Department for
Energy Security
& Net Zero

Quality Assurance

Guidance for models

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1. Introduction

Quality Assurance (QA) plays an essential part in any Analytical Project. Effective QA ensures that decisions are made with an appropriate understanding of evidence and risks, and helps analysts ensure the integrity of the analytical output.

The key objective of a systematic QA process is to ensure that policy decisions are underpinned by a sound understanding of all relevant evidence, including associated risks and uncertainties.

This guide aims to clearly set out the steps required to QA both new and existing DESNZ models, including those developed by third parties. It should be used to ensure that the model in question has been proportionately quality assured, with supporting documentation and evidence to demonstrate this.

Note that this document is intended mainly for use within DESNZ so many of the links are to documents only accessible through DESNZ internal systems. If you require access to any of the documents referenced here please contact the DESNZ Modelling Integrity Team: ModellingIntegrity@energysecurity.gov.uk**.**

1.1 How to use this guidance document

1.1.1 All models

For all models you must refer to the QA log, which needs to be completed for the model.

1.1.2 New models

If you are developing a new model you should review Section 2: Quality Assurance through the model cycle. This gives guidance on the Quality Assurance processes you should be embedding into each stage of the model cycle.

When developing a new model, first email the DESNZ Modelling Integrity Team (ModellingIntegrity@energysecurity.gov.uk), who will be able to advise on any of the information contained within this guidance.

1.1.3 Existing models

If you are quality assuring an existing model you should review Section 3: Performing and Recording your Quality Assurance. This describes Quality Assurance and testing procedures for an existing model.

1.1.4 Third party

If you are procuring a model, or any evidence, from a third party you should review Section 4: QA of Third Party Models. This section gives guidance on how to ensure that your procurement exercise includes the appropriate Quality Assurance requirements.

1.1.5 Models in languages other than Excel

Much guidance in this document is specific to Excel models. If you have any questions about non-Excel models that are not answered here please refer to the non-Excel QA log or contact the Modelling Integrity Team.

1.2 Quality Assurance and models

There is no hard and fast definition for what a computational model is and how this differs from a calculation. The cross Whitehall definition of a model is as follows:

> *"A model is defined as a set of calculations, assumptions, or mathematical manipulations that supports a key business decision, including structured sets of assumptions about how some system operates which represent stakeholders' shared understanding of that system. This might in practice have more than one element of modelling (e.g. it might be a number of different spreadsheets, or a mind map or system thinking map with some calculations) but a cluster of such elements supporting a single set of decisions should be treated as a single model where possible."*

This definition covers large simulations such as projections for policies, but also internal DESNZ spreadsheets, or toolkits, such as for tax revenues from North Sea oil and HR.

An additional distinction between toolkits and models is:

- For a toolkit, if the input data are correct and the mathematical formulae are correct, the output will be fit for purpose.
- For a model, if the input data are correct and the mathematical formulae are correct, the output may still not be fit for purpose because a model has an element of approximation, abstraction, or conceptualisation of reality that may be flawed.

The key outcomes from any Quality Assurance exercise are that the deliverable should be:

1. **Fit for purpose**, with purpose defined as part of the scoping process.
2. **Reliable and accurate**, as far as this is possible.
3. **Transparent and accountable**. The deliverable should be fully approved, have an audit trail and be reproducible.

Proportionality to the business criticality of the model is also necessary when considering the level of Quality Assurance to apply. The definition of a business- critical model will be different in different departments. More details on proportionality of testing can be found in this section.

1.3 Accountability for Quality Assurance

This section outlines the accountabilities for QA across DESNZ.

There is an explicit distinction between responsibilities and accountabilities. Responsibility is carried by the individual who carries out the task and can be shared by the accountable person, who is ultimately answerable for the activity being completed.

Commissioner (formerly Senior Responsible Owner (SRO))

Responsibilities

- Considering the advice provided in the QA Clearance Statement from the Assurer/Approver into the overall decision to use the analysis or evidence

Accountabilities

- Holds overall accountability for the success of the programme and for ensuring the full range of evidence needs have been identified, that relevant evidence has been obtained and decisions are taken understanding the limitations of the evidence.
- Achieved through securing resources, delegating responsibility for QA, and ensuring risks are logged, escalated, and managed.

Approver (formerly Approving Body)

Responsibilities

- For complex or high-risk analysis, advise the commissioner of the evidence requirement and on the quality of the evidence and risks on the advice of the assurer.

Accountabilities

- Accountable for the advice they provide and clearance statement they produce.

Assurer (formerly Senior Analyst)

Responsibilities

- Responsible for signing-off analysis plans: scope, timings and engaging with analytical disciplines.
- Responsible for clearing the analysis (in consultation with other analytical leads where appropriate) prior to submitting to the Commissioner or Approver.
- Responsible for advising the Commissioner and Lead Analyst on evidence requirements and on the quality of the evidence and risks.

Accountabilities

- Accountable for the advice they provide and the clearance statements they produce.

Lead Analyst (formerly Project Manager)

Responsibilities

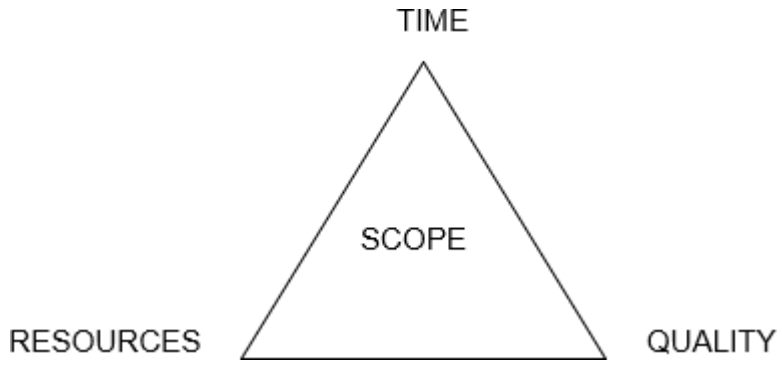
- Responsible for planning QA, agreeing these plans with the Assurer, and ensuring that QA takes place. Responsible for managing the outcomes of the review process and for recording analytical risks.

- The Lead Analyst may delegate these QA responsibilities, which will often be to an analyst.
- The Lead Analyst can also be the analyst; however, they must ensure that QA, and other responsibilities are done by different individuals.
- Generally, the main contact point with the modelling integrity team Accountabilities
- Accountable for the advice they provide.

1.4 The importance of quality

Quality is one of three, often competing, attributes of all project deliverables; cost and time being the other two.

Figure 1: The quality triangle



Concentrating on any one attribute may give rise to trade-offs with the others. For instance, higher quality may mean more time and cost to produce, though this is not always the case. Whereas it is usual to comment on Timescales and Cost, at least in terms of resources, within the early scoping documents, the required Quality should also be defined at this stage.

Given the constraints of resources and time it is important that QA activities are prioritised based on the risk of not undertaking them. In DESNZ, time is often an issue and QA frequently suffers as a result because this part of the process is usually left to the end. It is important that quality processes are embedded at the very beginning of the modelling project and are therefore adequately addressed in the project plan, which is the responsibility of the Lead Analyst. It is worth noting that this process can save time overall, especially if multiple developers work on the same model. Though it may take up to 5% longer to set up the model, the template leads to a potential saving of 15% in familiarisation times and 20% in QA time.

In line with AQuA book principles, analysis should be done with **RIGOUR**: Repeatable, Independent, Grounded in reality, Objective, have understood and managed Uncertainty and that results should address the initial question Robustly. It is important to accept that uncertainty is inherent within the inputs and outputs of any piece of analysis.

2. Quality Assurance through the model cycle

2.1 The model cycle

When developing a new model, QA must be embedded throughout the model cycle. Below is a checklist of what you must consider, including tools and templates to help you do this.

If you are Quality Assuring an existing model this guidance will still be useful, but you may want to look first at Section 4: Quality Assurance Review.

Figure 2 shows a visualisation of a modelling cycle, and the individual sections are detailed further below.

Figure 2: A visual representation of the model creation cycle

2.2 New model QA checklist

This process is a cycle and following review further iterations should be carried out as required, with QA documented throughout. The QA log is the central place for recording reference to this material; or to record the activity if the model is sufficiently small.

QA stage	What do I need to do?	Templates/ Documentation	Evidence and analysis stage
Scope	Agree the scope of the model with a broad range of stakeholders.	Scope development Checklist DESNZ Model Report Template	Plan
Specify	Turn the scoping exercise into a functional specification for the model including an outline design.	DESNZ Model Report Template	Plan
QA Planning	Write a QA Plan to enact throughout the model cycle.	QA Log (Excel or non Excel)	Plan
Design & Build	Design then build the model using the approved Excel template (if in Excel). Follow the best practice for development outlined in Section 2.6.	DESNZ Quality Assurance (QA) modelling: Excel template	N/A
Populate	Populate your model with relevant data and assumptions in a transparent and traceable manner.	Assumptions log template	N/A
Test	Embed automated error checking in the model. Fully Quality Assure the model at this stage using the QA Log. Provide a report on the QA done.	QA Log (Excel or non Excel)	Expert Review
Clearance	Decide appropriate clearance level for the model.	Clearance Statement (optional)	Analytical clearance
Sign off	Final sign off on the use of the model and its outputs.	Clearance Statement (optional)	Approval/ Sign off
Use	Be clear about how the model should be used. Continue to log any errors, keep a run log, use appropriate version and change control.	Issues log within the QA Log	N/A
Review	Review the model against the original specification. Refresh if necessary and determine timeline for further model development.		N/A

QA stage	What do I need to do?	Templates/ Documentation	Evidence and analysis stage
Document	Documentation should be produced throughout the cycle. A list of documentation your model should have been provided in this section.	Appendix A gives a list of the documents your model should have	N/A
Communicate	Communication to relevant stakeholders must happen throughout the above cycle.		N/A

2.3 Scope

The aim of a model scoping exercise is to bring together modellers, assurers, customers and other stakeholders to think comprehensively about the task before the project begins. This will help to provide a common understanding of what the model will and will not do ("acceptability criteria") given time and resource constraints[1].

There is a scope development checklist available on gov.uk.

2.4 Specify

A model specification should be agreed to cover requirements relating to timescales, resource, key inputs, functionality and outputs, a brief model design, level of accuracy and some initial agreement around the QA to be deployed for the project.

A key component of model specification is to decide the software/language that is going to be used to create the model. This should consider the capabilities of the end- users and the constraints (e.g. available Information Technology, learning curve) of the options. Before starting work on an Excel model, you should consider whether the model may become too large to run on a standard laptop.

This document should be agreed in writing so that those involved can refer to it in future. This can be in the Model Report Template.

2.5 QA planning

Quality Assurance should be embedded at every stage of the model cycle as outlined in section 2.1. The QA plan is the responsibility of the Lead Analyst or a delegated analyst and should include:

- An overview of QA activities you intend to carry out at each stage of the model cycle, with timings as appropriate.
- The identity of the roles

[1] See Figure 1: The quality triangle

- A list of analytical professions, with potential names, who will be best placed to QA various aspects of the model.
- Details of the documentation you will provide as a record of QA activities, which should include a mandatory QA log as a bare minimum.
- An outline of the governance structure of the evidence you will be providing, including arrangements for the final sign-off for publication/use of analysis.

In DESNZ, the Lead Analyst will arrange and agree QA activities, and the Assurer must approve these plans. The Lead Analyst must also contact reviewers and Approvers (when appropriate) to request their input. **It is important to document and communicate what will and will not be covered in the QA process**. This will help to ensure that the resulting risks are appropriately factored into any decisions made.

For large, long-term projects, if the scope changes and a new specification is produced, the QA process will need to be reviewed and possibly redefined.

In parallel with a QA Plan, the completion of a QA log should commence at the start of the project and be completed during the model cycle. This will assist with developing a robust model as well as any future auditing activities. It is important to review this document at the planning stage as it will need to be filled in throughout development and especially at the testing stage. All DESNZ models should aim for a model score of 90% for business critical models and 85% for non-business critical models as assessed within the QA log. It is therefore extremely important to understand what is required to do this prior to commencing development.

2.6 Design and Build

Design: You need to decide the type of model required (i.e. methodology), and the data that will be needed to populate it. It may be useful to hold brainstorming sessions amongst analysts to determine the most appropriate solution. At least some of this should have taken place at the scope and specification stages.

Take extra care when reusing an existing model to determine whether the assumptions are applicable, and the outputs are suitable for the new use. Checking the existing model's specification document should help you understand its intended use.

It may also be useful to develop a small pilot model to determine if the proposed methodology is appropriate. Regression tests can be designed at this stage to aid the developer understand the impact of changes to the model during the build phase.

Build: This is the technical development of the model. Models should be built in a transparent and logical fashion. How this is implemented will differ for different types of models, but some general principles will apply to all types of models.

The DESNZ Excel Model Template will aid and assist the model building process.

Version History: It should be clear which version of the model an analyst is working on and what has changed since previous versions. Version control is particularly important where your model is based on a suite of separate components, such as several Excel Spreadsheets.

Version control of a model may need to be separated from version control of model runs. This is because development of a model and the log of runs/scenarios may be two separate processes, requiring separate documentation to enable change control.

Calculation flow: Calculations should where possible follow a logical structured flow. Avoid the use of unnamed constants and variables. Comment all exceptions.

Inputs, Calculations & Outputs: Should be easily identifiable. Consider protecting parts of the model if it is being handed over to a customer to ensure that only inputs inside a valid range are allowed.

Data Protection: Certain models may use sensitive data sources. It is essential that the appropriate data protection procedures are followed.

2.7 Populate

At this stage, the model is populated with the key data and assumptions that underlie the core methodology.

It is important to ensure that all data sets used are correctly sourced and that assumptions are clearly stated and logged, with a RAG rating – see the section on Data and Assumptions for more information on this. It is also important to check that there are no errors in importing or transforming data, and that all data transformations are clearly documented. This leaves a clear audit trail should the assumptions be questioned at a later date and also allows them to be easily shared for verification by peer review. There should be enough information to recreate the formatted data.

DESNZ has a template for an Assumptions log.

2.8 Test

Quality assuring an existing model involves completing a QA log with the aim that the model achieves a score of 85% or 90% or above according to the weighted criteria set out in the DESNZ QA log. These criteria fall into 5 key areas:

- Documentation;
- Structure & Clarity;
- Verification;
- Validation; and
- Data & Assumptions.

If you have followed this guidance the model should score highly in the Documentation, Structure and Clarity and Data and Assumptions sections, but now is the time to check if you have missed anything crucial.

The remaining sections of the QA log relate to testing the model through a variety of Validation and Verification exercises.

The testing phase requires independent scrutiny of the evidence and analysis by QA reviewers. The type and extent of testing is agreed between the Lead Analyst and the Assurer and depends on the complexity and risk of the project.

It is the responsibility of the Lead Analyst to record details of the review process.

2.9 Analytic Clearance

This is a statement from the Assurer to the Approver/Approving body on the fitness for purpose of the model and its outputs and must express an understanding of the risks and limitations of the evidence, including an expression of the extent of the QA that has taken place. It may use the Clearance Statement template but may also be recorded via e-mail or minutes of a meeting. The Lead Analyst must ensure that the Assurer provides this clearance decision. The statement should reflect the outputs of the QA process. The clearance decision does not require full fresh scrutiny of each small detail but instead is an explicit record of the assurance the product has been subjected to, based on the QA log and comments received from the testing process. The statement must include at a minimum:

- A description of the objective, decision, or publication the analysis feeds into
- The scope, type and level of QA that has been undertaken.
- The key outstanding risks, uncertainties, and issues with the model. Any significant remaining risks around quality must be clearly communicated to the approver.
- A concluding and substantiated statement of whether the model and its outputs are fit for purpose and a recommendation for clearance/approval.

The detail and complexity of the clearance statement depends on

- The complexity of the evidence
- The risks and limitations associated with the analytical product
- The decision it underpins

2.10 Final approval / sign-off

This is the final agreement that the model is fit for purpose and must come after clearance. The decision will factor in the advice of the Assurer from the clearance stage. It will also factor in wider considerations beyond the analytical quality: while the clearance stage establishes the level of confidence in the analysis, the approval stage focuses on the appropriateness of the analysis for its intended use. In routine cases, these two stages will be combined and carried out by the Assurer i.e. when advice from the Assurer is sufficient for the Commissioner to have confidence in the use of the product, and there are no significant risks in the evidence/analysis.

The Assurer may require a more senior analyst or body of experts, an Approver, if the model is complex and has greater evidence risks. The purpose of this is to determine if the analytical product is a strategic fit or to address issues of consistency in approach or evidence. In many

cases, the Approver will be an existing group such as a Programme Board or Projects & Investments Committee.

The sign-off decision must factor in advice from the Assurer, but may also include the wider considerations above, such as any strategic factors, trade-offs among objectives and risks. Sections 3 and 4 of the QA of Evidence and Analysis document provide detail on QA accountabilities and processes.

Additionally, it is important that signoff is reconfirmed if the analysis, or the supporting model, is subsequently used for a different purpose than originally intended.

The Assurer is responsible for reporting the key risks to the Commissioner. If the Assurer feels that the risks highlighted by the QA process are not being appropriately addressed, it is their responsibility to escalate the risk to Line Management and the relevant Head of Profession.

2.11 Use

The QA process should continue even if the model has been designated as 'fit for purpose'. Quality Assurance at this stage involves:

- Ensuring the model is used as intended, with the relevant context and caveats included.
- Logging any errors or bugs that become apparent in an issues log.[2]
- Ensuring a run log is kept so that the variables used for each run are traceable.
- Recording any areas for improvement that could be implemented when reviewing the suitability of the model.
- Ensure data sets and assumptions are kept up to date.

2.12 Review

Project reviews should include comparing the model with the original specification to complete the modelling cycle. The review can be used to agree with the customer that the model can be handed over and/or to determine timelines for further model development. **Reviews should capture lessons learned, feedback and suggestions on model improvement.** Future reviews of the model should be planned in for maintaining and upgrading the model. Reasons for this could include data refreshes, structural changes, changes in assumptions, different modelling techniques etc.

Following a review, proportionate reuse of necessary stages of the whole cycle may start again. Ensure that relevant sections of documents, particularly the QA Log's Issues and QA History tabs and the Model Report Sections 1, 2 and subsection 4.9, record changes to the model software to provide clear evidence of what changes have been made and who approved these. The first of these should be to revisit the specification document.

[2] An issues log can be found within the QA log

2.13 Document

Good documentation allows the developer to keep track of the all the QA procedures that must be carried out. Secondly, it is also highly likely that at some point a model that one develops will be handed over to either another analyst or onto a non-technical customer and it is important that the documentation exists to allow the required knowledge transfer. Finally, it is always possible that a model may be audited either internally or by an external body such as the National Audit Office. Passing an audit is more about showing that the right processes have been followed, rather than having to prove that the model is correct. As such it is essential that the required documentation is in place.

A QA log is always required to document the technical QA of a model; however, the range of documentation that is used to assist a user or developer can vary. For some smaller spreadsheet-based models, much of the documentation can be included in the model itself as comments. Larger models may require a series of stand-alone documents.

All analysis should have documentation for the user, even if it is just the analyst leading the analysis. This is to ensure that they have captured sufficient material to assist them if the analysis is revisited in due course.

For analysis that is more likely to be revisited or updated in the future, documentation should be provided to assist a future analyst and should be more comprehensive. This documentation should include a summary of the analysis including the context to the question being asked, what analytical methods were considered, what analysis was planned and why, what challenges were encountered and how they were overcome and what verification and validation steps were performed. In addition, guidance on what should be considered if the analysis is to be revisited or updated is beneficial.

A full list of model documentation is given in Appendix A.

2.14 Communicate

Communication throughout the model cycle is critical to ensure there is alignment:

- Within modelling teams, to ensure the agreed versioning system is kept to, changes and errors are logged centrally, and learning is shared.
- Between modellers and Commissioners to ensure risks are flagged and any changes to timelines can be managed.
- Between modellers and policy colleagues, to discuss changes to the scope of the model or policy timescales.

2.14.1 Communicating uncertainty

Communicating uncertainty disseminates analytical risks and unknowns in a piece of analysis and its outputs to customers and decision makers. It is an essential part of making effective policy. Typically, this communication will start with the Lead Analyst, but it should continue by anyone using or communicating the analysis and its outputs.

- Make sure to communicate uncertainty in methodology, as well as data and assumptions.
- Present a range of results as opposed to a point estimate.
- Tailor communication based on the purpose and audience.
- Carry out thorough scenario and sensitivity analysis, not just focusing on individual uncertainties in isolation.

How you communicate uncertainty will not change depending on the size of the project but how you manage uncertainty will, for example in larger projects you may focus more on identifying uncertainties and making efforts to minimise the risk of these. It might be worthwhile to share with customers some of the following documents:

- Data registers.
- Assumptions registers.
- Sensitivity analysis.

2.14.2 Knowledge Management

To facilitate the transfer and dissemination of knowledge through the model cycle, all documents, where appropriate, should be made accessible in a file structure that is clear and easy to navigate.

The Modelling Integrity Team maintains a tracking log of models used within DESNZ. The model's entry is kept up-to-date and reviewed regularly to ensure that the information contained is still relevant.

For the Modelling Integrity Team to properly monitor the QA status of models within DESNZ, we require permission to access the QA log, which should be confirmed in the discussion between the analyst team and the Modelling Integrity Team.

Where issues emerge with analysis the Lead Analyst should inform their Line Manager. Where the issue can not be addressed locally it should be communicated to the Assurer, Approver and Commissioner so that residual evidence risk is understood by the Commissioner.

3 Performing and Recording your Quality Assurance

This section describes the tests that should be applied to quality assure a model in DESNZ.

This guidance should be used in parallel with the DESNZ QA log and relates to the following QA criteria:

- Documentation;
- Structure & Clarity;
- Verification;
- Validation; and
- Data & Assumptions.

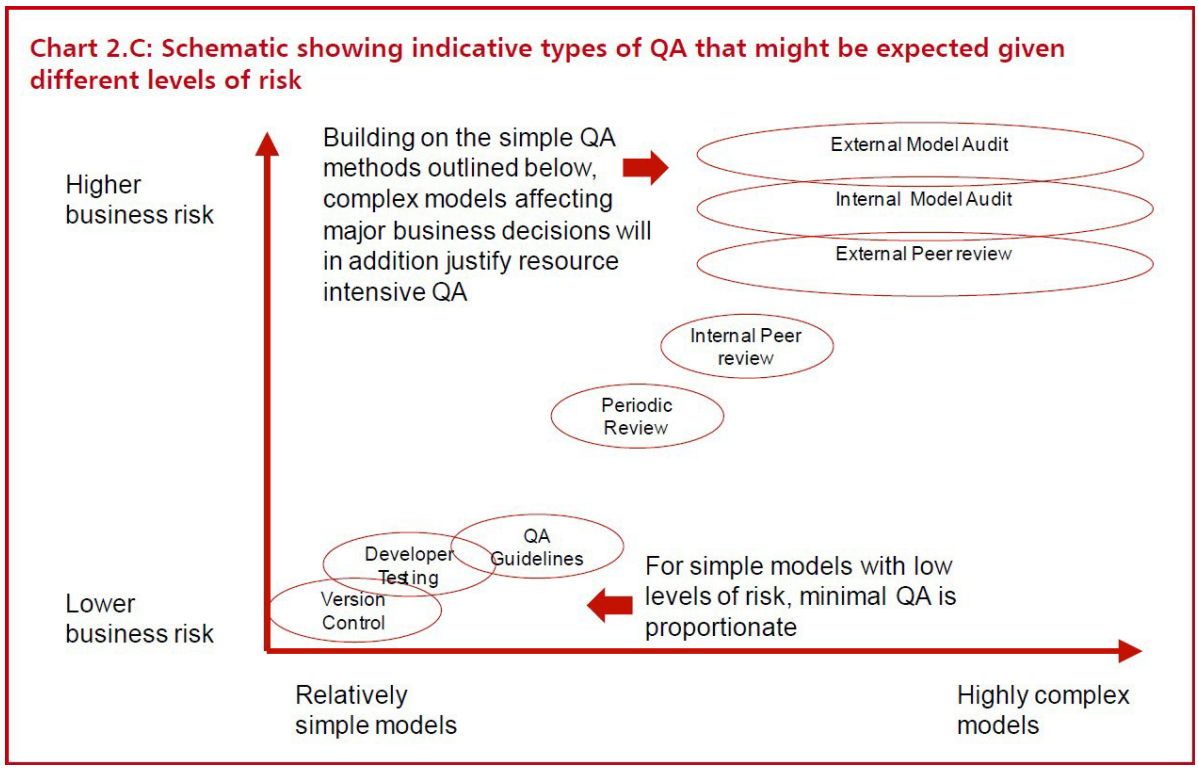
3.1 Testing methodology

3.1.1 How much testing should you do?

The levels of assurance carried out should be proportionate to the business criticality of the model. This should be agreed and signed off at the planning stage by the Senior Analyst. These levels are provided as a guide; however, a mix-and- match approach can be taken as necessary.

Figure 3 is taken from the HM Treasury report: Review of quality assurance of Government analytical models, and provides a schematic overview of the types of QA that may be expected to happen, given a model's risks. This should be used as a guide for the type and scale of QA that is necessary for your own model.

Figure 3: Schematic of types of QA, taken from "Review of quality assurance of Government analytical models"[3]



At the lowest, the QA review will involve sense-checking by a nearby colleague. At the highest level, this will involve a rigorous, formal, external expert peer review.

Table 1 outlines the **minimum testing that is advised** if you find yourself (the model developer) in the following time-bound situations. You should also consider how the model outputs will be used when making this decision, and the type of model and modelling approach when prioritising QA tasks.

Agree with the reviewer what checks have been performed and confirm this in writing, ideally within the model documentation itself.

It is the responsibility of the Assurer to challenge and agree to any QA plan to ensure they are sufficiently rigorous and to ensure any risks that exist from insufficient testing are recorded and communicated in the clearance and sign-off stages (see Section 3.2 on documenting QA).

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

Table 1: An overview of what QA should be performed within a variety of time constraints

Time available	Tests to be performed
0.5 days or less	• Perform a quick check on the modelling approach with another analyst or area expert. • Review basic Formula correctness and Code Correctness by looking for errors within cells. • Perform basic Sensitivity and scenario testing to broadly assess the behaviour of the model i.e. magnitude and direction of travel. • Sense check outputs against similar models or historical analysis – are policy experts surprised by the results? • Check that the output sheets are clearly labelled; contain units, and clearly list strengths and limitations. • Communicate that the model has not been fully QA'd in a clearance statement.

0.5 – 2 days	• Perform all tasks above.
	• Validate the methodology correctness.
	• Review Formula correctness by using Spreadsheet Debug software to create a model map to spot formula errors.
	• Use Adam Slim's Modelling Toolkit to produce a worksheet interaction map to check if they are logical.
	• Review any critical areas of code to determine their correctness.
	• Perform focussed QA of high-risk formulae/areas as defined by the model owner. Consider the following points when doing this:
	  • Prioritise given available time
	  • Think about end-to-end calculations for a small sample
	  • Check unit conversions
	  • Check a sample of external links to ensure that data is pulled through correctly
	• Review:
	  • Version control
	  • Data log including sign-off
	  • Assumptions log including sign-off
	  • Labels, Units & Conversions

2 – 5 days	• Perform all tasks above.
	• Perform some basic Validation on the outputs.
	• Review[4]:
	  • Scope document
	  • Specification document
	  • User guide
	  • Technical guide
	  • Usability testing
	  • Worksheet structure
	  • DESNZ Intranet page
	  • Formatting
	  • Workbook Comments
	  • Code Comments
	  • Formula clarity & robustness
	  • Named ranges management

[4] Review these in the following order as dictated by available time.

>= 5 days	• Perform all remaining tests within this section of the QA Guidance to their fullest extent possible, in conjunction with a full review of the QA Log.

In circumstances where there are significant time-constraints and QA activities that would normally be considered appropriate cannot be performed:

- Verification and validation efforts should focus on those areas of the analysis that are likely to have the largest impact on the analytical output and that are associated with the greatest risk.
- The analysis should be communicated with appropriate caveats outlining what has, and importantly, has not been through verification or validation together with a practical interpretation of the associated risk.
- When time allows, further assurance activities should be performed after the event to capture lessons learnt.

The guiding principle is that all policy decisions must be made with a full understanding of the risks and limitations of the evidence, including an understanding of the QA that has or has not taken place.

The clearance and approval/sign off stages must reflect these constraints. The Lead Analyst **must record evidence and analysis risk** in the relevant risk register. The Assurer is responsible for making clear in their clearance statement the limitation of the review process and highlights the remaining risks around the analysis.

3.1.2 Who should carry out model testing?

As a minimum, and before a model is independently tested, it must be tested by the modeller. The purpose of self-testing is to ensure that the maximum useful output from the independent reviewer can be obtained. This can be thought of as “model proof-reading”. Documented evidence of this must be shown, both within the model itself, in terms of data and assumptions logs, model flow sheets etc, and in the QA log for the model.

It is essential that more detailed testing is conducted independently i.e. by someone who was not directly involved with the development. This is because they can provide a fresh perspective and potentially discover issues that were overlooked by the original model developers. Ideally an individual who has the required skills in both the technique and the subject matter should be identified and approached well in advance of the time they will be required.

In many situations, it is difficult to find someone with such skills and therefore compromise happens by having some of the QA performed by the model builder themselves or by another member of the team while an external reviewer is used to test certain aspects of model such as assumptions or exploratory tests. The risk of missing an error by self-performing the QA is lowered if all the testing has been adequately documented and reviewed / audited.

If appropriate, the project team, including your customer, should consider external QA[5]. Section 2.2 of the QA of Evidence and Analysis document gives further detail on QA options.

Details on the Modelling Integrity Network, which can be used to find an Assuring Analyst for a model, can be found in Section 3.1.3.

Expertise from other analytical disciplines. Some aspects of a model will require expertise from other disciplines. For example, performance data for certain technologies will need scientific or engineering approval. You should consult with colleagues with the appropriate expertise.

3.1.3 Modelling Integrity Network

The concept of an independent pair of eyes is important in ensuring a model has been properly quality assured.

The Modelling Integrity Network (MIN) is a resource with which you can find a DESNZ analyst to act as an independent assuring analyst.

Access to the network is via the Modelling Integrity Team. For large models with a detailed QA plan, contact should be made with the Modelling Integrity Team early in the model building cycle. This will allow time for an Assuring Analyst to be found and to plan the work.

When you contact the MIN, provide the name of the model, the estimated time required to review it and a draft version of the QA log completed by the model builder. These details will be sent to the MIN and, if a volunteer analyst if found, the Modelling Integrity Team will facilitate communication between the Assuring Analyst and the model builder.

The MIN works best for smaller models that require 1-3 days of effort from the Assuring Analyst. For larger models, finding someone in your team who is separate from the model building process early in the process ensures that an independent reviewer is available when needed.

For more information, contact the Modelling Integrity Team.

3.2 Documentation

A model may be developed over several years by a variety of developers and can be at risk of a lack of or inconsistent documentation.

Documentation is critical for allowing the transfer of knowledge from developers to users, auditors, and future developers. No or limited documentation to explain the analysis or model may result in inappropriate use or inappropriate adoption for a new problem. Having an agreed scope & specification ensures that modellers, customers and other stakeholders understand what the model will and will not do ("acceptability criteria"). It is wise to maintain up to date user guides and technical documentation, and to ensure that several staff are sufficiently well versed in a model to cope with any sudden departures or absences of key staff.

[5] See Figure 3: Schematic of types of QA, taken from “Review of quality assurance of Government analytical models”

Further to this, documentation should provide the Commissioner with evidence of model requirements, accountabilities, and risks.

It is important that effort spent on documentation is proportionate, and there are various ways in which good documentation can be achieved, including providing comments on the code in the model itself.

Testing whether a model has appropriate documentation involves reviewing the areas detailed below. The QA Log gives further details on the rating for each area, and the reference numbers within each of the following section headers will point towards the relevant section of the QA log.

3.2.1 Scope document (QA Log reference D1)

The scoping document for a model should provide an overview of the aims of the model, what function it is trying to fill and who the main stakeholders are. When testing the appropriateness of the scoping documentation the following should be considered:

- Does it set out clearly and comprehensively the scope of the model?
- Does it describe involvement of key stakeholders?
- Does it include details of sign off and clearance?
- Does it describe any limitations and exclusions?

The model report template can be used as a scoping document.

Note that the document should be proportionate. For a smaller model a short scoping note or email may be appropriate.

3.2.2 Specification document (QA Log Reference D2)

The specification documentation for a model should describe in detail how the model will try to answer the questions posed. When testing the appropriateness of the specification documentation the following should be considered:

- Does the model purpose and design match the specification document, or does it need to be updated?
- Does it describe the main data inputs, calculations, and outputs?
- Is there a model map/logic diagram setting out how the model will achieve its purpose?

The model report template can be used as a specification document.

Note that the document length should be proportionate. For a smaller model a short specification note, or email may be appropriate.

3.2.3 User guide (QA Log Reference D3)

The user guide should support independent use for a new model user who needs to run/operate the model and view outputs. It does not need to give details of the background

to the model methodology[6]. The user guide could be within the model or an external document accompanying the model; either way it should be easy to locate and up to date.

An excellent example of a user guides for a DESNZ model is the 2050 Calculator:

3.2.4 Technical guide (QA Log Reference D4)

The technical guide should explain the "nuts and bolts" of the model. This should be sufficiently clear to allow a model auditor or developer to understand how the model has been developed and to repeat the calculations if necessary.

3.2.5 Knowledge Management & Transparency (QA Log Reference D5)

The development of a model and the QA process associated with that will generate several documents, including but not limited to the documentation listed in 2.2. It is important to have a knowledge management system that is easily navigable, and all appropriate documents can be accessed.

The following information should be easily accessed by independent reviewers.

- Purpose and use – scope and specification documentation
- Business critical status
- Documentation mandated by QA policy
- Details of the governance/sign off structure and records of these processes
- The model file if appropriate

A Model Report is a useful document to use as a repository of the documentation for a model. It is useful as a knowledge management tool by collating all relevant information into a single place. This is especially useful for familiarisation.

3.2.6 Version control (QA Log Reference D6)

Testing that a model has sufficient version control involves making sure that the model has:

1. A clear system for version labelling
2. A version control log with clear documentation of the version history enables change control. It should be clear what has changed since previous versions and the distinction between a version and a scenario. An example Version log can be seen in the DESNZ Excel template.
3. Focus should be placed on models that rely on several components with separate development of each (such as a collection of Excel Spreadsheets).

3.2.7 Governance and Responsibilities (QA Log Reference D7)

It is important to check that the correct responsibilities and accountabilities, as laid out in the appropriate Evidence Framework, have been assigned and that the sign off process is complete. The DESNZ QA of Evidence and Analysis guidance defines the following roles, which should be assigned and clearly stated:

[6] For this see the following section on technical guides

- Commissioner (formerly SRO);
- Approver (formerly Approving Body);
- Assurer (formerly Senior Analyst); and
- Lead Analyst (formerly Project Analyst).

Data and assumptions should be signed off by the appropriate approving body. An evidence clearance statement should be available.

Risk management processes should be followed and documented with all relevant model risks identified, logged and escalated as necessary, and with appropriate mitigation actions put in place. A risk log template can be found within the DESNZ Excel template.

3.2.8 Model classification (QA Log Reference D8)

The tester should ensure that the model has been classified correctly. If classified as “Official”, this does not need to be explicitly stated. **If any other classification is necessary, including a caveat to the Official classification, this should be checked to ensure it is done correctly**. If the model uses sensitive data sources, the appropriate data protection procedures must be followed.

3.2.9 QA planning and resourcing (QA Log Reference D9)

An appropriate QA plan should be in place to ensure that sufficient resource, in terms of both quantity and skills, is acquired at the right points of the cycle(s) of the model. The QA resource should be proportional to the size, complexity, and frequency of use of the model. An assessment of business criticality can help with this. The QA plan should be recorded. The format of this will depend on the analysis but can be completed in the QA Plan tab of the QA Log.

The model assurer should also check that if there have been recommendations made in previous QA exercises these have been implemented.

3.3 Structure and Clarity

3.3.1 Model structure (QA Log Reference S1)

Excel models should read like a book: from left to right and top to bottom. Things to consider when reviewing a model’s structure include:

- Is a model map or influence matrix showing sheet interactions available?
- Is there a clear distinction between inputs, calculations and outputs and no unnecessary circularity across worksheets, i.e. if worksheet A refers to worksheet B then worksheet B should NOT refer to worksheet A?
- Does the model contain any data / structure / “clutter” which serve no apparent purpose?

Further information can be found at the following resources:

- Guidelines on best practice about structure can be found in the "Overview" sheet of the Excel Template.
    - An example of good structure is the 2050 Calculator model.
- A flow chart of the model structure.

3.3.2 Worksheet structure (QA Log Reference S2)

It should be possible to read the worksheets like a book (left to right, top to bottom). Questions to consider include:

- Are calculation flows within worksheet logical and easy to understand?
- Do similar worksheets have similar structures?
- Are similar tables laid out in similar way?
- Is the model free from anomalous calculation/label/text cells (No undocumented inconsistencies with formulae)?

3.3.3 Labels, Units & Conversions (QA Log Reference S3)

Every input, table and output must be labelled and contain the correct units. The sheet "Unit Conversion" in the DESNZ Excel template shows how to correctly perform unit conversions. Things to check during QA include:

- Are titles, labels, and units present, logical and accurate?
    - These checks should include charts, tables, and text.
- Is a table used to perform unit conversions?
- Is rounding performed in a clear and correct way?

3.3.4 Formatting (QA Log Reference S4)

Formatting provides an essential set of signposts to a user of a model by helping them understand the model, and how to interact with it.

- Does formatting clearly distinguish inputs, outputs and calculations, and aid understanding?
- Are the parts of the models currently not used or under development easily recognisable through formatting?
- Is it clear through formatting when data is taken from different sources?

3.3.5 Workbook Comments (QA Log Reference S5)

Workbook comments can be used in lieu of a user guide for a small model but should be clear and comprehensive regardless of model size. Several checks should be performed to confirm their correct implementation:

- Check that descriptive sheets are present and include the following:
    - cover sheet including version number.
    - contents illustrated as flowchart with hyperlinks.

- Is model sufficiently annotated with up to date comments?
- Are all data sources cited in the model?
- Are complex formulae sufficiently explained?
    - If formulae change midway through an array, row or column are there comments to state this has happened and why?
- Are there short descriptions of the content and logic of every sheet?

3.3.6 Code Comments (QA Reference S6)

As a rule, each line of the code should be commented. Things to look for include:

- Is there a description of what each macro/unit does?
- Is the code sufficiently and appropriately commented to allow someone with VBA/R/SAS/etc. knowledge to follow what is happening?
- Is the code implementing the policy in the correct way?

3.3.7 Formula clarity & robustness (QA Log Reference S7)

It is essential that formulae are clear to users. Formula clarity can be enhanced using “alt+enter” to break long equations over multiple lines. Spaces can also be added to assist users by indenting sections of an equation.

- Hardcoded values within formulae must be avoided as they are difficult to understand and often introduce errors.
- Robustness should be implemented using tables and functions like INDEX- MATCH.
- Are formulae easily understood?
- Are merged cells avoided for inputs, calculations, and outputs?

3.3.8 Named ranges management (QA Log Reference S8)

Named ranges (or tables), with an agreed naming convention, should be used extensively in the model as they are robust during model updates and easy to audit. They must be used in macros, as absolute cell references are not updated in the code when something is changed in the model.

You can check the Name Manager (Ctrl+F3) to ensure there are no corrupted names; external ranged names should not be used unless it is necessary, and the names should be meaningful and follow a common convention.

3.4 Verification

This section contains subsections with tasks that should be carried to out ensure that a model is implemented correctly. **Verification can be thought of as checking that the model is solving the equations correctly, as opposed to validation, which is about checking that the correct equations are being used.**

This part of reviewing a model is likely to take more time than any other task.

Some of the tasks in this section, and in the following Validation section can be argued to belong in the other section. This may happen as we have grouped the tasks thematically to avoid duplication of work on similar sections. Therefore, this section may not be fully aligned with the Macpherson/ISO 9000 definitions of verification and validation.

3.4.1 Formula correctness (QA Log Reference Ve1)

In theory, all formulae in a model need to be reviewed. In practice, models based on time series (i.e. periods across columns) are often constructed by using a formula in the first period and then copying this formula across all the columns to the right. Similarly, formulae can also be copied down to replicate formulae for items with the same logic. This functionality creates the concept of a “unique formula”.

Definition: A unique formula is one which has not been copied from an adjacent cell (either above or to the left). For example, a first period formula ,i.e. the first column in a profile of costs over several years, will normally be a unique formula, and all other formulae in the time series (row) will be copied formulae.

Ensure that none of the following errors exist in cell outputs:

- **#NULL!** : this is possibly caused by specifying two ranges that do not intersect as intended.
- **#DIV/0! :** caused by trying to divide a number by zero. Do not mask this using the generic ISERR function. Instead force a zero output if the denominator is zero. e.g. =if(A1 = 0, 0, A2/A1).
- **#VALUE!** : caused by a few possibilities, but typically when an operand in a formula is not consistent with the action being attempted – for example multiplying text by a number.
- **#REF!** : incorrect reference – generally caused by deletion of cell/row/columns.
- **#NAME?** : caused by using a non-recognised function. If using custom functions, check that you have included them in this workbook, and that all add- ins are working.
- **#NUM!** : caused by using a non-valid number to a function. E.g. using a negative number when only a positive works. e.g. =sqrt(-1).
- **#N/A! :** commonly caused by a lookup function not finding a value it is seeking.

When reviewing whether all formulae are correctly implemented the following points should be considered:

- Do all formulae refer to the correct cell?
- Have formulae been copied down and across as far as they should be?
- Are all formulae which refer to named ranges calling the correct range?
- Is the data being pulled into the calculation modules correctly?
- Do numbers apply to the correct period (e.g. the middle of the month/year versus the beginning/end)?

- Are financial year and calendar year data managed correctly?

Further detailed inspections include:

- Can you replicate model output by independently re-performing key calculations on sections of the model?
- Check formula functionality against the row and column titles - if is not clear what the formula is doing, then this indicates an implicit or undocumented assumption.
- Debugging software like Adam Slim's Modelling Toolkit can help spot potential errors.
    - Map the whole model and investigate any inconsistencies in formulae patterns.
- Check the Name Manager (ctrl+F3) to ensure all the range names are correct and cover the full range of cells necessary.

3.4.2 Usability Testing (QA Log Reference Ve2)

Usability testing aims to ensure that a user can easily perform the functions required to operate the model. Things to check include:

- Can a new user easily operate the model and view outputs?
- Do hyperlinks, macros, and buttons work?
- Is routine operation of the model smooth and free of bugs?
- Does the model open in an acceptable amount of time?
- Is the run-time of the model appropriate for the demand placed on the model and the complexity of what is being modelled?
- Have restrictions been implemented to avoid illogical input values?
- Have relevant cells been protected to avoid the user introducing unwanted changes?
- Have table titles been locked from editing?
- Can all user options be selected without generating errors or unexpected results?
- Do routines work without runtime errors?
- Are there buttons with dead links?

3.4.3 Code correctness (QA Log Reference Ve3)

Many Excel models use VBA (Visual Basic for Applications) code to automate procedures or perform more complex manipulations. Other non-Excel models will also use code, and the following review steps should be considered when reviewing the functionality of procedures:

- **Understand** (via documentation) the purpose of the code.
- **Review** the code logic to ensure that each operation or calculation corresponds to its stated purpose and functionality. This review should be appropriately evidenced by marking up or annotating the code listing or by separate work papers.
- "Step through" the code to inspect its operation.
- Consider using test inputs to test the output of packages of code.

- Be wary of cell references in macros. Unlike Excel, cell references in VBA do not automatically update when rows or columns are inserted. The procedure may work on the model in its current state, however, if the structure of the model changes, the cell references may result in incorrect results, or corrupt the model. Almost all procedures created using the macro recorder will contain hard-coded cell references.
    - This can be mitigated by using named ranges which will continue to refer to the correct cell, even if data is moved.
- In Excel, ensure all code is considered during the review. While the bulk of information will normally be contained in modules within the workbook, additional procedures may be contained in the Workbook object, Worksheet objects and Form objects.
- Only comment on code which can affect the output of the model. Many procedures are recorded to automate tasks such as printing. These do not normally impact the logical integrity of a model. On the other hand, procedures used to automate tasks such as “Goal Seek” involve modifying the actual data within the model and should therefore be reviewed carefully.
- Does the code function as intended without error, and produce the intended results?
- Are hard-coded references to cells used only when absolutely necessary?
    - If they are used, are they referring to the correct values?

3.4.4 External links (QA Log Reference Ve4)

External links can be both powerful and provide a more integrated user experience; however, they can also slow down a model and make it harder to QA the provenance of input data.

Additionally, if the source files are not under the control of the analyst creating the destination model, then a “service-agreement” may be necessary to ensure that important input data isn’t altered without warning[7].

External links need to be used proportionally and with suitable protection. A list of checks to be performed during QA includes:

- Are links to external documents used only when necessary?
- Are they properly documented?
- If external links are used, do they pull in the correct, up to date data?
    - Can the external data be 'refreshed'?
    - Open the file on a different machine to original to ensure no undocumented error messages occur.
- Check the external links to ensure the most up to date data is used.
    - This may involve requesting access to source files and engaging with owners of the data.

[7] This could range from an informal agreement between colleagues to a more formal agreement of the process required to ensure data is always available.

3.4.5 Auto-checks, Error trapping & Regression Testing (QA Log Reference Ve5)

Auto-checks and error traps are important QA procedures and should be designed to flag to model analysts and users that there may be an issue with data or the calculations that are being performed.

Look at the following aspects of auto-checks:

- Are auto-checks used to highlight correct functionality (e.g. a cell within Excel to highlight when all data is filled in)?
    - Are they implemented correctly?
- Are error-trapping auto-checks used in the model (e.g. conditional formatting for negative values, overall data sums when data is disaggregated in different ways)?
    - Are they implemented correctly?
- Check that auto-checks / error trapping produce expected results.
    - Repeat a handful of important calculations manually[8].

Regression testing is used to give a model developer confidence that errors are not introduced when the model undergoes development. This can be done by using a set of standard inbuilt tests within the model which can be run after model development work. Additionally, a reference set of data, formulae or outputs can be compared before and after model development to confirm that changes made have only had implications in the intended areas.

3.5 Validation

This section contains several subsections with tasks that should be carried to out ensure that a model reflecting the reality it is simulating as far as is possible.

Validation should be an integral part of the creation of a model, and analysts should always be asking themselves: “Is this model a suitable representation of what I am analysing?” Often this will mean that Subject Matter Experts (SMEs) are necessary to provide specialist guidance on whether this is successfully happening.

SMEs may come from any profession; however, within DESNZ will often be drawn from the following professions:

- Policy
- Economics
- Science
- Engineering
- Commercial
- Social Research

[8] E.g. confirm for critical auto-checks that flags for issues are capturing all the relevant data.

- Operational Research

This part of reviewing a model is more subjective than verification; however, it should not be ignored or given a lower status than other aspects of QA.

The following subsections provide a series of checks that should be performed to assist with the validation of a model.

3.5.2 Review of Methodology (QA Log Reference Va1)

A model can implement its equations perfectly, with zero errors, but if the underlying methodology is incorrect, or not adequate for the required purpose then the model is no better than one littered with equation errors.

Think about the following items when reviewing methodologies of models, and ensure engagement with appropriate SMEs:

- Is the methodology used sensible and fit for purpose?
    - "Purpose" should be agreed and defined in the model specification.
- Was the model methodology reviewed and agreed with relevant stakeholders?
- Does the model produce “logical” outputs?
    - Are they in the range of what would be expected?
    - Do the values change in expected direction, at an expected magnitude when inputs are changed?
- Have model outputs been sense / reality checked and agreed with relevant stakeholders?
- Check if the outputs are reasonable when selecting each different scenario.
- Review the model logic:
    - Check the actual flow of data through the model against a stylised example of how data is perceived to be flowing through the model.
    - Follow the evolution of the key model inputs across the model to understand how the data is transformed.
    - Check if the outputs of different scenarios (high, medium, low) are sensible.

3.5.3 Comparison with historical data / backcasting (QA Log Reference Va2)

Does the model match historical results when using historical input data, to within an agreed tolerance level?

- This could also include a cross-check of model outputs against an alternative set of data or model.

3.5.4 Sensitivity and scenario testing (QA Log Reference Va3)

Sensitivity and scenario testing involves checking the response of the model to changes in variables. For some models, this will be a core part of their design, and it is critical to ensure that results make sense and are logical. Perform the following checks:

- Run sensitivities on key variables that the model developer identifies as important and on more uncertain assumptions.
    - These should focus on reasonable changes according to the distribution of each variable being tested.
    - As a general guideline, focus on the range of -20%, -10%, -5%, +5%, +10%, +20% from the base case value for each item tested.
    - Specialist software can help with sensitivity testing and/or Monte Carlo analysis on cells in Excel models. Ask the Modelling Integrity Team if you are interested.
    - Where random sampling is used, is it as consistent as possible with real- world distributions?
- Select and evaluate some representative policy scenarios to check whether expected outputs are produced – if not, then investigate whether this could be a modelling or a policy structure issue.

3.5.5 Extreme values testing / model breaking (QA Log Reference Va4)

This is a test of the robustness of the model to values at the extreme limits of expected range. Often, users may want to set values to very low or high levels to test certain assumptions, and it is important that a model, where appropriate, can cope with this.

Things to check include:

- Does the model respond as expected to extreme values, zeroes, negative values, and critical limits?
- Is it possible to 'break' the model or get implausible outcomes (e.g. percentages adding to more than 100%, people adding up to more than the population...)?
    - Check that entering extreme values to input data/ parameters does not break the model or result in unintended outcomes.
- The stress test should vary the inputs cells for the key values by +50%, +100%, -50%, -100% from the base case values.

3.5.6 Re-performance testing (QA Log Reference Va5)

Re-performance testing involves implementing the model methodology in a completely new model. This may seek to completely replicate the functionality of the original in a shadow model or may be a simpler calculation of key transformations from the original. This is not always necessary and will depend on the business criticality of the model, the level of risk and the model's complexity.

Where possible, this should be done using an alternative methodology to prove the concepts in the original model. For example, a bottom-up approach instead of top- down.

The following points may be considered:

- When creating an entire shadow model, are the same results achieved as the original?
- Are any differences explained by decisions to use alternative methodologies?

3.6 Data and Assumptions

This section covers data and assumptions, which are usually as important to the model as the calculations and structure. “Assumptions” can include published data sets, user chosen inputs, simplifying structural assumptions, policy assumptions or economic assumptions to name a few.

Data and assumptions must be logged and commented upon at all stages, in order to provide clear information to policy makers and customers of the models.

3.6.1 Data log (QA Log Reference DA1)

- Is a log containing key data characteristics (description, units, source etc.) available?
- Has appropriate data been used?
- Are the quality, characteristics, strengths, and limitations of the data set fully understood and recorded?
- Have data inputs been agreed and signed-off with the relevant approving body?
- Is data plausible?
    - E.g. do percentages add up to 100 etc.?

An Input and Assumptions Log can be found in the DESNZ Excel template or as a separate document.

3.6.2 Data transformation (QA Log Reference DA2)

- Has input data been checked against primary reference for potential errors in copying / pasting / transforming?
- If required, have details on how the data have been imported/transformed or processed been recorded?

3.6.3 Assumptions log (QA Log Reference DA3)

- Have assumptions been fully understood and clearly recorded?
- Are assumptions appropriate, applicable, and logically coherent?
- Are any limitations/caveats adequately described?
- Are the quality, characteristics, strengths, and limitations of the assumptions fully understood and recorded?
- Have assumptions been agreed and signed-off with relevant stakeholders?
- Are implicit assumptions also logged – for example an assumption of rational economic decision making?

An Input and Assumptions Log can be found in the DESNZ Excel template or as a separate document.

3.7 Reporting the QA

With all models, **it is important to document and communicate how much testing/ checking has been performed** so that the risks around any associated decisions can be fully understood.

The QA log is the main way to report QA.

If necessary, identify results as ‘provisional’ and let your Commissioner know that more time would be needed for more ‘robust’ outputs from your model.

The Assurer clearing the work is accountable for the advice they provide to the Approver and Commissioner, so must accurately report their key concerns and risks around the evidence and analysis. The QA log should be sent alongside the clearance statement from the Assurer to the Approver and Commissioner.

4 Using and commissioning external modelling and analysis

4.1 Types of Third Party Engagement

Frequently within DESNZ we procure models or analysis from third-parties such as consultancies or academic institutions. Typically, this is done when we do not have the in-house capacity, experience, or specialist knowledge to develop the models ourselves.

Typical types of 3rd party engagement that may occur are as follows:

1. Commissioning an external model to be developed for DESNZ use.
2. Use of an existing external model for analysis.
3. Bringing an external model under the ownership of DESNZ.
4. Commissioning external QA or peer review resource.

The general principle across all types of procurement is that **the standard of QA applied elsewhere must be at least what we would do in DESNZ** according to the guidance laid out in this document and in the QA log, aligning with AQuA book guidance. Evidence of this should be provided in both existing and future contracts.

4.2 Commissioning third party models / analysis

When commissioning a third-party model, it is common to undergo a tendering process to obtain best-value for the Department. Details on how to commission research will be different for each department.

Assuring a third-party model need be no more complicated than assuring an in- house model. Most issues which are likely to be faced are resolved by including sufficient description of expected deliverables within an invitation to tender (ITT), and any contracts of Memorandums of Understanding (MoU).

The expected deliverables are at least those which would apply for an internally generated model; albeit with a higher requirement for clear documentation as there will be fewer opportunities to ask questions about a model once the delivery of a contract is complete.

As a minimum, the following documents will need to be presented to a third party to communicate our QA requirements for models:

- This guidance.
- QA log template.
- A model functional specification (What you want as an outcome from the modelling).
- The DESNZ Excel Model template (if applicable).

- Statement of what QA has and has not been done (and the associated risk), with a signature from someone suitably senior.

4.3 Ownership of third party models

DESNZ should own the Intellectual Property (IP) for both data and models in all but exceptional circumstances. Exceptions to this will be where the use of a pre-existing model is essential due to external proprietary knowledge, and developing an alternative would be a poor use of resources.

4.4 “In-housing” of external models

When a model is brought “in-house” it is important to minimise the business continuity risk as far as possible. Things to consider include:

- QA done on the model to date.
- Version control system in place.
- User guidance and technical documentation for smooth handover,
- IT requirements.
- Post-handover support.
- Intellectual Property.

4.5 Advice from the Modelling Integrity Team

We highly recommend that you speak to the Modelling Integrity Team when working with third party models as they can provide substantial support at all stages.

Appendix A: Model Documentation

The table below outlines the key documents that should be captured during a project to ensure best practice Quality Assurance is in Place

Area	Documentation	Key QA/Audit content
Model Scope	Model aims and limitations Scope development Checklist Model Report Template	Does a clear and comprehensive project scope document exist with evidence of key stakeholder involvement and sign off? Is the scope of the modelling / analysis sufficient to meet the stated modelling aims? Are limitations due to key exclusions fully understood and has anything been excluded which could be critical to model performance/ accuracy of analysis?
Model Specification	Model Description / Work-stream Brief Model Report Template	Does the model match the description in the specification? Has the methodology been agreed with experts?
QA Plan	QA log	Has an appropriate QA plan been implemented with adequate consideration of resource quantity and skills required? Does the plan include a list of specific checks that need to be done on the model before outputs are shared? Is there evidence of QA processes carried out to date?
Assumptions	Assumptions Log	Has the quality of the assumptions been logged with RAG ratings? Have the assumptions been agreed with the customer? Have issues with poor quality assumptions been addressed?
Data	Assumptions Log	Is it clear where the data is sourced from? Is it clear how the data has been cleaned or transformed? Has data quality been assessed with a RAG rating? Have issues with poor quality data been addressed?

Area	Documentation	Key QA/Audit content
Usability	User documentation and Technical Guides[9]	Does it describe how the model works? Is there a model map? Would a new user be able to understand how to use the model? Is it clear how to refresh the source data if required? Have potential future modifications been addressed? Is there a technical guide that demonstrates the methodology employed and logical flow of the model?
Technical QA	QA log	Proof of general model documentation Review of the model structure and clarity Proof of version control Verification of the implementation of the methodology Validation of the methodology being suitable Proof of the suitability and documentation around data and assumptions
Security Classification		Has this been assigned and is it clearly visible?
Evidence Clearance Statement	Clearance Statement	Do any outputs to be used for policy have an evidence clearance statement and are marked as cleared for use?

Other useful documents may include the following, which address the wider Project Management practices:

- Project Initiation Document.
- Spend forecast for project.
- A stakeholder map and/or list: This should include all parties with an interest in the model. The Commissioner, Assurer, Lead Analyst, Approver, key stakeholders (i.e. who the model developer actually works with) and the model developer / owner.
- Benefits register: To log foreseeable benefits of the model – this may be part of the specification document already.
- Final Project Review Minutes

[9] These may be a single document or split into two depending on model use.

- Issues register: Like a risk register, this is to log issues (general or specific) that arise during project planning and model build which need be resolved in order for the project to be successful. It should be reviewed regularly and lists the following:
    - Issue description;
    - The impact of the issue and its status;
    - Who owns the issue (may be beyond the project team);
    - What mitigating action (if any) is being taken; and
    - When the issue needs to be resolved by.

Appendix B: Change log

Change history

Version 1.0 23/07/2018 Initial version of external version of BEIS QA guidance (adapted directly from in-house version) Author: Aubrey Kendrick

Version 1.1 04/01/2024 Updated external version reflecting move from BEIS to DESNZ Author: Erin Symonds

Version 1.2 28/05/2024 Updated external version incorporating detail on sign off and escalation of issues Author: Ian Mitchell

Version 1.3 27/06/2024 Updated external version incorporating detail on change control Author: Ian Mitchell

Version 1.4 27/09/2024 Updated external version incorporating detail on change control Author: Ian Mitchell

Approval History

Alec Waterhouse, Central Modelling, 31/07/2018 Version 1.0

Ian Mitchell, Modelling Integrity, 04/01/2024 Version 1.1

Paul March, Central Energy and Emissions Modelling, 31/05/2024 Version 1.2

Paul March, Central Energy and Emissions Modelling, 27/06/2024 Version 1.3

Sanchia Bailey, Central Energy and Emissions Modelling, 27/09/2024 Version 1.4

QA Log

This guidance corresponds to version 4.3 of the Excel Model QA log.

This publication is available from: www.gov.uk/government/publications/quality-assurance-guidance-for-models

If you need a version of this document in a more accessible format, please email alt.formats@energysecurity.gov.uk. Please tell us what format you need. It will help us if you say what assistive technology you use.