional nuclear patters (results)

1. In ERAA 2024 ***Executive Report (Annex I.a to this Decision)***, adequacy results for TY 2030 and TY 2035 for France and Belgium are amended as follows:

	2030		2035	
	original	amended	original	amended
France	4.2h	1.8h	6.8h	4.9 h
Belgium	6.1h	3.*8h*	10.4h	9.4h

2. ERAA 2024 ***Annex 3: Detailed results (Annex I.d to this Decision)*** is amended as follows:

   2a. Adequacy results for TY 2030 and TY 2035 for France and Belgium are amended as follows:

LOLE results						
Study zone	TY 2030					
	Average [h/year]		P50 [h/year]		P95 [h/year]	
	original	amended	original	amended	original	amended
BE00	6.14	3.76	0	0	33.05	19.05
FR00	4.21	1.79	0	0	26	13
Study zone	TY 2035					
	Average [h/year]		P50 [h/year]		P95 [h/year]	
	original	amended	original	amended	original	amended
BE00	10.39	9.36	0	0	57.05	57
FR00	6.78	4.95	0	0	35	29

EENS and ENS results						
Study zone	TY 2030					
	Average [GWh]		P50 [GWh]		P95 [GWh]	
	original	amended	original	amended	original	amended
BE00	2.91	1.19	0	0	18.49	4.34
FR00	8.03	2.42	0	0	46.77	4.56
Study zone	TY 2035					
	Average [GWh]		P50 [GWh]		P95 [GWh]	
	original	amended	original	amended	original	amended
BE00	13.01	8.73	0	0	76.55	52.41
FR00	12.92	5.07	0	0	74.75	18.47

2b. The following section is added after *section 2.2.5. Changes in number and distribution of scarcity events from ERAA 2023 to ERAA 2024*:

2.2.6. Results of the proof of concept: French nuclear availability

This section presents an overview of LOLE results for the proof of concept introducing additional High Availability profile and Low Availability profile for the French nuclear fleet for the two study years: 2030 and 2035. The adequacy indicators are calculated as a simple average of the loss of load expectation resulted from all three profiles, that is, the reference case, High Availability and Low Availability.

For TY 2030, Table XX lists the average LOLE and LLD percentiles for BE00 and FR00 study zones.

Study zone	TY 2030		
	Average [h/year]	P50 [h/year]	P95 [h/year]
BE00	6.14	0	33.05
FR00	4.21	0	26

For TY 2035, Table XX1 lists the average LOLE and LLD percentiles for BE00 and FR00 study zones.

Study zone	TY 2035		
	Average [h/year]	P50 [h/year]	P95 [h/year]
BE00	10.39	0	57.05
FR00	6.78	0	35

Amendment 4. Completing the geographical scope

1. ERAA 2024 ***Executive Report (Annex I.b to this Decision)*** is amended as follows:

1a. Adequacy results for TY 2026 for Italy and Malta are added as follows:

	2026	
	original	amended
ITCA	(excluded)	0
ITCN	(excluded)	0.72
ITCS	(excluded)	0.86
ITN1	(excluded)	0.12
ITS1	(excluded)	0.02
ITSA	(excluded)	0.01
ITSI	(excluded)	0.06
MT00	(excluded)	1.4 / 41.6

1b. Section 2.3 is amended as follows*:*

Note that for 2026 TY, despite a net decrease of more than 50 GW of thermal capacity, the ERAA 2024 results indicate only limited adequacy concerns – only in a few study zones, and not necessarily those where most of the capacity would be decommissioned (10 GW in Italy, 7 GW in Poland, 6 GW in Germany and 3 GW in France) or in those relying on imports to guarantee adequacy (e. g. Italy).

2. ERAA 2024 ***Annex 3: Detailed results (Annex I.d to this Decision)*** is amended as follows:

2a. Adequacy results for TY 2026 for Italy and Malta are added as follows:

LOLE results						
Study zone	TY 2026					
	Average [h/year]		P50 [h/year]		P95 [h/year]	
	original	amended	original	amended	original	amended
ITCA	(excluded)	0	(excluded)	0	(excluded)	0
ITCN	(excluded)	2.73	(excluded)	0	(excluded)	16
ITCS	(excluded)	2.21	(excluded)	0	(excluded)	12
ITN1	(excluded)	0.67	(excluded)	0	(excluded)	5
ITS1	(excluded)	0.4	(excluded)	0	(excluded)	3
ITSA	(excluded)	0.11	(excluded)	0	(excluded)	0
ITSI	(excluded)	0.7	(excluded)	0	(excluded)	3.05
MT00	(excluded)	37/619.5	(excluded)	606/865.1	(excluded)	35.1/89

ENS results						
Study zone	TY 2026					
	Average [GWh]		P50 [GWh]		P95 [GWh]	
	original	amended	original	amended	original	amended
ITCA	(excluded)	0	(excluded)	0	(excluded)	0
ITCN	(excluded)	0.72	(excluded)	0	(excluded)	4.08
ITCS	(excluded)	0.86	(excluded)	0	(excluded)	4.82
ITN1	(excluded)	0.12	(excluded)	0	(excluded)	0.68
ITS1	(excluded)	0.02	(excluded)	0	(excluded)	0.09
ITSA	(excluded)	0.01	(excluded)	0	(excluded)	0
ITSI	(excluded)	0.06	(excluded)	0	(excluded)	0.36
MT00	(excluded)	1.4 / 41.6	(excluded)	39.6/0.98	(excluded)	65.13/3.98

2b. Footnote 9 is deleted.