

Explanation of SEL/MEL

Consider two generators, A with MEL of 600MW and SEL of 200MW, the B with MEL of 600MW and SEL of 400MW.

Both units have a MEL of 600, and so if synchronised would increase system margin, (total system MEL – total demand) by 600 MW each.

For A, this 600 MW of margin can be obtained by buying 200 MW of energy, whereas for B you have to buy 400 MW of energy to get the same amount of margin. In this case, if the prices were the same, then A is clearly the preferable option.

The next question is what you do if the price is different. The volume of energy is different between A and B, and you will have to take different balancing actions elsewhere depending on which station you choose, and what else is happening on the system. The energy reference price is calculated in order to give a base price against which actions can be costed. Using this methodology, the price of taking A or B is the offer price – the energy reference price which reflects the unconstrained action price.

The cost of taking either A or B is then (Offer Price – ERP) x SEL

The price of each MW of margin provided by the unit is the cost divided by the amount of margin: (Offer Price – ERP) x SEL / MEL.

In the event that there is a constraint that causes 600 MW of sterilised headroom, but we also need a further 300 MW of margin, both A and B may be synchronised. How do we allocate the cost between a constraint action and a margin action? Note that while these two machines are synchronised, it may be that they both run at full load and a different machine provides margin.

The basic principle is that the most expensive margin action is allocated to constraint actions, as the cheaper actions would have been taken anyway.

In this case, if A offered £65 / MWh against an energy reference price of £50, and B offered £60 / MWh then the price per MW of margin (unit margin reference price) for A is $(65-50) \times 200/600 = £5$ while the unit margin reference price for B is $(60 - 50) \times 400/600 = £6.66$. Thus B is the more expensive margin action, and so this action is allocated against the constraint.

With a single unit, the constraint margin reference price works out the same as the unit margin reference price, and so the cost of the sterilised headroom is the volume of sterilised headroom (600 MW) x CMRP (£6.66) = £3996. Note this is (within rounding) (Offer Price – ERP) x SEL.

Example Analysis of Real Data

To look at a slightly more complicated example, I have picked a random half hour period from a couple of years ago (period 35 on 6th October 06). This was a fairly simple half hour, with 3 constraints active and only 37 BOAs and PGBTs taken.

The attached spreadsheet shows some of the tables used in calculating the cost of the constraints. Note that this is not the spreadsheet used for the calculation, it is a download into Excel of a few of the database tables used in the calculations, with a few columns added by me to try to explain what is going on.

The **BidOffer_Acceptance** tab shows all the bids and offers taken in the half hour.

The **BidOffer_Tags** tab, shows that the actions taken on LOAN-3, LOAN-4 and PEHE-2 were as a consequence of export constraints, with a manual tag noting which constraints are biting.

The **Constraints** tab, shows all the constraints over the day, with period 35 highlighted in red. Note that in period 35 three dummy BMUs have been created, with extensions .CM to provide somewhere to allocate the sterilised headroom within the constraints.

The **BMU_Activity** tab, shows the SEL and MEL of each unit with an accepted Bid or Offer. I have inserted some dummy lines just to line up with the previous tabs where there has been more than one BOA on the same unit.

The **STER_VOL** tab shows the FPNs and MELs of the units for which constraint actions were taken, and thus the sterilised headroom on these units.

The **MWh by BMU** tab shows the energy traded on each BMU. There are seven actions where energy has been brought (Col D), three trades on the French interconnector (EDFT, SHELL and TFE) as well as BOAs on FFES-1, FFES-3, FIDL-3 and IRNPS-1. Scrolling across this tab, we see that the IRNPS-1 action was unwinding a previous position, the FFES actions were fast reserve actions, FIDL-3 was for constraint margin and the French actions were pre-gate constraint margin actions. We also see the volume of bids at LOAN and PEHE as a result of the constraints (Col Q).

The next tab shows the **calculation of the CMRP**. As discussed above, four actions are identified as replacing sterilised headroom. For these we see the volume, the volume weighted offer price (in this case only bid-offer pair 1 were taken), then the effective MEL and SEL. Note that in this case, FIDL-3 was ramping up and so while it's SEL was technically 140 MW, its effective SEL was the same as the volume it generated. For interconnector actions, SEL = MEL. This tab is a manual re-creation of the process, and shows the calculation of unit margin ref price as $(\text{Offer Price} - \text{ERP}) \times \text{SEL}/\text{MEL}$, as well as the calculation of the CMRP as volume weighted sum of $(\text{UMRP} \times \text{MEL})$

Now we come to **Other Sterilised Headroom**. This tab shows all the other units in each of the active constraint groups, together with their MELs, FPNs and Instructed Loads. The sterilised headroom on each unit is the MEL – Instructed Load for all units with a non-zero FPN. This table also shows the offer price of the units, and the volume weighted offer price of headroom in each group. Note that while Peterhead constraint was biting, no other units in this group had any FPNs, so the constraint has no net effect.

First we resolve the cheaper group, NKILGRMO at £40.43 per MWh. This group has a total of 215 MW of constrained headroom (50 at Fife + 165 at LOAN 2). This equates to 107.5 MWh volume constrained.

We now come to some logic not on the table. Both of these units are also part of the SCOTEX constraint, so only allocate half of their sterilised headroom volume to the NKILGRMO constraint. Thus 53.75 MWh of sterilised headroom are allocated to the NKILGRMO.

Next we look at the next cheapest constraint, SCOTEX. We now have to consider the available margin. From the Calc of CMRP sheet we see that the total useable volume synchronised to replace the sterilised headroom is 430 MWh. It is not reasonable to consider sterilised headroom where no replacement action has been taken, and so the sterilised headroom is capped by this useable volume. From the STER_VOL sheet we know that LOAN-3, LOAN-4 and PEHE-2 have had $(172.5+17.83+99.5) = 289.83$ MWh of headroom sterilised. Combined with the 53.75 MWh allocated to NKILGRMO, this gives 343.58 MWh already accounted for, leaving

$(430 - 343.58) = 86.42$ MWh of sterilised headroom that can be allocated against the SCOTEX constraint. These values appear in the next sheet.

The final tab, **Super_BAAR_results**, shows the outcome of the analysis.

Column AH shows the cost of the headroom replaced, both for the constrained units, and for the dummy units representing other sterilised headroom in the same group. This is the volume of headroom replaced (Col M) x CMRP (Col AE) (Note that there was no cost for the constrained headroom at Peterhead as there was no volume replaced)

Column AR shows the cost of taking the bid on these units – ie the cost of the replacement energy at the ERP less the money received for the bid. ie $(\text{Bid Price (Col F)} - \text{ERP (Col AD)}) \times \text{volume of bid (Col H)}$

Column AY shows the total cost – i.e. the cost of taking the bid, col AR + the cost of replacing the headroom, col (AH).

The total cost of the constraints was the sum of the costs of the three constrained units and the three sterilised headrooms, or £ 6282.37 in Col BC.

To divide this up between the constraints, LOAN contributes to both NKILGRMO and SCOTEX, so half of the cost is allocated to each constraint. PEHE contributes to all three constraints, and so the cost is split three ways. The .CM sterilised headroom costs are obviously specific to each constraint.

Therefore the costs of each constraint work out as

$$\text{NKILGRMO} = 3062.21 / 2 + 321.04 / 2 + 1865.82 / 3 + 396.24 = 2709.81$$

$$\text{PETRHEAD} = 1865.82 / 3 = 621.94$$

$$\text{SCOTEX} = 3062.21 / 2 + 321.04 / 2 + 1865.82 / 3 + 637.06 = 2950.62$$