MSP Software Penalty Cost Parameters Proposed Values for 2017

Document History

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1. Introduction

1.1 Purpose

Under Section N.25 of the Trading & Settlement Code, the Market Operator (MO) is required to propose values for the parameters used in the MSP Software for the coming year at least 4 months before the start of that year.

Proposed values for the following parameters are provided:

a) The Over-Generation MSP Constraint Cost
b) The Under-Generation MSP Constraint Cost
c) The Aggregate Interconnector Ramp Rate MSP Constraint Cost
d) The Energy Limit MSP Constraint Cost
e) The Tie-Breaking Adder
f) Maximum Export Available Transfer Capacity MSP Constraint Cost
g) Maximum Import Available Transfer Capacity MSP Constraint Cost

Analysis of the current values used for the year 2015/2016 was performed. With reference to this analysis, this document proposes values for the year 2017.

1.2 Audience

The target audience for this document is the Regulatory Authorities and Market Participants.

1.3 Background

The core algorithm of the MSP software attempts to optimise a mixed integer non-linear objective function with non-linear constraints. On occasion, the mathematical problem posed may be infeasible (i.e. there will be no solution that will satisfy all the constraints). In these cases, rather than return no answer, it is customary in numerical solutions to produce an answer where some of the constraints have been breached slightly. To achieve this, slack variables are introduced with suitably chosen cost coefficients that ensure that these variables are used only in the case of infeasibility. In addition, the setting of these coefficients can prioritise the order in which constraints will be breached for a given situation. The correct choice of these coefficients will ensure that the associated penalty term will only be used if there is no set of dispatchable resources that can meet the constraints.

The current values of the parameters were determined in 2007/2008 using methods detailed in AIP-SEM-07-439. The values of the parameters were analysed in August 2008 (AIP-SEM-08-104B), August 2009 (AIP-SEM-097A), August 2010 (AIP-SEM-10-065B), August 2011 (AIP-SEM-11-074b), August 2012 (AIP-SEM-12-082d), August 2013 (AIP-SEM-13-062b), August 2014 (AIP-SEM-14-105) and August 2015 (AIP-SEM-15-093). The reviews resulted in no change to the original values chosen. Further analysis, described in this report, has been undertaken by SEMO using data from between July 2015 and July 2016.

1.4 Existing Values

PARAMETER	2016 PENALTY SETTING
Over Generation MSP Constraint	73
Under Generation MSP Constraint	73
Aggregate Interconnector Ramp Rate MSP Constraint Cost	292
Energy Limit MSP Constraint Cost	38
Tie-Breaking Adder	0.001
Maximum Export Available Transfer Capacity MSP Constraint Cost	100
Maximum Import Available Transfer Capacity MSP Constraint Cost	100

Table 1: Existing Values used in MSP Software

While the 2009 and 2010 reports remarked on the absence of any price events in the market where penalties occurred, the 2011 report included the testing of four Trading Days where a significant price event occurred. The report found that these events were caused due to infeasibility, rather than economic reasons. The 2012, 2013, 2014, 2015 and 2016 reports also concluded that all price events tested occurred due to infeasibility. These reports, in themselves, show the robustness of the values used, considering the large number of MSP runs which would have occurred over the entire period.

There have been situations in this testing year where price events have occurred. There have been twenty two Market runs with a Price Cap event due to Under Generation, one with a Price Floor event due to Over Generation, one Market run with an Energy Limit violation, one with a mix of Under Generation and Energy Limit violation, all of which occurred when using the LR solver. It has been demonstrated in academic literature on LR and confirmed in SEMO's Study '*Solver Choice in the SEM:*

A Comparative Study of Lagrangian Relaxation vs. Mixed Integer Programming''[1], that LR has limitations where the search space has additional complexities due to the nature of the inputs. These can be, for example, bidding patterns with Offers that vary substantially in magnitude, sudden drop/increase in wind or periods with large Import immediately followed by periods with large Exports. Particularly since late 2013, a combination of the last two conditions has resulted in what is known as a search space with added 'ruggedness', increasing the likelihood of infeasible solutions with LR.
A mix of constraints violations is likely when in addition to Under Generation events, inaccurate Technical Offer Data is submitted. This has happened where Pumped Storage Units have submitted Reservoir Target Level when unavailable. An Energy Limit alarm is automatically triggered; however, in isolation, this would not result in a price event. For this reason, such cases have been regarded as Under Generation only for the purpose of this study; schedules showing inconsistent Technical Offer Data and producing Energy Limit alarms without a price event, are not to be considered infeasible.
In all infeasible cases, SEMO used the MIP solver, in line with SEMO's published policy regarding price events 'SEM-14-006d - Market Operator Solver Policy V6.2'. In all cases the price event did not recur when MIP was used as the solver. As these cases did occur when LR was used as the solver, tests were performed to ensure that any price events occurring were not due to inappropriately set MSP parameters.

Additional testing was carried out on a number of non-price event days from the analysis period in a similar manner to those in previous years, to ensure that the values proposed for 2016 are robust.

It should be noted that the set of parameters chosen represents one of a range that could have achieved the objective of ensuring that the slack variables are only used to alleviate infeasibilities. The bounds of this range are established from below at the point where the slack variables begin to be used for economic reasons and from above at the stage where the magnitude of the penalty prices causes the mathematical problem to become poorly scaled.

1.4.1 MSP Value Objective – Well Scaled but Not Economic

The following simple example is given here to illustrate, at a high level, how a suitable value is chosen for the penalties on the slack variable. In Figure 1 the value in red represents the penalty set at €300/MWh, while the other values are offers from the Price Maker Generator Units, ranging from €50/MWh to €300/MWh.

[1] Published in 2010 and available in the General Publications of the SEMO website.

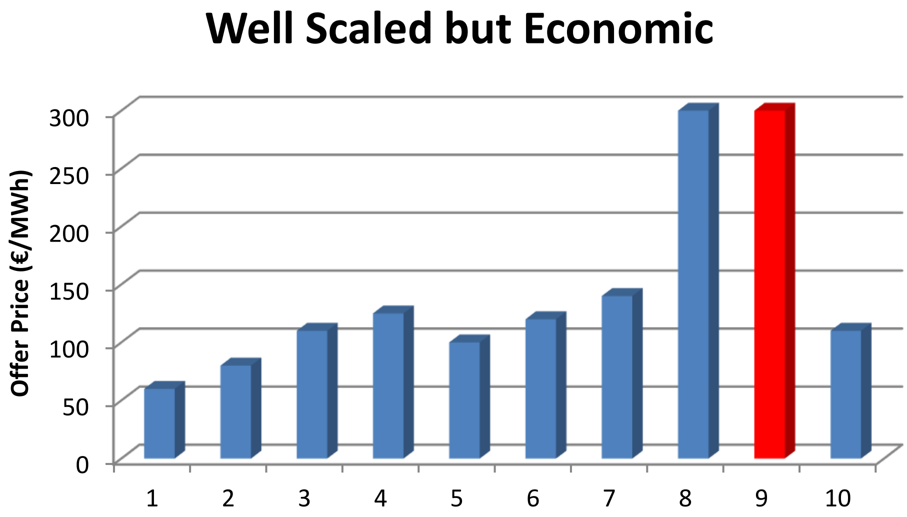

Figure 1: Well Scaled but Economic

A unit commitment problem featuring the above offers is regarded as well scaled, as the offers can easily be differentiated by their magnitudes. However, the magnitude of the penalty is too close to other offers and there is a chance that it would be incurred for economic reasons in place of another similarly priced Generator Unit. Therefore, this value would not be a suitable choice for the penalty.

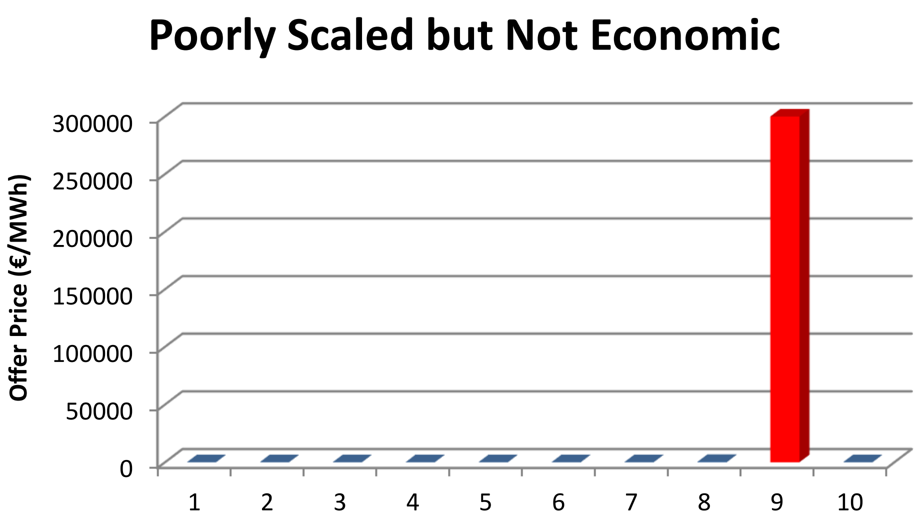

Figure 2: Poorly Scaled but Not Economic

All offers shown in Figure 2 are the same as for the previous example except for the penalty value which has been set to €300,000/MWh. However, due to the large magnitude of the penalty, the offers can no longer be distinguished on the scale. A unit commitment problem featuring these offers would be regarded as poorly scaled as the offers cannot easily be differentiated by their magnitudes. Poor scaling may impact the mathematical solver's ability to resolve the problem. In contrast to the previous example, the penalty is much higher than the other offers and there is little chance that it would be incurred for economic reasons in place of another Generator Unit. However, due to the large magnitude this value would not be suitable choice for the penalty either.

All offers in this final example, shown in Figure 3 below, are the same as in the previous examples with the exception of the penalty value which was set at €3,000/MWh. The magnitude of the penalty is such that the difference in offers can be seen on the below graph. A unit commitment problem featuring these values is regarded as well scaled as the offers can still be differentiated by their magnitudes. Additionally, the penalty is much larger than the other offers and there is little chance that it would be incurred for economic reasons in place of another Generator Unit. This value would be a suitable choice of penalty as it strikes a balance between being sufficiently well scaled and not being economic.

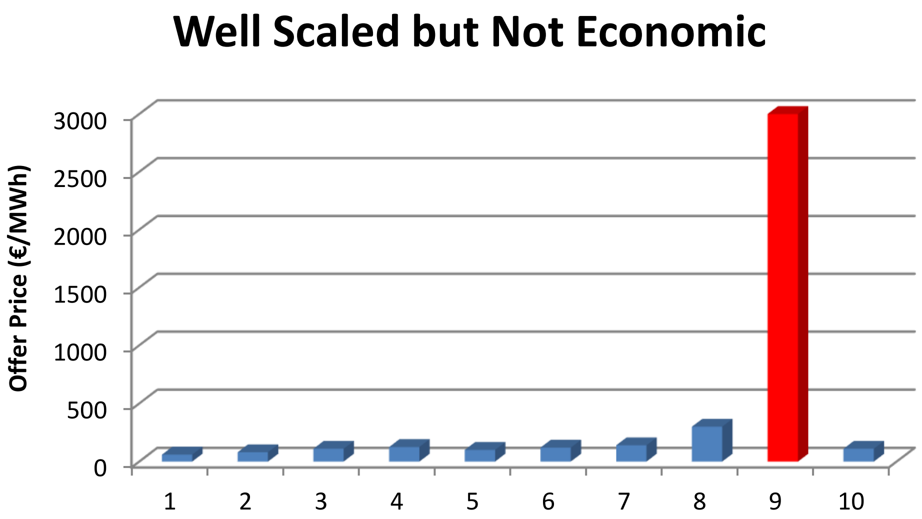

Figure 3: Well Scaled and Not Economic

While it is possible to determine the lower bound of a penalty with a good degree of confidence through the tests included here, the upper bound is more difficult to define. The settings for the penalties used to date are two orders of magnitude greater than the lower bound. This level has achieved the objective of being 'well scaled and not economic' and thus far, over the thousands of runs of the MSP Software, the penalties have only been incurred to resolve infeasibilities.

Note: The MSP software multiplies these penalty factors by an additional variable, which is equal to five times the maximum available daily bid price. The proposed penalty used by the MSP software is thus a much higher value than those listed above in Table 1.

2. Analysis of MSP Parameters

The MSP software allows for 20 price-quantity pairs for each slack variable constraint that can be violated. For each step, price and quantity values may be set by the operator. The prices and quantities must be strictly monotonically increasing. The price of the last offer step of the slack variable is multiplied by a factor equal to five times the maximum offer submitted by Generator Units for that day. Regardless of the quantity offered for the last step, the MSP internally imposes no limit on the quantity that can be scheduled for the final step.

The proposed method for setting the penalties is to use just one offer step and to enter a relatively low penalty factor in the cost field. This factor effectively sets the penalty used internally to be that factor multiplied by five and multiplied by the greatest available offer price during the day (assuming that offer price exceeds 0.1). This approach results in penalty values that vary from day to day; however, they will always be significantly higher than the maximum offer on that day.

Example:

- The penalty cost is set to 73 and the quantity is set to be 1750 (this value is not relevant as it is the last offer step and there is no limit to the quantity that can be scheduled).
- The maximum available generator offer for the day is €547.68/MWh
- Therefore, the effective penalty will be:
  73 x 5 x €547.68/MWh = €199,903.20/MWh
- The quantity of violation allowed will be infinite.

The specific penalty functions are:

1. Over Generation MSP Constraint Cost
2. Under Generation MSP Constraint Cost
3. Aggregate Interconnector Ramp Rate MSP Constraint Cost
4. Energy Limit MSP Constraint Cost
5. Maximum Export Available Transfer Capacity MSP Constraint Cost
6. Maximum Import Available Transfer Capacity MSP Constraint Cost

Setting penalties is not arbitrary. A penalty will only occur if it (a) results in a lower production cost than other options available or (b) if the schedule would be infeasible otherwise. If the penalties are set incorrectly then constraints could be violated simply because it is cheaper to do so. In other words the penalties could be incurred for purely "economic" reasons. In accordance with Appendix N paragraph 17.4 of the Trading & Settlement Code, this should not occur and the penalties should only be incurred in cases where the schedule would otherwise be infeasible.

To test the adequacy of the current costs of breaking the slack variables, a selection of days were chosen for analysis. The days were spread throughout the analysis period and contained a combination of Ex-Ante, Within-Day and Ex-Post market runs. Days chosen for testing had one of the following characteristics:

- Price Cap was reached
- Price Floor was reached
- System Marginal Price > €500/MWh
- Shadow Price was high
- Shadow Price was low

Tests were carried out on the chosen days containing the above features but also on a number of sample days with no issue to ensure that the penalties are set sufficiently high so that they are only incurred to alleviate infeasibility. The days tested were spread throughout the calendar year, yet most price events occurred during the autumn and winter months, as expected with higher levels of generation.

2.1 Over Generation MSP Constraint Cost

2.1.1 Context

An Over Generation (OG) penalty is in place to absorb extra power in order to match supply to demand in the case where the Schedule Demand is less than the total output of the Price Maker Generation Units.

The MSP software can use the over generation slack variable in two situations:

1. To relieve an over generation infeasibility: In certain situations the software may be unable to reduce the power output from physical units adequately to allow generation to equal demand. In this case the over-generation slack is used to absorb the extra power.

2. To reduce MSP Production Costs: In certain situations it may be more economical to schedule the OG penalty than it is to curtail physical generator units. In this case the over-generation slack is used.

If the over generation penalty is to be used, the penalty cost applies to each Trading Period on a per MW rate of violation. Using the current value of the over-generation slack variable, an OG penalty will result in the shadow price getting set equal to the price floor (PFLOOR).

2.1.2 Analysis

Price Floor (PFLOOR) events:

Since July 2015, there has been one Trading Day featuring a PFLOOR. This occurred in the Ex-Post Initial MSP Software run. In line with SEMO policy regarding price events of this nature, this was re-run using the alternative MIP solver algorithm and the resulting published prices did not feature a PFLOOR.

This case was included to confirm that the current settings continue to be fit for purpose in that they are 'well scaled and economic' – i.e. that the PFLOOR did not arise from the breaching of a constraint for economic reasons.

The OG penalty constraint was used in each case where a PFLOOR event had occurred. To show that this occurred to solve infeasibility, the cost of the OG slack was increased to a very large number (10,000). The OG penalty was still used irrespective of how expensive the penalty became.

This indicates that the value of the OG penalty was not the reason for the use of the OG constraint. If it had been then it would have ceased to be breached when the value became sufficiently high. Therefore the OG penalty was breached to resolve infeasibility.

Infeasibilities of this nature are rare in occurrence and are related to the manner in which the LR algorithm solves the unit commitment problem under certain conditions. The occurrence of these PFLOOR events and their resolution without any disruption to the operation of the market is an indication of the robustness of SEMO's internal processes. SEMO continues to monitor any occurrences of this nature.

Additional Days:

In order to study the effectiveness of the OG penalty it was reduced to the lowest possible value but, as expected, the penalty was not used in any situation. This is shown in the plot below in Figure 4.

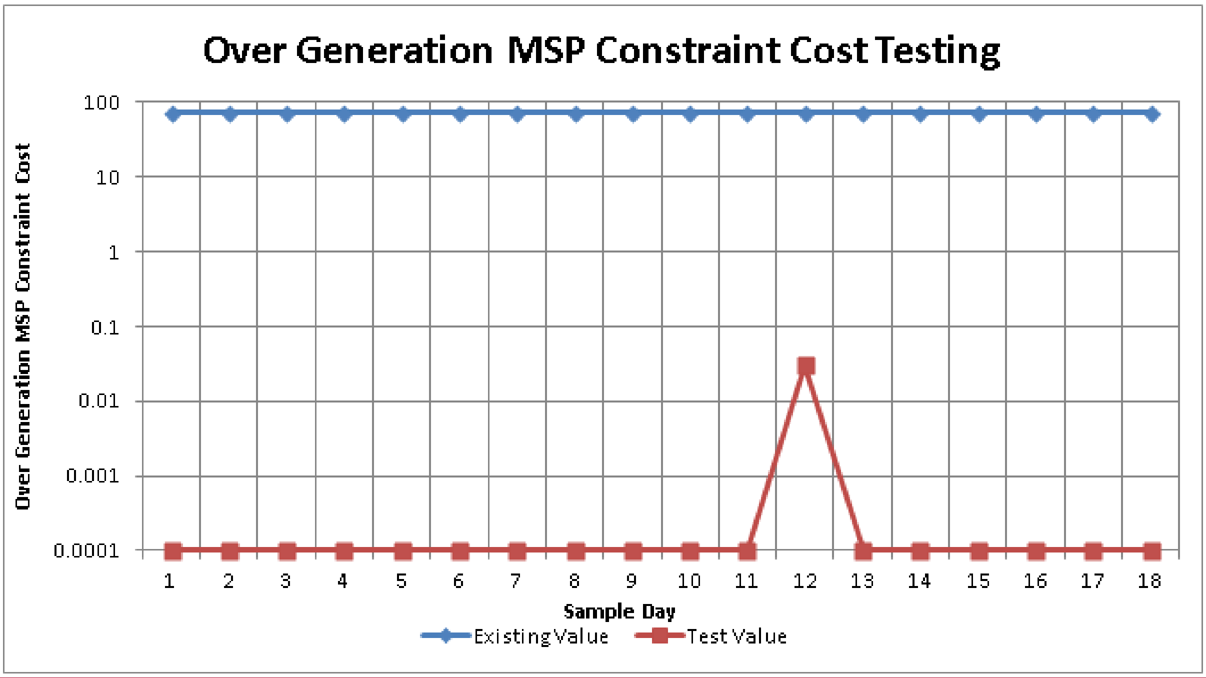

Figure 4: Over Generation MSP Constraint Cost Testing

To further examine this penalty, the demand was forced negative for each of the test cases and the penalty was incurred as expected because the problem became infeasible to solve. Similar to the PFLOOR cases, the OG penalty was increased to a very large number but was still used due to infeasibility. The shadow price was reduced to PFLOOR when the OG penalty was used.

To prove that the OG penalty was being used for the cases when the PFLOOR was reached, the cost of the penalty was changed. The cost of the penalty is normally 73, from which the software produces a PFLOOR. For a particular case, the value of the constraint was reduced to a minimum value; at which the solver no longer reached PFLOOR as the cost of the penalty was not large enough. However, the OG penalty was still being used but now set OG Penalty Cost at an increased value of €66.26/MWh for the periods in which there had been a PFLOOR.

To prove that the OG constraint is setting the shadow price for this period we use the equation:

$$\text{Over Generation Penalty} = \text{Max Shadow Price} \,/\, (5 \text{ x Max Offer})$$

$$0.03 \text{ x } €441.76/\text{MWh x } 5 = €66.26/\text{MWh}$$

If the demand were to increase infinitesimally, the production costs would decrease by €66.26/MWh. This illustrates how the OG penalty is setting the shadow price. It is important to note that the penalty will not necessarily set the shadow price in all cases where over-generation occurs. If the OG penalty is used, it can, in some cases, change the generator schedule in certain ways which may result in a different variable setting the shadow price. In some circumstances, the cost of the OG penalty may be adopted to set the shadow price for the periods in which there had been a PFLOOR.

2.1.3 Conclusion

With the value set to 73, the Over Generation penalty only occurs to alleviate infeasibility due to an Excessive Generation Event in line with paragraph N17.4 of the T&SC.

2.1.4 Recommendation

SEMO recommends retaining the Over-Generation MSP Constraint Cost setting of 73 for Year 2017.

2.2 Under Generation MSP Constraint Cost

2.2.1 Context

The Under Generation (UG) penalty is in place to match supply to demand in the case where the Schedule Demand is greater than the total output of all Price Maker Generator Units.

The MSP software will use the under generation slack variable in two situations:

1. To relieve an under generation infeasibility: In certain situations the software may be unable to increase the power output of physical units by the required amount to meet the demand. In this case the demand is met by scheduling the under generation slack.

2. To reduce MSP Production Costs: In certain situations it may be more economical to schedule the UG penalty to meet the demand than it is to schedule the next cheapest generator.

If the under generation slack is used, the penalty cost applies to each Trading Period on a per MW rate of violation. The under generation slack should only be used in cases of infeasibility and so the cost of using this slack should always be greater than the cost of changing the output of Price Maker Generator Units. Using the current value of the under-generation slack variable, the UG penalty will result in the shadow price being set equal to the price cap (PCAP).

2.2.2 Analysis

Price Cap (PCAP) events:

As mentioned in section 1.4 above, the substantial increase in Price Cap events is symptomatic of the difficulties encountered by LR while searching for optimal solutions in a Market displaying more dynamic conditions. SEMO has included a number of these in the analysis to confirm that the current settings continue to be fit for purpose in that they are 'well scaled and not economic', i.e. that the PCAPs did not arise from the breaching of a constraint for economic reasons.

The UG penalty constraint has been used in the cases where the PCAPs have occurred. To show that this occurred to solve infeasibility, the cost of the UG slack was increased to a very large number (10,000). The UG penalty parameter was still used irrespective of how expensive the penalty became.

This illustrates that the value of the penalty was not the reason for the use of the UG constraint. If it was it would have ceased to be breached when the penalty value became sufficiently high. Therefore, the UG constraint was breached to resolve infeasibility.

The occurrence of these PCAP events and their resolution without any disruption to the operation of the market is an indication of the robustness of SEMO's internal processes. SEMO continues to have the MSP Software regularly re-certified and continuously monitors any occurrences of this nature.

Additional Days:

For the non-price event test cases, the value of the penalty was successively reduced from 73 to test at what order of magnitude it becomes economical for the solver to use the penalty over a physical unit. The graph below in Figure 5 illustrates the lowest possible values for each day tested in which the UG constraint is not used.

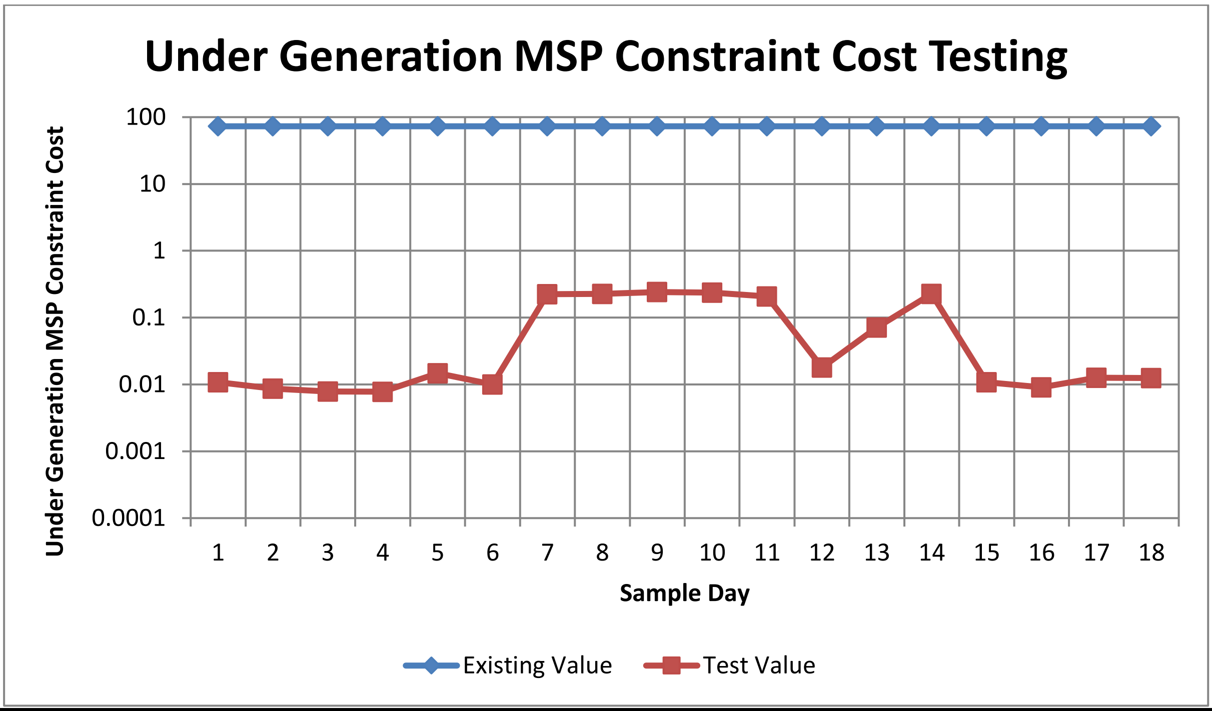

Figure 5: Under Generation MSP Constraint Cost Testing

As can be seen from the graph, the upper bound of the lower plot is two orders of magnitude less than the current setting of 73.

For a particular case where the PCAP was reached due to an UG event, if the cost of the UG penalty is decreased to 0.4828, which is the rounded up value of the penalty binding point, this still corresponds to a shadow price of €1000/MWh and so PCAP remains. However, if the cost is further decreased to a lower value for example 0.2414 the highest shadow price reported becomes €500.06/MWh. To prove that the UG constraint sets the shadow price for periods when the cost of the penalty is reduced we use the relationship:

$$\text{Under Generation Penalty} = \text{Max Shadow Price} \; / \; (5 \text{ x Max Offer})$$

$$0.2414 \text{ x } €414.30/\text{MWh x } 5 = €500.06/\text{MWh}$$

Therefore, it has been shown that the highest Shadow Price is being set by the UG penalty parameter. It is important to note that the penalty will not necessarily set the shadow price in all cases where under generation occurs. If the UG penalty is used it can, in some cases, change the generator schedule in certain ways that result in Generator Units and the UG penalty setting the shadow price.

2.2.3 Conclusion

With the UG penalty value set to 73, the Under Generation Penalty only occurs to alleviate infeasibility due to an Insufficient Capacity Event in line with paragraph N17.4 of the T&SC.

2.2.4 Recommendation

SEMO recommends retaining the Under Generation MSP Constraint Cost setting of 73 for Year 2017.

2.3 Aggregate Interconnector Ramp Rate MSP Constraint Cost

2.3.1 Context

A single ramp rate applies for each interconnector. This can be violated in either direction, i.e. increasing or decreasing flow between Trading Periods beyond the allowed ramp rate. The penalty cost applies to each Trading Period on a per MW rate of violation of the ramp rate.

Interconnector Ramp Rate penalties will only be incurred if the Interconnector Ramp Rate is binding on a particular day. To ensure that the penalty would not be incurred in these instances for economic reasons, a number of tests were carried out where the Interconnector Ramp Rate was binding to determine the level at which this would occur.

If the interconnector was ramping up for 60 Trading Periods and its ramp rate was binding in every Trading Period, violating the ramp rate in the first Trading Period by 1MW would allow an additional 1MW to flow in each of the 60 Trading Periods. With the current capacity of the Moyle interconnector and a ramp rate of 5MW/min (currently used for calculating MIUNs on the Moyle Interconnector and EWIC interconnectors), it would only be possible for the ramp rate to be binding for one Trading Period.

It is desirable that the MSP software uses the OG and UG penalties before it uses the Interconnector Ramp Rate penalty. To ensure this is the case, the penalty for the ramp rate violations is set significantly higher than both the OG and UG penalties. Tests were performed to confirm that the occurrences of OG or UG penalties take precedence in resolving infeasibility in the unlikely case where the ramp rates are binding.

2.3.2 Analysis

Using current settings, the Interconnector Ramp Rate was not binding for any day throughout the test year. Thus the Interconnector Ramp Rate was changed to an artificially low value of 1MW/Trading Period for a number of Trading Periods for each of the days tested. This resulted in several periods where the Interconnector Ramp Rate became binding.

To ensure that the UG and OG penalties take precedence over the ramp rate penalties, the cost of the UG and OG constraints were raised to different values for each test day. When the UG and OG penalties were at their existing values of 73, the Interconnector Ramp Rate penalty was incurred in all of the eighteen test days, with the Ramp Rate set to 1MW/Trading Period. However, further testing was carried out with the Interconnector Ramp Rate set to 100MW/Trading Period. Using this setting, the constraint was binding on five of the market runs tested, although with a lower number of trading periods affected, confirming that the current value is adequate.

~~2.3.4~~2.3.3 Conclusion

The Interconnector Ramp Rate Penalty can be used to alleviate infeasibility by breaching the ramp rate constant, during periods when the ramp rate is binding. However in the case of an under generation event the UG penalty will be breached first, likewise in the case of an over generation event, the OG penalty will be triggered. Therefore the value of current value of 292 ensures that the penalty would only be used to alleviate infeasibility in line with paragraph N17.4 of the T&SC.

~~2.3.5~~2.3.4 Recommendation

SEMO recommends retaining the Aggregate Interconnector Ramp Rate MSP Constraint Cost setting of 292 for Year 2017.

2.4 Energy Limit MSP Constraint Cost

2.4.1 Context

This penalty applies to the MWh violation of energy limits, maximum reservoir levels and minimum reservoir levels. The Energy Limit needs to be binding on the particular day to incur the penalty; it will not be incurred otherwise. For the Energy Limit to be breached on a particular day, two criteria must be met:

1. The Energy Limit for that day must be binding – the total output of an individual Energy Limited Unit over a Trading Day, in energy terms, must equal the energy limit set for that unit on that Trading Day, i.e. a constraint cannot be breached unless it is binding.

2. The maximum generation must not be binding for at least one Trading Period – The Energy Limited Unit must be capable of increasing output in the period where the Energy Limit Penalty is incurred.

2.4.2 Analysis

During the analysis, the MSP software was able to incur a penalty in all of the days tested. The graph below in Figure 6 shows the values at which the energy limit becomes binding for economic reasons.

Similar to the Interconnector Ramp Rate, breaking an Energy Limit could be used to alleviate infeasibility due to an Insufficient Capacity Event or an Excessive Generation Event. It is desirable that the UG penalty is used for an Insufficient Capacity Event and an OG penalty is used for the Excessive Generation Event.

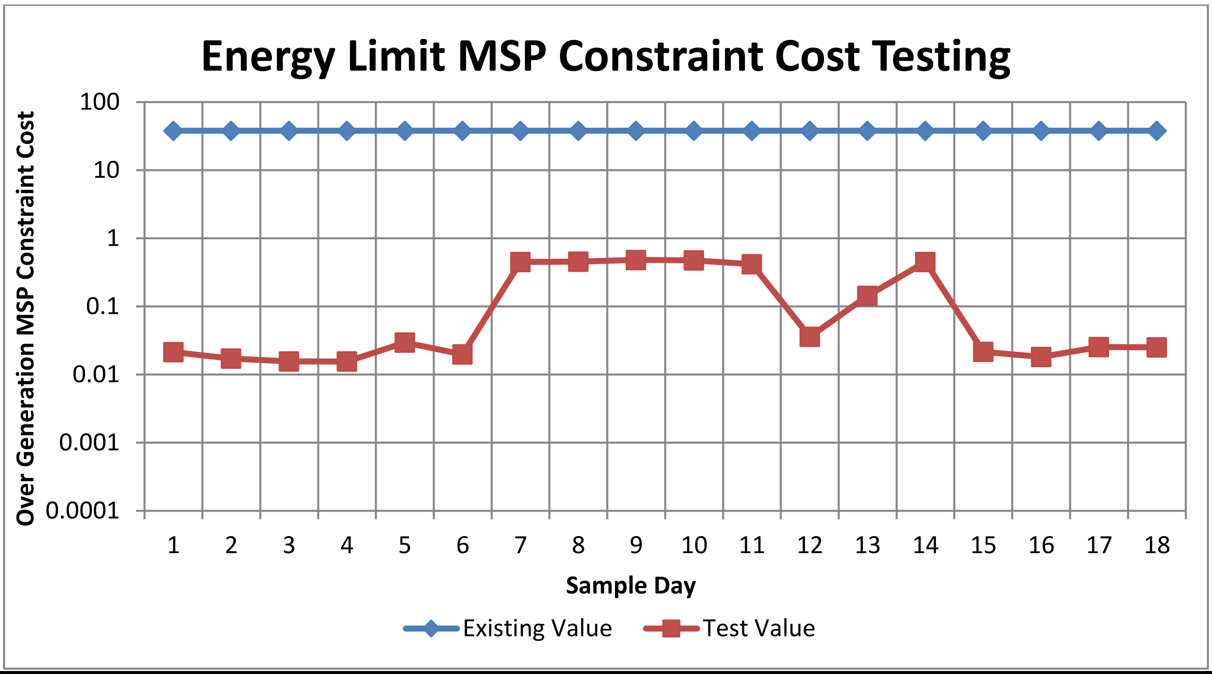

Figure 6: Energy Limit MSP Constraint Cost Testing

As demonstrated in previous years report, the Energy Limit is measured in MWh, while Over Generation and Under Generation are measured in MW. Breaking an Energy Limit by one unit for a half-hour trading period would yield an extra generation of 1 MWh. Breaking the UG or OG limit by one unit for a half-hour trading period would only yield an extra generation of 0.5 MWh. Therefore, given the same penalty value, in the event of infeasibility the market software would choose to incur the EL penalty as it would account for the generation deficit/surplus while only incurring half the penalty cost. Based on this, an EL Penalty Cost Parameter equal to 147 (just over double the OG and UG Penalty Cost Parameters) would ensure that the UG penalty is used for an Insufficient Capacity Event and an OG penalty is used for the Excessive Generation Event.

2.4.3 Conclusion

For a particular case where the PCAP was reached due to an EL event, if the cost of the EL penalty is decreased to 0.945, which is the rounded up value of the penalty binding point, this still corresponds to a shadow price of €1000/MWh and so PCAP remains. However, if the cost is further decreased to a lower value for example 0.473 the highest shadow price reported becomes €500.006/MWh. To prove that the EL constraint sets the shadow price for periods when the cost of the penalty is reduced we use the relationship:

$$\text{Energy Limit Penalty} = \text{Max Shadow Price} \,/\, (5 \text{ x Max Offer})$$

$$0.4726 \text{ x } €423.23/\text{MWh x } 5 \text{ x } 0.5 = €500.06/\text{MWh}$$

Therefore, it has been shown that the highest Shadow Price is being set by the EL penalty parameter. The current value of the Energy Limit Penalty Cost Parameter is 38. As highlighted in last year's report and in section 2.4.2 above, a case could be made to increase the value to 147. The only implication of changing the value would be to change the position of the Energy Limit in the constraint breaking hierarchy. In previous years, limited testing was completed on the non-price event days using this increased value, and the solutions produced were as expected. The current value is nearly two orders of magnitude above the point at which it would become economic to violate the Energy Limit constraint and will ensure the Energy Limit Penalty is only incurred in the event of an infeasible solution in line with paragraph N17.4 of the T&SC. Any change to the current values would need further testing for robustness and to ensure no adverse effects to the market.

2.4.4 Recommendation

This report and all the corresponding reports from previous years have demonstrated that the current MSP Penalty Cost Parameters have satisfied the requirement of being well scaled but not economic. The MIP solver has also resolved any of the relatively few cases of infeasibility (including any cases of Energy Limit violation) that have arisen during the LR market runs. The current value of the Energy Limit Penalty Cost Parameter is nearly two orders of magnitude above the point at which it would become economic to violate the Energy Limit constraint and altering the penalty would only affect the position of the Energy Limit in the constraint breaking hierarchy. Given the above, SEMO would be reluctant to recommend any change to the current value of the Energy Limit Penalty Cost Parameter for Year 2017 without further comprehensive testing.

2.5 The Tie-Breaking Adder

2.5.1 Context

The Tie-breaking Adder is used to adjust prices for individual Generator Units in the event of a Tie-Break.

2.5.2 Analysis

While the MSP Software will allow prices and costs of up to €99,999.99/MWh to be specified without material loss of precision, the tie-breaking feature cannot be operated at that level so as to apply an adder significantly less than €0.001/MWh while being reflected in prices and costs for any price or cost above €9,999.99/MWh. This is because the MSP Software records costs to a precision of seven significant figures and such a small tie-breaking adder would appear in the eighth significant figure over any number above €9,999.99/MWh.

2.5.3 Conclusion

A Tie-breaking Adder of €0.001/MWh is the lowest possible adder that can be resolved at seven significant figures up to €9999.99/MWh.

2.5.4 Recommendation

SEMO recommends retaining a Tie-breaking Adder of €0.001/MWh for Year 2017.

2.6 Interconnector Limit Constraints introduced for Intra-Day Trading

2.6.1 Context

Interconnector Unit Nominations calculated in EA2, WD1 and Ex-Post runs are limited in aggregate in each Trading Period in the relevant Optimisation Time Horizon by the Maximum Export Available Transfer Capacity and the Maximum Import Available Transfer Capacity for a given Interconnector. As part of the software implementation of these limits for Intra Day Trading, the CMS vendor has included two additional slack variables and associated penalty costs. These constraints are documented in *Mod_15_12: Inclusion of ATC limit slack variables and associated penalty cost parameters,* which was approved by the Regulatory Authorities in September 2012. These slack variables were introduced to account for the unlikely scenario that where there is a change (reduction) in Available Transfer Capacity (ATC) between MSP Software Runs and the MIUN calculator is not triggered in sufficient time to calculate new MIUN values corresponding to the new ATC limit.

For IDT Go-Live the Maximum Export Available Transfer Capacity MSP Constraint Cost and the Maximum Import Available Transfer Capacity MSP Constraint Cost were set to a value of 100. This value is above the Over-Generation and Under-Generation MSP Constraint Costs, so that in the case of infeasibility the Under and Over Generation constraints would be breached first and the Interconnector Import and Export constraints should never be breached for economic reasons.

2.6.2 Analysis

During the analysis period, there have been three instances whereby an Interconnector Import or Interconnector Export violation has occurred. In all three instances, a revision was made to the Moyle Available Transfer Capacity (ATC), post the completion of the Ex-Ante Market Schedule. The violation occurred due to the inability of the MIUN calculator to capture the reduced ATC for periods within the Optimisation Horizon (OTH). Therefore, the Interconnector Import and Export constraints were only breached when the scenario detailed in 2.6.1 was encountered.

A number of simulations have also been performed in which violation of these limits has been forced in order to test the penalty parameter values further. This has been achieved by reducing the Interconnector Import and Export limits while leaving the MIUN values unchanged. Theoretically, given that these values have the same unit as the other parameters tested (except for the energy limit) they will have the same bind point. The analysis performed confirmed that using the current settings the interconnector import and export limits would not be broken for economic reasons and would only be broken in the event where the ATC was reduced and the MIUNs were not recalculated.

2.6.3 Conclusion

There have been three instances in the analysis period when interconnector limits constraints have been broken. The analysis confirmed that interconnector limits constraints had only been breached due to ATC limits being breached. Additional analysis performed has shown that using the current settings the interconnector limit constraints will be broken only after the other constraints have been broken.

2.6.4 Recommendation

SEMO recommends retaining the Maximum Export Available Transfer Capacity MSP Constraint Cost and Maximum Import Available Transfer Capacity MSP Constraint Cost at their current values of 100 for the Year 2016.

3. Recommendations

Analysis of the current values used for the year 2016 was performed. With reference to this analysis, this document proposes values for the year 2017.

SEMO proposes that all the MSP Constraint Parameters retain their existing values for 2016 (unless significant changes in the T&SC rules dictate their re-evaluation). Section 2.4 presents analysis of the Energy Limit Penalty Cost Parameter and notes the possibility of changing the value. However, as highlighted in Section 2.4, SEMO would not consider beneficial to recommend any change to the current value of the Parameter for Year 2017 without further comprehensive testing. This is because a change would only impact the priority given to penalty triggered in case of infeasibility without affecting the optimality of the solution. The current levels have been demonstrated to be sufficiently high that have never been incurred for economical reasons. The proposed parameter settings are shown below in Table 2:

PARAMETER	RECOMMENDED 2017 PENALTY SETTING
Over Generation MSP Constraint	73
Under Generation MSP Constraint	73
Aggregate Interconnector Ramp Rate MSP Constraint Cost	292
Energy Limit MSP Constraint Cost	38
Tie-Breaking Adder	0.001
Maximum Export Available Transfer Capacity MSP Constraint Cost	100
Maximum Import Available Transfer Capacity MSP Constraint Cost	100

Table 2: Proposed Values for MSP Software in 2017

The values in Table 2 are processed internally to arrive at the actual penalty values used in the MSP Software runs as shown in Table 3:

PARAMETER	RECOMMENDED 2017 INTERNAL MSP SOFTWARE PENALTY
Over Generation MSP Constraint	73 x 5 x Max Offer
Under Generation MSP Constraint	73 x 5 x Max Offer
Aggregate Interconnector Ramp Rate MSP Constraint Cost	292 x 5 x Max Offer
Energy Limit MSP Constraint Cost	38 x 5 x Max Offer
Tie-Breaking Adder	0.001 x 5 x Max Offer
Maximum Export Available Transfer Capacity MSP Constraint Cost	100 x 5 x Max Offer
Maximum Import Available Transfer Capacity MSP Constraint Cost	100 x 5 x Max Offer

Table 3: Internal Formulae used in MSP Software Run Calculations

The tests described in this report have demonstrated that the values are safely above the level where they would be breached for economic reasons and would only be breached in the case of infeasibility.