Department of Energy & Climate Change

Annex G: Modelling Quality Assurance

December 2013

Any enquiries regarding this publication should be sent to us at correspondence@decc.gsi.gov.uk.

This publication is available for download at www.official-documents.gov.uk.

AND

This document is also available from our website at www.gov.uk/decc.

Contents

Introduction 4
Quality assurance of input data and assumptions 4
Evidence sources for key input assumptions 4
Governance and documentation of agreed changes 4
Definition of scenarios 4
Quality assurance of the Dynamic Dispatch Model 5
Developer testing 5
Academic review 6
Internal testing 7
National Grid testing 8
Code review 8
Documentation of changes to the model 8
Future developments to the model 9
Quality assurance of model runs 10
Documentation 10
Model users 10
Quality assurance of outputs 10
Quality assurance of the RO equivalent strike price calculations 10
Data and assumptions 10
Quality assurance of the spreadsheet tool and outputs. 10
Extension of the spreadsheet tool to model Northern Ireland deployment 11
The role of National Grid in Quality Assurance 11
Specification of model developments 11
Network modelling 11
Testing of developments 11
Data and assumptions 11
Appendix A – Quality assurance of model outputs checklist 12

Introduction

1. This annex describes the quality assurance undertaken for the analysis in the final Delivery Plan. This includes quality assurance of input data and assumptions, the modelling tools used, and results from those tools.

Quality assurance of input data and assumptions

Evidence sources for key input assumptions

2. Key assumptions used for the analysis are published separately by DECC, and subject to their own quality assurance procedures:

    - Fossil fuel price assumptions - these are published annually by DECC[1], and have previously been subject to academic peer review;

    - Electricity demand - projections of demand are taken from DECC's Energy Demand Model underpinning its Emissions Projections[2];

    - Electricity generation costs - DECC commissions external experts to provide annual updates to its electricity generation costs[3]. The 2013 generation costs were consulted on as part of the draft Delivery Plan consultation and a revised report is being published alongside the final Delivery Plan[4].

Governance and documentation of agreed changes

3. A board consisting of senior officials and chaired by the DECC Chief Economist considered and agreed the assumptions used in the analysis for the final Delivery Plan.

4. Changes to assumptions since the publication of the draft Delivery Plan in July 2013 are described in detail in Annex H[5].

5. The section 'Quality assurance of model runs' (paragraph 29) explains assurance that these changes are incorporated in the DDM runs.

Definition of scenarios

6. As part of the final Delivery Plan, National Grid has run a number of scenarios looking at the impact of changes to a number of key input variables[6]. These scenarios test the effect of these inputs on output metrics such as total LCF spend in 2020/21 and the renewables generation percentage. Assigning robust probabilities to future outcomes for the key input variables is very difficult. Therefore the probabilities associated with these scenarios have not been calculated. Instead the scenarios are intended to illustrate a range of plausible outcomes, and are not intended to cover the full range of possible outcomes.

---

[1] https://www.gov.uk/government/publications/fossil-fuel-price-projections-2013

[2] https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2013

[3] https://www.gov.uk/government/collections/energy-generation-cost-projections

[4] https://www.gov.uk/government/publications/electricity-market-reform-delivery-plan

[5] See Annex H, https://www.gov.uk/government/publications/electricity-market-reform-delivery-plan

[6] See Annex D, https://www.gov.uk/government/publications/electricity-market-reform-delivery-plan

7. The low fossil fuel prices scenario uses the low scenario from DECC's fossil fuel price projections[7]. The gas price used represents the lower end of estimates of the long run marginal cost of gas supplies to Europe. It does not represent an absolute floor on gas prices, but is instead a plausible low price scenario.
8. The high and low demand scenarios use outputs from DECC's Energy Model. They are derived from Monte Carlo simulation of demand for energy, taking into account variation in economic growth, fuel prices, and the effectiveness of energy efficiency policies. The high demand scenario corresponds to the upper end of the 95% confidence interval, the low demand scenario to the lower end. These scenarios do not represent absolute maximum or minimum demands but instead are plausible low and high demand scenarios.
9. The high and low technology cost scenarios use a +/- 10% variation in capital and predevelopment costs to represent a plausible range of future technology costs, but it is recognised that future cost variation could fall outside this range.

Quality assurance of the Dynamic Dispatch Model

10. The Dynamic Dispatch Model (DDM) is a comprehensive fully integrated power market model covering the GB power market over the medium to long term. It models electricity dispatch from GB power generators and investment decisions in generating capacity from 2010 through to 2050. It considers electricity demand and supply on a half hourly basis for sample days. Investment decisions are based on projected revenue and cash flows allowing for policy impacts and changes in the generation mix. The full lifecycle of power generation plant is modelled, from planning through to decommissioning, and also allows for risk and uncertainty involved in investment decisions. The DDM enables analysis comparing the impact of different policy decisions on generation, capacity, costs, prices, security of supply and carbon emissions, and also outputs comprehensive and consistent Cost-Benefit Analysis results[8].
11. At the time of the Macpherson review of quality assurance of government models[9], the DDM was internally assessed as having undergone developer testing, internal peer review, external peer review and periodic review and being subject to version control, governance and transparency through regularly published results. It was noted that the DDM was being brought into line with DECC's (then) new quality assurance guidelines. The DDM had not at that stage undergone either internal or external audit. As noted in paragraph 19 below, the DDM has now undergone a partial external audit, and a full audit is in progress. In addition, internal audit is scheduled for early 2014. A key output of the internal audit will be a plan to bring the DDM fully into line with DECC's latest quality assurance guidelines.

Developer testing

12. Before release to DECC, the original DDM and all subsequent developments have been tested by the contractors, LCP. This testing is conducted by an independent team within LCP - none of the testers are involved in the coding. This testing includes:
    - Within code tests: Within the code unit tests have been constructed to ensure that key modules are producing the expected output.

[7] See footnote 1.

[8] More details on the DDM may be found at https://www.gov.uk/government/publications/dynamic-dispatch-model-ddm

[9] https://www.gov.uk/government/publications/review-of-quality-assurance-of-government-models

- Output testing: These tests are completed by creating a combined version of the input and output files and then by using this file to run as both the input and output templates for the model. This meant all output from the model was recorded in a file with the input values included. This enabled the calculation of outputs based on the model's input file to be done externally to the model and compared directly with the model's output.
- Regression testing: This process is automated via a spreadsheet comparison tool which compares values between two spreadsheets of the same structure (run to compare a number of sheets such as prices, installed capacity and generation) and flags up any differences. When the numbers do differ in regression tests, but for expected reasons, more simplified tests are run to isolate the differences and ensure they are in the correct location and of the right magnitude.

Academic review

13. When the DDM was first delivered to DECC, an academic peer review was commissioned[10]. This review, carried out by Professors Newbery and Ralph (University of Cambridge) concluded that 'the DDM is an impressive model that meets DECC's original specification well'
14. The review made a number of recommendations for future changes to the DDM – 7 of the 9 of these have since been implemented, as shown in Table 1.

Table 1. Changes suggested by the academic peer review. For full details of the upgrades suggested, see the published peer review referred to in the main text.

Suggested upgrade	Included in current DDM?
Index of inputs and outputs	This has been added
Specification of units	Units have been clarified
Cumulative investment cost output	This is now a DDM output
Net Present Value (NPV) output	This is now a DDM output
Comparison of expected and actual IRRs	Not automated, but easy to examine
Modelling low wind outputs	The DDM models a number of wind levels for each sample day
Automated sensitivity analysis	Not implemented
Price duration curve output	This is now a DDM output
Some modelling of grid constraints	Modelling of network costs added

[10] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65711/5427-ddm-peer-review.pdf

Internal testing

15. The original DDM and all subsequent developments also underwent extensive user acceptance testing within DECC before use. This testing always includes regression testing, where the same input file is run on the old and new version of the model to confirm that no unintended changes are occurring elsewhere in the model. Any unexpected changes are referred back to LCP to identify the cause and take any necessary action. Expected changes are tested to confirm that they are in the correct location and of the right magnitude. Any new features are tested by off-model calculations on the same inputs where possible or testing input sensitivities on the magnitude of changes to the outputs.

16. As new data becomes available back-casting is used to check that the DDM accurately reproduces the outturn/forward prices (Figure 2) and outturn generation (Figure 3). This back-casting will also in future be carried out for all new model versions.

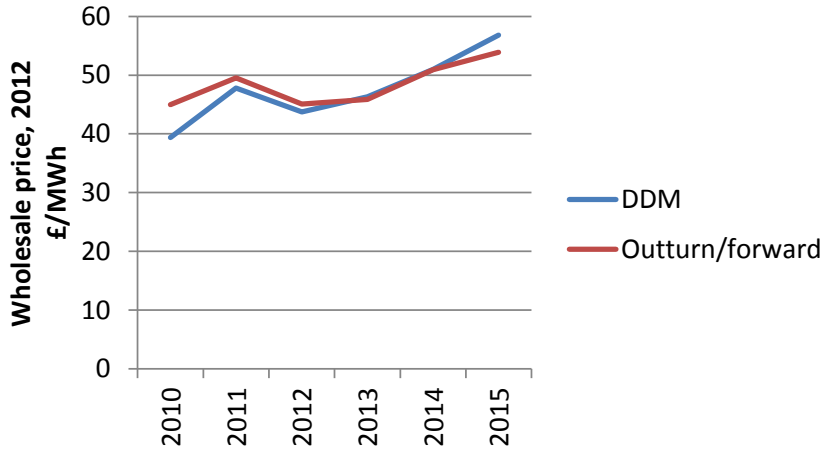

Figure 1. Comparison of baseload DDM price with the outturn/forward prices.

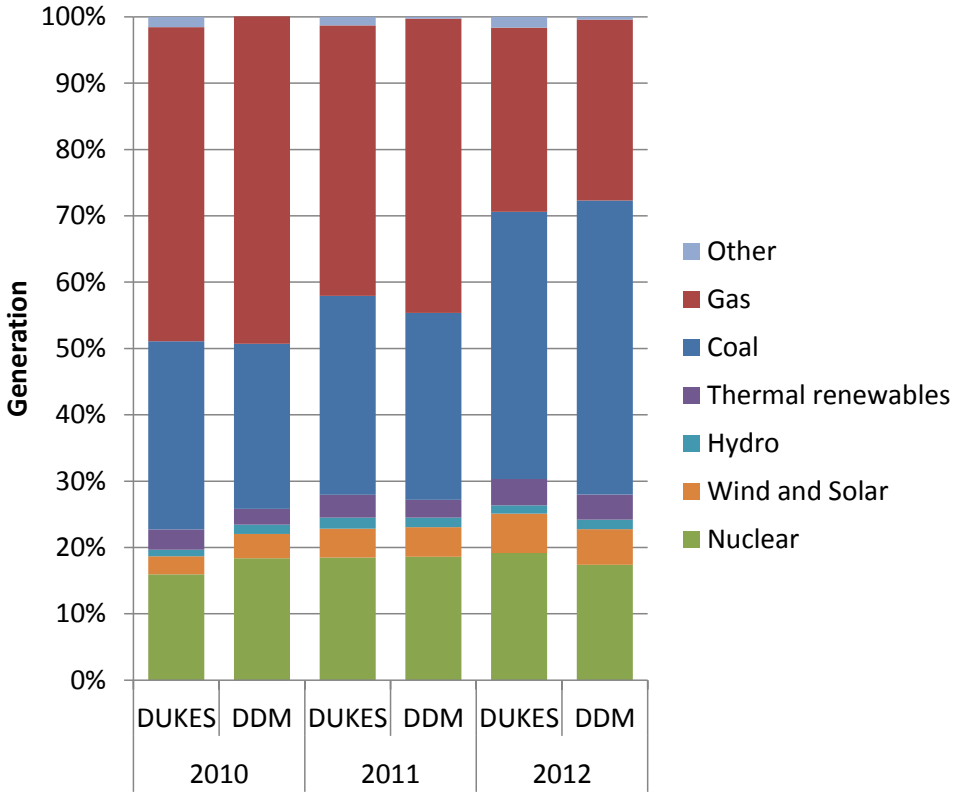

Figure 2. Comparison of outturn GB generation mix and DDM generation mix. DUKES GB figures derived from Table 5.6 (DUKES 2013), adjusted for Northern Ireland (using Energy Trends December 2012, assuming that Northern Ireland generation in 2012 was the same as 2011).

17. Figure 2 and Figure 3 demonstrate that the prices and generation mix modelled by the DDM are close to that observed historically. The DDM is a medium to long term projections tool. When back-casting it is difficult to account for seasonal variation in demand, fossil fuel prices and weather that is different to the historical average. Modelling of specific historic plant outages (which can sometimes have a significant impact on the generation mix) is also difficult.

National Grid testing

18. See paragraphs 40-43.

Code review

19. Key sections of the DDM code have recently been reviewed by PwC. This review concentrated on the investment decision modelling within the DDM. The review found one very minor issue in the code, which was not having any impact on the output.

20. Following this initial review, DECC has commissioned PwC to extend their work to cover all of the model code.

Documentation of changes to the model

21. DECC maintains details of all changes to the model, and strict version control is used. This is being collated, along with other quality assurance documentation to create a log of all changes to the model. The user documentation is periodically updated.

22. Over the last year some changes have been made to the DDM, which are summarised in Table 2. These changes are largely to allow DECC and National Grid to more accurately model EMR policies. It should be noted that these changes have no impact on strike prices.

Table 2. Changes to the DDM since the draft Delivery Plan.

Upgrade	Description
Create a demand curve for the capacity auction to target	The modelled auction previously set a fixed target to clear, based on peak demand for the year plus a user-defined capacity margin. The auction then cleared at the first plant past the target. This upgrade ensured that National Grid's modelling for the EMR Delivery Plan was in line with the proposals laid out in the most recent EMR: Capacity Market proposals for generating the demand curve. The new inputs are net CONE, maximum price cap, tolerance up and tolerance down (referring to a +/- capacity tolerance around the capacity target), all of which are allowed to vary by the auction's delivery year. From these user defined inputs, a demand curve can be generated. The auction now runs until the supply curve crosses the demand curve.
Basing the capacity target on LOLE rather than derated margin	Capacity mechanism modelling in the DDM was based on a capacity margin target (peak demand plus a required margin). Previously we have used the independent Unserved Energy Module (UEM) to calculate the annual Loss Of Load Expectation (LOLE) for any DDM output. This upgrade incorporated the UEM into the DDM so that the

	capacity mechanism could be based on a LOLE target in line with the policy intention rather than the capacity margin.
Specify when in the year decisions are made and plant come online	This upgrade allows the user to specify which quarter plants that are built come online. This affects variables such as policy costs, which were calculated based on the assumption that a plant was online all year. Build decisions are still made the same way as previously but the online date will be delayed accordingly. This will improve the accuracy of policy costs, enhancing the accuracy of National Grid's projections of the Levy Control Framework for the final EMR Delivery Plan.
Build limits based on technology groups	This upgrade allows the user to define build limits based on the technology group. These work alongside the current method of defining build limits by technology. The user has the option to define any number of groups with a technology being able to exist in more than one group. The model tracks build by group and checks the limit before making any build decision.
Ability to set a renewable percentage by technology that is used when calculating the support revenue	This replaces the binary modelling of a plant receiving support revenue or not, with a scale of support. The user is able to define a renewable percentage for each technology, and the plant then receives a CfD / ROC according to that percentage. This is then incorporated into calculating the plant's revenue and SRMC. This allows National Grid to better model waste fuelled technologies for the EMR Delivery Plan.
Improvements to outputs	Inclusion of time collapsed UEM output in the main EnVision run; additional CBA output metrics; retirement decision summary.

Future developments to the model

23. Following recommendations from the NAO[11], DECC will be considering how best to model potential strategic behaviour of generators. DECC will commission a review to design/recommend a suitable modelling approach early next year.

24. The EMR Delivery Plan Panel of Technical Experts commented[12] that the modelling would be improved by using the DDM's functionality to dispatch interconnectors based on price differentials between GB and interconnected markets. DECC is currently engaged on a project with Baringa, an output of which will be price series for interconnected markets. Once this data is received, it will be included in the DDM, and this functionality will be activated.

25. DECC will consider how the DDM could be made more transparent by the time of the 2014 EMR Annual update in late 2014.

[11] http://www.nao.org.uk/wp-content/uploads/2013/11/Volume-II1.pdf

[12] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223656/emr_consultation_annex_f.pdf

Quality assurance of model runs

Documentation

26. Documentation of the DDM comprises of a technical guide describing in detail how the model functions, and a user guide describing how model runs can be carried out, and detailing the various outputs available. These guides are updated periodically as developments are added to the DDM.

Model users

27. In DECC, only analysts with experience of using the DDM use the model unsupervised. When required, new users of the model undergo training, and are closely supervised by experienced users during their initial use of the DDM.

Quality assurance of outputs

28. Version control is used throughout the DDM, and applied to input templates, the model itself, and output templates. The version numbers of the DDM itself are automatically recorded, allowing verification that the correct version of the model has been used, and recreation of previous results.

29. Embedded within DDM input files is a tool which highlights any changes that have been made from a defined reference input file. This facilitates checking that changes made are based on appropriate assumptions and have been implemented correctly, and provides an audit log of which changes have been made and why.

30. Outputs from a model run are compared with a known reference case, with graphs produced of differences in key metrics. This allows easy examination of whether the changes in the output reflect the changes made to the inputs.

31. All outputs from the DDM are quality assured by an analyst who was not involved in the run itself. This quality assurance takes the form of a checklist, focussing on key output metrics, and the input file (and hence input data and assumptions), which is completed for each run. Following completion of this checklist, analysts will discuss any issues, and where necessary repeat the run with the changes identified. The checklist used for this process is included in Appendix A.

32. In the case of the scenarios for the final Delivery Plan, scenarios were run by National Grid, and quality assured by DECC.

Quality assurance of the RO equivalent strike price calculations

33. Annex B of the EMR Delivery Plan[13] describes the calculations used to determine the RO equivalent ('RO-X') strike prices, used for the first years of CfD availability (2014/15 to 2016/17). These calculations were implemented in a spreadsheet tool.

Data and assumptions

34. All data and assumptions used in the RO-X calculations are consistent with those used in the DDM, and are subject to the same governance and QA processes (see paragraph 4).

Quality assurance of the spreadsheet tool and outputs.

35. At the time of the draft Delivery Plan, the logic of the spreadsheet tool was verified by a separate team of analysts within DECC.

[13] See Annex B, https://www.gov.uk/government/publications/electricity-market-reform-delivery-plan

36. The outputs of the spreadsheet tool have been validated by independent analysts within DECC. As the outputs were used as the basis for the consultation on strike prices in the draft EMR Delivery Plan, they have also been examined widely.

37. Although many consultation responses disagreed with the final strike prices presented, the vast majority disagreed with the underlying assumptions rather than the calculation itself. The few consultation responses that reproduced the calculation, obtained very similar results to those contained in the draft Delivery Plan when using DECC inputs.

38. Since the draft Delivery Plan, the strike price tool has been formally reviewed by DECC's Modelling Integrity team. The review found that the 'model achieves the design purpose' and that there were 'no critical issues with the implementation of the methodology'.

Extension of the spreadsheet tool to model Northern Ireland deployment

39. For the final Delivery Plan, the spreadsheet tool was extended to allow the modelling of Northern Ireland deployment under CfDs. This extension was verified by analysts within DECC, and by National Grid analysts.

The role of National Grid in Quality Assurance

Specification of model developments

40. DECC and National Grid worked closely together when considering how best to develop the DDM for the final Delivery Plan analysis, and specifying the work to be done.

Network modelling

41. For the draft Delivery Plan analysis, National Grid added a module to the DDM to enable the calculation of TNUoS, BSUoS and other costs of system operation. For the final Delivery Plan, this module has been further refined.

Testing of developments

42. As a complement to DECC's testing of DDM developments, National Grid also carried out functional testing of the model, to ensure that the developments provided by the contractors were producing the expected results.

Data and assumptions

43. As system operator National Grid's access to detailed data, market intelligence and networks expertise enabled them to provide a range of data and assumptions, and to validate assumptions provided by DECC.

Appendix A – Quality assurance of model outputs checklist

Run name:			**Run by:**	**QA by:**
Counterfactual:				
OUTPUTS				
Capacity	*Enter QA comments here*			Expected?
Generation				Expected?
Meeting 2020 constraints?		Run	Counterfactual	
	LCF spend, £m			Yes?
	Renewable %			
New Build				Expected?
Retirements				Expected?
Prices				Expected?
Emissions				Expected?
Meeting 2030/2040/2049 decarbonisation ambition?		Run	Counterfactual	Yes?
	2030			
	2040			
	2049			
Capacity Margin				Expected?
Emissions Factor				Expected?
Policy Costs				Expected?
INPUTS				
Fossil Fuel Price/Demand	-			Correct?
Carbon Price	-			Correct?
Policies – New				Correct?
Policies –Existing	-			Correct?
Max build limits (FOAK/NOAK)	-			Correct?
Pipeline	-			Correct?
Existing plant	-			Correct?
Contents and Policy validated	-			Correct?
CBA				
				Expected?

Department of Energy & Climate Change
3 Whitehall Place
London SW1A 2AW
www.gov.uk/decc
URN 13D/343