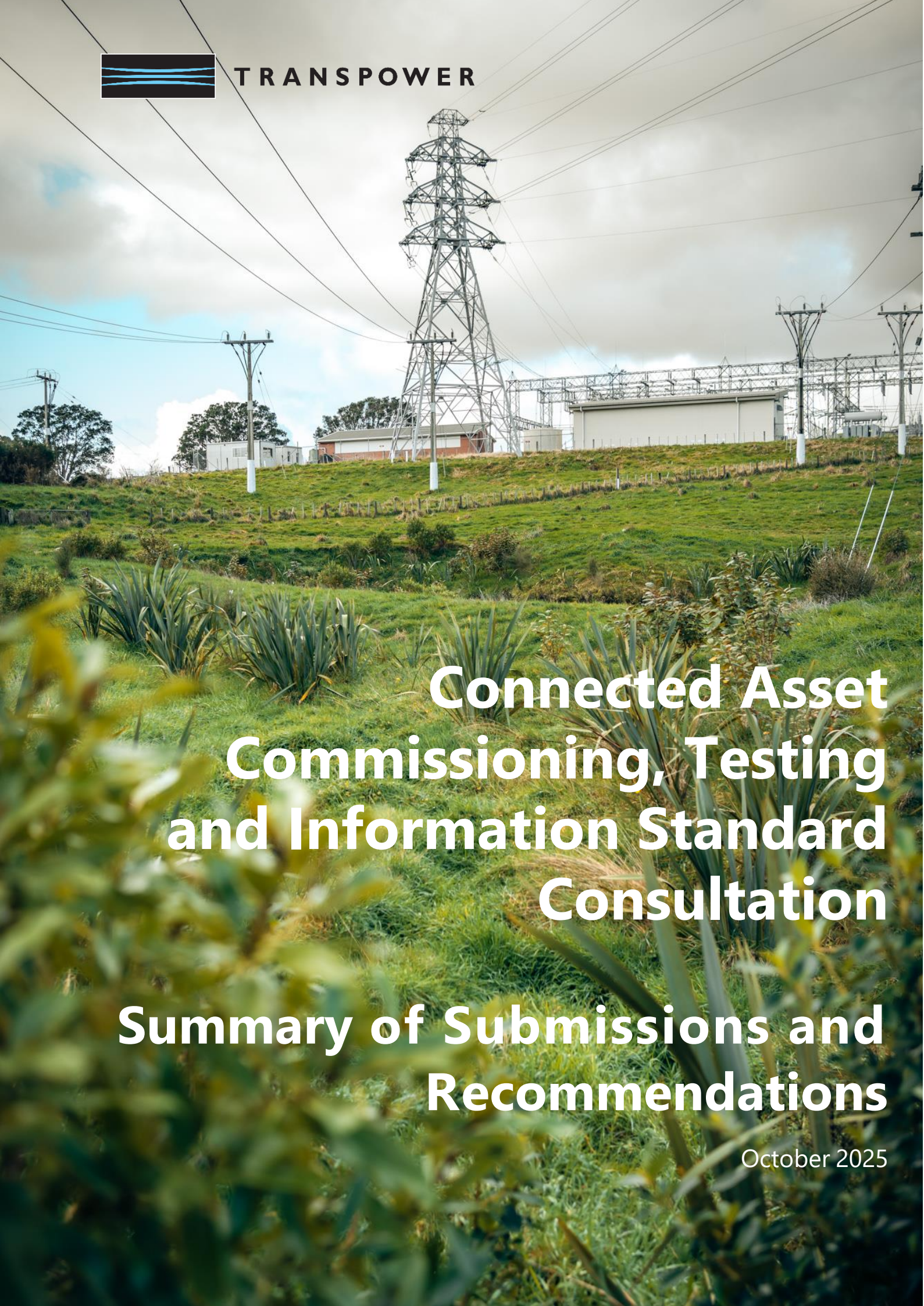

TRANSPOWER

Connected Asset Commissioning, Testing and Information Standard Consultation

Summary of Submissions and Recommendations

October 2025

Contents

Purpose

The purpose of this document is to:

- summarise the submissions received in response to the System Operator's September 2025 consultation on the proposed *Connected Asset Commissioning Testing and Information Standard* (*CACTIS*), and
- present the System Operator's responses to stakeholder submissions.

1.1 Background

In July 2025, the Authority consulted on a Code amendment proposal to incorporate the proposed CACTIS into the Code. Submissions from that consultation that were related to the technical content of the proposed CACTIS were considered as part of the System Operator's review of submissions. Hence, our responses in this document include feedback from both consultations.

We appreciate all submitters who have set aside time to consider the proposed CACTIS draft and who have made submissions to either or both consultations. These contributions will strengthen the proposed CACTIS and support its aim of clarifying technical requirements to address the growing complexities of the energy landscape.

1.2 Scope

The System Operator reviewed submissions that queried or proposed changes to the technical requirements between the existing Code provisions and the proposed CACTIS. This document addresses that feedback and makes recommendations to the Authority.

The scope of this work excludes feedback related to the following areas:

- Suggested changes to elements of the Technical Codes that have been carried over unchanged to the proposed CACTIS
- Cost-benefit considerations, as these were undertaken by the Authority in its July 2025 consultation
- Considerations for grandfathering existing assets from some requirements, as these are already being considered by the Authority
- Proposed changes to existing definitions in Part 1 of the Code that are unchanged under the proposed CACTIS.

1.3 Next Steps

Following the publication of this document, the System Operator will propose an amended draft of the CACTIS that incorporates the changes and recommendations outlined in this document. This revised draft will be subject to legal review before being submitted to the Authority.

The Authority will consider the amended CACTIS draft alongside the submissions received in response to its consultation. The Authority plans to publish its decision by April 2026.

Submission Summaries and Recommendations

We received 15 submissions on the proposed CACTIS, which are available publicly on our consultations webpage.

We have addressed and grouped the feedback according to the chapters of the proposed CACTIS. For ease of reference, we have summarised the feedback into key themes. For each theme we have consolidated the substantive arguments from across multiple submissions to capture the essence of the question, concern, or suggestion made.

In the section below, we address topics that span multiple chapters of the proposed CACTIS or refer to more general matters. Accordingly, our responses and recommendations apply more widely. We have signalled resulting changes we have made to the CACTIS in **bold**.

2.0 General: Definitions, Applicability and Thresholds

Multiple submitters supported the Authority's objective to improve the clarity, quality, and timeliness of information provided to the System Operator.

Submitters requested more clarity regarding the applicability of the time frame requirements in the proposed CACTIS. One submitter suggested that the term "asset" should be defined to distinguish between assets that significantly impact the power system and those that do not. Another suggested that each section should identify the asset types and sizes to which requirements apply.

Another submission suggested that the proposed CACTIS could be improved by clearly linking the type of information required to the type of asset owner.

Some submitters noted ambiguity around the term "connected to," querying whether it refers to connections to the transmission grid (grid) or to a local network. A submission recommended using participant-type-specific references to ensure obligations apply as intended and are proportionate to the identified information requirements. One submitter proposed using the Code-defined term "commissioning" instead of "electrically connect" to avoid further confusion.

In reference to CACTIS clause 1.13(d), one submitter highlighted that, for embedded generation, it is more efficient for protection coordination at the grid interface to be confirmed by the distributor and the Grid Owner.

There was also a request from a submitter to clarify when test plans are required for generating plants under a certain MW threshold. Another submitter proposed raising the required threshold for submitting both test and commissioning plans to 10 MW.

A submission requested further clarification on which testing requirements apply to existing versus new assets, and what the term "modify an existing asset" entails. Another submitter expressed concern that the proposed CACTIS adopts a more prescriptive approach than the current framework, and called for greater discretion for asset owners in determining when testing is required.

A submitter suggested the proposed CACTIS should take into consideration existing processes and timelines that manage delivery of large volumes of grid asset information, including for new or upgraded connections. They were concerned that applying the time frames proposed

under chapter 1 for Grid Owner activities would significantly impact outcomes.

Several submissions questioned the System Operator's interpretation of the term "generating unit" in Appendix A. Some submitters noted that this interpretation may render some existing units non-compliant with clause 8.23 of the Code. One submission suggested that the single line diagrams in Appendix A are not applicable to solar farms with string inverters.

Our response: We appreciate submitters seeking clarity on how the chapters of the proposed CACTIS apply to specific asset types and participants. We have **amended** the proposed CACTIS to improve clarity and usability. Specifically, we have **defined** the group of 'assets' that each chapter of the CACTIS applies to and signalling, at the start of each chapter, which asset groups are subject to the relevant obligations. We have included our proposed definitions below with a table (Table 1) to help readers visualise which chapters of the CACTIS apply to each asset group.

Asset group 1 comprises the following assets connected, or planned to be connected, directly or indirectly[1] to the grid:

- generating stations[2] with at least one generating unit with a rated capacity[3] of at least 1 MW, and
- reactive power devices with rated capacity of at least 5 MVAr, and
- assets owned by connected asset owners (including local networks) and embedded networks, and
- assets owned by grid owners.

Asset group 2 comprises the following assets connected, or planned to be connected, directly or indirectly[1] to the grid:

- generating stations that are not excluded generating stations, and
- generating stations, which may be excluded generating stations, for which the system operator requires offers or other information under clause 8.25(5) of the Code in order for the system operator to meet its principal performance obligations (PPOs), and
- dynamic reactive power compensation devices with a rated capacity of at least 10 MVAr.

Additional Asset Types comprises asset types connected, or planned to be connected, directly or indirectly[1] to the grid that are:

- not comprised in asset group 1 or 2, and
- referred to in the relevant Chapter.

[1] By "indirectly connected" we mean connected to the grid through another network or other asset.
[2] The current definition of "generating station" in the Code requires the station to be directly connected to the grid or a local network. In the CACTIS, we propose to capture stations connected directly to embedded networks as well.
[3] By "rated capacity" we mean the full nameplate capacity of the asset. This way of sizing an asset in the CACTIS may need to change for consistency with Part 8, depending on the final changes the Authority decides to make to Part 8.

Table 1: Applicability of the proposed CACTIS chapters by asset group.

Requirements Chapter of Proposed CACTIS	Asset Group 1	Asset Group 2	Additional Asset Types
1. Time Frame	☑	☑	☑
2. Commissioning Plan		☑	☑
3. Asset Capability Statement	☑	☑	
4. Modelling		☑	
5. Connection Study		☑	
6. Test Plan		☑	☑
7. Testing		☑	☑
8. Operational Communications		☑	☑
9. High Speed Data		☑	

We consider the clearer delineation of what is required from which participant would allow existing operational processes and timing procedures to continue to be utilised. This approach avoids additional costs and enables a rapid response when assets are damaged or involved in catastrophic events.

Regarding the feedback on continuing to use the existing information sharing processes between the Grid Owner and System Operator, we agree these processes are consistent with our information needs except for dynamic reactive power compensation devices. We acknowledge these processes have been developed over time to manage large volumes of data for new and changed grid assets other than dynamic reactive power compensation devices, and that it would be inefficient to change these processes.

Therefore, we have **amended** the proposed CACTIS to say the existing information sharing processes between the Grid Owner and System Operator will be followed, except in the case of dynamic reactive power compensation devices. We have set out alternative information sharing processes for these devices in the proposed CACTIS, consistent with these devices being used and managed similarly across asset owners.

Regarding the submission on clause 1.13 of the proposed CACTIS draft, we agree and have **amended** clause 1.13(d) to reflect where the obligation sits, in line with clause 4(1) of Technical Code A of the Code. To further tidy up clause 1.13, we propose removing subclauses 1.13(a) and (d), as these cannot be demonstrated to the System Operator by asset owners.

Regarding definitions, terms presented in bold (such as 'network') in the proposed CACTIS have the meaning set out in Part 1 of the Code. For clarity, except in Part 6A of the Code,

network means the grid, a local network, or an embedded network. When considered alongside the definition of "connected asset owner", the use of the term "network" in the proposed CACTIS is applicable to grid owners and connected asset owners.

Lastly, we have **updated** Appendix A to better reflect configurations used in solar farms with string inverters. We note that the definition of the term "generating unit" has been identified as an issue in previous Authority consultations and the Authority is addressing this issue as part of the wider Future Security and Resilience (FSR) work programme.

2.1 Time Frame Requirements (Q1, Q2)

2.1.1 Time Frames

Multiple submitters expressed strong support for clearly defined time frames for both asset owners and the System Operator to provide and review documentation. Submitters noted that this would help manage delays and provide industry certainty.

Some submitters proposed modifications to the time frames. Several submissions emphasised that the timing for submitting the engineering methodology should align with the commissioning plan, as these are typically developed together. One submitter suggested a 2 month (T-2) time frame. Another submitter considered that the connection studies timing requirement was inadequate, while another submitter recommended adding a separate check of final hold point test results. One submission also suggested that the 2 month (T-2) requirement for the pre-commissioning Asset Capability Statement (ACS) was too tight, given that connection study results may be required to update the ACS.

There were mixed views on whether time frames should be uniform or case-by-case, with some submitters noting that a one-size-fits-all approach may not suit the diversity of assets and grid localities. One submission suggested a reduced ACS time frame requirement for smaller connections (less than 10 MW), while another suggested clarifying whether the requirements apply only to new assets or also to upgrades of existing assets. Transpower in its capacity as Grid Owner recommended the proposed CACTIS exclude it from these time frame requirements in favour of existing operational processes.

Submitters provided differing opinions on the System Operator's 20-business day review period. One submitter considered the period too long, while others agreed with the proposed time frames, provided the System Operator could meet them.

Regarding models, concerns were raised that the proposed model submission and review periods may be insufficient and could lead to unintended delays in project schedules. Submitters suggested more flexibility to enable collaboration between asset owners and the System Operator.

One submitter suggested the proposed 3 month (T-3) time frame for providing indications for operational communications was too long, and recommended 1 month (T-1) time frame as a more viable alternative.

Our response: We appreciate the scrutiny of submissions on this matter. Upon consideration of the feedback, we have **amended** the proposed CACTIS to align the timing for providing the final copy of the engineering methodology and the final copy of the commissioning plan to 2 months (T-2) before connection of the asset to the power system.

As for the submissions on ACS requirements and timing based on connection type and MW thresholds, we note that these requirements have been shifted from the Code unchanged. We have proposed the asset groups in section 2.0 to provide further clarification.

We have not amended the System Operator's 20-business day review periods in the proposed CACTIS. Due to resource constraints, we may not always have a resource available when information is received for immediate review, so the review period supports resource allocation efforts. To accelerate project delivery, we suggest asset owners submit information for review as early as possible.

In terms of modelling, the m1 and m2 time frames refer to deadlines for submitting the final version of the model. In practice, models are typically submitted well in advance of these times and alongside connection studies. By defining a time frame, we aim to set clear expectations for both the System Operator and asset owners, thereby enabling better project planning and resource management for both parties.

Currently, modelling time frames are discussed and agreed to in commissioning project kick-off meetings. The proposed CACTIS simply formalises this process to provide clear and consistent guidance. Therefore, we have not amended the modelling time frame requirements in the proposed CACTIS.

Regarding the submission on the operational communications indications, we have **changed** this to 4 months (T-4) in the proposed CACTIS. Although earlier provision is possible, our experience is that there can be more variance. The proposed time frame accommodates this variability and supports planning certainty.

2.1.2 System Operator Discretion and Reasonableness

Some submitters expressed concern that the proposed CACTIS grants the System Operator too much discretion in determining what constitutes 'common quality' information and amending these requirements over time. One submission emphasised that information requirements should be fit-for-purpose—tailored to the specific asset, project, or risk—and cautioned against overly prescriptive rules that may not suit all scenarios.

Submitters objected to the CACTIS not applying the "reasonableness" standard to the System Operator in the same way as the main body of Part 8 of the Code. They suggested that the System Operator should only be able to request information that is reasonable to acquire in order to meet its PPOs. Another submission requested clarity on what constitutes a 'reasonable' information request.

Our response: Considering the range of feedback on this issue, we have retained the existing clauses taken from the main body of the Code that allow the System Operator to request additional information for the purpose of carrying out a review of commissioning documentation or meeting its PPOs and the dispatch objective.

We consider these clauses essential, particularly for assets with topologies or types not explicitly considered in the Code or the proposed CACTIS. Maintaining this flexibility ensures that the System Operator can continue to meet its obligations effectively across a diverse and evolving asset landscape.

We have **placed** a reasonableness requirement on the System Operator in the proposed CACTIS.

2.1.3 Revision Process

Some submissions requested that future updates to the CACTIS be subjected to formal consultation processes and rigorous cost-benefit analyses. One submitter considered that the process of developing the proposed CACTIS should have been governed by regulation. Another submitter suggested that a framework allowing for frequent, minor incremental changes would be more robust than infrequent substantive changes. They proposed a review cycle of twice annually.

A submission noted that the Authority relies too heavily on the System Operator to manage the information requirements in the proposed CACTIS. The submitter considered that this diminished the Authority's ability to assess whether compliance costs are proportionate to asset risk and size.

Our response: If the proposed CACTIS is incorporated into the Code, any future changes to the document will be governed by clauses 7.13 to 7.21 of the Code. These clauses apply to all system operation documents incorporated by reference into the Code.

Currently the minimum period for reviewing a system operation document is 2 years. However, an out-of-sequence review can be carried out if required, provided it meets the requirements outlined in Part 7 of the Code.

2.1.4 Flexibility

Some submitters requested the proposed CACTIS include a provision allowing time frames to be modified by mutual agreement between the asset owner and the System Operator. This flexibility would enable responsiveness to changing project schedules.

Another submitter requested clarity on whether backup generation operating in parallel under contingency conditions would be subject to the requirements in the proposed CACTIS.

Our response: In light of these submissions, we have **amended** the proposed CACTIS to include a definition of, and provision for, emergency maintenance on previously fully commissioned assets, including like-for-like replacements. While these projects would still require commissioning and test plans as a minimum, the asset owner could submit these plans on a relaxed time frame. This approach would enable the asset to be returned to service as quickly as possible.

2.2 Commissioning Plan Requirements (Q3, 4)

2.2.1 Template

Submitters supported the introduction of a standardised commissioning plan template, noting that it would streamline both preparation and review processes and help ensure consistent, unambiguous information from original equipment manufacturers (OEMs). However, submitters emphasised the need for flexibility within the template to accommodate the wide range of technologies and implementation approaches across the industry. Submissions also recommended that the template be scalable to reflect the size of the generation asset.

Our response: The existing template can be simplified by allowing asset owners to indicate which sections do not apply depending on the nature of the commissioning activity and the

performance obligations to be demonstrated. Over time, we aim to further develop the template to meet stakeholder needs; we welcome feedback in our efforts towards continuous improvement.

2.2.2 Situations where a Commissioning Plan is Required

A concern was raised about the clarity of the proposed CACTIS in distinguishing which assets would be required to submit a commissioning plan. Multiple submitters recommended refining the applicability of this requirement, suggesting it should only be mandatory when a control system firmware upgrade or setting change leads to a known change in the generating plant's performance. Another submitter proposed that owners of small distributed generation could develop the commissioning plan collaboratively with distributors then submit this to the System Operator.

Our response: Regarding the applicability of the requirement to submit a commissioning plan, we note we have carried over the requirement unchanged from the main body of the Code, with one addition: the explicit reference to "firmware."

Whether control system changes have an impact on performance of assets can be demonstrated through modelling or regression testing. Other supporting information may be considered on a case-by-case basis. When a control system setting or firmware change is identified, it prompts the System Operator to check that the asset continues to meet the requirements set out in Part 8 of the Code.

We have retained the wording regarding changes in protection systems—excluding changes to a protection system setting—which has been carried over unchanged from Part 8 of the Code. When a protection system change is identified, it prompts the System Operator to check that the protection system still meets the requirements set out in Part 8 of the Code.

2.2.3 Commissioning Plan Content

A concern raised in submissions was that protection and control system settings were required to be specified in a commissioning plan. Submitters proposed that it would be more appropriate to detail these settings in the engineering methodology.

Our response: We have retained the wording that requires protection and control system setting changes to be included in the commissioning plan, as this wording has been carried over unchanged from Part 8 of the Code. An example of when these settings should be included in a commissioning plan is if the protection setting group used for the initial livening of assets is later changed to a different protection setting group. Including this information in the commissioning plan ensures the System Operator can assess whether the asset continues to meet Code requirements throughout the commissioning process.

To further improve clarity, we have **renamed** commissioning plans in the CACTIS as *Code commissioning plans*.

2.3 Asset Capability Statement Requirements (Q5, 6, 7)

2.3.1 Information

One submitter requested that the System Operator declare all required ACS information

required at an early stage of a project in a standardised form.

Another submitter noted that the Authority's Code amendment proposal would remove some of the Code clauses referenced in the proposed CACTIS, such as clause 2(2) of Technical Code A. As a result, some references in the proposed CACTIS need to be updated.

Our response: Clause 3.4 of the proposed CACTIS currently includes details of information required at various stages (planning, pre-commissioning and final). We acknowledge the need to update the Code clause references and will work with the Authority to ensure all cross-references between the CACTIS and the main body of the Code are correct.

2.3.2 Submission Time Frames

Submissions were generally in favour of clearly defining time frames for asset owners to provide ACS information and for the System Operator to review that information. Some submitters recommended that we reduce the 12-month planning ACS submission requirement, especially for assets that may progress through the commissioning process more quickly.

One submission pointed out that updating the ACS within one month of completing testing may be impractical since model validation and the associated report (m2) are typically only available three months post-testing.

It was also suggested that time frames should be extendable by mutual agreement, instead of resorting to "breaching" practices.

Our response: We agree that the 12-month planning ACS submission requirement in the proposed CACTIS may not fit with certain commissioning project timelines. Accordingly, we have **changed** the planning ACS submission requirement from 12-months to 5-months. Nonetheless, we encourage asset owners to provide a planning ACS as early as possible to assist the System Operator in managing commissioning activities.

We have retained the requirement to submit the final ACS (excluding the m2 model and report) 1 month after the end of commissioning (E+1 month), as this timing facilitates the System Operator's essential need to maintain accurate information in our suite of tools better than if the final ACS was submitted with the m2 model and report up to 3 months after the end of commissioning (E+3 months). We note an m1 model may be submitted to the System Operator until the m2 model is submitted to us.

We remind asset owners of the existing obligation to keep the ACS information up to date at all times – this requirement remains unchanged under the proposed CACTIS.

Regarding time frame extensions, this remains an option under the proposed CACTIS, provided they are agreed upon by both the System Operator and the asset owner. Missing a time frame will not result in a breach, though it may affect the commissioning/testing schedules.

2.3.3 Update Time Frames

Several submitters agreed that it was important to keep an ACS up to date, but raised concerns about the proposed time frame for making updates. They mentioned that the requirement

from clause 3.5(a) of the to update an ACS within 2 business days was impractical, especially if complex modelling or analysis was needed. Extensions to 5 business days and 3 weeks were proposed.

There was also a concern raised about updating the ACS for temporary or urgent changes, with suggestions that notification alone should suffice.

Our response: We agree that certain capability changes would require further analysis or assessment and the requirement to update the ACS within 2 business days could be onerous. As such, we have **extended** the requirement to update the ACS to be within 5 business days. However, the requirement to inform the System Operator of any change in capability immediately via real-time operations remains.

We would also like to provide clarification on the urgent or temporary capability change requirements. Capability changes, whether they are temporary or urgent, refer to changes expected to last less than 4 weeks. These should be communicated promptly to the System Operator in written form. In such a case, there is no requirement to update the ACS as the capability change would be under 4 weeks.

2.3.4 Urgent or Temporary Changes

A submission regarding asset owners being required to indicate urgent temporary ACS changes commented that the current wording means it applies across any size asset. The submitter recommended a more risk-based approach. Another submission suggested the definition of "temporary" should be expanded from 4 weeks to 3 months. A submitter also raised the prospect that if the requirements to update an ACS due to modifications are too complex, it would defer investment in the modification of equipment.

Another submission sought clarity on what it means to "unexpectedly" become aware of capability changes in an asset, and how an asset owner might know if a change in asset capability affects the System Operator's PPOs.

Our response: To meet its PPOs, the System Operator needs to ensure its tools accurately reflect the capability of assets on the power system. The 4-week threshold for urgent or temporary capability change is for short-term capability changes that we may not model. However, any capability change lasting 4 weeks or more requires an ACS update as the System Operator will use this information to update our tools.

The urgent or temporary capability change process is meant to cover scenarios where an asset's capability has changed due to a breakdown or maloperation that has occurred "unexpectedly." In situations where the change is "expected," asset capability should be known and the ACS updated accordingly.

If an asset owner's performance obligations are at risk of not being met due to a temporary or urgent change in asset capability, they must notify the System Operator in written form and consider how they are going to maintain compliance with the Code.

2.4 Modelling Requirements (Q8, 9, 10)

2.4.1 Multiple Model Types

Some submissions indicated that requiring asset owners to provide four model types may be more demanding than international standards, and suggested aligning with jurisdictions such as North America, Australia, and the United Kingdom (UK). These submissions noted that the new requirements could potentially increase project connection costs and completion time.

Submitters also inquired about the purpose and use of each model type. Further, some submissions questioned whether detailed models were necessary and proposed the use of a standard model instead.

There was also a concern that multiple model formats might lead to differences in model response, potentially leading to inconsistent simulation outcomes or misaligned operational decisions. One submitter considered that the System Operator does not need PSCAD and TSAT to meet the PPOs.

Our response: It is common practice for System Operators globally to request models in multiple software platforms. The requirements are driven by the complexity of inverter-based resource (IBR) models and the type of studies they need to perform. Transpower is no different. Our models serve distinct purposes:

- PSCAD is used for electromagnetic transient (EMT) studies.
- PowerFactory is used for load flow, fault analysis, and root mean square (RMS) stability studies and other planning studies.
- TSAT is used for real-time operations, including frequency reserve adequacy, transient stability limits, post-event analysis and system security forecasts.

The appendix of this document expands on:

- our software platforms,
- how our modelling requirements we compare with other jurisdictions,
- how we apply models in real-time operations, and
- how we use models for future-proofing the power system.

Since models are built from actual source code or defined block-by-block and benchmarked by OEMs, we expect similar responses across platforms. We are actively working with OEMs to address model quality issues, understand limitations, and resolve any performance discrepancies.

Although some submitters tended to agree with the inclusion of generic WECC models as part of the m1 and m2 modelling packages, we have reconsidered our initial position. After reflecting on the feedback regarding the differences in model quality across platforms, we recognise that the response of a generic WECC model may differ significantly from that of a detailed model.

Hence, we have **amended** the proposed CACTIS to remove the requirement to provide WECC models for IBR.

2.4.2 TSAT

Several submitters disagreed with the TSAT model provision requirements due to cost and a lack of capability within New Zealand to develop such models.

Our response: We acknowledge the reticence that submitters expressed to the TSAT requirement, but we remain adamant about its importance to power system security. Our critical operational tools require a TSAT model to accurately assess the safe and secure operating boundaries of the power system, ensuring stable operation.

A detailed explanation of the need for TSAT as a dynamic assessment tool, along with its use internationally, is provided in the appendix.

We therefore have retained the TSAT model requirement in the proposed CACTIS.

2.4.3 Updating Models for New Software Versions

One submitter recommended extending the 1-month time frame for submitting updated control system models after the System Operator transitions to a new software version. This is to allow OEMs adequate time to prepare models in the updated formats, and for asset owners to submit them. They also suggested that the System Operator assess the compatibility of existing control system models with the proposed new software versions.

Our response: Our current process, outlined in the appendix, accounts for the circumstances pointed out in the submission. We therefore consider it reasonable to have a 1-month time frame from when we officially request an asset owner to submit an updated model to its submission to the System Operator. However, we acknowledge that asset owners may need time to secure internal budget approvals, and OEMs may require time to prepare and package the models.

In recognition of these practical constraints, we have **amended** the proposed CACTIS to extend the requirement of 1-month up to a maximum of 3-months from the date of formal request by the System Operator.

2.4.4 Model Accuracy

Some submissions requested clarification about the criteria used for model acceptance, validation, and benchmarking, as well as the specific software versions required of each model type.

One submitter highlighted the difficulty of assessing model performance across different software platforms. They noted that the presence of confidential information—such as encrypted OEM models—can make it difficult to obtain and validate the necessary data.

Our response: Upon further review of the relevant clauses in the proposed CACTIS (4.13 and 4.14), we would like to clarify that:

- *Validation* involves an asset owner comparing test results with the response of the model. Validation is performed using "as-left" settings; in other words, site-specific or "as-built" parameters.
- *Benchmarking* involves comparing the responses of a model with those of a different model; it does not involve test results. Benchmarking uses default OEM parameters.

- Asset owners only need to *validate* PowerFactory and PSCAD models.
- The System Operator has the capability to benchmark and validate TSAT models in-house. To provide this additional service, a cost recovery scheme will need to be established.
- Asset owners need to obtain *benchmarked* TSAT models from OEMs and provide them to the System Operator.

To support asset owners, we publish information related to model acceptance, validation, and benchmarking criteria, as well as the software versions currently in use, in our modelling guideline document GL-EA-716. When we need to inform the industry of relevant changes, we update our modelling guidelines to provide further details on model validation and benchmarking, ensuring transparency and consistency.

Given the speed of technological development, we consider it appropriate for the model accuracy specifications in the proposed CACTIS to be less prescriptive, with the detail located in our modelling guidelines.

2.5 Connection Study Requirements (Q11, 12, 13, 14)

2.5.1 EMT Study Requirements

Submissions recognised that the power system is becoming increasingly complex, requiring EMT studies for certain stability issues that RMS simulations from software such as PowerFactory cannot identify. One submitter recommended that the proposed CACTIS should not have a blanket requirement for all assets to provide EMT studies. Instead, they suggested these studies should be requested on a case-by-case basis, based on system strength.

Some submissions also noted that EMT studies require more resources and incur higher consultant costs compared to RMS studies.

Our response: We appreciate the thought behind these submissions. The System Operator's proposal to conduct EMT studies for each connection is driven by recent grid events and international research, which indicate that IBR instability or failure to ride through a fault can occur independently of system strength. We are aware of concerns about a lack of resourcing to conduct EMT studies and higher costs on asset owners. In recognition of these concerns, we have already made significant efforts to reduce resource requirements and the cost of conducting an EMT study by publishing regional PSCAD network models for asset owners.

Our connection study guideline (GL-EA-953) also guides asset owners through the process of conducting RMS studies to identify critical generation scenarios and contingencies, thereby reducing the number of study cases for the EMT studies. We have expanded on our observations and options in the appendix.

Considering the submissions, we have kept the requirement to perform selective EMT studies in the proposed CACTIS. The asset owner would need to identify the scope of the EMT studies based on the results of RMS studies. The scope of the EMT studies would need to be determined collaboratively by the asset owner and the System Operator.

2.5.2 Sharing Models to Run Studies

All submissions agreed that accurate power system studies depend on correct models. However, due to intellectual property (IP) concerns, sharing encrypted models is not feasible. It was also noted that asset owners do not hold the IP rights to the models and therefore cannot authorise their disclosure. Most submissions acknowledged the need to protect model confidentiality, with some emphasising that the proposed CACTIS framework should strike a balance between accessing essential information and avoiding processes that could deter supplier participation due to IP risks.

Our response: These submissions prompted us to contact to various OEMs supplying wind, solar, and battery energy storage system (BESS) models to understand their position more clearly. Most OEMs said they are willing to share encrypted, simplified or reduced models that replicate some of the performance characteristics without revealing proprietary control logic. From the perspective of system security, it is essential that these models accurately reflect fault ride-through (FRT) and oscillatory stability behaviour to ensure the validity of the studies in which they are used.

However, we acknowledge submitters' concern with IP rights. For EMT FRT studies, if it is necessary to incorporate a confidential model from neighbouring plant, but the direct sharing of that model is not feasible due to IP concerns, one option is for the System Operator to perform the study on behalf of the asset owner. We have outlined our rationale for this in the appendix. Note that the asset owner would still need to conduct all other studies as indicated by the proposed CACTIS, including RMS FRT studies.

We therefore have **amended** the proposed CACTIS to say that, in the event asset owners cannot obtain models for neighbouring assets as required in the proposed CACTIS, the System Operator will conduct the EMT FRT study on behalf of the asset owner. The asset owner would still need to share with the System Operator the plant model in PSCAD along with PowerFactory FRT study cases.

To provide this additional service, a cost recovery scheme will need to be established.

2.5.3 Review Time Frame

One submission raised concerns that the 20-business day time frame for the System Operator to review connection studies might be too long.

Our response: We have kept the time frame requirement unchanged in the proposed CACTIS. The time frame refers the System Operator's review of the *final* version of the connection studies (see the definition of "final copy" in the proposed CACTIS). We recommend asset owners submit drafts of studies well before the deadline for submitting the final copy, so that the System Operator can provide feedback.

2.5.4 Number of Studies and Contingencies

Multiple submissions questioned the need to perform certain types of connection studies, like power flow studies, given that asset owners will have carried out their due diligence assessment to ensure that their asset will not be constrained during operation.

Our response: Each power system study is designed to assess an asset's compliance with the relevant Code requirements, as outlined in our connection study guidelines (GL-EA-953).

Power system studies are also designed to ensure the System Operator can continue to plan for and meet its PPOs with the new asset connected to the power system.

We remind asset owners that they can submit their due diligence assessment report, provided it adequately covers the models and all study scenarios from the connection study requirements.

2.6 Test Plan Requirements (Q15)

2.6.1 When Test Plans Should be Submitted

Submitters were generally supportive of submitting test plans. One submission proposed that the requirement to submit test and commissioning plans should only apply when a generator is testing for compliance with AOPOs.

Our response: We have kept unchanged in the proposed CACTIS the requirements for when test plans must be provided to the System Operator, as these requirements have been carried over unchanged from the main body of the Code. We note test plans are submitted to us for reasons other than testing compliance with AOPOs. We use the information in test plans to assess any impact on the power system.

2.6.2 Test Plan Requirement for Control System Setting Changes

One submitter recommended refining the requirement to submit a test plan for a change to control systems, suggesting it should only be mandatory when a control system firmware upgrade or setting change leads to a material impact on plant performance. Another submitter raised a concern that the wording describing what constitutes a change to a control system setting is too broad and may include changes to settings that do not impact the power system.

Our response: Regarding the applicability of the requirement to submit a test plan, we note we have carried over the requirement unchanged from the main body of the Code, with one addition: the explicit reference to "firmware."

Whether control system changes affect an asset's performance can be demonstrated by modelling or regression testing. If other information is available, we can consider it on a case-by-case basis. Any change to control system settings or firmware serves as a trigger for the System Operator to verify that the asset does not have an adverse impact on the power system and continues to meet the requirements set out in Part 8 of the Code.

2.7 Testing Requirements (Q16, 17)

2.7.1 Wind, Solar, BESS Testing

Multiple submissions agreed with the proposed testing requirements for wind, solar, and BESS assets. There was support for applying routine testing requirements to new IBR stations, along with a request to specify the commissioning tests in more detail. There was also agreement that testing should not be mandated for excluded generation stations.

One submission expressed concern about the volume of documentation required after testing these technologies, suggesting that reporting should be limited to exceptions, when commissioning and retesting outcomes differ. Another submitter questioned whether high speed data requirements would replace the need for 10-yearly testing.

Our response: We remind submitters that the testing frequency has not changed between Part 8 of the Code and the proposed CACTIS. As testing of this asset type is typically conducted at the station level rather than unit level, the documentation required should be similar to that for a synchronous generating unit. More guidance is available in our testing guidelines (GL-EA-010).

The introduction of testing requirements for a generating unit producing power from wind, solar or BESS has generally followed the same requirements as for synchronous generating units, with some accommodation for clear differences, such as the location of the electrical protection on those assets.

Regarding the last submission, we would like to clarify that stations exporting 30 MW or above must still follow current Code requirements. However, asset owners of 10-30 MW assets have the option to use high-speed data in lieu of routine testing.

2.8 Operational Communication Requirements (Q18)

2.8.1 Phase-in Time

Some submitters called for a transitional or phase-in period for existing assets to provide controllable load indications. It was also noted that, for embedded generators, some of the required indications may already be available, and adding the missing ones would incur costs.

Our response: We acknowledge the concerns raised by submitters and are supportive of a phase-in period for existing assets to whom new indications would apply. Since this sits beyond the scope of the proposed CACTIS, we have communicated this suggestion to the Authority.

2.8.2 Controllable Load Requirements

Some submissions expressed concern that the accuracy requirements for the controllable load indications are not achievable as these values are inherently estimates. They also raised concerns that the obligation to provide controllable load indications would be affected by how some loads on their network are controlled by third parties—information that would not be visible to connected asset owners.

One submitter questioned how the System Operator will communicate requests and when data must be provided, and the reliance on voice phone calls and manual responses for load reduction signals. They stated that the proposed CACTIS reflects a historic operating model rather than a future system with more flexibility and suggested it should align with evolving electricity system needs. They considered these obligations would better sit in Part 8 of the Code.

Another submitter questioned whether controllable load indications would replace the obligation to submit difference bids. One submitter also requested clarification on how the

proposed obligation to provide controllable load indications applies to direct connect customers.

Our response: We appreciate the feedback regarding accuracy requirements for controllable load. Upon further consideration, we have **updated** the proposed CACTIS to require reasonable endeavours for accuracy instead of a specific value.

We acknowledge and share submitters' concerns about load controlled by third parties and understand that connected asset owners do not have visibility of these loads. We have also considered feedback that the proposed CACTIS reflects a historic operating model. We consider the proposed CACTIS provides for the power system of the future to the extent possible given current understandings of system complexities and within the boundaries permitted by the Code. In principle, we are not opposed to moving from voice phone calls to a digital system or replacing difference bids with indications in the future. However, this would require more in-depth analysis, and difference bids are still required at present by the Code.

We consider these matters are best addressed as part of other Authority workstreams, outside the proposed CACTIS process. As mentioned in section 2.1.3, should the Authority approve a version of the proposed CACTIS, it will be updated at least every two years. As parallel workstreams proceed and the future of controllable load becomes clearer, we would propose updates to the CACTIS to reflect any changes. For now, we have **amended** the proposed CACTIS to specify that only load controlled by connected asset owners is required in indications.

Regarding the question about direct connect customers, our position is that a direct connect customer with controllable load should provide indications.

2.8.3 Wind and Solar Data

Some submissions expressed the view that real-time solar irradiance and windspeed indications are not an essential requirement, but more of a "nice to have." One submission maintained that global horizontal irradiance is insufficient for accurate solar output forecasting and proposed alternative indications. This submitter also pointed out that the Authority has engaged DNV Services for centralised forecasting, questioning the value of duplicating this work in the proposed CACTIS.

Our response: The System Operator requires this data for a variety of purposes, including validating forecasts, longer term forecasting, and event investigation purposes. Our intention is not to replicate DNV's forecast, but rather to supplement it. We note that asset owners would not be providing DNV with these indications.

While we are aware of the limitations of using only global horizontal irradiance for forecasting, it is sufficient for our purposes in most cases. Through the proposed CACTIS, we are striving to find a balance between the demands we place on participants and ensuring we have enough information to uphold system security and the demands we place on participants. We have **changed** the proposed CACTIS to make the unit for wind speed m/s rather than km/h, but otherwise have left the indications as proposed.

2.8.4 Terminology, Sufficiency, and Other Matters

Several submissions requested clarification on terms used in this chapter, such as "frequency control mode" and "MV bus voltage." One submitter also wished to know the methods that should be used to measure state of charge (SoC), recommending that it be reported in megawatt-hours (MWh) rather than percentage of nameplate capacity. They also proposed that SoC indications should be considered confidential. A submitter questioned the need for "number of active inverters" and "available MW" indications.

One submitter questioned the need for high voltage (HV) bus voltage indications, while another requested the System Operator ensure this section does not duplicate other Code provisions. There was also a submission that questioned whether inter-control centre communication protocol (ICCP) was required or whether application planning interface (API)-based data transmission was an acceptable alternative.

Our response: The term "frequency control mode" refers to one or more modes in a frequency control system that change in real-time and affect the generating plant's response to changes in system frequency. Examples include "tail-water depressed" (TWD) mode or "feed-forward" status. The exact requirement depends on the individual control system, and the System Operator is happy to discuss with asset owners their particular needs. We have **amended** the proposed CACTIS to include a more precise explanation of "frequency control mode" to clarify this point.

Regarding "MV bus voltage" and circuit values, we recognise the need for clarification. We would expect embedded generation to provide circuit indications if they are connected to a GXP via a dedicated circuit. "MV Bus voltage" refers to the collector bus of an IBR station. We have **updated** the single line diagrams in Appendix A of the proposed CACTIS to clarify these points.

Regarding SoC, our view is that each asset owner is best placed to determine which measurement method/s are most appropriate for their asset. In principle, we would expect the same method to be used for the indication that is used by the battery management system, although we recognise this may not always be possible. Our tools require SoC to be reported as a percentage, so we have made no changes to this requirement in the proposed CACTIS.

As for other matters, the number of active inverters helps to determine the ability of the plant to provide reactive power support, which is largely independent of the fuel source (e.g., irradiance/wind speed). In contrast, "available MW" depends on both the number of available inverters and the available fuel source, and is used to determine the ability of the plant to respond to underfrequency events.

HV bus voltage indications are required for various operational and event investigations. We note that in most cases these indications are already provided by Transpower as Grid Owner and do not need to be duplicated by generators (as specified in the proposed CACTIS).

The data transmission requirements in the proposed CACTIS are identical to those currently in Technical Code C of the Code. Transpower as Grid Owner has selected ICCP as the protocol for SCADA data exchange.[4] When correctly configured, ICCP meets the requirements of both Technical Code C and the proposed CACTIS. Therefore, we have made no changes to these requirements in the proposed CACTIS.

[4] Customer ICCP Interconnection Policy GC 29.01.pdf

2.9 High Speed Data Requirements (Q19, 20, 21)

2.9.1 Scope of High Speed Data Requirements

Multiple submissions opposed the requirement to retrofit existing generating stations with high speed monitoring (HSM) equipment, citing high costs and a lack of justification. They recommended grandfathering existing stations. All these submitters, except one, supported the proposed HSM requirements for new generating stations, with some caveats.

One submission supported HSM indications for new IBR stations, but not for existing plants or synchronous machines. They suggested it would be more efficient for Transpower as Grid Owner to install phasor measurement units (PMUs) at strategic locations.

A couple of submitters recommended introducing a threshold for the HSM requirement. Another submitter raised concerns that most generators connected to Transpower HV buses lack HV bus voltage transformers (VTs). They requested clarification on whether gross or net values were required.

Our response: We acknowledge this feedback and understand that retrofitting existing assets to meet this requirement would incur costs related to design, outage, and implementation. We recommend that the Authority consider grandfathering existing assets from installing HSM equipment. However, we encourage asset owners to consider installing HSM equipment at their stations where feasible, as it provides advantages for both the System Operator and asset owners (see the next section). For asset owners who do have HSM equipment installed, we intend to request this data when needed to support power system operation.

2.9.2 Benefits of HSM

A couple of submissions requested clarity on the relationship between monitoring and testing requirements. Another submitter raised a broader concern that the consultation underestimates the overall system cost of implementing HSM equipment without articulating a clear benefit.

Our response: The primary benefits of the proposed high speed data requirements are the ability to use event data in lieu of testing in some cases and enabling the System Operator to use data for event investigation. Other benefits include:

- for the asset owner, performance optimisation and proactive maintenance of critical equipment such as generators and turbines, and
- for the System Operator, enabling us to perform detailed fault analysis.

These benefits apply to both synchronous and inverter-based generating stations.

2.9.3 Data Submission and Sufficiency

One submitter stated that requiring data submission in specific formats could create unnecessary work. They suggested asset owners collaborate with the System Operator to ensure compatibility.

Another submission, while generally supportive of the HSM requirements, raised concerns about using HSM data for EMT model validation. They highlighted that the unknown frequency

signature of existing instrument transformers could pose challenges. They also questioned whether requirements for reliability, repair time, and minimum data storage would be included, and pointed out that a higher sampling rate may be required to help with analysis of fast transients or high frequency oscillations.

Our response: We consider the formats specified in the proposed CACTIS are commonly used and are not too onerous for asset owners to supply. Although we have previously received a wider range of formats, the increasing complexities in the energy industry make this less practical, especially as we move to automate existing manual processes. We therefore have made no changes to the required data submission formats in the proposed CACTIS.

We understand the limitations caused by the unknown frequency signature of existing instrument transformers and the required sample rate. However, the proposed requirement balances capability with imposed cost. We have made no changes to the required sample rate.

We acknowledge the concerns about reliability and minimum data storage. However, we consider it unnecessary to introduce into the proposed CACTIS, at this time, specific requirements to address these matters. Hence, we have made no changes to the proposed CACTIS in this respect.

Appendix: Rationale for Modelling and Connection Study Requirements

In response to the submissions querying or disagreeing with the proposed requirements in chapters 4 and 5 of the CACTIS, we have compiled this appendix to inform readers of the reasoning for our stance and the recommendations listed in sections 2.4 and 2.5 of this document. See the referenced material in the footnotes for further information.

Uses of Multiple Software Platforms

Simulation tools are typically compatible with models built only for their respective platforms. Each simulation tool is used for its specific purpose, and the System Operator requires models tailored to each tool to conduct[5] targeted studies that ensure the power system remains secure and resilient now and into the future.

We use PSCAD simulation software to perform EMT studies, which are essential for analysing fast and complex phenomena such as fault ride-through capability and IBR stability. These studies help us understand how assets respond to disturbances at sub-cycle timeframes, ensuring accurate modeling of control interactions. Traditionally, this tool has been widely applied in insulation coordination, HVDC and FACTS design and operation, protection and control studies, harmonic analysis, and filter design.

PowerFactory is a comprehensive and versatile power system simulation tool that supports a wide range of analyses, including load flow, fault analysis, and RMS stability studies. Its flexibility makes it suitable for both planning and operational assessments, enabling engineers to model and evaluate system performance under various scenarios with high accuracy and efficiency.

The System Operator utilises Powertech Labs' Dynamic Security Assessment (DSA) suite which includes several offline tools—TSAT, VSAT, PSAT, and SSAT—each designed for specific types of stability analysis. These tools are integrated through the DSA platform, which provides an online interface that enables real-time use of TSAT and VSAT capabilities for continuous system security monitoring and assessment. As a core component of DSA suite, TSAT is specifically designed to simulate and evaluate transient stability following system disturbances such as faults or sudden changes in generation or load. These assessments are performed every few minutes to maintain system security. TSAT's integration with the Energy Management System (EMS) in the control room allows for seamless snapshots of current system conditions, enabling timely and accurate security analysis. Its fast computational capabilities make it particularly well-suited for real-time use in control room environments.

Requirements in Other Jurisdictions

The multi-model approach aligns with international best practices, reflecting the global trend of using different models tailored to specific simulation tools. System Operators such as AEMO, ERCOT, and National Grid UK employ different software platforms to conduct their studies, depending on the nature of the analysis. Further details on this practice are provided in Question 3 of the Questions and Answers supplement to the initial Code amendment

[5] A Review of Power System Modelling Platforms and Capabilities

document released by the Authority (see towards the end). Below, we present an expanded table of simulation software tools that are either preferred, nominated, or required by transmission System Operators across a range of jurisdictions:

Jurisdiction/System Operator	Tools for RMS Studies	Tools for EMT Studies	Other Tools*
UK (National Grid ESO (Electricity System Operator))	PowerFactory	PSCAD	TSAT
European Union	PowerFactory	PSCAD	PSS/e
North America	PSS/e	PSCAD	TSAT
Ireland (EirGrid/SONI)	PSS/e	PSCAD	TSAT
Saudi Arabia	PSS/e	PSCAD	TSAT
Australia (AEMO)	PSS/e	PSCAD	SSAT+
South Korea (KEPCO)	PSS/e	PSCAD	SSAT
New Zealand (Transpower)	PowerFactory	PSCAD (proposed)	TSAT (proposed)

* Although TSAT model provision may not be formally mandated in each jurisdiction/System Operator, several System Operators are actively requesting either detailed or generic models in TSAT format.

+ AEMO's latest version of their power system guidelines (25 September 2025) indicates SSAT is the designated tool for small-signal stability modelling, and its use is expected unless an alternative format is agreed upon through consultation.

The Need for Dynamic Security Assessment Tools and TSAT in Real-Time Operation

The power system is becoming increasingly dynamic and unpredictable due to the rapid growth of renewables, bidirectional flows from demand response and storage, hybrid HVAC/HVDC systems, increased use of power electronics, advanced protection technologies, and evolving market behaviours. These factors can quickly disrupt power balance, potentially leading to cascading failures or blackouts if not properly managed.

To address this, many System Operators worldwide are performing real-time dynamic security assessments (DSA) to maintain synchronism, and ensure acceptable frequency and voltage levels immediately after disturbances—supporting both situational awareness and reliable, economic operation[6].

DSA offers key advantages over traditional offline studies for determining power system limits.

[6] IEEE Xplore Full-Text PDF:

It uses actual system conditions to define operational boundaries, eliminating uncertainties such as generation mix and voltage profiles.

Currently, over 60 System Operators—primarily in North America, South America, the Middle East, and Asia—use Powertech Labs' online DSA tools in their control rooms to manage system security. Powertech is currently implementing online DSA in India and is preparing for deployment with TenneT in the Netherlands.

In 2005, Transpower implemented VSAT in the control room to assess voltage stability. In 2016, Transpower implemented TSAT in the control room to assess transient stability, focusing on frequency reserve adequacy between trading periods.

In 2023, Transpower expanded the use of TSAT to monitor Manapouri transient stability limits, ensuring that the generating units at Manapouri remain synchronised following transmission circuit faults.

In 2024, Transpower expanded use of TSAT conducting first ever Transient Rotor Angle Stability analysis (TRAS)[7] [8] across the New Zealand power system, helping identify regions of potential instability. Transpower intends to keep pursuing the TRAS reporting as part of the SSF[9], which is an obligation that the System Operator must comply with.

Looking ahead, Transpower plans to utilise scenarios identified through SSF-TRAS to run additional real-time simulations in TSAT, supporting ongoing system security assessments. TSAT will also be used to manage rotor angle stability issues, including Manapouri stability limits, as part of the broader strategy for real-time system security.

This explanation demonstrates that Transpower has utilised DSA tools, including TSAT, for both offline and online applications over several years. The reliance on TSAT is expected to grow in the coming years, as its role in system security assessments and real-time operations continues to expand.

Future Power System Needs

We anticipate that DSA applications will become increasingly common in control rooms to help manage system security, especially as system responses grow more dynamic and unpredictable. Additionally, System Operators, grid operators, and asset owners are pushing for greater asset utilisation and return on investment.

To meet these goals, more sophisticated and accurate simulation tools are needed in the control room to define power system boundaries in near real-time—ensuring safe and secure operation. As these tools are introduced, we expect our modelling requirements to evolve accordingly[10] [11].

To ensure the long-term sustainability and adaptability of our modelling framework, we are actively exploring collaborative initiatives with international System Operators and OEMs. By

[7] Transient Rotor Angle Stability Study.pdf ,
[8] Additional Transient Rotor Angle Stability Study Additional studies 2025.pdf
[9] System Security Forecast | Transpower
[10] power-system-analysis-tools--future-requirements---independent-review.pdf
[11] Control Room of the Future Research Roadmap (Topic 3), Australia Research Planning for Global Power Systems Transmission

participating in working groups and technical forums such as CIGRE, EEA, IEEE PSE, and ESIG, we aim to stay aligned with emerging standards and best practices in dynamic modelling and simulation.

These efforts will help us anticipate future modelling needs, streamline model validation processes, real-time implementations of the models and reduce duplication of effort across jurisdictions—ultimately supporting more efficient and interoperable system operations.

As the power system becomes more dynamic and unpredictable, and as modelling requirements continue to evolve in response to new technologies and operational challenges, Dynamic Security Assessment (DSA) tools will be *essential* for enabling real-time system security and future-proofing our operational strategy.

Emerging Methods for Oscillation Analysis

As the System Operator, we are committed to learning from the latest developments in the international power system community and from significant power system events worldwide. We have observed that frequency domain methods are increasingly recognised as effective tools for investigating oscillations in the sub-synchronous frequency band, particularly those associated with IBR installations.

Two widely used approaches for frequency domain analysis are state-space analysis and impedance scanning. We are currently evaluating both techniques using PSCAD and SSAT.

PSCAD offers the advantage of leveraging existing models without requiring additional data from asset owners. However, its slower computational speed—ranging from minutes to hours depending on scenario complexity—limits its suitability for real-time operations.

SSAT, on the other hand, is well-suited for faster simulation time requirement and hence control room applications. A key challenge, however, is the limited availability of SSAT-compatible models.

Furthermore, we are exploring the feasibility of using a TSAT model within SSAT studies by preparing a control system model that can be linearised. Our understanding is that a user-defined TSAT model—developed using block-by-block representation—can be shared between TSAT and SSAT with minimum effort. In contrast, DLL-based models are more challenging to be used between TSAT and SSAT due to the difficulty in linearising a compiled model.

We are currently working with Powertech to understand the necessary modifications and engaging with OEMs to assess the suitability of their TSAT models for SSAT applications.

Further Clarification on TSAT

Since 2014, the System Operator has been developing TSAT models for synchronous generation in-house, based on PowerFactory models. Since 2016, we have been using TSAT models while conducting transient stability assessments in real-time. Submissions supported the System Operator's willingness to continue to provide the service of translating PowerFactory to TSAT and PSCAD format as needed. For synchronous generating units, simple model translation and complete validation typically require 2–3 weeks of effort from the modelling team, while complex models may take 3–6 weeks.

By contrast, IBR models are significantly more complex. In many cases, the models submitted to us are encrypted, making it impossible to view the logic. Moreover, it is not feasible for the System Operator's modelling team to translate site-specific PowerFactory or PSCAD models into TSAT user-defined models due to their complexity, encryption, and confidentiality constraints.

To address the challenge of acquiring TSAT models suitable for both offline studies and real-time applications, we considered several approaches:

One path was for us to translate IBR models from PowerFactory or PSCAD to a generic WECC model through curve fitting techniques. However, for IBR-based generating units, model translation from PowerFactory or PSCAD, including complete validation into WECC generic models, requires 2–3 weeks per case. Also, these generic WECC models often lack accuracy that the System Operator is looking for in specific real-time studies like TRAS.

Moreover, our translation of the models may lead to delays for asset owners seeking to connect new or upgraded assets to the power system and may increase system security risks due to model inaccuracies. With the growing penetration of IBRs, we do not have the resources or capability to manage the volume and complexity of incoming model translations—especially given sensitivity concerns.

An alternative path would be to acquire TSAT model directly from OEMs, which have better visibility of the actual source code and better understanding of the logic developed for their controller. The System Operator acknowledges the claim raised in submissions that OEMs supplying wind, solar, and BESS models might not have capabilities to provide TSAT models. However, upon discussion with OEMs, we understood most IBR suppliers in New Zealand also serve international markets such as Australia, Asia, and North America, where TSAT or SSAT models are commonly required. As a result, many suppliers already have the capability to provide TSAT models, aligning with international practice.

Currently, around 10 OEMs supply equipment to New Zealand asset owners:

- All can provide PowerFactory models.
- 6 have submitted PSCAD models.
- 5 have either submitted or agreed to submit TSAT models to the System Operator.

Discussions with OEMs indicate that most have in-house capability to develop TSAT models. Some use standardised digital twin frameworks to create simulation models of their inverter and power plant controllers. These models are built from real source code, making the model conversion across different platforms seamless.

Most OEMs indicated an integral process of benchmarking one software model with another model through HIL or equivalent frameworks, making models suitable for each software platform while keeping the model performance intact.

Additionally, OEMs indicated that due to having in-house capability of developing TSAT model and existing submissions to international projects, the incremental cost of developing TSAT models would be minimal.

The OEMs who reported not having the capability to develop TSAT models in-house have engaged Powertech to develop TSAT models or used conventional techniques to translate models between platforms. OEMs indicated that engaging software developers such as

Powertech and PowerFactory is a common practice. However, we understand that these approaches can be time-consuming and may involve additional costs.

The System Operator is actively working with OEMs to identify their capability to provide TSAT models, with the goal of improving model coverage and supporting operational requirements.

Our Position and Options

The updated modelling requirements in the proposed CACTIS strive towards enhancing the resilience of the power system and future-proofing our ability to manage the demand and supply of electricity. With increasing IBR uptake, we anticipate a shift in the generation mix. IBRs are expected to contribute a larger share of generation—particularly during summer midday periods with high solar output and during windy conditions with elevated wind generation. We have already observed lower energy prices during sunny and windy periods, indicating that renewable IBR generation is displacing more expensive thermal generation. Under these conditions, IBR dynamics become critical for assessing system stability, even if IBRs do not provide under-frequency reserves.

As reflected in the recent introduction of TRAS assessments (see above), we have increased our reliance on online TSAT. Accurate IBR modelling is therefore essential—incorrect models can lead to either overly conservative or insecure operations, both of which are suboptimal. Ensuring TSAT model accuracy is vital to our operational needs.

We considered using tuned generic models for DSA applications. This approach can be effective for specific scenarios, such as frequency stability assessments, where a generic model can be tuned to produce the desired response. However, it becomes extremely difficult—or even impossible—to tune a generic model for system-wide stability assessments, including when evaluating fault ride-through, small-signal or sub-synchronous instability. These cases require accurate representations of the actual control systems or hardware.

Another option would be to replace our DSA platform with one that supports models we have already requested. While some studies suggest that DIgSILENT PowerFactory can be integrated with SCADA for DSA functions[12], this approach has not been widely validated in real-world operations, and solution speed remains a significant concern.

An alternative would be to adopt Gridscale X Dynamic Security Analysis software developed by Siemens, which is compatible with PSS/e models. The only advantage with this is that PSS/e is more widely used by utilities and System Operators globally. However, this would still require us to request at least three model formats—PowerFactory, PSS/e, and PSCAD.

Reviewing these options demonstrates that replacing the existing DSA software remains impractical for the System Operator. The cost would be prohibitively high for installation and licensing. Integration, testing, and internal skill development would take years. For comparison, it took Transpower nearly a decade to fully build, operate, and maintain the TSAT online DSA platform.

To support the current DSA tools we use, we need site-specific TSAT models developed by OEMs. These models can be developed as a compiled Dynamic Link Libraries (DLLs) model, either using OEM-proprietary DLLs or the IEEE/CIGRE modelling standard DLLs.

[12] IEEE Xplore Full-Text PDF:

The IEEE/CIGRE standard allows OEMs to provide the actual source code of their equipment as pre-compiled DLLs. These models are cross-platform compatible, enabling use across various simulation tools that support the standard. We understand that Powertech TSAT supports this standard. However, the standard is newly released and has not yet been widely adopted by OEMs.

Until such standards are broadly adopted and proven in operational environments, maintaining separate models for **TSAT remains necessary** to ensure accuracy, reliability, and security in system operations.

System Operator Process for Updating Software Tools to New Versions

Currently, we do not immediately upgrade PowerFactory, PSCAD, or Powertech DSATools software once a new version is released by the vendor. Typically, software updates are implemented 1–2 years after release.

The versions currently in use are:

- PowerFactory v2024 (while v2025 has been available since early 2025)
- Powertech DSATools v24 (while v25 has been available since June 2025)
- PSCAD v5.02, released in March 2023

Once the System Operator makes an upgrade decision, it typically takes 2–3 months to acquire, install, test, and resolve any issues with the new version. Following installation, an additional 1–2 months are required to assess model compatibility with the updated software. After compatibility is confirmed, further time is needed to update modelling requirements and formally communicate them to the industry.

We expect that OEMs will have their models ready for submission once we have formally updated and released the new software requirements.

Requirement to Perform EMT Study

Historically, RMS studies have been sufficient for most power system analysis. However, the rapid switching dynamics of IBR are not fully captured by RMS simulations, making EMT studies necessary for a more accurate assessment.

Furthermore, system strength conditions contributing to instability among IBRs have become a key topic of international discussion[13]. Over the years, we have learned from system events involving IBR instability, and extensive research is underway to better understand and simulate these issues.

We have concluded that relying solely on low system strength as a trigger for EMT studies is not appropriate. Notably, recent research[14] suggests that oscillations may occur even under high system strength conditions, indicating that such instabilities are not exclusively

[13] Real-World Subsynchronous Oscillation Events in Power Grids With High Penetrations of Inverter-Based Resources | IEEE Journals & Magazine | IEEE Xplore

[14] Oscillation Analysis in Power Grids Dominated by Grid Forming Converters: A Study of VSM and Droop Control Strategies | IEEE Conference Publication | IEEE Xplore

dependent on system strength. This evidence validates our approach to expanding the use of EMT studies beyond traditional system strength thresholds.

However, we recognise the challenges associated with EMT simulations, including longer simulation times, limited resources, and increased costs.

To address these issues, improve efficiency and support asset owners and reduce the burden of EMT studies, the System Operator has introduced several cost-reduction measures:

- We provide regional PSCAD network models (unlike, say, AEMO's system-wide EMT study requirement).
- We recommend conducting EMT studies in parallel with RMS studies wherever possible. Our connection study guidelines suggest to conduct RMS studies first in order to identify critical scenarios and contingencies, and then derive the EMT study scope from those RMS results. We are committed to regularly improving our connection study guidelines based on evolving understandings and feedback.
- To further improve the efficiency of our study process, we are conducting in-house evaluations of advanced simulation methods—including impedance scanning and small signal eigenvalue analysis—and plan to apply these techniques. This approach will strengthen our capability in assessing oscillatory stability and system strength for inverter-based resources.
- We are investigating using PowerFactory or TSAT online power flow cases as inputs for PSCAD to streamline the setup of EMT scenarios.

All these initiatives necessitate accurate asset information and models from asset owners.

Upon receiving feedback on the proposed CACTIS, we considered the following options:

Option 1: Remove EMT study from proposed CACTIS requirements

This would remove the cost of performing EMT studies but poses a risk that RMS tools may miss fast transients from IBRs, leading to unidentified system risks. The potential market and operational impact from undetected disturbances would likely exceed those cost savings of not conducting any EMT studies. Given our objective to maintain system security and mitigate risks, we judged this option unfeasible.

Option 2: Mandate asset owners to conduct the full suite of EMT studies

This option requires asset owners to conduct a study involving every individual scenario under the EMT study criteria. We acknowledge that the volume of EMT studies needed would be excessively time-consuming, costly and ultimately impractical, especially given the limited benefits it offers.

Option 3: Make the EMT study scope flexible in the proposed CACTIS (preferred)

This option considers EMT studies as a supplement to RMS. Asset owners would first conduct a comprehensive set of RMS studies (including an RMS FRT study) and based on the results of those derive the scope for their EMT study. The EMT study scope would be jointly defined by asset owners and the System Operator, enabling flexibility and fostering collaboration. We prefer this approach as it offers a balanced trade-off between cost efficiency and maintaining confidence in identifying and mitigating system risks.

Requirement to Share Models with Other Asset Owners for Studies

Accurate power system studies require accurate models. The models we receive typically include clauses that prohibit disclosure to third parties without prior consent. We have consulted OEMs to understand what they are willing to share for system-wide studies. Most are comfortable to provide encrypted simplified or reduced models that replicate performance characteristics but do not expose proprietary control system details. These simplified models must accurately represent fault ride-through and oscillatory stability behaviour, otherwise the study loses relevance.

Upon receiving feedback on the proposed CACTIS, we propose that asset owners engage the System Operator to conduct their FRT studies using EMT regional models. The System Operator would incorporate additional models from other asset owners and conduct further studies in-house. Our aim is to minimise delays and ensure accurate, consistent, and secure system analysis.

Asset owners would then be required to support the System Operator during these studies and assist with re-tuning controller parameters if fault ride-through or oscillatory stability issues are identified.

One challenge with this approach is our current resource limitations. We could address these through establishing a cost recovery scheme to increase our resourcing to provide this additional service.

We also foresee needing to establish a mechanism to resolve a fault ride-through and/or an oscillation issue once it has been identified. This would involve coordination with asset owners and OEMs for both existing and new assets.