

SEM Establishment Programme

Title	UUC Software Version 1.3.7 Certificate
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Introduction

This report contains the certification of the within-scope functions of ABB's Market Applications software, version SEM MA 1.3.7 17 August 2007 (the "UUC Software") to be used in the Single Electricity Market in Ireland. This certification relates to the adequacy of the relationship between, and the consistency of, the UUC Software supplied by ABB and the UUC mathematical formulation (the "Formulation Document"), as documented by ABB comprising:

- "Software Design Specification: Market Applications (MA) – UUC (Unconstrained Unit Commitment)" Document # 1KUS007970D0009, Revision Index: H, Date: 1 July 2007;
- Within scope parts of "Market Applications (MA) - Ex-Ante", Document # 1KUS007970D0012, Revision Index: E, Date: 28 June 2007, and "Market Applications (MA) - Ex-Post", Document # 1KUS007970D0013, Revision Index: F, Date: 29 June 2007;

This certification also addresses the consistency of the Formulation Document, relative to the NIAUR/CER document "Single Electricity Market (SEM): Trading and Settlement Code", version 2.0, 31 May 2007 (the "T&SC").

The scope of certification is presented in Appendix 1.

This report presents the overall conclusions of, and limitations upon, the certification of the UUC Software. It is supported by associated documentation:

- 2007-08-31 Formulation Document Certification Report v1.0.
- 2007-08-31 Certification Testing Report, MA Versions 1.3.0 to 1.3.7 v0.8.¹

Methodology

Certification began with an initial review of an earlier version of ABB mathematical formulation documents against Trading and Settlement Code version 1.0. Revisions to the ABB documentation stemmed from that initial review. Certification tests were then developed based on that revised documentation

¹ The Certification Testing Report is supported by documentation of the tests conducted and an extensive record of test cases and test results recorded on the SEM Establishment Programme LAN.

Testing was based on a power system representation that deviated significantly from the actual power system. No attempt was made to represent capabilities of actual generators or power system components or to reproduce the economics of the actual power system. Rather, testing was conducted with data designed to test the functionality and functional limits of the UUC Software. A base set of relatively simple test cases was developed, with more complex tests developed from these. A significantly smaller set of generating units was considered in the Certification Testing than would occur in reality, so as to make data interpretation more tractable. Test cases generally fell in to one of three categories:

- Test where no unit commitment effects were included so as to allow comprehensive testing of the Economic Dispatch and price calculations.
- Tests with only a very small number of units being subject to unit commitment scheduling or with very simple unit commitment constraints imposed. These tests allowed testing of unit commitment functionality and constraints in a context where the solutions could be intuitively understood.
- Tests with a full combination of unit commitment and economic dispatch effects. These cases were less easily analysed in detail, but given other testing could be used to confirm the overall operation of the software.

Over 170 distinct tests have been developed, where often each test was performed in each of indicative ex ante, indicative ex post and initial ex post modes. The test results are well documented and the cases have been saved in a form where they can be retrieved and re-run with future software versions.

Testing was performed on four different official releases of the MA software plus a number of unofficial interim releases.

Limitations

In drawing conclusions about the compliance of the Formulation Document with the T&SC this study has been subject to the following limitations:

- Certification work began with T&SC version 1.0.² This version included relatively little detail on the UUC Software functionality. .
- Near the completion of Certification Testing, T&SC version 2.0 became available. T&SC Version 2.0 is understood to have been developed to reflect the functionality of the market systems within the T&SC. While this process has greatly clarified the T&SC, there are still aspects of the T&SC which are incomplete, logically inconsistent or internally inconsistent. Consequently it would be impossible to state that the UUC Software complies exactly with the T&SC. The approach has been taken that in situations where the T&SC is incomplete, logically inconsistent or internally inconsistent it is deemed that the UUC Software cannot be inconsistent with the T&SC. The areas where T&SC version 2.0 is incomplete, logically inconsistent or internally inconsistent have been identified in the report 2007-08-31 Formulation Document Certification Report v1.0.
- The Formulation Document comprises ABB design documents which are the basis for its software development and which were never required to provide unlimited detail of the software functionality. ABB has accommodated some requests for changes. Consequently:
 - ⇒ The description of the optimisation formulations used in the unit commitment, economic dispatch and SMP processes are entirely adequate.

² A review and interpretation of version 1.0 of the T&SC is documented in “Provisional Formulation Certification Report”, 8 December 2006.

- ⇒ The solution algorithms for solving these optimisation formulations are not described adequately for testing and hence have not been tested other than via reviewing the actual solutions. The solution algorithms include ABB's Lagrangian relaxation algorithm, and the third-party vendor solvers AMPL/CPLEX and MINOS. The use of "black box" problems solvers which cannot be directly tested is the norm in most markets.
- ⇒ The pre-processing and post-processing steps which set up input data for the UUC Software and process its outputs are documented to a much lesser degree than the UUC Software itself. The ABB documentation in this area is more process oriented, without covering explicit details. ABB have added enhanced functional descriptions during the course of Certification Testing, but not precise algorithms.

In drawing conclusions about the compliance of the within-scope functionality of MA version 3.1.7 with the Formulation Document, this study has been subject to the following limitations:

- Certification testing has been conducted by directly loading test data in the DSI application within the Market Applications (MA) software. This by-passes the interfaces used by participants, TSOs and the market operator, as well as all validation tests applied to that data. Further, Certification Testing by-passes pre-processing of data performed within the Market Infrastructure (MI) system and in the passing of data from the MI to the MA. Functionality implemented prior to the entry point of Certification Testing data has not been tested as part of this study.

Discussion

In certifying market software it is never possible to make an absolute statement that the software will perform to expectations in every conceivable circumstance. The limitations described in this section are intended to identify known areas where the software may perform in ways which may differ from expectations. These limitations may be a result of the market design, the nature of the optimisation problems being solved, or representative of limitations in data validation processes prior to data reaching the software:

1. The unit commitment process used in the UUC Software determines a scheduling solution for the purpose of unit commitment, while the economic dispatch component of the UUC Software takes the unit commitment solution and determines a new schedule and prices. This separation of processes means that any infeasibility in the unit commitment process may compromise the quality of the economic dispatch solution, and, except where the UUC Software produces alarms, this may not be apparent to the user.
2. The Lagrangian Relaxation (LR) methodology cannot be guaranteed to find a feasible unit commitment solution in all situations, even where one is known to exist. This has been demonstrated for a case with only two generating units. While the software has performed robustly for normal scheduling scenarios it is not possible to extend this observation to all possible scenarios.
3. The Mixed Integer Programming (MIP) methodology overcomes some of the limitations of Lagrangian Relaxation but the major cost of using this method is that it can converge very slowly. In most instances where run times are very limited, the Lagrangian Relaxation method can find better solutions than the Mixed Integer Programming methodology.
4. The market systems have limited data validation processes. It is known that if unrealistic or extreme valued data enters the UUC software, it may perform slowly, fail to solve, or produce solutions that are unusable or unacceptable.
5. The UUC Software includes features which can create results which may not be expected by users or, if used incorrectly, could produce unacceptable market outcomes.

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- ⇒ The Lagrangian Relaxation solver makes use of a post-processing heuristic to ensure a feasible solution. This heuristic has two parameters which drive it, 'Altcom1' and 'Altcom2'. The vendor settings for these values are 60 and 5 respectively, and the Lagrangian Relaxation performs well with these values. However other values may produce very poor solutions. For instance, for a case where only one unit was cycling (while all others were 'must-run') and both Altcom parameters were zero, the start up cost at which the unit first started differed from the value at which it should have first started by several thousand euro. Using the Altcom parameters set by ABB, this difference reduced to a gap of less than one euro.
 - ⇒ The MIP solver can take a long time to solve and consequently may terminate, with the problem timing out. The solver actually stops running some time after the timeout is reached (potentially several minutes), which should be factored into considerations of how the timeout time is set. Further, even if the same case is run twice and is set to timeout after the same time, the resulting solutions may not be identical. This is not unreasonable in that the actual time the case times out is a function of system loading etc. It is understood that the market will run using the Lagrangian Relaxation solver which solves sufficiently quickly that timeout issues are not expected to be such an issue.
 - Tie-breaking adders can accumulate in the determination of the SMP value. For cases configured such that:
 - i. the algorithms are indifferent as to which period to increase the SMP relative to the shadow price;
 - ii. the algorithm chooses to raise SMP in only a small number of periods, e.g. 1;
 - iii. one generating unit is driving SMP over the day and incurs bid-related costs above the shadow price, because it is constrained-on (e.g. by a ramp constraint); and
 - iv. the bids driving SMP are tied bids;
...then the value of SMP in the periods it differs from the shadow price may have values which include a few euro cents created by tie-breaking adders even when the base tie-breaking adder applied is significantly less than one cent (e.g. €0.001/MWh).
 - ⇒ While the software includes tie-breaking features, these have no impact on pumped storage units. Consequently, the total quantity supplied or consumed by a pumped storage station can be distributed randomly between individual pumped storage units (where ramp rates, etc., permit this), resulting in a 'saw tooth' schedule for individual units. This is not likely to be a significant issue in reality, as the total station schedule is stable.
 - ⇒ The same tie-breaking adder is applied for all tied bid steps for any given generating unit. Different bids do not have different tie-breaking adders.
 - ⇒ Energy limits and shared energy limits should not be applied to Pumped Storage Units. Pumped Storage Units can raise or lower the cumulative energy scheduled over the day and this undermines the logic of the energy limit and shared energy limit constraints.
 - ⇒ The UUC Software includes a feature whereby, in addition to applying aggregate interconnector ramp rates to interconnector units, it is possible to apply a ramp rate to the aggregate flow on multiple interconnectors. This feature can be disabled by setting a sufficiently large ramp rate. If not disabled, it could result in market solutions in violation of the T&SC.

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- ⇒ The internal numeric accuracy of the UUC Software price recording is seven (7) significant figures. Tests have shown that a price above €9,999.99 will always lose numeric accuracy below the last cent. This applies to incremental costs, start-up and no-load costs. Any cost submitted above this value will be recorded and used but will lose accuracy. For example a submitted price of €11,111.16 would be converted to €11,111.20.
 - ⇒ The UUC Software cannot be relied upon to solve reliably or in a timely fashion if presented with pumped storage efficiencies outside of the range 0-100%. This is not regarded as a defect as values outside this range are physically impossible.
 - ⇒ If ever a pumped storage station has initial conditions that involve one unit pumping and another generating, then the UUC includes no feature to automatically resolve this (as it should never happen). However, if it did happen, the operator could manually change the initial conditions.
 - ⇒ Pumped storage units are subject to ramp rate limits. These ramp rates are based only on the ramp rate over the generating range, but are applied over both the generating and pumping ranges. It is understood that the ramp rates for these units are sufficiently high that they will have no impact on the solution.
 - ⇒ For indicative ex post runs, the software is required to populate data beyond trading period 36 with the data present at trading period 36, on the grounds that no data will be available beyond trading period 36. The vendor has implemented this by extending the data for the last period for which data is available. Thus if trading period 36 has data, and there is no data in subsequent periods, then the correct output will occur. However, if data is only available to some other trading period, then that data will be extended to the end of the optimisation time horizon. This means that if more or less data is available than expected, then the result will be different to that expected, though there would be inadequate data to produce the expected result. This issue has been classified as not being a defect, as in many regards it is a more general solution.
 - ⇒ Where maximum on-times, minimum on-times, and maximum off-times have values shorted than one trading period, they are treated as having a value of 30 minutes. This is a logical outcome as the alternative is that the unit is unavailable, in which case it should be declared unavailable.
 - ⇒ The default ABB penalty cost functions used in the UUC may not be suitable for all situations. In particular, the function for violating interconnector ramp rates is a relatively weak penalty compared to others because one period of violation can increase interconnector flows in every subsequent period of the day. Further, the suitability of any given penalty cost functions depends on numerous other factors, including start-up costs and no-load costs, interactions with minimum down-time constraint, etc. It is recommended that a formal process of determining these penalty cost functions be undertaken.
 - ⇒ In an over-generation situation the UUC will use slack variables to resolve the problem. This means that the Market Schedule Quantity (MSQ) values determined will cumulatively exceed the actual demand. A factor which may mitigate any settlement consequences of this is that the generation requirement in the ex post case is derived from metered generation and should therefore already account for mitigation of over-generation.
6. When restoring saved cases the work flow process can have problems tracking how far through the process it is, if the workflow is not re-run from the start. Hence, upon restoring a saved case, the DSI Application must be run before running the UUC Software.

7. While the Market Applications software includes features to change zero ramp rates to non-binding ramp rates, these features are implemented in the DSI Application. This will result in there never being zero ramp rates in the UUC Input Table. However, were an operator to then manually set a ramp rate in the UUC Input Tables to zero, this would stop the UUC running. This is not considered to be a fundamental issue as the operator changing the ramp rate would see alarms produced by the UUC Software, and could then correct the ramp rate to a non-zero value. Note that a ramp rate of 0.001 will not stop the UUC Software from solving.
8. A basic limitation recognised in the scope of certification is that Certification Testing cannot identify software bugs if the underlying feature is not documented. Situations of this nature, which have resulted in software not producing a solution, have been found during Certification Testing by chance. These kinds of outcomes have been observed with extreme and unrealistic data cases, but no guarantee can be given that these are the only situations in which this might occur. The situations recorded to date have been addressed by the software vendor, but further instances of such problems may exist.
9. The last step of penalty functions used in the UUC Software is scaled by 5 times the largest bid within the optimisation time horizon. This feature generally performs very well. However, in principle if a very large bid price (e.g. 100,000) were to be combined with a very large penalty function in the last bid step (e.g. 20,000) then a very large penalty could be incorporated in to the optimisation (e.g. 10^{10}). Penalties at this level could undermine the quality of the solution, and may cause the software to fail to solve. While any selected penalty function values should be tested, the limited experience gained with Certification Testing indicates that penalty functions in the region of 10^8 should not cause undue problems.

Summary of Deficiencies

The following material limitations of the UUC Software have been found:³

- *High Impact Issues:* None
- *Medium Impact Issues:*

While the UUC Software will allow prices and costs of up to €99,999.99 to be specified without material loss of precision, the tie-breaking feature cannot be operated so as to apply an adder significantly less than one (1) cent (e.g. €0.001) while being reflected in prices and costs for any price or cost above €9,999.99. This is because the UUC Software only 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. This is only a compliance issue if the Market Price Cap is set in excess of this level.

Low Impact Issues: None

The following deficiencies, or potential deficiencies, in the Formulation Document relative to the T&SC have been found:⁴

- The ABB design limits the maximum unrounded price to €99,999.99, and this will undermined tie-breaking for bids above €9,999.99/MWh. The lack of a maximum start up or no load cost in the T&SC means there is no level of precision which can be guaranteed to be complied with.
- The limits of the scope of the MSP Software are not clearly defined in the T&SC.

³ Further detail can be found in 2007-07-05 Certification Testing Report, MA Versions 1.3.0 to 1.3.5 v0.6.

⁴ Further detail can be found in 2007-07-05 Formulation Document Certification Report v0.8

- The body of the T&SC has not been brought properly into alignment with changes to Appendix N.
- The T&SC has gaps and inconsistencies as to how Price Taker schedules are set for different run types.
- Some of the defined terms used in the T&SC are inappropriate in contexts they are used. For instance, the “MSP production cost”, a defined term, is used to describe the optimisation objective function. But the MSP production cost only has the value of the optimal objective function value, it is not the general function.
- Inconsistent wording between similar clauses have left gaps in the T&SC. Simplifying wording by referencing text from other (fundamentally different) clauses also creates ambiguity.
- The T&SC clauses relating to the SMP calculation have inconsistencies with respect to whether revenue is minimised across the market, whether all start-up and no-load costs are recovered, and (again) with how defined terms are used.
- The T&SC has some inconsistencies with respect to which modes of MSP Software are being referred to and the time periods to which different data values apply.
- The T&SC is ambiguous or incorrect as to the treatment of special units in a number of situations. This is both with respect to which clauses apply to them and to which data is associated with them.
- The T&SC includes inconsistent units (e.g. MWh being compared with MW) and conventions (e.g. definition of pumped storage cycle efficiency compared with how it is used).
- The T&SC both allows the market operator to modify data when required, while also forbidding this.
- While not a fundamental issue for certification, the T&SC allows manifestly incorrect text to take precedence over unambiguously correct equations.

Restriction on Certification

The ability to categorically state that the Formulation Document complies with the T&SC has been compromised by incompleteness, logically inconsistency and internally inconsistency in the T&SC. For the purpose of this certification in situations where the T&SC is incomplete, logically inconsistent or internally inconsistent it is deemed that the UUC Software cannot be inconsistent with the T&SC. The areas where T&SC version 2.0 is incomplete, logically inconsistent or internally inconsistent have been identified in the report 2007-08-31 Formulation Document Certification Report v1.0.

This certification does not apply to features which cannot be assessed for compliance owing to limitations identified in this report, including limitations to certification included in the scope contained in Appendix 1.

Certification of the UUC Software for use operationally is subject to the understanding that EirGrid and SONI inform market participants of the issues in the sections titled “Summary of Deficiencies” and that EirGrid and SONI sign off that these issues will not have a material impact on its ability to operate the market within the provisions of the T&SC.

This certificate applies only to the within-scope functions of ABB's Market Applications software, version 1.3.7, 17 August 2007, and to any subsequent version of ABB's Market Applications software for which the within-scope functions are – in their function and in their software coding – unchanged relative to this version. For the avoidance of doubt, if EirGrid and SONI deploy a new version of ABB's MA software with modified functionality, then this certificate only applies to that new version if the within-scope functions of that version are, in their function and in their software coding, unchanged relative to those in ABB's Market Application software version 1.3.7, 17 August 2007.

This certification is limited to the use of the UUC Software with the following execution control settings set:

- Minimum up time enabled
- Minimum down time enabled
- Maximum up time enabled
- Minimum ramp time enabled
- Start-up time disabled⁵
- Input status enabled
- 'Altcom1' limit and 'Altcom2' limit set to appropriate values (e.g. ABB's recommended default values of 60 and 5 respectively).
- Values of alpha, beta, delta and the tie-breaking adder set in accordance with the T&SC.
- If the Market Price Cap is between €1.00000×10ⁿ/MWh and €9.99999×10ⁿ/MWh where n is a whole number less than or equal to 3 then the tie-breaking adder must be set to a value not less than €1.00000×10⁽ⁿ⁻⁶⁾/MWh. For example, the tie-breaking adder must be set to a value not less than €0.001/MWh if the Market Price Cap is between €1,000.00/MWh and €9,999.99/MWh.

The use of the Lagrangian Relaxation solver methodology is recommended, but the MIP solver option may be used on the understanding that:

- the quality and solution time of the MIP solution will vary significantly with the setting of the optimality tuning parameters set by the operators, and that no responsibility is taken for the performance of the MIP solver with respect to those settings.
- the MIP solver will generally not produce the same solution as the Lagrangian Relaxation solver given the same data.

This certification expires upon the coming into force of any change made to the Single Electricity Market Trading and Settlement Code (or any equivalent successor document) which would mean that the UUC Software is no longer in compliance with that version of the Single Electricity Market Trading and Settlement Code (or any equivalent successor document).

This certification is provided only for the purpose of scheduling and pricing performed in the Single Electricity Market operating in the Republic of Ireland and Northern Ireland and administered by EirGrid and SONI, and is void in terms of the use of the UUC Software, as it is currently configured, for any other purpose.

This certification supersedes all prior certifications of the UUC Software. All certificates issued with respect to certification of the UUC Software prior to 13th September 2007 are void.

⁵ It is understood that the intention while developing the UUC Software was that it be operated with this feature enabled. However, the wording of the T&SC (see clause N.17.2.c) requires it to be disabled.

Certification of the UUC Software

Subject to the limitations and caveats expressed in the foregoing text, the within-scope functions of the Formulation Document as supplied for review have been found to be substantially in compliance with the requirements of the T&SC⁶, and the UUC Software has been found to be substantially in compliance with the Formulation Document, and that provided due attention is paid to addressing the points noted above, any remaining aberrations or anomalies observed in relation to those specifications are not likely, of themselves, to have material or systematic detrimental effects with respect to T&SC compliance or the operation of the UUC Software.

⁶ The “Restriction on Certification” section states that the purpose of this certification in situations where the T&SC is inconsistent or incomplete it is deemed that the UUC Software cannot be inconsistent with the T&SC.

Appendix 1: Scope

The following points collectively describe a proposed formalisation of the scope:⁷

- Certification is to be limited to the ex ante market schedule and ex post market schedules (including the calculation of SMP prices) for Day 1. Specifically:
 - ⇒ An ex ante Indicative Market Schedule (IMS) solved in multiple phases comprising:
 - A non-convex unit commitment to determine indicative ex ante unit schedules. This problem excludes transmission and reserve constraints;
 - A convex linear optimisation to determine indicative market schedules and indicative short run marginal cost based prices (SP) given the indicative ex ante unit schedule and a forecast of energy to be scheduled. This problem excludes transmission and reserve constraints,
 - A convex linear optimisation, to determine indicative initial SMP values which recover unit costs while minimising total payments to units, given the indicative market schedules and the indicative SP values; and
 - A convex linear or quadratic optimisation⁸ to determine the indicative final SMP values which recover unit costs and controls how the indicative final SMP values change relative to the indicative SP values, and which includes a constraint that limits how much the total payment to units can change from the total payment based on the indicative initial SMP values.
 - ⇒ An Ex Post Unconstrained Schedule (EPUS) solved in multiple phases comprising:
 - A non-convex unit commitment to determine ex post unit schedules based on actual availabilities. This problem excludes transmission and reserve constraints;
 - A convex linear optimisation to determine market schedules and short run marginal cost based prices (SP) given the ex post unit schedule and actual energy to be scheduled. This problem excludes transmission and reserve constraints;
 - A convex linear optimisation to determine initial SMP values which recover unit costs while minimising total payments to units, given the market schedules and the indicative SP values; and
 - A convex linear or quadratic optimisation (depending on the value of the parameter “beta”) to determine the final SMP values which recover unit costs and controls how the final SMP values change relative to the SP values, and which includes a constraint that limits how much the total payment to units can change from the total payment based on the initial SMP values.
- The Certification of the UUC Software is to be restricted to the use of the UUC Software in the SEM for the purpose of the determination of ex ante market schedule and ex post market schedules (including the calculation of SMP prices) as required by the T&SC.

⁷ This scope was originally presented in the High Level Certification Test Plan, 25th August 2006. The versions of the Code and other documents referenced in the High Level Certification Test Plan are now out of date and it is accepted that the current versions of documents stated in the Introduction of this Certification Testing Report apply. Note that since this scope was stated it has been agreed that the: DSI Application processing of Net Output Functions, Actual Availabilities, minimum stable generation, minimum outputs and the Generation Requirement have been added to the scope where included in the DSI Application (though Net Output Functions are not in the DSI so have not been tested).

⁸ It is linear if the parameter “beta” is zero and is quadratic otherwise.

- Where the T&SC is silent on a feature included in the formulation then the formulation will be deemed to be in compliance with the T&SC. Where the T&SC appears to be internally inconsistent, documentation is to be provided by the certifier documenting such instances and what interpretation has been applied.
- Any functional change to the formulation beyond the functionality specified in the Functional Specifications for the determination of ex ante and ex post schedules and prices is out of scope, unless the Certifier agrees to the addition of such changes to the scope. To be clear, the Day 1 specifications for the RCUC function are excluded from this scope.
- Where the T&SC makes reference to “minimising costs”, this will be interpreted to mean that the relevant formulation should minimise the costs to the extent reasonably allowed within the limitations of optimisation theory and practice. In particular:
 - ⇒ Where the problem to be solved is convex with linear constraints and either a linear or quadratic objective function then the least cost solution should be found within the numerical accuracy of the solution algorithm.
 - ⇒ Where the problem to be solved includes non-convexities⁹ then the algorithm should reasonably be expected to provide an efficient solution (although not necessarily the most efficient or optimal solution).

Similar interpretations will apply in the context of any other terminology which implies that an optimal solution must be found.

- The UUC Software does not need to produce physically feasible solutions where it appropriately makes use of “slack variables”¹⁰, contemplated in the Formulation Document for allowing constraint limits to be relaxed when the input data and the formulation imply that no feasible solution is achievable without so doing. However, the use of such slack variables should be recorded in the output data. The costs associated with these “slack” variables may be reflected in prices produced.
- Where the UUC Software contains a feature that is not documented in the Formulation Document and which materially impacts only some schedule or pricing solutions produced by the UUC Software then it is possible that such a feature will not be detected during certification. Such a feature, where not detected and identified by the Certifier, is outside the scope of certification. However, where any such a feature is detected and identified by the Certifier it may be considered as a failure of the UUC Software to comply with the Formulation Document.

⁹ Non-convexity means that convergence to optimality can not be guaranteed. While the optimisation algorithm may find an optimal solution to an approximation of the non-convex problem, if this approximation does not fully represent the non-convex problem then an optimal solution to this approximation may not be an optimal solution to the non-convex problem (where an optimal solution to the non-convex problem exists). In extreme cases the approximated solution may not even be a feasible solution to the non-convex problem. Further, it may not be possible for the Certifier to determine an optimal solution to a given non-convex problem. Consequently the Certifier is not required to categorically state whether or not the schedules produced for non-convex problems are optimal (though the Certifier can check for feasibility against the documented formulation of the problem).

¹⁰ A slack variable gives an optimisation solver the option of violating a constraint, though typically at a high cost. Consider the equation $x < 5$. If another constraint required x to equal 6 then there would be no solution to this problem and the optimisation would not be able to solve. A version of this constraint with a slack variable might be $x - y < 5$, where y must be positive and each unit of y used would have a very high cost in the objective function. If another constraint required x to equal 6 then the optimisation could solve by setting $y = 1$. The optimisation would not use y unless it has to because of its high cost (but if it has no choice but to use y then the cost is irrelevant). Slack variables help to ensure that constraint violation does not prevent the optimisation solution from converging.

- Testing of the calculation of the demand to be met by price maker units as documented in TSO_CR355 is in scope. However, the processes for determining inputs to that calculation are out of scope. In particular, the calculation of the following values is not within the scope of certification: the forecast demand, constrained-up generation, constrained-down generation, and metered values.
- Software testing will be restricted to the UUC Software, with the following excluded from certification:
 - ⇒ Any data transfer features.
 - ⇒ Any special systems or processes used to facilitate Certification Testing which will not be used in that role in the market when the market is operational.
 - ⇒ Any calculations or pre-processing performed on data, including validation testing, by systems other than the UUC Software prior to that data being entered into the UUC Database (being the immediate source of all input data and the immediate destination of all output data from the UUC software), with the exception of the calculation of the demand to be met by price maker units to the extent described above.
 - ⇒ The implementation and operation of any systems external to the UUC Software, including interfaces.
 - ⇒ The appropriateness of any parameter or data values entered into the UUC Software, including parameters set by market operators and data values submitted by Market Participants.
- Certification will test the formulation in a generic sense, and is not required to provide any indication of expected price or schedule behaviours in reality, or test the performance of the systems in the context of realistic market data. However, any significant robustness or reliability problems observed with the UUC Software during Certification Testing will be reported.
- The T&SC includes detail of the UUC Software functionality merged to some degree with rules on entirely separate functionality. This creates some uncertainty as to where the boundary is between calculations required to be performed outside the UUC Software and calculations required to be performed within that software. For the avoidance of doubt, terms, values or identifiers whose calculation or use is not required to be in the Formulation Document (except to the extent identified), include, but are not limited to:
 - ⇒ Residual Units
 - ⇒ Error Units
 - ⇒ Netting generator units¹¹
 - ⇒ Net Output Functions
 - ⇒ The calculation of System Operator set Actual Availabilities, minimum stable generation and minimum output (though the final values must appear in the Formulation Document)
 - ⇒ Eligible Availabilities
 - ⇒ Eligible Netting Quantities
 - ⇒ Metered Generation

¹¹ These are used to account for the situation when any generator is a net consumer. The optimisation models do not allow negative generation, so this netting term can only have a significant role in settlement. The ex post schedules use metered generation as an input, and these metered values should capture any consumption by generators.

- ⇒ Dispatch Quantities
- ⇒ Maximisation Instructions
- ⇒ Constrained-on and constrained-off quantities.
- ⇒ Interconnect Capacity Holding Data
- ⇒ Available Transmission Capacity
- ⇒ Active Interconnection Capacity Holding
- ⇒ SO Interconnector Trades
- ⇒ Settlement calculations, including Energy Payments, Energy Charges, Capacity Payments, Capacity Charges and Constraint Payments.