
FTE resources estimate – WA departments and WA support functions

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Proposal to the Economic Regulation Authority



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1. Forecasting resource requirements

The WA energy sector is becoming more complex; the generation mix more diverse; the network more constrained; and the market more competitive. As a result, the rules, regulations and procedures that govern the changing sector are too becoming more complex and exhaustive.

All these factors drive a need for more detailed modelling, data management, analysis and effort. While automation and IT systems can aid processes, an uplift in human resources is still required to ensure WA's market and power system can continue to operate efficiently, compliantly and within acceptable risk tolerances.

AEMO WA resource requirements fall into two broad categories:

- WA departments – WA Markets and System Management
- WA support functions – IT (WA Solutions) and various corporate services such as External Affairs, Finance and Governance

Changes in AEMO's FTE resourcing requirements are driven by changes in obligations, work practices and increases in system and market operations and GSI activities. For the AR6 period, the following factors will drive resourcing requirements:

- Energy Transformation Strategy outcomes – increased volume and complexity of activities resulting from new market arrangements from October 2023 and DER Roadmap actions.
- New obligations – AEMO has new obligations commencing immediately relating to the introduction of the network access quantity (NAQ) framework and reserve capacity cycle changes, and new obligations regarding generator performance standards (GPS) and network constraint modelling.
- Power system requirements – new processes and increased power system modelling required to address low load and changing generation mix issues. AEMO must also uplift its operational forecasting capabilities to keep pace with changing energy system characteristics and consumer trends. AEMO requires an increase in control room operators to mitigate succession planning risks.
- Ongoing market development – AEMO has an ongoing obligation to implement market development activities, including WEM/GSI rule changes and supporting further government policy initiatives.
- Operational requirements – increase in support function costs associated with growth in systems, process and data management over the period. For example, the increase in the number of IT applications utilised by AEMO WA requires an uplift in IT resources to support the systems.

Labour costs are also subject to annual review and uplift in line with inflation, remuneration reviews and terms of the enterprise bargaining agreement (EBA).

Risk tolerance

An important part of the labour cost forecasting process is consideration of risk. Any proposed changes to FTE forecasts during the transition to and commencement of new market arrangements is considered against AEMO's approved Risk Appetite and Tolerance Statements.

The risk tolerances for market operations and power system security are summarised in Table 1.

Table 1 AEMO market and power system risk tolerance statements

Function	Risk tolerance statement	Tolerance level	Guidance
Market operations	<i>We will not tolerate activities that threaten AEMO's ability to operate the markets efficiently and effectively.</i>	Low	<ul style="list-style-type: none"> • Inaccuracies or errors in settlements or credit limits that increase exposure to the market will not be tolerated (e.g. need to ensure accuracy and completeness of metering data). • Ensure correct credit security is maintained for market participants to reduce exposure in the market. • Ensuring systems are appropriately managed and delivered to minimise reputational and financial impact to AEMO and market participants. • Adequate procedures in place to ensure parties used by AEMO are accredited in accordance with the Rules.
Power and gas system security and reliability	<i>We will not tolerate activities that threaten AEMO's ability to deliver power and gas system security and supply reliability.</i>	Zero*	<ul style="list-style-type: none"> • Operational Group Managers have delegated authority to approve planned outages up to a medium risk. Planned outages with a risk level above a medium require an Executive General Manager approval. • Escalation procedures are followed in the WEM when the standard outage guidelines cannot be achieved. • Emergency events may result in risk thresholds not applying to balance the risk between safety and power/gas system security.

* AEMO's 'Zero tolerance' for the core business (e.g. power and gas system security) is as close to zero as reasonably practicable considering the regulatory and economic impacts (e.g. keeping costs to as low as economically practicable in achieving zero tolerance).

In many cases the new market arrangements and energy transition will result in an increase in market and system complexity and/or an increase in volumes of core activities (e.g. settlements, registrations and certification). It is important to recognise that a growth in complexity and volume increases the risk associated with providing system operation and market operation functions.

When estimating any increase or decrease in resourcing levels, particularly within the WA departments, AEMO must consider the potential impact on risk tolerance and its ability to maintain operations without materially increasing risk.

1.1 Forecasting method

To forecast the FTE effort required to fully resource the transition to and commencement of the new market arrangements, AEMO undertook an exhaustive estimation process.

Table 2 provides an overview of the FTE forecasting method.

Table 2 FTE forecasting method

Forecasting step	Summary
<p>1</p> <p>Identify base</p>	<ul style="list-style-type: none"> • For each WA department, use the current (2021-22) FTE effort required to provide existing services as the efficient baseline for forward-looking forecasts. • Review current activities and to the extent possible, quantify the FTE effort required to undertake each activity/function today, prior to any reform-driven or power system operations changes.
<p>2</p> <p>Identify drivers of change</p>	<ul style="list-style-type: none"> • Consider the drivers of change over the AR6 period. How is the market changing and how does it affect each function? How is the power system changing and how does it affect each function? What new obligations are being placed on AEMO? • Consider AEMO's approved 'Risk Appetite and Tolerance Statements' relating to market and system operations and identify any risks and vulnerabilities that need addressing. • Identify what activities would remain the same during AR6, what activities would increase/decrease given the identified drivers of change, and when the changes will occur.

Forecasting step	Summary
<p>3</p> <p>Estimate step changes</p>	<ul style="list-style-type: none"> • For activities that are not changing, retain or roll-forward the existing resourcing level. • For activities that are changing, estimate the increase or decrease in volume and/or complexity of activities, and escalate/deescalate the resourcing effort accordingly. • For activities/obligations that will no longer apply to AEMO, remove the resourcing effort or redeploy it to other areas. • For new obligations, estimate the increase in resourcing effort for each activity, and length of time the additional resources are required for (i.e. is the requirement recurrent or non-recurrent).
<p>4</p> <p>Consider resourcing mix</p>	<ul style="list-style-type: none"> • For activities that require increase effort, consider whether these are best resourced by permanent or variable resources (i.e. permanent employee vs fixed term contractor). • Consider level of expertise, seniority etc of resources required to deliver each activity. • Consider what current resources (if any) could take on the additional activities without impacting risk or delivery of current functions. • For activities/obligations that will no longer apply to AEMO consider where existing resources could be redeployed. • Consider what other AEMO resources/experience can be leveraged.
<p>5</p> <p>Top-down challenge</p>	<ul style="list-style-type: none"> • For each function, WA Leadership Team challenge the resource requirements and justification for any changes. • Review resourcing requirement across all functions to identify prudence and efficiency across the forecasts. • Identify potential synergies between roles and eliminate duplication (for example through capitalisation assumptions) if it exists. • Review resourcing assumptions across functions for consistency. • Benchmark resourcing requirement for each function and overall, against the NEM where practicable.
<p>6</p> <p>Translate FTE requirement to opex forecast</p>	<ul style="list-style-type: none"> • For existing resources/roles, roll-forward current actual remuneration. • For new resources/roles, use comparable existing roles as proxy for remuneration. • Where no relevant proxy exists, or where the role will be resourced externally, use current market-tested contractor rates to identify forecast remuneration.
<p>7</p> <p>Further top-down challenge</p>	<ul style="list-style-type: none"> • Challenge at WA Leadership Team and Executive level. • Review overall resource costs, target reduction. • Test certainty and timing of resourcing effort, remove resources that are less certain from forecast.
<p>8</p> <p>Apply trend changes and finalise</p>	<ul style="list-style-type: none"> • Escalate opex forecast for CPI and EBA adjustments.

The above steps were undertaken over an exhaustive six-week challenge period, and applied to all WA departments and functions supporting WA markets and systems.

Estimate of FTE effort

Managers were tasked with developing a forecast of the change in resourcing requirements over the AR6 period, and identifying and justifying any step-increases (and decreases) where required. Managers were asked to develop a granular estimate of effort required to conduct existing activities, and make an assessment on whether the resourcing effort in each case would increase, decrease or remain the same based on expected changes in functions.

Where possible, managers were asked to quantify the change in resourcing effort, which then informed whether any additional resources would be required, how many, and why that represents an efficient resourcing level.

This resulted in an FTE effort forecast for:

- The period up to new market go-live (noting that not all resourcing uplifts are a direct result of the new market).
- New-market go-live and the transition period thereafter.
- The period immediately after post go-live transition (noting this will not yet be a 'new normal').

The FTE effort forecast was then used as the basis for top-down challenge, subsequent refinement into the FTE forecasts presented in Table 3 and Table 4 below, and ultimately translation into the AR6 labour forecasts detailed in the models provided to the ERA.

Top-down challenge

While the resource requirements for the first 15 months of the AR6 period are well understood, the requirements during and post go-live are less certain. While it is clear that the new market arrangements will drive more FTE effort, it is difficult to forecast precisely how challenging the new environment will be until the market is switched on.¹

The uncertainty around the resourcing effort required in the outer years of the AR6 period was the focus of the top-down challenge by both the WA Leadership Team and the broader ELT.

The ELT accepted that while a peak in resourcing requirements is likely to occur during go-live and the remainder of 2023-24, it is reasonable to assume there may be some opportunity to refine and reduce the resourcing effort during the third year of the period – noting that AEMO does not expect 2024-25 to represent a 'new normal'.

The AEMO ELT therefore set an efficiency target for resourcing the third year of AR6, reducing the labour opex forecast by 5%. The ELT considered a 5% efficiency target represented a balance between uncertainty and risk tolerances associated with market and power system operations.

The top-down challenge also resulted in AEMO applying an additional 1% reduction to the overall labour cost forecast to accommodate a 'vacancy allowance'. This reduction accounts for periods during the AR6 period whereby roles may be vacant (and therefore are not being paid for).

These reductions were applied to the FTE forecast before being translated into the labour opex forecast.

1.2 Resource requirements by department/function

AEMO WA resources are split into WA departments and WA support functions.

WA departments resources are dedicated personnel with 100% of their FTE effort charged to AEMO WA. The WA departments category includes:

- WA EGM
- WA Markets
 - GM WA Markets
 - WA Market Operations
 - Reserve Capacity
 - WA Reform & Market Development
- System Management
 - GM System Management
 - Power System Operations

¹ For example the IMO ended up being significantly under-resourced when the Balancing Market and LFAS markets commenced in 2012, and required a significant FTE uplift to support the new market.

- Power System & Market Planning
- Operations, Governance & Integration

WA support functions are central resources, which may have all or a portion of their FTE effort allocated to WA. WA support functions are:

- External Affairs
- Operations
- System Design and Engineering
- Technology (Digital)
- Strategy & Markets
- People & Culture
- Finance & Business Services
- Governance

The AR6 labour costs forecast for each department/function is provided in the following sections.

1.2.1 WA departments

Table 3 summarises the resulting FTE resourcing requirements for the WA departments.

Table 3 WA department FTE forecast AR5 to AR6

WA department (FTEs)	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	AR5 avg	AR6 avg	Change avg
EGM WA	2.0	2.0	2.0	2.0	2.0	-4.8*	2.0	-0.3	0.0
GMs	4.5	4.4	4.0	3.3	3.2	3.2	4.3	3.2	-1.0
WA Markets									
WA Market Operations	10.0	10.0	10.0	10.2	15.0	16.0	10.0	13.7	3.7
Reserve Capacity	6.0	7.9	8.0	12.0	12.2	12.0	7.3	12.0	4.7
WA Reform & Market Development	0.4	0.4	1.7	2.5	2.6	3.6	0.8	2.9	2.1
System Management									
Power System Operations	13.8	15.0	15.0	15.9	16.3	17.8	14.6	16.7	2.0
Power System & Market Planning	10.8	12.8	15.5	16.6	23.0	24.3	13.0	21.3	8.3
Operations, Governance & Integration	7.5	7.8	8.0	7.8	8.7	9.1	7.8	8.5	0.7
Total FTE	55.0	60.3	64.2	70.2	83.1	81.0	59.9	78.1	23.3

* FTE reduction of 6.8 FTE reflects 5% efficiency target and 1% vacancy allowances as determined by the top-down challenge.

The largest step increase will occur during 2023-24, correlating to the commencement of the new market arrangements. AEMO expects there will ultimately be a reduction in resourcing effort post reform as processes become more familiar and transitional processes end. However, given the new market arrangements commence three months into the second year of the AR6 period, AEMO does not expect the resourcing effort to decline until AR7.

Experience with previous major reforms suggests there will be a 12 to 18-month bedding-down period as AEMO staff and market participants implement and refine new processes and systems. Following commencement of the Balancing Market in 2012, more than 26 WEM rule and procedure changes were made within the first two years of operation, many to address manifest errors and refine Balancing Market rules to

ensure they were operationally fit-for-purpose. AEMO expects there to be at least a similar level of post go-live activity and effort following commencement of the new real-time energy and ESS markets, noting this reform is a materially larger scale than the Balancing Market introduction.

The WA department most impacted by the new market arrangements is WA Market Operations. This department is responsible for the day-to-day operation of the wholesale markets, and management and oversight of the market settlement and prudential functions. As such the WA Market Operations team's activities will ramp up significantly when the new, more dynamic market commences, meaning more resources will be required.

Power System & Market Planning (PSMP) will also be materially impacted by the new market arrangements, as this is the department responsible for managing constraint equations, facility and network outages and determining energy and ESS requirements ahead of time. PSMP's workload is also driven by increased power system complexity, the new GPS arrangements, and the need for improved operational forecasting and modelling to manage increased generation intermittency.

The resourcing uplift for each WA department is discussed in more detail in the following sections.

1.2.2 WA Market Operations

The WA Market Operations team is responsible for the daily operation of the WEM and the WA Gas Bulletin Board (GBB). Key functions include operating the wholesale market mechanisms (day-ahead and real-time markets), performing all settlement and prudential management functions, facilitating the full range of registration processes, and providing stakeholders with high quality, efficient support 24x7x365.

Based on information available at the time of making this proposal, AEMO estimates the effort required to deliver market operation functions within accepted risk tolerances during the AR6 period will increase by 6.0 FTE.

The resourcing uplift is driven by the new market operating arrangements, and increases to the volume and complexity of market settlements and prudential management. This additional resourcing effort is offset to some extent by the transfer of some activities to the ERA such as the margin values review, load rejection reserve review and energy price limits review.

The following sections describe the two key changes impacting WA Market Operations activities:

- New real-time market arrangements
- Increase in volumes and complexity of settlements and prudentials

New real-time market arrangements

The current wholesale market mechanisms, the Balancing Market and Load Following Ancillary Services (LFAS) markets operate ex-ante on the premise that generation availability is not affected by network limitations (i.e. on an unconstrained network access basis). They are relatively basic markets, with simple systems and processes. The Market Operations team is responsible for operating and supporting these mechanisms.

The Market Operations team receives and validates submissions from market participants via the WEM System Market Participant Interface (WEMS MPI) application. Market participants submit price quality pairs, which AEMO's systems verify and validate. AEMO's systems then use the submissions to create an economic merit order for energy and for LFAS. This is sent to the System Management teams to issue dispatch instruction to market participants for each facility. This is done on a half-hourly basis, 90-minutes ahead of time for a horizon of up to 43 hours.

In relation to these processes, the Market Operations team:

- Ensures market participants can access market information and make submissions in the WEMS MPI on a 24x7x365 basis.
- Ensures information and files are exchanged with System Management teams for dispatch.
- Monitors the WEMS and action any operational, data or system alerts as required.
- Answers queries email and telephone queries from market participants and other stakeholders, in line with agreed response times.

- Monitors the Balancing and LFAS markets' events and processes.
- Ensures reports are published within the required timeframes.
- Ensures data is prepared and ready for settlement in line with the settlement cycle timeline.
- Monitors rule compliance.
- Undertakes analysis and reporting on submissions or market outcomes as required.

In the new real-time market, the broad process for operating and supporting the wholesale market mechanisms remains the same. However, the new arrangements introduce network constraints and more complex power system constraints into the market and dispatch processes by co-optimising energy and ESS (more ancillary services than just LFAS). This will increase the complexity of systems, processes, data and analysis in some areas.

Market participants will still make submissions. The WA Market Operations team and systems will still be required to verify and validate those submissions. The fundamental changes for submissions is that the complexity and volume of market participant submissions will increase. For example, the inclusion of multiple bids and/or offers across multiple services will be included in one file. Supporting market participants, validating submissions and analysing submissions will therefore be more onerous.

In the real-time market the dispatch algorithm is required to be defined and published by AEMO. The dispatch algorithm will specify the formulation of the constraint equations that are used to automate the calculation of the least cost overall dispatch of all facilities in all energy and ESS markets over the dispatch horizon. This replaces the simplistic Balancing Market and LFAS approach. The Market Operations team will be the business owner for the dispatch algorithm.

Creation of dispatch instructions will be automated via WEMDE, a complex linear program that will solve thousands of market, system, facility and network constraints. Some of these constraints will change frequently and will require close management and verification. In addition, WEMDE will calculate a number of key settlement inputs including the dispatch intervention pricing and intervention compensation. These processes will continue to require substantial human oversight and intervention across the WA Market Operations and System Management teams. Most significantly, this cycle of submission validation, data management, input, running of the algorithm, output and verification will occur every five minutes with real-time gate closure, rather than every half-hour 90-minutes ahead of gate closure.

The new energy and ESS markets will be operated using systems including the new WEMDE, a new real-time market submission user interface, and the Market Operations System Monitoring Interface (MOSMI). These will be owned and managed by the Market Operations team, who will continue to be responsible for the day-to-day operation of the energy and ESS markets. This will involve 24x7x365 support for the systems and to market participants. The PSMP team will be responsible for the development and management of technical constraints and the PSO team responsible for the issuing of dispatch instructions.

AEMO anticipates the effort required to execute Market Operations functions for the new real-time market will increase. The team will be required to develop a detailed understanding of inputs (e.g. participant submissions), the dispatch algorithm (e.g. the formulation), the outputs (e.g. pricing outcomes, dispatch outcomes) and post-processing activities (e.g. affected dispatch interval pricing). The team will continue to have a critical role in managing and monitoring of the market, including ensuring the necessary aspects of the WEMS and WEMDE are operational, ensuring information is exchanged, monitoring the systems and events / processes, ensuring reports and data is published within the specified timeframes, and ensuring data is prepared for settlement.

Accordingly, the volume and complexity of internal and external support (e.g. understanding of pricing outcomes, queries on participant submissions), related documentation (e.g. dispatch algorithm, market procedures, technical specification, guidelines) and data publication requirements is expected to increase. In particular, based on experience from the NEM, the effort required to undertake and present analysis of pricing outcomes for internal and external stakeholders will be more onerous.

These changes to Market Operations activities account for 2.0 FTE.

A further 1.0 FTE uplift in resourcing effort is the result of incremental increases across a range of related activities such as reporting, market system ownership, and rule change support.

Increase in volumes and complexity of settlements and prudentials

The new market arrangements will materially impact the volume and complexity of market settlement and prudential management activities. Currently, there are three settlement cycles in the WEM, totalling 100 settlement runs:

- Short Term Energy Market (STEM) transactions settled on a weekly basis (52 runs per year)
- Non-STEM transactions settled on a monthly basis (12 runs per year)
- Non-STEM adjustments undertaken three times at three-monthly intervals (36 runs per year)

Non-STEM settlements include settlement of the balancing, ancillary services, reserve capacity, market participant fees, outage compensation, and reconciliation components. There are currently more than 500 settlement calculations in the WEM, with a similar number of unique input variables.

For each of these settlement runs, the WA Market Operations team conducts the following activities:

- Input preparation – the preparation of all inputs, including meter data, is undertaken. Meter data preparation is the most significant activity which involves defined processes and the resolution of data gaps and inconsistencies with Western Power as the meter data agent.
- Settlement calculations and processing – verification and validation checks on all settlement inputs are undertaken. Once confirmed, settlement calculations are executed in the settlement systems. This is the new WEM Prudential and Settlement Solution (PaSS) system.
- Settlement verification and validation – once results are produced, a detailed verification and validation process is undertaken. This includes extracting settlement outputs and undertaking a comprehensive analysis to verify that results are explicable and reasonable. This involves data analysis and analysis of the rules and supporting documentation. Due to the criticality of these processes, a second verification is also undertaken.
- Issuing settlement statements and invoices – once results have been verified and approved, invoices and other supporting information is released to market participants. This requires review and approval by the Manager. Documents are published through the Settlements Processing, Account Reporting and Transaction Administration (SPARTA) system.
- Settlement day processes – on settlement day, AEMO must ensure all invoices are settled by 10:00 AM Australian Western Standard Time (AWST) and all settlement remittances before 1:28 PM AWST. The settlement process is time critical and any delays or failure by participants or AEMO will result in a WEM rule breach. AEMO uses the ASX Austraclear system to transfer and settle WEM invoices and remittance amounts via 'Real Time Gross Settlement'.

The settlement process also includes activities such as disagreement management, dispute resolution and market participant support and engagement.

Broadly from a prudentials perspective, AEMO sets a credit limit in accordance with the WEM Rules and procedures. Market participants must provide AEMO with credit support (either a bank guarantee or a security deposit with accompanying documentation) to the value of their market exposure (their credit limit). Market participants must manage their trading and participant activities in the WEM to ensure their exposure does not exceed their defined limits. The WA Market Operations team actively monitors this and is responsible for managing all WEM prudential requirements.

Under the new market arrangements, settlement activities will remain broadly the same, however the volume of settlements will more than double.

The WEM is moving to the following weekly settlement cycles:

- Initial transactions, which are settled for all market components in a single invoice on a weekly basis (52 runs per year)
- Adjustments which are undertaken three times at 8, 35, and 51 weeks after the end of a trading week (156 runs per year)

This totals 208 settlement runs per year.

All calculations in the current WEM will be amended. Invoices will include calculations related to the STEM, real-time market, ESS, reserve capacity, market participant fee, outage compensation settlement and reconciliation settlement components. This will require redevelopment of the full suite of settlement equations. While there will be a similar number of settlement calculations under the new arrangements, AEMO expects there will be an increase in the number of unique input variables and a significant increase in the number of data points (for example, driven by the transition to a 5-minute dispatch interval). AEMO anticipates a significant increase in the complexity associated with these calculations.

Prudential management will be directly impacted by the increase in market settlement activities. While the prudential process will not materially change, an increase in the number of settlement runs and introduction of a more dynamic market, means the effort in daily prudential management will also increase. This may include a rise in number of prepayments, the number of trading margin breaches or near breaches that require management, and an increased risk of default events. AEMO expects the WEM credit limit review frequency will be more closely aligned with the NEM (i.e. three times per year up from two times per year), which will also increase operational resources required.

Given the volume of settlements is doubling, coupled with the expected increase in the complexity of settlement calculations and prudential management, AEMO estimates an increase in FTE effort of 2.5 to 3.0 is required to ensure market settlement and prudentials can be conducted without impacting accepted risk tolerances.

1.2.3 Reserve Capacity

The Reserve Capacity team manages the operation of the Reserve Capacity Mechanism (RCM). The RCM ensures sufficient generation and demand side management capacity is available to meet and maintain reliable supply of electricity to customers in the SWIS. The Reserve Capacity team also develops a number of key major reports annually including the WEM Electricity Statement of Opportunities (ESOO) and the WA Gas Statement of Opportunities (GSOO).

Based on information available at the time of making this proposal, AEMO estimates the effort required to deliver RCM functions during the AR6 period within accepted risk tolerances will increase by 4.0 FTE.

The resourcing uplift is primarily driven by recent changes to the RCM processes, resulting from the WA Government's changes to [improve Reserve Capacity Pricing signals](#). Specifically, the time and effort required to assess Certified Reserve Capacity (CRC) applications, which is a core RCM process, will increase. This is due to the expected increase in the number of CRC applications, coupled with the complexity of the CRC process. Additional complexities include:

- Introduction of the Network Access Quantity (NAQ) framework.
- Certifying facilities at the component level.
- Applying a new CRC methodology.
- Considering additional classifications.
- Managing the now mandatory expressions of interest (EOI) process.

As part of a second stage of the Energy Transformation Strategy, EPWA is undertaking a review of the RCM. This will require significant input from AEMO's Reserve Capacity team with support from other internal AEMO teams. Note that while AEMO has allowed for subject matter expertise into the RCM review, no provision has been made for implementation of any actions/systems that arise from the review.

Unlike Market Operations, the Reserve Capacity resourcing uplift commences in advance of the new market go-live date. The changes to the RCM have already commenced for the 2021 Reserve Capacity Cycle, meaning that the resource uplift for Reserve Capacity is immediate and continues over the AR6 period.

In summary, the Reserve Capacity resourcing uplift of 4.0 FTE is summarised as follows:

- Two new resources to support the greater complexity and volume of activities associated with changes to the Reserve Capacity Cycle (e.g. the CRC process changes, the NAQ process, mandatory EOIs and indicative facility class assessments).
- Two new resources to support the overall uplift in other Reserve Capacity activities being driven by the increase in complexity of facilities and general reporting requirements (e.g. the WEM ES00, WA GS00,

market training, monitoring rule compliance, supporting and implementing Rule and Procedure changes and stakeholder management).

The uplift in the Reserve Capacity team resourcing is partially offset by a decrease of approximately 0.25 FTE due to removal of AEMO's obligation to determine the Benchmark Reserve Capacity Price (BRCP) which has been transferred to the ERA.

The following sections describe the key changes impacting Reserve Capacity activities.

Changes to the Reserve Capacity Cycle

In December 2020, the Minister for Energy amended the WEM Rules to defer key events for the 2021 and 2022 Reserve Capacity Cycles. These deferrals were made to provide sufficient time for AEMO and market participants to implement changes to the RCM made as part of the Energy Transformation Strategy².

In summary, the key Reserve Capacity Cycle changes that will impact the Reserve Capacity team's workload for the AR6 period are:

- The EOI process is now mandatory for new facilities and upgrades looking to receive capacity revenue. This process will require engagement with Western Power and the PSMP team.
- A new step of assigning an indicative facility class to new facilities is required. This involves consideration of each facility's technology, controllability and potential impact on system security.
- The introduction of electric storage resources (ESR) and hybrid in the RCM will require AEMO to:
 - certify facilities at the component level, as well as new types of facilities, including hybrid facilities and standalone ESR;
 - determine and publish the intervals during which it expects to dispatch ESR facilities (ESR obligation intervals, or ESROI);
 - undertake facility sub-metering assessments and validate related metered data; and
 - operationalise and apply a linearly derating capacity methodology for ESR components.
- The introduction of the NAQ process and annual execution will require consideration of constraints on facilities, and the expected impact of those constraints on the availability of each facility.

These new obligations all increase the complexity of the registration and certification processes. While registration is a one-off process, the CRC process is an annual undertaking.

The expected increase in the number of hybrid and ESR facilities over the period is a key contributor to the growing complexity and volume of reserve capacity certification activities. This is because a new set of technical assumptions, assessments and certification criteria will need to be developed for these new types of facilities. While the Reserve Capacity team will seek to refine and improve the CRC process over subsequent Reserve Capacity Cycles, it is expected that the CRC process for hybrid and ESR facilities at the component level, and ultimately virtual power plants (VPPs), will be more onerous than certifying traditional synchronous generating facilities.

Network Access Quantities (NAQ)

The most significant change to the Reserve Capacity certification process is the introduction of the NAQ framework. Currently, Appendix 3 of the WEM Rules (Reserve Capacity Auction and Trade Methodology) is used to determine the number of Capacity Credits assigned to each facility with CRC in the relevant Reserve Capacity Cycle. This will be replaced by the much more complex NAQ assignment process.

Participants' ability to obtain capacity credits and earn capacity revenue is dependent on whether they are able to obtain NAQs through the NAQ assignment process. That is, there must be available network capacity to support all, or some of the CRC assigned to a facility participating in the relevant Reserve Capacity Cycle. The NAQ process imposes new requirements on Western Power and AEMO to facilitate the consideration of constraints on facilities, and the expected impact of those constraints on the availability of each facility.

² As published in the WEM Tranche 2 and 3 Amendment Rules, available at: <https://www.erawa.com.au/cproot/21670/2/Wholesale-Electricity-Market-Amendment-Tranches-2-and-3-Amendments-Rules-2020.pdf>.

To facilitate the NAQ, the Reserve Capacity team is working with the PSMP team to prepare the NAQ model, which the Reserve Capacity team will own and operate going forward. Following the annual EOI process, AEMO must develop preliminary RCM constraint equations and liaise with Western Power to form limit advice for the purpose of developing final RCM constraint equations for the NAQ. While PSMP will be responsible for developing the constraint equations, the Reserve Capacity team is the business owner of the process and the primary contact point for market participants.

As part of the NAQ process, the Reserve Capacity team will also be required undertake the following recurring activities with support from the PSMP team:

- NAQ model preparations
- NAQ model running
- NAQ model input and output validation
- Model bug fixing, maintenance and calibration
- Publication of NAQ results.

As such, additional resourcing effort will be required in both Reserve Capacity and PSMP teams. Effort will be required to support the additional requirements in the WEM ESOO. Another layer of complexity is added to the WEM ESOO development, which will require consideration of the NAQ information and relevant RCM constraint equations in the report.

Increases in RCM participation

The energy transition in WA is driving growth in the number and variety of facilities seeking to participate in the RCM. This growth in participation is already driving an increase in the Reserve Capacity team's resourcing requirement.

During the 2021 Reserve Capacity Cycle, AEMO received 31 EOIs. Of these, three are standalone ESR, and seven are hybrid ESR running parallel with gas or solar generation. The remainder are a combination of non-intermittent and intermittent generator upgrades. Processing this increase in EOIs alone has consumed 1 FTE over three months.

AEMO expects this trend of increasing volumes of EOIs to continue as the energy transition progresses, particularly given the improving economic viability of ESR technology. In summary:

- Falling prices of ESR and intermittent technologies combined with commercial incentives for transitional facilities (existing facilities subject to transitional pricing - price floor of \$114,000 plus CPI) may encourage these participants to increase their assigned CRC and make more of their transitional pricing arrangements. The Reserve Capacity team expects majority of these transitional facilities (currently 62) to submit EOIs and subsequent applications for CRC for upgrades over the AR6 period.
- Falling prices of ESR technologies and the commercial incentives for participants with existing non-intermittent generation facilities to reduce the operational strain on these generators (e.g. reducing cycling) and improve efficiency, may encourage these participants to increase their assigned CRC. The Reserve Capacity team expects at least 10 of the 42 non-intermittent generators currently in operation will submit an EOI and subsequent applications for CRC over the AR6 period.
- Falling process of ESR technologies and new ESR-targeted services such as fast start and black start, will encourage greater participation in the WEM from ESR facilities. The Reserve Capacity team expects to see at least 10 standalone ESR facilities and 12 VPPs to make EOIs and subsequent applications for CRC over the AR6 period.

While not every EOI will ultimately translate into a CRC application, all EOIs need to be assessed. It is reasonable to assume the increased number of EOIs will result in an increase in the number of facilities participating in the RCM. As a conservative estimate, AEMO expects 90 facilities will be participating in the RCM by the end of the AR6 period, up from the current 72 facilities.

Resourcing impacts due to Reserve Capacity Cycle changes

AEMO estimates an uplift of approximately 2.0 FTE is required to manage the workload driven by these increases in the complexity and volume of Reserve Capacity Cycle activities. This may decline once the first full

cycle (2022) which will include the NAQ and facility class assessments has been completed, noting that it will take a few cycles for both the Reserve Capacity team and market participants to fully comprehend the requirements of the CRC process, prior to identifying and refining the new processes.

It should be highlighted the resourcing uplift does not account for any changes in FTE effort associated with proposed changes to the Relevant Level Methodology (RLM).

The September 2021 Market Advisory Committee meeting identified that proposed changes to the RLM will likely be deferred until at least the 2023 Reserve Capacity Cycle. There is also some uncertainty as to what the revised RLM will entail and what additional resources may be required to administer it. AEMO has therefore taken a conservative approach and not provided for an RLM resourcing uplift at this time. The Reserve Capacity team will endeavour to deliver any new RLM obligations within existing resourcing levels. AEMO will review this position during the AR6 period when further certainty on the RLM changes is available.

Uplift in other Reserve Capacity activities

In addition to the Reserve Capacity Cycle activities, the Reserve Capacity team is also responsible for a range of ongoing reporting, assessment and stakeholder management activities. These include:

- Developing the annual WEM ESOO, including the ESROI.
- Developing the annual WA GSOO.
- Progress reports and security deposits/returns.
- Subject matter expert input to WEM Rule and Procedure changes.
- Market and RCM training.
- Annual market audit and monitoring compliance activities.
- Managing stakeholder/participant queries.

Each of these recurring activities are being impacted by the growing volume and complexity of the power system and the facilities connected to it.

For example, an increase in the number of new facilities and facility upgrades submitted for CRC assessment directly impacts the volume of monthly progress reports. An increase of 18 participants will result in:

- An additional 216 progress reports per year for two years.
- 36 reserve capacity tests per year in the relevant capacity year for when their reserve capacity obligations commence.
- 18 facilities that require reserve capacity security return assessment (commissioning and commercial operation status assessment).
- 18 facilities that require ongoing management (e.g. reserve capacity security management).

The implementation of security constrained economic dispatch (SCED) also drives additional complexity and effort required to develop the WEM ESOO. Historically, the Long-Term Projected Assessment of System Adequacy (LT PASA) forecasting study was prepared assuming unconstrained network access. The move to SCED means that a full set of constraint equations has to be built into the LT PASA, which is published and analysed in the WEM ESOO.

Essentially, reliability assessments conducted over a ten-year horizon will have to take into consideration a suite of constantly shifting network, system and facility constraints, with a view to informing the long-term reliability and security of the SWIS. This will require considerable coordination between the Reserve Capacity team, PSMP and Western Power, and necessitates an uplift in resourcing.

EPWA has also signalled it will undertake a detailed review of the RCM, scheduled to be completed during 2023. This will require considerable input and subject matter expertise from the Reserve Capacity team. Whilst allowance has been made for AEMO to support this RCM review, no allowance has been made to implement any recommendations that may come out of that review given they are unknown.

AEMO estimates an FTE uplift of approximately 2.0 FTE is required to support these additional activities.

1.2.4 WA Reform and Market Development

The WA Reform and Market Development team is responsible for coordinating AEMO's efforts to prepare for and facilitate the evolution and development of the WEM and the WEM Rules. This includes activities such as regulatory and legislative assessment, providing expert input into WEM rule and procedure changes, supporting the Coordinator of Energy (and EPWA) and ERA in their market development activities and facilitating the implementation of policy initiatives such as the WEM Reform program.

Based on information available at the time of making this proposal, AEMO estimates the effort required to deliver market development and evolution functions within accepted risk tolerances during the AR6 period will not materially increase over AR4 and early AR5 estimates. However, the costs of the resources responsible for will be allocated to AEMO's opex budget rather than capex. This results in an opex labour uplift of 1.9 FTE by the end of the period.

Prior to the formal start of the WEM Reform program, the WA Market Development team comprised four FTEs, responsible for business-as-usual market development activities. Since the commencement of the WEM Reform program, the Market Development team's time has predominantly been booked to the Market and Regulatory Design project within the Program as most of the market development activities have been within the WEM Reform project scope³.

As the WEM Reform driven rule changes near completion in early 2022 and the new market arrangements go-live in October 2023, the WA Reform and Market Development team's focus will return to non-capex activities such as WEM rule and procedure changes and ongoing market evolution. This results in a gradual increase of expensed (opex) resourcing effort over the period, returning to historical levels of just under 4.0 FTE during the final year of the AR6 period once the new market has gone-live and new market arrangements are embedded.

In addition to business-as-usual market development, the team will also need to coordinate AEMO's input into Stage 2⁴ of the WA Government's Energy Transformation Strategy. While detail of the Stage 2 activities is yet to be released at the time of preparing this proposal, the program intersects with many of AEMO's functions and it will be imperative for the Reform and Market Development team to provide and/or coordinate AEMO's input to that work program. There are currently no new capex projects associated with Energy Transformation Strategy Stage 2 at this point in time, therefore the assumption for the AR6 forecasts is all WA Reform and Market Development team input into the Stage 2 initiatives will be incurred as opex.

Figure 1 provides an overview of the potential Energy Transformation Strategy Stage 2 work program, including assumptions on the input and advice likely required from AEMO.

³ From 2019 to 2021 the business-as-usual market development activities for non-WEM Reform rule and procedure changes were coordinated out of the OGI team.

⁴ Stage 2 was announced in July 2021 - <https://www.wa.gov.au/sites/default/files/2021-07/Energy-Transformation-Strategy-Stage2-July2021.pdf>

Figure 1 Potential Energy Transformation Strategy Stage 2 work program – AEMO assumptions

AEMO WA - Market Development Overview						AEMO Functions/Activities					Primary OPEX Support				
	ARS 21/22	22/23	AR6 23/24	24/25	AR7 25/26		Mkt Dev	Mkt Ops	RCM	OGI	SMP				
MAC - WEM Rules Changes & Market Development Plan															
1. 'BAU' Rule Changes															
RC_2014_05 (Timing of Reviews - IMO)	█					Rule Change Support under WEMR 2.1A.2(IA) - ON HOLD	✓								
RC_2018_03 (CC Allocation - Collgar)	█					Rule Change Support under WEMR 2.1A.2(IA) - ON HOLD	✓		✓						
RC_2019_01 (Relevant Demand - EnelX)	█					Rule Change Support under WEMR 2.1A.2(IA) - ON HOLD	✓		✓						
RC_2019_03 (RLM - ERA)	█					Rule Change Support under WEMR 2.1A.2(IA) - ON HOLD	✓		✓						
2. Market Development Plan															
RCM Review						Rule Change Support under WEMR 2.1A.2(IA) - Workshop attendance, data provision, consultation responses									
Planning	█	█					✓		✓					✓	
Stage 1		█	█				✓		✓					✓	
Stage 2			█	█			✓		✓					✓	
Stage 3				█	█		✓		✓					✓	
Implementation					█	Implementation in line with future proposed WEMR Obligations			✓					✓	
Market Fees/Cost Allocation Review(e.g. Causer Pays)		█	█			Rule Change Support under WEMR 2.1A.2(IA) - Workshop attendance, data provision, consultation responses	✓								
WEM Procedure Change Review		█	█			Rule Change Support under WEMR 2.1A.2(IA) - Workshop attendance, data provision, consultation responses	✓								
NAQ Review				█	█	Rule Change Support under WEMR 2.1A.2(IA) - Workshop attendance, data provision, consultation responses	✓		✓					✓	
WEM Procedure Changes (BAU)															
AEPC_2021_04 (Market Procedure: Prudential Requirements)	█	█				Procedure Change process initiated by Change Energy - activity under WEMR 2.1A.2(h)	✓	✓							
GAB - GSI Rule Changes															
LNG Trucking	█	█				Rule Change Support under GSI 8(1)(jb) - Workshop attendance, data provision, consultation responses	✓	✓							
GBB - Storage Facility Capacity	█	█				Rule Change Support under GSI 8(1)(jb) - Workshop attendance, data provision, consultation responses	✓	✓							
ETS Stage 2 (adapted from: https://www.wa.gov.au/sites/default/files/2021-07/Energy-Transformation-Strategy-Stage2-July2021.pdf)															
1. Implementing Taskforce Decisions															
Commence new network access and wholesale market arrangements															
Foundation Reg Frameworks (aka WEM Reform)															
Tranche 5 Rules	█	█				Supporting EPWA on market and regulatory design	✓								
Market Power Mitigation		█	█			Supporting EPWA on market and regulatory design	✓								
Tranche 6 Rules		█	█			Supporting EPWA on market and regulatory design	✓								
Implementation (incl. WEM Procedure Change - Transitional Process)				█	█	Implementation under WEMR 2.1A.2(n) and broader set of reformed WEMR for new WEM Commencement Date									
SMS					█	Support EPWA under WEMR 2.1A.2(IA) and (n) on market design - shifting to CAPEX in line with new WEMR obligations	✓	✓							
Deliver DER Roadmap actions					█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n)									
Prepare the next WOSP					█	Support EPWA under WEMR 4.5A.11 (e.g. support on market and power system modelling)	✓	✓							✓
2. Integrating New Technology															
EV Action Plan Implementation															
Options to transition to improved electricity tariff structures	█	█	█	█	█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n) - e.g. consultation response, data provision	✓	✓							✓
Transition to modular grid in the SWIS	█	█	█	█	█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n) - e.g. consultation response, data provision	✓								
Mining sector transition to renewable energy	█	█	█	█	█	No specific AEMO role assumed although may be asked to contribute to analysis and modelling under WEMR 2.1A.2(n)									
AMI Roll out	█	█	█	█	█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n) - also 2.1A.2(b)	✓	✓							
Commonwealth Government Funding	█	█	█	█	█	No specific AEMO role assumed although may be asked to contribute to analysis and modelling under WEMR 2.1A.2(n)									
3. Keeping the Lights On															
Continue to modernise contingency planning/management															
Review the RCM (reflected above in Mkt Dev Plan)					█	Rule Change Support under WEMR 2.1A.2(IA) - Workshop attendance, data provision, consultation responses	✓		✓						
Continue to plan and manage coal transition					█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n) - e.g. modelling, data provision	✓			✓				✓	
4. Regulating the Future															
Review Western Power Access Framework															
Further energy sector governance reforms (aka Project Eagle)					█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n) - e.g. consultation response, data provision	✓								
					█	Prepare for and facilitate evolution of the WEM under new WEMR 2.1A.2(n) - e.g. consultation response, data provision	✓								

Assumed review/analysis phase - OPEX

Assumed implementation phase - CAPEX

The WA Reform and Market Development team's role in supporting the Energy Transformation Strategy Stage 2 initiatives will comprise both direct advice to EPWA and support to the other AEMO WA departments required to provide subject matter expertise into the various initiatives. AEMO estimates the WA Reform and Market Development team will comprise one manager, one business analyst and up to two subject matter experts. This team composition is consistent with the historical team makeup and AEMO considers is an efficient resourcing level to support ongoing market development and evolution based on current information.

1.2.5 Power System Operations

Power System Operations (PSO) is responsible for the secure operation of the SWIS. PSO manages the dispatch of facilities to meet forecast load demand and the scheduling and dispatch of facilities to meet the ESS requirements while ensuring power system security is maintained. Where there are threats to power system security, the team will intervene within the WEM Rules to ensure the system remains secure or to return it to a secure state. The team plans for, aims to prevent, and manages non-normal situations and directs real-time emergency response when required. PSO is responsible for liaising with the Western Power and market participants in relation to real-time power system operations.

Based on information available at the time of this proposal, AEMO estimates the effort required to deliver power system operational functions during the AR6 period within accepted risk tolerances will increase by approximately 2.8 FTE.

The resourcing uplift in PSO is not directly related to the new market arrangements. The assumption is that that new market arrangements and increasing complexity of the power system will continue to be covered with existing control room requirement of two desks operated each shift. The increase is driven by two key factors:

- Current under-resourcing in the control room, which is affecting PSO's ability to conduct non-real-time operational activities such as skills maintenance, subject matter expert contribution to ongoing training materials, addressing compliance risks, improving the real-time decision-making process, and is contributing to a leave backlog.
- An emerging succession planning risk, as the duration to train new controllers is 1.5-2 years. Should any existing controllers leave the business, planned or otherwise, there is business continuity risk that must be addressed.

During most of the AR5 period, the control room comprised 15 controllers and one manager⁵, noting that through most of the AR5 period only 12 fully authorised controllers were able to be rostered, with the remaining being trainees. While this resourcing level was satisfactory to cover 24x7x365 operations and deliver core power system management activities, there was limited and sporadic opportunity to deliver other non-real-time deliverables.

The energy transition is placing additional strain on AEMO WA's control room. Increasing system volatility caused by distributed energy resources (DER), and the ongoing change in the generation mix, means more of the control operators' and manager's workload is focused on 'keeping the lights on', and less on non-core operational activities such as training, process coordination, audit close out and continuous improvement.

The PSO controller team is a diverse team, with a breadth of experience across different power systems, years of experience and qualifications ranging from trade based to tertiary educations. It is recognised that there is a retention and succession planning risk that needs to be managed on the basis of the time required to train new PSO Controllers being up to two years from commencement date. While there is no immediate risk of a critical resourcing shortfall, AEMO considers it prudent to increase the number of skilled controllers available, to ensure the team is able to prepare for succession planning and ensure the necessary expertise will be available throughout AR6 and into AR7.

For the AR6 period it is proposed another controller be appointed, and a principal/analyst (non-controller) resource be appointed to PSO to provide support to the controllers and the PSO Manager⁶. This

⁵ One FTE of the 15 controllers was booked to capex projects during the AR5 period, meaning 14 controllers and one manager was included as opex.

⁶ There will be 18 FTE controllers in the AR6 period. Early in the AR6 period, 1.5 FTE of the controllers will be booked to capex projects to facilitate the WEM Reform program. BY the end of the period, this will revert to opex.

principal/analyst resource will be required to focus on the identified gap in non-real-time operational activities. The role will provide continuity for progressing improvements and consistency in operational practices by being a point of operational continuity. This will enable the contribution of controllers on shift without progress on compliance and process improvement work stalling due to shift roster cycles.

Having this additional resource, coupled with the additional controller, will help relieve pressure in the control room, clear the leave backlog, and allow the controllers to focus on managing the power system.

1.2.6 Power System & Market Planning

PSMP is responsible for ensuring the short to medium term planning of the power system, enabling the power system operators to manage the system securely, and ensuring adequate information is available to support the operation of the market. Historically, this focused predominantly on short-term operational planning activities, including generator and network outage assessment and approvals, as well as the pre-dispatch planning of generators to meet forecast load. This team provides the operational load forecast and technical and engineering support to the control room.

As the complexity of the power system has evolved over the last few years, this team's accountability has evolved to include taking responsibility for managing the system security impact associated with penetration of inverter-based generation, already trending close to 70% of installed capacity. During AR5, PSMP has also become responsible for new obligations under the evolving WEM Rules, particularly as relates to managing the new GPS and the technical analysis required to support introduction of SCED.

The complexity of managing the power system in the short-term operational planning time frame has already increased and will continue to do so. It is expected that the increase in complexity can be absorbed within the current headcount. This will be achieved through upskilling of staff and the provision of improved tools and analysis from the more engineering focussed part of the team.

The increase in resourcing requirements in the PSMP team over the AR6 period is driven by three key factors:

- Significant increase in the challenges and effort requirement to maintain power system security over the medium and long-term while accommodating ever increasing levels of inverter-based generation. A critical aspect is the ability to better forecast and predict the changes operationally.
- Identifying and preparing for medium term challenges in a structured and efficient manner.
- Additional obligations introduced through the commencement of new market arrangements in 2023, including technical analysis and forecasting information necessary to ensure efficiency in the new market.

Based on information available at the time of making this proposal, AEMO estimates the effort required to deliver PSMP functions during the AR6 period within accepted risk tolerances will increase by around 8.8 FTE. This is offset to a small extent by a reduction in FTE effort to create dispatch plans for the Synergy portfolio, as under the new market arrangements Synergy will be required to manage and dispatch its own fleet. There is also currently significant effort with Western Power to finalise the Generator Performance Standards of the existing generators, which will reduce as these are completed and effort shifts to the ongoing compliance monitoring.

The key challenge for PSMP is the significant uplift in the level of AEMO's operational, modelling and engineering capabilities necessary to not only to keep the power system secure now and into the future, but also to maximise the efficiency of the new market arrangements. The levels of technical challenges and uncertain outcomes experienced and predicted to occur within the next few years are unprecedented even in other utilities, and new methodologies, tools and processes are required to be trialled and tested before implementation.

Ensuring power system security can be maintained

Since 2018, the amount of large-scale renewable capacity connected to the SWIS has more than doubled, with around 600 MW of solar and wind generation coming online in recent years. Much of this has been connected through the Generator Interim Access (GIA) arrangement, the complexity of which needed to be understood and implemented by the PSMP team. Rooftop solar PV generation connections have increased by 51%, with one in three homes and businesses in WA having solar panels. This brings the total amount of renewable inverter based capacity to 2,784 MW.

While the growing level of variable renewable generation is helping the SWIS transition towards clean energy production and low-cost generation, it can pose operational challenges and requires a different approach to aspects of power system operation that have been relatively static over time. AEMO's team in WA is at the forefront of a change that has transformed the energy system to a level such that many conventional and fundamental aspects of power system are losing their currency or validity. There are few other jurisdictions to learn from, and it is necessary for WA to develop solutions to its unique challenges.

As outlined in AEMO's recent [Renewable Energy Integration – SWIS Update](#) report, the power system is becoming increasingly volatile, featuring load swings of up to 750 MW within a single half-hour interval⁷ and ever declining minimum system load⁸. Alternative approaches to system restart and emergency response schemes such as the Under Frequency Load Shedding scheme are required. The work undertaken by the PSMP engineering team in managing grids with low inertia levels is one example of these solutions.

Four specific areas require a progressive increase in resourcing, although all are interrelated:

1. Power system modelling
2. The technical investigation of incidents and analysis of events on the power system
3. Medium term system security - the development of alternate means to manage traditional requirements such as system restart and UFLS
4. The critical aspects of operational forecasting, particularly as the system moves from more discrete and deterministic behaviour to a significant probabilistic outcome

These four areas are described below.

Power system modelling

PSMP is responsible for a suite of models for different types of power system analysis. Up until recently, this has only included the *Powerfactory steady state* and the *RMS* model for operational and planning studies at a bulk system level. The PSMP team has developed an in-house frequency analysis model for current needs.

It is now necessary to also develop an electromagnetic transient (EMT) model, and to further develop the existing models to incorporate various DER technologies. PSMP does not currently have the resources to produce this. For example recently, when a component of system restart studies needed to be reviewed, AEMO had to contract out the activity due to insufficient resources to do this important task.

Changing power system conditions require new models to be developed and more complex system analysis to be conducted in greater volumes. Particular focus will be on managing frequency stability with reduced inertia and fewer synchronous generators. While the behaviour of large generators and network elements is relatively well known, the ability to model and predict the behaviour of the vast range of emerging DER technologies and inverters across a range of operational conditions is lacking. While experience is shared with NEM colleagues, different analysis software⁹, different available information and different network topology requires specific aspects of this work to be done for the WEM. As more information becomes available to better understand the characteristics of the power system, such as that from phasor measurement units (PMUs) in future, this will need to be built into, and then maintained in, the power system model.

Due to the increasing levels of uncertainty being introduced in the operation of the power system, particularly as relates to the introduction of DER technologies, there can be a tendency to operate the system with greater levels of safety margins. These operational outcomes reduce the risk but result in higher market cost. With more detailed analysis comes greater confidence and while the uncertainties will remain, the greater certainty will allow more appropriate risk mitigation actions to be taken at an expected lower cost

These modelling requirements going forward are substantially beyond those currently undertaken, and as such require an immediate resourcing uplift. Given these modelling requirements will be ongoing, AEMO proposes an uplift in resourcing effort of approximately 1.0 FTE, most likely a permanent engineering resource.

⁷ 10 Aug 2021 saw a 750 MW swing, while 18 Oct 2020 saw three 250 MW swings within half an hour.

⁸ A new record minimum system load of 868 MW was reached on 14 November 2021.

⁹ To improve efficiencies in WA and ensure a consistent SWIS model, AEMO in WA utilises Powerfactory power system simulation software for steady state and Root Mean Square (RMS) analysis to align with Western Power.

Investigation of incidents and analysis of events

To ensure a thorough understanding of the behaviour of the power system as well as the impacts of specific decisions and inputs on market outcomes, it is essential that technical incidents are investigated and the contributing factors to specific outcomes reviewed. The PSMP team currently conducts investigations (supported by OGI), with a focus on:

- Technical incident investigation and reviewing power system performance.
- Providing input into the compliance, dispatch, and pricing outcome analysis.

The main driver of the resourcing increases with regard to investigations is complexity. For example, as power system complexity increases, the nature of technical incident investigations will also get more complex. It will no longer be simply a case of looking at generator outputs, PSMP will need to consider network constraints and model load and DER behaviour in its assessments.

A greater number of incidents will need to be investigated. For example, line trips previously had little impact on the system but now due to the resulting DER behaviour, can result in a significant power system response. The outcomes of these investigations also feed back into enhancements of the model, to better be able to predict and prepare for future events.

When the new market arrangements commence in 2023, there is expected to be an increase in the technical input required to support understanding and investigation of dispatch outcomes. While AEMO expects the workload will peak over the go-live period and subsequent 12-18 month bedding-down period, investigation requirements will remain higher than current levels beyond AR6, simply because of the greater process and system complexity and greater market participation. Ensuring compliance with the new GPS framework and the new ESS requirements will also require additional investigation by the PSMP team to ensure confidence in the appropriate level of response.

AEMO estimates an uplift of approximately 0.8 FTE is required to adequately resource these investigations and this analysis going forward.

Medium term system security

While much of the immediate focus of PSMP is on short-term emerging issues, these same issues (and others) need to be built into future plans with longer lead times. Examples include the evolving requirements for the UFLS scheme and identifying any changes to the System Restart Plan. Some initial work is being done under the DER Roadmap program, but this is an ongoing power system requirement that will need to be reviewed and updated regularly. Under the new WEM Rules, AEMO has a number of obligations related to the UFLS scheme and System Restart that require ongoing review.

Going forward, AEMO has a role in the Technical Rules Committee as well as having to provide input to Western Power's Network Development Plan. There is a need to provide strategic technical input to both the Technical Rules and the WEM Rules. AEMO estimates an uplift of approximately 1.5 FTE is required to resource this.

Operational forecasting

One of the most important inputs to power system security is the ability to forecast likely operating conditions and range of outputs. With increasing DER and intermittent generation this is becoming more important.

Existing forecasting models and approaches are no longer suitable. New forecasting models need to be developed with new data sources, and there is a greater burden of operational support required to be provided to operational planners and the control room. Extraordinary actions such as curtailing distributed PV require a slightly longer lead time than other dispatch decisions, and must only be made on accurate information so as to reduce the impact on end consumers and PV system owners.

Projects such as the Operations Forecasting Roadmap are being established to enable these enhancements to be introduced. The actual models and systems will require maintenance and review to ensure relevance and provide the best indication of what's likely to occur.

AEMO estimates an uplift of approximately 1.5 FTE is required to resource this area going forward.

Transitioning from synchronous generation

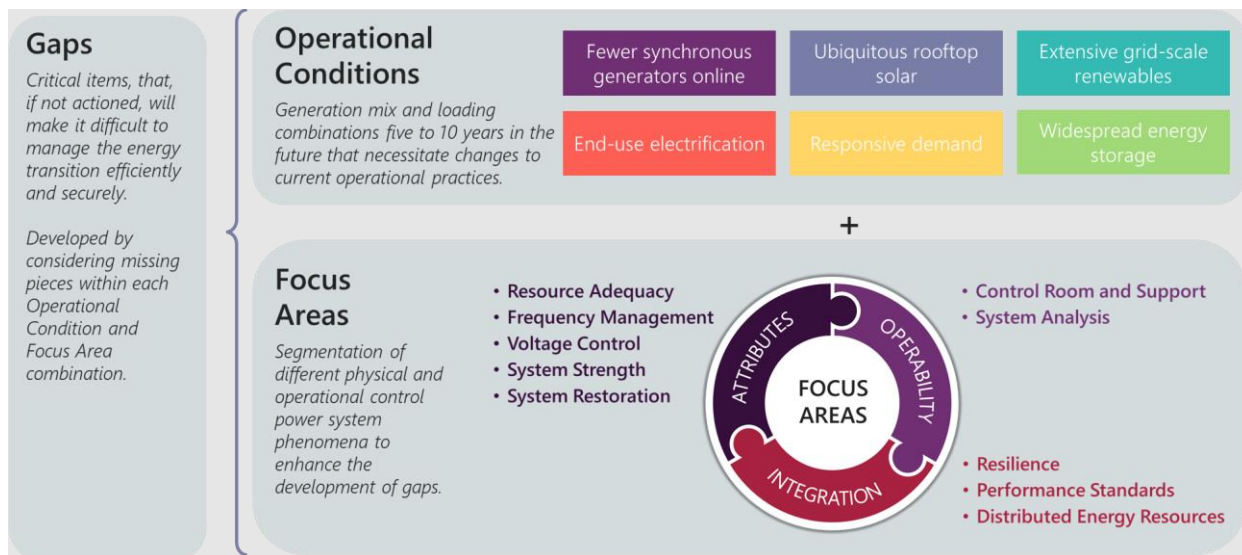
In addition to the operational activities necessary to maintain power system security today, PSMP must undertake a further body of work to support power system security tomorrow. Specifically to aid the transition of the power systems away from synchronous generation.

The transition from traditional, synchronous generating facilities to renewable inverter-based generation has been highlighted as a priority issue in recent years. Declining minimum system load and the decarbonisation of the SWIS are continuing trends, as they are in other markets including the NEM.

These challenges of low load and system volatility were the catalyst for the WA Government’s Energy Transformations Strategy. While the work undertaken over the past three years (such as the DER Roadmap actions and operational enhancements) has deferred the immediacy of the risk to power system security, day-to-day issues management has largely been reactive, with solutions put in place on an urgent basis.

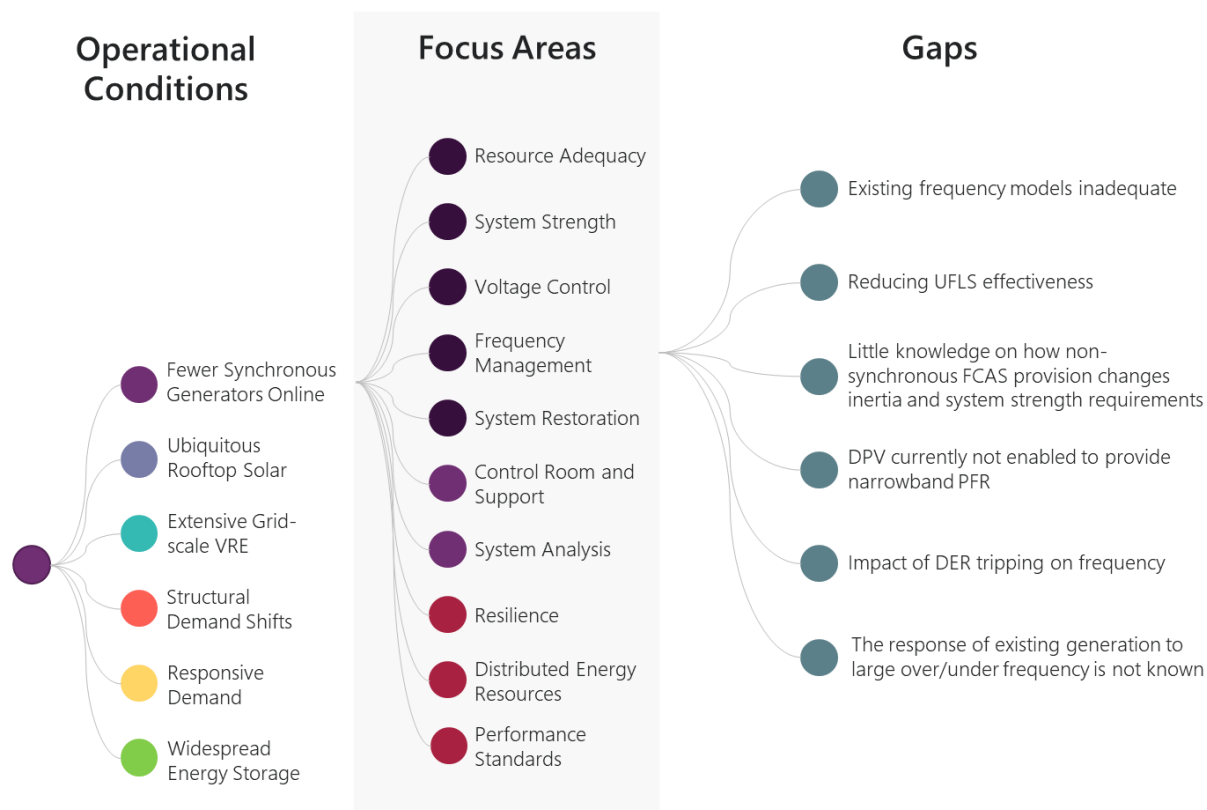
AEMO is developing an overarching Engineering Framework, which defines the full range of operational, technical and engineering requirements to support this transition. While this work is being developed by NEM based teams, it is relevant for WA too, although the actual analysis needs to be done for the SWIS and WEM and the appropriate WA outcomes developed. A summary of the gaps identified in the development of the Engineering Framework is provided in Figure 2.

Figure 2 Overview of engineering gap analysis – energy transition challenges



This engineering gap analysis is being used to develop a prioritised roadmap of actions needed to prepare for operation under the identified operational conditions. This includes system preparedness for operation with 100% instantaneous penetration of renewable energy. Figure 3 summarises some of the major gaps (and categories of gaps) already identified.

Figure 3 Summary of engineering challenges, or ‘gaps’



WEM Reform and implementation of DER Roadmap activities will enable solutions to the low load issue to be implemented. However, the engineering analysis is necessary to identify those solutions, when they are required, what they are protecting us against, and how they will change going forward. Transitioning to a system with up to 100% renewable generation¹⁰ will introduce different engineering challenges. Working with colleagues in the NEM, AEMO has already identified around 300 engineering challenges or ‘gaps’ in the WEM that will need to be addressed.

For AEMO, these engineering gaps will be filled by uplifting its skills and expertise, together with increased investment in operational tools and systems development. A detailed transition plan will need to be developed, which would better support a considered pathway as opposed to ad-hoc risks being identified and mitigated. A less structured approach would increase cost and reduce the confidence in AEMO’s ability to manage the transition securely, while also increasing risks to power system security if issues are not identified.

Work to be conducted by the additional resources necessary as part of the Engineering Framework includes:

- Extensive engineering studies.
- Developing planning and operational processes.
- Developing planning systems, and tools.
- Large-scale proof of concept trials.
- Performing live system testing for validation.

A number of projects are also being introduced to support the more secure operation of the power system in an increasing non-synchronous environment. These include the introduction of the operational simulator to support better operational awareness and ability to take necessary actions as well as utilising data being brought in from PMUs to improve power system understanding and modelling going forward.

AEMO’s focus is to deliver high priority activities in parallel with detailed planning process. Other system operators have taken similar actions, for example, Ireland’s system operator EirGrid undertook a

¹⁰ The SWIS is currently at up to 70% renewable penetration.

comprehensive programme starting in 2010. EirGrid allocated between 30 and 50 staff to prepare the Irish power system over ten years for high penetrations of inverter-based resources.

The resourcing uplift for PSMP to address the engineering gap is far more conservative. Leveraging off work being done in the NEM, AEMO estimates an initial uplift of around 2.5 FTE is required to address the gaps and ensure the SWIS can continue to transition securely away from synchronous generation.

AEMO submits these engineering activities will be ongoing throughout the AR6 period, and will continue to be required as the power system evolves.

Maximising efficiency of the market

Power system planning (keeping the lights on) is only one part of PSMP's responsibility. A crucial component of PSMP's work resolves around operational forecasting. This work directly contributes to market efficiency and effectiveness, particularly under the new market arrangements.

The quality and efficiency of any market's outcomes are driven by the quality and content of bids and offers into that market. Participants rely heavily on demand and operational forecast data, historical dispatch outcomes, supply availability, pricing and a range of other inputs when developing their bids and offers for each 30-minute trading interval. PSMP is responsible for producing a significant amount of this data.

Under the new market arrangements, the criticality of operational forecasting and dispatch data in particular increases. There are two key drivers of this:

- SCED and co-optimisation of energy and ESS.
- Moving from a 30-minute to a five-minute trading interval.

When the new market goes live, SCED and the consideration of network constraints adds a new layer of complexity to forecasting and ultimately the bidding process. Participants will want and need to understand constraints, ESS requirements, dispatch patterns and demand/supply patterns so that they can determine what facilities are likely to be required and when, and then bid accordingly.

As discussed in the Reserve Capacity section, the introduction of SCED also introduces a new requirement to calculate Network Access Quantities (NAQ) to support the determination of capacity credits. A key component of this is the development of relevant constraint equations to support this process, different to the constraints developed for the operational SCED model. While the early years of this process are expected to require 1 FTE this is expected to reduce to 0.5 FTE going forward.

Co-optimisation of energy and ESS means participants will be making more complex bids, and will seek to understand ESS requirements and what opportunities there are in the provision of ESS. Given co-optimisation and SCED are new to the WEM, it will take some time for participants (and AEMO) to work out dispatch dynamics and participant behaviour. AEMO also has a new obligation to develop and publish the Congestion Information Resource.

Dispatch will occur every five minutes (down from 30 minutes), with participants able to amend their bids right up to the beginning of the relevant trading interval. As such, the reliance on quality data and forecasting will be paramount.

The challenge for PSMP is that provision of this operational forecasting data is becoming more difficult. In summary:

- SCED and increasing intermittent generation makes forecasting supply more complex.
- DER penetration and changing technology/consumer behaviours makes forecasting demand more complex.

Under the new arrangements, PSMP must factor network constraints and congestion modelling into its operational forecasts, introducing thousands of additional calculations to the process. The changing energy mix and prevalence of inverter-based generation means more than ever, the SWIS and market is reliant on accurate operational forecasting, weather data, pre-dispatch data and system adequacy assessments.

Poor forecasting can directly impact market efficiency. It is therefore vital PSMP has the resources and capabilities to be able to provide forecasting data at a quality and frequency desired by market participants. As such, an uplift in PSMP resourcing is necessary.

In addition to the 0.8 FTE resources detailed above to improve the operational forecast model, AEMO estimates a resourcing effort uplift of approximately 1.5 FTE is necessary to deliver quality operational forecasts, support the determination of Network Access Quantities for the RCM, manage congestion information, and support real-time dispatch when the new market goes live.

Impact of automation

There is a perception that a lot of the workload in the new market environment will be automated. The new dispatch algorithm (WEMDE) will automatically process constraint equations, developing optimised and complex dispatch outcomes more quickly than human analysts ever could. However, the amount of human analysis required to enable that automation is substantial.

WEMDE co-optimises energy and ESS. This will result in the lowest overall cost of securely and reliably supplying electricity, and will be a huge benefit in terms of process efficiency and system security. However, the power system is constantly changing. This means that with WEMDE it is not a case of 'set and forget'. Bids/offers must be validated (by Market Operations) and system inputs, network constraints, system constraints and other aspects of an increasingly dynamic power system must also be validated, verified, updated and modified.

More data analysis is required to consider a range of probabilistic outcomes, as system risks are no longer discrete individual events that can be easily quantified. For example, the potential for DER output to fall and trip, the system must factor in the different types of PV, location, type of fault, network constraints, and the technical standards under which they were installed. It is no longer a case of analysing a single large synchronous generator that has tripped. Though there may be opportunity to automate some of this analysis over the long term, the vast majority of this analysis during and after the market go-live period will be conducted by human engineers.

Automation does not materially reduce the engineering/operational workload, at least not in the short to medium term. Essentially, the current human effort in PSMP is being displaced and redirected to a different and more complex form of analysis.

For example, if automation was not happening, co-optimisation of energy and ESS would be done on a very manual and discrete basis. Note that some manual co-optimisation is being done to some extent right now based on what can be managed in the current operational environment, however, the outcomes are not necessarily optimal. WEMDE and reform will enable co-optimisation to be done in a more comprehensive and efficient manner, but the human effort it displaces will be re-focused on the numbers inputs and constraints required to feed into WEMDE, which will be a lot more complex than in the past.

1.2.7 Operations Governance and Integration

The Operations Governance and Integration (OGI) team is responsible for real-time 24/7 support to market participants, acting as a central point of contact on behalf of PSO. Other key functions include analysing and verifying generator performance data, monitoring compliance and undertaking investigations when necessary, managing Ancillary Services contracts and issuing real-time dispatch advisories to market participants.

Based on information available at the time of making this proposal, AEMO estimates the effort required to deliver system management functions during the AR6 period within accepted risk tolerances will increase by approximately 1.1 FTE.

The resourcing uplift is driven primarily by increased support required by market participants and the resulting need for greater compliance monitoring and investigations under the new market arrangements, specifically during the go-live phase and the subsequent 12-18 months. This additional resourcing effort is offset to some extent by introduction of market competition in the provision of ESS, which means the number of ancillary services contracts OGI currently administers will be reduced.

The co-optimised energy and ESS market represents a significant departure from the current arrangements. SCED will increase the complexity of power system analysis and dispatch outcomes. The resourcing uplift is the result of incremental increases in effort required across many OGI activities during the period from go-live until the end of the AR6.

Following the new market going live in October 2023, AEMO expects that the volume queries from market participants will increase substantially. These queries are also expected to require complex analysis to identify any issues that require remediation through appropriate Rule Change or Procedure changes, or through IT changes. AEMO estimates it will take at least one full seasonal cycle to understand how new market dispatch will occur under the co-optimised energy and ESS framework with SCED, translating into the 12-18 month period following go-live point.

Accordingly, the volume of compliance monitoring and the complexity of investigations are expected to increase. Currently investigations take up to 180 minutes for the more complex breaches compared to about 15 minutes for the simpler one. The OGI team will also expand its compliance activities to include two additional functions introduced under WEM Reform:

- Monitoring ongoing compliance obligations under the Generator Performance Standards (GPS) for each market participant.
- Maintaining the DER Register and verifying data provided by Western Power, with instances of non-compliance raised with ERA.

Internally, the PSO team will undergo major changes to the way it performs its functions and will require assistance with rule interpretation at go-live and over the subsequent 12-18 months. The volume of related documentation (e.g. dispatch algorithm, market procedures, technical specification, guidelines) and data publication requirements is expected to increase.

The OGI team will monitor workload during this period and will seek to find efficiencies as the process become more mature towards the end of the AR6 period. However, AEMO submits the 2.2 FTE uplift is the minimum required to be able to continue to provide a quality service to market participants during market go-live and the months that follow.

The additional resourcing effort is offset to some extent by a decrease in the following activities:

- Market data transactions – OGI is reliant on manual processes to validate and address data integrity issues, with WEMDE expected to automate many of these manual processes. However, these processes will continue to require substantial human oversight and intervention across WA Market Operations and System Management as the volume of inputs and outputs associated with the new dispatch algorithm will be significantly greater than those managed currently. Overall, a small FTE increase is expected at the go-live stage before reducing to 0.5 FTE.
- Management of Ancillary Services contracts – OGI is currently involved in the tendering process for the Ancillary Services contracts, as well as monthly analysis and settlement calculation of Ancillary Services. The introduction of a competitive ESS market will eliminate the need for these activities, however, OGI will remain responsible for System Restart Services contracts and potentially for contracts associated with Non-Co-optimised Essential System Services (NCESS).
- Supporting IT accountabilities – Historically, OGI has been managing the Western Power IT Service Agreement; this function is no longer required. However, OGI will continue to assist the implementation of IT changes on behalf of the control room to eliminate any disruptions to the power system operations.

1.2.8 WA support functions

WA support functions are central resources, whereby a portion of FTE effort is allocated to AEMO WA based on estimated ongoing resource requirements. Some support staff are dedicated 100% to AEMO WA, others may share time between markets and jurisdictions including the WEM and the NEM.

Where resources are not dedicated 100% to WA, for example some Digital and Technology resources, employees and contractors will complete time sheets and FTE effort will be charged to AEMO WA or other AEMO NEM functions accordingly. This ensures WEM participants are only paying for the portion of support resources that are providing services to the WEM.

Table 4 summarises the FTE resourcing requirements for the WA departments.

Table 4 WA support functions FTE forecast AR5 to AR6

WA support (FTEs)	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	AR5 avg	AR6 avg	Change avg
External Affairs	1.6	1.7	1.8	1.6	1.6	1.6	1.7	1.6	-0.1
Operations	0.9	1.4	2.0	3.0	3.0	3.0	1.5	3.0	1.6
System Design and Engineering	1.7	2.2	2.7	2.0	2.0	2.0	2.2	2.0	-0.2
Technology (Digital)	12.2	18.7	22.9	23.5	28.7	31.0	17.9	27.7	9.8
Strategy & Markets	0.0	0.0	0.0	0.4	0.8	0.8	0.0	0.7	0.7
People & Culture	1.8	1.0	1.0	1.0	1.0	1.0	1.3	1.0	-0.3
Finance & Business Services	2.4	3.6	2.8	3.6	3.6	3.6	2.9	3.6	0.6
Governance	3.3	4.7	4.1	4.2	4.2	4.2	4.0	4.2	0.2
Total FTE	23.9	33.3	37.3	39.3	44.9	47.2	31.5	43.8	12.3

Resourcing levels for all support functions other than Technology (also referred to as the Digital department) are not materially changing from AR5 levels. However, the Technology function will continue on its recent path of growing resource requirements. As shown in Table 4, Technology resource requirements increased from ~12FTE to ~23FTE over the AR5 period, as more systems and IT solutions (e.g. settlement system changes (RoPE and SMST)) increased the scope of the WA Solutions team’s responsibilities. This trend will continue into the AR6 period, as the breadth of systems and scope of work for the team increases.

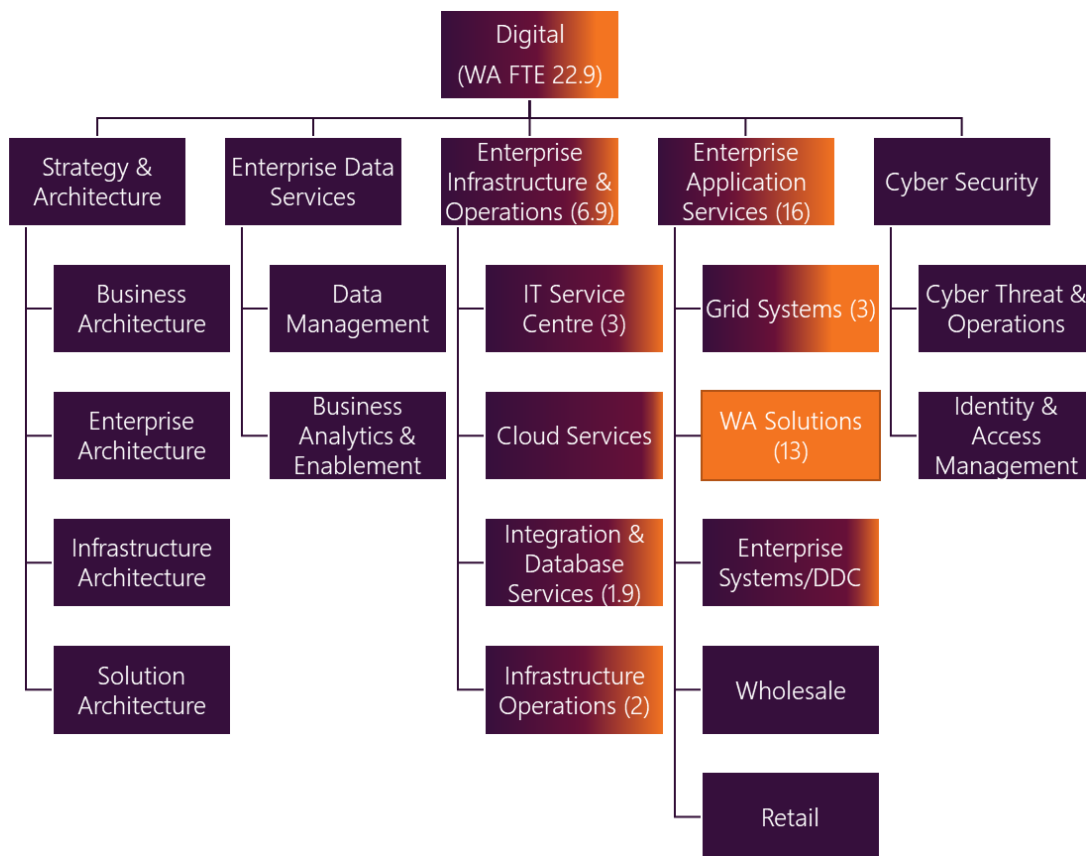
Technology (Digital)

The Digital department includes the following groups:

- Strategy & Architecture
- Enterprise Data Services
- Enterprise Infrastructure & Operations
- Enterprise Application Services
- Cyber Security.

Digital is an enterprise-wide department, providing centralised support across multiple AEMO jurisdictions. The Digital department’s WA allocation is approximately 23 FTE. Figure 4 shows the current Digital department structure and FTE allocation across the department.

Figure 4 Digital department structure and number of FTEs allocated to WA on 1 December 2021



The orange shading indicates the WA operational labour allocation relative to the total size of the group or team with the WA allocation of FTE indicated in brackets.

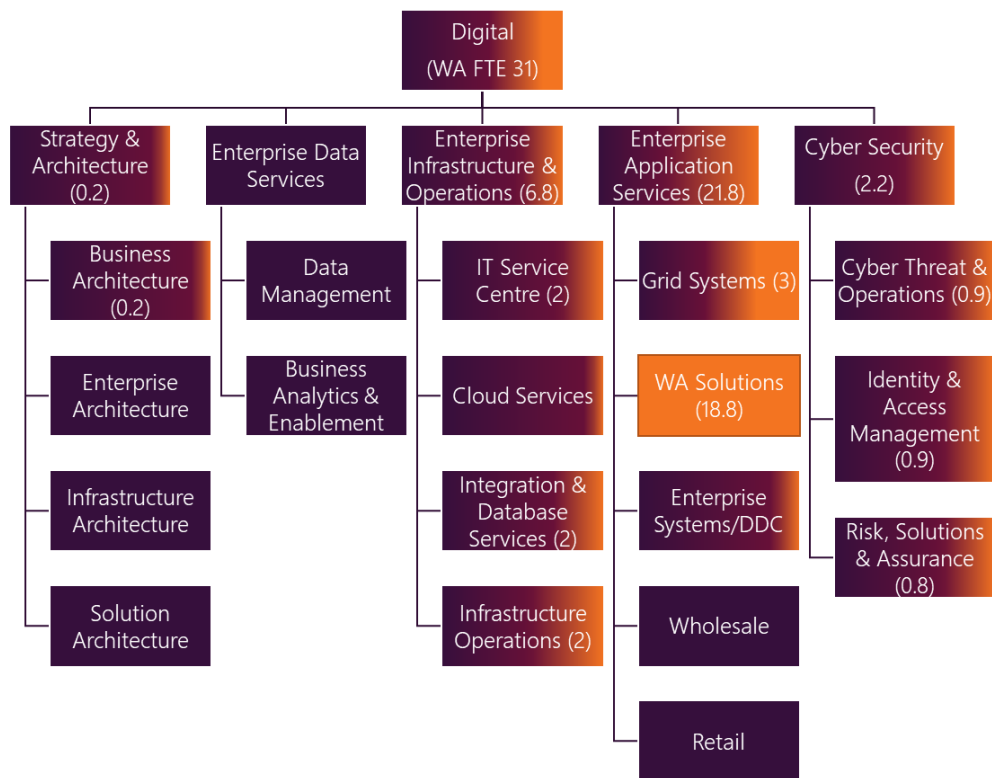
Table 5 summarises the change in WA allocation at a group level through the AR5 and AR6 periods.

Table 5 Digital FTEs WA allocation AR5 to AR6

Digital (FTEs)	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	AR5 avg	AR6 avg	Change (avg)
Strategy & Architecture	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.2	0.2
Enterprise Data Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enterprise Infrastructure & Operations	5.4	6.4	6.9	6.8	6.8	6.8	6.2	6.8	0.6
Enterprise Application Services	6.7	12.3	16.0	15.9	20.3	21.8	11.7	19.3	7.7
Cyber Security	0.0	0.0	0.0	0.7	1.4	2.2	0.0	1.4	1.4
Total FTE	12.0	18.7	22.9	23.5	28.7	31.0	17.9	27.7	9.9

The expected changes to the teams are highlighted below. Once again, the orange shading indicates the WA operational labour allocation relative to the total size of the group or team with the WA allocation of FTE indicated in brackets.

Figure 5 Digital department structure and number of FTEs allocated to WA by end of AR6 period



The following sections provide an overview of the Digital department’s groups and teams as well as an overview of the expected changes to operational labour allocations.

Strategy & Architecture

The Strategy & Architecture team is responsible for defining and owning the technology strategy as well as the governance that ensures that AEMO continually aligns solutions to the agreed strategy. This includes establishing and maintaining:

- Technology capability models
- Technology principles
- Strategic product selection
- Architecture governance
- Solution architecture
- Technology roadmaps and target states
- Standards and patterns.

Historically, AEMO WA has leveraged these resources throughout the implementation of capital projects. For every project, a solution architect would be responsible for creating the software and hardware designs and patterns required to complete implementation. For that reason, there has not been a specific allocation of opex labour resources.

During the AR5 period, and as part of the delivery of the Digital Roadmap, the Enterprise Architecture Uplift project was approved. As part of this project, new software (iServer) and governance processes were introduced to manage AEMO’s architecture design. By creating and managing a single-source-of-truth for all AEMO WA’s architectural artefacts, AEMO has introduced significant efficiency to project delivery. Projects no longer need to recreate ‘current state’ architecture designs and have a standard pattern to follow when

creating 'future state' designs. This process and the supporting software has reduced cost, lowered risk, and improved the quality of delivery.

While this has reduced project planning and execution costs, a small operational labour overhead is required for ongoing maintenance of both the iServer product and the underlying processes.

Enterprise Data Services

AEMO's Enterprise Data Services team supports an evolving range of capabilities, designed to enable fast access to trustworthy data and provide analytical solutions that are dynamic and scalable. Throughout both AR5 and AR6, there is no operational labour component for this team for WA as much of their work is managed through capital project delivery. Much of the operational support required is managed by AEMO's Level 1 (Service Desk) IT support team, the Support Hub, which is part of the Infrastructure & Technology Operations team.

Enterprise Infrastructure & Operations

The Infrastructure & Operations team provides a range of services to AEMO as whole and to WA specifically:

- **IT Service Centre:** This team is responsible for the Level 1 (Service Desk) and Level 2 (End User/Desktop Support), as well as the overall IT Service Management capability. This includes the management and governance of IT Incidents, Changes, and Service Requests. Despite the significant growth in the number of resources in the WA department, the number of FTE required to support them will remain static across both AR5 and AR6. This is due to efficiencies available to AEMO WA through the use of a larger, enterprise-wide team – as well as continuous improvements delivered through the Digital Strategy in AR5 as part of the IT Service Management projects.
- **Cloud Services:** A relatively new team to AEMO, with the introduction of cloud capability in AR5, this team manages AEMO's relationship with these external service providers. For AEMO WA, the first public cloud service was provisioned through the Generator Performance Standards (GPS) project completed under WEM Reform. There is no FTE labour component as the implementation activities are delivered through capex projects; with operational costs captured following the go-live of those projects through the ongoing fees to the cloud providers.
- **Integration & Database Services:** This team provides 24x7x365 support to AEMO WA's Oracle and SQL databases, as well as at the integration layer through webMethods. This team has grown from 2 FTE to 2.8 FTE to accommodate the additional databases and integration requirements introduced by the Western Power transition projects (SMST and PSO).
- **Infrastructure Operations:** This team provides support to AEMO WA's physical, on-premises infrastructure including data centre facilities, server, storage, network. The number of resources required to support this increased during AR5 to support the additional requirements following the Western Power transition projects (SMST and PSO).

Enterprise Application Services

The Enterprise Application Services group provides software support and delivery services across AEMO. For AEMO in WA, there are two teams responsible for these services: WA Solutions and Grid Systems.

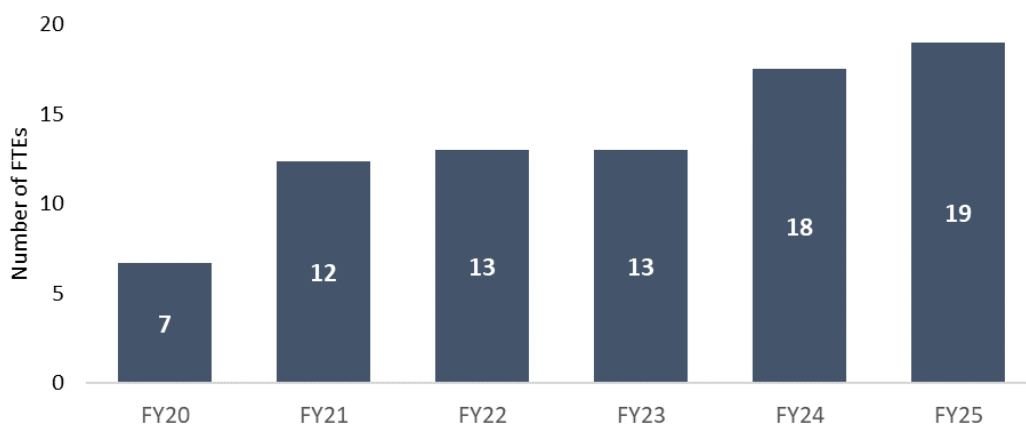
WA Solutions

The WA Solutions team is responsible for delivery and support of software and systems required by AEMO WA. The team is the technical owner of many of the WA market and system operations systems and provides 24x7x365 support to ensure these IT systems remain operational and secure. WA Solutions resources are allocated to the relevant AEMO WA departments by completing time sheets.

Background and the AR5 period

The AR5 period has seen considerable change to the number and complexity of systems managed by the WA Solutions team. This has driven an increase in the number of IT resources since 2019-20 and will continue into AR6 (see Figure 6).

Figure 6 WA Solutions labour uplift AR5 to AR6

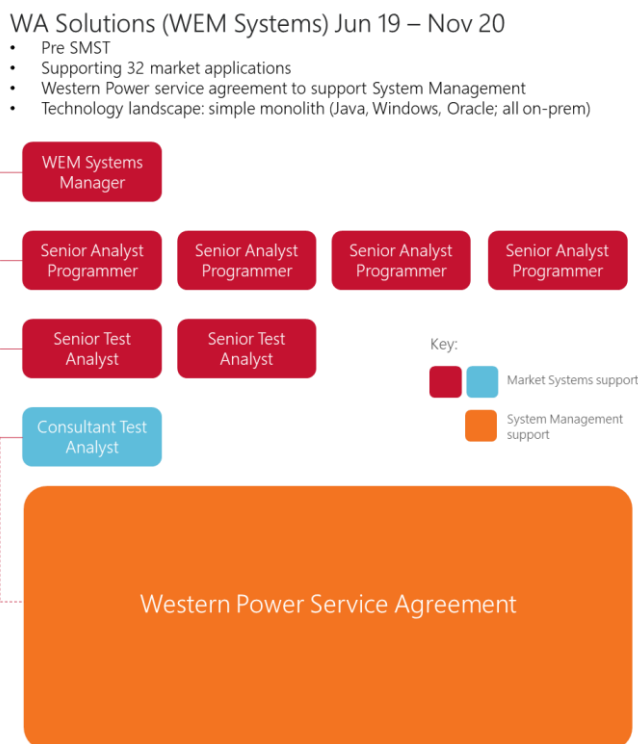


In July 2019, at the beginning of the AR5 period, internal software services for AEMO WA were limited to WA market systems. The WA market is operated with 40 applications of varying size and complexity. WA Solutions was (and still is) responsible for technical support of 32 of these applications, as well as providing general technical support to the WA Market Operations, Reserve Capacity and Market Development departments.

The WA Solutions team at the beginning of the AR5 period (then called the WEM Systems team) consisted of one manager and four software developers, supported by two internal test resources. A consultant test analyst was also used on an ad-hoc basis. The technology landscape was relatively simple, founded on applications including Java, Microsoft Windows and Oracle, all hosted on internal data centres. A fifth developer was added to support the new Prudentials solution developed as part of the Reduction of Prudential Exposure (RoPE) project.

The below diagram summarises the team structure, resourcing level, and technology landscape at the time.

Figure 7 WA Solutions (WEM Systems) resources and structure in 2019-20



At the beginning of the AR5 period, WA System Management system operations systems were not supported by AEMO. Instead, the applications necessary to enable system operations functions were supported by a third party, Western Power, under a Services Agreement. The Service Agreement charges were typically \$3 million per year, with AEMO incurring \$17.7 million over the life of the agreement. The System Management

System Transition (SMST) and Power Systems Operations (PSO) projects were designed to change this position by bringing these systems in-house.

The SMST and PSO projects commenced prior to the start of the AR5 period. An outworking of IMO/Western Power System Management merger in 2015, the SMST and PSO would see the transfer of the Western Power system operations legacy IT systems to AEMO WA. The aim was to replicate these applications in AEMO's IT environment. The support of these applications split between the WA Solutions and Grid Systems teams (see below for details on Grid Systems). The WA Solutions became the technical owners of 20 applications and no longer relied on Western Power for software support.

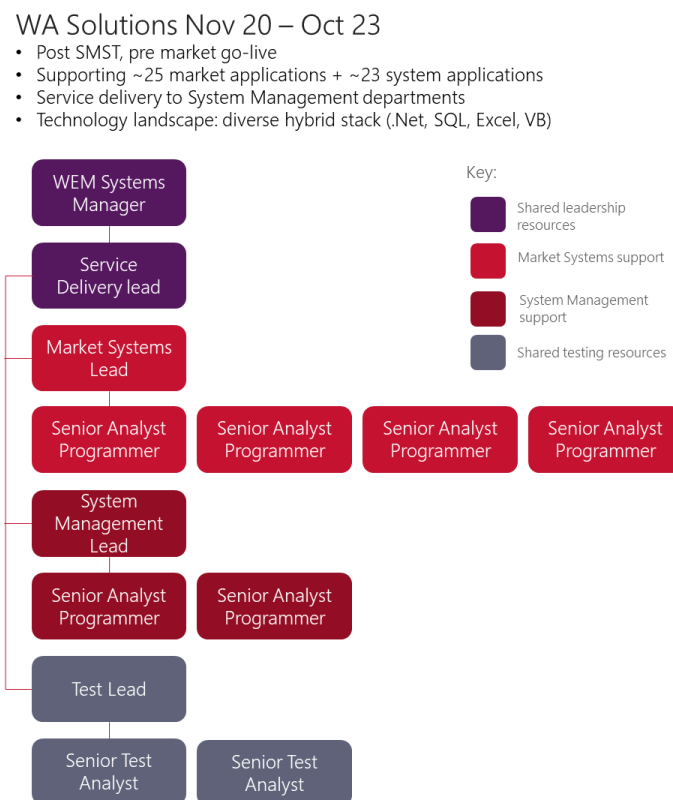
When delivering the transition projects, the AEMO recognised there are common attributes, shared capabilities and dependences across AEMO WA's system and market operations functions. As such, rather than replicate the Western Power IT service functions like-for-like, AEMO reviewed its existing resources and capabilities, and uplifted its resource requirements by the minimum required to support the WA systems without materially impacting risk.

A total of 5.0 FTE resources were added to the team to support bringing system management applications inhouse.

Four of the resources were required to provide technical support to system management applications. This included three programmers and one test analyst. A service delivery lead was brought into the team to support management and delivery activities across both WA Markets and Systems Management. As the application landscape was now all internal, the cross-functional activities required additional oversight.

The revised structure, resources and technology landscape is summarised in Figure 8.

Figure 8 WA Solutions (WEM Systems) resources and structure post SMST project, pre market go-live



The above structure is in place today. WA solutions is responsible for supporting 50+ applications. The IT landscape also shifted during the AR5 period. System architecture was evolved to minimise reliance on legacy technology, where possible replacing Java with .Net and Oracle with SQL. This new technology stack formed the basis of new applications delivered during the period such as RoPE and Settlements Enhancements.

Despite the shift in the IT landscape, the current technology stack is largely based on the existing Western Power architecture. This is because the SMST project was based on a 'lift and shift' approach rather than a

significant architecture redesign. It was understood that much of the technology will be replaced as part of the WEM Reform program in the AR6 period.

Based on information available at the time of making this proposal, AEMO estimates the effort required to support the WA market and system operations applications within accepted risk tolerances during the AR6 period will increase by up to ~6.0 FTE.

The resourcing uplift is driven by two technical factors caused by the implementation of WEM Reform. The first is that while the total number of applications supported before and after the delivery of reform is relatively static, the complexity of the applications and the scale of support required is significantly increased to accommodate the requirements of the new market. The second factor relates to the new digital platform underpinning this new environment.

The following sections provide more detail on those two factors.

Scale of support

From October 2023, the software landscape for systems supporting AEMO's WA departments and functions will alter significantly. Delivery of WEM Reform will result in the decommissioning of ~20 applications supported by the WA Solutions team - mostly in the System Management area. The majority of the WA market applications will not only remain but the scope of work they will be required to perform will increase significantly.

For the *WA Markets* support capability, following the delivery of WEM Reform, the following WA market applications will be decommissioned. However, their data will need to be retained:

- WEM Services (Balancing and LFAS microservices only)
- CAST
- MPI Portal
- Gator.

WEM Reform will introduce two new market applications Real-Time Market Submission (RTMS) and RCM NAQ as well as replacing the existing MPI portal with a modern equivalent. While the applications being commissioned are relatively simple, both the RTMS and RCM NAQ are required to support a greater amount of business requirements.

In the new real-time market, the broad process for operating and supporting the wholesale market mechanisms remains the same. However, the new arrangements introduce network constraints and more complex power system constraints into the market and dispatch processes by co-optimising energy and ESS (and more than just LFAS). This will increase the complexity of systems, processes, data and analysis in some areas.

Market participants will still make submissions, but the complexity and volume of the market participant submissions will increase. The new RTMS application replaces the simplistic Balancing Market and LFAS applications. The application will be scaled-up to support these business processes and ensure the availability, security, and confidentiality of the data.

The new RCM NAQ application will implement the Network Access Quantity framework to allow AMO to accommodate network and system constraints in its determination of capacity credits. The consideration of these network and system constraints requires significant more complex linear programming and testing capabilities.

The additional estimated effort to support these new capabilities is 1 FTE for development and 0.5 FTE for testing.

As previously mentioned, a number of applications will be decommissioned following the implementation of the new market arrangements and associated systems and processes. The following WA System Management applications will be decommissioned, and their data retained:

- System Management Market Participant Interface (SM MPI)
- Archive Database
- Modified Automatic Balancing Control (M-ABC)

- Non-Scheduled Generation Forecast (NSG Forecast)
- Operational Data Store (ODS)
- Demand Forecasting System (DFS)
- Projected Assessment of System Adequacy (PASA) (legacy)
- Instruction Manager (IM)
- Real Time Dispatch Engine (RTDE) (legacy)
- Network Operator Interface (NOI)
- System Operating Command and Control Centre User Interface (SOCCUI).

While this is a significant number of applications, it must be noted that these applications are of simple construction and would likely have needed to be replaced or upgraded even if WEM Reform was not in flight. Excel spreadsheets and basic java applications are simpler to manage but lack stability, useability, and have severe limitations with their performance and availability. A number of incidents have been recorded since the transition from Western Power due to outages related to these under-engineered applications.

As part of the delivery of WEM Reform, new applications will be introduced including:

- WEM Dispatch Engine (WEMDE)
- WEMDE User Interface
- Generator Performance Standards
- Commissioning Test
- Outage Management
- Short Term PASA (ST PASA)
- Constraints Management.

WEMDE will be the dispatch engine for the new market and introduce the most complex application ever used in AEMO WA. WEMDE will automatically process system and network constraint equations, developing complex dispatch instructions co-optimising energy and ESS. The optimisation and linear programming requirements exceed even RCM NAQ. The application will be required 24x7x365 and must be rigorously maintained.

WEMDE UI will deliver the new user interface that controllers will use to coordinate dispatch in the control room. WEMDE UI will replace the Controllers' existing SOCCUI system and connect to the new WEM Dispatch Engine. The current SOCCUI is an excel spreadsheet. WEMDE UI is to be built to latest standards expected of an application that required to provide support to system critical control room operations.

The new Commissioning Test, Outage Management and ST PASA applications are required to support AEMO WA's System Planning capability. The simple applications currently providing similar capability were developed in legacy technology that would need to be replaced and uplifted even if reform was not in flight. The current applications were designed when there was little renewable penetration in the SWIS, meaning they too basic to be fit-for-purpose under the new dynamic market and system arrangements. Again, these new applications will be more complex than their predecessors and are critical to system operations. Each will require 24x7x365 support and ongoing development.

Constraint Management is a new obligation under the new market arrangements and requires a new application to ensure that AEMO can comply with these requirements. The network and system constraint library, or the Congestion Information Resource, will help AEMO enhance its commitment to transparency and assist market participants as they understand and transition to the new system.

The additional estimated effort to support these new capabilities is 1 FTE for development and 0.5 FTE for testing.

Digital Platform

During the AR5 period, AEMO enhanced its digital delivery capability through the introduction of enterprise capabilities in areas such as public cloud, cyber security, data and analytics, and other common services. As part of WEM Reform, a specific project was created to ensure WA applications were able to adopt this new

Digital Platform. All of the new applications mentioned in the previous section are built on this WA Digital Platform. The WA Solutions team will be required to operate in this new environment and adapt to the capabilities provided both internally and externally.

The introduction of an Enterprise Data Platform will provide improvements to data analytics and reporting throughout the new market and across multiple applications in both the market and system operations space. The additional estimated effort to support these new capabilities is 0.20 FTE for each of the development teams and 0.20 FTE for testing.

Prior to and during the AR5 period, AEMO made a strategic decision to invest significantly in uplifting their cyber security capability. The importance of this investment has been seen with cyber attacks becoming more frequent and the consequences becoming more significant. Ransomware attacks have become prolific. In October 2021 alone there were notable incidents for Sandhills Global^[1], Hong Kong marketing firm Fimmick^[2], , Thailand-based luxury hotel chain Centara hotels^[3], Pacific City Bank (PCB)^[4], and Graff Diamonds^[5].

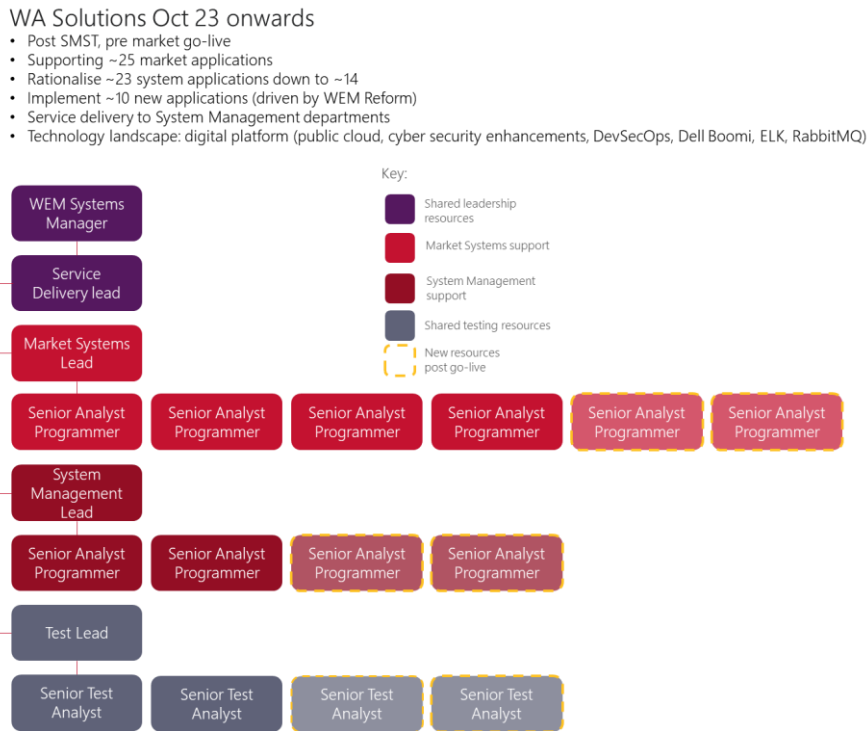
More specifically in the energy sector and during the AR5 period, the European Network of Transmission System Operators for Electricity (ENTSO-E) confirmed a cyber attack in early 2020^[6]. In May 2021, the Colonial Pipeline, which supplies about half of the gasoline to the east coast of USA, went down for several days following a ransomware attack^[7]. This caused panic-buying, shortages, and price spikes in some states. More recently, wind turbine maker Vestas Wind Systems, supplier to WA market participants, experienced theft of data following a cyber-attack^[8].

In response to these growing threats, AEMO has increased the requirements expected of its internal team to ensure software is developed and maintained more securely. Application security testing software has been introduced and proactively scans all code developed internally for vulnerabilities. Additional and regular training in the latest best practice is also required for all staff. Rather than ad-hoc penetration testing during project delivery, all external facing applications are proactively and regularly examined. This is necessary but does place additional imposition on software developers to ensure code is precise and well maintained. The additional estimated effort to support these new capabilities is 0.5 FTE for each of the development teams and 0.5 FTE for testing.

The Digital Platform also introduces a common integration tool across all its applications. The purpose of the integration layer is to allow multiple applications to operate as a seamless, united system. The new enterprise integration solution improves performance, quality and data integrity, as well as reducing risk to the overall system availability. The WA Solutions team will be required to support this new integration solution. The additional estimated effort to support this new capability is 0.20 FTE for each of the development teams and 0.20 FTE for testing.

The diagram below illustrates the future-state, post-reform team structure.

Figure 9 WA Solutions (WEM Systems) resources and structure post market go-live



Grid Systems

The second Enterprise Application Services team that provides support to the WA department is the grid systems team. This is a national team that, prior to the AR5 period, provided support for the NEM’s EMS. This includes the real-time SCADA system that is essential to the ongoing management of the energy system. As part of the transition of services from Western Power to AEMO, support for the equivalent systems in the WEM was allocated to this team. Three new resources were brought in to the existing team to support the transfer of System Management to AEMO. While these systems will be upgraded both during and after WEM Reform, no change to this FTE requirement is expected as there is no significant uplift to the capabilities required of these systems.

Cyber Security

During the AR5 period AEMO made a strategic decision to invest significantly in uplifting its cyber security capability. The importance of this investment has been seen with cyber attacks becoming more frequent and the consequences becoming more significant. The bulk of this investment during the AR5 period was capex. Now that these projects have been operationalised, there is a requirement for the ongoing management of AEMO’s cyber security processes, governance, and capability. Three teams will require resources to support WA share of these enterprise capability, as shown in Table 6.

Table 6 Cyber security FTE requirements AR5 to AR6

Cyber (FTEs)	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	AR5 ave	AR6 ave	Change (ave)
Cyber Risk, Solutions & Assurance	0.0	0.0	0.0	0.3	0.6	0.8	0.0	0.6	0.6
Cyber Threat & Operations	0.0	0.0	0.0	0.3	0.6	0.9	0.0	0.6	0.6
Identity & Access Management	0.0	0.0	0.0	0.1	0.2	0.5	0.0	0.2	0.2
Total FTE	0.0	0.0	0.0	0.7	1.4	2.2	0.0	1.4	1.4

The Cyber Risk, Solutions & Assurance team ensures that AEMO applications are 'secure by design'. They perform pen-testing and other assurance activities to independently validate compliance with agreed cyber security requirements. They manage risks as a result of non-compliance with our Cyber Security Policy. They provide user awareness activities such as 'Switch on Cyber' and targeted cohort specific security training so that AEMO has a 'culture of cyber security awareness'. The additional estimated effort to support these new capabilities rise to 0.8 FTE by 2024-25 as part of the shared enterprise team.

Cyber Threat & Operations looks for anything unusual in our network that may indicate there's been a breach. They respond to incidents so when something has gone wrong, we're able to contain then recover from the situation. They share cyber threat intelligence with domestic and international peers so we all benefit from current, vetted and actionable intelligence to protect AEMO and the industry from cyber attacks. The additional estimated effort to support these new capabilities rise to 0.9 FTE by 2024-25 as part of the shared enterprise team.

Identity & Access Management capability was introduced during the AR5 period and ensures AEMO's onboarding, offboarding and regular access reviews occur as smoothly as possible. The additional estimated effort to support these new capabilities rise to 0.5 FTE in 2024-25 as part of the shared enterprise team.