NTESMO

Attachment 7.1

Transitional Tools Compliance Summary

Endorsement

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1. Executive Summary

1.1. Project Background

In the NT, the shift to renewable technologies commenced a decade ago with households investing in behind the meter PV generating systems. The level of behind the meter PV generating systems has increased over the last 5 years with almost 1 in 5 customers installing behind the meter PV generating systems, with a total capacity of 97 MW, and providing 12 per cent of underlying energy consumption. We are also likely to see a surge in dispatchable large-scale solar in the immediate term, with an expected 55 MW of capacity connecting on the DKIS transmission line.

This generator mix change from predominately gas-thermal synchronous generators to small and large solar generation has and continues to created increased complexity and demands on the Northern Territory Electricity System and Market Operator (NTESMO) to fulfil its role and functions outlined in the System Control Technical Code, particularly as System Controller.

1.2. Identified Need

As a direct result of the increasing uptake of behind the meter (BTM) and grid connected renewable energy technologies, the power system demand and supply profile has become increasingly volatile due to the inherent volatility of local weather conditions. These two impacts necessitate NTESMO's need to increase its systemised capabilities to accurately forecast power system demand, by utilising a combination of accurate weather and forecast generation capacity inputs.

In addition to the need for improved accurate demand forecasting tools, with the increased large-scale generators being connected and commissioned in the DKIS, there is a need for the System Control to be able to monitor and respond to compliance against the Generator Performance Standards. As the market transitions more heavily to renewables, the complexity for managing system frequency and responding to disturbances needs to become more dynamic.

To address this, a suite of transitional tools have been developed during the current regulatory period to ensure that NTESMO can continue to comply with its legislated responsibilities. The expenditure on these tools was unavoidable from a compliance perspective and exceeds the allowances previously approved by the Utilities Commission. This document provides supporting information and summaries of the program of work undertaken to date, along with the benefits delivered by the program.

1.3. Meeting Compliance Obligations

As the Licensed System Controller across the NT Power Systems, NTESMO is required to meet its legal responsibilities under the *Electricity Reform Act 2000* and the System Control Technical Code.

The transitional tools developed by NTESMO during the current regulatory period for which we are seeking retrospective recovery include:

- Darwin-Katherine Demand Forecast (DKDF)
- Forecast Compliance Tool
- Capacity Forecast Dispatch Tool
- Frequency Control Ancillary Services Tool

The development of all transitional tools have been subject to the stringent business case approval framework which is established through the Project Investment Delivery Management Standard[1].

The transitional tools are required to ensure that NTESMO continues to meet its obligations to ensure the security and reliability of the NT power systems. Should the investment in the transitional tools not have been made in the current regulatory period, and in the face of the generation mix transformation currently underway in the DKIS, NTESMO would not have been able to provide adequate operational capability for the DKIS to function efficiently and operate within an acceptable risk tolerance.

In this regard, existing processes that were highly manual and often conducted on Excel spreadsheets would not have allowed NTESMO to accommodate the dispatch of renewable facilities with increased capacity of such participants entering the market. The tools developed by NTESMO in this regulatory period have enabled the enhanced visibility of the volatility of supply and demand and response capability in the management of contingency and regulating reserves.

Operating as a prudent System Controller, NTESMO proactively developed and deployed these transitional tools by making a series of least cost investment decisions to continue to effectively perform its obligations as the NT power systems evolve.

1.4. Benefits identification

Along with meeting NTESMO's legislative compliance obligations, there are several benefit streams that investment in the transitional tools has enabled including:

- Improvement in system security and reliability
- Optimised/enhanced dispatch efficiency
- Reduced risk of damage to physical network assets
- Enables future NT Government reform of the NTEM and NTESMO's capability to efficiently provide its services post-reform.

2. Project Background

2.1. Background on NTEM transitional tools

NTESMO has understood for quite some time that a suite of tools would be required to meet its compliance obligations to enable increasing uptake of intermittent renewables and associated firming technology (both behind the meter and at a large scale level) and be ready to efficiently operate the DKIS following NTEM reforms. However, NTESMO anticipated that NTEM reforms would be completed prior to the change in the energy mix occurring, thereby triggering a cost pass through event in the current regulatory period allowing NTESMO to seek recovery of the expenditure.

However, while NTEM reform is still being considered, the rapidly changing operating conditions of the DKIS and other power systems in the Northern Territory has meant that as a prudent System Controller, NTESMO has had to take actions to ensure that it can continue to effectively perform its legislative obligations. To do this, NTESMO has had to develop transitional tools to provide the required services as System Controller. We have tried to do so prudently and efficiently, with a series of no regret investments that will be the foundation of dispatch capabilities in future, including investment in the TDE.

[1] Attachment 2.3 to the NTESMO Regulatory Proposal

The transitional tools that have been developed by NTESMO include:

- Prototype Market Systems
- Darwin-Katherine Demand Forecast (DKDF)
- Forecast Compliance Tool
- Capacity Forecast Dispatch Tool
- Frequency Control Ancillary Services Tool

The nature of the tools has meant their development and implantation has be iterative in nature to ensure the evolution of their functionality. While the majority of these tools have been developed and implemented in the current regulatory period, at least one is currently in its development phase, with its implementation occurring in the first year of the next regulatory period. As discussed below, the evolution of these tools is critical to underpinning the integrated solution expected to be delivered by the Territory Business Case. Accordingly projects which are expected to be deliver in the 2024-25 to 2026-27 regulatory period are outlined in *NTESMO Transitional Tools Future State Regulatory Business Case.*

2.2. Alignment of Transitional Tools with the Territory Dispatch Engine

The transitional tools when considered as a set of discrete projects represent a short to medium term series of no regrets investments that are required to meet NTESMO's legal responsibilities under the *Electricity Reform Act 2000* and the System Control Technical Code.

The transitional tools provide NTESMO with the ability to manage the entry of new generation market participants. These transitional tools have been refined over time as DKIS market developments have evolved and will continue to be evolved. This dynamic response to a changing wholesale market is effectively a business-as-usual option.

The capability inherent in the current suite of transitional tools allows NTESMO to provide its market operation and system control role in the DKIS given the physical wholesale electricity market assets currently operating in this system. This includes mainly gas and renewable generators (large scale and rooftop), plus a recently operational large-scale battery and a small number of household/commercial batteries. Future investment in synchronous condensers is also foreshadowed.

However, NTESMO's transitional dispatch tools, which entail highly manual processes, will not have the capability to deliver system operator functions under the expected market design features of the prospective (post-reform) NTEM. This includes not being able to co-optimise the supply of energy and Essential System Services to meet demand in accordance with the future NTEM design.

While the suite of transitional tools may not provide the full functionality envisioned by NTEM reform as it is currently understood, which will require investment in a security constrained economic dispatch engine capable of real-time market evaluation of offers to produce a least-cost dispatch of online resources, they will comprise the foundations for a large number of functions and data processing and parameter estimation requirements that will underpin the development of the Territory Dispatch Engine.

2.3. Current governance arrangements

To ensure alignment throughout the transformation process, the same project board oversees Energy Management System (EMS), Territory Dispatch Engine (TDE) and the transitional tools. The importance of the ongoing transitional tools project is underlined by the project board being chaired by Executive General Manager, Core Operations, with senior members from across Power and Water on the project board.

2.4. Actual expenditure in current regulatory period

The actual total expenditure incurred between 2019-20 through to 2022-23 is outlined in Table 1 below.

Table 1 Transitional tools expenditure seeking retrospective recovery ($000, nominal)

	2021-22	2022-23	Total
Expenditure	155	495	650

3. Identified need

This section provides a brief outline of the identified need that each discrete transitional tool addresses.

3.1. Prototype market systems

Due to the evolving Northern Territory energy landscape, existing and long-standing NTESMO business processes, ad-hoc tools and operational systems are fast becoming no longer fit for purpose. The Prototype market systems project was undertaken to investigate and create prototypes of feasible technology solutions under the I-NTEM market rules and procedures to assure NTESMO's continued operation of the regulated power systems until a Territory Dispatch Engine (TDE) could be delivered and NTEM reform completed. While the Prototype Market Systems project has been critical in informing other transitional tool projects, the NTESMO Regulatory Proposal does not seek to recovery this expenditure.

3.2. Darwin-Katherine Demand Forecast (DKDF) tool

NTESMO must develop reliable forecasts of upcoming DKIS power system conditions and have confidence in how the DKIS will perform having regard to NTESMO's system operator legislative obligations. The increasingly variable nature of generation in the DKIS[2] due to the inherent volatility of local weather conditions adversely impacts the profile certainty of generation capacity and is placing significant pressure on NTESMO to invest to accurately forecast the DKIS demand profile. This will reduce the frequency of manual out of merit order dispatch interventions in response to the variability in demand.

System Control had been managing demand in the DKIS by using generic weather forecasts provided by Solcast as their reference point, supported by operators' expertise and power system risk notices for holding required quantities of spinning reserve to maintain system security. Those systems and processes did not give System Control sufficient confidence to further optimise spinning reserve below current levels, which are deemed to be conservative.

A DKDF tool was developed with a high level of accuracy and in which System Control has sufficient confidence, to be used to inform System Control of more accurate forecast demand to preserve system security through centrally scheduling and dispatching grid connected generators. The DKDF will provide improved visibility and vital decision support, to accurately project the aggregated effect of BTM solar on the system.

[2] with the uptake of behind the meter solar and grid connected renewable energy technologies

For the reasons noted above, the implementation of the DKDF tool was required as soon as possible. Two forecast regions were captured, Darwin and the Darwin to Katherine regions. It was necessary to develop forecasts for the two regions to provide decision support to the control room during planned and unplanned outages that separate the two town centre networks, also known as islanding. In an islanded scenario, the Darwin region demand forecast will be critical for decision support.

The DKDF provides the System Controller with improved visibility and vital decision support to accurately project the aggregate effect of the BTM solar on the Power System. This in turn provides a more accurate demand forecast which enables preserve system security through centrally scheduling and dispatching grid connected. The forecasting services, data integration and display format of the DKDF tool is a transitional solution that will be subject to further enhancement as part of its planned eventual integration into the TDE.

3.3. Forecast Compliance Tool (FCT)

The FCT computes the compliance requirements set out in the generator forecasting compliance procedure as part of the Generator Performance Standards (GPS) located in the Network Technical Code (NTC). The FCT provides System Control with the necessary data to provide decision support to enforce the Generator Forecast Compliance Procedure[3] , published by NTESMO and used to respond to clause 3.3.5.17- Capacity Forecasting of the Network Technical Code.

The NTEM and I-NTEM obliges generator participants to provide accurate capacity forecasts for their facility to System Control to ensure dispatch of sufficient capacity to meet operational demand. This obligation is a significant element of the generator performance standards to ensure the power systems operate securely with variable renewable energy sources that do not have the security of dispatch that traditional large scale synchronous generators have.

The tool is an application that System Control can access to support real-time operational decision making. The tool requires inputs from the real-time energy management system (EMS) which includes the generator participant forecasts so that the output can be computed. The FCT detects forecasting non-compliance and calculates a percentage generator de-rating that can be applied by the System Controllers within the EMS to constrain a generator's output.

In the absence of the FCT, system control operators would have no real time decision support to validate an applied generator constraint due to a forecast non-compliance. This would see a loss of income incurred by generators should their output be constrained; therefore, the constraint should be calculated with a systematic and procedural approach. Additionally, had the tool not been developed, the System Controller would not have been compliant in its NTC obligation to monitor forecast compliance.

3.4. Capacity Forecast Dispatch System (CFDS) tool

The CFDS is required to dispatch generators against their NTC 3.3.5.17 Capacity Forecast in real time. Capacity Forecast data is provided by generation connections through SCADA and processed by the CFDS for validity, MW capacity, MW constraint and ramp rate. The CFDS then calculates and issues dispatch instructions to the generator and monitors dispatch compliance and 30 minute ahead reserve

[3] Generator Forecasting Compliance Procedure- https://www.powerwater.com.au/__data/assets/pdf_file/0027/49176/Forecasting-Compliance-Procedure-Final-Procedure-following-consultation.pdf

requirements. The CFDS does not dispatch new generation connections for BESS, synchronous condensers or conventional gas turbines.

The development of the CFDS tool has been undertaken iteratively to increase its functional capability. The initial iteration and current version of the CFDS does not provide the required functionality to securely and simultaneously dispatch the 15 expected solar connections over the next three years.

To manage the cognitive loading of the System Controller and eliminate the above risks, the CFDS v2.0 is being developed to provide a power system aggregate view of solar generation with a hierarchical regional and unit views to access more detailed information, events and alarms for generators, capacity and reserves.

Enhancements to CFDS version 2.0 is designed to address with greater operational risk of cognitive overload on part of the system controllers using CFDS version 1.5 to derive a dispatch solution for each individual solar facility and then needing to synthesise the individual solutions into a whole of system dispatch solution. As a consequence, CFDS version 2.0 is currently under development and further enhancements are expected to be required to incorporate batteries into the dispatch solution.

The CFDS is not responsible for contingency FCAS assessment, provision or validation. This functionality is to be delivered by the FCAS tool.

3.5. Frequency Control Ancillary Services Tool

As the generation mix in the DKIS continues to transition from traditional baseload generation to renewable sources, there will be significant pressure on NTESMO to ensure that the grid stays within the required frequency limits at any given time. Traditionally, NTESMO has managed frequency by running a fixed policy of scheduling two high inertia gas units and reserving 25 MW of C-Frequency Control Ancillary Services (FCAS) to respond. However, as the market transitions, the policy is changing to a dynamic policy based on the rate of change of voltage frequency and Under Frequency Load Scheduling limits, which is how frequency is controlled in the National Electricity Market.

Traditionally, NTESMO has managed system frequency by running a fixed policy to respond to disturbances. However, as the market transitions more heavily to renewables, the policy is changing to a dynamic policy, which is how frequency is controlled in the National Electricity Market and Wholesale Electricity Market in Western Australia.

To ensure that this requirement can be achieved in the NT power systems, a specific tool to quantify the frequency and manage the dispatch of FCAS must be established. This investment is proposed for the next regulatory period and its business case is currently under development. The expenditure to date relates to preliminary design work and business case development.

4. NTESMO's Compliance Obligations

As the licensed System Controller, NTESMO is required to meet its legal responsibilities under the *Electricity Reform Act 2000* and the System Control Technical Code (SCTC).

Section 38 of the *Electricity Reform Act 2000* states that:

A system controller for a power system has the function of monitoring and controlling the operation of the power system with a view to ensuring that the system operates reliably, safely and securely.

Section 3.2.10 of the SCTC outlines the general principles for maintaining power system security:

a) This includes consideration of the operational ability to ensure that voltage and frequency of a power system are maintained within limits, that a power system is able to withstand most single credible supply or delivery system contingency scenarios, without significant disruption of the frequency or voltage:
   1) that the relevant power system protection schemes are coordinated;
   2) that the appropriate operating safety margins are maintained; and
   3) that the relevant power system voltages remain stable in the disruptions likely under the most credible contingency scenarios.

b) The characteristic of a secure power system is essentially identified with the existence of stable voltages and frequency throughout a power system.

c) The power system security principles are as follows:
   1) To the extent practicable, a power system should be operated such that it is and will remain in a secure operating state.
   2) Following a contingency event (whether or not a credible contingency event) or a significant change in power system conditions, the Power System Controller should take all reasonable actions to adjust, wherever possible, the operating conditions with a view to returning a power system to a secure operating state as soon as it is practical to do so, and, in any event, within thirty minutes.
   3) Adequate load shedding facilities initiated automatically by frequency conditions outside the normal operating frequency excursion band should be available and in service to restore a power system to a satisfactory operating state following significant multiple contingency events.
   4) Sufficient system restart ancillary services should be available in accordance with the system restart standard to allow the restoration of power system security and any necessary restarting of generating units following a major supply disruption.

Given these legislative and Code obligations, ongoing investment by NTESMO in the transitional tools has been required from a compliance perspective and to ensure an ongoing secure power system is maintained. Should the investment in the tools not have been made, and in the face of the generation transformation currently underway in the DKIS, NTESMO could not have provided adequate operational capability to maintain the market in a secure state.

Existing processes that were highly manual and often conducted on Excel spreadsheets would not allow for NTESMO to control dispatch with more participants entering the market, and importantly changes to FCAS policy that could not be implemented without the implementation of additional tools to assist NTESMO staff meet Code requirements.

Operating as a prudent market operator, NTESMO has undertaken development and deployment of these transitional tools to meet these compliance obligations and has resolved to do so in a prudent and efficient manner, with a view to making a series of least cost investment decisions that will inform future development of the TDE. This included undertaking multiple options analysis for all projects and looking at procurement options for the larger projects (in particular, DKDF), including comparing multiple vendors where a larger scope of works was required.

5. Benefits identification

In addition to the primary investment driver of meeting legislative compliance obligations, NTESMO has identified several benefit streams that its investment in the transitional tools have already and will continue to deliver including:

- Improvement in system security and reliability, which provides confidence to existing and prospective market participants and maintains a secure electricity supply for NT consumers.
- Optimised dispatch efficiency in the DKIS, including as more large-scale generators connect to the system.
- Reduced risk of damage to physical network assets arising from voltage disturbances as solar penetration increases on the NT power systems.
- Enables future NT Government reform of the NTEM design and associated market operations in the DKIS.

5.1. Improvement in system security and reliability

As complexity is added to the DKIS by an increasing uptake in behind the meter and large-scale renewables, the investment in ensuring system security and reliability is required to ensure that the system stays in a secure state.

The implementation of these transitional tools is aimed at producing a reduction in the probability, frequency and duration of supply interruptions. If these events occur, they can cause significant economic damage to users through lost production, higher substitution costs and lost confidence in the power system. Of the recent System Blacks in the Northern Territory, the impact of these events has been quoted at:

- 2014 (Darwin) - $80 million for a 10 hour event;
- 2019 (Alice Springs) - ~$20 million for an 8 hour event[4]

The implementation of these transitional tools also assists NTESMO in overcoming the limits of human capability in responding to instances when the system moves out of a secure state. Managing frequency excursions requires almost instantaneous responses, which cannot be done manually. The implementation of the transitional tools allows much faster responses to these issues.

5.2. Optimised dispatch efficiency

The implementation of the transitional tools allows for a more precise/greater dispatch of renewable energy arising from increased visibility of forecast dispatch due to the integration of more precise weather

[4] this is based on the AER's methodology for deriving a lost value for outages in the NT. Please see AER Website

forecasting into NTESMO operations, and more precise dispatch tools. This outcome is consistent with the NT Government's Climate Change Response and Three Year Action Plan, including Net Zero by 2050 goal.

As there is a lower marginal cost of renewable generation compared to existing gas fired plans, a more efficient dispatch process will not only provide a more efficient price mix of energy dispatched because less solar will be curtailed due to manual (and conservative) dispatch calculations, but also lower the carbon intensity of the DKIS generation profile over time.

A decreased generation profile from the Territory's gas plants will also allow Power and Water to free up gas for other uses, including the ability to sell it into the East Coast market.

5.3. Reduced risk of damage to physical network assets

Inefficient operation of Power and Water's distribution network, in particular sub-optimal frequency control and voltage excursions, puts additional strain on the physical network assets. If physical assets are subject to sustained usage in this environment, or particularly severe instances of voltage excursions, it can lead to excessive wear and tear on the network, resulting in additional costs that are eventually passed on to the Northern Territory public through energy bills or the Customer Service Obligation.

By implementing the transitional tools, NTESMO can reduce these instances through better visibility of generation dispatch forecasts, compliance with forecasts and increased FCAS capabilities.

5.4. Enables future NT Government reform of the NTEM

The series of least cost, no regrets investment in transitional tools will underpin the next generation of tools, including TDE, which will be used by NTESMO when the NT Government implements the NTEM reform in relation to the DKIS.

The tools will provide the basis to optimise the use of energy and essential system services, manage plausible operational situations and efficiently manage the increased amounts of solar generation, batteries and potential future synchronous condensers that will be connected to the DKIS.

NTESMO's proposed transitional tool investments in 2023-24 and the 2024-25 to 2026-27 regulatory periods will ensure both that it can continue to fulfil its roles as system and market operator as the DKIS market rapidly evolves, as well as be ready for implementation of a new NTEM market design and associated market operations.

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