AEMO WA IT ROADMAP 2022-2025

AUSTRALIAN ENERGY MARKET OPERATOR

December 2021

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Executive summary

AEMO's ability to provide market and system operations functions, as prescribed by the WEM Rules, depends on having fit-for-purpose and secure IT systems. The pace of technological change is rapid, as is the evolving cyber security threat as society becomes more reliant on IT and cyber-attacks become more sophisticated.

To ensure AEMO can continue to operate the power system and market securely in a changing IT landscape, it is imperative AEMO's systems are regularly reviewed, upgraded and evolved. To manage this IT evolution, AEMO regularly produces IT Roadmaps, designed to inform key IT system changes. Typically, each Roadmap builds on the previous edition, providing transparency of how AEMO's critical systems have developed over time.

This IT Roadmap is the sixth such document produced since the Independent Market Operator (IMO) was established. It outlines the systems, applications, infrastructure, and digital capital projects required over the three-year period July 2022 to June 2025. This strategic document is designed to guide AEMO's IT investment and help inform AEMO's AR6 Allowable Revenue submission for the same three-year period.

The focus of this IT Roadmap is aligned with AEMO's strategic priorities, which are:

1. Operate Markets and Systems
2. Navigate Energy Future
3. Engage our Stakeholders
4. Evolve the Way We Work

The projects and systems to be delivered in line with these priorities are summarised in the following sections.

Priority 1: Operate markets and systems

Providing functioning and vendor-supported IT systems that enable AEMO to operate the market and power system is AEMO's first priority. To ensure this, over the next three years AEMO will continue its program of IT lifecycle replacement (see section 5.6) and upgrade, delivering timely investment to make certain AEMO has the systems it needs to 'keep the lights on'. Allied with this, the IT Roadmap for the next three years also includes three capability uplift projects for AEMO WA (see section 5.5), which will deliver new tools to enable better power system monitoring, control and forecasting.

Most critically, AEMO will continue to invest in and uplift its cyber security capabilities (see section 5.8.4). Cyber-attacks are becoming more frequent and more sophisticated. 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]. In December 2021, companies around the world had to respond rapidly when a new 'Zero Day' vulnerability[6] was detected in commonly used software.

In 2022, the Australian Federal Government is expected to pass legally binding regulations on cyber security for the energy sector based on the Australia Energy Sector Cyber Security Framework (AESCSF). AEMO will almost certainly be nominated as Critical Infrastructure and Systems of National Significance (CI/SONS), and therefore will be subject to enhanced security obligations.

[1] https://www.bleepingcomputer.com/news/security/sandhills-online-machinery-markets-shut-down-by-ransomware-attack/

[2] https://www.zdnet.com/article/hong-kong-firm-becomes-latest-marketing-company-hit-with-revil-ransomware/

[3] https://www.itpro.co.uk/security/cyber-attacks/361401/thailand-luxury-hotel-chain-hit-by-desorden-group

[4] https://www.bleepingcomputer.com/news/security/pacific-city-bank-discloses-ransomware-attack-claimed-by-avoslocker/

[5] https://www.dailymail.co.uk/news/article-10148265/Massive-cyber-heist-rocks-high-society-jeweller-Graff.html

[6] https://www.abc.net.au/news/2021-12-11/log4shell-techs-race-to-fix-software-flaw/100692876

Compliance with *SOCI Act*[7] requires an assessment of AEMO's current cyber security compliance state, development of a plan for uplifting from the current state to the required compliance level, and implementation of the plan to achieve AESCSF Security Profile 3 (SP-3) level compliance. It is highly likely AEMO will be required to uplift its maturity level to meet AESCSF SP-3 compliance within five years of the Act coming into effect. This IT Roadmap therefore sets out the cyber security projects to be delivered during the AR6 period to ensure Australia's power systems and markets remains secure and AEMO is on the pathway to compliance.

Priority 2: Navigate Energy Future

The second strategic priority sees AEMO's focus on delivering the new systems and technologies to support new market arrangements in WA. During the AR6 period, there are two significant programs of work:

- WEM Reform (see section 5.3)
- WA DER program (see section 5.4)

WEM Reform sees introduction of a real-time co-optimised energy and essential system services (ESS) market in WA. Implementing WEM Reform will require changes to more than 80% of AEMO's existing WA software applications, as well as ongoing refinement and support following market go-live in October 2023.

The WA DER program introduces and entirely new function to AEMO and will ultimately enable aggregated DER to participate in the wholesale electricity market. The WA DER program requires a suite of new systems and market interfaces to be developed, tested, implemented and supported.

To the extent possible, both these WA programs draw on systems and resources already deployed in the National Electricity Market (NEM). This allows the WEM to benefit from lessons learnt in prior projects, and cost savings associated with modifying existing systems (e.g. NEMDE and Project EDGE's Local Services Exchange) rather than building bespoke standalone systems from scratch. Sharing resources and expertise in this way helps AEMO WA to deliver these projects for the lowest practicably sustainable cost.

Priority 3: Engage our Stakeholders

AEMO is conscious that any changes made to market systems may have flow on impacts for market participants' systems and processes. That is why as part of the WEM Reform package of work, AEMO is sharing and testing IT specifications with participants, with a view to making sure all parties are prepared for market go-live in October 2023.

Further, as part of the WA DER program, AEMO will deliver a Market Visibility project, which aims to create new suites of data visualisation, training material and outreach to inform potential new market participants, particularly DER aggregators. AEMO will also continue to invest and refine other key market data platforms, such as the GBB, which will be migrated to AEMO's digital platform (cloud) during the AR6 period.

To help deliver projects for the lowest practicably sustainable costs, AEMO will leverage existing systems and data visualisations where possible. AEMO will test any assumptions that are likely to impact market participants and energy industry stakeholders before implementing new systems.

Priority 4: Evolve the Way We work

In 2019, AEMO recognised that the organisation's technology landscape had become antiquated, complex, and unsuitable for further development. A digital roadmap was developed to facilitate a more efficient, scalable, and secure digital environment in which to build and enhance IT systems now and in the future.

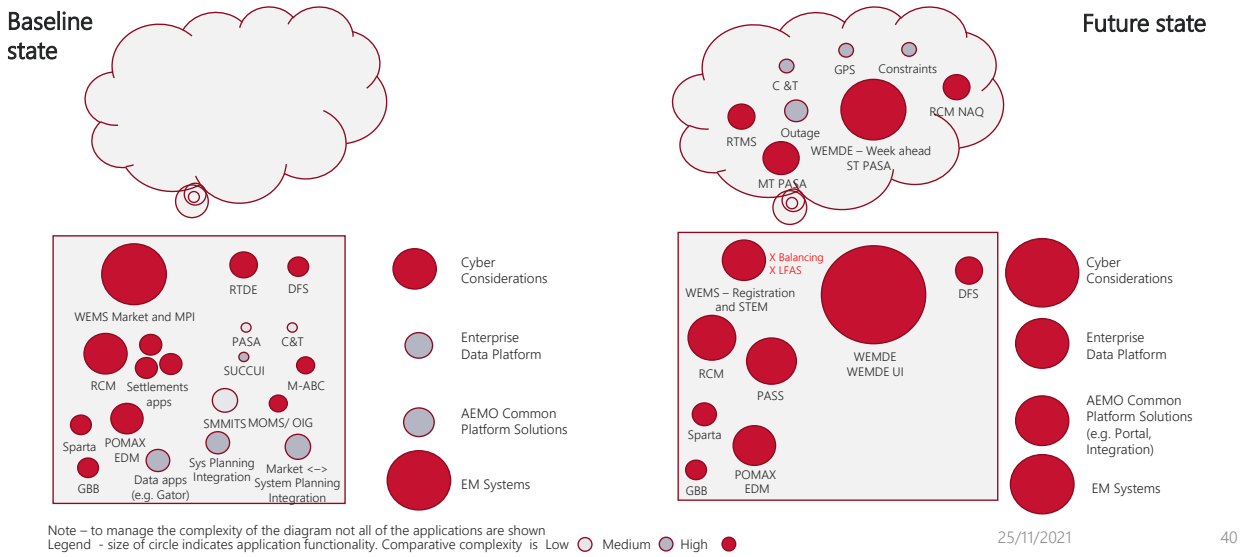
This edition of the IT Roadmap builds on the work undertaken to date and will see AEMO move towards a predominantly cloud-based IT environment. WEM Reform is one of the first programs to take advantage of AEMO's new digital platform (along with five-minute settlement in the NEM), with the new Generator Performance Standards application moving into production in July 2021 on AEMO's public cloud. The solution

[7] https://www.homeaffairs.gov.au/about-us/our-portfolios/national-security/security-coordination/security-of-critical-infrastructure-act-2018

design process for reform has been completed and many of the applications will also be deployed into this new digital platform.

AR6 will see AEMO's current complex IT landscape, with multiple bespoke systems hosted on-premises, transition to a simpler cloud-based landscape with shared enterprise-wide systems.

Figure 1 Change in complexity between application landscapes[8]



Note – to manage the complexity of the diagram not all of the applications are shown
Legend - size of circle indicates application functionality. Comparative complexity is Low Medium High

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The drivers for moving to cloud-based work were speed to market, scalability, quality, security and cost. AEMO's cloud service provider is Microsoft Azure. As a heavy IT user and a longstanding client of Microsoft, AEMO was able to negotiate a significant discount when establishing its cloud agreement.

An advantage of cloud pricing is that all the running costs that would be incurred if servers are managed on-premises are built into the price. This includes power, air conditioning, operational support to upgrade/patch services etc. It also enables AEMO to eliminate ongoing asset upgrade and server/infrastructure replacement costs.

The next three years is where the bulk of this transition will take place, with the new market and its associated systems being the catalyst for change in AEMO WA. The transition will require significant IT investment during the AR6 period. However, subject to the initiatives in the IT Roadmap being delivered as planned, AEMO expects the future IT landscape to be realised during the AR7 period, and with it the benefits of centralised systems and more efficient ways of working.

To test that AEMO WA's IT Roadmap only reflect investment in projects and systems that would be incurred by a prudent service provider, AEMO has mapped its proposed projects against AEMO's functions under the WEM Rules (see section 5.1). Throughout delivery of the IT Roadmap, AEMO will continue to review and refine its works program, ensuring the solutions developed remain aligned with AEMO's obligations.

This process of ongoing review, allied with AEMO's established project governance framework, will help ensure WEM participants only pay for investments that will benefit the WEM, and promote delivery of quality, customer-focused IT solutions at the lowest practicably sustainable cost.

[8] A larger diagram is available in the Appendix.

1. Introduction

The Australian Energy Market Operator (AEMO) administers the Western Australian Wholesale Electricity Market (WEM) under the Wholesale Electricity Market Rules (Rules) and provides the system management capability required to operate the South West Interconnected System (SWIS). AEMO is also responsible for operating the Gas Services Information (GSI) under the GIS Rules, which includes the Gas Bulletin Board (GBB) for Western Australia

To ensure AEMO's system management and market operation functions evolve with regulatory and technology changes, a level of ongoing IT investment is required. Systems that support AEMO's digital platform, infrastructure, and non-core business functions must also be periodically replaced/upgraded to ensure they remain fit for purpose.

The IT Roadmap outlines the systems, applications, infrastructure, and digital capital projects required over the three-year period July 2022 to June 2025. This strategic document is designed to guide AEMO's IT investment and help inform AEMO's AR6 Allowable Revenue submission for the same three-year period.

The IT Roadmap has been created with AEMO's strategic priorities in mind. The activities outlined in this document focus on AEMO's regulatory obligations, business enablement opportunities, and a risk-based approach to lifecycle management.

AEMO's strategic priorities are outlined below.

AEMO WA strategic priorities

1. Operate Markets and Systems

   Delivering the electricity, gas and other statutory responsibilities that are fundamental to AEMO's mission. AEMO is committed to maintaining secure and reliable operation of systems and markets, while maximising benefits in the interest of consumers.

2. Navigate Energy Future

   Collaborating with our members and stakeholders to identify emerging issues, provide technical and economic expertise and support new and ongoing reforms. AEMO works to meet the physical and commercial challenges associated with the energy transition.

3. Engage Our Stakeholders

   Being transparent, collaborative and stakeholder focused, AEMO is establishing new ways to better incorporate feedback into our decision making.

4. Evolve the Way We Work

   Being a more transparent, efficient stakeholder and customer focussed business with clear financial transactions, have prudent governance oversight and with corporate risks proactively managed.

1.1 History

WA IT roadmaps (IMO and AEMO)[9]

All AEMO's functions under the WEM Rules rely on having fit-for-purpose and secure IT systems. The pace of technological change is rapid, as is the evolving cyber security threat as society becomes more reliant on IT and cyber-attacks become more sophisticated.

To ensure AEMO can continue to operate the power system and market securely in a changing IT landscape, it is imperative AEMO's systems are regularly reviewed, upgraded and evolved. To manage this IT evolution, AEMO regularly produces IT Roadmaps, designed to inform key IT system changes. Typically, each Roadmap builds on the previous edition, providing transparency of how AEMO's critical systems have developed over time. The following table provides a summary of the IT Roadmaps produced by AEMO (and formerly the Independent Market Operator (IMO)).

2008	The first IT Roadmap was established in December 2008. It focused on establishing the technical capability of the IMO, which was initially dependent on the WA Department of Treasury and Finance infrastructure and associated support. This roadmap drove significant investments in server and network infrastructure to complete the transition.
2010	The second IT Roadmap, which covered the three years commencing 1 July 2010, focused on improvements to the Wholesale Electricity Market Systems (WEMS) application suite. In April 2011, the Market Evolution Program commenced and was given priority. This program of work saw the IMO deliver more substantive changes to the WEM while adopting a stronger governance framework.
2012	The third IT Roadmap delivered new systems and advances in the operational maturity of business systems. Notably, the IMO delivered the GBB during this period, which AEMO continues to support. The IMO also made significant inroads to providing greater data transparency with the new IMO website design, the development of data visualisations and the creation of a central repository for market data.
2016	The fourth IT Roadmap focused on evolutionary changes to WEMS while addressing systems and infrastructure that did not support AEMOs required risk profile. It also addressed requirements to support a constrained grid market model and critical metering and settlements functions. AEMO evolved the GBB, improved market data transparency and began centralising non-core business functions.
2019	The fifth IT Roadmap completed the transition of System Management software from Western Power on to AEMO's managed infrastructure. It also introduced Digital capabilities not previously available to the WEM, with a focus on cyber security, a scalable hybrid cloud platform, enterprise data capability, and agile software solutions. These new capabilities were used to enhance the delivery of business capability as part of the WEM Reform program. There were also software lifecycle updates to metering and settlements applications.
2021	This AEMO WA IT Roadmap builds on these previous editions, continuing with WEM Reform and Distributed Energy Resources (DER) programs. Focus remains on cyber security, as well as shoring up control room and operational forecasting functions, and maintaining a reliable and robust technology environment into the future.

[9] IMO (Independent Market Operator) was established in 2006 and a precursor to AEMO, which began operating in WA in 2016.

2. Business context

Like all energy system and market operators, AEMO WA is grappling with the challenge of maintaining secure and reliable power system operations while incorporating increasing amounts of renewable generation capacity into the grid. The past decade has seen the concentration and volume of renewable energy in the power system more than double. This leads to increased system volatility, requiring more complex tools and monitoring processes to keep the SWIS secure.

Over the same period the number and type of market participants has increased, driving a need for greater participant interaction and more complex market operation processes. This in turn leads to greater cyber security risks and increased vulnerability to system security threats.

This pattern of increasing complexity, system volatility, and market participation is expected to continue over the AR6 period and beyond, particularly as the WA Government's Energy Transformation Strategy gathers momentum. Now, more than ever, AEMO's ability to provide secure system management services and efficient market operations is dependent on having fit-for-purpose IT applications and a robust IT landscape.

This chapter provides an overview of the AEMO WA's core functions, and the initiatives being delivered to support the ongoing energy transition in Western Australia. It also provides an overview of the key IT applications relied upon by each function/initiative, and overview of the current IT landscape and how that landscape needs to evolve.

2.1 Core functions

AEMO's core functions of operating and maintaining the power system and wholesale market are managed across two WA groups consisting of six teams. These teams are described below.

2.1.1 WA Markets

The WA Markets group is the main contact point for market participants in Western Australia and is responsible for the market operation of the WEM and GSI functions.

Market Operations

The Market Operations team is responsible for the effective and efficient day to day operation of the WEM and the GBB WA. Key functions include operating the energy market mechanisms, performing all settlement and prudential management functions, facilitating the full range of registration processes, operating the GBB WA and providing stakeholders with high quality, efficient support 24/7.

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 are 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 including the WA Electricity Statement of Opportunities and the WA Gas Statement of Opportunities.

Market Development

The Market Development team supports the Group Manager to deliver Market teams' BAU activities through regulatory and legislative assessment, policy development and subject matter expertise input to rule amendment, reform programs and special projects.

This team is also responsible for engaging with Energy Policy WA (EPWA) on WEM rule changes.

Applications required for market operations

The WA Markets team are the business owners of 43 applications, providing software services to business process. The full list of the applications, including their criticality and the level of service provided, is available in confidential Appendix B2.

2.1.2 System Management

The System Management Group the main contact point for technical and engineering queries from market participants and is responsible for delivery of AEMO's system operation functions.

Power System Operations

Power System Operations (PSO) is responsible for dispatch of market generators to meet forecast load and the scheduling and dispatch of essential system services (ESS) to ensure sufficient reserve margin is available, as well as dealing with power system incidents, contingencies, and emergencies. This team is also responsible for liaising with the networks, market generators on outages, dispatch, and ancillary services issues.

Power System & Market Planning

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 security constrained economic dispatch (SCED).

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.

Applications required for system operations

The WA System Management team is the business owner of 49 applications, providing software services to business process. The full list of the applications, including their criticality and the level of service provided, is available in the confidential Appendix B3.

2.2 Energy transition initiatives

WA's energy sector, like many other worldwide, is going through a transition towards decentralised, distributed energy resources, greater use of renewable energy, and greater consumer choice. In 2019 the WA Government launched the Energy Transformation Strategy, designed to facilitate this transition.

As power system and market operator, AEMO is responsible for facilitating and delivering a number of the Energy Transformation Strategy initiatives, as well as complementary initiatives to facilitate the energy transition and keep the power system secure.

All of these initiatives have a substantial IT component and rely on development of new applications and processing.

2.2.1 WEM Reform

WEM Reform is part of the WA Government's broader Energy Transformation Strategy which includes three components:

- Development of a DER Roadmap
- Development of an initial Whole of System Plan (WoSP); and
- Foundation Regulatory Framework

The Foundation Regulatory Framework is known colloquially as WEM Reform, and includes two subcomponents:

- Improving Access to the SWIS – changes to Regulations and other instruments to implement constrained network access, as well as necessary, consequential changes to the Reserve Capacity Mechanism (RCM).
- Delivering the Future Power System - Modernisation of the Wholesale Electricity Market to enhance power system security and enable new generators' access to the network.

For AEMO, WEM Reform means delivering a new WEM that addresses today's security and market effectiveness challenges to shape a better energy future for WA.

New market rules developed by the Energy Transformation Taskforce will require more than 60 market procedures to be developed or substantially re-written by AEMO, and around 80% of AEMO's current WEM systems will require significant change. The WEM Reform Program has been designed to achieve this change through 23 projects grouped into six workstreams.

WEM Reform will have significant impacts on AEMO's IT landscape and that of market participants. The pace of change will be high, with RCM changes coming into effect from late 2021 and SCED go-live in October 2023. This is addressed in further detail in Section 5.3.

2.2.2 Distributed energy resources

Distributed energy resources, or DER, are smaller-scale devices that can either use, generate or store electricity, and form a part of the local distribution system, serving homes and businesses. They include renewable generation, energy storage, electric vehicles, and technology that consumers can use at their premises to manage their electricity demand (e.g., hot water systems, pool pumps or smart appliances).

DER are transforming our electricity system, and while they offer opportunities, they are presenting serious risks to our power system.

The DER Roadmap, released in April 2020, is a five-year plan to guide the better integration of all distributed energy resources, including solar panels, battery storage and electric vehicles, and ensure that the benefits are shared across all members of the community.

The DER program of work builds capability to enable AEMO to:

- Manage a highly distributed power system and market which has an increasing role for the customer owned DER devices.
- Facilitate a marketplace for the trade of energy and other services (as appropriate) for DER customers via DER Aggregators.
- Register DER aggregators and understand the composition of their facilities, in order to include them in dispatch and settlement.
- Approve DER technologies and aggregation platforms to participate in the provision of market services.
- Facilitate a central data hub and data exchange for registered and unregistered DER, including to gather data to support operational visibility.

2.2.3 Upcoming initiatives

Western Australia's energy transformation is ongoing. As such, there are a range of further initiatives that will be developed and delivered over the next 3-5 years, and potentially beyond. While the scope of these

upcoming initiatives is not yet sufficiently advanced to be able to be included in AEMO's AR6 submission, they are still being assessed within the broader context of this roadmap to aid least-cost investment planning.

These upcoming initiatives and the potential IT requirements are summarised below.

Settlement and metering

AEMO's market systems (e.g., WEMS, Settlement, Metering) perform adequately for current business and market requirements (e.g., calculations involving ~47k meters on 30-minute granularity). However, there are several policy, regulatory and operational drivers– specifically the introduction of five-minute settlement (5MS) currently expected in October 2025, the roll out of advanced metering infrastructure by Western Power, and the increasing participation of DER – that require AEMO to consider its ongoing settlement and metering capabilities.

More broadly, AEMO anticipates the importance of accurate and granular metering data will increase through the energy transition. It is therefore essential that AEMO's WA market systems and processes are capable of scaling to manage significantly larger volumes of meter data. Meeting these requirements will require investment in IT systems and AEMO wants to ensure that this is done in the most efficient manner.

For 5MS, AEMO notes that the information available on the regulatory changes is currently high-level policy intent and that detailed rule drafting will be required. Therefore, AEMO has undertaken a high-level assessment of several options including extension of current WEM systems, adoption of NEM systems and hybrids. AEMO expects changes would be required across at least nine systems with implementation taking ~2-3-years. Given the level of uncertainty on the final regulatory requirements, AEMO will request funding for the planning phase to develop requirements and a cost estimate that is provided during an in-period submission.

Critical infrastructure

In 2022, the Australian Federal Government is expected to pass legally binding regulations on cyber security for the energy sector based on the Australia Energy Sector Cyber Security Framework (AESCSF). AEMO will almost certainly be nominated as Critical Infrastructure and Systems of National Significance (CI/SONS), and therefore will be subject to enhanced security obligations.

Compliance with SOCI Act requires an assessment of the current state, development of a plan for uplifting from the current state to the required compliance level, and implementation of the plan to achieve AESCSF Security Profile 3 (SP-3) level compliance by 2025.

It is highly likely AEMO will be required to uplift its maturity level to meet AESCSF SP-3 compliance within 5 years of the Act coming into effect. As such, an amount of capex has been included in the AR6 forecast to improve AEMO's resilience to cyber-attack. The proposed cyber security program is presented in section 5.8.4 of this Roadmap.

However, until the final legislation is passed, the level of uplift required is uncertain. It is feasible that the SOCI legislation may place additional obligations on AEMO. If this requires further investment above and beyond the proposed program and the expenditure overrun allowances in the WEM Rules, AEMO may need to revise its cyber security capex forecast via an in-period submission.

Relevant Level Methodology (RLM)

The Relevant Level Methodology (RLM) is used to assign Certified Reserve Capacity to Intermittent Generating Systems (IGS) and Non-Scheduled Facilities (NSF), with some limited exceptions for NSF that contain only Electric Storage Resources.

The Economic Regulation Authority (ERA) completed a review of the Relevant Level Methodology (RLM) in 2019 and concluded that the current RLM does not meet the WEM Objectives, and proposed changes in the Rule Change Proposal RC_2019_03.

No specific timeframe has been provided to finalise this rule change. However, significant consultation has already taken place on RC_2019_03 and WA stakeholders are pressuring EPWA to further refine the

methodology due to the associated financial impacts. AEMO understands the RLM review will be incorporated into the broader Reserve Capacity Market review which has uncertain outcomes, however given stakeholder interest in RLM, it is assumed that there will be some changes in RLM recommended in 2022 and implementation to follow thereafter.

This project is to implement the ERA proposed rule changes to ensure AEMO WA remains compliant. The intention is that these changes will improve the accuracy of the RLM in assessing the capacity contribution of IGS and NSF in the SWIS.

Energy Transformation Strategy Stage 2

Further to the WEM Reform changes to the existing IT systems, the WA government is pursuing further reforms[10], which will likely require some IT system changes or upgrades. This activity includes a review of the RCM which formally commenced in November 2021 and is targeting updated WEM Rules in 2023 and subsequent implementation activity.

Discussions with EPWA on the requirements of the Energy Transformation Strategy Stage 2 have commenced, however, AEMO has not yet received sufficient scope or formal direction on what new IT systems or modifications it will need to deliver. Engagement will continue throughout the AR6 period, and AEMO will propose an in-period adjustment to its forecast capital expenditure where necessary once the Stage 2 initiatives have been defined.

Operations Technology Roadmap

AEMO is currently working on an Operations Technology Roadmap to be developed and published by mid-2022. Development and implementation of an overarching operations technology roadmap will enable AEMO to achieve the required uplift in capability and facilitate the renewable energy transition, aligned with our FY22 Corporate plan Priority 1 item 3 and other AEMO initiatives. This work is co-funded by the CSIRO, building on work undertaken as part of the CSIRO research roadmaps (stability tools and control room of the future), and in collaboration with industry partners such as Global Power System Transformation Consortium (G-PST), EPRI as well as direct engagement with other system operators.

[10] https://www.wa.gov.au/sites/default/files/2021-07/Energy-Transformation-Strategy-Stage2-July2021.pdf

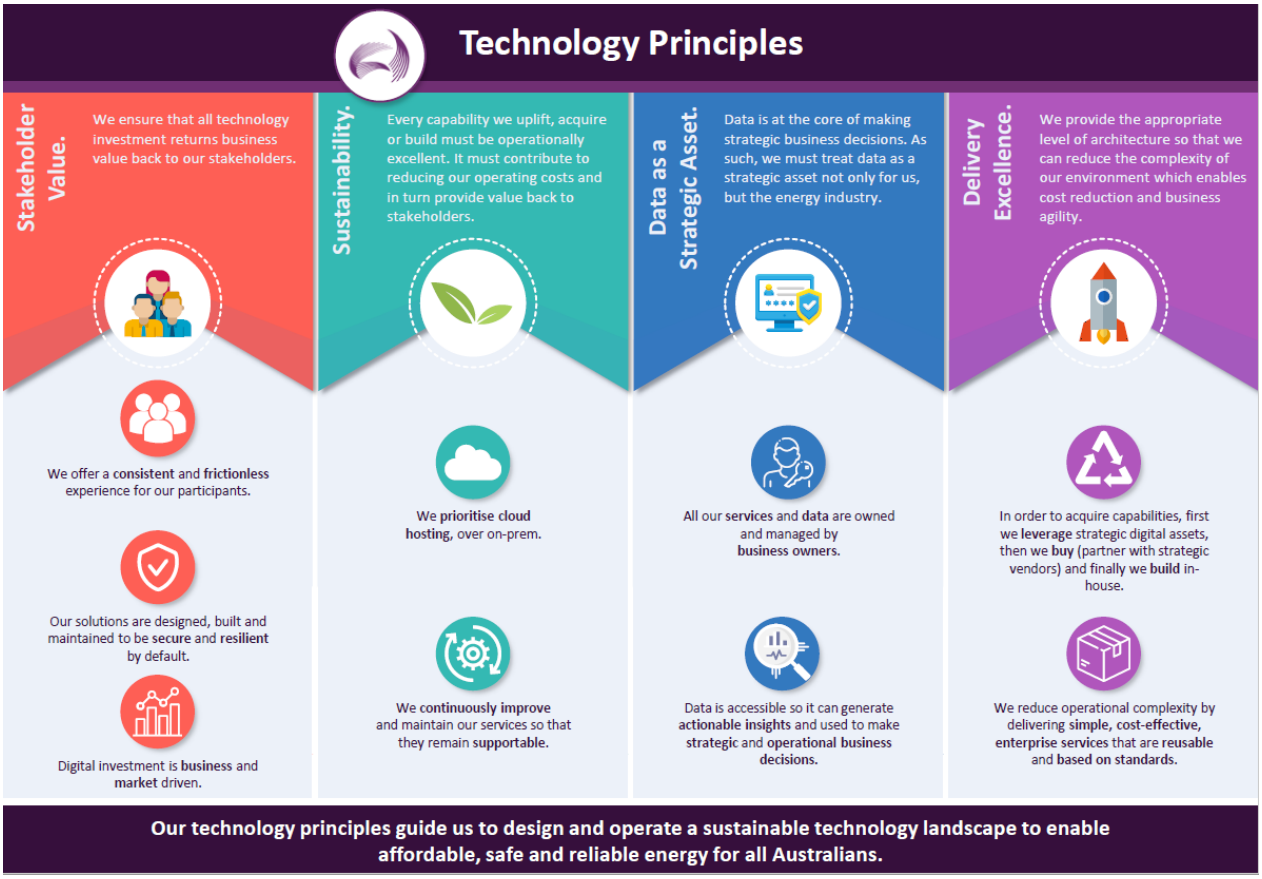
3. IT context

This section describes the IT context at the commencement and conclusion of the AR6 period. It provides the book ends for the roadmap covered later in this document. Three topics are covered in this section. The first is a set of principles that have been used to shape the future state, and parts of the roadmap. The second topic is the IT baseline which describes the foundation of the proposed roadmap extends. The last topic is the final state of the IT environment that will be in place at the end of the roadmap/AR6 period.

3.1 IT principles

The transition from the baseline to the future IT landscape covered in this document was shaped by a set of underpinning technology principles. These principles guide AEMO to design and operate a sustainable technology landscape to enable affordable, safe and reliable energy for all Australians. This section describes these principles.

Figure 2 AEMO's technology principles



3.1.1 Stakeholder value

AEMO ensures that all technology investment returns business value back to stakeholders:

- AEMO offers a consistent and frictionless experience for market participants.
- Solutions are designed, built and maintained to be secure and resilient by default.
- Digital investment is business and market driven.

3.1.2 Sustainability

Every capability AEMO uplifts, acquires or builds must be operationally excellent. It must contribute to reducing operating costs and in turn provide value back to stakeholders:

- AEMO prioritises cloud hosting over on-prem.
- AEMO continuously improves and maintains services so they remain supportable.

3.1.3 Data as a strategic asset

Data is at the core of making strategic business decisions. As such, data must be treated as a strategic asset not only for AEMO, but the energy industry:

- All AEMO's services and data are owned and managed by business owners.
- Data is accessible so it can generate actionable insights and used to make strategic and operational business decisions.

3.1.4 Delivery excellence

AEMO provides the appropriate level of architecture so that it can reduce the complexity of the IT environment, which enables cost reduction and business agility.

- In order to acquire capabilities, first AEMO leverages strategic digital assets, then buys (partnering with strategic vendors), and finally builds in house.

3.2 AEMO cloud and hosting

AEMO prioritises cloud hosting, over on-premises infrastructure. This is further addressed in this section. AEMO considers all requirements and ability to deliver the business outcome. The option that provides the best outcome for AEMO is selected.

Business drivers

The drivers for the cloud strategy were speed-to-market, elasticity and scalability, nimble provisioning, improved reliability, quality, efficiency and transparency. Adopting infrastructure as Code (IaC) in collaboration with security, ensures AEMO has repeatable ways of working to reach those goals.

Benefits and benchmarking

AEMO conducted post-build analysis against major project and programs that have been built in the public cloud. This looked at the costs to build and run an equivalent on-premise environment for peak workloads of 5MS, Plexos, CDP, DERR. This analysis demonstrated significant cost savings of between 10% and 66% in Azure when compared to the equivalent on-premises solutions. It would also take additional time to procure, setup and productionise the physical infrastructure. The risks of not having this physical hardware available would have caused significant delays to these programs and projects. Benefits included being able to meet our business requirements in a timely and cost-effective manner which could not have been possible if done on-premise in the same time frame.

Cloud costs vs on-premises costs

Baked into cloud pricing are all associated running costs such as: power, air conditioning, operational support to upgrade/patch services, etc. On-premises costs may not include these ancillary costs. Using a standalone third-party provider would need to be assessed from cost, risk and security points of view. In comparing to on-premises, cost should always be a factor in the decision-making process.

AEMO strategic cloud provider

AEMO chose its cloud provider (Microsoft Azure Platform as a Service (PaaS)) based on strategic relationships and has negotiated a significant discount.

Clear cost allocation

A traditional on-premises solution relies on a shared infrastructure footprint. This shared service can make it challenging and time-consuming to correctly attribute cost allocation. NEM, WEM and Gas services share physical servers, network infrastructure and storage. The split of these costs can be opaque and difficult to assess – especially as much of the physical capital spend must be spent in advance without knowing exactly what services will consume the resources.

Within a cloud deployment, the costs charged for a single application can be isolated. WEM costs are clear and are charged to WA cost centres. This reduces manual effort and is more accurate.

AEMO WA savings

By being part of the larger AEMO entity, AEMO WA has access to a significant Azure Cloud EA discount, which entitles the organisation to a significant discount on costs of consumption of Azure services. This level of discount would be unlikely in a standalone organisation.

Now that AEMO have established the foundations for the cloud, the effort to on-board Azure Services is minimal (hours or days to deploy all infrastructure instead of weeks or months).

3.3 Baseline IT landscape

This section presents AEMO's IT baseline. It outlines the applications and technologies used to support AEMO's market and system operations.

The baseline landscape is described from two perspectives:

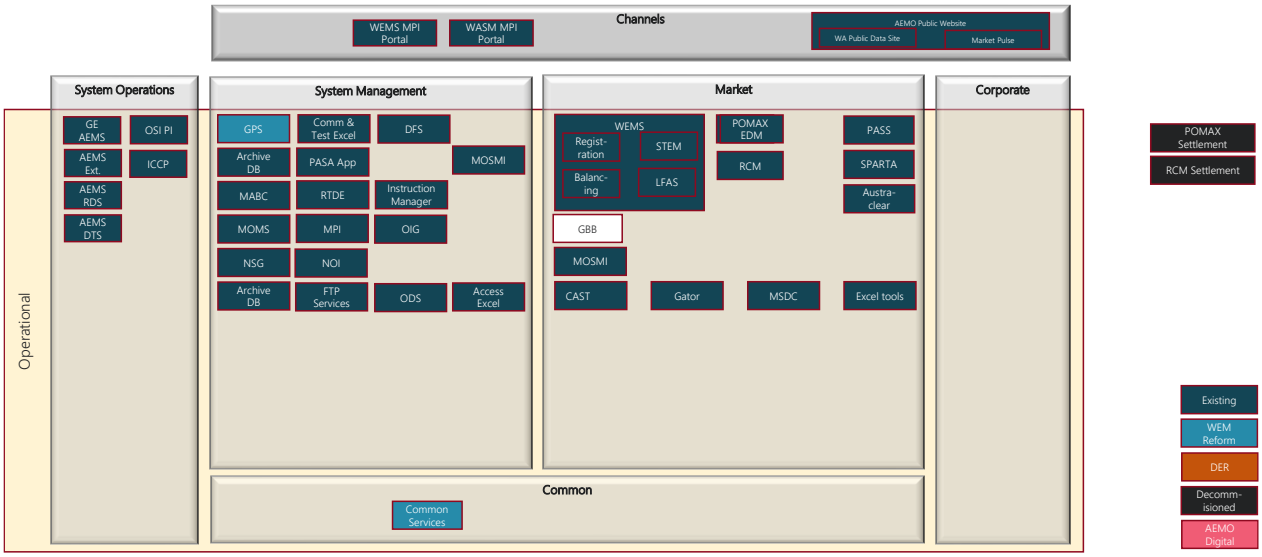
1. Application landscape
2. Technology platform landscapes.

The application landscape describes the operational applications that support the WEM business areas. The technology platform landscape summarises the enabling technologies that support the various applications or provide direct services to the AEMO and the market.

3.3.1 Application landscape

Focusing on the application landscape first, the following diagram illustrates the key applications (but not all) that make up the baseline.[11]

Figure 3 Baseline application landscape



[11] Full-size diagram available in the Appendix

The applications shown in the diagram can be described using the domains of System Operations, System Management, Markets and Corporate.

- System Operations. The applications were delivered as part of the transition of software from Western Power and cover the GE Advanced Energy Management System (AEMS)/e-terra platform and the OSI PI platforms to support the real-time management and monitoring of the electricity energy system. Various modules of the AEMS have been implemented to support simulation and training needs.
- System Management. These applications represent those migrated from Western Power via the System Management System Transition (SMST) project. Initial remediation activities have since been undertaken, but major changes have been deferred as they will be replaced when the relevant WEM Reform systems are operational. Changes to the original SMST applications have been undertaken to address urgent audit, compliance, or cyber security considerations, but any such changes have been minimised.
  The inclusion of the WEM Reform Generator Performance Standard (GPS) project in the baseline landscape is important. This application was early in the WEM Reform program to meet market rules.
  Note the data exchange/interactions between the System Management and Market systems has a range of challenges and exposures. Major changes in this area have also been deferred as WEM reform will significantly change elements of the data exchange between these two domains.
- Markets. The applications in the market's domain support the current WEM Rules . Note that at the date of the baseline, the two settlement applications that have been subsumed into the Prudential and Settlement Service (PaSS) are still part of the landscape. The legacy Prudentials application will be decommissioned before the start of the AR6 period with the legacy Settlements application to follow soon into the AR6 period.
- Corporate. The applications in this domain support the whole of the AEMO organisation and are not WEM specific. In the interest of maintaining the focus of this document, they have not been enumerated in this document but examples include HR, Finance, Procurement, and End User software.

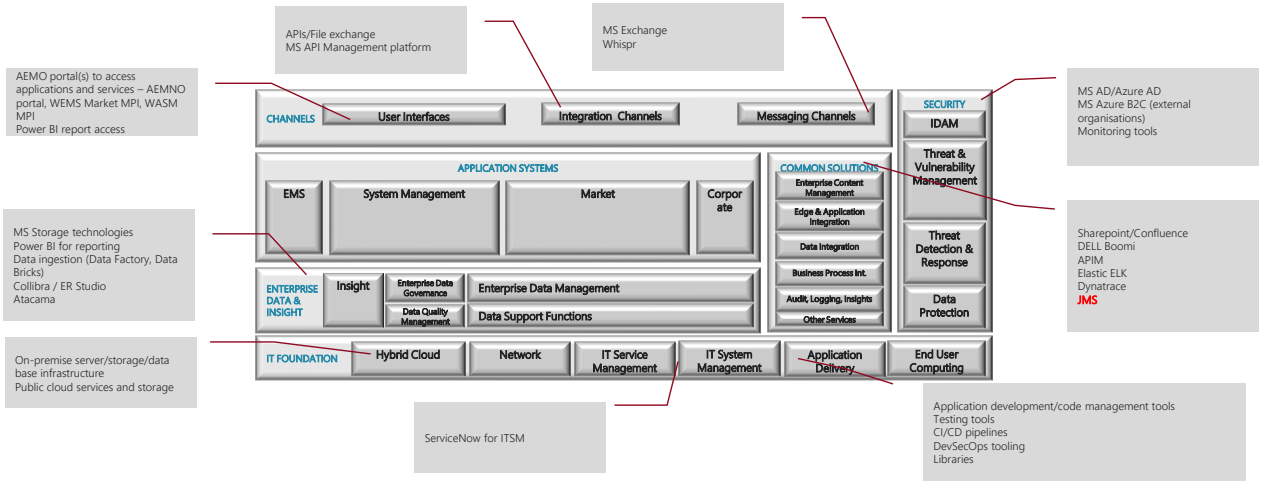
The appendix provides a more detailed list of the applications pertaining to the first three domains that make up the baseline application landscape.

3.3.2 Technology landscape

The other viewpoint mentioned at the start of this subsection is that of the enabling technology landscape. The technology platforms comprising the landscape are shown in the following diagram[12]. (Noting the same framework that will be used when describing the future IT environment in the following subsection.)

[12] A larger diagram is available in the Appendix

Figure 4 Baseline technology landscape



The overarching elements of the technology landscape is summarised in the following points.

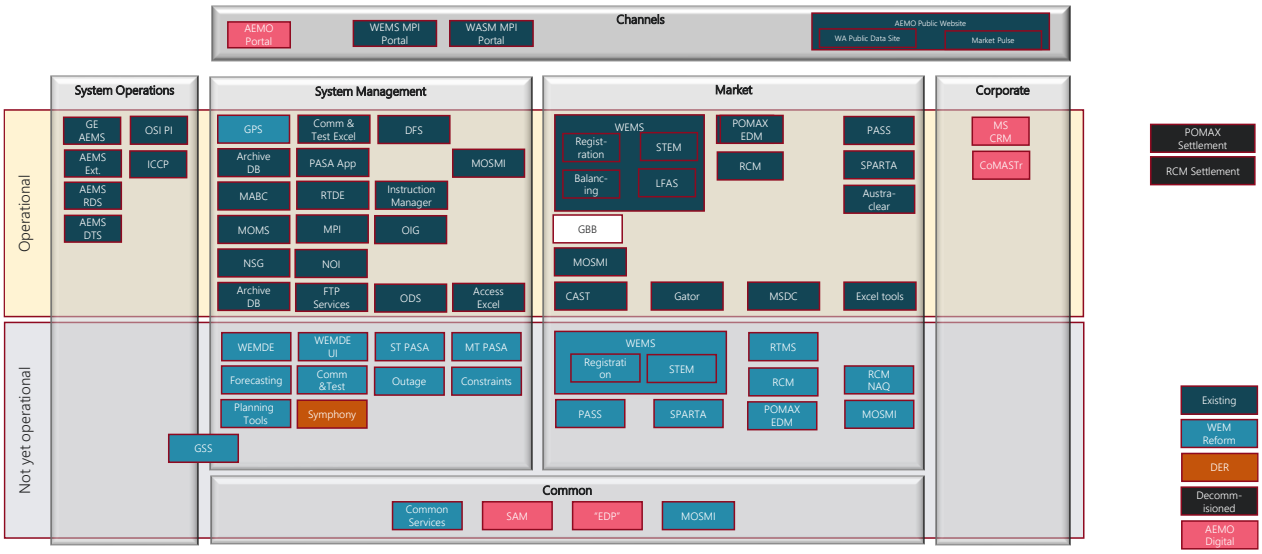
- Application system - covered previously via the application landscape
- Channels - This element of the framework covers access to services or how information is exchanged. Three portals will be available. The first is a common AEMO portal which will be the strategic platform going forward. The other are the existing WEMS Market MPI and WASM MPI that will also continue to be used to access existing applications.
- Security - The focus of this element is on the underlying tools and technologies to support the management, detection, response, and protection of cyber security across the whole organisation and from an extended enterprise perspective.
- Enterprise Data and Insight - Data is foundational to AEMO and the market. This part of the landscape addresses the management/governance, use and coordination of data. This element supports both operational and decision-making needs across all facets of the business, market, and regulatory reporting needs.
- Common Solutions - To support applications, services, and data a range of capabilities around content management, integration, audit and logging, automation, etc are provided to support the applications and other elements of the technology landscape.
- IT Foundation -The IT foundation provide the underlying physical infrastructure (servers, storage and networks), tools to support the management of the application and technology environments, and the core application delivery capabilities.

3.4 WA Reform landscape

The infrastructure environment is more complex that what might have been expected. The reason for this is that the landscape includes not only the current technology capabilities, but also the capabilities that are used to support the delivery of WEM Reform. This is due to the inclusion of the Generator Performance Standards (GPS) application and the requirement to expose capabilities to market participants earlier than the formal market trial period as an early WEM Reform deliverable.

The application landscape presented earlier conveys only part of the WEM application landscape. In parallel to the operational system, delivery of WEM Reform and the DER solutions are progressing. This diagram illustrates this overlap and serves as a link between the baseline and the future IT landscape covered in the next section.

Figure 5 Baseline WEM Reform landscape

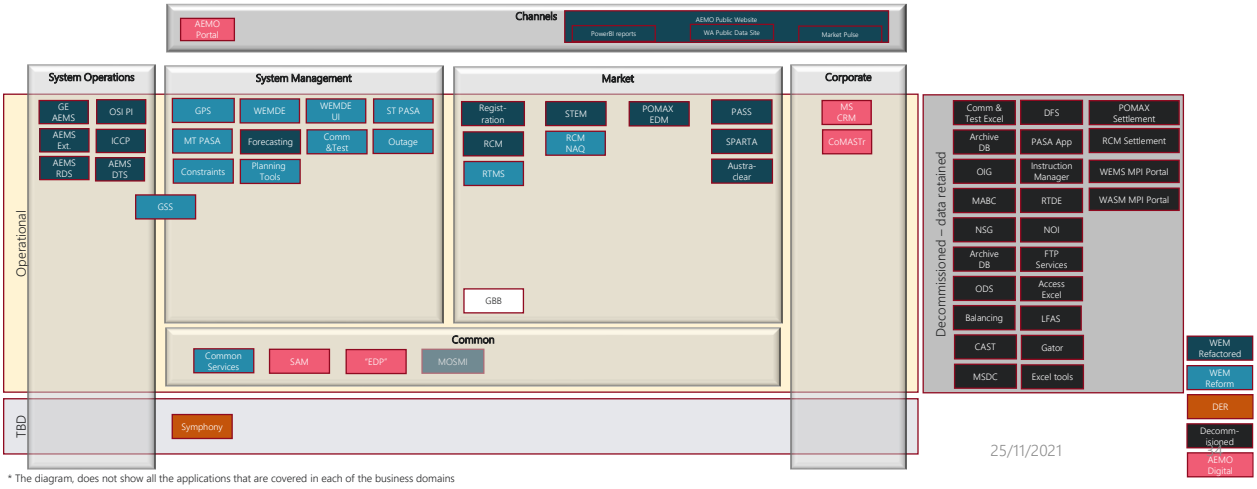


3.5 Future IT landscape

The description of the future IT landscape mirrors how the baseline IT landscape was described. The application landscape is described first followed by the technology landscape.

At the end of AR6, all the WEM Reform and DER applications will have been deployed and the replaced applications will have been or are in the process of being decommissioned. Noting that the data associated with these replaced applications will be retained for analysis and reporting purposes. The resulting application landscape is shown in the following diagram.[13]

Figure 6 Future IT landscape



* The diagram, does not show all the applications that are covered in each of the business domains

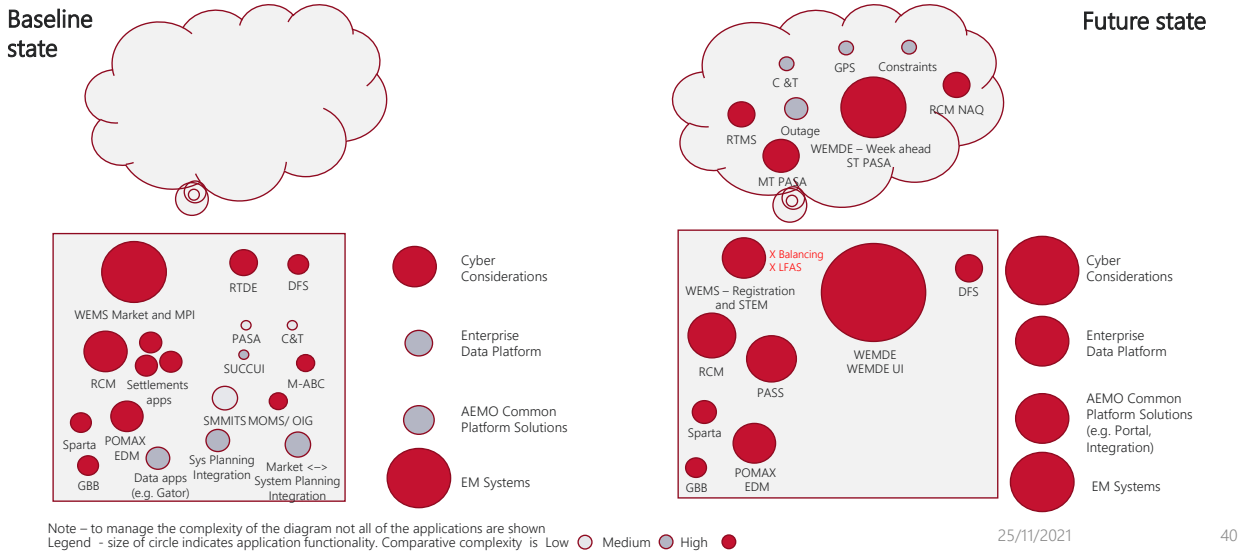
3.5.1 Complexity

The challenge with comparing the baseline and the future application landscape during the AR6 period is that the future state appears simpler than the baseline landscape. Such a perception understates the significant change in complexity, and coverage of the new WEM Reform/DER applications. The following figure seeks contrast the two time periods by illustrating the relative change in complexity between the different application landscapes.[14]

[13] A larger diagram is available in the Appendix

[14] A larger diagram is available in the Appendix

Figure 7 Change in complexity between application landscapes



The figure above also provides a useful segue into addressing the technology landscape. An important aspect of the approach to delivering WEM reform was to align with and/or leverage technical capabilities delivered as part of AEMO's digital program. In terms of strategic alignment, WEM Reform will deliver a range of capabilities in the cloud and aligned with key cyber requirements retaining to data management and IT infrastructure.

Leveraging common AEMO technical capabilities includes:

- Hybrid integration platform (DELL BOOMI).
- API management platform (AZURE APIM).
- Extensions to the cyber monitoring and defensive capabilities.
- Enterprise Data Platform (EDP) services.
- Portal and Identity and Access Management capabilities.

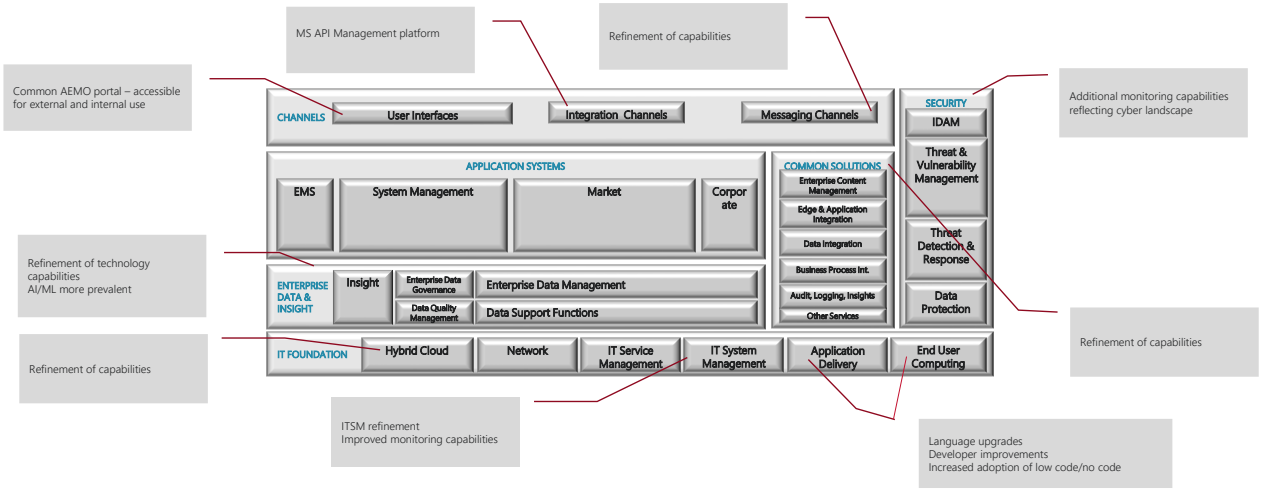
In addition, "engines" such as Plexos and Fico Express used in other parts of AEMO will be adopted to minimise cost and leverage existing knowledge and skills.

The range of technologies was illustrated in the previous subsection when the technology landscape was described.

3.5.2 Technology landscape

In this final state, the technologies capabilities will be more pervasive and embedded across the applications and services that are delivered for AEMO and to the market. Hence the focus of the technology landscape at this stage will be leveraging the capabilities delivered as part of the baseline - other than an uplift the cyber capabilities. The following diagram illustrates this concept in which the capabilities are leverage more fully at the end of AR6.

Figure 8 Future technology landscape



It is also important to note that a range of legacy technologies will have been replaced at this stage. Examples include JMS, Bamboo, etc. The full details of these changes have not been included to keep the document at an appropriate level of detail.

4. Risk and investment governance

4.1 Risk management

It is AEMO's stated goal to create a culture that is risk aware, rather than risk averse. A strong risk management culture is key to enabling AEMO to achieve its strategic and operational objectives.

4.1.1 Policy statement

AEMO is committed to maintaining a comprehensive and integrated risk management capability that is embedded into every business activity, decision, function, and process that is aligned to the International Risk Management Standard ISO 31000:2018.

4.1.2 Risk appetite and tolerance statements

The purpose of AEMO's risk appetite and tolerance statements (Statements) is to provide guidance to all staff on the amount of risk the company is prepared to accept or undertake to achieve objectives.

The intended outcomes of these Statements are to:

- Document the Board's appetite and tolerance to accept or pursue differing levels of risk in achieving strategic objectives; and
- Define the risk boundaries for Departments/functions to enable them to make risk informed decisions, encourage taking on more risk where appropriate to pursue opportunities which may not have been considered historically.

AEMO ENTERPRISE RISK APPETITE STATEMENT

AEMO acknowledges and accepts that it faces a variety of risks given the nature of its evolving operations. These include industry transformation, technology & cyber security, consumer affordability, legal & compliance, financial, reputational, people and operational risks. AEMO also acknowledges that risk is not necessarily negative and encourages a culture that promotes an open and proactive discussion on the management of risk, including assuming additional risk in order to achieve its corporate plan and objectives.

4.1.3 Framework

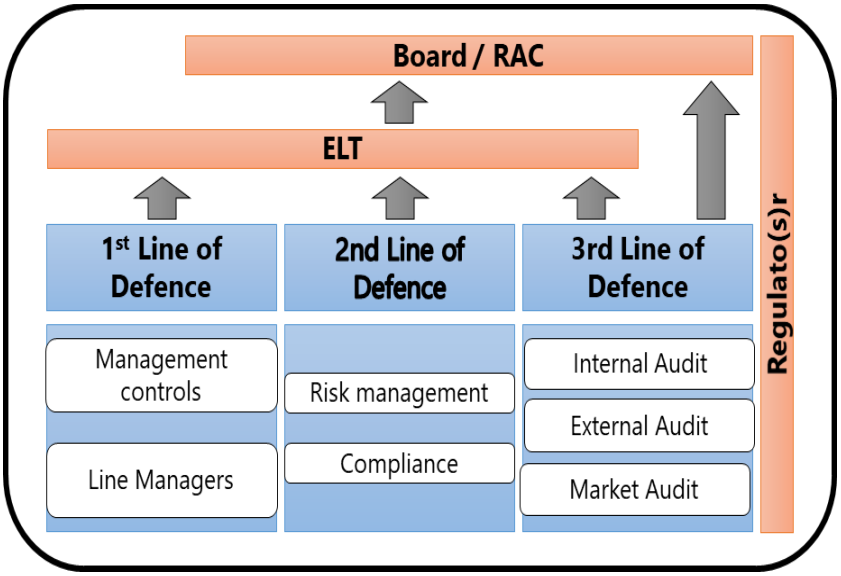
The purpose and scope for this Framework is to:

- Provide an overview of the risk management practices adopted by AEMO.
- Define the key attributes and objectives for AEMO's risk culture.
- Describe roles and responsibilities for managing risk; and
- Outline the process for reporting on risk and ongoing monitoring and review.

3 Lines of Defence model

The 3 Lines of Defence (3LoD) model provides a simple and effective way to enhance communications on risk management and controls by clarifying essential roles and duties.

Figure 9 3 Lines of Defence model

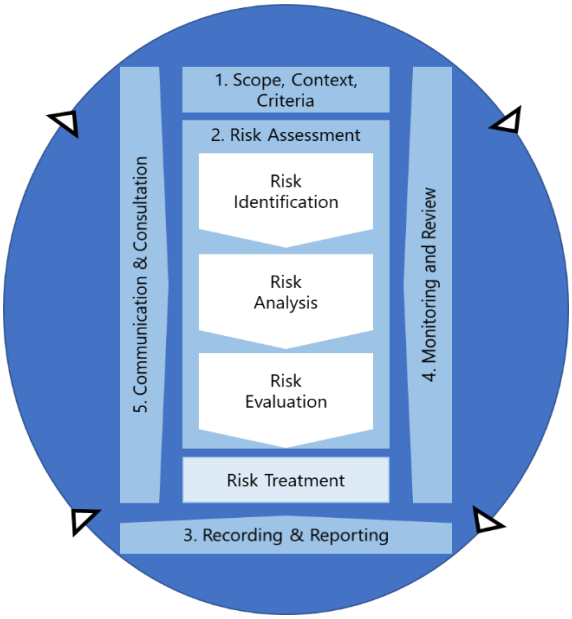


Risk management process

The risk management process is the systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk.

This diagram illustrates the risk management process contained within ISO 31000:2018.

Figure 10 Risk management process within ISO 31000:2018



4.1.4 Risk matrix

A risk matrix is a risk management tool within the risk management framework. It is used to perform a risk assessment by establishing a risk rating by considering the likelihood of a risk event happening against the consequence of the risk event when it actually occurs (outcome of an event impacting the Australian Energy Market Operator's (AEMO) objectives).

This guidance sets out the risk matrix for AEMO and how it should be interpreted and applied when assessing risks. AEMO's approach to the measurement of risk is from the perspective of the risk exposure for a 1-year horizon, i.e., the following 12-month period. Risks should therefore be reviewed regularly (e.g., at least annually) to reflect the exposure at that point in time.

Determining the risk rating

Once an assessment of the likelihood and consequence of the risk event occurring has been performed, using the risk matrix, the outcomes can be plotted on the risk heatmap. The likelihood and consequence are plotted against each other to determine the risk rating. For example, the risk of involuntary disruption to supply assessed as "Likely" and "Moderate" would have a risk rating of "High". Also, a risk event could have varied consequences, in determining the appropriate consequence for a risk event, the most conservative consequence should be considered in the assessment of the risk rating.

LIKELIHOOD

The risk matrix clearly defines the annual probability of a risk event happening that can be taken as a guide to assessing the likelihood of the risk event occurring. In establishing the likelihood, consideration should be given to whether, and how frequently the risk event has occurred over the previous 12 months.

The Likelihood ratings used within the matrix are: Rare, Unlikely, Possible, Likely, Almost Certain. In assessing issues/breaches that have occurred the likelihood should be "Likely" as a minimum. It is important to remember that the likelihood being assessed is the likelihood of a risk event occurring.

CONSEQUENCE

Every risk event can have varying consequences under the different criteria within the risk matrix. Establishing the consequence rating for a risk event requires all the individual criteria to be considered and assessed with the most conservative assessment/rating applied. For example, the risk of a compliance breach might be assessed as 'Minor', however, the reputational and stakeholder impact is determined to be 'Moderate' as there may be some adverse media exposure. In this situation, the conservative assessment would be a 'Moderate' consequence rating.

A copy of AEMO's Risk Matrix has been included in the Confidential Appendix.

4.2 Investment Governance Structure

AEMO has a strong governance framework managed by the Corporate ePMO. WA has a Steering Committee with delegated authority to manage investment decisions at the local level.

Figure 11 IT investment governance structure

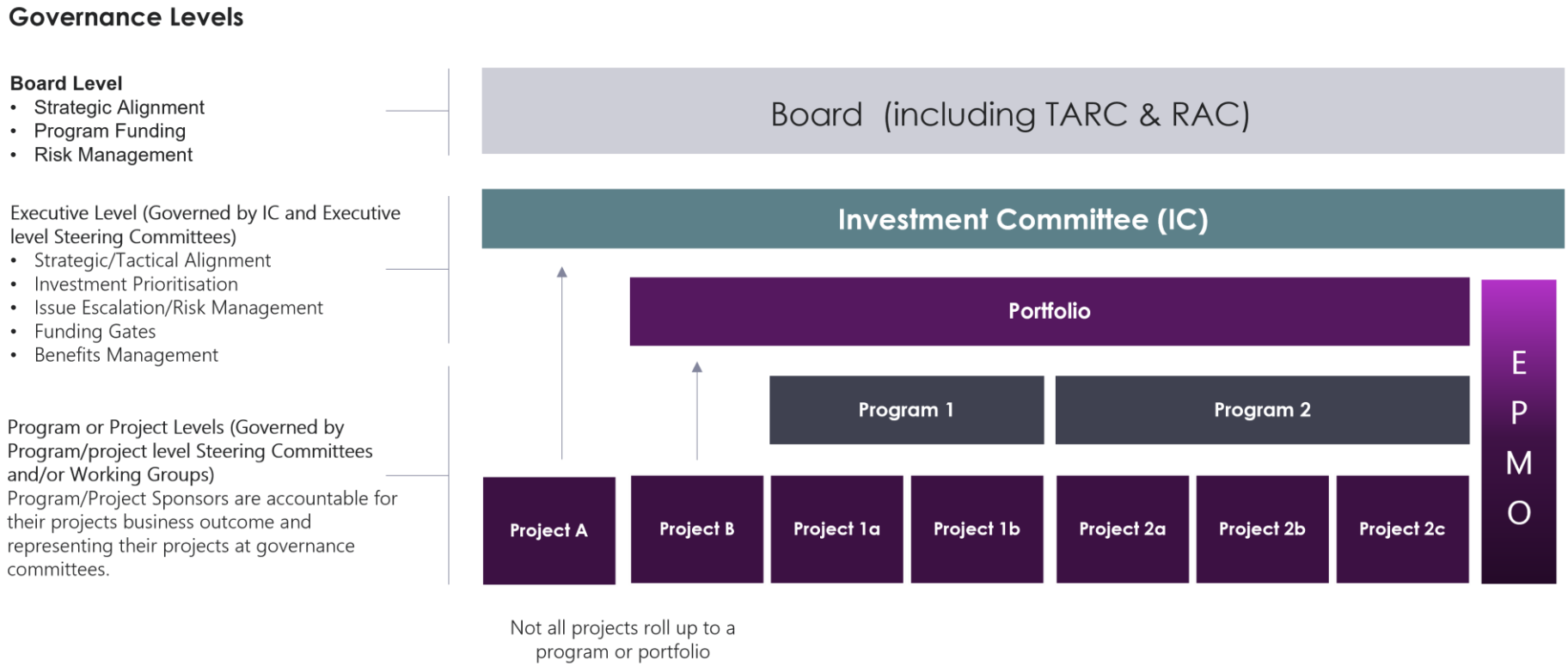


Figure 12 Governance Roles and Responsibilities

Executive Sponsor

Executive or Senior Manager

Ultimate decision maker

Decisions made by the Sponsor and Steering Committee represent the entire stakeholder group for the project

Accountable for achieving business **outcomes**, delivering benefits and accepting risks and operating costs of the project

If across multiple areas of AEMO, the Sponsor engages the relevant people to ensure collaboration and information sharing – ensures all potential stakeholders are informed and included

Steering Committee

Members are key stakeholders from across AEMO that are impacted by the project

Members represent all stakeholders, not just a particular team or department

Supports the effective governance of a project and provides a point of escalation

Works with the Project Sponsor and Project Manager as a decision-making body

Members provide advice and guidance from their areas of expertise to support effective decision making

Delivery roles

Project Sponsor/Business Owner

Accountable for delivery of a project including **outcomes** i.e., what is delivered to the business

Works with the Steering Committee to inform decision making through information sharing
Business resource from the Business Unit

Portfolio/Program/Project Manager

Project resource from EPMO

Ensures projects remains in scope, on time and on budget meeting quality metrics

Works with the Steering Committee to inform decision making through information sharing

EPMO

Oversees all aspects of an investment lifecycle

Drives improvement, standardisation and delivery of Portfolio, Program and Project delivery framework including standard, processes, tools, reports and policies

Provide support to the Portfolio/Program/Projects

Investment Committee

Manage investments/project approvals, including spend/benefit profiles
Approve investments defined by the DOA levels

Govern investment strategic alignment and mix

Govern the prioritisation of the investments in consideration of the current portfolio

Govern all investment changes that are above agreed investment tolerance, such as project CRs

4.2.1 AEMO project delivery framework

- The framework aims to ensure that all AEMO critical audiences are brought along the journey ('hook in' as required).
- All stakeholders are aware of the ePMO governance requirements.
- The expectation is that within projects, project methodologies align to the ePMO stage gates.
- In addition, this framework ties in the PMO mandates and guides as the base tool kit for all projects.
- A single process that is methodology agnostic that can be seamlessly applied to Waterfall, Agile or a combination of both.
- Tight alignment with the investment management to the point where processes are indistinguishable.
- Clear statements of actions and outputs at all stages of delivery, to direct delivery leaders and eliminate the need for interpretation; and
- Low overhead, transparent and auditable processes, and documentation.

Figure 13 Project stage gate process

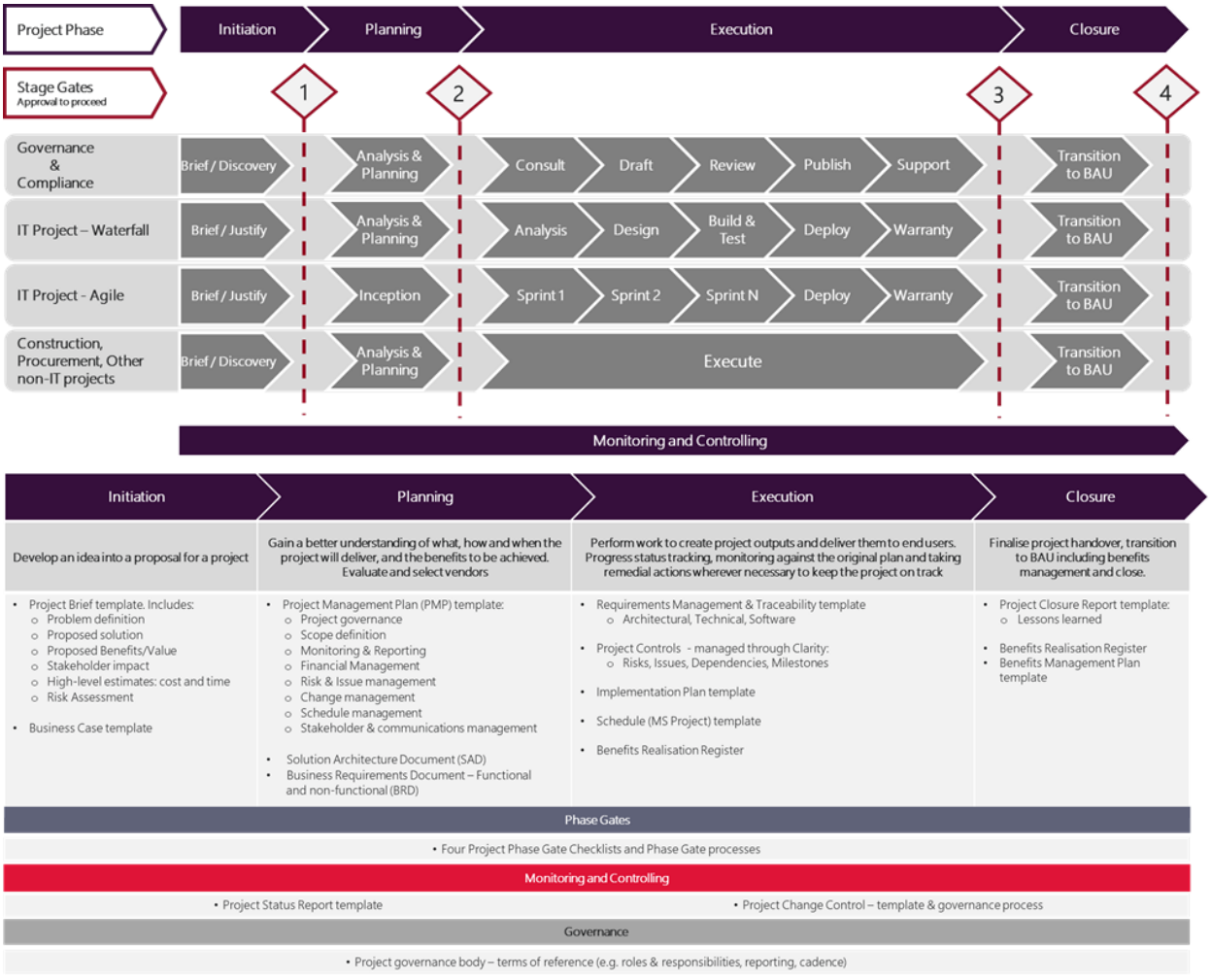
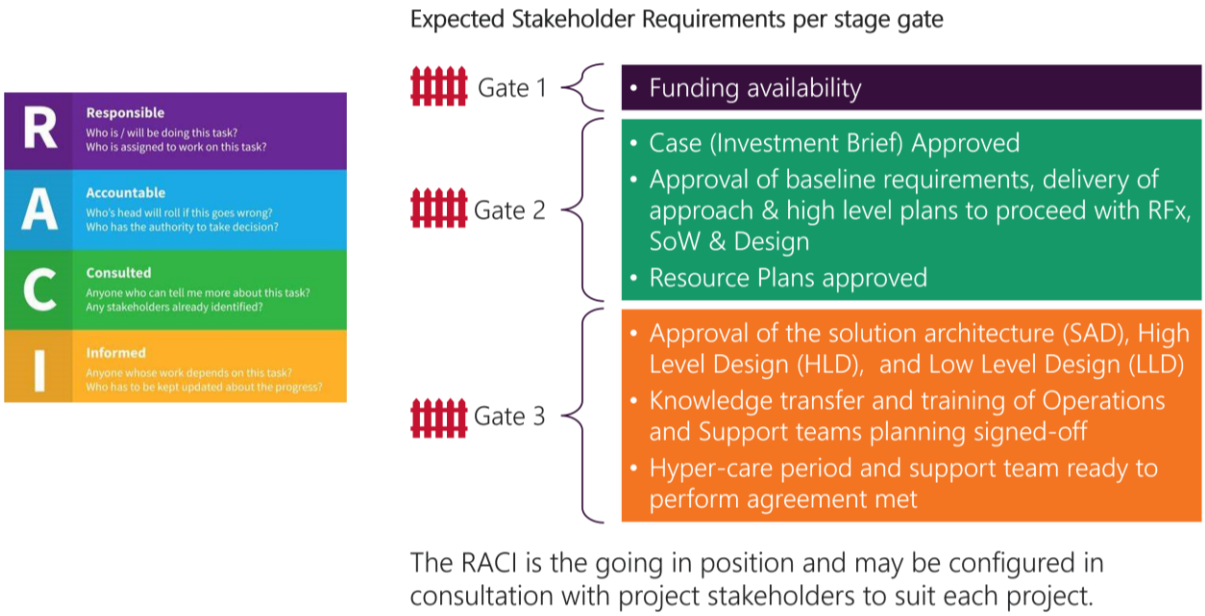


Figure 14 Project RACI



5. Roadmap

Section 2.1A of the WEM Rules confers functions on AEMO. Section 1.2 defines the Wholesale Market Objectives. AEMO only incurs expenditure on activities and projects related to the provision of these functions and to promote the WEM Objectives.

To ensure that AEMO remains compliant during the AR6 period, it must implement changes to its IT systems. To prevent duplicated or unnecessary effort, the interdependencies across the system changes have been evaluated. A consolidated IT Roadmap is required to manage these interdependencies and subsequent implementation of the changes. This section outlines the workstreams and projects AEMO will undertake to realise the IT Roadmap and remain compliant.

All IT projects in this Roadmap are designed to support either one of more of the functions listed in the Rules.

5.1 Workstreams and WEM Rules alignment

This Roadmap aligns AEMO's obligations under the WEM rules with the organisation's IT principles and corporate priorities. There are six workstreams which together provide a comprehensive plan to ensure AEMO WA remains compliant, is prepared for the future, enables current and future business operations, and provides supported and stable technology platforms to reduce operational risk.

The six work streams are outlines in the table below.

Table 1 WEM Reform workstreams and Rules alignment

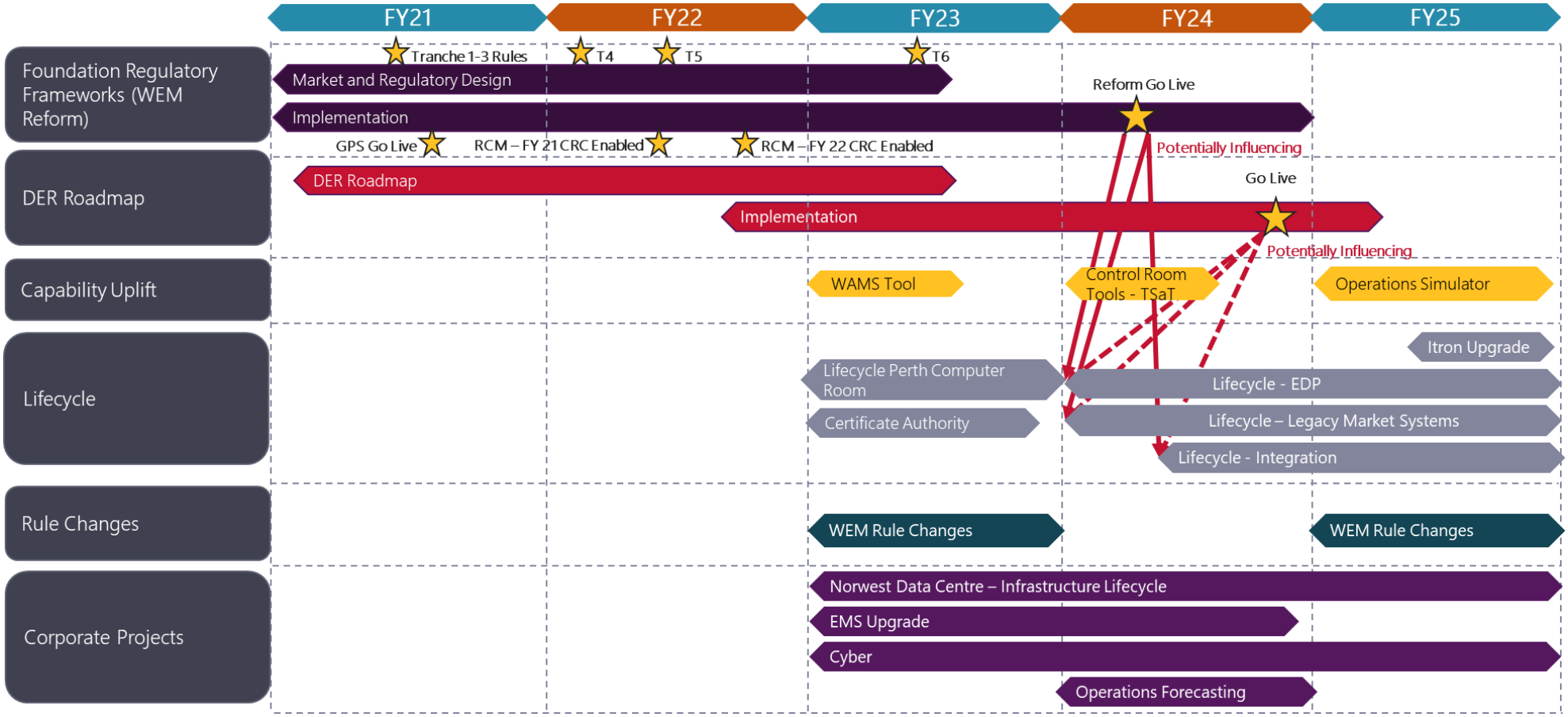
Workstream	Relevant WEM Rules	Projects
Foundation Regulatory Frameworks (WEM Reform)	1.2.1(a) to (d) 2.1.A.1A 2.1A.2(a), (ll)	• Digital Platform • RCM Reform • STEM Reform • Registration Reform

		• Settlements Reform • WEM Dispatch Engine • WEMDE User Interface • DTS Integration and SCED Offline Tools • Outage Management • Commissioning Test • Medium Term (MT) PASA • Forecast Integration • System Outage Planning • Short Term (ST) PASA • Integration and Market Trial • Compliance Reporting • Decommissioning • Hypercare and Support
Distributed Energy Resources (DER) – DER Roadmap	1.2.1(a) to (e) 2.1.A.1A 2.1A.2 2.1A.2(d), (IA), (n)	• Project Symphony (DER Marketplace Orchestration) • Technology Integration • DER Participation • Participation Implementation • Network Services Market Design and Trial • Market Visibility • DER Data Access and Management • Electric Vehicles (EV) in DER
Capability Uplift	1.2.1(a) to (e), 2.1A.1A.	• Wide Area Monitoring Systems • Transient Stability Tool • Operations Simulator
Lifecycle	1.2.1(a) to (d) 2.1A.1A 2.1A.2 clauses (a), (b), (d), (e), (f), (g), (iA), (j), (k), (lE), (m)	• Lifecycle EDP • Lifecycle Legacy Market Systems • Lifecycle Integration • Lifecycle Perth Computer Room • ITRON Upgrade • Certificate Authority
Rule Changes	1.2.1(a) to (d) 2.1A.2.(lA) and (ll) GSI Rules 8(1)(jc)	• WEM and GSI Rule Changes
Corporate Projects	1.2.1(a) to (e) 2.1A.1A 2.1A.2 clauses (a), (b), (d), (e), (f), (g), (iA), (j), (k), (lE), (m)	• NORWEST Data Centre • Energy Management System • Cyber Security • Operations Forecasting

5.2 Project sequencing over the FY21-25 period

The following timeline illustrates AEMO WA's proposed sequencing of all projects included in the IT Roadmap for the AR6 Submission. It considers dependencies between projects, constraints imposed by loss of vendor product support and regulatory compliance requirements.

Figure 15 IT Roadmap project sequencing



5.3 Foundation regulatory frameworks (WEM Reform)

The WEM Reform program consists of 26 work packages grouped into 11 implementation projects across six workstreams. Each of the implementation projects will involve:

- Development of WEM Procedures relating to the required Market changes.
- System enhancements and integration, including associated requirements analysis, design, build and testing activities.
- User acceptance testing (UAT) and Business and Market Trials to ensure that changes are fit for purpose.
- Business process change relating to required market and system changes.
- Stakeholder engagement and training to ensure our stakeholders understand the changes and are trained and ready to operate in the new market.

5.3.1 Digital platform

Scope and background

The components in scope for this project include delivering a standard framework for managing system environments and deployment frameworks, a standard method for publishing applications to Market Participants and internal AEMO teams (the AEMO Portal) and the approach, tools and framework for data storage, data management, integration and data visualisation.

The project also includes software (e.g., licencing), on premise infrastructure, penetration testing for all application developed across the program, and cloud consumption estimates.

Solution and benefits

This project aims to design and guide the implementation of platforms that will be enablers for the business-facing projects in WEM Reform. This includes moving to modern cloud platforms where appropriate and leveraging components of AEMO's Digital Program.

5.3.2 RCM reform

Scope and background

The Reserve Capacity Mechanism allows for AEMO to assess the capabilities of new or existing facilities to provide energy services to ensure AEMO can dispatch electricity to meet an expected system peak event. The reforms to the RCM allow for this assessment to occur in a system constrained context (NAQ assessment) with some modification to the existing functions of the RCM. Complimentary changes resulting from the new registration framework will need to be incorporated throughout the RCM systems and processes. The settlement functions (RCM Settlement and IRCR) will not be in scope of this project; however, this project will be expected to modify and/or re-platform existing RCM systems and tools to align with AEMOs technology roadmap.

Solution and benefits

The RCM is a bespoke market mechanism and AEMO (previously IMO) has continued to invest in internal systems to meet requirements (including the RCM Pricing Project which concluded in Sep 21) – this prolongs life and ensures maximum value from previous system modifications

For RCM Phase 1 (supporting registration and Relevant Level changes for the 2021 Cycle) AEMO ran an RFP in Jan 2021 and chose a technical delivery partner based on value for money criteria.

For RCM Phase 2 (changes for the 2022 Cycle) AEMO intends to build the Network Access Quantity (NAQ) model as the design is bespoke to the WEM – AEMO plans to use an augmented team with specialist internal and external development resources.

Initial NAQ model release to enable current 2022 Cycle timelines to be maintained will include some manual operations, which will be automated following initial successful operation to reduce operational risk and

labour in subsequent Reserve Capacity Cycles. For RCM Phase 3 (Year 3 changes to Reserve Capacity Testing and Reserve Capacity Obligation Quantities) AEMO intends to modify existing systems.

5.3.3 STEM reform

Scope and background

The Short-Term Energy Market (STEM) provides market participants with an ability to buy and sell electricity in a day ahead forward market to manage their contracted position. The STEM processes include provision of contractual position, bids and offers for the day ahead market, and calculation of a Net Contract Position for settlement. The STEM foundations remain largely unchanged through reform but there will be a few peripheral changes that need to be accommodated. This project will also address STEM's reliance upon a legacy scheduling application that is used to manage the flexible nature of the STEM.

Solution and benefits

AEMO's STEM auction system was upgraded to a modern code base in the AR5 period and was an approved WEM Reform precursor project in the AR5 determination. With no "off the shelf" solution available, reusing this software is the appropriate and prudent solution.

The STEM is a bespoke market mechanism in the WEM. AEMO is only making consequential changes to technical and functional elements of the STEM that are necessary for ongoing operations). This approach of only making the minimum necessary changes (rather than full reform) to the STEM systems is helping minimise total costs.

AEMO has worked with EPWA to reduce the implementation risk to STEM and other projects by reducing complexity and interdependency through revisions to the proposed rules.

5.3.4 Registrations reform

Scope and background

The WEMS Registration system caters for the current Participant and Facility classes and registration frameworks, which are changing as a part of the new market design. The project will make the necessary changes to support the new Registration taxonomy (Participant and Facility Classes)and improved processes including but not limited to the Registration portal, Registration form management functionality and processes, Standing Data, and reporting functionality.

Solution and benefits

A new solution, whether bought or built, was discounted in favour of repurposing existing WEM Registration system as the implementation and timeline risk is decreased by using operational knowledge and support for the existing system.

By using a façade to integrate with other projects, the foundation of the WEM Registration can be updated to newer technologies in the future to maintain support levels and reduce operational support risks.

5.3.5 Settlements reform

Scope and background

The Settlements reform work package contains three components – Settlements, Invoicing & Transaction and Metering.

Settlements

Due to the significant changes to Registration, RCM, SCED, and ESS, the settlement system calculations (including prudential calculations) will need to be modified to reflect the new formulas and parameters required under the new WEM Rules. In addition, the reforms are introducing a weekly settlement period to replace the current monthly settlement period. This project will also consider an archival strategy for historic settlement data (pre-reform data) and will need to cater for calculation of reform settlement (weekly) and adjustments to pre-reform settlement (monthly) for the first 12 months.

Invoicing & transaction

The current invoicing tool caters for the current market structures and settlement cycles in the WEM. As most of these are changing, this project will modify the existing invoicing application to support the changes in reporting requirements, settlement frequency and invoice aggregation. It will need to cater for hybrid settlement invoicing arrangements between old and new markets as adjustments occur over a period of 12 months after the initial settlement. Introducing a new product, whether the equivalent NEM solution or a new product off-the-shelf, would introduce cost and risk to the reform program and was therefore dismissed.

Metering

Western Power is the Meter Data Agent (MDA) for the collection and processing of all information relating to the physical metering infrastructure. It provides the required information to AEMO to allow market settlement. While it is anticipated that there should be no fundamental changes to the metering data provided (as AEMO are maintaining a 30-minute settlement interval for now), the MDA has identified that it will be upgrading its metering back-office software, which will require updates to the interface between to AEMO and the MDA. This project will also be modernising the metering verification tools to ensure meter data integrity.

Solution and benefits

Settlements Enhancements was undertaken with explicit view that the PaSS would provide an extendable platform to be used for Reform – as such, AEMO continues to be able to leverage knowledge, skills and recent experience to scope and deliver project.

This approach also provides a longer economic life for the underlying solution and initial assessment of WEM 5MS includes an option for the continued use of the PaSS (with modifications).

5.3.6 WEM Dispatch Engine (WEMDE)

Scope and background

The current dispatch engine (RTDE) is not capable of co-optimising energy and Essential System Services (ESS) and therefore needs to be replaced to enable AEMO to operate the new real-time market. This project will replace the RTDE with a modified version of the NEM dispatch engine, which will co-optimise energy with the ESS services in accordance with the market design.

In addition to providing real time dispatch capability, WEMDE will also be responsible for the physical implementation of the new ESS framework (e.g. Regulation, Contingency Raise/Lower, RoCoF service), determining pricing outcomes, producing forward-looking dispatch schedules up to one week ahead, and providing data for a number of downstream publication requirements (e.g. binding and near-binding constraints) and settlement outcomes (e.g. ESS activation, dispatch compliance, net offer shortfall, etc).

Determination of the dispatch algorithm, the various constraints that it needs to cater for and the associated violation penalties, will be a key part of developing the WEMDE solution.

Solution and benefits

The WEMDE is built following the development of a prototype engine than proved the core elements of the market design

While not a full re-purpose of NEM systems the WEMDE utilises the same linear solver engine and shares many elements of the NEMDE architecture (and lessons learned through 20+ years of its operation).

AEMO ran a request for proposal in Q2 2021 and assessed options to augment AEMO team and build a new solution as well as buying and customising a vendor product. AEMO proceeded with a build option and chose an experienced vendor with international dispatch engine experience based on a total cost of ownership and risk assessment.

5.3.7 WEMDE user interface

Scope and background

This project encompasses system operator real-time reform. It also addresses the definition of the e-terra integration interface for other WEM Reform projects.

The control room tools presently used are catering to the current market design and are not fit for purpose when the WEM moves to a SCED market model. This project will modify and re-platform existing System Operator Real-time tools and replace the existing market interface tools and UIs to support the control room in its operation of the power system under a SCED arrangement.

Other users will also require visibility of dispatch outcomes and the ability to support forward dispatch planning, e.g., planning engineers, compliance analysts, and therefore these tools will need to support other user classes that may require access to WEMDE and associated data. To the extent possible the user interface should seek to unify the available "market data" in one location (e.g., dispatch, market schedules, forecast, constraints, PASA, compliance, standing data, etc).

Solution and benefits

WEMDE-UI will be built based on the AEMO Digital Portal platform and will be the primary visualisation and control mechanism for WEMDE.

Using NEM systems was discounted due to amount of customisation necessary to support the WEM, coupled with the fact that the technology and tools are no longer on strategic roadmap.

Where possible AEMO is also utilising and revising existing systems (e.g., newly implemented e-terra EMS and AEMO's public Market Pulse website).

5.3.8 DTS integration & SCED offline tools

Scope and background

The dispatch training simulator lacks integration with market systems. This project will deliver the platforms and integration of the new SCED dispatch systems into the DTS environment to support analysis and training. In addition, this project will deliver an off-line version of WEMDE to provide analysis capability and to support industry in investment planning (in particular the network operator).

Solution and benefits

Extensions of WEMDE, WEMDE-UI and supporting interfaces into the simulation environment to support ongoing Power System Controller training and accreditation.

5.3.9 Outage management

Scope and background

The current outage management mechanism sits on a legacy application, which was adopted from Western Power with a view of minimising cost at the time, knowing that WEM Reform would be delivering a new outage management interface for Market Participants. This new outage management system standardises the look and feel as well as accommodating the changes to the information required to submitted.

Solution and benefits

Outage management will be built based on the AEMO digital portal platform and will be the primary entry point, visualisation and process flow mechanism for both market participant and network operator outages.

Existing WEM systems were discounted due to amount of customisation necessary to support the new market design, coupled with the fact that the technology and tools are no longer on strategic roadmap. The NEM equivalent (Network Outage Schedule (NOS)) was reviewed but not selected due limited capability (only network outages) and diverse identity mechanism adoption of NOS will not be possible. There are no off-the-shelf products available.

5.3.10 Commissioning test

Scope and background

The new market design incorporates changes to the commissioning test plan framework to provide greater flexibility for AEMO and participants and improve transparency. This project will implement a new interface with the capability to support the lodging, updating, assessment and processing of commissioning test plans. This approach will enable AEMO to replace its current commissioning test plan mechanism which sits on a legacy application adopted from Western Power.

Solution and benefits

Commissioning test Plan will be built based on the AEMO digital portal platform and will be the primary entry point, visualisation and process flow mechanism for market participant commissioning test plans.
Existing WEM systems were discounted due to the fact that the technology and tools are no longer on strategic roadmap. There are no equivalent off-the-shelf products and there are no existing equivalent solutions in the NEM.

5.3.11 Medium term (MT) PASA

Scope and background

The underlying methodology and principles for forecasting risks to power system security and reliability in a SCED environment need to be developed for the WEM. This project will replace the existing PASA toolset, delivering a model (in PLEXOS) capable of estimating dispatch outcomes up to 3 years in the future, incorporating different input scenarios (forecasts, outages, etc) with processing capability to identify potential security and reliability risks. This project will deliver user interface, integration, data processing, reporting and notification capability.

Solution and benefits

AEMO intends to progress with a PLEXOS model utilising NEM knowledge and leveraging the licensing model already in place with the external vendor. Using a different model and software solution for the WEM was considered but the requirements of both markets are close enough that there are efficiencies available in using a single solution. These efficiencies would not be realised with a standalone WA solution.

AEMO will build the interfaces necessary to feed the PLEXOS model and process the output data. Where possible AEMO will utilise the native PLEXOS user interface, however, some user interface development will be required to manage the inputs and visualise the processed data.

Existing WEM Systems were discounted due to the fact they were fundamentally incapable of being extended to support new market requirements, and in addition the technology and tools are no longer on strategic roadmap.

5.3.12 Forecast integration

Scope and background

While the current load forecasting capabilities can be leveraged to support the new SCED design, some model adjustments will be required to support new downstream processes (e.g., moving to 5-minute net-based dispatch, half-hourly long-term forecasts, etc). The project will also look to rationalise how data inputs are managed and forecasting outputs are serviced to downstream systems and users.

Solution and benefits

AEMO will utilise existing forecast systems and build new interfaces to new market systems for provision of forecast data.

This project will also incorporate a software upgrade to the latest supported version of the forecasting software to ensure ongoing supportability and leverage new API capability for interface build.

5.3.13 System outage planning

Scope and background

This project will deliver tools to support system planning functions such as the ability to import and analyse dispatch outcomes into offline security analysis packages (e.g., PowerFactory) and interfaces to automate the collection of high-speed monitoring data.

Solution and benefits

The solution will implement APIs to pull data from Outage Management, Pre-Dispatch and MT PASA into EMS and PowerFactory, develop UI to link EMS Facility list and Equipment list, develop automated mechanism to retrieve data from Western Power and store centrally, develop UI to view fault recorder data, store forecast data centrally in EDP and develop reports.

The project is expected to deliver increased System Planner efficiency and improved forecast visibility and reporting.

5.3.14 Short term (ST) PASA

Scope and background

The Pre-Dispatch (PD) and ST PASA systems are the core systems used by AEMO and market participants to warn them if there are any system reliability issues in the pre-dispatch and short-term time frame.

The PD & ST PASA has a dual role of providing information for market participants to respond to market needs and, if there is not an adequate response from participants, for AEMO to intervene in the market to manage system security and system reliability. AEMO may use different operational levers e.g., rescheduling a network outage, activating RERT etc. to maintain system security and reliability.

This project will replace the existing PASA toolset by leveraging the WEMDE solver to analyse different potential dispatch outcomes over a weekly horizon based on the most up to date market offers and different input scenarios (forecasts, outages, etc) to identify risks to power system security and reliability. It will deliver user interface, integration, data processing, reporting and notification capability.

Solution and benefits

AEMO will leverage the systems delivered as part of the WEMDE and WEMDE-UI projects and extend these to cover ST PASA analysis.

Existing WEM Systems were discounted due to the fact that they were fundamentally incapable of being extended to support new market requirements, and in addition the technology and tools are no longer on strategic roadmap. The use of the equivalent NEM solution was dismissed due to the different market constructs and the integration required with WEMDE.

5.3.15 Integration & market trial

Scope and background

The scope of this project includes Business Analysis, Change Management and SME Resources to 'operate' and support the market trial activities including planning activities, engagement with market participants, coaching/training and issue resolution.

Project resources include development and test resources to carry out final solution integration activities and system integration/regression testing to enable end-to-end trials. Resources also available to fix defects that arise.

Solution and benefits

The Industry Testing Working Group (ITWG) will be established to co-ordinate and execute industry testing and market trials for the WEM Reform program. It will engage and collaborate with market participants on WEM Reform industry testing activities, collaborate on the development of the detailed test plans and test cases and ensure that market testing considerations are captured in program timelines as readiness activities.

Each participant will provide market test resources to be part of the ITWG for the duration of market testing preparation and execution activity. It is expected that those resources will be adequately skilled to meet the

needs of the preparation activity. The ITWG will meet as required to drive the planning and preparation and execution process, as per the ITWG Terms of Reference.

5.3.16 Compliance reporting

This project will deliver capability to gather and report on various aspects of SCED operation to support monitoring both AEMO's own compliance and rule participant compliance where we have obligations to monitor.

5.3.17 Decommissioning

This project contains all decommissioning activities of the WEM Reform program including removal of redundant systems and interfaces, archival and storage of historical data. It contains activities to disable and retire legacy functionality and infrastructure once new infrastructure and capability is in production, and also to relocate and make available historical information to support ongoing audit, compliance and operational reporting going forward.

5.3.18 Hypercare & support

This project contains activities to support operational teams (e.g., SME knowledge share, issue resolution) and critical post go-live defects to ensure that obligations can be met, and power system security and reliability is able to be maintained.

5.4 WA Distributed Energy Resources (DER) Program

The WA DER Program has been established to support the effective integration of DER into the WEM and SWIS as outlined in the WA government's DER Roadmap, published in April 2020. The WA DER Roadmap outlines a collaborative approach by EPWA, AEMO, Western Power, Synergy and other stakeholders to address challenges arising from increasing DER installations[15].

the WA DER Program consists of three in-flight projects and five new projects to commence in the AR6 period, all considering various activities around design and implementation.

5.4.1 Project Symphony (DER Orchestration Pilot)

Scope and background

Project Symphony is an innovative project where customer distributed energy resources like rooftop solar, battery energy storage and other major appliances, like air conditioning and pool pumps, will be orchestrated as a virtual power plant (VPP) to participate in the WEM to unlock greater economic and environmental benefits for customers and the wider community.

The 'Hybrid Model' provides the foundational framework for the implementation of Project Symphony, and the framework contemplated by EPWA[16]. This model is expected to provide the most efficient outcome in the SWIS as it leverages existing roles (hence is already supported by foundational regulatory arrangements), avoids duplication of systems across AEMO and the DSO (i.e. does not require duplicate optimisation and dispatch systems) and supports ease of market entry for new DER aggregator participants (i.e. enables lower barriers to entry through interfacing with a single market operator).

Solution and benefits

Project Symphony is 'piloting' capability to support the Hybrid Model in the WEM and SWIS in order to inform the solutions that AEMO will implement in an operational version of this model, suitable to local conditions. This future model will be informed by policy decisions and rules, yet to be confirmed by EPWA.

Give this arrangement Project Symphony is supported by a platform that strikes the right balance between automation and manual data handling aiming to inform appropriate system design that would support future DER orchestration operational arrangements. The pilot is being run 'off market' (i.e. whilst there is real energy

[15] EPWA, 2020, Distributed Energy Resources Roadmap.

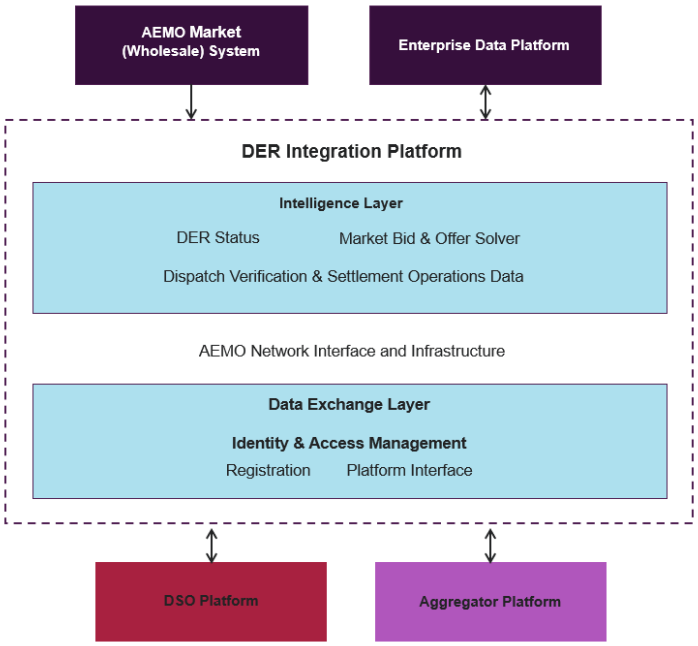
[16] Open Energy Networks (AEMO and ENA) , 2019, Required Capabilities and Recommended Actions.

being moved around and monitored by the DER Aggregator, in response to a dispatch instruction being issued by AEMO's platform, all financial transactions are simulated to avoid interaction with the wholesale market).

The 'market platform' comprises two key layers, each providing distinct and critical capabilities:

- The Intelligence Layer manages takes in actual and simulated market data and DER Aggregator bids and offers, solves for dispatch, issues dispatch instructions, and simulates settlement, providing key insights into the operational nature of a DER Aggregator.
- The Data Exchange Layer manages access, DER Aggregator and device registration, ingestion of actual market data, receipt and management of significant volumes of data from the DSO and Aggregator and provides data transfer to the Intelligence Layer.

Figure 16 DER Integration Platform



The design and implementation approach taken to the platform is to strike the right balance between automation where this is valuable based on data volumes and enablement of real-time exchanges (for example solving and dispatching the aggregator), and manual data handling with simpler tools (e.g. registration will be spreadsheet based and likely rely on emails and uploading of data). This approach enables the technology to pilot an operating environment that benefits from learning and will feed into the design of more detailed automated operational solutions.

To deliver Project Symphony the technology platform is being delivered in partnership with a similar project in the NEM (Project EDGE) that shares the same foundational platform and vendors to deliver core functionality. This has enabled an economy of scale to the extent that the core functionality applies across both projects. However, each project has distinct requirements fit for purpose to each pilot and jurisdiction, so the benefit of this economy of scale cannot extend to the entire project.

Project Symphony will enable learning and the definition of requirements for implementation of AEMO's operational systems to manage the orchestration of DER, via market participation (yet to be defined through policy and rules). The approach taken by AEMO enables the identification of the most efficient balance of new technology solutions where they are specific to DER participation, and augmentation of existing solutions where this is acceptable to meet requirements.

For Project Symphony the project team has specified and procured the foundational platform, in partnership with Project EDGE. During this process AEMO identified that vendor capability is not perfectly matched to project requirements, as such 'off-the shelf' solutions are not available (other Symphony project partners also found this[17]). From this foundational platform the detailed design for the test cases and scenarios is subject to ongoing negotiation with the project partners. Through these negotiations AEMO is applying principles of prudence on an ongoing basis (for example, relying on daily data uploads for post-even analysis rather than real-time data provided through costly SCADA systems). As such AEMO's approach to deliver Project Symphony's requirements represents the most efficient pathway to procurement and delivery that AEMO has been able to identify.

5.4.2 DER Participation

Scope and background

Run in parallel to Project Symphony the DER Participation project has largely been a market and rules design project to date. The project's goal is to tackle the regulatory and market development requirements to enable DER to participate in the WEM alongside provision of network support services to the Network Operator. AEMO's goal in this project is to deliver a more efficient and sustainable WEM through the participation of DER aggregators.

To deliver this goal AEMO must consider early implementation activities alongside providing advice to support the design of more holistic implementation of the Hybrid Model. The former being driven by emergent needs for power system security[18], and the latter being defined by EPWA based on policy and learnings from Project Symphony.

Solution and benefits

The priority actions for the DER Participation project include:

- The implementation of the Emergency Solar Management scheme based on existing forecast approaches and drawing on AEMO's existing powers for direction of rule participants.
- The implementation of new requirements for visibility of DER Aggregations where they are established or deployed in an 'off-market' context, providing new information into AEMO's forecasting and dispatch systems.
- Exploring contractual arrangements that support the resolution of issues and system security risks resulting from very high levels of DER participation in the WEM and SWIS. Where these are provided such arrangements would integrate with relevant existing technology solutions.

The extent to which these actions require changes to operating and/or market procedures and/or have implications for AEMOs technology solutions is currently under exploration.

5.4.3 DER Participation Implementation

Scope and background

Building on both Project Symphony and DER Participation the Implementation project would undertake all necessary changes to implement EPWA's preferred version of the DER orchestration model in the WEM and SWIS. As described above Project Symphony does not lock in a specific solution. Rather the requirements and details for this implementation project are dependent on EPWA's policy and rule landings, leveraging the solutions implemented for Project Symphony and the early-stage implementation actions undertaken in DER Participation as far as practicable.

Solution and benefits

Per the above the technology solutions implemented in this project are dependent on prior effort and EPWA's rule implementation. Further, AEMO understands that the timeframes for implementation do not

[17] Project Symphony, 2021, Lessons Learned Repot 1: https://arena.gov.au/knowledge-bank/project-symphony-lessons-learnt-report-1/

[18] AEMO, 2021, Renewable Energy Integration - SWIS Update Report: https://aemo.com.au/en/energy-systems/electricity/wholesale-electricity-market-wem/system-operations/integrating-utility-scale-renewables-and-distributed-energy-resources-in-the-swis

allow for significant delay between Project Symphony and participation in the WEM, with little flexibility between the DER Roadmap, and Project Symphony's schedule. As a result, AEMO intends to commence development of aspects of this project whilst submitting an in-period capital adjustment submission to the ERA to support full implementation. Those aspects within scope of the Regulatory Planning stage will include:

- Defining an implementation plan that supports EPWA's preferred implementation model (AEMO understand this is likely to be an incremental 'glide path' approach),
- Changes to and/or the development of new WEM procedures, and related stakeholder engagement,
- Undertake detailed planning for implementation including system and architecture designs that will support the ERA's consideration of the in-period forecast capital adjustment, in accordance with the ERA's guidelines[19], and
- Prepare and negotiate an appropriately detailed in-period submission for ERA consideration and approval as an adjustment to the approved AR6 forecast capital expenditure.

To remain efficient and prudent AEMO intends that this Regulatory Planning phase does not undertake significant technology investments until the ERA has made a final determination on the in-period adjustment. AEMO will consider how procurement processes align at the appropriate time. Rather, this phase intends to set up the related instruments and define all relevant technology solutions and their implementation activities (including UAT, market readiness and change activities, business process changes etc).

5.4.4 Electric Vehicles in the DER Register

Scope and background

The Western Australian Government has implemented their WA Electric Vehicle (EV) Action Plan to prepare the state for an expected rapid uptake of EV's. Visibility of EV's is one of 11 actions in this plan, and this includes expansion of the DER Register to incorporate EV charging infrastructure.

The flexibility of Electric Vehicles, with varying options for charging and the projected growth of the resulting electricity consumption, means that this form of DER has significant potential to create system-wide challenges if not well understood and effectively planned for.

The DER Register captures static DER devices that create implications for System Management and Market Operations. However, unless an EV is approved to export to the grid it will not be captured in the DER Register, leading to low understanding or visibility of the potential impact of this emerging technology.

As a result of this situation the WEM and SWIS may become exposed to large volumes of controllable DER (EV chargers) that may have implications for system management (likely in the form of load ramping) as EV uptake increases.

Solution and benefits

The proposed technology solution for the inclusion of EV charging information expands on that already in place for the DER Register. This scope of this project will include:

- Updating the WEM DER Register Information Procedure, and undertaking the relevant stakeholder consultation,
- Expanding the API arrangements for receipt of the data to be provided to AEMO,
- Developing and applying validation rules to the data,
- Expanding the data models to hold the data within AEMO's Enterprise Data Platform, and
- Relevant UAT and business changes to ensuring the data is accessible and can be utilised operationally.

[19] See https://www.erawa.com.au/electricity/wholesale-electricity-market/annual-price-setting/allowable-revenue-and-forecast-capital-expenditure-determinations.

AEMO proposes that the above approach to expand existing systems and solutions is prudent, with the DER Register already benefiting from a nationally consistent solution. Further, AEMO will utilise resources that were involved in the delivery of the DER Register to ensure the project is delivered efficiently.

5.4.5 Market Visibility

Scope and background

The success of the WEM in attracting DER Aggregators rests in part in AEMO's ability to reduce barriers to entry. The benefits of doing so include increased visibility and control of DER across the SWIS, and improved market outcomes.

Over the long term the WEM is expected to become increasingly reliant on services provided from DER via DER Aggregators. In accordance with the incremental approach preferred by EPWA for encouraging participation in the WEM, AEMO's role in market development includes understanding barriers and supporting market entry.

Solution and benefits

This project's core benefit is to provide greater access to the market. To do this requires understanding of the barriers that may existing and reinforcing value of participation by DER Aggregators. This project's goal is to enable earlier realisation of the benefits of visibility and control of DER Aggregations through the provision of services to the WEM.

The technology solutions considered in this project include building on AEMO's long-standing capability in providing market data transparently to educate, and to aid equitable and low-friction market access. The new focus on DER Aggregators and the distribution network means that the supporting assets (e.g. visualisations, dashboards and training material will require some adjustment).

As far as possible AEMO intends to build on the digital platform from the WEM Reform program, building on existing systems and utilising expert resources to enable prudent and efficient delivery of this project.

5.4.6 DER Data Access & Management

Scope and background

Increased DER penetration and risks in relation to more frequent low load conditions and more volatile demand create the need for greater visibility of DER across the SWIS. In particular, the prevalence and behaviour of unregistered DER (especially solar PV) has an impact on AEMO's capacity to effectively forecast. As the WEM and SWIS adopt increasing amounts of DER, the inherent volatility of these resources impacts AEMO's ability to operate the power system, requiring greater investment in related market services (such as spinning reserve, or contingency services).

The DER Register provides a data source for AEMO to access static information through manual processes. However, as the distribution network becomes more active due to DER there are increasing opportunities to access data to represent DER generation more accurately across the SWIS that would provide significant benefit in enabling efficient market and system operational activities.

Solution and benefits

The technology solutions for this project aim to collect and provide enhanced forecasting information that can be used in market and system planning and operations. This will include:

- locally measured data from locations across the SWIS to represent the locational volatility of the system (to understand ramp rates due to cloud cover and therefore regulation service requirements for example)
- Further effort to integrate DER Register information into AEMO's operational systems (to efficiently estimate contingency essential system service requirements on a temporal basis for example).

Implementing these enhancements will lead to the efficient operation of the WEM under current and increasing DER penetrations, especially where DER remains passive or unregistered. To deliver these solutions

AEMO proposed to draw as far as possible on data sources that are already available (from Western Power for example) but would also explore establishing access to new data sets for (for example solar irradiance monitoring).

The requirements for this data would also be developed in accordance with the requirements of the Operational Forecasting project, to ensure the efficient and prudent delivery of enhanced forecasting capability.

5.4.7 Technology Integration

Scope and background

DER is now the single largest generator in the WEM and SWIS with an installed capacity that exceeds combined capacity of all the coal generators. However, unlike these known conventional generating systems the performance of DER is not as well understood and is not required to comply to equivalent generator performance standards, despite presenting similar contingency risk characteristics.

The Technology Integration project is uplifting AEMO's foundational planning and system simulation capabilities in order that AEMO and effective plan and operate a secure and reliable high-DER WEM and SWIS, today and into the future.

Solution and benefits

The Technology Integration project combines detailed data examination and analysis to understand the actual behaviour of DER, uplifting of modelling and processing capabilities to inform standards development and the power systems 'safety margins' that drive requirements of ancillary and contingency services.

The core technology solution in this project is an updated power system simulation model that provides a more accurate three phase (root mean squared, RMS) and electro-magnetic transient simulation (EMTS) representation of DER and load – both of which have been shown to impact the system during disturbances.

To deliver this solution AEMO has leveraged significant learning from the NEM effort to do the same. However, the NEM applies a different software solution to this challenge (PSSe), so it is not possible to apply that software directly to support the WEM's requirements (where PowerFactory is the model used by AEMO and Western Power). Despite this limitation AEMO has been able to leverage many learnings and experiences to ensure the project is delivered efficiently and prudently.

5.4.8 Network Services Market Design and Trial

Scope and background

The Network Services Market Design and Trial project will test and demonstrate the technical and regulatory capability for AEMO to facilitate a marketplace for network services in the WEM, alongside wholesale services. AEMO will support the delivery and management of the trial, with the intention to define future regulatory changes to implement a network services marketplace within AEMO's systems.

Solution and benefits

The objectives of this project are to design solutions that enable dynamic, integrated and consistent DER management, increasing competition for both wholesale and network services via a common market access point managed by AEMO. In executing this project AEMO aims to test and learn from the proof-of-concept network services marketplace in the WEM context.

AEMO aims to fulfil EPWA's scope efficiently by leveraging design and investments made in AEMO's NEM-based Project EDGE which has implemented a 'Local Services Exchange' to provide a similar functionality. Utilising this trial platform would represent the most efficient means to deliver the Network Services Market trial platform for the SWIS. As with Project Symphony this would be undertaken in an off-market arrangement that does not interfere with AEMO's operational systems.

If implemented post the trial this trial would provide a sound understanding of the system and regulatory changes required to operate a network services marketplace in the WEM, and the inform regulatory changes required to implement such an arrangement.

5.5 Capability uplift

Rule 2.1A.1A of the Wholesale Electricity Market Rules confers the function on AEMO of ensuring that the SWIS operates in a secure and reliable manner for the purposes of the WEM Regulations. The three projects that make up the capability uplift workstream add new capability to AEMO WA, aimed at increasing system security through technology-driven initiatives.

In this IT Roadmap, the business enablement projects primarily address management of the impact of increasing amounts of renewable energy input to the energy system. The capability uplift workstream includes two power system control room projects (WAMS and the Transient Stability Tool), which are concerned with monitoring and situational awareness, while the operations simulator looks at predicting and analysing wind and solar generated energy inputs to the grid.

For each of the projects in this workstream, a standalone WA solution was considered. These options were dismissed due to the significant additional costs associated with the both the implementation and ongoing operational support. AEMO has already implemented similar solutions in the NEM, and it is considered appropriate that the same technology is implemented in WEM.

5.5.1 Wide area monitoring systems

Low system strength and reduced inertia due to an exponential increase in inverter-based generation has been shown through simulations and observations to cause challenges that can be a threat to power system security. As power system load reduces and is expected to reach operational limits within the next few years, the more accurate these limits can be determined and monitored, the more efficiently actions can be taken to manage the limits. Western Power is currently planning the installation of phasor measurement units (PMU) as part of a trial.

Scope and background

The key objective of this project is to provide enhanced situational awareness to the control room with access to real-time synchrophasor data. The project will also establish a high-speed data historian for phasor measurement unit (PMU) data, to provide easy access of historical high-speed data to the organisation

The provision of the data also assists in improving the accuracy of the State Estimator component of AEMO's energy management system (e-terra). Analysis of the data from PMUs provides essential input to incident investigations and the tuning and validation of power system models.

AEMO currently has no real-time visibility of these phenomena and operates the power system based on estimated quantities. Going forward, system limits are based on these estimated quantities, which are expected to be more conservative than the actual limits.

Solution and benefits

Cost-effective PMUs and wide area monitoring systems (WAMS) are widely used in power system monitoring and control. However, they have not been used in the WEM. The information provided through these systems increases operational awareness of power system events, and potential events, which are not captured by SCADA. Power system characteristics such as inertia and system strength, can be better estimated with input from the PMUs, as opposed to the offline estimates currently utilised. This allows AEMO operators to better manage the impact of increasing Variable Renewable Energy (VRE) and DER.

The ability to incorporate the PMU information generated by Western Power is now essential. It is necessary to now develop the skills and systems to effectively analyse and utilise the information so it can continue to be enhanced as limits become more extreme.

5.5.2 Transient stability tool

Transient stability is becoming a larger issue with the displacement of synchronous generation by wind and solar farms as well as the changing operation of thermal plant.

Scope and background

There is currently no process for AEMO to monitor N-1 rotor angle or oscillatory stability in the WEM in real time. This lack of awareness / visibility could potentially lead to the insecure operations of the power system in the future. There are a limited number of known transient stability issues currently on the system and these are largely mitigated through remedial actions schemes (special protection schemes).

The introduction of a real-time transient stability tool will provide enhanced situational awareness to the control room using results from the tool.

Solution and benefits

The NEM's existing tool – DSA - can be used to find power system issues and act on them in real-time. It is also used in a study environment so the outage planners can check on limits for planned outages. DSA (along with other control room tools) gives situational awareness to control room operators.

Implementing DSA in the WEM will give AEMO WA greater visibility of transient stability issues under all operating conditions. It will also provide better feedback to Western Power on the statistically based limit equations by benchmarking against the real time limits calculated by this application.

The advantages of this approach are that WA is leveraging the approach that has already been implemented at the national level, providing consistency across AEMO, with associated benefits of skills development to support the tools across the organisation nationally.

5.5.3 Operations simulator

Existing energy industry tools are not able to fully support the transitioning and future energy system effectively or to address current or emerging challenges arising from increasing asynchronous generation.

Scope and background

The key objective of this project is to strategically position AEMO WA with the capability necessary to analyse, predict and resolve security issues created by the connection and operation of large proportions of inverter-based generation. These issues, that are ongoing within the NEM, are not yet experienced within the WEM, but are almost certain over the 3–5-year horizon given current trends in the industry and generation profile. This project will allow the WEM to avoid the complex operational security issues (see e.g.: West Murray case study) and connections pipeline congestion currently experienced within the NEM, by leveraging both experience and technical expertise developed in response to these ongoing issues.

Solution and benefits

AEMO (NEM) has implemented an Australian Operations Simulator to support the transitioning and future energy systems. It also addresses current and emerging challenges arising from increasing asynchronous generation. This "core system" can be extended to providing simulation services to industry.

AEMO has created a base capability that has been specified, built, and tested so that the on-boarding for WEM/SWIS will only consist of licensing, some dedicated hardware and local network modelling necessary to be able to use the simulator.

This solution leverages the experience and conclusions of over 5 years of intensive analysis, operational management of power systems issues, industry consultation and engineering development in the NEM. For the WEM, it is an opportunity to leverage technical and process expertise, as well as design and hardware, to pre-emptively manage the emerging security issues associated with inverter-based generation.

5.6 Lifecycle

Rule 2.1A.1A of the Wholesale Electricity Market Rules confers on AEMO the function of ensuring that the SWIS operates in a secure and reliable manner for the purposes of the WEM Regulations. Various clauses under Rule 2.1A.2 confer multiple additional functions on AEMO including, but not limited to, operation of the Reserve Capacity Mechanism, the Short-Term Energy Market, the LFAS Market, and the Balancing Market.

AEMO has a planned software and hardware remediation program that applies across the organisation to ensure all software and hardware remains under support. This workstream includes upgrades to software and hardware that will come out of support during the 2023-2025 submission period. Failure to mitigate or remediate these legacy systems prior to their support ending is considered technical debt and places significant risk to the confidentiality, availability and integrity of AEMO's systems and data.

AEMO has a zero tolerance for risks relating to the availability of critical systems supporting power and gas operations and is willing to provide appropriate technology and maintenance of these critical systems to ensure they are current, reliable, supported and cost effective to run.

5.6.1 WA applications lifecycle projects

The WEM Reform program will transform AEMO's application landscape; however, many systems will remain either unchanged or minimally changed as they are sufficient to deliver Reform. These applications will not be concurrently upgraded to remediate technical debt that manifests during reform. To remediate these issues would add risk to WEM Reform delivery. When WEM Reform is delivered, many WA applications will have one or more of the following legacy components:

- Unsupported operating systems
- Legacy active directory domain services
- Unsupported Java programming language
- Legacy Oracle databases
- Other legacy technologies.

The applications impacted and how they are impacted is addressed in the table below:

Table 2 AR6 lifecycle program – impacted applications

Application	Legacy/Unsupported Software				
	Operating System	Oracle	Java	Active Directory	Other
WAMS Calendar Service	x			x	
WAMS Engine	x	X		X	
WAMS GBB (Gas Bulletin Board of WA)	x	x	x	X	
WAMS Gofer	X			X	
WAMS Manager	X	X		X	X Java Applet
WAMS Market Participant Interface	X	X		X	
WAMS Metering		x		X	

Application	Legacy/Unsupported Software				
	Operating System	Oracle	Java	Active Directory	Other
WAMS MOSMI	X	X		X	
WAMS MOSMI Probe	X	X		X	
WAMS Notifications	X			X	
WAMS PaSS				X	
WAMS RCM				x	
WAMS Services	X	X		X	
WAMS SFTP Transfer Tool	X			X	
WASM Enterprise Service Bus					X WebMethods
WASM File and FTP Server					X FTP
WASM Interface FTP Server					X FTP
WASM PDRBatcher				X	
WASM REST Application Programming Interface				X	

AEMO has either a zero or low risk tolerance with regards to the availability of critical systems. These legacy technical issues will introduce critical risk. Three projects are proposed during the AR6 period to remediate these risks and address this technical debt.:

- Lifecycle EDP
- Legacy Market Systems and
- Lifecycle Integration.

The segregation of work across these projects are based on the solution that will remediate the risks.

Lifecycle EDP

This project will replace certain functional capabilities of legacy applications with an Enterprise Data Platform (EDP) capability.

Scope and background

The WEM Reform program will introduce an EDP capability into AEMO's WA technology landscape. Following the delivery of WEM Reform, many applications will require remediation to remove the risks associated with running unsupported, legacy versions of various software components. Functionality from eight of these applications can be replaced by the new EDP platform:

- WAMS Calendar Service
- WAMS GBB (Gas Bulletin Board of WA)
- WAMS Gofer
- WAMS SFTP Transfer Tool
- WASM File and FTP Server
- WASM Interface FTP Server
- WASM REST Application Programming Interface
- WASM Enterprise Service Bus.

These applications are required to ensure AEMO meets its compliance and reporting obligations.

Options, solution and benefits

Upgrading or replacing these applications in parallel with WEM Reform was considered but dismissed as this would add unacceptable risk to Reform delivery. Retaining these applications in their current state was dismissed due to the unacceptable risks associated.

During the delivery of WEM Reform, AEMO WA will introduce a capability known as an EDP (Enterprise Data Platform). The EDP will deliver multiple capabilities including:

- Data automation
- Central data repository
- Data consumption, analytics and visualisation
- Data governance
- Data support and maintenance.

When considering alternative solutions, replacing these applications with like-for-like applications on the latest software versions was considered. This was dismissed due to the higher cost to deliver as well as the ongoing costs for maintenance and management of the replacement applications when compared with using the existing EDP solution.

A standalone alternative to the EDP was dismissed due to the additional overhead associated with managing and maintaining such a system.

Lifecycle integration

This project will replace certain functional capabilities of legacy applications with an enterprise integration capability.

Scope and background

The WEM Reform program will introduce an enterprise integration capability into AEMO's WA technology landscape. Following the delivery of WEM Reform, many applications will require remediation to remove the risks associated with running unsupported, legacy versions of various software components. Functionality from nine of these applications can be replaced by the new enterprise integration platform:

- WAMS Calendar Service
- WAMS Gofer
- WAMS Notifications
- WAMS SFTP Transfer Tool
- WASM File and FTP Server
- WASM Interface FTP Server

- WASM PDRBatcher
- WASM REST Application Programming Interface
- WASM Enterprise Service Bus.

These applications are required to ensure AEMO meets its compliance and reporting obligations.

Options, solution and benefits

WEM Reform will already have delivered a new digital integration platform that will have the capability to replace the existing nine integration applications.

Further benefits of implementing these initiatives are:

- Near real-time visibility of critical market transactions.
- Enhanced security for data exchange and centralised access management.
- Improved speed to market of business and regulatory changes.

When considering alternative solutions, replacing these applications with like-for-like applications on the latest software versions was considered. This was dismissed due to the higher cost to deliver as well as the ongoing costs for maintenance and management of the replacement applications when compared with using the existing integration solution.

A standalone alternative to the new integration platform was dismissed due to the additional overhead associated with managing and maintaining such a system.

Lifecycle legacy market systems

This project will upgrade legacy components of WA Market applications to ensure the entire software stack remains supported.

Scope and background

Following the delivery of WEM Reform, nine applications will require remediation to remove the risks associated with running unsupported, legacy versions of various software components These applications are:

- WAMS Services
- WAMS MOSMI Probe
- WAMS MOSMI
- WAMS Market Participant Interface
- WAMS Manager
- WAMS Engine
- WAMS RCM
- WAMS PaSS
- WAMS Metering

These applications are required to ensure AEMO meets its obligations under WEM Rule 2.1A.2 and its various sub-clauses.

The risk of not doing the legacy market systems project is that AEMO will not be able to undertake core functions of market operations and settlements, will not be able to provide necessary information to market participants via the market participant interface, and monitoring systems (MOSMI) will not be able to provide error and warning messages via the UI. This project reduces the likelihood and consequence of a major market systems failure, and the consequential risk of reputational damage, stakeholder, legal and regulatory impacts.

Options and benefits

Upgrading or replacing these applications in parallel with WEM Reform was considered but dismissed as this would add unacceptable risk to Reform delivery. Retaining these applications in their current state was dismissed due to the unacceptable risks associated.

These applications are all specific to the WEM. AEMO does have similar capability in the NEM but those solutions have been assessed and the uplift cost to align is greater than an upgrade of the current solution based on current WEM requirements. The capabilities provided by these applications are bespoke and as such no off-the-shelf products are available.

For that reason, an upgrade of the existing services to a modern, supported pattern leveraging the capabilities now available as part of AEMO's digital solutions is deemed to the most prudent approach.

All or some of this project may no longer be required should there be more certain direction on WA 5-minute Settlements (5MS) as that program of work will replace or uplift many of the applications listed here. Any in-period submission related to WA 5MS will take this into consideration, however, approval is sought for this project in the interim.

5.6.2 Lifecycle Perth computer room

AEMO's planned upgrade program includes a replacement for all end-of-life computer room hardware. AEMO's WA computer room hardware will be upgraded during AR6 and will ensure that the computer room always maintains current and supported components. This reduces the risk of technical failure and the associated business impacts.

Scope and background

AEMO's WA department and Perth office is supported by physical technology infrastructure to provide staff and market participants with access to critical WA System Management and Market Operations systems, as well as core corporate applications. This hardware is located both in the Perth office and in a local data centre. Without regular maintenance or replacement, this hardware degrades and presents risk to the availability and integrity of WA data and services.

The following components have been identified as reaching end of support during the AR5 period:

- User firewalls
- Internet firewalls
- Office core switches
- Office wireless access points
- RTNET replacement
- WAN routers
- DC core switches.

Options, solution and benefits

The option to continuing to use the aging hardware (*sweating the assets)* was considered and dismissed as due to the significant risk this adds to the availability of critical applications and services. Migrating these services to an alternative AEMO data centre or to public cloud services was also dismissed due to the requirement for a local presence for certain critical System Management applications.

AEMO's procurement policies ensure that all new hardware is purchased at lowest possible cost and is some cases AEMO WA receives preferential prices by being part of large, national organisation.

5.6.3 ITRON Upgrade

Itron MetrixIDR is the incumbent AEMO load forecasting software. This is a critical system supporting market operations. Maintaining technology upgrades is in line with AEMO's policy on supporting critical systems. By maintaining upgrades AEMO is mitigating commercial and operational risks.

Scope and background

The Itron Roadmap includes an upgrade to Itron MetrixIDR in 2021-22 and one in 2024-25. The 2021-22 upgrade is included in the WEM Reform program. The 2024-25 Itron MetrixIDR upgrade is within this roadmap.

Options, solution and benefits

Upgrading the MetrixIDR load forecasting System to the latest version, will ensure that the critical operational system, which produces load forecasts used in dispatch, WEM STPASA and WEM MTPASA, continues to run on a supported application version.

Running on unsupported software has not been considered due to the associated risk. Alternative solutions were not considered due to the significant costs associated with a migration including additional support costs.

5.6.4 Certificate Authority

Public Key Infrastructure (PKI) is an ecosystem of people, process and technology services forming a security foundation for a substantial number of core business capabilities – e.g., staff remote access, Market participant access, digital service presentation such as AEMO website etc.

The existing WEM PKI service and issued certificates expire during the AR6 period (2024), i.e., participants (some 160 individuals/identities) will not be able to access AEMO systems from this date – The WEM PKI uses legacy technology (SHA-1) which is being blocked by modern internet browsers due to security issues.

Scope and background

This project will replace the expiring PKI certificates using the new AEMO solution, the new AEMO solution is the separately identifiable asset.

Replacing security certificates will enable market participants to maintain their connectivity with AEMO systems after migration. Use of the new PKI infrastructure will replace a known vulnerable algorithm that supports WEM market operations. When certificates expire, future certificate refresh can be automated whereas the current process is manual. The provision of current certificates is manual, and the distribution is not secure. The new solution will implement a secure delivery process for new certificates.

Options, solution and benefits

WEM will issue new security certificates using the new AEMO DigiCert solution to the market participants and revoke the existing security certificates that are expiring. Adopting a new certificate solution, either enterprise or standalone WA, was considered and dismissed due to the additional costs associated with implementation and ongoing support. Removing the requirement for certificates would introduce unacceptable risk to the security of AEMO applications. Basic maintenance to an existing system was deemed to be the most prudent approach.

5.7 Rule changes

Clause 2.1A.2.IA of the WEM Rules requires AEMO to contribute to the development and improve the effectiveness of the operation and administration of the Wholesale Electricity Market.

On 1 July 2021, responsibility for the administration and rule-making functions of the Wholesale Electricity Market (WEM) Rules and Gas Services Information (GSI) Rules was transferred from the former Rule Change Panel to the Coordinator of Energy.

WEM Rule changes

All rule changes to be implemented by AEMO WA are in response to directives from the Coordinator of Energy. It is unknown how many rule changes will be required though the AR6 period, and how complex the rule changes will be. In order to maintain compliance AEMO WA must implement the rule changes.

Scope and background

The exact scope of any potential rule changes is currently unknown but the type that may materialise include those that may resolve manifest issues, improve market's ability to satisfy WEM Objectives or ensure that AEMO maintains compliance with WEM and GSI rule amendments.

Options and benefits

AEMO has therefore included an amount in its AR6 capex forecast to accommodate rule changes that occur in period. Without an allowance for rule changes, there is a risk AEMO does not comply with rule amendments because insufficient funding is provided.

5.8 Corporate projects

As part of a national organisation, AEMO WA consumes a number of shared services. By sharing in these services, the benefits provided are achieved at marginal cost compared to those that would be associated with a standalone, WA-specific equivalent. These services will be maintained throughout the AR6 period.

5.8.1 NORWEST Data Centre

AEMO's planned upgrade program includes a replacement for all end-of-life data centre hardware. AEMO's Norwest Data Centre hardware will be upgraded during AR6 and will ensure that the computer room always maintains current and supported components. This reduces the risk of technical failure and the associated business impacts.

Scope and background

AEMO owns and operates its own data centre in its Norwest facility. WA System Management and Market Operations applications and services are hosted there, including production, development, and test environments. As this data centre also hosts a significant number of NEM services, WA receives the benefits of an enterprise-scale data centre capability at relatively low cost.

AEMO has a planned hardware upgrade program that applies across the organisation and includes a replacement timeframe for all data centre hardware. The components included in the AR6 Submission are those which will reach planned end of life in the 2023-2025 timeframe.

AEMO WA must maintain a data centre that is reliable, robust, and technologically up to date to service the AEMO WA business and mitigate the risk of business disruption due to failing hardware components.

AEMO has a low tolerance for activities relating to availability of critical systems supporting market operations and a zero tolerance for activities relating to availability of critical systems supporting power and gas operations. The impact of running on legacy infrastructure/ technology/ power supplies would introduce a critical risk which is unacceptable to AEMO.

Options and benefits

The option to continuing to use the aging hardware (*sweating the assets)* was considered and dismissed due to the significant risk this adds to the availability of critical applications and services. Migrating the WA

services that are hosted in the Norwest Data Centre on to the public cloud was dismissed as these services are in scope for WEM Reform. Parallel activities that change the underlying architecture would add significant risk to the delivery of that program.

AEMO's procurement policies ensure that all new hardware is purchased at lowest possible cost and is some cases AEMO WA receives preferential prices by being part of large, national organisation.

The specific data centre infrastructure in scope for upgrade or replacement during the AR6 period is:

- Uninterruptible power supply (UPS) units A and B including batteries
- Computer Room Air Conditioning (CRAC) units 2 and 3
- Static network switches A and B
- Power Factor Correction (PFC) Unit A

5.8.2 Energy Management System (EMS)

The AEMO Energy Management System (EMS) is used to monitor, control and optimise energy management. It is a critical system for AEMO WA for the operation of their core business.

Scope and background

The EMS software was introduced into the Western Australian market as part of the transition of services from Western Power. The current version aligns with AEMO's EMS version in the NEM (Version 3.2). GE's roadmap for this version is end of life in July 2024 which will leave AEMO (NEM and WEM) on legacy support beyond July 2024. This is an unacceptable risk to AEMO as the EMS is a critical operational system.

The EMS will be upgraded nationally, and cost will be apportioned between the two entities (NEM and WEM). A factor in apportioning cost will be the customisations required for the WA market. The version upgrade will roll out to both WEM and NEM as they share a common EMS code base.

Options and benefits

The option of not making any changes has been dismissed due to the critical risk this would introduce to the operations of the WA energy system. Creating a standalone WA instance of this, or other software, has been dismissed as this contradicts the intent of previously delivered projects related to the Western Power transition and also due to the significant additional cost associated with delivering and supporting this. Transitioning to an alternative solution at a national level has also been dismissed due to similar cost considerations.

The opportunity to provision regular, small upgrades rather than less frequent large upgrades exposes AEMO to less business risk associated with high cost, long duration major upgrades. AEMO WA will benefit by having access to the latest tools, a better user interface, functional improvements in the power system applications, security improvements, design improvements, and rely on a standardised foundation for future improvements.

5.8.3 Operations forecasting

The Power System is undergoing rapid change due to the increasing penetration of variable renewable technology including distributed energy resources, coupled with climate induced stress which is resulting in increased incidences of extreme weather events, affecting both the demand and the supply side of power system operations. This is leading to increased weather sensitivity and a reliance on forecast accuracy and deep understanding of forecast uncertainty for the secure operation of the power system.

Scope and background

To meet these challenges and position Operational Forecasting to be able to meet its vision of adopting the best forecast practices and systems to provide the best situational awareness for a power system operator, AEMO has developed the AEMO Fusion Methodology, which encapsulates a number of forecasting best practices.

Options and benefits

If AEMO's new Operational Forecasting capability were to be adopted in WA, it is expected that a more accurate forecast will reduce the cost of frequency regulation. While WEM Reform will introduce new markets for this and hence the cost of service in this new market is unknown, current LFAS costs are around $80 million annually. The way new data is brought into the AEMO systems is currently complex and depending on the system may be up to $175k per feed. This project will significantly simplify the approach to bringing in new data feeds which will be a frequent requirement going forward.

The proposed solution incorporates different forecasting methods to provide a range of different approaches to suit the variety of challenges being faced by AEMO WA and to mitigate risks. The end state solution, being the "Fusion methodology", incorporates the following concepts:

- Ensemble forecasting: a method to use multiple independent forecasts to create a single forecast. The divergence of the ensemble members can be used to gain an understanding of the uncertainty in the forecast.
- Probabilistic forecasting: an application of ensemble forecasting - where the spread of forecast outcomes is used to assign probability (or conversely, to understand the uncertainty) to/of the forecast scenario.
- Consensus forecasting - the business process Operational Forecasting uses to deliver the forecast products which includes probabilistic forecasts - it uses the ensemble forecasting technique, the Forecasting as a Service platform, and expert knowledge.
- Forecasting as a Service - the approach used to ingest multiple independent forecasts from vendors and describes the platform used to enable ensemble forecasting.

The choice to not implement this was considered but dismissed due to the associated risk:

- Strategic risk: Unable to maintain power system security and reliability due to disruption in the energy industry, extreme events and climate change.
- Regulatory risk: The failure to produce a forecast is a failure to meet one or more rules obligations, particularly clause 7A.3.15 of the WEM Rules.
- Operational risks: Single vendor and deterministic forecast methodologies are insufficient to meet the requirements of the evolving energy market.

The option to develop a standalone, WA equivalent was considered but dismissed due to the higher costs associated with delivering, maintaining, and supporting.

5.8.4 Cyber security

Prior to the AR5 submission, AEMO made a strategic decision to invest significantly in uplifting its cyber security capability. The importance of this investment cannot be overstated, with cyber-attacks becoming more frequent and the consequences becoming more significant. Ransomware attacks have also become prolific. In October 2021 alone there were notable incidents for Sandhills Global[20], Hong Kong marketing firm

[20] https://www.bleepingcomputer.com/news/security/sandhills-online-machinery-markets-shut-down-by-ransomware-attack/

Fimmick[21], Thailand-based luxury hotel chain Centara hotels[22], Pacific City Bank (PCB)[23], and Graff Diamonds[24]. In December 2021, companies around the world had to respond rapidly when a new 'Zero Day' vulnerability[25] was detected in commonly used software.

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[26]. 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[27]. 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 an attack[28].

Due to the critically important role of AEMO to ensure energy security, it is imperative that AEMO maintains the highest standards with regards to cyber security. AEMO has measures its cyber security capability against the NIST Cybersecurity Framework[29]:

- Identify: Develop an organizational understanding to manage cyber security risk to systems, people, assets, data and capabilities.
- Protect: Develop and implement appropriate safeguards to ensure delivery of critical services.
- Detect: Develop and implement appropriate activities to identify the occurrent of a cyber security event.
- Respond: Develop and implement appropriate activities to take action regarding a detected cyber security incident.
- Recover: Develop and implement appropriate activities to maintain plans for resilience and to restore any services that were impaired due to a cyber security incident.

Scope and background

The need for cyber security has never been greater. AEMO faces threats from a variety of sources, nation states, rogue operators through to criminal organisations. Additionally, organisations such as AEMO are coming under increased scrutiny by Government to ensure the security of energy supply to consumers.

By leveraging the national cyber security function, Western Australia takes advantage of the scale and experience of the national cyber security teams to maintain cyber resilience and provide a secure technology environment to ensure market participants encounter least disruption due to cyber security events.

Nationally, AEMO has established four persistent work streams to develop organisational capability and maturity to identify, protect, detect, respond and recover from a breach to cyber security. This approach reflects the NIST (U.S. National Institute of Standards and Technology) cyber security framework.

These four streams are:

- Ransomware resilience
- Threat detection & response
- Threat & vulnerability management
- Identity & access management.

[21] https://www.zdnet.com/article/hong-kong-firm-becomes-latest-marketing-company-hit-with-revil-ransomware/

[22] https://www.itpro.co.uk/security/cyber-attacks/361401/thailand-luxury-hotel-chain-hit-by-desorden-group

[23] https://www.bleepingcomputer.com/news/security/pacific-city-bank-discloses-ransomware-attack-claimed-by-avoslocker/

[24] https://www.dailymail.co.uk/news/article-10148265/Massive-cyber-heist-rocks-high-society-jeweller-Graff.html

[25] https://www.abc.net.au/news/2021-12-11/log4shell-techs-race-to-fix-software-flaw/100692876

[26] https://www.securitymagazine.com/articles/91898-european-electricity-association-confirms-hackers-breached-its-office-network

[27] https://www.bloomberg.com/news/articles/2021-06-04/hackers-breached-colonial-pipeline-using-compromised-password

[28] https://www.vestas.com/en/media/company-news/2021/vestas-impacted-by-cyber-security-incident-c3457473

[29] https://www.nist.gov/cyberframework

This approach means AEMO can react quickly to a cyber security event, with experienced teams in place to respond. These teams ensure AEMO has the capability in place for detection, protection, response and recovery to cyber security events.

AEMO's cyber security uplift is an in-flight program of work program of work commencing prior to the AR6 period and is being implemented nationally. Seven projects will be implemented during the AR6 period.

Due to the criticality of having robust security in place in an increasingly complex cyber security environment, "do nothing" is not considered an option as it significantly increased the risk of penetration of AEMOs networks and systems both within WA and nationally. For Western Australia, the solution and scope presented below is the prudent option. Creating a standalone capability would be more costly and may leave Western Australia out of sync with the rest of the organisation.

Due to their sensitive nature, the specific project details have been provided in a separate confidential appendix.

5.9 Project mapping to corporate priorities

The following diagram maps the projects covered by this IT Roadmap to the four corporate priorities.

Table 3 Project mapping to corporate priorities

	Corporate priorities			
	1. Operating today's systems and markets	2. Navigating the energy future	3. Engaging our stakeholders	4. Evolving the way we work
Stream 1 - Foundation Regulatory Frameworks				
WEM Reform	✓	✓	✓	✓
Stream 2 - Distributed Energy Resources (DER)				
DER Roadmap	✓	✓	✓	✓
Stream 3 - Capability Uplift				
Wide Area Monitoring Systems	✓	✓		✓
Transient Stability Tool	✓	✓		✓
Operations Simulator	✓	✓	✓	✓
Stream 4 - Lifecycle				
Lifecycle – EDP	✓			
Lifecycle – Legacy Market Systems	✓			
Lifecycle – Integration	✓			
Lifecycle Perth Computer Room	✓			
ITRON Upgrade	✓			
Certificate Authority	✓			
Stream 5 - Rule Changes				
WEM and GSI Rule Changes	✓	✓		✓
Stream 6 - Corporate Projects				
NORWEST Data Centre	✓			
Energy Management System	✓			
Cyber Security	✓			
Operations Forecasting	✓	✓	✓	✓

A1. AEMO functions as defined in the WEM Rules

Section 2.1A of the WEM Rules is reproduced below.

2.1A. Australian Energy Market Operator

2.1A.1. AEMO is conferred functions in respect of the Wholesale Electricity Market under the WEM Regulations and AEMO Regulations.

2.1A.1A The function of ensuring that the SWIS operates in a secure and reliable manner for the purposes of the WEM Regulations is conferred on AEMO.

2.1A.2. The WEM Regulations also provide for the WEM Rules to confer additional functions on AEMO. The functions conferred on AEMO are:

(a) to operate the Reserve Capacity Mechanism, the Short Term Energy Market, the LFSA Market, and the Balancing Market;

(b) to settle such transactions as it is required to under these WEM Rules;

(c) to carry out a Long Term PASA study and to publish the Statement of Opportunities Report;

(cA) to procure adequate Ancillary Services where Synergy cannot meet the Ancillary Service Requirements;

(d) to do anything that AEMO determines to be conductive or incidental to the performance of the functions set out in this clause 2.1A.2;

(e) to process applications for participation, and for the registration, de-registration and transfer of facilities;

(f) to release information required to be released by these WEM Rules;

(g) to publish information required to be published by these WEM Rules;

(h) to develop WEM Procedures, and amendments and replacements for them, where required by these WEM Rules;

(i) to make available copies of the WEM Procedures, as are in force at the relevant time;

(iA) to monitor Rule Participants' compliance with WEM Rules relating to dispatch and Power System Security and Power System Reliability;

(j) To support:

i. the Economic Regulation Authority's monitoring of other Rule Participants' compliance with the WEM Rules;

ii. the Economic Regulation Authority's investigation of potential breaches of the WEM Rules (including by reporting potential breaches to the Economic Regulation Authority); and

iii. any enforcement action taken by the Economic Regulation Authority under the Regulations and these WEM Rules;

(k) to support the Economic Regulation Authority in its market surveillance role, including providing any market related information required by the Economic Regulation Authority;

(l) to support the Coordinator and the Economic Regulation Authority in their roles of monitoring market effectiveness, including providing any market related information required by the Coordinator or the Economic Regulation Authority;

(IA) to contribute to the development and improve the effectiveness of the operation and administration of the Wholesale Electricity Market, by:

i. developing Rule Change Proposals;
ii. providing support and assistance to other parties to develop Rule Change Proposals;
iii. providing information to the Coordinator as required to support the Coordinator's functions under these WEM Rules; and
iv. providing information and assistance to the Coordinator and the Economic Regulation Authority as required to support the reviews they carry out under the WEM Rules;

(IB) to develop and maintain a Congestion Information Resource;

(IC) to establish, maintain and update a DER Register in accordance with clause 3.24;

(ID) to participate in the Technical Rules Committee and provide advice on Technical Rules Change Proposals as required by the Economic Regulation Authority under the Access Code, to provide submissions as part of the public consultation process in respect of Technical Rules Change Proposals and to develop and submit Technical Rules Change Proposals relating to System Operation Functions;

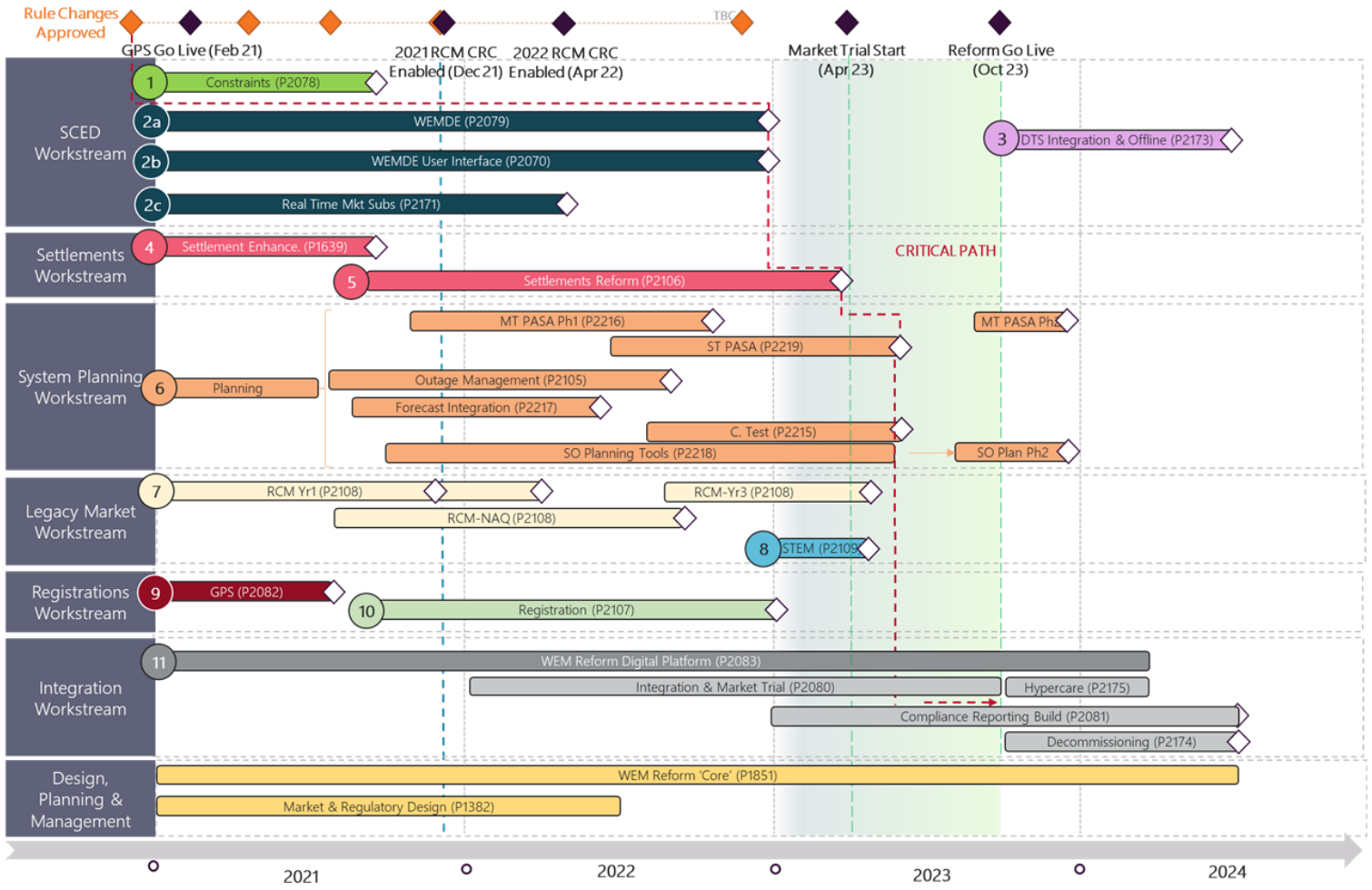
(IE) to support each Network Operator in relation to the standard or technical level of performance in respect of a Technical Requirement applicable to Transmission Connected Generating Systems and perform the associated functions set out in Chapter 3A of these WEM Rules;

(IF) to advise and consult with each Network Operator in respect of AEMO's System Operation Functions as contemplated under the Technical Rules applicable to the Network;

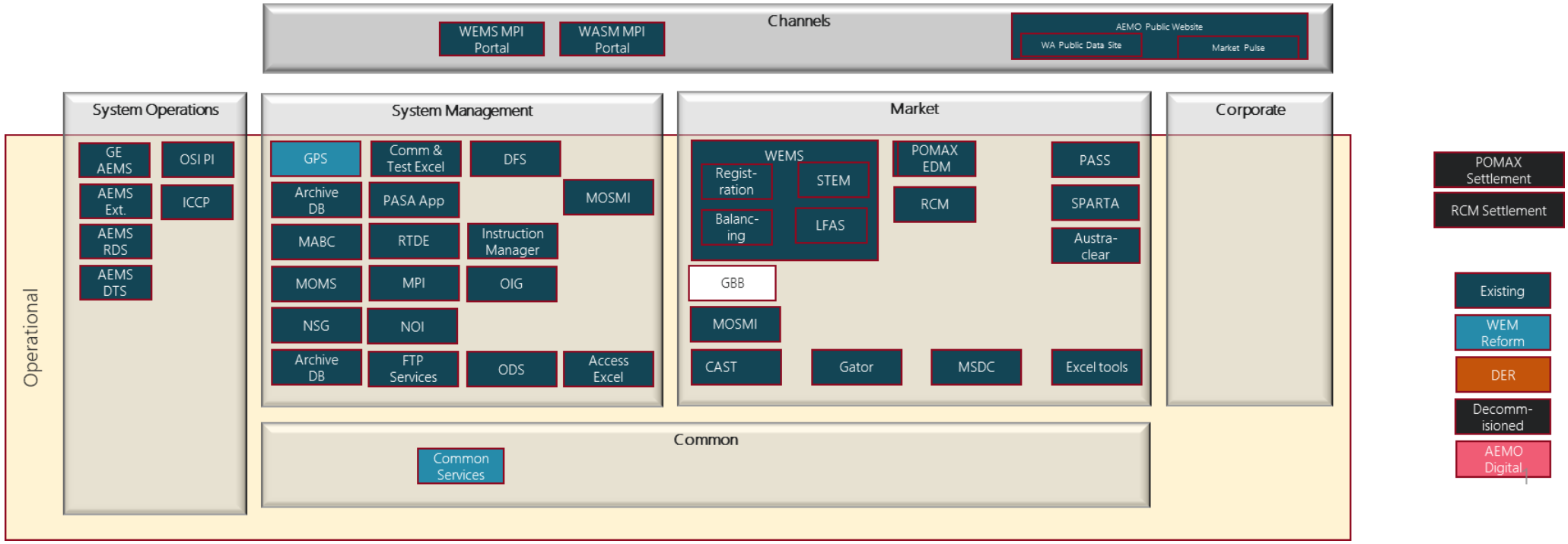
(II) to support the Coordinator's role, and to facilitate and implement decisions by the Coordinator and the Minister regarding the evolution and development of the Wholesale Electricity Market and the WEM Rules, and the management of Power System Security and Power System Reliability in the SWIS; and

(m) to carry out any other functions conferred, and perform any obligations imposed, on it under these WEM Rules.

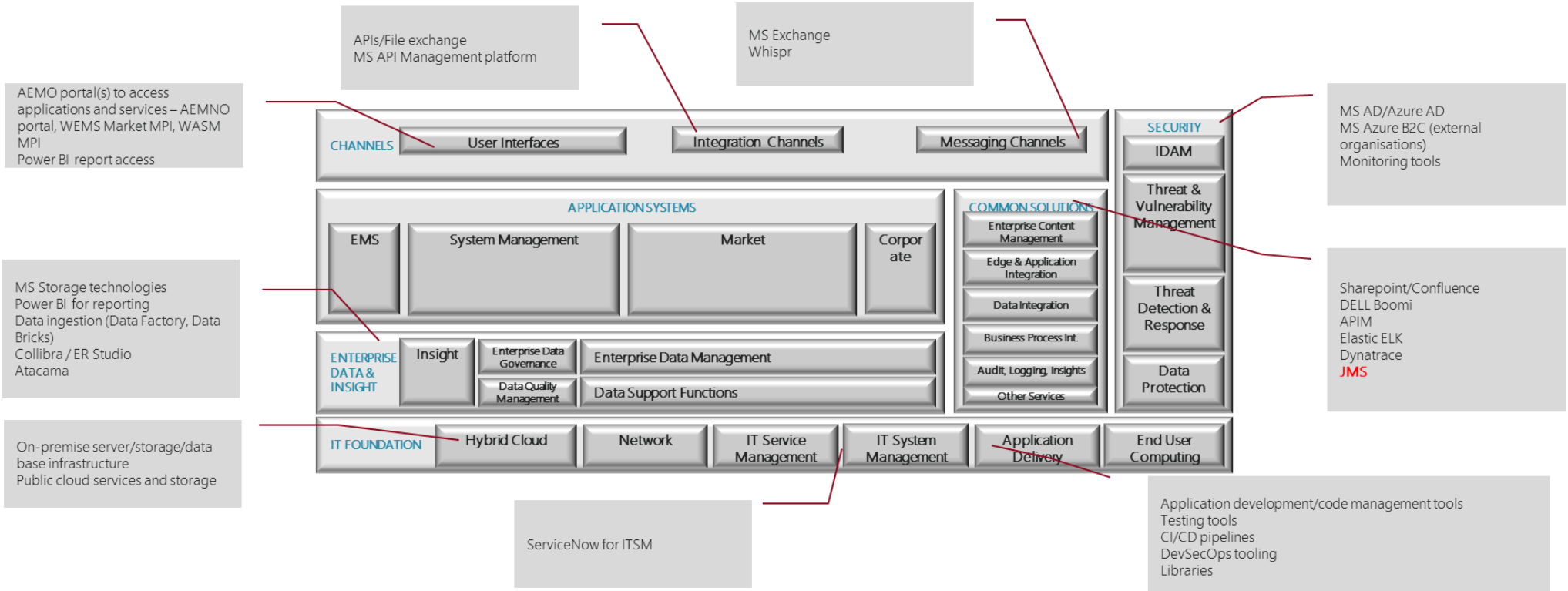
A2. WEM Reform Timeline



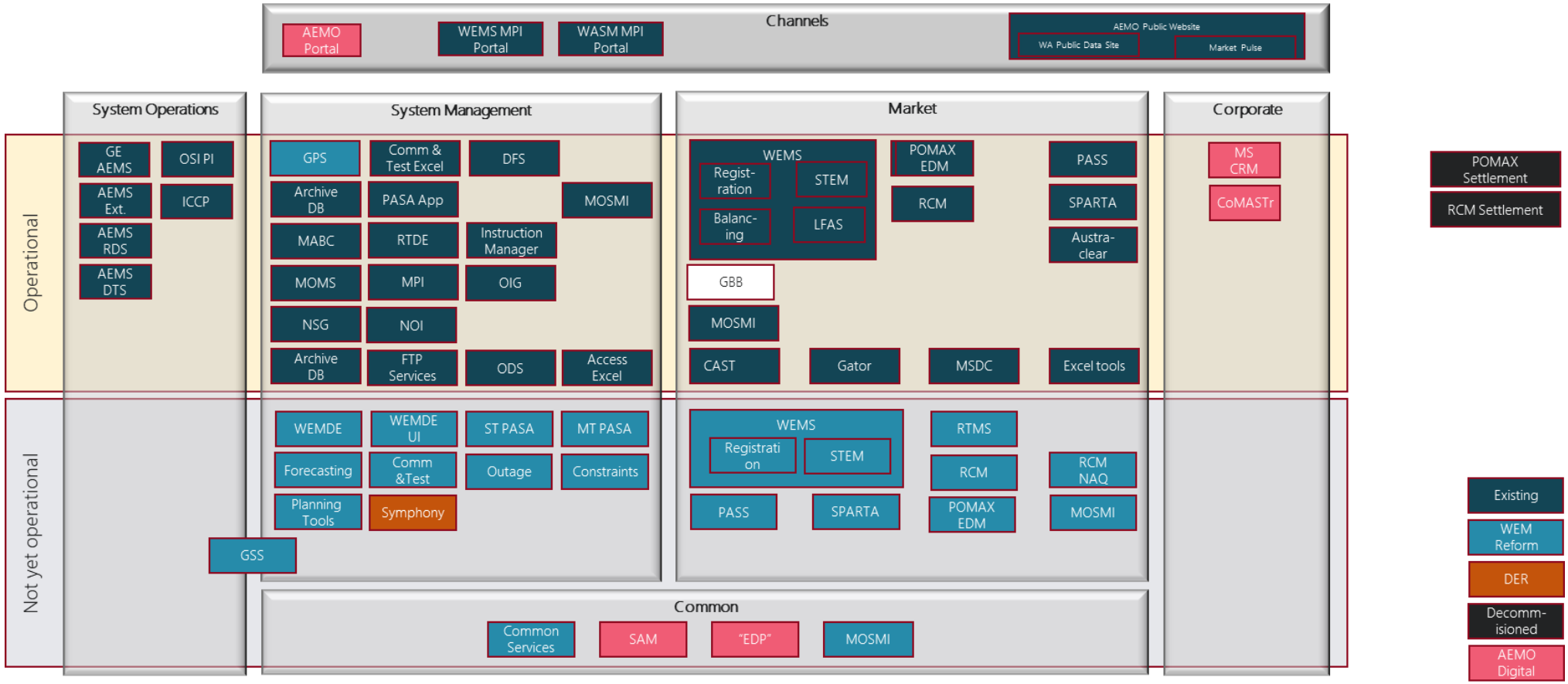
A3. Baseline Application Landscape



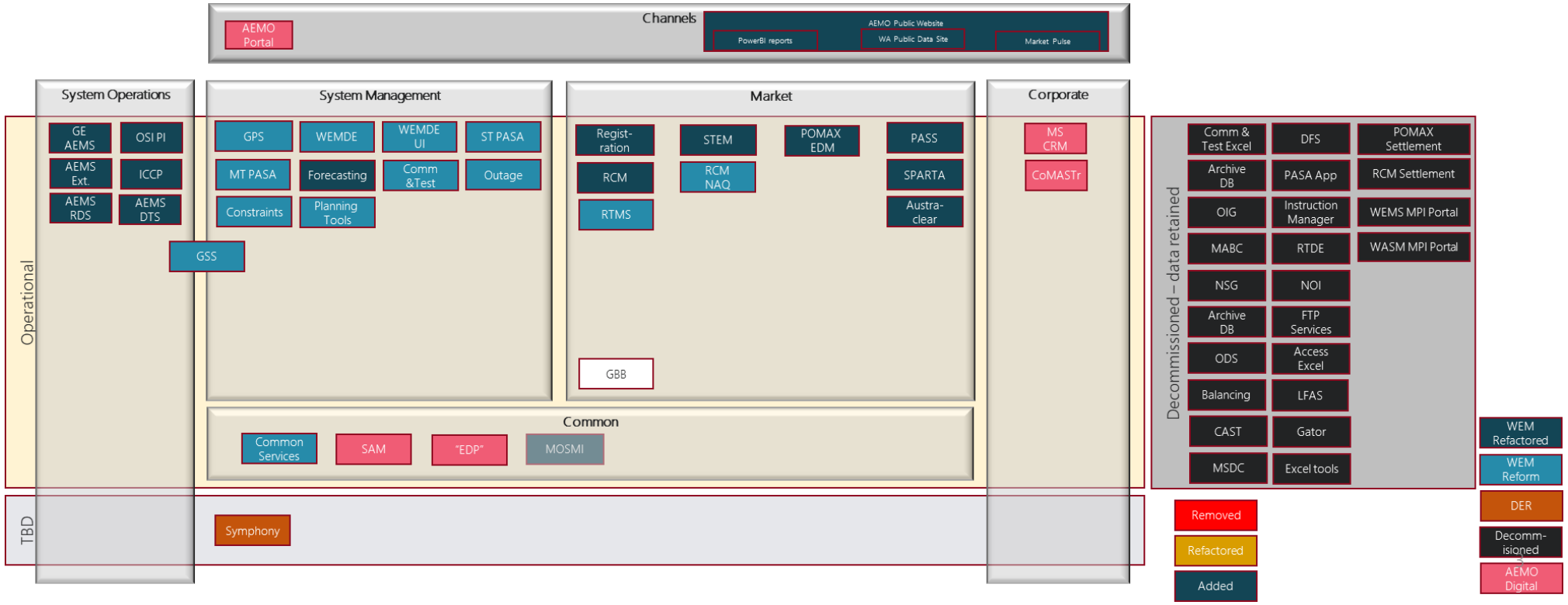
A4. Baseline Technology Landscape



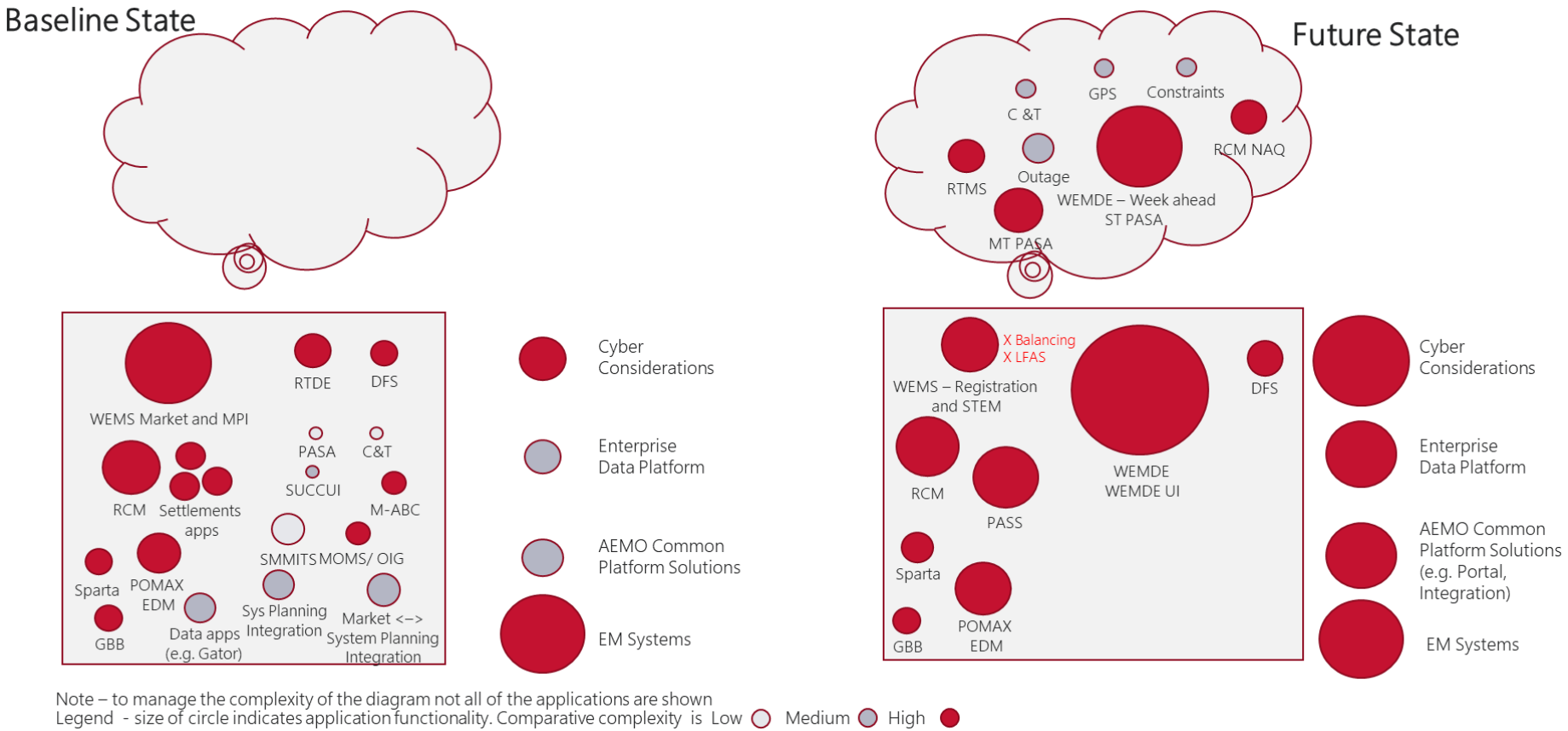
A5. Baseline WEM Reform Landscape



A6. Future Landscape



A7. Future State Complexity



Note – to manage the complexity of the diagram not all of the applications are shown
Legend - size of circle indicates application functionality. Comparative complexity is Low ○ Medium ◎ High ●

A8. Future Technology Landscape