Technical Limits

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Current arrangements

- Customers wishing to connect to a GSP are currently categorised by the Transmission System Operator (ESO) in what is known as the Appendix G (App G)
- The App G is an annex to the Bilateral Connection Agreement (BCA) between the DNO and the ESO for each GSP
- The categories are:
  - Part 1 – Already connected DER before App G
  - Part 2 – DER that can connect
  - Part 3 – DER that can connect with Transmission circuit restrictions under N-1 scenario
  - Part 4 – DER that can't connect until Transmission works are completed
- Currently some customers in Part 4 have connection dates that go out to 2037 owing to the wider Transmission system reinforcements needed

Technical Limits – what is it?

- As part of Connections reforms, the ESO has introducing Technical Limits (TL) at GSPs
- Expressed in MWs, TLs represent the minimum and maximum acceptable power flow at the GSP beyond which wider Transmission system constraints could be active
- TLs are calculated by the ESO, considering all existing App G Part 1 and Part 2 DER and deducting the GSP minimum demand to identify net power flows on the wider Transmission system
- Should a qualifying customer choose, TLs will allow the connection of Part 4 DER ahead of wider Transmission system reinforcements
- The connection would be **non-firm** and **uncompensated**
- The DNO will manage the Part 4 DER such that the TLs are not breached
- However, should the TL be breached, the DNO would curtail/interrupt relevant DER
- For ENWL the TLs will be controlled by its Active Network Management (ANM) software

Implementation of Technical Limits

Technical Limits phased rollout – our GSPs

- November 2023
  - Phase 1a – Sole use GSPs with Fault level headroom >1kA and Part 4 customers
    - There are five GSPs that meets these criteria:
    - **Bredbury, Kearsley, South Manchester, Penwortham and Kirkby**
  - Phase 1b – Sole use GSPs with fault level headroom <1kA and Part 4 customers
    - There are no GSPs that meets these criteria
- April 2024 onwards
  - Phase 2 – Complex sites(more than one User at the site) with Part 4 customers
    - There are five GSPs
    - **Padiham, Rochdale, Stalybridge, Washway Farm and Whitegate**
    - Three sites fall all have fault level limitations
    - TL will be available once the substation SGTs/fault level reinforcement works are done:
    - **Harker, Hutton, Heysham**.

Roll out across our GSPs

GSP Name	Transmission Constraints (Y/N)	TECHNICAL LIMITS IMPLEMENTATION PHASE
Bredbury	Y	Phase 1a - Nov 23 Notification
Kearsley & Kearsley Local	Y	Phase 1a - Nov 23 Notification
Kirkby	Y	Phase 1a - Nov 23 Notification
Penwortham	Y	Phase 1a - Nov 23 Notification
South Manchester	Y	Phase 1a - Nov 23 Notification
Paddiham	Y	Phase 2 - Apr 24 Notification
Rochdale	Y	Phase 2 - Apr 24 Notification
Stalybridge	Y	Phase 2 - Apr 24 Notification
Washway Farm	Y	Phase 2 - Apr 24 Notification
Whitegate	Y	Phase 2 - Apr 24 Notification
Harker	Y	Potentially future phase
Hutton	Y	Potentially future phase
Heysham	Y	Potentially future phase
Carrington	N	Currently No Part 4 Schemes
Macclesfield	N	Currently No Part 4 Schemes
Stanah	N	Currently No Part 4 Schemes
Warrington / Fiddlers Ferry (Risley 11kV)		SPEN GSP
Rainhill / Bold (Golborne)		SPEN GSP

- Table showing the planned roll out across all our GSPs

Dependencies

- We will manage Technical Limits through our Active Network Management (ANM) system
  - We expect to begin commissioning Technical Limits late 2024/early 2025
  - Ahead of commissioning of the Technical Limits, we will work with the ESO and NGET to ensure that the ANM solution meets all their requirements
- If TLs are breached, we will use our Merit Order Management (MOM) software to curtail Part 4 DER.
  - To ensure a more equitable approach to curtailment, we aim to use a curtailment index rather than ‘last-in/first-off’
- Some of our networks are formed of two or more GSP ‘groups’ that operate in complex arrangements, eg Penwortham.
  - We’re working with our ANM provider to understand how we’ll configure Technical Limits on these networks
- Inter-control room communications protocol (ICCP) is a digital link between ENW and the ESO and provides ‘control and visibility’ between the two control rooms. The ESO has made control and visibility a requirement of TLs.
  - We will start working with the ESO to introduce ICCP functionality in the new year

Curtailment

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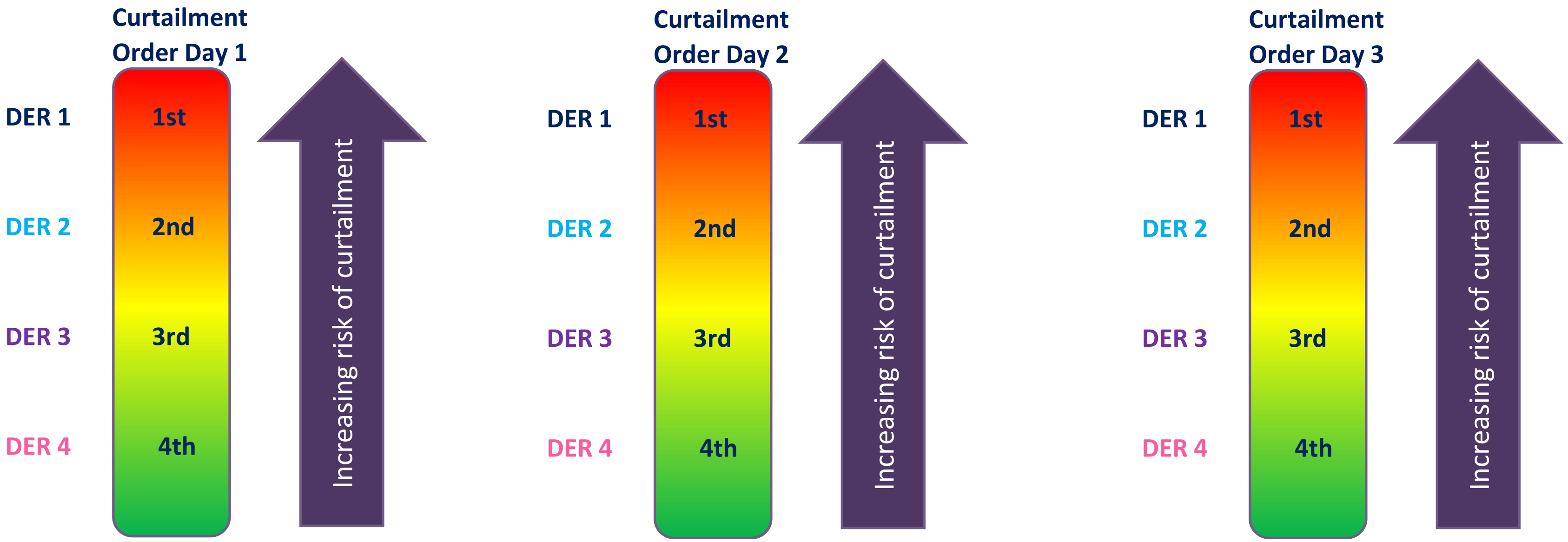
Merit Order Stacks - Explanation

- The ENWL Active Network Management System is continuously monitoring SCADA measurement points across the Network
- When it detects a constraint on the network, signified by a SCADA measurement exceeding pre-set thresholds, it will look to resolve that constraint utilising Flexible Connections, Services, and Assets.
- ANM will utilise a Pre-defined stack of Flexible connections and services to define the order in which DERs are dispatched/curtailed. This is called the Merit Order.
- Current common UK methodologies for merit orders generally either follow a Last in First off (‘LIFO’)approach, or a Curtailment index methodology.
- ANM will only select DERs from the list which it identifies can help to resolve the constraint.

LIFO

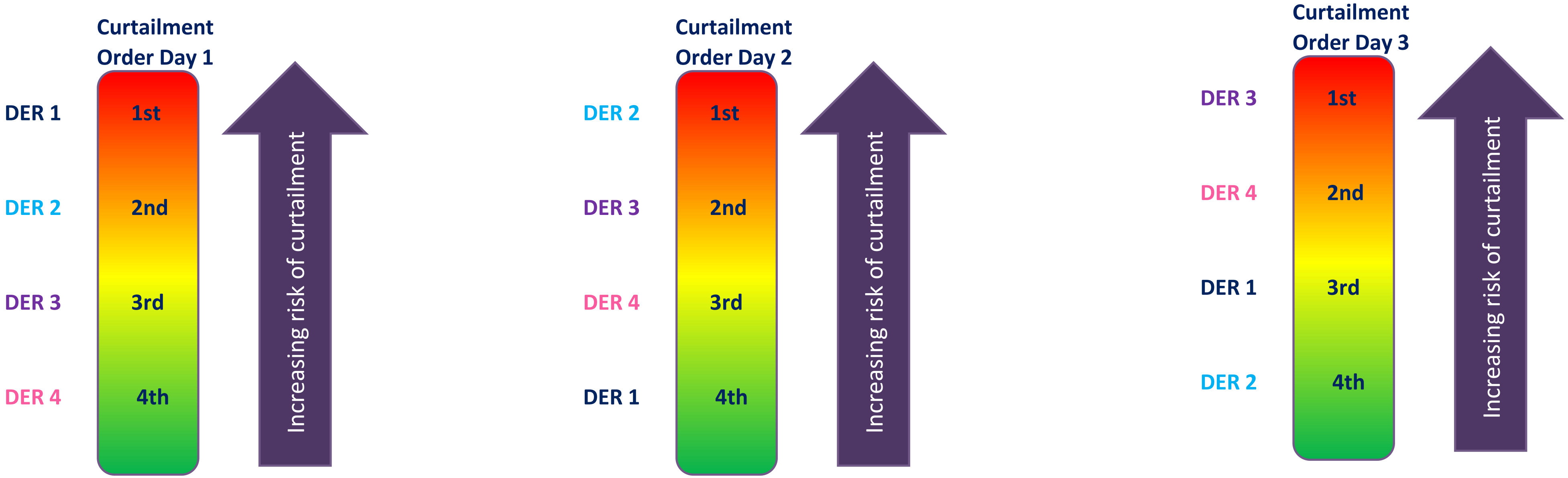
- With the LIFO methodology, the DER which was the last to connect to the network would always be the first to be curtailed in the event of a network constraint.
- This methodology is better for DERs who can mobilise faster to get connected, however negatively impacts customers who might have more complicated connections.
- This also means that for the lifetime of the Flexible Contract (“Part 4” limits) will mean they are always the first to be curtailed.



Curtailment index

$$\text{Curtailment Index value} = \frac{Curtailment\ throughout\ the\ year\ so\ far\ (MWh)}{Curtialment\ allowace\ for\ the\ year\ (MWh)}$$

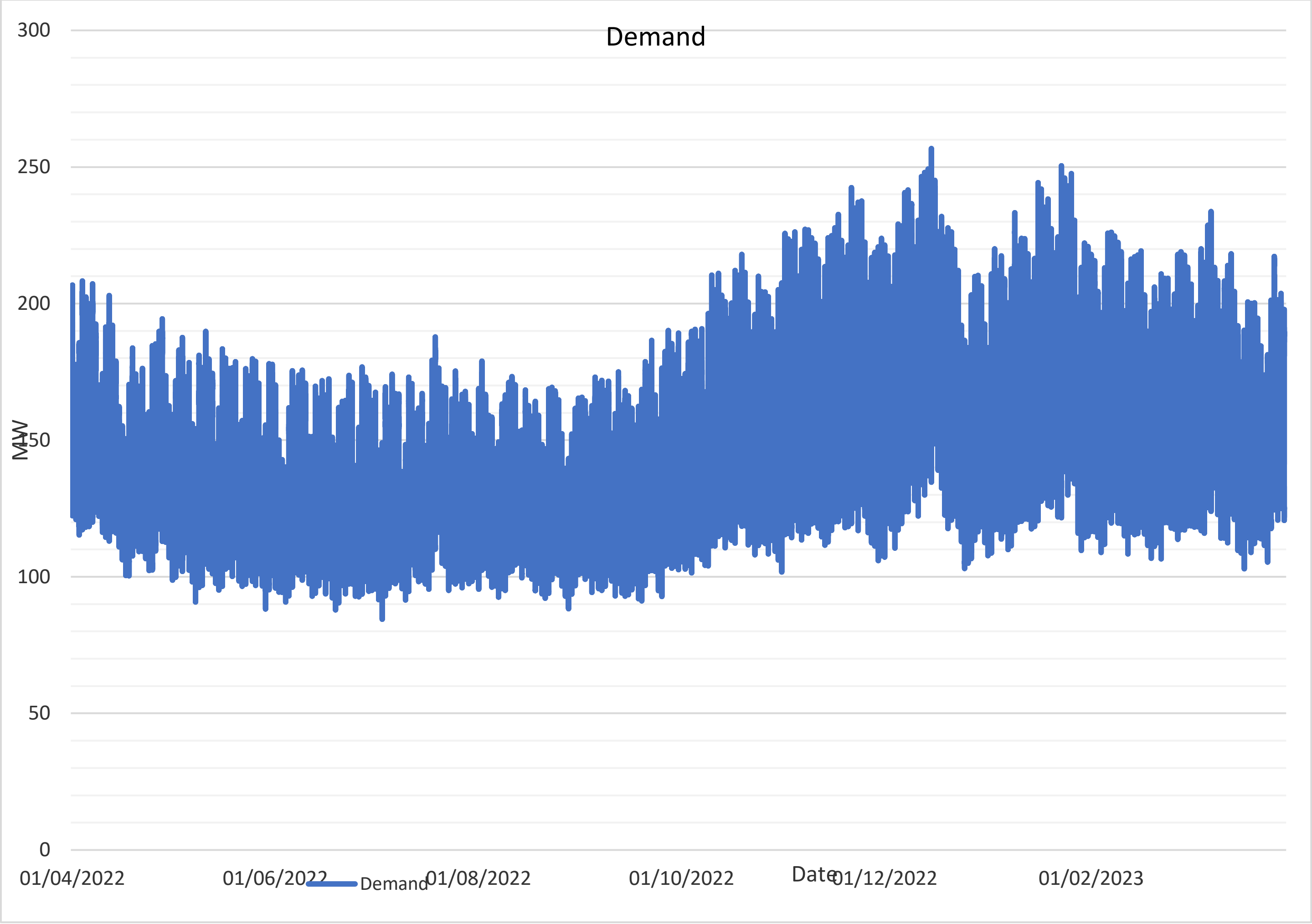
- The curtailment index methodology means that when a DER is curtailed the curtailment index value is recalculated.
- Whichever DER has the highest amount of remaining curtailment allowance (proportional to the level of allowance at the start of the year) is the first to be curtailed.
- The curtailment index methodology allows for a fair allocation of curtailment across a stack of DER. Curtailment is equitably shared over the period of a year between the DERs held within the stack.
- **Customers are not negatively impacted by being the slowest to connect.**



Curtailment modelling

Bredbury GSP - Typical year

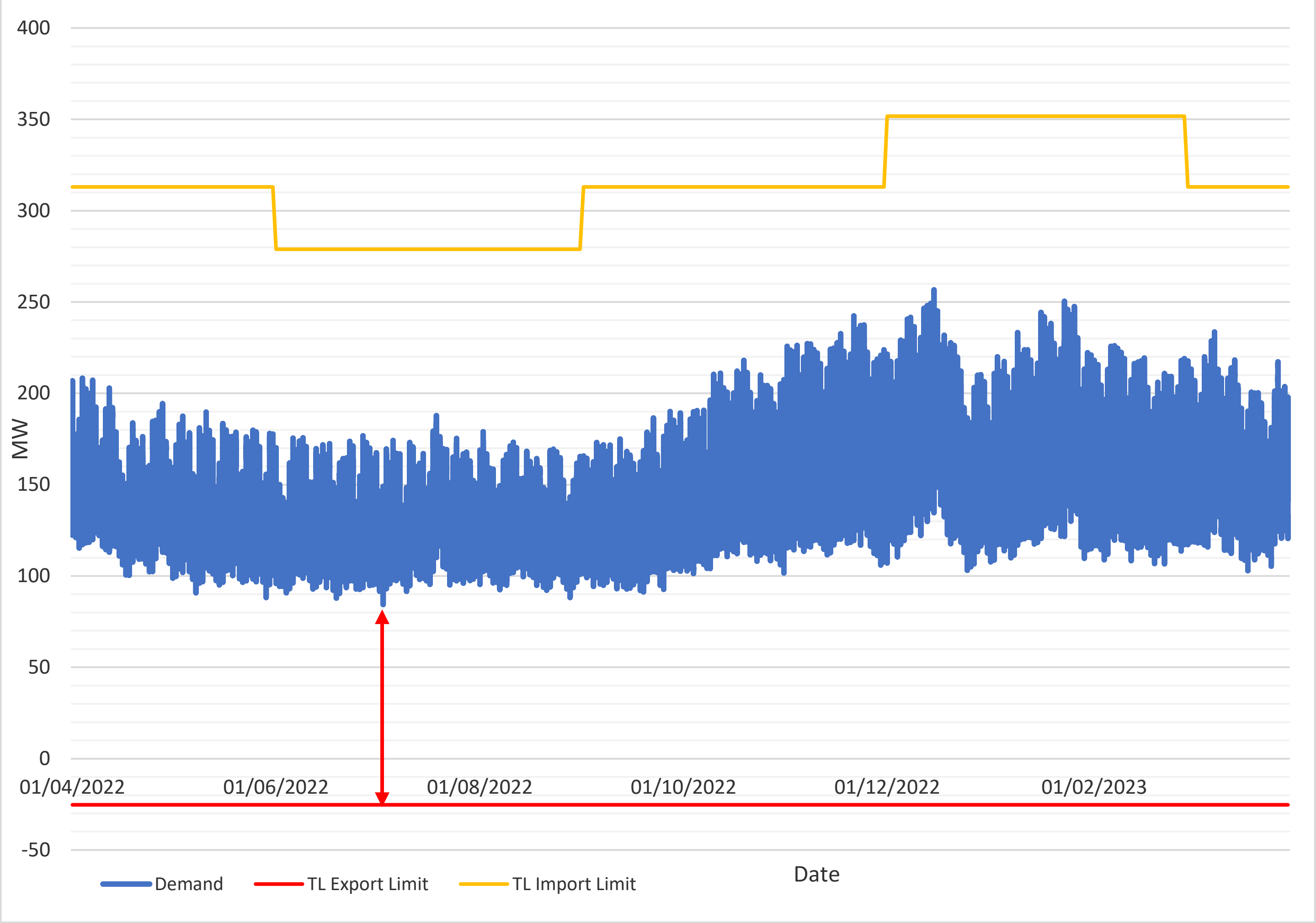
Bredbury GSP 2022/23 Demand – Illustration



- This shows the net demand profile for Bredbury GSP during 2022/23

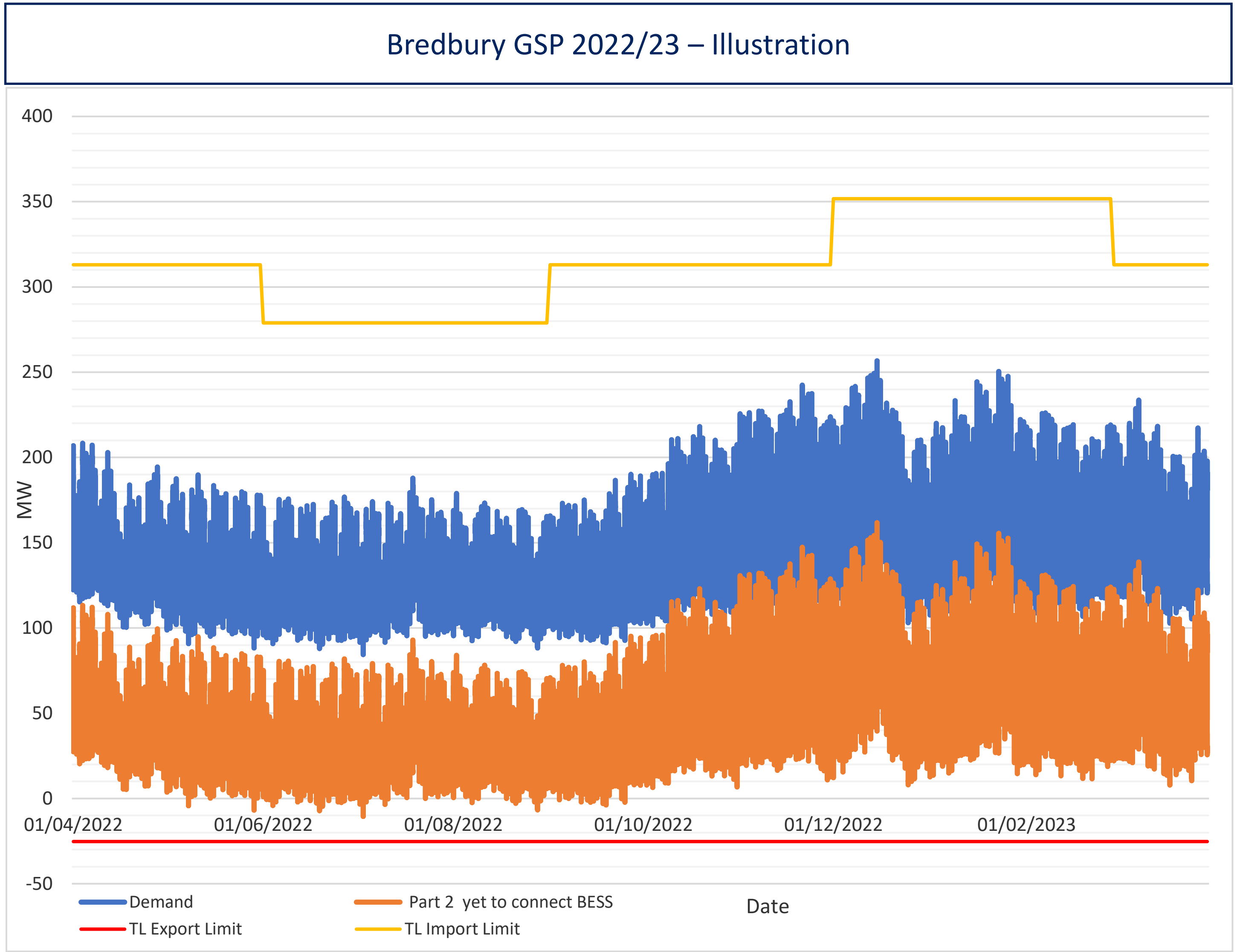
Bredbury GSP - Typical year with Technical Limits

Bredbury GSP 2022/23 – Illustration of demand with available headroom upon introduction of TL



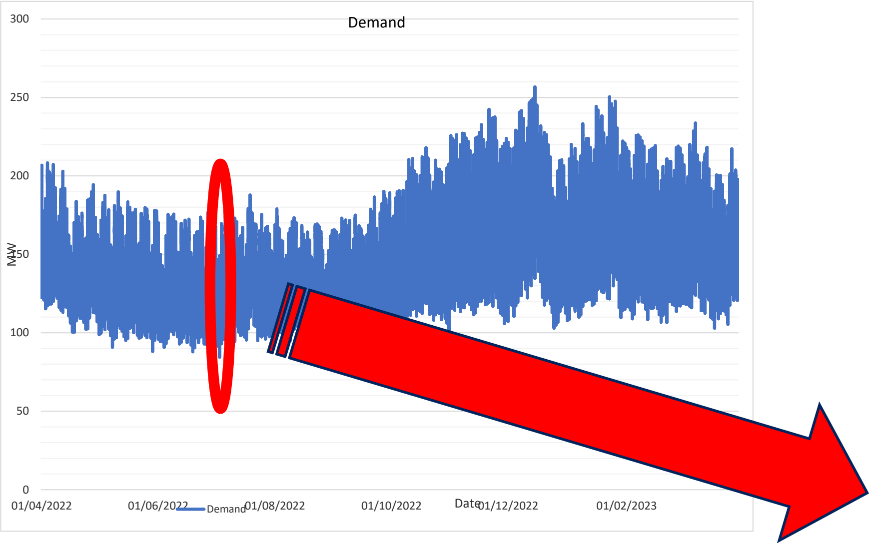
- The change in approach is that the ESO is providing an operating envelope for the maximum import and export at each GSP
- The DNO just needs to ensure that it can operate within that window
- The headroom varies depending on month/time of day but the minimum headroom is shown with the red arrow
- This headroom will be made available to all Part 4 projects to connect

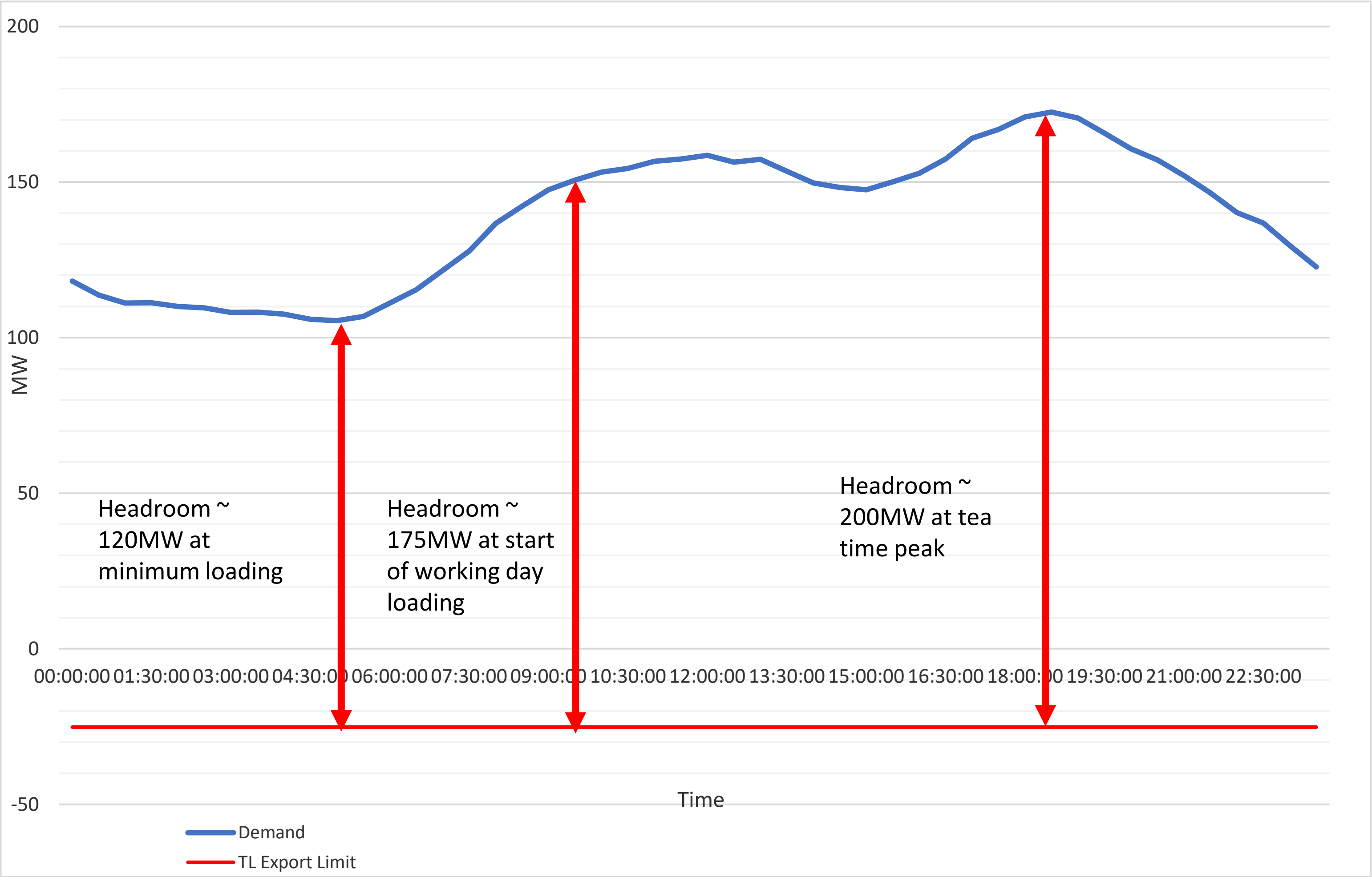
Bredbury GSP - Typical year with consented connections added



- This shows the net demand profile for Bredbury GSP during 2022/23
- When all the App G Part 2 not yet connected BESS is added (orange) most of the available capacity headroom is used up
- Any other DER wishing to connect needs to wait until extra Transmission capacity has been added (Part 4)

Bredbury GSP -Typical day

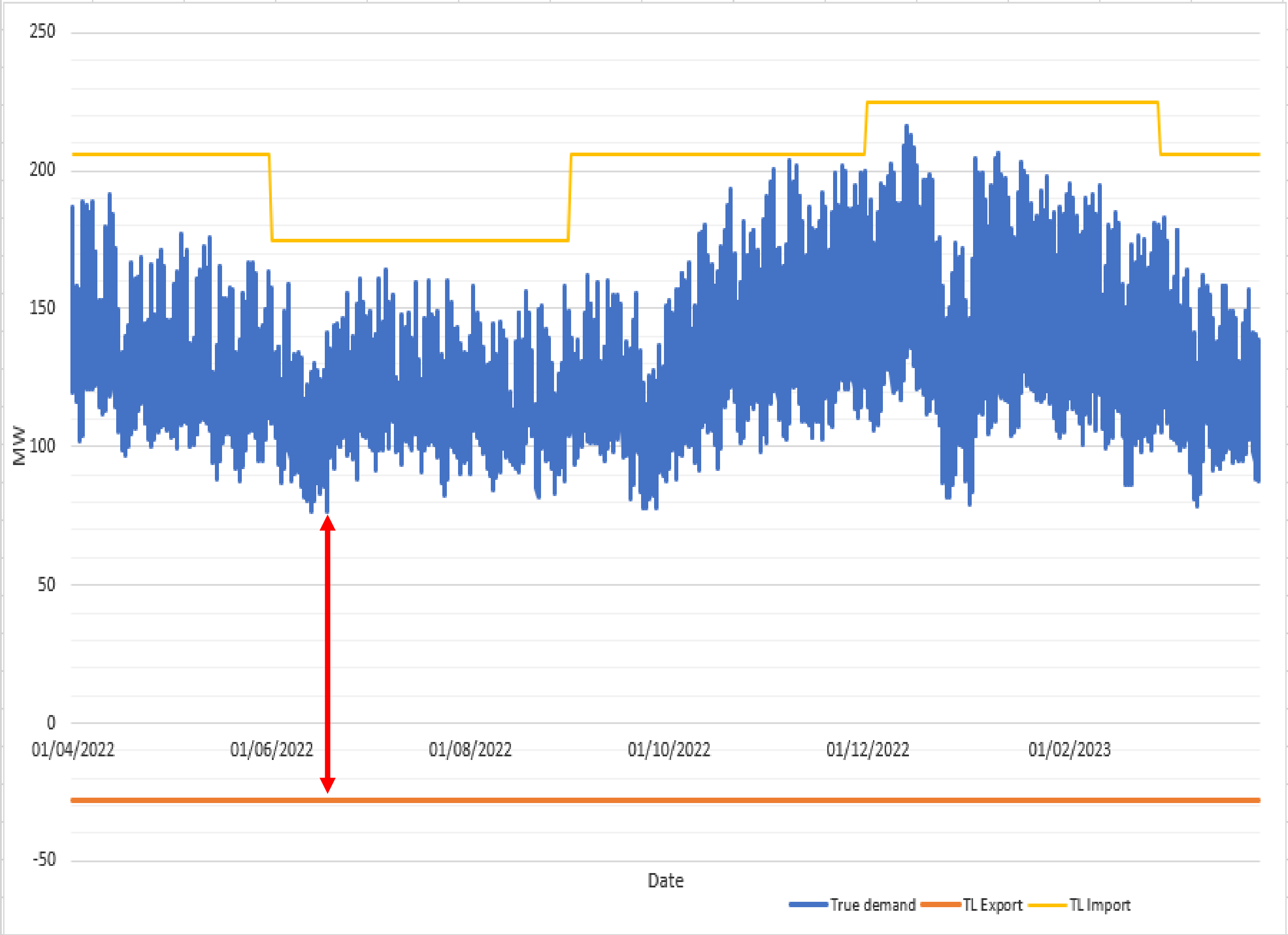




- Over 100MW headroom available all throughout a typical day
- Headroom increases to 200MW at the teatime peak

Technical Limits implementation – Padiham GSP (proposed)

Padiham GSP 2022/23 – Illustration of demand with available headroom upon introduction of Proposed TL



- Already connected:
  - 8 MW BESS
  - 38.2 MW Fossil gas/Oil
- Yet to connect:
  - 2.9 MW PV
  - 86 MW Fossil Gas/Waste
- Delayed Projects (Proposed Part 4):
  - 99.9MW Wind
  - 4MW Wind
  - 45 MW BESS
  - 35 MW PV
  - 26MW PV
- About 80 MW available headroom which will be available to all projects not yet connected

Technical Limits implementation – Rochdale GSP (proposed)

Rochdale GSP 2022/23 – Illustration of demand with available headroom upon introduction of Proposed TL

- Already connected:
  - 4.5 MW Solar
  - 51.2 MW Fossil gas/Oil
- Yet to connect:
  - 153 MW BESS
  - 1MW PV
  - 58.8MW Fossil Gas
- Delayed Projects (Proposed Part 4) – going through PP:
  - 285.3MW BESS
  - 20 MW PV
- About 180 MW available headroom which will be available to all projects not yet connected

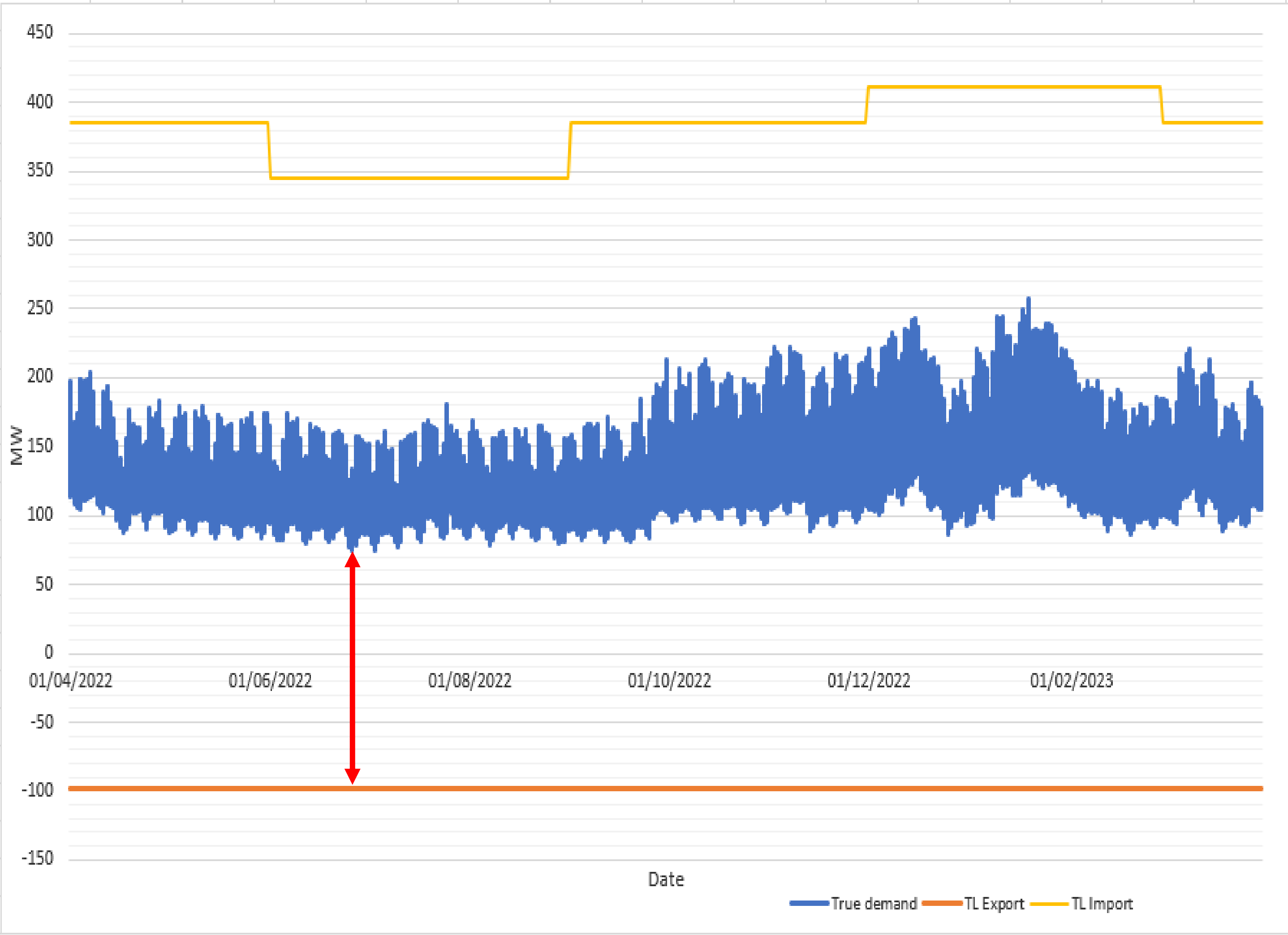
Technical Limits implementation – Stalybridge GSP (proposed)

Stalybridge GSP 2022/23 – Illustration of demand with available headroom upon introduction of Proposed TL

- Already connected:
  - 28MW Fossil Gas
- Yet to connect:
  - 122 MW BESS
  - 1.5MW PV
  - 85.3MW Fossil Gas/oil
- Delayed Projects (Proposed Part 4) – going through PP:
  - 70MW BESS
- About 180 MW available headroom which will be available to all projects not yet connected

Technical Limits implementation – Whitegate GSP (proposed)

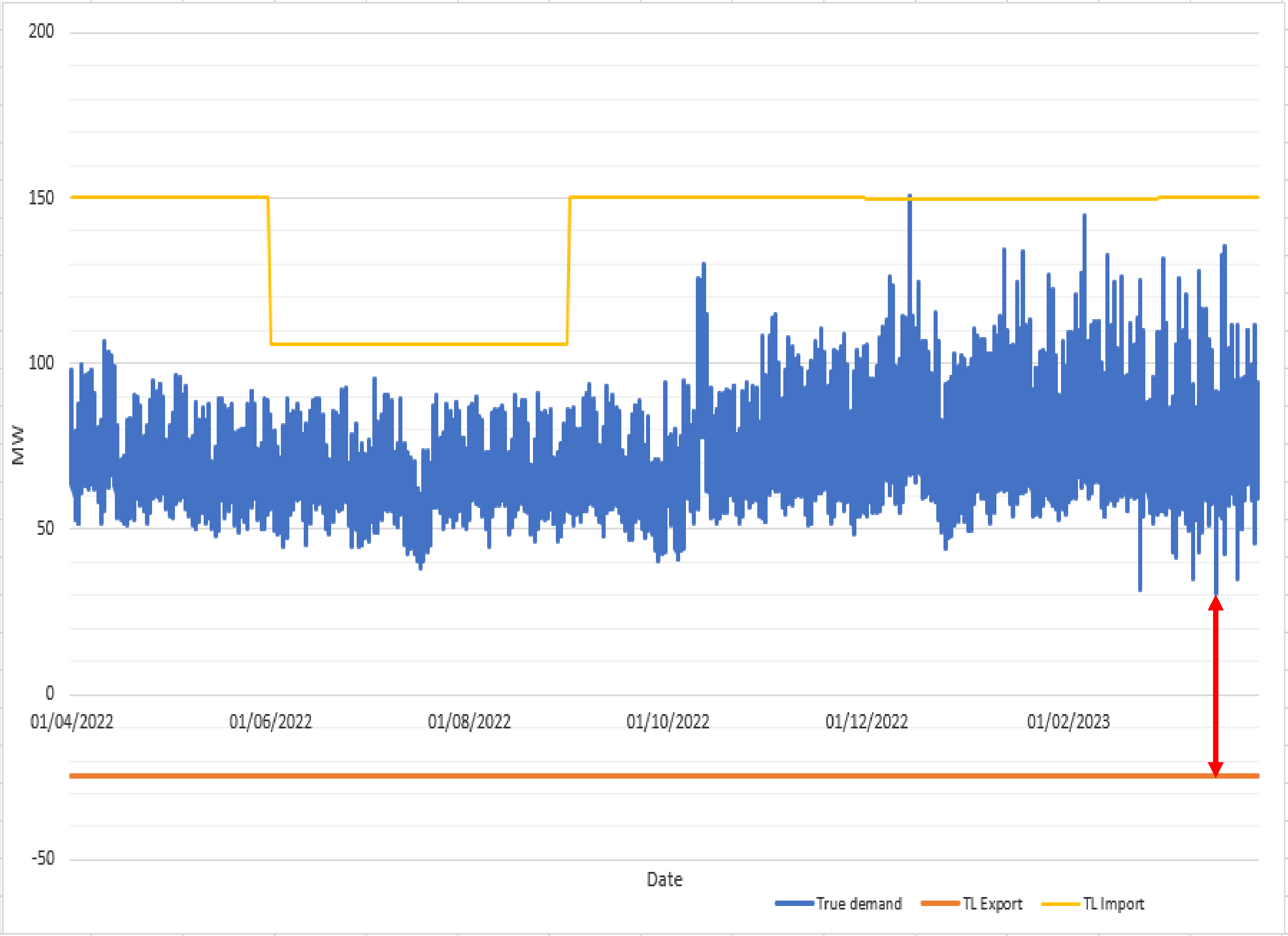
Whitegate GSP 2022/23 – Illustration of demand with available headroom upon introduction of Proposed TL



- Already connected:
  - 20MW BESS
  - 25.1 MW Fossil Gas/Oil
- Yet to connect:
  - 120 MW BESS
  - 1.5MW PV
  - 53.2MW Fossil Gas/Oil
- Delayed Projects (Proposed Part 4) – going through PP:
  - 77MW BESS
  - 49.9 MW PV
  - 1.26MW Gas
- About 150 MW available headroom which will be available to all projects not yet connected

Technical Limits implementation – Washway Farm GSP (proposed)

Washway Farm GSP 2022/23 – Illustration of demand with available headroom upon introduction of proposed TL



- Already connected:
  - 1.3 MW Solar
  - 48 MW Fossil Gas
  - 49.9MW BESS
- Yet to connected:
  - 2 MW BESS
- Delayed Projects (Part 4):
  - 49.9 MW BESS
  - 2 MW PV
  - 85 MW BESS – going through PP
- About 50 MW available headroom which will be available to all projects not yet connected

Overview of the modelling

- The modelling starts with the historic observed loading for the GSP by each half hour period
- It then applies a series of assumptions to indicate what the net impact on the GSP demand would be
- It then compares this to the Technical Limits to identify any half hour periods where the Technical Limits are breached
- Where the Technical Limit is breached it calculates the extent of the breach and thereby the likelihood of curtailment

Historic Load
- This is the starting point

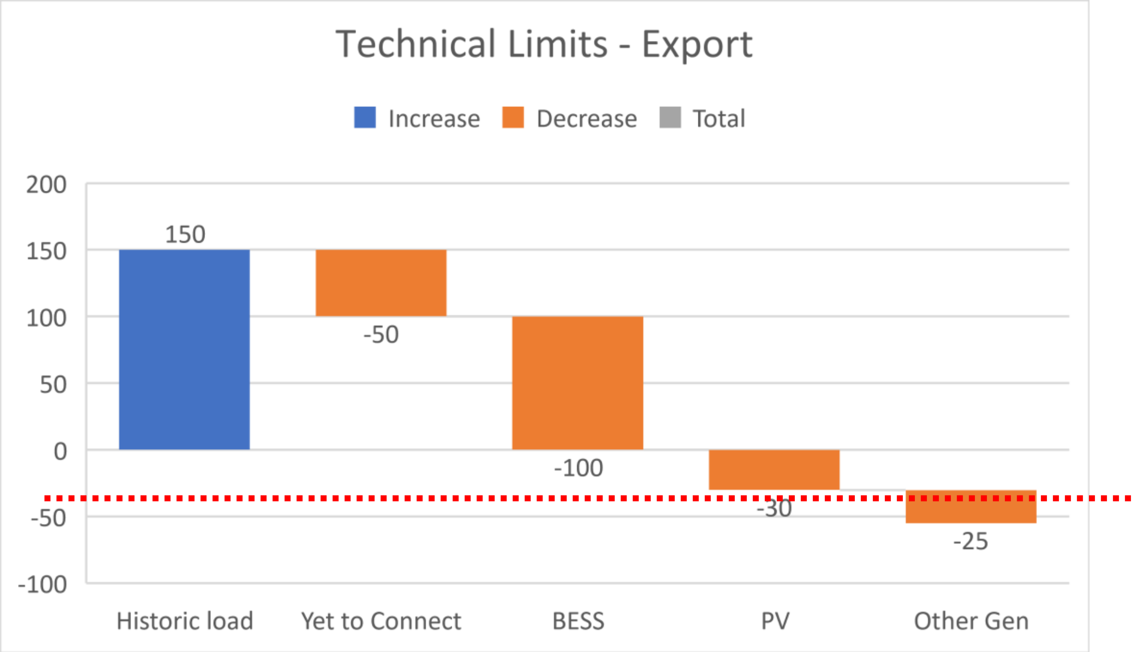
Part 2 Yet to connect
- Can make assumptions on how much is connected, ie all, none or some

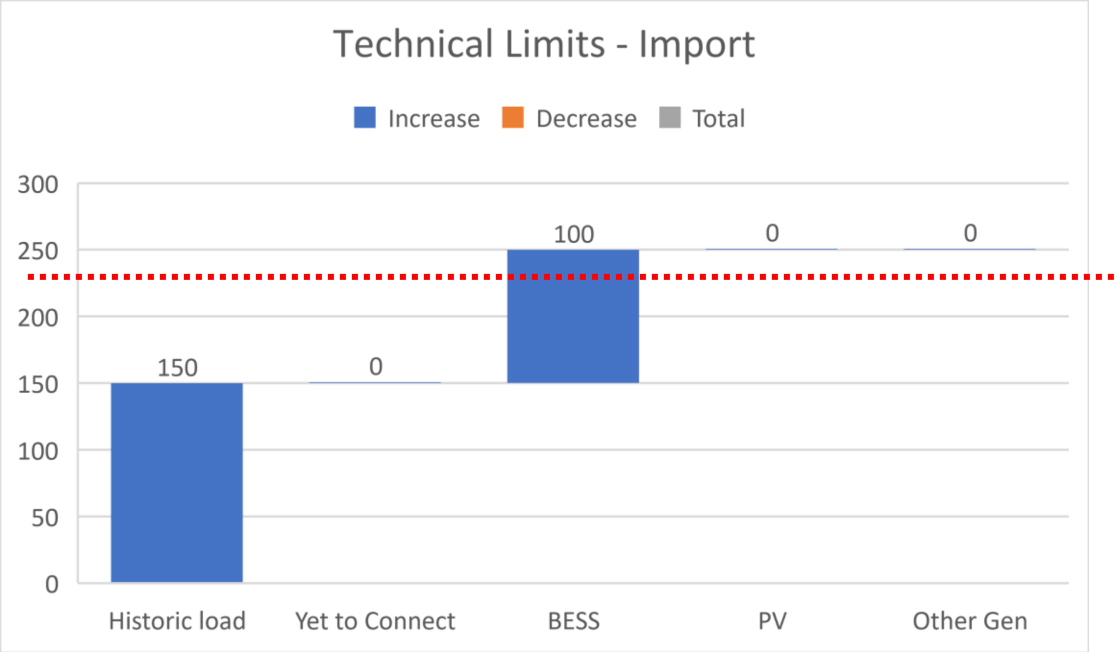
Part 4 BESS
- Makes assumptions on the time periods it operates

Part 4 PV
- Makes assumptions on the time period it exports and applies a scaling factor

Other Generation
- Applies a scaling factor

Simplified view of the modelling





- The model looks at each half hour and takes account of the behaviour of each component
- The charts above try to illustrate the extremes
  - The Export Technical Limits will be most at risk if there are periods where all export is happening concurrently
  - The Import Technical Limit will be most at risk when generation is low and BESS is importing

Curtailment forecast methodology – Assumptions

Forecast net flow at GSP for each half hour of the year using the following equation :

Previous year HH observed flow

BESS capacity (MW) x HH BESS profile x Scaling factor

PV capacity (MW) x PV Profile x Scaling factor

Other capacity (MW) x Scaling factor

BESS profile is set as 1/0/-1
Scaling factor is set as 1

- *-ve Forecast net flow value indicates* ***export*** *(to the Grid) while*
- *+ve indicates* ***import*** *(from the Grid)*

Curtailment forecast methodology – Assumptions

1. Modelling assumes all Part 4 customers and those in Project Progression are connected.

2. Modelling applies assumptions for BESS operating and PV as shown

3. Modelling applies a scaling factor as shown
   - This effectively reduces the impact on the network

- **You can change these assumptions based on your experience**

Assumed PV Profile

Months	Mar -May	Jun- Aug	Sep - Nov	Dec- Feb
Sun Hrs	08:30 -17:00	07:30 -20:00	08:30 -17:00	09:30 -15:30

Assumed BESS Profile

6hrs daily charge (01:00- 4:00 & 13:00- 16:00)
6hrs daily discharge (06:00-09:00 & 18:00 – 21:00)

Scaling factors used for calculating TLs (based on ESO values)

Fuel Type	Winter Peak	Access Period Peak*	Summer Min (Solar Max)	Summer Min (Solar Min)
Solar PV	0.2	0.051	0.84	0.33
Waste/ CHP	0.88	0.88	0.85	0.85
Hydro	0.84	0.84	0	0
Wind	0.7	0.7	0.5	0.1
Other	0.65	0.65	0.3	0.3
BESS	1	1	1	1

For solar PV, Summer (Solar Max) scaling factor assumed for Autumn and Spring months.
* BESS scaling factor changed from -1(charging) to 1 (discharging) to align with assumed BESS profile

Curtailment forecast methodology – Assumptions

Export curtailment

- Curtailment commences at breach of 90% of export Technical Limit.
  - For example, Technical Limit =-25MW, curtailment is at over -22MW.

Import curtailment

- Curtailment commences at breach of seasonal import Technical Limit.
  - For example, Summer – 200MW, Autumn/Spring – 280MW & Winter – 323 MW

Scenario – export example, no Part 2 connected

<u>Typical April morning day; PV is generating and BESS is exporting with no Part 2 yet to connect customers</u>

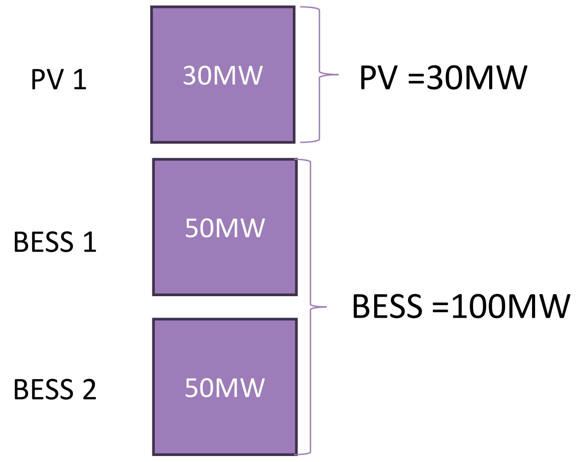
= Previous year HH observed flow – (BESS capacity(MW) x HH BESS profile(1,0 or -1)) – (PV capacity (MW) x PV Profile x Scaling factor) – (Other capacity (MW) x scaling factor)

= 100.41MW – (100MW x 1) – (30MW x 1 x 0.84)

= 100.41MW – 100MW– 25.2MW

Forecast net flow (@ 8:30am) = -24.79MW(net export to Grid)
Export TL = -22MW

Curtailed capacity = -24.79 – (-22) = - 2.79MW



Customers considered

<u>Curtailed customer(s)/capacity</u>

Based on Curtailment Index (CI) approach, depending upon stack order on the day, curtailed customers could be any of the options below to reduce by 2.79 MW:

i. Part 4 BESS 1
ii. Part 4 BESS 2
iii. Part 4 PV 1

Note this is not a LIFO stack so the customer constrained today reduces their likelihood of being constrained tomorrow is the same situation arises.

Scenario 3 – import example, no Part 2 connected

<u>Typical August afternoon day; PV is generating and BESS is importing with no Part 2 yet to connect customers</u>

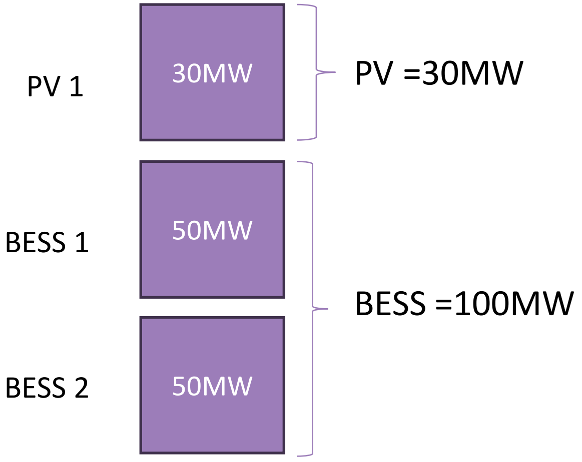
= Previous year HH observed flow – (BESS capacity(MW) x HH BESS profile(1,0 or -1)) – (PV capacity (MW) x PV Profile x Scaling factor) – (Other capacity (MW) x scaling factor)

= 137.19MW – (100MW x -1) – (30MW x 1 x 0.84)

= 137.19MW + 100MW – 25.2MW

Forecast net flow (@ 13:00) = 211.99 (net import from Grid)
Import TL = 200MW

Curtailed capacity = 211.19 - 200 = 11.19MW



Customers considered

<u>Curtailed customer(s)/capacity</u>

Based on Curtailment Index (CI) approach, depending upon stack order on the day, curtailed customers could be any of the options below to reduce by 11.19MW:

i. Part 4 BESS 1
ii. Part 4 BESS 2

Scenario 4 – import example, Part 2 now connected

Typical August afternoon day; PV is generating, BESS is importing and Other also generating

= Previous year HH observed flow – (BESS capacity(MW) x HH BESS profile(1,0 or -1)) – (PV capacity (MW) x PV Profile x Scaling factor) – (Other capacity (MW) x scaling factor)

= 137.19MW – (150MW x -1) – (30MW x 1 x 0.84) – (25.6MW x 0.3)

= 137.19MW + 150MW – 25.2MW – 7.68MW

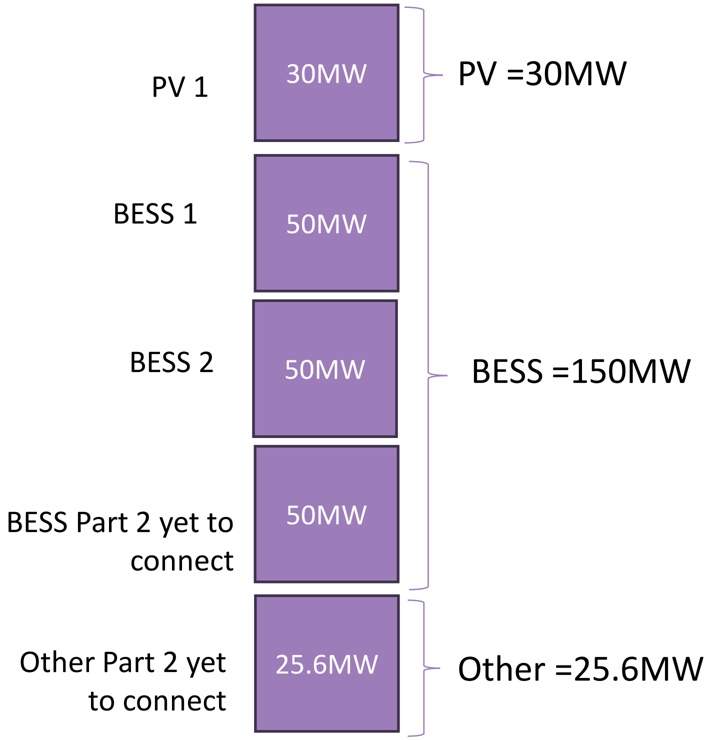
Forecast net flow (@ 13:00) = 254.31 (net import from Grid)
Import TL = 200MW

Curtailed capacity = 254.31 - 200 = 54.31MW

Curtailed customer(s)/capacity

Based on Curtailment Index(CI) approach, depending upon stack order on the day, curtailed customers could be any of the options below:

i. Part 4 BESS 1 (50MW) and Part 4 BESS 2 (4.3MW)
ii. Part 4 BESS 2 (50MW) and Part 4 BESS 1 (4.3MW)



Customers considered

Key features cont'd

- To maintain the integrity of the electricity Transmission system, the ESO mandates that the Technical Limit at each GSP shall not be breached.
  - Any breach may result in the ESO suspending use of the Technical Limit at the associated GSP.
  - Should the ESO suspend the use at a GSP, we reserve the right to suspend it for all customers connected using Technical Limits
- Should a customer fail to respond to a signal from ENWL, eg a signal sent to a customer by ENWL requiring the customer curtail its output, ENWL will suspend immediately the customer's access rights until further notice.