Attachment 8.1

AA4 Forecast Capital Expenditure - REDACTED

Access Arrangement Information

Public

2 October 2017

westernpower

EDM#43664655

An appropriate citation for this paper is:

AA4 Forecast Capital Expenditure Report - REDACTED

Western Power

363 Wellington Street
Perth WA 6000
GPO Box L921 Perth WA 6842

T: 13 10 87 | Fax: 08 9225 2660
TTY 1800 13 13 51 | TIS 13 14 50

Electricity Networks Corporation
ABN 18 540 492 861

enquiry@westernpower.com.au
westernpower.com.au

Enquiries about this report should be directed to:

AA4 Project Team

Email: AA4@westernpower.com.au

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Abbreviations

The following table provides a list of abbreviations and acronyms used throughout this document. Defined terms are identified in this document by capitals.

Term	Definition
AA3	Third Access Arrangement Period
AA4	Fourth Access Arrangement Period
AA5	Fifth Access Arrangement Period
AAI	Access Arrangement Information
ACMA	Australian Communications and Media Authority
AIP	Asset Investment Planning
AMI	Advanced Metering Infrastructure
ARDS	Rules Engine
BESS	Building a Battery Energy Storage System
BTT1	Bus Tie Transformer #1
BTT2	Bus Tie Transformer #2
BUCC	back-up control centre
Capex	Capital expenditure
CRAM	Cost and Revenue Allocation Methodology
CRM	Customer Relationship Management System
DMS	Distribution Management System
DSLMP	Dedicated Streetlight Metal Pole
EMS	Energy Management System
ERA	Economic Regulation Authority
ERP	Enterprise resource planning
EWP	Elevated Work Platforms
FESA	Fire and Emergency Services Authority
HIA	Housing Industry Australia
HV	High Voltage

Term	Definition
IAM	Investment Adjustment Mechanism
ICT	Information and Communications Technology
LiDAR	Light Detection and Ranging
LMC	Last Mile Communications
LV	Low Voltage
MRL	Mean Replacement Life
MWEP	Mid-West Energy Project
NFIT	New Facilities Investment Test
NMS	Network Management System
NPV	Net Present Value
NRMT	Network Risk Management Tool
PDH	Plesiochronous Digital Hierarchy
PTS	Power Training Services
PV	Photovoltaic
RAB	Regulated Asset Base
RET	Renewable Energy Target
RF	Radio Frequency
RMRA	Renewal and Maintenance Requirements Analysis
RMUs	Ring Main Units
SCADA	Supervisory Control and Data Acquisition
SF	Sodium Hexaflouride
SPIDA	Spatial Display and Analysis
SSAM	Service Standard Adjustment Mechanism
SSBs	Service Standard Benchmarks
SSTs	Service Standard Targets
Supply Code	Electricity Industry (Network Quality and Reliability of Supply) Code 2005
SUPP	State Underground Power Program
SVC	Static VAr Compensators

Term	Definition
SWIS	South West Interconnected System
TRDA	Targeted Reliability Driven Automation
WP	Western Power
XLPE	Cross-Linked Polyethylene

1. Introduction

1. The purpose of this report is to provide further detail regarding Western Power's capital expenditure (**capex**) forecast for the fourth access arrangement period (**AA4**). This document is attached to, and should be read in conjunction with, the main access arrangement information (**AAI**) document.

2. This report provides information on:

   - the drivers for investment
   - the risk based asset management approach
   - forecast expenditure by regulatory category for the AA4 period.

3. Unless otherwise stated, all capex amounts in this report are presented in real dollars at 30 June 2017, excluding forecast **labour cost escalation, and excluding indirect costs.**

4. The AA4 forecasts in this capex report are presented by the regulatory capex categories as required by section 4.4.1 of the Economic Regulation Authority (**ERA**) Guidelines for Access Arrangement Information. The forecast values in this report are presented as base capex – without labour cost escalation and indirect costs – as it allows for a more accurate comparison of expenditure in each regulatory category between the AA3 and AA4 periods.

5. The AAI capex chapter presents the capex forecast categorised by investment outcomes,[1] rather than by the regulatory expenditure categories. This is because the investment outcomes better represent how Western Power actually develops its capex program and manages the network. As a result, some values in this capex report may vary slightly from those presented in the AAI capex chapter. The forecast values in the AAI capex chapter also include labour cost escalation and capitalised indirect costs.

6. Calculation of labour escalation and indirect cost forecasts is discussed in Chapter 8 of the AAI (forecast operating expenditure).

1.1 Summary of forecast capex

7. During the AA4 period, Western Power will invest total capex of $4,394 million including labour cost escalation and indirect costs. This is comprised of:

   - $3,720 million of base capex (direct costs)
   - $48 million labour escalation
   - $626 million of indirect costs

8. As discussed above, this report details the $3,720 million of base capex only, separated by regulatory expenditure category.

9. Western Power will invest $3,720 million of capital to deliver covered services. Of this, approximately $793 million will be recovered directly from customers in the form of either capital contributions or gifted assets. We forecast $2,926 million will be added to the regulated asset base (**RAB**) and recovered through reference tariffs.

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1 Investment outcomes are: maintain safety, maintain service performance, meet growth, satisfy compliance, and improve efficiency of operations.

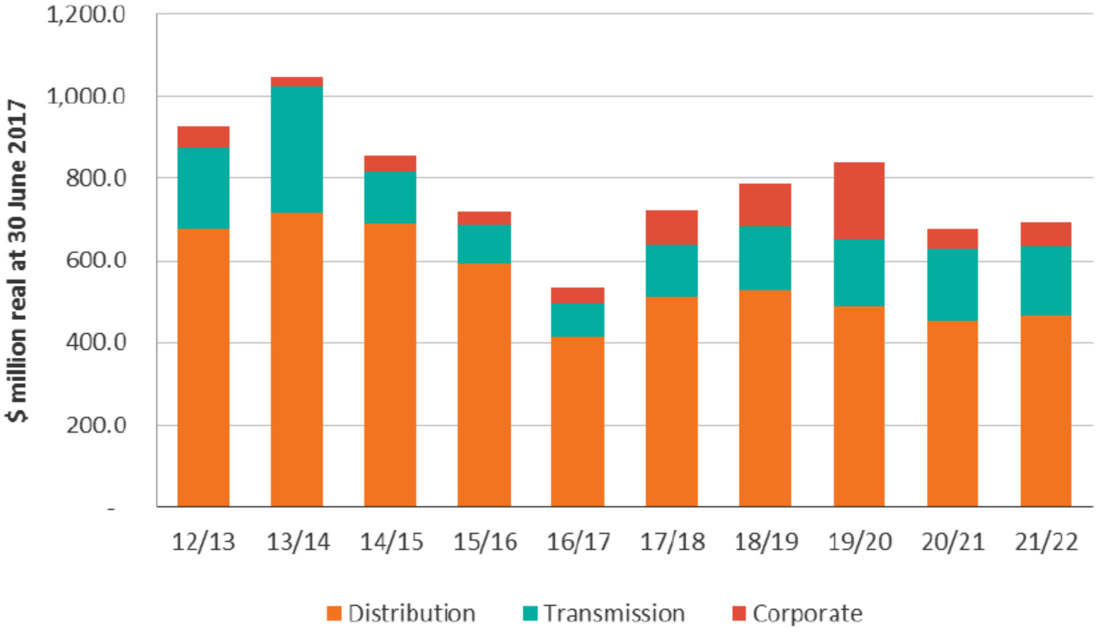
10. Table 1.1 summarises the total AA4 capex forecast, split between investment in the transmission network, the distribution network, and corporate support.

Table 1.1: AA4 forecast capex summary, $ million real at 30 June 2017[2]

Expenditure category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP[3] gross capex
Transmission capex	123.5	157.2	162.5	173.0	168.0	784.2	21%
Distribution capex	513.0	528.2	487.3	454.2	465.5	2,448.3	66%
Corporate capex	84.4	101.5	190.8	51.6	58.7	487.1	13%
Gross capex	**720.9**	**787.0**	**840.7**	**678.8**	**692.2**	**3,719.6**	**100%**
Less contributions	161.0	175.5	158.4	147.1	151.4	793.4	
AA4 capex to be added to the RAB	**559.9**	**611.4**	**682.3**	**531.7**	**540.8**	**2,926.1**	

11. Figure 1.1 shows how AA4 forecast capex compares with that incurred during the AA3 period.

Figure 1.1: Comparison of AA4 forecast and AA3 actual gross capex[4]



2 Excluding forecast labour cost escalation

3 Western Power (**WP**)

4 Excluding forecast labour cost escalation

12. Forecast capex by regulatory capital expenditure category is provided in section 1.2 below.

1.1.1 Regulatory capital expenditure categories

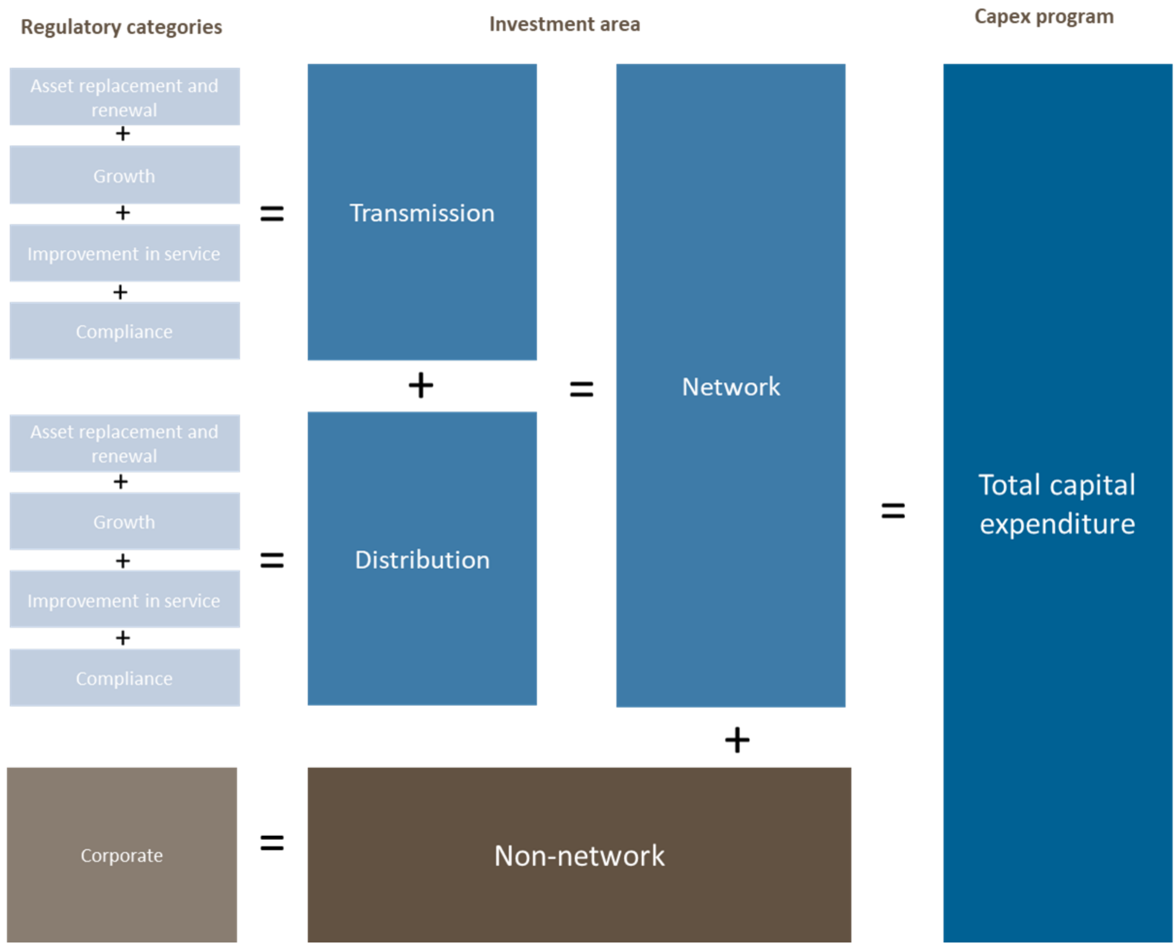
13. Western Power is required by the ERA's Access Arrangement Information Guidelines to present its capex forecasts in discrete regulatory categories. Distribution and transmission projects are grouped into activities and then grouped by sub-category into the four regulatory network expenditure categories:

- asset replacement and renewal
- growth
- improvement in service
- compliance.

14. Western Power also incurs non-network expenditure, which is captured in the corporate regulatory expenditure category. The corporate expenditure category is then separated into Information and Communications Technology (**ICT**) and business support. ICT covers investment in IT assets and infrastructure with business support capex including property and fleet.

15. Western Power's regulatory capex categories are illustrated in Figure 1.2.

Figure 1.2: Regulatory capital expenditure categories



16. The capex forecast provided in this report is essentially the forecast developed for Western Power's 2018/19 version of its 10-Year Business Plan, re-cut by the ERA's required expenditure categories.

17. The following sections describe the drivers for investment in each of the regulatory expenditure categories.

1.1.1.1 Asset replacement and renewal capex drivers

18. Expenditure in this category is driven by the need to maintain network safety, security and reliability. The key factors influencing this are asset condition and risk.

19. Western Power's Network Strategy determines the asset management strategies that guide investment. These asset management strategies define the management plans for each asset type and, ultimately, determine the forecast levels of replacement. Detailed asset management plans have been established for each class of asset on the Western Power Network. All asset classes are continually assessed to ensure the security of the transmission and distribution networks.

20. Risk assessment is incorporated into asset management plans using Western Power's suite of network risk management tools. Our risk based renewal approach matured over the course of the AA3 period, particularly in relation to the management of our distribution assets.

21. The cost of broad asset replacement programs (such as distribution conductors or metering) are estimated using standard unit rates and forecast replacement volumes. Standalone projects are forecast using a cost build-up approach based on similar projects that have been delivered in the past.

22. Standard unit rates are formulated using detailed cost structures and established work practices. We have developed cost structures by breaking down every field work task into units of labour, fleet, contractor and materials. These units are based on current work practices, labour, fleet and material costs, and include negotiated contractor rates.

23. Major transmission network replacement projects are outsourced via competitive tender, with forecast costs developed using a bottom-up build. Minor projects are forecast on a standalone project basis using standard estimating tools and historical trends.

1.1.1.2 Growth capex drivers

24. Expenditure in this category is primarily driven by energy demand and customer growth forecasts. Load forecasts for each zone and distribution substation are prepared based on energy demand and customer numbers. The disaggregation of growth forecast to distribution substation means investment can be targeted to parts of the network that are growing, even if average demand across the entire network is flat. As a result, growth (and augmentation) capex is typically one of the largest categories of network capex even during periods of flat demand growth or declined average consumption.

25. Customer driven transmission projects, for example connection of generators or large loads, also have a major influence on growth capex. Transmission projects generally require detailed analysis and substantiation both from a timing and cost perspective. We develop customer driven capex forecasts using a cost-build up based on current unit rates and comparisons to similar projects. We also consider current and expected upcoming technical issues[5] facing the transmission network, including voltage and thermal management due to customer growth, and incorporate the impact of these issues into forecast expenditure profiles.

26. When assessing upgrades to distribution substations and feeders, we consider average demand profiles and map these against specific areas of the network. This allows us to identify parts of the network that are

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5 Current and expected issues are outlined in the Network Development Plan, which is updated annually.

experiencing growth, and ensure investment is appropriately targeted. Feeder loadings are also impacted by changing demand patterns, which we factor into investment plans.

27. Expenditure relating to distribution network customer connections also falls into the growth category. Western Power's Contributions Policy is the overarching document that establishes the nature of the connection services we offer and the charges that may apply for those services. The forecasting methodology for customer connections varies by segment:

- residential and sub division connections are forecast using a combination of Housing Industry Australia (**HIA**) forecasts for new home starts, energy forecasts and historical trend analysis. The majority of residential connections are included in gifted assets by property developers, with the remaining based on forecast quantities and unit cost. Individual subdivision connections are based on a cost build-up estimating approach.
- minor commercial connections are forecast using historical trend analysis, taking into account actual costs of similar recent projects.
- major commercial connections are forecast using unit costs from projects with similar scope.

1.1.1.3 Improvement in service capex drivers

28. This expenditure category is driven by Western Power's obligation to achieve the specific service standards defined in the access arrangement. The access arrangement contains:

- a series of minimum service standards (known as service standard benchmarks (**SSBs)**) that Western Power must achieve in providing services
- service standard adjustment mechanism (**SSAM**) that contains a series of service standard targets (**SSTs**), which is set at a higher standard than the SSBs. The SSAM provides for a financial reward if Western Power exceeds the SSTs and a penalty if it falls below.

29. The SSBs and SSTs relate to aspects of service including transmission and distribution network reliability, call centre performance and streetlight repair times.

30. When developing improvement in service capex, Western Power considers the minimum amount of investment required to achieve the SSBs, and how much investment is required to then achieve the SSTs.

31. It should be noted that for the AA4 period Western Power proposes to maintain current levels of service, therefore there is no expenditure targeted at improving overall service levels. Instead, the SSTs are being set at a level consistent with maintaining today's level of service, and network investment is designed so that Western Power achieves the SSTs (rather than exceed or fall below the SSTs) such that the business receives no overall rewards or penalties[6] at the end of the AA4 period.

1.1.1.4 Compliance capex drivers

32. Expenditure in this category is driven by the cost required by Western Power to meet its licence requirements, safety and environmental obligations, and other legislative and regulatory obligations. Forecasts are based on achieving the lowest sustainable costs of maintaining current compliance levels,

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6 Western Power may qualify for rewards or penalties against individual SSTs during the course of the AA4 period, however, the overall investment program has been planned so the various penalties and rewards offset each other and Western Power remains revenue neutral come the AA5 period.

with expenditure increasing only where the business is non-compliant or is directed to do so by a relevant regulatory body.

33. Any new or amended compliance requirements that are not known at the time of making our AA4 proposal (for example, in the AA3 period this would have related to costs associated with the previous Government's Electricity Market Review), are treated as unforeseen events during the period, with opportunity to recover those costs in future access arrangement periods.

1.1.1.5 Corporate capex drivers

34. Corporate capex is forecast at a whole of network level and then allocated between the distribution and transmission networks using the methodology contained in the Cost and Revenue Allocation Methodology (**CRAM**). We use a bottom-up approach for each category of expenditure.

35. Asset replacement such as ICT, buildings and fleet are validated based on the forward works programs and employee numbers. Specific projects are validated individually according to the process outlined in Western Power's Investment Governance Framework.

1.1.1.5.1 Information technology

36. Expenditure must cover current technologies, be cost efficient and be in line with customer requirements. Western Power's ICT Strategy establishes the business requirements for ICT equipment and services.

37. Asset replacement is based on a life-cycle management approach to maximise utilisation and minimise cost. Specifically, ICT assets are replaced or upgraded when:

- the likelihood and consequence of failure becomes intolerable
- support costs exceed replacement costs
- unacceptable cyber risks arise from expiry of vendor support.

38. Systems reaching the end of their useful life are assessed and either replaced or upgraded to improve operational efficiency and maintain vendor support.

39. Investment in any new technology must be subject to a cost benefit analysis and net present value (**NPV**) assessment. Competitive tendering is used in the supply of hardware, software and service provision.

1.1.1.5.2 Business support

40. Business support capex incorporates the cost of Western Power's property and fleet. Property capex generally incorporates:

- leasehold improvements
- security upgrades
- property plant and equipment purchases
- compliance with regulatory requirements.

41. Historical trends and forward-looking costs are used to inform property investment. The network capital works program and associated workforce movements are key inputs.

42. Property is acquired through market purchases, and new facilities are designed and costed via a market driven tender process. Property expenditure is supported by detailed business cases, which include cost benefit analysis.

43. Capex on fleet follows the same governance process as property capex.

1.2 Capex forecast for the AA4 period

44. This section provides a breakdown of forecast capex by regulatory expenditure category.

45. Western Power will invest $3,720 million of capital (including capital contributions) to deliver covered services during the AA4 period. Overall AA4 period investment will be below that undertaken during the AA3 period, with total forecast capex being around $362 million (nine per cent) less than during the AA3 period.

46. The $3,720 million is base expenditure, meaning it does not include labour cost escalation or capitalised indirect costs. Labour cost escalation is estimated at $48 million, and capitalised indirect costs at $626 million.

47. The profile of the investment program has changed significantly to that proposed for the AA3 period. We propose lower levels of expenditure on asset replacement and growth, and greater investment in ICT systems, and operating facilities designed to support more efficient delivery of the capital works program.

48. Table 1.2 summarises total AA4 period forecast capex by regulatory category.

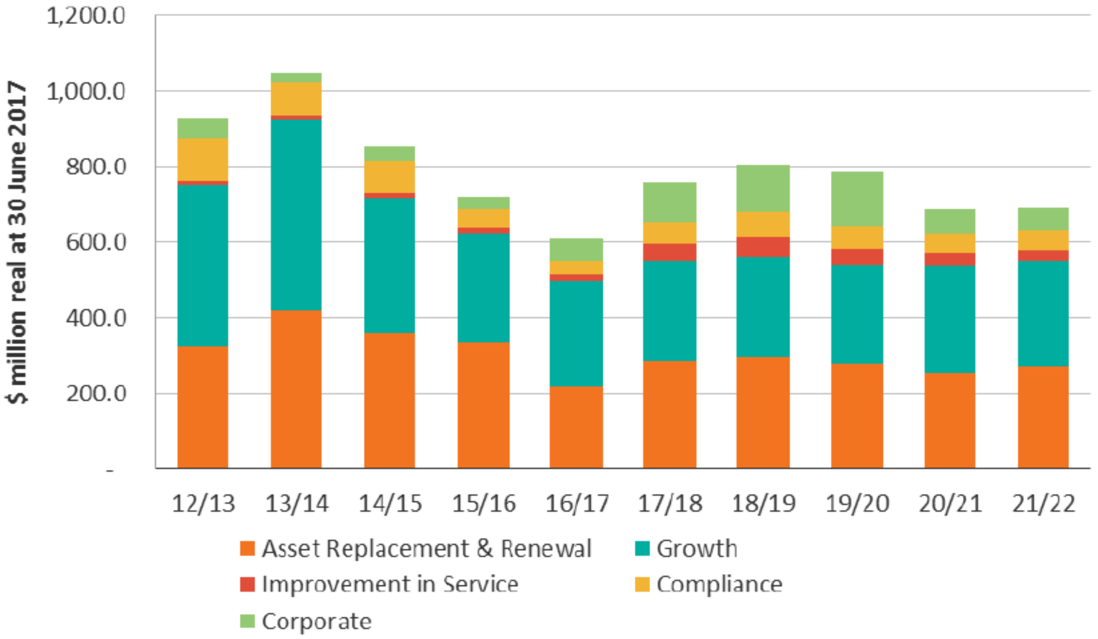
Table 1.2: AA4 forecast capex by regulatory category, $ million real, 30 June 2017[7]

Capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Asset replacement and renewal	286.3	298.3	276.1	253.5	270.5	1,384.6	37.2%
Growth	260.2	268.6	265.5	284.5	279.9	1,358.7	36.5%
Improvement in service	34.6	48.7	38.8	34.0	27.9	183.9	4.9%
Compliance	55.5	69.8	69.5	55.2	55.2	305.2	8.2%
Corporate	84.4	101.5	190.8	51.6	58.7	487.1	13.1%
Gross capex	**720.9**	**787.0**	**840.7**	**678.8**	**692.2**	**3,719.6**	**100.0%**
Less contributions	161.0	175.5	158.4	147.1	151.4	793.4	
AA4 capex to be added to the RAB	**559.9**	**611.4**	**682.3**	**531.7**	**540.8**	**2,926.1**	

49. Figure 1.3 shows how forecast AA4 period capex compares with historical levels.

7 Excluding forecast labour cost escalation.

Figure 1.3: Comparison of AA4 forecast and AA3 actual gross capex by regulatory category[8]



50. The following sections summarise capex by investment area (transmission / distribution / corporate) and by regulatory category.

1.2.1 Transmission network capex

51. Western Power will invest $784 million of capital in the transmission network (including capital contributions) during the AA4 period (see Table 1.3).

Table 1.3: AA4 forecast transmission capex by regulatory category, $ million real at 30 June 2017[9]

Transmission capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Asset replacement and renewal	35.1	58.9	48.0	47.4	55.8	245.2	6.6%
Growth	44.2	44.9	57.4	78.1	69.4	294.1	7.9%
Improvement in service	11.5	19.7	22.8	20.2	15.6	89.9	2.4%
Compliance	32.6	33.7	34.2	27.2	27.2	155.0	4.2%
Gross transmission capex	**123.5**	**157.2**	**162.5**	**173.0**	**168.0**	**784.2**	**21.1%**
Less contributions	10.7	10.7	10.7	10.7	10.7	53.3	

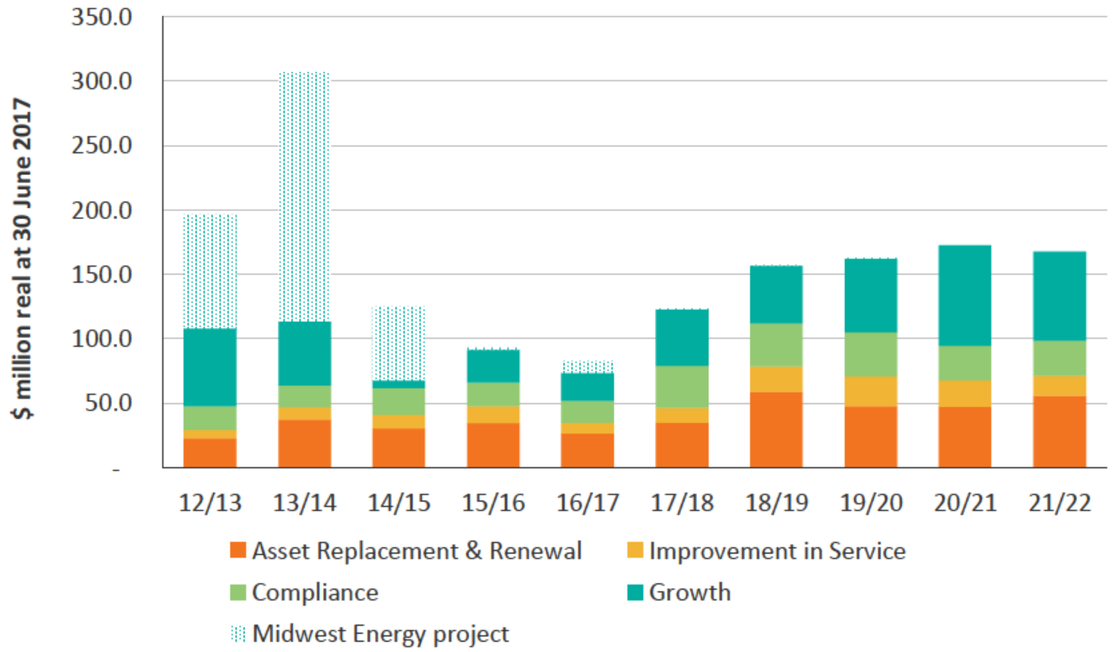
8 Excluding forecast labour cost escalation.

9 Excluding forecast labour cost escalation.

Transmission capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
AA4 transmission capex to be added to the RAB	**112.8**	**146.6**	**151.9**	**162.3**	**157.3**	**730.9**	

52. Figure 1.4 shows how AA4 period forecast transmission capex compares with that incurred during the AA3 period.

Figure 1.4: Comparison of AA4 forecast and AA3 actual transmission gross capex by regulatory category, $ million real at 30 June 2017[10]



53. Forecast transmission capex for the AA4 period is $21 million (three per cent) less than that incurred during the AA3 period. While overall forecast transmission capex is a similar level to that incurred during the AA3 period, the mix of capex projects is substantially different.

54. During the AA3 period, growth-related capex accounted for around 64 per cent of total transmission capex, with the Mid West Energy Project (**MWEP**) stage 1 southern section accounting for 68 per cent of growth-related transmission capex.

55. In addition, levels of transmission asset replacement during the AA3 period were lower than originally forecast (and lower than those forecast for the AA4 period). This is due to the limitations placed on the network as a result of two major transformer failures at Muja.

10 Excluding forecast labour cost escalation.

56. In February 2014 the Bus Tie Transformer #2 (**BTT2**) at Muja failed, causing significant disruption to customers, and also to the forward works program. The Muja Bus Tie Transformer #1 (**BTT1**) had also failed in 2012. This second failure, in less than two years, highlighted the issues facing the network.

57. The BTT2 failure and resulting network security issues meant much of the southern part of the Western Power Network was no longer switchable[11], therefore planned asset replacement could no longer go ahead. The BTT1 and BTT2 issues have now been addressed, and transmission asset replacement programs can recommence, hence the relative increase in transmission asset replacement proposed for the AA4 period.

58. As the MWEP project is now complete (there are currently no plans to commence MWEP stage 1 northern section during the AA4 period), and the bus tie transformer issues have been addressed, this means the transmission capex program for the AA4 period comprises a more even mixture of asset replacement and growth-related investment.

59. Customers are therefore benefitting from a broader range and higher volume of transmission projects, all for around the same overall cost. Put simply, during the AA4 period Western Power proposes customers will get more value for money.

60. The AA4 transmission capex forecast benefits from optimised asset replacement and capacity expansion planning methodologies. These methodologies have been developed over the course of the AA3 period as we have gathered more information about our assets, and greater insight into forecast demand and customer expectations.

1.2.1.1 Developing the transmission asset replacement forecast

61. For asset replacement capex, Western Power has improved its risk based asset renewal approach drawing from improved asset data, and greater insight into failure modes and consequences gained over the AA3 period. We apply our Renewal and Maintenance Requirements Analysis (**RMRA**) standard to all transmission and distribution assets. The steps of the RMRA (shown in Figure 1.5) are:

    1. functional definition
    2. asset ageing analysis
    3. renewal/maintenance decision analysis
    4. asset class strategy
    5. bundling optimisation.

62. Following these five steps during the course of investment planning, helps identify the most prudent and efficient asset treatment, and supports the efficiency of the forward investment program. Further details on the RMRA standard is provided in Western Power's Network Management Plan and its RMRA standard document.

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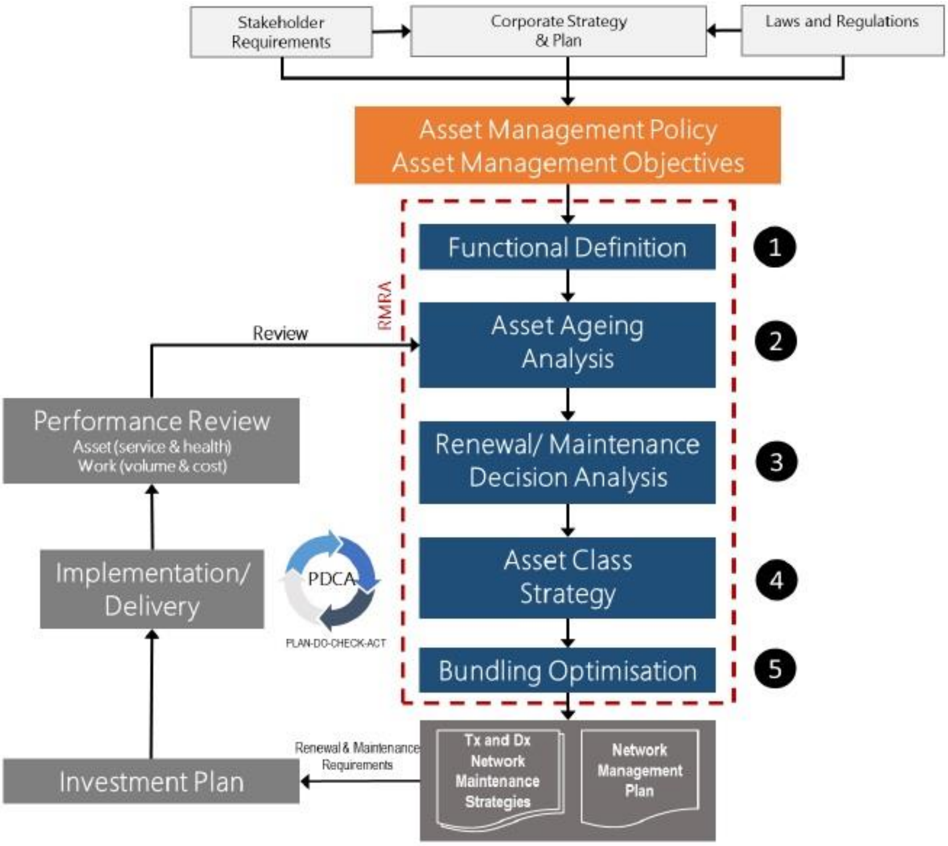
11 The ability to re-route electricity to alternative circuits so planned work can commence on specific parts of the network.

Figure 1.5: Renewal and Maintenance Requirements Analysis standard



63. Once asset treatments have been identified, the required renewal and maintenance activities across asset classes are reviewed to see where the works program can be optimised. The optimisation process for asset renewal includes:

- identification of opportunities for optimisation
- completion of risk reduction benefit assessments
- review of outputs from condition assessments for impacted in-service assets
- cost analysis to identify the lowest cost option

64. We consider alternative approaches such as building higher capacity assets at the same location (upgrade), decommissioning existing assets, building new substations and transferring loads to neighbouring substations.

65. This optimised asset renewal approach also applies to forecast capex in the 'improvement in service' and 'compliance' regulatory expenditure categories. Asset renewal optimisation is discussed further in Western Power's Network Management Plan.

66. As a result of the more mature growth and asset replacement planning methodologies being applied to investment, the transmission capex forecast for the AA4 period represents the lowest efficient cost of maintaining network safety and reliability, meeting growth, satisfying compliance requirements, and improving operational efficiency.

67. Forecast transmission capex by regulatory expenditure category is provided in the following sections.

1.2.1.2 Developing the transmission growth capex forecast

68. For growth-related investment, Western Power uses a risk based planning methodology, which apportions the cost of reliability to any lost load resulting from critical transformer outages at zone substations. Further, rather than assessing zone substations solely on capacity issues, we look at other issues (security, compliance, options for load transfer) and prioritise the risk accordingly.

69. Western Power adopts a bottom-up approach in identifying the current and emerging network limitations relating to forecast demand, security, reliability, power quality, customer and compliance drivers. Using peak demand forecasts, we conduct power system studies across a range of sensitivities and consider the most likely generation planting scenarios. Feasible network and non-network options are then developed.

70. We consider the trade-off between capex and operational expenditure (**opex**) measures to manage network risk. Where network risk is very low, preference can be given to operational measures over augmentation expenditure.

71. An important aspect of the risk based planning process is optimisation. Individual investment decisions are not assessed in isolation. Network optimisation is performed across various stages of the annual planning cycle to ensure we optimise network topology to meet the existing and future capacity needs.

72. Although network optimisation occurs across a range of network investment drivers, combining asset condition drivers typically provides the greatest optimisation opportunities. In transmission networks, substation power transformers and indoor switchboards are typically bulky, expensive, and have long lead times. This can present opportunities to optimise replacement plans with network demand drivers.

73. Once the optimised network plans are developed, Western Power's resource and delivery function assesses the feasibility of delivering the portfolio or projects in conjunction with other programs of works. Workforce capacity and project timings are all taken into consideration to prioritise activities and promote efficient delivery of all network plans.

74. This risk based growth planning methodology allows us to better understand and quantify the risk of outages, and then apply the most appropriate course of treatment. For example, during the AA3 period we identified that the Mandurah Substation, Picton and North Fremantle transformers required replacement/upgrade to accommodate load growth in the area and mitigate network security risks. By adopting our risk based planning approach, we looked at how we could address the risk by re-shaping the network rather than doing a like-for-like asset replacement. We were able reconfigure the network and transfer the load to Cottesloe, deferring the need to upgrade the North Fremantle transformers while still addressing the network risk.

75. Demand management strategies are also incorporated into growth planning where possible. This was applied successfully in Mandurah, where customer load management was used to defer a significant network investment.

76. This optimised risk planning approach is now applied as part of our business as usual network investment practices and underpins the AA4 transmission (and distribution) growth-related forecast. Western Power's network planning approach for growth-related capex, including an overview of the current and emerging network capacity issues, is discussed in the Network Development Plan.

1.2.1.3 Transmission asset replacement and renewal capex

77. During the AA4 period, around 62 per cent of forecast transmission capex is not related to growth. The largest non-growth transmission capex category is asset replacement. This category covers expenditure on

replacing poor condition or outdated transmission network assets, and is necessary to ensure the ongoing safety and security of the Western Power Network.

78. The main driver of replacement capex across the Western Power Network is risk, comprising safety, reliability and environmental considerations. However, customer requirements, cost, forecast demand, compliance and power quality issues are also influencing factors.

79. As discussed above, Western Power adopts a risk-based approach to asset renewal, whereby asset treatments are assigned based on an assessment of risk reduction per dollar spent. Asset data and knowledge of transmission assets has improved over the AA3 period, meaning we have been able to move away from age-based asset replacement and have a greater opportunity to optimise the replacement program.

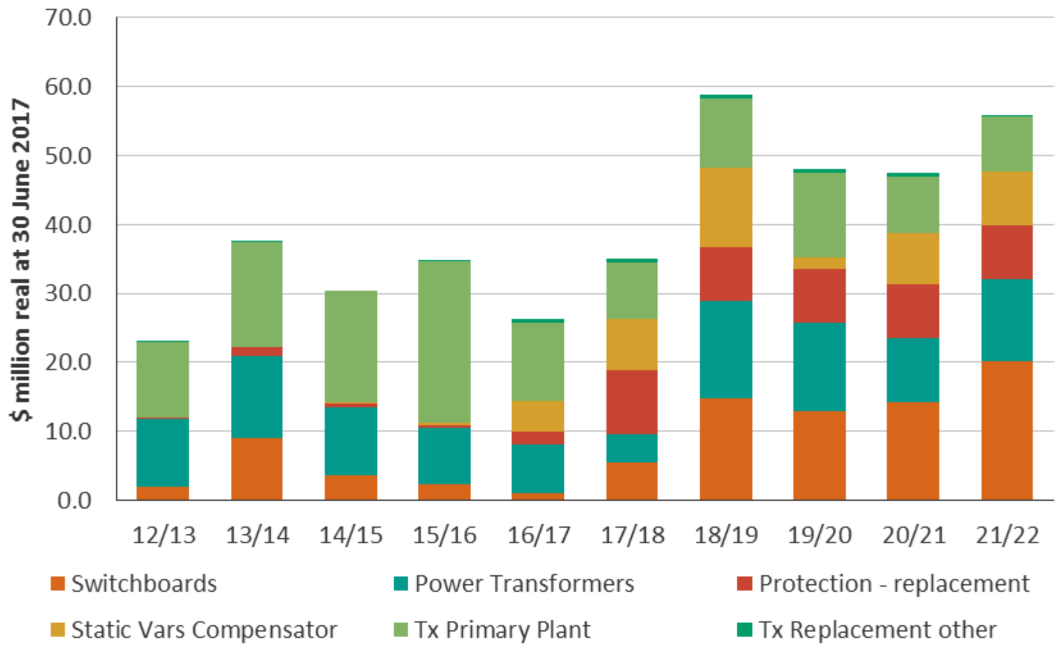
80. Optimisation activities include bundling renewal and maintenance activities across asset classes as set out in the RMRA standard discussed in section 1.2.1.1 above. There is also optimisation between different categories of investment such as growth, customer driven and compliance. Discussion of Western Power's optimisation process is provided in Chapter six of the Network Management Plan.

81. For the transmission network:

- investment in transmission lines is mostly for maintaining the integrity of the transmission structures. This is primarily driven by safety risks, but also has reliability impacts (for example due to pole top fires/ failure of Tx structures)
- investment in plant assets and secondary system assets is primarily driven by network reliability (and power quality) risks, and workforce safety risks
- all asset replacement investment improves the integrity of the network assets and therefore also contributes to maintaining the network reliability performance
- capital investment is predominantly targeted at voltages other than 66 kV, as most of the 66 kV network is planned to be gradually removed/ replaced by 132 kV.

82. Western Power will invest $245 million in transmission asset replacement during the AA4 period. This is $93 million more than during the AA3 period (see Figure 1.6).

Figure 1.6: Comparison of AA3 actual and AA4 forecast transmission asset replacement and renewal gross capex, $ million real at 30 June 2017[12]



83. The increase in transmission asset replacement capex compared to the AA3 period is due to three material increases:

- **switchboards** – several switchboards were originally scheduled for replacement during the AA3 period. However, replacement of these assets was postponed in the wake of the Muja Bus Tie transformer failures, as much of the network was not switchable and therefore these assets could not be accessed safely or without compromising network security. Western Power does not consider it prudent to defer replacement of these switchboards any longer. They must be replaced during the AA4 period, at a cost of $67 million
- **static VAr compensators (SVC)** – the condition of SVCs have deteriorated over the AA2 and AA3 period, therefore these assets are scheduled for replacement during the AA4 period. Two SVCs will be replaced, at a cost of $36 million. SVCs are an integral part of providing dynamic reactive power on the high voltage network. Failure to replace SVCs at the end of their life will jeopardise Western Power's ability to control the voltage, harmonics and stability of the transmission system
- **protection** – high replacement rates of protection systems is required during the AA4 period to help maintain network reliability and stability. Historically, spend on secondary systems has been low. However, the proposed decrease in primary plant asset replacement during the AA4 period means investment in protection is more critical. Forecast expenditure on protection replacement for the AA4 period is $40 million.

84. In contrast to the transmission assets listed above, transmission overhead conductor is in relatively good condition. The number of unassisted failures is currently averaging one per year and, as at 30 June 2016,

12 Excluding forecast labour cost escalation.

there were no overhead transmission conductors beyond their mean replacement life. Transmission conductor failure poses a lower risk to public safety than distribution overhead conductor.

85. The current impact of assisted and unassisted failures of the overhead conductors is within transmission network reliability targets,[13] therefore there is no capex forecast for proactive transmission overhead conductor replacement during the AA4 period. However, we will monitor ongoing asset condition and will review the transmission overhead conductor replacement requirements in our annual investment planning process. Table 1.4 shows transmission asset replacement capex for the AA4 period.

Table 1.4: AA4 forecast transmission asset replacement and renewal capex, $ million real at 30 June 2017[14]

Transmission asset replacement capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Switchboards	5.5	14.7	12.9	14.2	20.1	67.4	1.8%
Power transformers	4.1	14.2	12.8	9.3	12.0	52.4	1.4%
Protection - replacement	9.3	7.8	7.7	7.7	7.7	40.3	1.1%
Static Var Compensator	7.5	11.5	1.8	7.5	7.9	36.2	1.0%
Primary plant	8.1	10.2	12.3	8.2	8.0	46.8	1.3%
Replacement other	0.7	0.5	0.5	0.5	0.1	2.2	0.1%
Gross asset replacement capex	**35.1**	**58.9**	**48.0**	**47.4**	**55.8**	**245.2**	**6.6%**
Less contributions	-	-	-	-	-	-	
AA4 transmission asset replacement capex to be added to the RAB	**35.1**	**58.9**	**48.0**	**47.4**	**55.8**	**245.2**	

86. Forecast investment in the transmission asset replacement subcategories is provided below.

87. All investments are only undertaken where section 6.52(b) (ii) of the Access Code is met. The Network Management Plan outlines the risk management practices that are in place to manage network assets to ensure the safety and reliability of the covered network.

88. Optimisation of asset replacement and competitive market forces in project tendering help minimise costs, consistent with the requirements of section 6.62(a) of the Access Code.

13 Refer to Western Power's Network Management Plan.

14 Excluding forecast labour cost escalation.

1.2.1.3.1 Switchboards

89. Western Power proposes to invest $67 million on replacing switchboards during the AA4 period. Forecast switchboard replacement in AA3 had to be deferred due to network access being severely restricted following the Muja transformer failures.

90. There are 137 switchboards located at zone substations across the network. Five of these switchboards (four per cent) are beyond their mean replacement life[15] (**MRL**). If replaced only on failure, the number of switchboards beyond their MRL is likely to increase to ten per cent by 30 June 2022 and 12 per cent by 30 June 2027. It should be noted that age is not the determining factor of risk for switchboards. Asset history, past performance and condition guide asset replacement and maintenance strategies are the main considerations in determining risk.

91. Many of the indoor circuit breakers within switchboards contain a large quantity of oil (bulk oil) and/or SF6[16] gas that have a potential for environmental and safety impacts. There are 11 substations containing 17 pitch filled switchboards deemed a risk of arc flash exposure. SF6 insulated circuit breakers aged between 15 to 30 years old are prone to SF6 leaks that pose environmental contamination and safety risk. Nine switchboards (two GEC and seven Yorkshire) are approaching their MRL and are no longer made or supported by their manufacturers. Western Power does not have adequate spare parts for repair or replacement to maintain these switchboards.

92. Western Power's strategy is to mitigate the risks due to failure of these assets based on their condition, criticality and maintainability. During the AA4 period, Western Power will:

- monitor the condition of switchboards via routing maintenance and repair/treat defects prioritised by risk
- replace 13 switchboards (11 pitch filled) and decommission seven switchboards (five pitch filled)
- purchase one spare mobile switchboard as a precaution in case any of the poor condition switchboards and/or those no longer supported by the manufacturer fail before they are replaced (switchboards have a long production lead-time).

93. Six of the proposed switchboard replacements were deferred from the AA3 period and will be prioritised for replacement.

1.2.1.3.2 Power transformers

94. Western Power proposes to invest $52 million on transformer replacement during the AA4 period.

95. The network has 342 in-service power transformers, 22 spare transformers and four rapid response transformers. Over five per cent of power transformers are beyond their MRL. If replaced only on failure, this will increase to 19 per cent by 30 June 2022 and 29 per cent by 30 June 2027. Approximately 51 per cent of the total power transformer population is designed with planning criteria N-1 or N-1-1, which provides redundancy and supply security to the network.

96. As of 30 June 2016, approximately 26 per cent of the total in-service power transformer population is identified as being in either bad or poor condition. The majority of asset condition issues relate to bushing,

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15 Mean replacement life – reflects the average age at which assets in the population will require replacement.

16 SF6 – Sodium Hexafluoride. Compressed SF6 is used to assist in the operation of circuit breakers.

moisture and tap changers. If remediation is not undertaken, the number of bad or poor condition transformers will increase to 47 per cent by 30 June 2022.

97. Power transformers have a medium impact on reliability or safety of the network but have significant impact on system security and compliance. Western Power's strategy is to mitigate the risks due to failure of these assets based on their condition. Where the condition has been assessed as bad or poor, we can either replace or refurbish the transformer if practical (and effective).

98. Though a number of transformers are nearing the end of their life, it is possible they will not fail during the AA4 period. However, a failure of one of these transformers would place part of the network at risk of suffering an outage of unacceptable duration. Rather than incurring costs to replace all transformers, we propose to mitigate this risk by procuring a strategic spare that will not be installed until a failure occurs. If a failure does occur, there may be an outage of limited duration until the spare is installed. We consider this will provide an appropriate trade-off between reliability and capital costs.

99. The strategic spare can remain uninstalled throughout the AA4 period without any degradation. After this period, if the other transformers continue to function, the intention is to install the strategic spare to enable the load on the other transformers to be reduced further extending the life of the remaining transformers.

1.2.1.3.3 Protection

100. Western Power proposes to invest $40 million in protection asset replacement during the AA4 period.

101. Protection assets consist of protection and control relays, fault recorders, operational metering, battery banks and AC systems in the substations. Failure of these components may result in inadequate protection and loss of control systems that can lead to increased safety risks, inability to maintain minimum network performance standards and loss of supply.

102. The Western Power Network contains 44,394 in-service protection and control relays. Over 36 per cent of protection and control relays are beyond their MRL. This is likely to increase to 50 per cent by 30 June 2022 and to 61 per cent by 30 June 2027 unless proactive replacement occurs. A large number of these relays are obsolete and lack manufacturer support.

103. Western Power's strategy is to prioritise replacement of relays according to their condition and obsolescence. There are 361 high risk protection relays (obsolete and condition based) on the 132 kV, 220 kV and 330 kV networks that are planned to be replaced during AA4.

104. Battery banks that are operating at less than 80 per cent of their nameplate rating are also targeted for replacement. Western Power will replace 35 during the AA4 period.

105. Western Power also proposes to replace one AC system per year to maintain the level of risk associated with AC systems.

1.2.1.3.4 Static VAr compensators

106. Western Power proposes to invest $36 million on replacing SVCs during the AA4 period.

107. There are three SVCs located at terminal stations in the Western Power Network. The Western Kalgoorlie and Merredin Terminal SVCs are critical assets in that their failure would represent a significant risk to Western Power's ability to deliver reliable power and power quality to customers in those areas. These assets have been rated under Western Power's condition based risk management system as being in bad

condition. The units are continuously leaking oil and produce a significant level of mechanical vibration during operation.

108. There were plans to commence replacing these assets towards the end of the AA3 period, however, work was deferred in the wake of the Muja Bus Tie transformer failures. Since then, we have conducted further analysis on the potential solution and have identified the following additional works that are required as part of the SVC asset replacement:

- an additional requirement for a line reactor
- additional site works
- increased communications requirement
- relay replacements, as part of an optimised program of asset condition works

109. The first SVC will be replaced in 2017/18 and the second in 2020/21. There is a third SVC on the Western Power Network that will need to be replaced in the future, however, this can be deferred until the fifth access arrangement (**AA5**) period. Replacement cost for the units have been estimated based on condition assessments, networking planning studies and historical actual costs.

1.2.1.3.5 Primary plant

110. Primary plant includes outdoor circuit breakers, instrument transformers, surge arrestors, disconnectors and earth switches. There are four separate asset classes each with their own profile, condition and strategy information.

111. During AA4 Western Power proposes to invest $47 million on primary plant replacement and renewal. This is 39 per cent less than incurred during the AA3 period. This level of expenditure is based on risk assessments of the individual asset classes that are categorised as primary plant.

Outdoor circuit breakers

112. The circuit breaker is a switching device capable of making, carrying and breaking currents in order to connect or disconnect circuits. Western Power has 1,587 outdoor circuit breakers installed in its transmission network. Outdoor circuit breakers are subject to environmental factors, which may result in moisture ingress, lightning damage, external interference, pollution and both heat and mechanical stress.

113. Visual inspections are conducted on a bimonthly basis to proactively identify faults with outdoor circuit breakers, which may result in safety concerns, reliability degradation and environmental performance.

Instrument transformers

114. Instrument transformers reproduce current and voltage from its primary high voltage circuit to a secondary low voltage (**LV**) circuit that allows the safe measurement of current and voltage present on the main conductor. Western Power's transmission network has 6,602 in service instrument transformers. Instrument transformers are subject to environmental as well as electrical and mechanical factors that cause degradation of the asset.

115. Our strategy is to repair or replace the instrument transformers based on asset condition. Instrument transformers are also replaced because of other asset programs such as capacity expansion projects, network reconfiguration projects and changes to customer requirements.

Surge arrestors

116. Surge arrestors are protection devices that limit voltage surges by diverting surge currents to ground thereby preventing the protected plant from over-voltages. Western Power has 2,312 surge arrestors in its transmission network. Surge arrestors are subject to pollutants, moisture ingress, mechanical stress, electrical surges, corrosion and external influences. Our strategy is to mitigate the risk of failure of these assets through routine inspection resulting is repair or replacement as required.

Disconnectors and earth switches

117. Disconnectors and earth switches are mechanical switches that provide isolation and earthing to unloaded and unfaulted equipment, circuits, plant and busbars. Western Power has 10,452 disconnectors and earth switches in the transmission network. These assets are subject to conditions such as corrosion, metal fatigue, high resistance joints leading to hotspots, overheating, mechanical breakdown and thermal expansion and contraction. Our strategy is to mitigate the risk of failure through routine inspection.

1.2.1.3.6 Other assets

118. Western Power conducts inspection and tests on the remaining reactive plant assets to allow for early repairs to be conducted on any identified defects. Typically, a single failure of these assets will not present an immediate risk to the reliability or power quality of the network. We minimise replacement capex by only replacing the units upon failure. The forecast cost of replacing these assets during AA4 has therefore been developed based on condition assessments and forecast in-service failures.

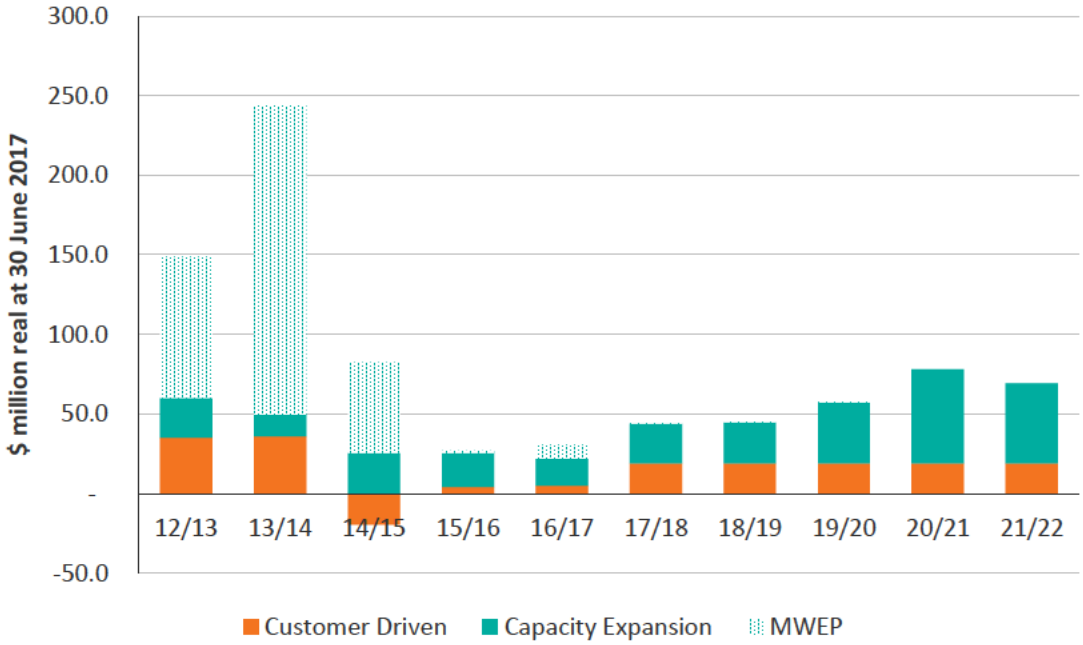
1.2.1.4 Transmission growth capex

119. Growth capex (both transmission and distribution) is typically one of the largest areas of investment for an energy network business. However, this category of expenditure is dependent on a range of external factors including peak demand, economic conditions, emerging technology and customer actions. As a result, actual growth capex can vary significantly from forecast if there are major shifts in any or all of these external factors (as was the case during the AA3 period).

120. We therefore propose transmission (and distribution) growth capex remains subject to the investment adjustment mechanism (**IAM**) during the AA4 period, as it was during the AA3 period. This will allow for revenue to be adjusted in the AA5 period for variances from forecast, and will ensure customers are no worse off as a result of changes in growth investment.

121. Western Power will invest $294 million in transmission growth projects during the AA4 period. This is $219 million (43 per cent) less than that incurred during the AA3 period (see Figure 1.7).

Figure 1.7: Comparison of AA4 forecast and AA3 actual transmission gross growth capex by expenditure sub-category,[17] $ million real at 30 June 2017[18]



122. Table 1.5 shows forecast transmission growth capex for the AA4 period.

Table 1.5: AA4 forecast transmission growth capex, $ million real at 30 June 2017[19]

Transmission growth capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Capacity expansion	25.4	26.0	38.6	59.3	50.6	199.8	5.4%
Customer driven	18.9	18.9	18.9	18.9	18.9	94.3	2.5%
Gross growth capex	**44.2**	**44.9**	**57.4**	**78.1**	**69.4**	**294.1**	**7.9%**
Less contributions	10.7	10.7	10.7	10.7	10.7	53.3	
AA4 transmission growth capex to be added to the RAB	**33.6**	**34.2**	**46.8**	**67.5**	**58.8**	**240.8**	

123. Transmission growth capex is split into two sub-categories:

17 The negative amount in 2014/15 reflects the transfer of ~$22 million from the customer driven expenditure category to capacity expansion on completion / buy back of the Three Springs terminal. As noted in the 2014/15 Regulatory Financial Statements provided to the ERA.

18 Excluding forecast labour cost escalation.

19 Excluding forecast labour cost escalation.

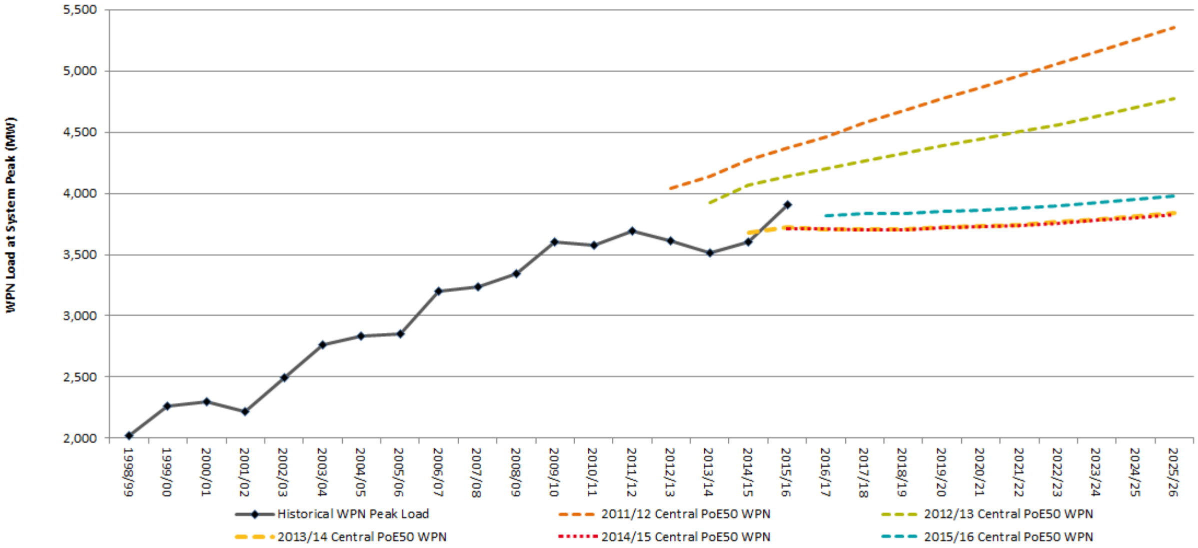
- transmission capacity expansion
- transmission customer driven projects.

124. These expenditure sub-categories are discussed below.

1.2.1.4.1 Transmission growth capex – capacity expansion

125. The main drivers of capacity expansion are forecast peak demand and customer numbers growth. Over the AA3 period, forecast growth did not materialise and peak demand growth rates have been substantially revised downwards each year since 2012 (see Figure 1.8).

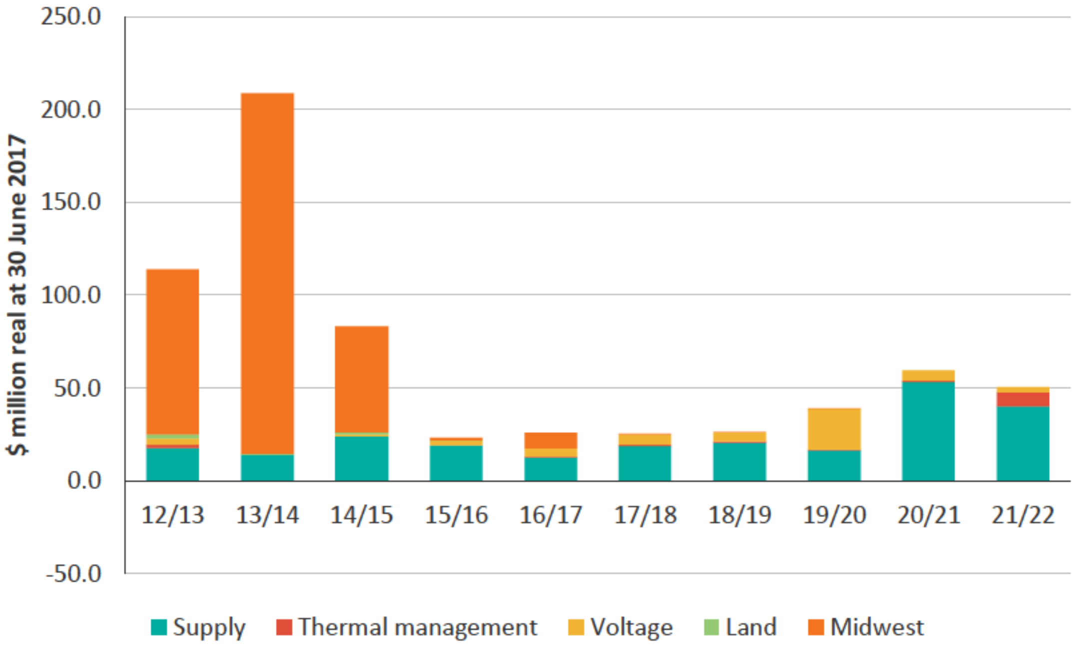
Figure 1.8: Peak demand growth projections 2012 to 2016



126. The flattening of peak demand growth in recent years is due to decreasing economic activity in Western Australia (particularly in the resources sector), the uptake of rooftop solar generation systems, improved efficiency of electrical appliances and changes in consumer behaviour. These falling projections mean less transmission capacity expansion investment is required in the AA4 period to meet peak demand than in previous periods. However, it should be noted that there are still parts of the network that require investment, for example the Perth CBD and Bunbury areas, both of which require new transformers during the AA4 period.

127. Forecast transmission capacity expansion expenditure during the AA4 period is $200 million. This is $253 million (56 per cent) less than what was incurred in the AA3 period (see Figure 1.9).

Figure 1.9: Comparison of AA3 actual and AA4 forecast transmission capacity expansion gross capex, $ million real at 30 June 2017[20]



128. The biggest contributor to the lower levels of transmission capacity expansion capex forecast during the AA4 period compared to the AA3 period is the completion of MWEP. The MWEP stage 1 (southern section) was completed in 2015/16, and accounted for 77 per cent of transmission capacity expansion capex during AA3. There are currently no plans to undertake MWEP stage 1 (northern section) or MWEP stage 2 (southern section) during the AA4 period, however, they are listed as contingent projects in the Network Development Plan.

129. Contingent projects are projects that are dependent on a specific event or set of circumstances before they will go ahead and expenditure is committed. The MWEP stage 1 northern section and stage 2 southern section are two examples. Both of these projects are expected to be delivered in the future, however, they will only be triggered when there is sufficient demand from generators or major loads in the Mid-West region.

130. For example, the triggers for MWEP stage 1 northern section are:

- connection of generators north of Three Springs Terminal, with the Mid-West region being highly suitable for wind and solar generation. Western Power expects growth in renewable generation will come from this area
- the proposed Oakajee port development north of Geraldton and supporting infrastructure – currently on hold, however, should this project proceed then the additional capacity required to service Oakajee will trigger the need for investment
- reliability issues due to the retirement of dispatchable generation north of Three Springs.

131. If one or more of these triggers occur, Western Power would need to commence the MWEP stage 1 northern section project, which would cost in the order of $123 million to $144 million. However, we do not currently expect these triggers to occur during the AA4 period, therefore no expenditure has been

20 Excluding forecast labour cost escalation.

included in target revenue in this AA4 proposal. If Western Power is required to deliver this, or any other contingent project during the AA4 period, an adjustment to target revenue for the AA5 period can be made under the IAM to recover the costs that meet the New Facilities Investment Test (**NFIT**).

132. A list of contingent projects identified for the AA4 period is provided in the Network Development Plan.

133. Our risk based planning methodology looks at apportionment of the cost of reliability to any lost load for critical transformer outages at zone substations. This has significantly reduced the number of transformers recommended for capacity expansion, and has allowed deferral of major investment.

134. For example, Nedlands substation was during the AA3 period identified as needing significant augmentation to meet load growth requirements. A like-for-like replacement would cost an estimated $40 million. However, using our recently developed risk based planning approach, we have been able to draw on new and more integrated network information, and have revised our plans. We will now apply a solution whereby load is transferred to adjacent substations at a much lower cost.

135. We have also deferred significant line augmentation projects by using computerised modelling. Our planning approach for AA4 means only around one in 10 transformers proposed for treatment are being replaced like-for-like.

136. Table 1.6 shows the AA4 period forecast transmission capacity expansion capex.

Table 1.6: AA4 forecast transmission capacity expansion capex, $ million real at 30 June 2017[21]

Transmission capacity expansion capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
MWEP	0.3	0.1	0.0	0.0	0.0	0.4	0.0%
Supply	18.8	20.5	16.3	53.3	40.1	149.1	4.0%
Thermal management	0.7	0.5	0.4	0.6	7.7	9.8	0.3%
Voltage	5.5	5.0	21.8	5.4	2.8	40.5	1.1%
Gross capacity expansion capex	**25.4**	**26.0**	**38.6**	**59.3**	**50.6**	**199.8**	**5.4%**
Less contributions	-	-	-	-	-	-	
AA4 transmission capacity expansion capex to be added to the RAB	**25.4**	**26.0**	**38.6**	**59.3**	**50.6**	**199.8**	

137. Despite the flat forecast for peak demand, we have identified growth in some areas, which will drive the transmission network investment over the next 10 years. For example, growth in the Mandurah, Rockingham, Bunbury and Busselton areas is higher than the network average, and these areas are expected to experience steady growth in peak demand. There are also increasing block load connections in the Eastern Goldfields. As a result, investment is required in these areas to ensure the transmission

21 Excluding forecast labour cost escalation.

network can satisfy forecast peak demand under plausible contingency conditions, while complying with the Technical Rules and maintaining safety.

138. We have also identified several areas of the network where a shortage in voltage support is expected within the next 10 years. Insufficient voltage support can lead to network damage or damage to customers' equipment, and can also lead to widespread outages and non-compliance with Technical Rules requirements. Therefore, a number of projects are proposed for the AA4 period that are designed to maintain adequate network voltages and ensure maximum network fault levels do not exceed system plant or equipment ratings.

139. Consistent with customer feedback, Western Power aims to maintain current levels of reliability and security of supply, and will target investment to reduce the likelihood of outages in the poorest performing areas of the transmission network. Western Power's Network Development Plan outlines the current network risk and the projects that the business will undertake over the next 10 years to address transmission capacity issues.

140. It is important to note these capacity expansion forecasts are based on Western Power's 2016 customer number, energy consumption and peak demand forecasts, updated for changes resulting from 2017 updates. This is because the timing of Western Power's planning cycle means the 2017 forecasts were not available at the time of developing the capex program in this AA4 proposal.

141. These expenditure forecasts therefore do not factor in the impact of forthcoming closures of some of Synergy's generation fleet. We are currently working with Synergy and customers to understand the impact on the network from the Synergy generation retirements, and to ascertain whether additional network augmentation may be required.

142. We will update our transmission capacity expansion capex forecasts to reflect the generation retirements and Western Power's 2017 customer number and peak demand forecasts in our response to the ERA's draft decision.

143. Table 1.7 presents the key transmission capacity expansion projects to be undertaken during the AA4 period, and their estimated cost and start date.

Table 1.7: Summary of key AA4 transmission capacity expansion projects, $ million real at 30 June 2017

Project description	Estimated cost	Estimated timing
Install a new 132/11 kV CBD substation	62.2	TBC[22]
Install a 132 kV cable between Hay St substation and Milligan St substation	23.8	17/18 to 20/21
Construct a new 132kV line between Picton and Busselton	19.2	17/18 to 21/22
Install a third 132/22 kV transformer at Meadow Springs/ Install two x 66 132/22 kV transformers at Mandurah	14.4	17/18 to 21/22
Substation Distribution Energy Resources	12.5	17/18 to 21/22

22 A recent review of the 2017/19 load growth forecast suggests installation of the new CBD substation may be deferred to the AA5 period. However, it is likely some additional transmission and/or distribution works will be required in lieu of the new substation during the AA4 period. Therefore we have retained the CBD substation amount in the forecast amount in this proposal, and will revisit in our response to the draft decision by which time we will have more information.

Project description	Estimated cost	Estimated timing
Install a third Kemerton terminal transformer	12.0	18/19 to 21/22
Install a third 132/11 kV transformer at Rangeway substation and decommission Durlacher substation	9.4	17/18 to 21/22
Install dynamic line reactors on 132 kV transmission lines in Neerabup load area	7.7	19/20 to 21/22
Install a fourth 132/22 kV transformer at Bunbury Harbour	6.6	20/21 to 21/22
Install a third transformer at Black Flag Substation	5.6	19/20 to 21/22
Decommission Coolup substation	5.0	17/18 to 20/21
Decommission existing 66 kV Shenton Park and Herdsman substations	3.9	17/18 to 19/20
Install Statcom at Albany substation	3.2	17/18 to 20/21
Mandurah to Pinjarra 132 kV: Resolve overloading stage 1 & 2/Rebuild Mandurah to Pinjarra 132 kV as a double circuit	0.7	17/18 to 19/20
Rebuild the Mandurah to Pinjarra 132 kV single circuit to a 132 kV double circuit (Mandurah load area)	0.6	21/22

144. The impact of these projects not going ahead includes:

- the inability to fully support economic growth and state development by not being able to connect loads or generators
- allowing the network to become non-compliant with the Technical Rules, exposing Western Power to legislated penalties, which could compromise the business' transmission license, and could result in increased system outages
- sub-optimal (from a NPV perspective) network development, which may defer larger investments in favour of incremental, step sized investments, which are likely to be less efficient than the proposed Network Development Plan.

145. These projects will all be subject to the IAM and we believe that they will all meet the requirements of the NFIT as investments in transmission capacity expansion are only undertaken if they meet the requirements of sections 6.52(b)(ii) of 6.52 (b)(iii) of the Access Code. These investments will:

- have been assessed as providing a net benefit over the period in time that justifies the approval of higher reference tariffs
- will maintain the safety and reliability of the network
- have been planned in accordance with the Technical Rules and assessed as efficiently minimising costs as required under section 6.52(a) of the Access Code.

146. The projects listed in Table 1.7 are discussed below.

Supply projects

The supply component of capacity expansion includes growth-driven reinforcement of substations. Key supply projects are:

Installation of a new 132/11 kV CBD substation[23]

147. Recent peak demand forecasts for the East Perth and CBD load areas are significantly lower than historical levels and this has alleviated a number of capacity constraints. However, there remain significant asset condition issues with the 66 kV supplies and multiple assets at both Forrest Avenue and Wellington Street substations.

148. Western Power has developed an optimised asset plan for the area. Taking into consideration all the surrounding drivers, the most cost effective option that provides the greatest long term benefits involves the construction of a new 132 kV substation at Bennett St to resupply the Forrest Avenue and Wellington Street substation loads and decommission both 66 kV substations as well as the 66 Kv assets at the East Perth Terminal substation.

149. This project is likely to experience challenges through the congested CBD area with easements for both the transmission cables and dispersing all new distribution feeders from the new Bennett Street substation, as well as limitations in obtaining network outages. Internal and external stakeholders will be consulted throughout the project development and negotiations will be required to develop the least disruptive solution for all impacted parties.

150. The optimised asset plan results in lower costs than like-for-like replacements, is consistent with the East Perth and CBD strategy and the long term 66 kV network strategy, and provides flexibility to increase capacity should peak demand grow sharply in the future.[24]

151. The new 132 kV Bennett St substation is expected to be in service by 2024/25, followed by the decommissioning of the Forrest Ave and Wellington St substation by 2027/28. Due to the size and nature of the proposed augmentation, a regulatory test is expected to be developed as part of this project.

Installation of a 132 kV cable between Hay St substation and Milligan St substation

152. The Hay and Milligan Street substations are designed to meet higher levels of network security (N-2 criterion) under CBD planning criteria due to increasing levels of customer impact. Under an N-2 event involving the loss of both 132 kV supply lines at either Hay or Milligan Street substation during peak load conditions, the available distribution transfer capacity on the distribution feeders is inadequate to supply both loads. Based on the N-2 criteria, an existing substation capacity shortfall of approximately 4 MVA exists.

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23 Western Power has reviewed the CBD substation project in light of the updated 2017/18 load forecast and has determined the outcomes of addressing the aged asset conditions of Forrest Ave, Wellington St and East Perth 66kV substations can be addressed by transferring the load to the existing Hay and Joel Terrace substations with additional distribution feeders and the proposed new CBD substation project can be deferred outside the current 10-year investment plan. While there will be a reduction in transmission works associated with this deferment there will still be a requirement to invest in additional distribution works. The revised program will be included as part of Western Power's response to the draft decision

24 If the CBD substation project is deferred this component of the project will still need to be carried out in AA4, and will be reflected in Western Power's response to the ERA's Draft Decision.

153. Western Power has investigated a range of options to address this capacity shortfall, with the preferred option involving the installation of approximately 1.8 km of new 132 kV cables connecting Hay and Milligan Street substations.

154. The main benefits and drivers of the proposed option are:

- it is consistent with the East Perth and CBD strategy and ensures compliance with the Technical Rules (N-2, consistent with other Australian CBDs)
- it represents a more efficient solution than upgrading the distribution network – distribution cable congestion is a key challenge in supplying the CBD area, and the new cable transmission solution helps relieve that issue
- a number of new load applications may be at risk if the investment is not carried out
- additional benefits and efficiencies of the proposal are expected by freeing up some distribution feeder capacity to accommodate forecast peak demand.

155. This project aims to address the existing and forecast N-2 network security requirements in the CBD by summer 2019/20. Due to the size and nature of the proposed augmentation, a regulatory test is currently being developed as part of this project.

Installation of a third 132/22 kV transformer at Meadow Springs/ Installation of 2 x 66 132/22 kV transformers at Mandurah

156. The Meadow Springs and Mandurah substations both have existing substation capacity shortfalls. Substation capacity shortfalls of 31.28 MVA and 47.70 MVA are forecast at the Meadow Springs substation by the end of 2021/22 and 2027/28 without reinforcement. The Mandurah load area is forecast to experience the highest levels of peak demand growth in the Western Power Network.

157. A project is currently in the execution phase to reduce the existing capacity shortfalls at both of these substations. These works are the first stage of a broader long term investment path to alleviate thermal constraints within the area. The project work involves installation of a third 132/22 kV transformer at Meadow Springs and a 10 MVA load transfer from Mandurah to Meadow Springs substation via new distribution feeder interconnections by summer 2017/18.

158. The second stage of the long term investment path involves installation of two larger 66 MVA 132/22 kV transformers at Mandurah substation (2021/22 and 2024/25) and a series of distribution load transfers from Meadow Springs substation back to Mandurah substation.

159. Western Power is currently in the final stages of executing contracts with external suppliers for non-network options, which will facilitate a one year deferral of the first 66 MVA transformer. Risk based planning techniques have also been applied, which allow for a further one year deferral. Due to the size and nature of the proposed augmentation, a regulatory test is expected to be developed as part of this project.

Installation of a third Kemerton transformer

160. System studies show that a number of N-1-1 events can occur that can result in thermal overloads within the southern and southwest network. Under these scenarios, the AEMO may dispatch the Muja A/B generators to mitigate the N-1-1 network risk. However, the Muja A/B generators are planned to be retired by September 2018, which will bring forward a number of network security risks.

161. This project is the first stage of a broader long term strategy for the southern and south west network that aims toward decoupling the 132 kV networks between Muja and Bunbury load areas. The preferred

solution will address the forecast thermal issues to the Kemerton T1 and T1 Quad Booster transformers by installing a new 330 kV bay and a third 330/132 kV 490 MVA transformer by summer 2021/22. Additionally, these works will also facilitate the removal of the existing Binningup Desalination Plant substation load curtailment scheme.

Installation of a third 132/11 kV transformer at Rangeway substation and decommissioning of Durlacher substation

162. At the time when the project was first raised in 2012/13, capacity issues at the Durlacher substation and 33 kV supply lines were forecast. In addition, there were known asset condition issues with both the Durlacher step down transformers and switchboards.

163. Western Power investigated a number of replacement and upgrade options to address the range of network issues within Durlacher and Rangeway networks. Although the demand drivers have reduced since the project was first initiated, the recommended option remains unchanged as this option is still the cheapest option to address the remaining asset condition issues. The preferred solution includes installing a third 132/22 kV transformer at Rangeway substation and a transfer of the entire Durlacher load to enable the decommissioning of the Durlacher substation and both 33 kV supply lines.

164. The first stage of works involves the installation of two new feeders to partially offload the Durlacher substation and relieve the transformer loading, which is expected to be completed by summer 2017/18.

165. The second stage of works involves installation of a third 132/11 kV Rangeway transformer and a further six new 33 kV underground feeders with additional ducts, for potential future congestion issues, which will facilitate the load transfer of the entire Durlacher load to the Rangeway substation by summer 2017/18.

166. The final stage of works involves decommissioning and removing all the Durlacher substation assets and approximately 10.3 km GTN-DUR 61 and 62 supply lines, which is expected to be completed by summer 2021/22.

167. This proposed solution represents an optimised asset plan and is more efficient than like-for-like replacements. Benefits include consolidating the number of substation and line assets in the area, which aligns to the long term network strategy for the North Country load area.

Installation of a fourth 132/22 kV transformer at Bunbury Harbour

168. The Bunbury Harbour substation is forecast to experience capacity shortfalls of 12.47 MVA and 22.70 MVA by the end of 2021/22 and 2027/28. The preferred solution to address the substation capacity shortfall is to install a fourth 132/22 kV 33 MVA transformer at Bunbury Harbour substation by summer 2019/20. However, during the project development, we will look for demand side opportunities to further defer the installation if possible.

Installation of a third transformer at Black Flag Substation

169. Recent improvements in commodity prices (particularly gold) has translated to an increase in mining activity and higher overall demand in the area that has resulted in substation capacity shortfall at the Black Flag substation. In addition, there are a number of block load customer applications that are progressing through the customer connection process as defined in the AQP. Due to the nature of the loads supplied in the area, the forecast substation capacity shortfall is expected to be 9.73 MVA by the end of 2021/22.

170. We propose to install a third transformer at the Black Flag substation and address the forecast substation capacity shortfall, with works expected to be completed by summer 2021/22.

Decommissioning Coolup substation

171. The Coolup substation has asset condition issues relating to its long radial 66 kV supplies, step down transformers, and other substation assets that require replacement.

172. With the Coolup peak demand forecast to decline and remain below 10 MVA, an opportunity exists to optimise asset replacement plans in the area. The preferred option involves load transfers to the neighbouring Wagerup substation through a series of reinforcements on the distribution network. This solution also facilities the decommissioning of ~45 km 66 kV section between Coolup and Kemerton, with works expected to be completed by 2020/21.

Decommissioning of existing 66 kV Shenton Park and Herdsman substations

173. The first stage of a broader long term investment path for the northern section of the 66 kV Western Terminal network to transition to 132 kV voltage was completed in summer 2015/16, involving the construction of a new 132 kV Shenton Park substation. This new substation increased substation capacity in the area to accommodate future growth and facilitates the resupply and decommissioning of both 66 kV Shenton Park and Herdsman Parade substations by 2017/18 and 2018/19 to address multiple transformer and switchboard asset condition issues.

Thermal management projects

174. Thermal management projects are designed to overcome pre-and post-contingent thermal limitations on transmission and sub-transmission lines. Key projects in this activity class are described below.

Installation of dynamic line reactors on 132 kV transmission lines in Neerabup load area

175. Thermal overloads exist on multiple 132 kV circuits between Mullaloo and Pinjar. Western Power has investigated a number of options including reinforcement of the 132 kV network and smart protection inter-trip schemes. The preferred option is to install a series of line reactors across multiple 132 kV circuits in the Neerabup load area by 2022/23. These series line reactors will reduce the loadings on the affected lines by diverting power flows to adjacent lines. The number of reactors required will also depend on new customer and generator connections.

Mandurah to Pinjarra 132 kV – Resolve overloading Stage 1 & 2/Rebuild Mandurah to Pinjarra 132 kV as a double circuit

176. Under certain generation dispatch scenarios and following the loss of the Pinjarra to Meadow Springs and Cannington terminal 132 kV circuit, thermal overloads exist on the Mandurah to Pinjarra 132 kV circuit. The recent retirement of Worsley generation has reduced these thermal overloads, however, it is not sufficient to alleviate the forecast risk.

177. During the investigation of treatment options for addressing line clearance issues and pole replacement works on the line, an opportunity to deliver an optimised and staged investment path to mitigate the thermal overload risks emerged.

178. The first stage of works involves pole uprate works that increase the line circuit rating by approximately 10 per cent, deferring the line rebuild works from 2019/20 to 2024/25. The second stage of this project involves trialling series line reactors and dynamic line ratings on the Mandurah to Pinjarra 132 kV circuit, with works expected to be completed by 2017/18. The success of these trials may present opportunities for future project deferrals.

179. The final stage of works involves rebuilding the Mandurah to Pinjarra 132 kV circuit to a 132 kV double circuit line. This reinforcement work aligns with the long term plans for the load area and will mitigate the thermal overload risks and voltage step issues at Waikiki substation, as well as increasing the capability to accommodate future connections. Due to the size and nature of the proposed augmentation, a regulatory test is expected to be developed as part of this project.

Voltage projects

180. The voltage component of transmission capacity expansion capex is designed to maintain adequate transient, voltage and oscillatory stability margins to maintain network security following large and small disturbances. Key voltage projects are described below.

Construct a new 132kV line between Picton and Busselton

181. Load growth studies of the region south of Bunbury still show moderate growth, however, there remain significant asset condition issues in the existing 66 kV network. These issues are:

- asset condition – the majority of the 66 kV assets in the area are old and some of them have been assessed to be in poor and bad condition. The Picton 132/66 kV transformers are considered very critical as they are the main source for the 66 kV in the area and they are in bad condition
- voltage recovery issues – under loss of the four ended 132 kV Picton / Pinjarra / Kemerton / Busselton line, the remaining 2 x 66 kV lines are unable to supply all the load on the 66 kV network under peak loading conditions due to voltage issues
- thermal overload under N-1 contingency condition at the zone substations – some of the zone substations have transformer capacity related issues under N-1 conditions, especially at capacity where the thermal capacity is currently exceeded under N-1 conditions.

182. Optimised asset replacement and load growth studies indicate that the partial upgrade of one of the existing 66 kV circuits to 132 kV with additional new construction of the 132 kV line between Picton and Busselton will address the above issues with the following benefits:

- complete replacement of the 66 kV assets that are in bad condition and reducing reliance on the 66 kV network in the Bunbury load area
- addressing voltage recovery issues and N-1 overloading issues driven by continuous load growth in the area following the first stage of resolving the voltage recovery issues.

Install a statcom at Albany substation

183. Under peak demand conditions, switching of the large 132 kV cap banks at the Albany substation results in excessive voltage step change issues. To resolve this Western Power proposes to install a statcom at Albany substation to address the voltage step issues. This will be completed by summer 2020/21. Installing a statcom will also provide voltage support benefits once the Muja A/B generating units are retired.

Substation distribution energy resources

184. Increasing penetration levels of distribution energy resources (i.e. distributed generation) and resulting two way power flows are causing problems with existing substation protection systems. Without reinforcement, parts of the network connected to high levels of distributed energy resources will de-sensitise existing protection systems such that they no longer adequately detect and clear faults.

185. A number of substations are already experiencing reverse power flows during peak solar photovoltaic (**PV**) generation periods. The consequence of inadequate protection design can result in safety risks to Western

Power personnel and the public. Protection upgrade works are required at zone substations to address this increasing risk over the AA4 period.

1.2.1.4.2 Transmission growth capex – customer driven

186. Western Power is required to use all reasonable endeavours to provide network access to customers, while remaining compliant with the Technical Rules and safety requirements. Customer driven capex is entirely shaped by customer requirements and is inherently difficult to forecast. This is because customer driven capex tends to be heavily influenced by overarching economic conditions and trends in specific industry types.

187. We regularly engage with stakeholders regarding potential new loads and other impacts on the transmission network, and have recently been working closely with customers at the extremities of the grid to facilitate access and understand future connection requirements.

188. The customer driven expenditure category comprises all the capex required to augment the transmission network to facilitate customer access. This includes where customers seek to connect facilities and equipment or increase consumption or generation at a new connection point or modify their facilities.

189. Customer driven capex is forecast using historical trends and economic forecasts. Slower demand growth, high take-up of solar rooftop generation and rising electricity retail prices mean we expect the number of customer connections, particularly generators, during the AA4 period to be lower than in the AA3 period.

Figure 1.10: Comparison of AA3 actual[25] and AA4 forecast transmission customer driven capex, $ million real at 30 June 2017[26]

25 The negative amount in 2014/15 reflects the transfer of ~$22 million from the customer driven expenditure category (T0261908: Gindalbie Metals – Karara Mine) to the capacity expansion category (MWEP) on completion / buy back of the Three Springs terminal.

26 Excluding forecast labour cost escalation.

190. Customer driven capex for the AA4 period is forecast at around $19 million per year, $8 million per year once capital contributions are excluded (see Table 1.8).

Table 1.8: AA4 forecast transmission customer driven capex, $ million real at 30 June 2017[27]

Transmission customer driven capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Customer access	14.1	14.1	14.1	14.1	14.1	70.7	1.9%
Line relocations	4.7	4.7	4.7	4.7	4.7	23.6	0.6%
Gross customer driven capex	**18.9**	**18.9**	**18.9**	**18.9**	**18.9**	**94.3**	**2.5%**
Less contributions	10.7	10.7	10.7	10.7	10.7	53.3	
AA4 transmission customer driven capex to be added to the RAB	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**41.0**	

191. While Western Power goes to extensive measures to forecast customer driven capex, the potential for variance is still large given the timing of expenditure is driven by customer activity and prevailing economic conditions which are difficult to predict with accuracy.

192. The AA4 transmission customer driven capex assumes:

- fewer generators connecting to the network due to reduced peak demand growth effected by increased retail prices, increased PV uptake and energy efficient appliances
- a potentially lower cost to connect due to a move to a Generator Interim Access model.

193. Under present conditions, Western Power has not identified a need for new generation capacity beyond the requirements to meet the Renewable Energy Target (**RET**) over the short to medium-term, which is the key driver of forecast generation connections. The current pipeline of generator connections aligns with the projects in the EY Generation Scenario planting report. However, without knowing the specific generators that will request connection during the forecast period, the associated connections capex is difficult to forecast.

1.2.1.5 Transmission improvement in service capex

194. Improvement in service capex is designed to maintain current reliability levels in the transmission network. This expenditure category also includes investment in supervisory control and data acquisition (**SCADA**) and communications technology, which enables more efficient monitoring and control of the transmission network.

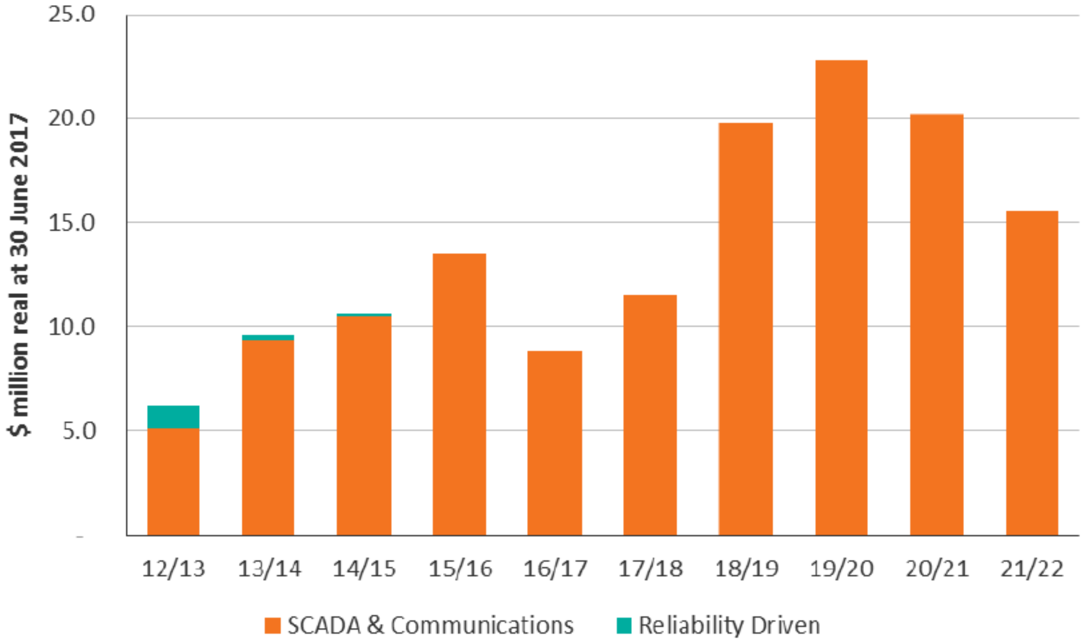
195. Our customer engagement program highlighted that customers are generally satisfied with overall reliability levels, and do not want Western Power to spend additional capital on improving reliability across

27 Excluding forecast labour cost escalation.

the network. With this in mind, we have not forecast any capex on reliability driven transmission projects for the AA4 period.

196. All expenditure in the improvement in service transmission capex category is on SCADA and communications. During the AA4 period, Western Power will invest $90 million in transmission SCADA and communications. This is $43 million (90 per cent) more than that incurred during the AA3 period (see Figure 1.11)

Figure 1.11: Comparison of AA3 actual and AA4 forecast transmission improvement in service gross capex, $ million real at 30 June 2017[28]



197. Table 1.9 shows forecast transmission improvement in service capex for the AA4 period.

Table 1.9: AA4 forecast transmission improvement in service capex, $ million real at 30 June 2017[29]

Transmission network improvement in service capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Reliability driven	-	-	-	-	-	-	0.0%
SCADA & comms	11.5	19.7	22.8	20.2	15.6	89.9	2.4%
Gross improvement in service capex	**11.5**	**19.7**	**22.8**	**20.2**	**15.6**	**89.9**	**2.4%**
Less contributions	-	-	-	-	-	-	

28 Excluding forecast labour cost escalation.

29 Excluding forecast labour cost escalation.

Transmission network improvement in service capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
AA4 transmission improvement in service capex to be added to the RAB	**11.5**	**19.7**	**22.8**	**20.2**	**15.6**	**89.9**	

198. The proposed SCADA and communications projects are discussed below.

199. Western Power's SCADA and communications assets provide the information and technology services required to protect, operate and manage the transmission and distribution networks and the Wholesale Electricity Market. Though in this capex report we have split capex between transmission and distribution, the overall SCADA and communications system serves both networks.

200. The SCADA and communications system is comprised of:

- the SCADA master station – located at the control centre from where Western Power centrally operates and manages the transmission and distribution networks
- substation SCADA and distribution automation – field monitoring and control of electronic equipment to operate plant and equipment at every substation (as well as across overhead and underground distribution networks)
- the telecommunications network – providing the voice and data infrastructure required to transfer information between the electricity network, substations, depots and the control centre.

201. The SCADA and communications assets enable the following business activities:

- operation of protection equipment
- real time visibility and control of the transmission networks
- metering and billing data for revenue collection
- back haul infrastructure to support distribution communications network
- corporate telecommunication services.

202. Over previous regulatory periods, Western Power's SCADA and communications network has been maintained on a reactive basis, and has now reached the point where technical obsolescence becomes an issue. An increase in investment is required to replace obsolete SCADA and communications equipment and maintain the performance of system monitoring and control. This applies to both the transmission and distribution SCADA and communications networks.

203. SCADA and communications capex (both transmission and distribution) can be split into the following subcategories:

- **asset replacement** – replacing assets with modern equivalents or upgrades to maintain the safety, reliability and performance of the in-service SCADA and communications network
- **compliance** – investment in replacement or additional assets to achieve compliance with regulatory and legislative obligations such as the Wholesale Electricity Market Rules and the Technical Rules

- **core infrastructure growth** – investment in new or upgraded assets to support expansions to the network or improve the capability of the SCADA and communications asset system
- **corporate** – investments required as part of wider projects such as establishing a new network control centre and the implementation of advanced meters
- **master stations** – investments to maintain and upgrade the central master stations and telecommunication network management systems, both hardware and software and including cyber security measures
- **third party actions** – responses to third party changes that impact on the SCADA and telecommunications asset system considerably – for example, NBN migration and spectrum clearance requests from the Australian Communications and Media Authority (**ACMA**).

204. Table 1.10 shows forecast transmission capex on the SCADA and communications network by expenditure subcategory.

Table 1.10: AA4 forecast SCADA and communications transmission capex, $ million real at 30 June 2017[30]

Transmission SCADA and communications capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total	% of total WP gross capex
Asset replacement	8.2	10.8	10.5	11.1	12.1	52.7	1.4%
Compliance	0.4	2.0	4.1	3.6	3.0	13.0	0.3%
Core infrastructure growth	-	-	-	-	-	-	0.0%
Corporate	1.8	3.1	3.1	1.0	0.4	9.4	0.3%
Master station	1.2	3.7	4.9	4.5	0.1	14.5	0.4%
Third party actions	-	0.1	0.1	0.1	0.1	0.3	0.0%
Gross SCADA and communications capex	**11.5**	**19.7**	**22.8**	**20.2**	**15.6**	**89.9**	**2.4%**
Less contributions	-	-	-	-	-	-	
AA4 transmission SCADA and communications capex to be added to the RAB	**11.5**	**19.7**	**22.8**	**20.2**	**15.6**	**89.9**	

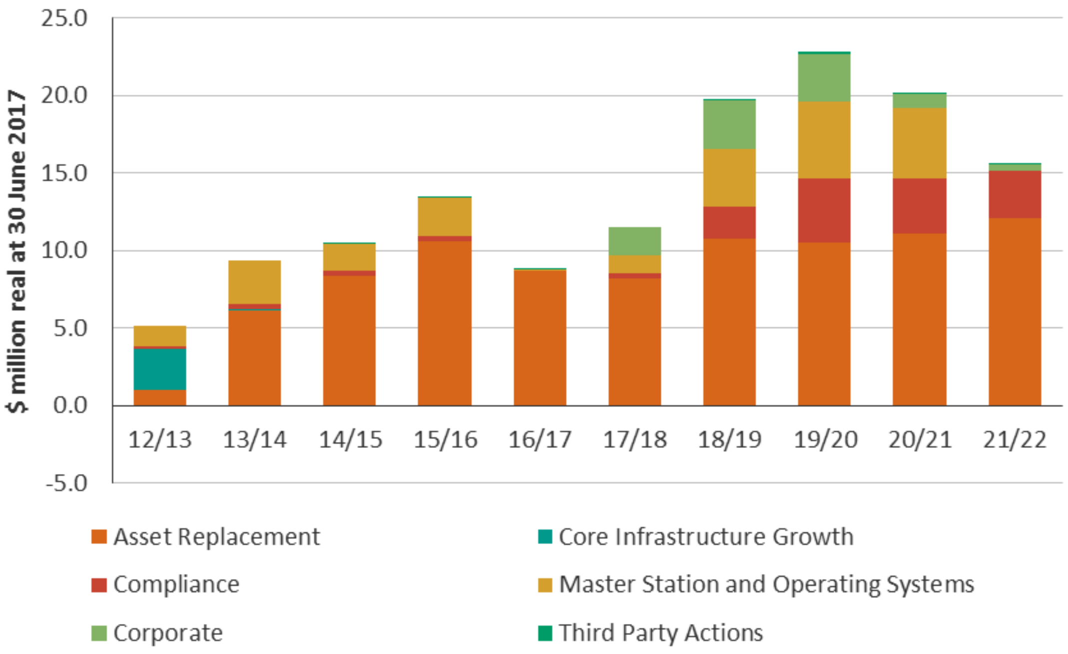
205. Western Power forecasts a significant uplift in investment in SCADA and communications for the transmission network. This reflects the growing importance of SCADA and communications in supporting a modern electrical network. SCADA and communications investment will enable a digital packet-based

30 Excluding forecast labour cost escalation.

platform, which will support future data, automation and protection applications. The new systems will in turn enable the application of new and/or alternative technologies such as microgrids and battery storage.

Figure 1.12 shows how the AA4 forecast transmission SCADA and communications capex compares with that incurred during the AA3 period.

Figure 1.12: Comparison of AA3 actual and AA4 forecast transmission SCADA and communications capex, $ million real at 30 June 2017[31]



206. Approximately $53 million of the total $90 million investment in SCADA and communications relates to asset replacement, $13 million relates to compliance requirements and $14 million is required to upgrade master station and operating systems. Investment in transmission SCADA and communications ($9 million) is also required to facilitate the proposed move of the network control centre to a new location and the construction of a new backup centre.

207. Further detail on specific transmission SCADA and communications investment is provided below.

1.2.1.5.1 Asset replacement (Improvement in service category)

208. During the AA4 period, Western Power proposes to invest $53 million to replace obsolete and critical systems infrastructure. This is a 51 per cent increase on the AA3 period. Obsolete assets include pilot cables, microwave radio transceivers and remote terminal units.

209. The obsolescence risk faced by Western Power is directly related to the age of the assets, which has already been extended well beyond the design life in many cases. For example, 68 per cent of pilot cables exceed the 35 year design life, on average by more than 10 years, and 23 per cent of cables will be more than 50 years old by the end of the AA4 period. Deferral beyond the AA4 period poses a risk to safe and reliable

31 Excluding forecast labour cost escalation

performance of the transmission network, as well as compromising the ability to integrate new technology and alternative network solutions into the South West Interconnected System (**SWIS**).

210. An independent engineering report by GHD in 2017[32] identifies that the majority of network operators are now actively looking to invest in SCADA and communications assets to improve the overall performance of the electricity network and thus reduce future operating costs. Two key transmission SCADA and communications asset replacement programs scheduled for the AA4 period are described below.

Transmission telecommunication equipment and supporting infrastructure

211. Western Power will invest to replace obsolete telecommunications equipment and supporting infrastructure. This infrastructure and the associated equipment provides communications circuits for electrical line protection and is critical to the operation of both the transmission and distribution networks.

212. This work is a continuation of a program that commenced in the AA3 period, which prioritises transmission telecommunication asset replacement by risk. Where possible, asset life has been extended by using recovered equipment. This has allowed us to defer some replacement and spread the replacement costs over a longer time period. The program is being delivered in stages across the AA3, AA4 and AA5 periods.

213. For the AA4 portion of this program, multiplexing, microwave and tele-protection equipment pose the greatest risk. The Plesiochronous Digital Hierarchy (**PDH**) based equipment used on the network trails current technology and architecture by more than two generations, while microwave equipment will exceed its design life by five years during the AA4 period. The majority of in-service tele-protection devices are more than 10 years past their intended design life. Manufacturer support has been withdrawn for many equipment models and the expected failures for the next four years exceeding the number of strategic spares available. Extending the life of these assets is no longer feasible.

214. We propose to migrate from PDH equipment to next-generation packet-based internet protocol (IP) architecture.

215. We have substantial investment in end-of-line PDH/SDH equipment. This legacy equipment is used in the back haul communication, which carries mission critical traffic for real time protection control and monitor of the electrical network. Like-for-like replacement is no longer a viable option because the current TDM technologies will not be compatible, and is interoperable with other modern communication equipment. The telecommunication industry is advancing to IP technologies for higher data rates, greater reliability, higher bandwidth, better cyber security protection and lower overall life cycle cost. Migrating the current end-of-line technology to a packet-based technology will improve Western Power's operational efficiencies and also be in line with a majority of the electricity network operators, as recommended by the independent consultant.

Pilot Cables

216. Western Power will invest $13 million to replace copper pilot cables with a digital fibre-optic communications path, in line with the design standard for protection schemes. This continues a program of work that commenced in 2012 and is scheduled for completion in 2028. The staged replacement program is supported through maintenance practices which transfers critical services to adjacent cores, rather than decommissioning entire cables.

217. The majority of Western Power's in-service pilot protection equipment (relays and cables) were commissioned concurrently, with original assets from the early 1960s still in use. Currently, 68 per cent of

32 *Investigation into Industry Practices for Managing SCADA and Telecommunications Infrastructure,* GHD, 2017.

pilot cables exceed their intended design life by an average of more than 10 years. At the end of the AA4 period, 23 per cent of cables will be more than 50 years old. Asset condition has deteriorated and Western Power has experienced an increase in failure rates and maintenance costs.[33]

218. Pilot protection failure requires temporary protection measures to be installed, which are becoming increasing difficult to implement. These faults are labour intensive and consume a disproportionate allocation of resources. There is also a lack of available emergency test racks, accredited cable joiners and subcontractors. Pilot failure introduces increased risk of system disturbances and the need to take transmission lines out of service, which may result in:

- transmission system protection contingency (i.e. a network fault will not be cleared, increasing the potential for hazard)
- under frequency load shedding performance
- non-compliance with Technical Rules.

1.2.1.5.2 Compliance (improvement in service category)

219. During the AA4 period, Western Power will invest $13 million on performance and regulatory compliance works relating to transmission substation SCADA and Telecommunications infrastructure. This work will allow Western Power to comply with new technical and regulatory rules expected to come into effect in the AA4 period. It will also allow additional benefits by addressing ageing assets that would shortly require replacement for obsolescence reasons. The replacement assets will align with Western Power's transition to the digital platform of IP SCADA, enabling robust and dynamic operational control and monitoring traffic.

220. The two key compliance programs for the AA4 period (Upgrade Substation SCADA and Substation SCADA Resilience) address the same elements of the asset base and are described together below:

Substation SCADA and Substation SCADA Resilience

221. The driver for this investment is non-compliance with the new AEMO Power Systems Data Communications Standard. The AEMO's standard is currently in draft and expected to be fully in place prior to the end of the AA4 period. Initial analysis has identified that Western power's legacy SCADA substation design only satisfies 60 per cent of the requirements in this standard. The two requirements which are the main cause of non-compliance are representation of data (data quality) and age of data (data latency). The root cause of the non-compliance is the continued utilisation of the original proprietary protocol Harris HR500 for signalling from site into centre, and the internal substation RS485 polling from Remote Terminal Units (RTU) to serially connected SCADA devices. Further non-compliance with the network technical rules also exists in that 45 per cent of all transmission substation sites have only single communications connectivity.

222. The investment will also address obsolescence risks. Older assets still utilise the original proprietary Harris HR5000 protocol and 30 per cent of sites continue to signal through original analogue VF equipment infrastructure. Under both the asset replacement and compliance activities, these assets will be targeted for replacement with modern integrated gateway devices.

223. This investment will also facilitate transition to a digital IP platform, enabling dynamic operational control and monitoring.

224. The AA4 capex program has been developed on the basis that the substation SCADA upgrade program will run concurrently with the SCADA asset replacement schedule. The investment will deliver a refreshed

[33] Between 2012 and 2017 there has been a 45 per cent increase in fault associated work orders.

technology landscape that achieves compliance with AEMO's reliability and data performance requirements.

1.2.1.5.3 Corporate (improvement in service category)

225. During the AA4 period Western Power will invest $9 million in SCADA and communications infrastructure relocation works to enable Western Power's facilities modernisation programs. These programs are required to address critical business continuity risks and also provide operational efficiency benefits.

226. The key corporate programs for the AA4 period are establishment of new network control centres and depot modernisation. These are discussed below.

Establish new Network Control Centre

227. Western Power is relocating its network control centre [redacted]. A new back up control centre is also being constructed. The new control centres require communication infrastructure to enable the remote control and monitoring of the network. Forecast transmission SCADA and communications capex on this project is $7.2 million.

228. [redacted]

Depot modernisation

229. [redacted] Where possible, existing communications infrastructure and third party providers will be used to provide the most efficient communications solutions for the depots. Forecast transmission SCADA and communications capex on this project is $2.3 million.

1.2.1.5.4 Master station and operating systems

230. During the AA4 period, Western Power will invest $14 million in the master stations and head -end information systems that enable the SCADA and communications services. Investments in this category have been segregated to map to organisational responsibility for the SCADA and communications assets, which are divided between ICT (master stations) and asset performance (communications assets and SCADA field assets). This activity includes elements of asset replacement, compliance, corporate and third party. The primary drivers for investment are obsolescence and cyber security risks.

231. The obsolescence risk faced by Western Power is a consequence of the nature of the assets addressed by this activity. The life cycles of hardware and software are relatively short and routine investment is required to ensure the products remain supported. Unsupported products represent risks in the form of extended outages, loss of interoperability with other assets and systems and cyber security vulnerabilities, all of which are unacceptable given the core role of the master stations in supporting Western Power's network. The investment program has already been deferred to allow time to understand the implications of recent market operator changes and for external technologies (converged transmission/distribution management systems) to mature.

232. Even with current generation hardware and software, the cyber security risk that Western Power faces has escalated considerably in recent times, with multiple utilities being subjected to cyber attacks across the globe.[34] Consequently, a portion of the master station investment has been dedicated to understanding and resolving cyber security vulnerabilities.

233. The key master station programs for the AA4 period are replacement of the transmission energy management system (**EMS**) and replacement of the telecommunications operational support system (Clarity). These are discussed in detail below.

Transmission energy management system

234. The drivers for investments in the EMS is the end of software and ICT hardware product life and ensuring continued cyber security assurance. The ICT hardware that was procured in 2013 and the PowerON Reliance software application installed in 2015 will reach end of life within the AA4 period. Rather than a like-for-like asset refresh program, Western Power will converge the distribution and transmission control systems, as well as moving all transmission substation SCADA and functional capability to a single control system. The convergence is anticipated to yield an annual cost saving of $1.2 million per annum, realisable in the AA5 period.

235. Addressing the forecast end of life of software and ICT hardware assets will avoid vendor support for products ceasing, which would limit the ability to respond to any hardware or software failures in a timely manner. Investment relating to cyber security reinforcements will mitigate a risk of a breach in critical operational systems. Forecast transmission SCADA and communications capex on this project is $5.3 million.

1.2.1.5.5 Third Party Action

236. During the AA4 Western Power will invest $0.3 million in activities to address third party changes affecting SCADA and communications service delivery. These programs are required to react to changes outside of the electrical industry that have significant impacts on the asset base. Western Power has limited, or no influence, over the relevant regulators or suppliers and therefore has limited options beyond a capital investment to respond to the change.

237. The key third party action programs for the AA4 period are the Australian Communications and Media Authority (**ACMA**) spectrum changes in the 800MHz band, and migration of services off Telstra copper lines. These are discussed below.

ACMA spectrum changes

238. The ACMA recently advised that the 800MHz band licensing agreements were changing.[35] This will impact several Western Power radio communication links/systems (protection, SCADA/DA and operational mobile voice). The changes will take effect from 2019 to 2024 with the majority of impacted Western Power radio links needing to be compliant by 2021.

239. Non-compliance to this new arrangement would lead to loss of critical services due to either suspension of the radio links or interference from the radio users to whom the spectrum has been re-allocated. Note that the ACMA spectrum change advice was recently received and a full analysis is still in progress. Forecast

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34 Ukraine Cyber-Induced Power Outage - Analysis and Practical Mitigation Strategies (2016).

35 ACMA 800MHz Band Plan Changes Advice Letter, dated 16 August 2017.

costs may change depending on the details of the links affected, the traffic they carry, the timing and the next best alternative communications path.

1.2.1.6 Transmission compliance capex

240. Western Power has a range of safety, environmental and service compliance obligations. Compliance requirements relating to non-growth investment on the transmission network include:

- **Regulation 11(1) of the *Electricity (Supply Standards and System Safety) Regulations 2001***

  Compliance by a network operator to whom Division 2 applies with a relevant provision of:

  a) a standard or code published under a law of any jurisdiction in Australia

  b) a standard or code published by Standards Australia, the Electricity Supply Association of Australia, or any other body approved by the Director

  c) a standard or code published by any other body and approved by the Director

  d) a standard or code published specified in Schedule 2.

- **Section 9 of the *Electricity Industry (Network Quality and Reliability of Supply) Code 2005***

  A transmitter or distributor must, so far as is reasonably practicable, ensure that the supply of electricity to a customer is maintained and the occurrence and duration of interruptions is kept to a minimum.

- **Section 10(1) of the *Electricity Industry (Network Quality and Reliability of Supply) Code* 2005**

  A transmitter or distributor must, so far as is reasonably practicable, reduce the effect of any interruption on a customer

- **Section 2.9.1 of the Technical Rules**

  a) All primary equipment on the transmission and distribution system must be protected so that if an equipment fault occurs, the faulted equipment item is automatically removed from service by the operation of circuit breakers or fuses. Protection systems must be designed and their settings coordinated so that, if there is a fault, unnecessary equipment damage is avoided and any reduction in power transfer capability or in the level of service provided to Users is minimised.

  b) Consistent with the requirement of clause 2.9.1(a), protection systems must remove faulted equipment from service in a timely manner and ensure that, where practical, those parts of the transmission and distribution system not directly affected by a fault remain in service.

  c) Protection systems must be designed, installed and maintained in accordance with good electricity industry practice. In particular, the Network Service Provider must ensure that all new protection apparatus complies with IEC Standard 60255 and that all new current transformers and voltage transformers comply with AS 60044 (2003).

- **Section 2.9.2 of the Technical Rules**

  d) Transmission system

1 *Primary equipment operating at transmission system voltages must be protected by a main protection system that must remove from service only those items of primary equipment directly affected by a fault. The main protection system must comprise two fully independent protection schemes of differing principle. One of the independent protection schemes must include earth fault protection.*

2 *Primary equipment operating at transmission system voltages must also be protected by a back-up protection system in addition to the main protection system. The back-up protection system must isolate the faulted primary equipment if a small zone fault occurs, or a circuit breaker failure condition occurs. For primary equipment operating at nominal voltages of 220 kV and above the back-up protection system must comprise two fully independent protection schemes of differing principle that must discriminate with other protection schemes. For primary equipment operating at nominal voltages of less than 220kV the back-up protection system must incorporate at least one protection scheme to protect against small zone faults or a circuit breaker failure. For protection against small zone faults there must also be a second protection scheme and, where this is co-located with the first protection scheme, together they must comprise two fully independent protection schemes of differing principle.*

3 *The design of the main protection system must make it possible to test and maintain either protection scheme without interfering with the other.*

4 *Primary equipment operating at a high voltage that is below a transmission system voltage must be protected by two fully independent protection systems in accordance with the requirements of clause 2.9.2(b)(1).*

- **Section 2.9.3 of the Technical Rules**

  a) *All protection schemes, including any back-up or circuit breaker failure protection scheme, forming part of a protection system protecting part of the transmission or distribution system must be kept operational at all times, except that one protection scheme forming part of a protection system can be taken out of service for period of up to 48 hours every 6 months.*

  b) *Should a protection scheme forming part of the main or back-up protection system protecting a part of the transmission system be out of service for longer than 48 hours, the Network Service Provider must remove the protected part of the transmission system from service unless instructed otherwise by System Management.*

  c) *Should either the two protection schemes protecting a part of the distribution system be out of service for longer than 48 hours, the Network Service Provider must remove the protected part of the distribution system from service unless the part of the distribution system must remain in service to maintain power system stability.*

- **Schedule 3 of the *Telecommunications Act 1997***

  A carrier may enter on land and exercise any of the following powers:

  - *the power to inspect the land to determine whether the land is suitable for the carrier's purposes;*

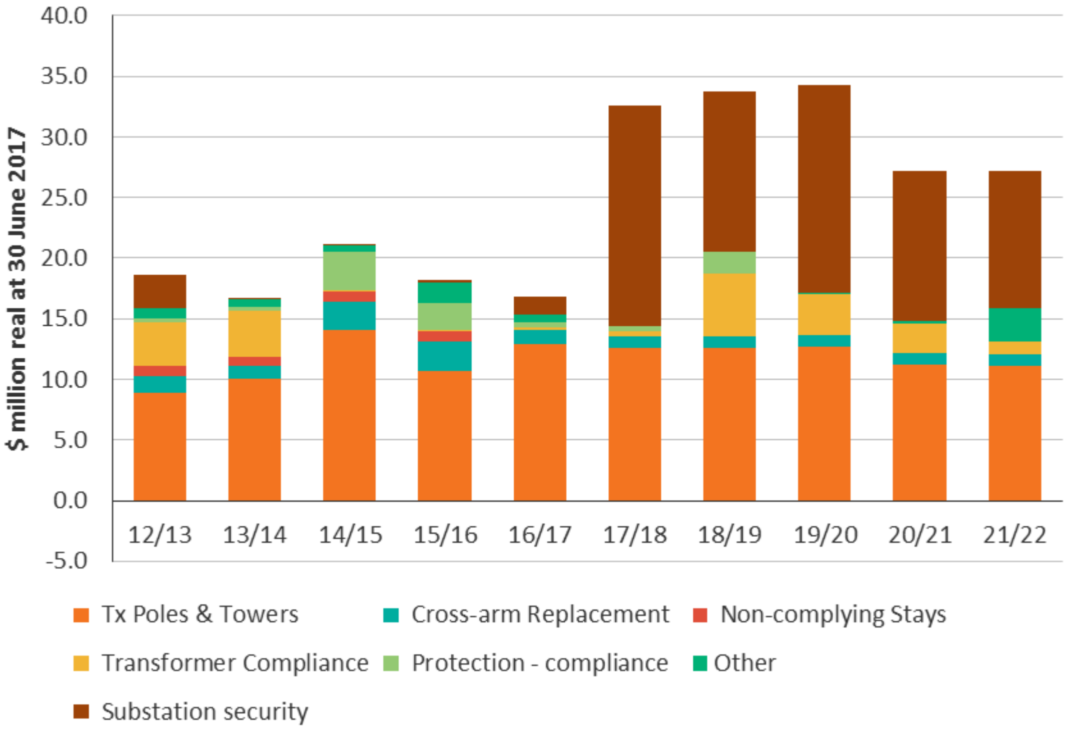
- *the power to install a facility on the land;*
- *the power to maintain a facility that is situated on the land.*

- ***Environmental Protection (Western Power Transmission Substation Noise Emissions) Approval Amendment 2012***

  Western Power is required to take action to ensure noise emissions from transmission substations are below specified levels. The 2012 amendment specifies a number of transmission substation sites that require noise mitigation activity by 30 June 2019.

241. Forecast capex on transmission compliance requirements during the AA4 period is $155 million. This is $64 million (70 per cent) more than that incurred during the AA3 period (see Figure 1.13).

Figure 1.13: Comparison of AA3 actual and AA4 forecast transmission regulatory compliance gross capex, $ million real at 30 June 2017[36]



242. The increase in transmission compliance capex during the AA4 period is due to substation security requirements. National guidelines[37] were introduced in 2015 relating to protection of critical infrastructure, including electricity substations. Therefore Western Power has developed an expenditure program to ensure compliance with the guidelines.

243. Table 1.11 shows forecast transmission compliance capex for the AA4 period.

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36 Excluding forecast labour cost escalation.

37 *National Guidelines for Protecting Critical Infrastructure from Terrorism*, Australia-New Zealand Counter-Terrorism Committee, 2015.

Table 1.11: AA4 forecast transmission regulatory compliance capex, $ million real at 30 June 2017[38]

Transmission regulatory compliance capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Poles and towers	12.6	12.6	12.7	11.2	11.1	60.0	1.6%
Cross arm replacement	1.0	0.9	0.9	0.9	0.9	4.8	0.1%
Substation security	18.2	13.2	17.1	12.4	11.3	72.1	1.9%
Transformers	0.4	5.2	3.5	2.5	1.1	12.7	0.3%
Protection	0.5	1.8	-	-	-	2.3	0.1%
Cables	-	-	0.1	0.2	2.7	3.0	0.1%
Gross compliance capex	**32.6**	**33.7**	**34.2**	**27.2**	**27.2**	**155.0**	**4.2%**
Less contributions	-	-	-	-	-	-	
AA4 transmission compliance capex to be added to the RAB	**32.6**	**33.7**	**34.2**	**27.2**	**27.2**	**155.0**	

244. Proposed transmission compliance capex projects are discussed below.

245. All investments are only undertaken where section 6.52(b) (ii) of the Access Code is met. The Network Management Plan outlines the risk management practices that are in place to manage network assets to ensure the safety and reliability of the covered network.

246. AA4 transmission regulatory compliance expenditure has been assessed as meeting section 6.52(b) (iii) of the Access Code. Non-compliance with the relevant codes and standards substantiates the evidence that non-compliance will impact the safety and reliability of the covered network.

1.2.1.6.1 Poles and towers (compliance)

247. During the AA4 period, Western Power will invest $60 million in transmission pole and tower replacement.

248. Transmission structures include wood poles, non-wood poles (steel, concrete), auspoles (steel butted wood poles), steel lattice towers, cross-arms / cross-beams (steel, wood), stay systems, and insulators. Western Power's transmission network has been built over several decades, to varying design standards and specifications, predominately using locally available hardwood poles. The most commonly used species was Jarrah, a local timber species grown only in Western Australia.

249. As of 30 June 2016, Western Power's transmission system contained approximately 40,372 poles and towers and ~2,286 poles with steel butts supporting wooden upper sections.

250. The MRL of transmission wood poles is 62.39 years. The MRL of the various types of transmission non-wood poles ranges from 55 to 100 years. Approximately one per cent of the transmission wood pole

38 Excluding forecast labour cost escalation.

population have exceeded their MRL. If replaced only on failure, this will reach four per cent by 30 June 2022 and seven per cent by 30 June 2027.

251. As of 30 June 2016, 846 wood poles require replacement and 6,449 wood poles require reinforcement. 21 per cent of poles that require replacement are in extreme or high fire risk zones and/or in very high or high public safety zones. Predominant defects are related to decay, splits, knots and rots.

252. As of 30 June 2016, 20 steel poles, 42 gantries and one concrete pole require replacement.

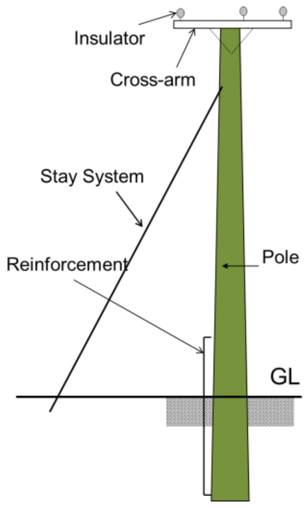
253. Western Power's transmission structure asset management strategy is to periodically monitor the condition of assets, to identify defective assets, to assess risk of failure of an asset and to treat assets based on cost-benefit of treatment prioritised on risk.

254. The impact on the performance of the transmission network of any failure of Western Power's transmission poles and towers depends on the pole location and the configuration of the surrounding electricity system. Much of Western Power's transmission network is highly meshed and those parts of the network are more resilient to the impact of a single wood pole failure than is the case for Western Power's radial transmission circuits, which have less redundancy and are far more susceptible to interruptions. Western Power's customers have indicated a willingness to pay to ensure that all people on the network (i.e. both those on radial and meshed transmission circuits) have similar levels of supply reliability.[39]

255. The Transmission Line Management Strategy describes the proactive pole treatment program that Western Power will implement during AA4. Western Power has identified two methods of treating poles deemed to be at risk of having an unassisted failure: reinforcing the pole or replacing the pole.

256. Reinforcing the pole involves encasing approximately one third of the base of the pole in metal as depicted in Figure 1.14. Pole reinforcement is the preferred treatment method, as reinforced poles are unlikely to experience a catastrophic failure, and the cost of reinforcing a pole is on average 10 times less than replacing it. However, pole reinforcement is only viable for defects that affect the structural integrity of a pole at ground level. All other defects must be treated by replacing the pole.

Figure 1.14: Example of pole reinforcement



257. We have forecast the required number of pole replacements and pole reinforcements for each year of AA4. This forecast was produced from a bottom-up estimate using historical failure data, the current backlog of

39 Western Power Customer Insights Report, Insight #13

treatment requirements and a forecast of new treatment requirements during AA4. Table 1.12 shows the forecast AA4 target for pole replacement and reinforcement.

Table 1.12: Forecast AA4 target for transmission pole replacement and reinforcement

Task	Volume
Pole replacement	2,534
Pole reinforcement	8,008

1.2.1.6.2 Cross arms and cross beams (compliance)

258. During the AA4 period, Western Power will invest $5 million in cross arm and cross beam replacement.

259. The Western Power network includes approximately 8,129 cross arms and cross beams. The primary purpose of these assets is to provide safe electrical and physical clearances between the overhead conductors and other objects.

260. The transmission system includes 7,501 structures with cross arms and cross beams. The expected service life for steel arms/beams is 50 years and 40-48 years for wood. A significant portion (29.9 per cent) of the population is currently operating beyond their MRL. If remediation is not undertaken, unassisted failure of cross arms and cross beams will increase from an average of 7 per year to 45 per year by 30 June 2022 and 72 per year by 30 June 2027.

261. At the start of the AA4 period, there are 275 cross arms requiring treatment. Western Power will treat an average of 191 assets per year (i.e. 62 asset more than those requiring stand-alone treatment each year).

262. Our strategy for transmission cross-arms and cross-beams asset management is to periodically monitor condition of asset, to identify defective assets, to assess risk of failure of an asset and to treat assets based on cost-benefit of treatment prioritised on risk.

263. To reduce disruptions to the network associated with replacement work, we often replace cross arms and cross beams when the associated pole or tower is replaced. This approach is efficient given that sending a work team to site is a significant component of the cost associated with asset replacements. During the AA4 period, Western Power will replace fewer transmission poles and towers than during the AA3 period. It is estimated that this will increase the number of stand-alone treatments required for cross arm and cross beams.

1.2.1.6.3 Substation security (compliance)

264. Western Power is required by the Office of State Security and Emergency Coordination[40] to comply with the National Guidelines for Protecting Critical Infrastructure from Terrorism. [redacted].

265. The substation security investment program for the AA4 period is forecast at $72 million and will continue into the AA5 period with a forecast of $50 million. [redacted]

40 Department of Premier and Cabinet.

[redacted]

266. [redacted]

1.2.1.6.4 Transformer compliance

267. During the AA4 period, **Western Power will** invest $13 million in transformer compliance.

268. Transformer non-compliance can be categorised into three areas:

- transformers with no bunding or with bunding that is no longer able to contain oil spills in accordance with Australian Standards and Western Power standards
- transformers with noise emission levels that do not comply with the limits prescribed under the 1997 Noise Regulations
- transformers with no firewalls or with firewalls that provide inadequate protection and containment of fires in accordance with Australian Standard 2067 and Western Power standards.

269. At 30 June 2016 there were 25 sites that were non-compliant in terms of the issues above. Of these, four will be addressed before the start of AA4, and one further site (North Fremantle) is being decommissioned. Western Power has assessed the risk associated with each of these sites and has determined that it will be prudent to address nine high risk sites through the AA4 period, taking the total addressed by the end of the AA4 period to 14. The remaining 11 low risk sites will be targeted in the AA4 period.

270. As well as meeting the regulatory requirements outlined above, further benefits of this program of works include helping to avoid potential failures, and the associated corrective clean-up or other rectifying costs. For example, a catastrophic transformer failure is likely to lead to oil containment issues and resulting environmental damage, as well as potential damage to adjacent transformers and a loss of supply. This expenditure aims at preventing such events from occurring.

1.2.1.6.5 Protection compliance

271. During the AA4 period, Western Power will invest $2.3 million in protection compliance.

272. Protection and control schemes are located within transmission terminal and zone substations. They are used to identify abnormal electrical operating conditions in the transmission network and send tripping signals to the circuit breaker(s).

273. Western Power has obligations under the Electricity Industry (Network Quality and Reliability of Supply) Code 2005 and the Electricity Act 1945 to provide customers a safe and reliable electricity supply. Protection systems are a key part of achieving these obligations.

274. As discussed above, a number of protection assets are operating at sub-optimal levels, therefore investment is required to replace/upgrade them.

1.2.1.6.6 Underground cables (compliance)

275. During the AA4 period, Western Power will invest $3 million in underground cable replacement.

276. The transmission network includes 53 km of underground cables, comprising of approximately 40 km of cross-linked polyethylene insulated (**XLPE**) cables and 12 km of fluid-filled cables. No unassisted underground cable failures were recorded between 2012 and 2015. However, the fluid-filled cables experienced seven oil leaks between 2012 and 2015 which released a total of 4,878 litres of oil. Western Power was required to report three of these leaks to the Department of Environment and Conservation due to potential environmental impacts. The XLPE cables did not cause any environmental incidents between 2012 and 2015.

277. There are eight fluid-filled cables in the network. Six of these will be decommissioned as part of an optimised capex project. The remaining two are scheduled for replacement during the AA4 period. It is the costs associated with replacing these two cables that comprise the $3 million in this compliance expenditure category.

278. If these two cables remain in the network, by the end of the AA4 period they will have exceeded their MRL by four years. We have assessed the environmental risk of fluid-filled cables exceeding their MRL as high. This assessment is primarily based on the adverse stakeholder reaction to fluid-filled cable related oil leaks that Western Power experienced between 2012 and 2015.

279. The primary cause of leaking fluid-filled cables is deterioration of the insulation through oil migration or water ingress. Table 1.13 shows how the rate of fluid loss increases substantially once the cable exceeds its MRL of 40 years.

Table 1.13: Average fluid loss from fluid-filled cables

Age as at 30 June 2015 (years)	Average fluid loss (litres/year)
30 - 40	300
41 - 50	N/A[41]
51 - 60	1,199
61 - 70	5,432

280. We will mitigate the risk of fluid-filled cable failure through targeted inspections and maintenance activities. However, we have determined that by 2019/20 the risk of fluid-filled cable failure will increase to a level such that it can no longer be mitigated solely through opex activities. At the start of 2019/20 we will replace the two remaining fluid-filled cables on a like-for-like basis. The forecast $3 million capital cost of replacing the two fluid-filled cables is based on the actual expenditure on three previous underground transmission cable replacement projects undertaken by Western Power.

281. No capex is proposed for replacement of XLPE cables during the AA4 period. Asset condition data for the XLPE cables gathered between 2012 and 2015 indicates that the XLPE cables are currently in an acceptable condition. We consider it will be efficient to mitigate the risk of XLPE cable failure through opex inspections and maintenance activities, rather than incurring replacement capex.

41 Western Power does not operate any fluid filled cables in this age bracket.

1.2.2 Distribution network capex

282. Western Power will invest $2,448 million of capital[42] in the distribution network (including capital contributions) during the AA4 period (see Table 1.14).

Table 1.14: AA4 forecast distribution capex by regulatory category, $ million real at 30 June 2017[43]

Distribution capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Asset replacement and renewal	251.2	239.5	228.0	206.1	214.7	1,139.4	30.6%
Growth[17]	216.0	223.8	208.1	206.4	210.5	1,064.6	28.6%
Improvement in service	23.0	29.0	16.0	13.8	12.2	94.0	2.5%
Compliance	22.9	36.1	35.3	28.0	28.1	150.3	4.0%
Gross distribution capex	**513.0**	**528.2**	**487.3**	**454.2**	**465.5**	**2,448.3**	**65.8%**
Less contributions	150.3	164.9	147.7	136.4	140.8	740.1	
AA4 distribution capex to be added to the RAB	**362.7**	**363.4**	**339.6**	**317.8**	**324.7**	**1,708.2**	

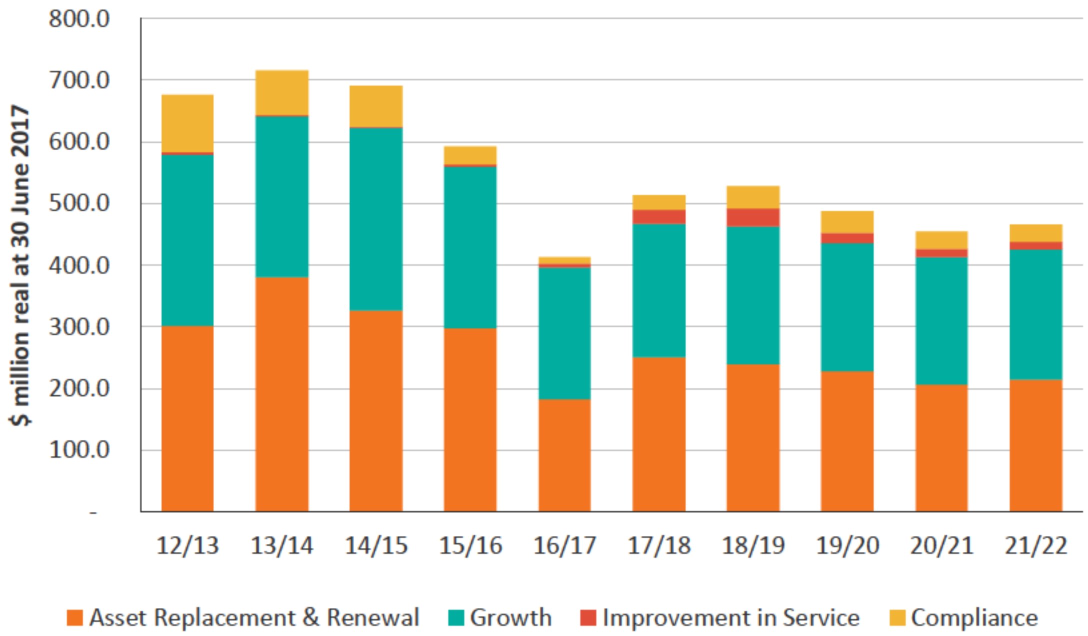
283. Forecast distribution capex for the AA4 period is $641 million (21 per cent) less than that incurred during the AA3 period). The main reasons for this are reduced investment in growth-related distribution projects and lower expenditure on distribution asset replacement.

284. Figure 1.15 shows how AA4 forecast distribution network expenditure compares with that incurred during the AA3 period.

42 Including gifted assets.

43 Excluding forecast labour cost escalation.

Figure 1.15: Comparison of AA4 forecast and AA3 actual distribution gross capex by expenditure category, $ million real at 30 June 2017[44]



285. As with transmission growth capex, distribution growth capex is driven by customer numbers, peak demand growth and economic activity. Over the AA3 period there has been a marked slowdown in peak demand growth, with forecast growth over the AA4 period being almost flat. As a result, there is less need to augment the distribution network during the AA4 period, however, there are parts of the network that still require distribution reinforcement such as the Mandurah, Rockingham, Waikiki, Ellenbrook and Bunbury areas.

286. Though there will still be considerable investment in distribution augmentation during the AA4 period, growth-related distribution network expenditure is forecast to be $245 million less than in the AA3 period.

287. Investment in distribution asset replacement during the AA4 period will be around $350 million less than that incurred during the AA3 period. This is due in part to the completion of the mandated[45] distribution wood pole replacement program, which saw record levels of distribution asset replacement during 2013/14 and 2014/15. Wood poles will continue to be replaced during the AA4 period and other distribution assets will also be targeted for condition-based replacement (conductors for example). In addition, improvements in asset management practices resulting from Western Power's Business Transformation Program conducted in 2015 to 2017, means our asset replacement program has been optimised, allowing the business to target asset replacement more efficiently, and reduce overall costs.

1.2.2.1 Developing the distribution asset replacement forecast

288. As with transmission asset replacement, Western Power's risk based approach to distribution asset management has improved over the AA3 period. Over the past five years there has been considerable focus on distribution asset replacement. This is primarily as a result of the Energy*Safety* wood pole order, which led Western Power to undertake its largest-ever distribution wood pole management program, reinforcing

44 Excluding forecast labour cost escalation.

45 Energy*Safety* Order 01-2009.

or replacing around 270,000 poles across the Western Power Network. Conductor management has also been a major area of focus in recent years, with more than 2,000 km of overhead conductor replaced over the AA3 period.

289. This high level of activity has resulted in improved information and data relating to distribution asset condition, failure modes, effectiveness of treatments, and the costs associated with various risk reduction strategies.

290. Renewal capital investment in Western Power's distribution network is a function of a number of variables and factors, including:

- asset failure, condition and age
- regulatory obligations
- reliability standards and security of supply.

291. Asset failure, condition and age are key drivers of risk and asset renewal expenditure. Forecasting the appropriate level of asset renewal requires an assessment of the past performance and present condition of Western Power's asset portfolio. This includes:

- an ongoing program of inspections, consistent with best-practice approaches
- the determination of average actual replacement lives for each asset class
- calculation of the risks and consequences of failure by asset class and risk assessments for each individual asset.

292. Ultimately, a determination is made for each asset class as to whether assets should be replaced on condition (proactive) or on failure (reactive), or a combination of both.

Distribution overhead

293. Western Power developed the risk based renewal methodology to assess the probability of distribution overhead assets suffering unassisted failures and quantify the likelihood of consequential impacts from these failures. This enables Western Power to prioritise and direct its capex investments towards high risk assets within the distribution overhead network.

294. The wood pole order experience challenged the business during AA3 with more complex and higher volumetric works with resource (funds, delivery and time) constraints. In the pursuit of automation, we developed a suite of IT solutions comprised of three core tools, now used to plan and deliver the distribution overhead lines program of work. These tools model, plan and package the high volume of assets within the network and support quantitative decision making and risk management.

295. The three tools are:

- **Network Risk Management Tool (NRMT)** – statistical modelling software used to calculate a risk score for each individual asset within its asset class. The NRMT quantifies the instantaneous risk of unassisted failure of individual assets
- **Asset Investment Planning (AIP) system** – a software application used to model distribution overhead asset strategies using a risk based renewal methodology to forecast future capex work. This is achieved by using asset strategy rules, asset conditions, NRMT risk scores, unit rates and applying business priorities and constraints to generate detailed or summarised plans

- **Rules Engine (ARDS)** – is a software application that uses coded business rules to automate distribution overhead maintenance decision making. It supports management of maintenance estimates and automates work orders with allocated delivery arms.

296. Risk assessment is built into the distribution capex forecast using the NRMT. The risk score provided by the NRMT is used as an input into the risk based renewal methodology. The AIP system allows the business to identify network areas and individual assets where treatment will yield the greatest risk reduction per dollar of capex. This is particularly effective for distribution overhead assets, which can be assessed as a group by distribution 'corridor'. By assessing all distribution assets within a specific area or corridor, we can develop the most efficient risk based replacement/renewal approach for large sections of the network. For non-distribution overhead assets, risks and required renewal rates are assessed individually.

297. Standard unit rates are an input into this planning process. Unit rates are formulated using detailed cost structures and established work practices. Cost structures have been developed using a compatible unit approach where every field work task is broken down into units of labour, fleet, contractor and materials for that task. These units are built on current documented work practices, current labour, fleet and material costs and incorporate negotiated contractor rates. Final expenditure forecasts are based on forecast volumes, work mix and associated costs.

298. Standalone projects are forecast using a cost build up approach based on established and documented estimating practices. A top-down assessment of replacement capital is made by category, where applicable, to ensure that proposed forecasts are in line with the expenditure a prudent and efficient network service provider would propose.

299. To perform the risk analysis in the AIP system, we have developed risk models for each asset class in the distribution overhead assets group. These risk models have been developed within the NRMT, and provide the relationships between future replacement volumes and future risk for any asset strategy. The NRMT allows for the total network risk to be quantified with respect to public safety, workforce safety, environment and reliability.

300. For example, when developing the wood pole management plan, we use the AIP to select poles within maintenance zones that would deliver an optimal reduction in overall network risk reduction per dollar spent. The risk reduction of each asset treatment was calculated within the NRMT to select poles outside of selected maintenance zones for treatment. NRMT and Markov models are used to forecast defects and unassisted failures. Forecasts for assisted failures and faults were based on historical performance data.

301. The primary function of the AIP is to model the distribution overhead lines strategy to forecast future work. This is achieved by using asset attribute and condition information, asset strategy rules, NRMT risk scores, unit rates and applying business priorities and constraints to generate detailed and summarised plans.

302. Outputs from the AIP are then reviewed by network planners to manually identify opportunities for alternative treatment solutions for the targeted assets. The purpose of this process is to align the proposed renewal treatments to the long term strategy of the load area given the planner's local knowledge of each load area.

Non-overhead distribution assets

303. For distribution non-overhead network assets, the selection and prioritisation of possible solutions are based on the number of immediate customers at risk, network risk and the long term strategy for the load area. Assessing the level of risk is an important aspect of prioritising replacement capex. Funding constraints and delivery constraints are also considered in the prioritisation exercise.

304. Risk assessment is driven by consideration of following elements:

- the likelihood of the asset failing (including its failure mode), which is based on knowledge of the asset, environmental conditions and past or future operating conditions
- the likelihood of failure resulting in an undesirable consequence, which is based on detailed knowledge of the asset failure modes and the effects of such failures
- the consequence (or potential cost) of failure, which is based on the physical location of the asset (e.g. fire risk zone or surrounding population density) as well as the electrical location of the asset (the number of customers connected to the asset).

305. The level of risk posed by an individual asset is influenced by a range of factors, including its condition, how it is operated, how many customers it supplies, its proximity to the public and its surrounding environment/location including the fire risk posed or environmental risk.

306. Risks assessed as unacceptable are treated immediately. Risks assessed as high are prioritised for early treatment, based on the level of safety risk they present and their cost.

1.2.2.2 Developing the distribution growth capex forecast

307. As with transmission growth planning, during the AA3 period Western Power moved towards incorporating more risk-based planning in its investment in distribution growth. Peak demand and reliability remain key investment drivers and historically we have applied a deterministic planning methodology when addressing these. However, in some cases it may not be prudent or efficient to simply address growth-related challenges by applying traditional network solutions or like-for-like replacements. Where possible, we identify and quantify the risk of capacity shortfalls in the distribution network and consider whether demand management or alternative and more efficient solutions such as microgrids can be applied.

308. We use a bottom-up approach to identify current and emerging distribution network issues while also taking into consideration broader network issues, customer requirements and asset replacement programs. We believe this generates an optimised capex program.

Investment optimisation

309. Optimisation is typically undertaken through a two stage process. The first stage of optimisation is performed after power system studies. During these studies we identify current and emerging demand and network security limitations which are then overlaid with other network drivers. In addition, the network utilisation levels are taken into consideration.

310. Although network optimisation occurs across a range of network investment drivers, combining asset condition drivers typically provides the greatest optimisation opportunities. For example, in the distribution network we optimise overhead conductor replacement against demand, safety, reliability and power quality drivers.

311. The second stage of optimisation involves adjusting volumetric asset replacement programs to reflect the preferred network development plans. This results in replacements that are not like for like but involves replacing assets with higher ratings or that can be reconfigured to cater for future network needs.

312. The NRMT is used to prioritise the replacements for the remaining assets that are managed through volumetric works programs. The NRMT is a risk management and prioritisation tool that allows for the total network risk (in dollars) to be quantified with respect to public safety, workforce safety, environment and reliability.

313. The NMRT can forecast the unmitigated risk for all in-service assets as well as calculate the improvement in risk levels as a result of the proposed network investments. The optimised network plans discussed in Western Power's Network Development Plan contribute to reducing the risks associated with each relevant asset class. For more detail, refer to the Network Management Plan.

314. This optimised risk planning approach is now applied as part of our business as usual network investment practices and underpins the AA4 distribution (and transmission) growth-related forecast. Our network planning approach for growth-related capex, including an overview of the current and emerging network capacity issues, is discussed in the Network Development Plan.

Planning methodology

315. As per the transmission planning approach described above, we adopt a bottom-up approach to distribution growth planning, identifying the current and emerging network limitations relating to forecast demand, security, reliability, power quality, customer and compliance drivers.

316. We undertake power system studies across a range of sensitivities to identify the current and emerging network limitations. Non network options such as demand management are all considered on a consistent basis with traditional network options.

317. We also consider the trade-off between capex and opex measures to manage network risk. Individual investment decisions are not assessed in isolation. Network optimisation is performed across various stages of Western Power's annual planning cycle. Once the optimised network plans are developed, Western Power's resource and delivery function assesses the feasibility of delivering the portfolio or projects in conjunction with other programs of works.

1.2.2.3 Distribution asset replacement and renewal capex

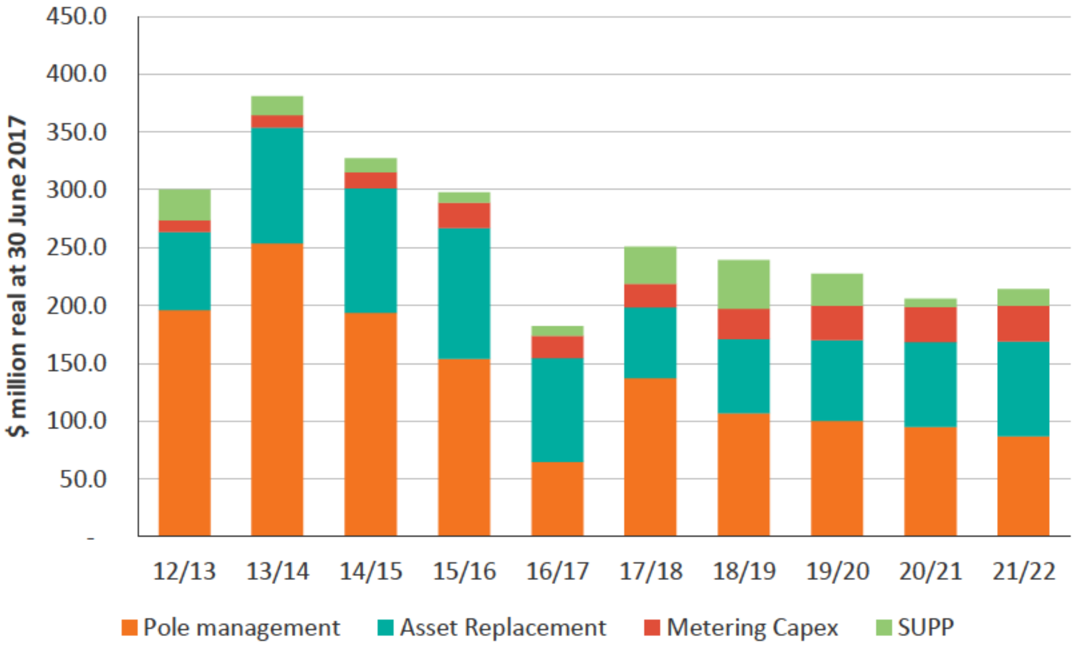
318. During the AA4 period, around 57 per cent of forecast distribution capex is not related to growth. The largest non-growth distribution capex category is asset replacement and renewal, which is driven primarily by the need to maintain safety.

319. Distribution assets include wood poles, overhead conductor and plant, and underground cables. All of these assets are typically in close proximity to the general public, and can cause serious harm to people or damage to property if they fail.

320. The work program typically comprises a high volume of relatively small jobs, often in densely populated areas. It is among the most crucial work program for any operator, and relies heavily on prudent asset management practices.

321. During the AA4 period, Western Power will invest $1,139 million in distribution asset replacement and renewal. This is $350 million (23 per cent) less than that incurred during the AA3 period (see Figure 1.16).

Figure 1.16: Comparison of AA3 actual and AA4 forecast distribution asset replacement and renewal gross capex by expenditure sub-category, $ million real at 30 June 2017[46]



322. As discussed in section 1.2.2, a key part of the reduction in asset replacement and renewal expenditure is the completion of the mandated[47] wood pole replacement program during the AA3 period. Wood pole management will remain a focus during the AA4 period, however, consistent with customer feedback, capex during the AA4 period is designed to maintain the current network safety risk rather than improve the overall risk rating. We will target expenditure on areas of the network that pose the highest safety risk.

323. Distribution poles, conductors and pole-top replacements are forecast using a risk based methodology. This results in an optimal renewal profile, which aims to prevent failures in areas where there is a high failure-to-incident conversion rate (for example in high bushfire risk areas), or where substantial risk to network safety, network reliability, or the environment has been identified.

324. As at the end of June 2016, 117,257 wood poles required reinforcement and 136,280 wood poles required replacement. Of these, Western Power will replace 60,850 and reinforce 65,738 wood poles during the AA4 period. This means 20 per cent of the wood pole population will be treated, a significant reduction on the 43 per cent treated during the AA3 period.

325. The reduction in wood pole management expenditure is offset to some extent by an increase in metering capex. State Underground Power Program (**SUPP**) investment will also increase during the period due to greater demand for retrospective undergrounding from councils, while expenditure on replacement of other assets, for example conductors, will be broadly consistent with historical levels.

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46 Excluding forecast labour cost escalation.

47 As per Energy*Safety* Order 2009-1.

326. The distribution asset replacement sub-categories shown in the table below are discussed in further detail in the following sections. Table 1.15 shows forecast asset replacement and renewal capex for the AA4 period, by expenditure sub-category.

Table 1.15: AA4 forecast distribution asset replacement and renewal capex, $ million real at 30 June 2017[48]

Distribution asset replacement capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Asset replacement	61.4	64.8	70.5	73.7	82.4	352.8	9.5%
Metering capex	20.0	25.8	29.9	30.7	31.0	137.3	3.7%
Pole management	137.2	106.6	99.8	94.8	86.5	525.0	14.1%
SUPP	32.5	42.3	27.8	6.9	14.8	124.3	3.3%
Gross asset replacement capex	**251.2**	**239.5**	**228.0**	**206.1**	**214.7**	**1,139.4**	**30.6%**
Less contributions	20.4	25.7	17.9	6.6	10.9	81.4	
AA4 distribution asset replacement capex to be added to the RAB	**230.8**	**213.7**	**210.2**	**199.5**	**203.8**	**1,058.0**	

1.2.2.3.1 Asset replacement

327. The asset replacement sub-category covers replacement and renewal of all other assets, including overhead conductors, distribution transformers, switchgear, protection systems, streetlights and underground cables. The largest component of this expenditure sub-category is conductor management, accounting for $219 million of the $353 million capex proposed (see Figure 1.17).

48 Excluding forecast labour cost escalation.

Figure 1.17: Comparison of AA3 actual and AA4 forecast distribution asset replacement sub-category gross capex by expenditure activity, $ million real at 30 June 2017[49]

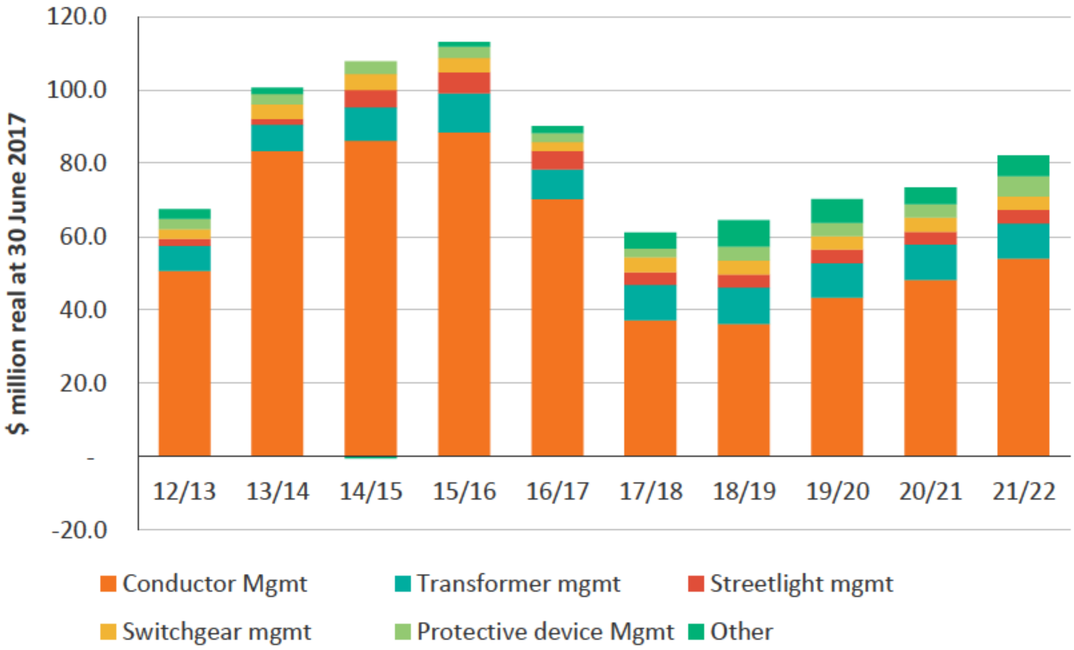

Table 1.16: AA4 forecast distribution asset replacement sub-category capex, $ million real at 30 June 2017[50]

Distribution asset replacement capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Conductor management	37.2	36.1	43.2	48.1	54.0	218.7	5.9%
Transformer management	9.5	9.9	9.6	9.7	9.6	48.3	1.3%
Streetlight management	3.9	3.9	3.9	3.9	3.9	19.4	0.5%
Switchgear management	3.9	3.8	3.8	3.8	3.8	18.9	0.5%
Protective device management	2.5	3.9	3.7	3.8	5.6	19.4	0.5%
Cable management	1.5	1.5	1.5	1.5	1.5	7.6	0.2%
Other	2.8	5.7	4.9	3.0	4.0	20.5	0.6%

49 Excluding forecast labour cost escalation.

50 Excluding forecast labour cost escalation.

Distribution asset replacement capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Gross asset replacement capex	**61.4**	**64.8**	**70.5**	**73.7**	**82.4**	**352.8**	**9.5%**
Less contributions	-	-	-	-	-	-	
AA4 distribution asset replacement capex to be added to the RAB	**61.4**	**64.8**	**70.5**	**73.7**	**82.4**	**352.8**	

Conductor management

328. During the AA4 period, Western Power will invest $219 million in in distribution conductor management.

329. Distribution overhead conductors refer to any bare or insulated wires on the Western Power distribution network that are predominantly used for carrying electrical current, which are placed overhead, in the open air and suspended between two or more structures (with the exception of the final lines connecting properties to the distribution network). As at 30 June 2016, there were approximately 68,000 km of distribution overhead conductors on the Western Power Network. Of that, around 11 per cent were classified as urban, 15 per cent as rural short and the vast majority, 74 per cent, as rural long.

330. Overhead conductors can age and deteriorate from a range of factors including the environment (e.g. lightning, corrosion), electrical stresses (overloading, or fault current) causing heating in the conductor beyond its melting point, and/or mechanical stresses exceeding the conductor's residual tensile strength.

331. The probability of conductor failure is mostly a function of age. Conductor failures can have severe consequences, including:

- customer supply interruptions which can last for several hours if the failed conductor is located far from operational depots on radial networks, i.e. on country feeders
- ground fires as a result of live conductors or sparks from clashing conductors coming into contact with dry vegetation
- electric shock through contact with live conductors, or through induction. Conductors with substandard clearance have an increased likelihood of coming into contact with vehicles, structures and vegetation, which carries the risk of electric shock, property damage and service disruption through contact with the conductor.

332. The impact of conductor failures can be mitigated primarily through electrical fault protection, which reduces the discharge of arc energy by clearing the fault as fast as possible. Western Power's approach is to identify conductor-related hazards and reduce the safety risk to as low as reasonably practicable, whilst managing reliability and power quality risks within the agreed service performance. Ageing conductors are identified through the presence of defects such as broken or deteriorated strands, identified via routine visual inspections. These can be classified as fire start defects based on the likelihood of resulting fires, or public safety defects based on the risk of electric shock and/or physical impact. As of 30 June 2016, Western Power has 4,191 open mains conductor defects, including 15 fire start defects and 125 public safety defects.

333. We improved our conductor asset management practices during the AA3 period. Results from conductor testing and sampling in recent years have given us a better understanding of asset condition and the likelihood of asset failure. As a result, we are better able to identify conductor at the greatest risk of failure.

334. This means that for the AA4 period we are adopting a more mature risk based renewal approach to managing conductors. Our risk based renewal approach optimises asset lifecycle costs and helps determine a more efficient level of expenditure. The approach involves:

- identifying conductors that are in poor condition
- assessing the risk posed by these conductors
- scheduling treatments to achieve optimal risk reduction per dollar spent.

335. We have assessed that approximately seven per cent (4,760 km) of the 68,000 km of distribution overhead conductor is in poor condition. Not all of this poorest condition conductor requires immediate treatment, and we do not propose that all 4,760 km will be replaced during the AA4 period. Instead, we will replace 2,196 km of overhead conductor, prioritised by risk. We will monitor the condition of the remaining distribution conductor during routine maintenance, and adjust the reactive and proactive replacement programs where necessary to keep the safety risk as low as reasonably practicable.

336. Note that in the AA3 forecast, conductor replacement was split between two programs. Conductor replacement in Low and Medium bushfire risk areas was forecast under the Conductor management activity within Asset Replacement, while conductor replacement in High and Extreme bushfire risk areas was forecast under the Bushfire management activity within Regulatory Compliance. During 2014/15, these programs were combined into the Conductor management activity within the Asset Replacement sub regulatory category. For the purpose of this submission, all conductor management forecast (AA3 and AA4) and actual expenditure has been included within Asset Replacement.

Transformer management

337. During the AA4 period, Western Power will incur $48 million to replace distribution transformers. This is relatively consistent with levels during the AA3 period. The proposed AA4 activity includes:

- proactive replacement - replacing 114 ground mounted transformers each year, primarily on the basis of asset conditions and replaced on failure where required
- reactive replacement – replacing on average 445 pole mounted transformers each year, with 87 per cent of these replaced on failure.

338. As at 30 June 2016, Western Power has 69,037 transformers in the distribution network. A significant number of these have been installed in the last 20 years due to growth in the network, and network expansion for customer access works. These devices include:

- 52,038 pole top and 16,077 ground-based station transformers
- 444 isolating transformers, to reduce the risk of unbalanced voltages
- 20 auto transformers, used to reduce voltage sag on long spur lines
- 448 regulating transformers.

339. Transformers are subject to ageing from their exposure to environmental factors, as well as normal and abnormal electrical stresses (load and short circuit currents). The effect of ageing can be seen through corrosion, loss of insulation and insulation degradation. These defects can lead to risk of failure, which in turn can have the following impacts:

- increased supply outages and excessive overload on other assets
- poor power quality due to loss of system stability
- increased likelihood of ground fire and damage to surrounding equipment
- environmental damage due to oil leaks.

340. Distribution transformers are usually located in public areas, and it is important to manage the safety risks associated with these assets. There is also a substantial environmental risk posed from transformer oil leaks. Western Power's approach to managing the risk is a mix of managing transformers on condition (where they present a safety or environmental risk) and replace on failure (where safety and environmental risks are low).

341. The transformer management capex forecasting approach is a combination of the application of the AIP for overhead assets, and a historical trend methodology for non-overhead assets.

Streetlight Management

342. During the AA4 period, Western Power will invest $19 million on managing streetlights.

343. There are more a quarter of a million streetlights connected to Western Power's distribution network. A streetlight typically includes the following asset components:

- a luminaire
- streetlight control box
- dedicated streetlight metal pole (**DSLMP**)
- a bracket
- and/or a streetlight underground cable.

344. Luminaires can be mounted on DSLMPs, or mounted via brackets on other Western Power poles (e.g. wood poles that are used for electricity distribution). Streetlights are managed to efficiently minimise cost based on the following factors:

- age and condition (risk based assessment)
- environment
- shared assets
- asset creation standards
- legislation and obligations
- energy efficient public lighting
- delivery capability.

345. Challenges facing the streetlight network include vehicle impact damage, ground line corrosion and meeting public safety requirements such as ensuring that lighting assets are double insulated upon luminaire replacement where relevant.

346. The streetlight expenditure program enables Western Power to:

- comply with jurisdictional safety obligations by maintaining current safety performance

- manage the public lighting network to maintain compliance with the minimum service standards for reliability performance.
- address higher risk assets
- provide a reliable and efficient public lighting service.

347. Streetlight poles are replaced or reinforced when they fail or are in poor condition. Annual remediation volumes are set to achieve the objective of meeting the agreed service performance with zero harm to members of the public and Western Power's workforce. Defects and expected failures are forecast based on historical find rates through the inspection process.

Switchgear Management

348. During the AA4 period, Western Power will invest $19 million in distribution switchgear renewal and replacement.

349. This expenditure activity covers the equipment used for switching, isolation, and connection between Western Power's distribution network and a customer's electrical installation. In addition to their switching functionality, these assets help maintain supply reliability and network safety (reduced risk of fire and electric shock) by isolating faulted sections of the LV network and allowing maintenance and flexibility of network operation.

350. Switchgear management includes equipment which is either mounted on distribution structures (poles) or installed as a standalone asset. Western Power assets within this expenditure category include Ring Main Units (**RMUs**), overhead LV disconnectors, LV distribution frames, load break switches and capacitor banks.

351. RMUs are ground mounted high voltage switchgear that perform isolation and protection of the distribution system. Their functionality is critical to safety and the reliability of supply. As with many other switchgear assets they are vulnerable to ageing from environmental, electrical and mechanical stresses. Where these stresses lead to defects that result in asset failure, the main consequences are:

- increased number of supply outages due to delays in identifying faulted sections and the inability to reconnect/reconfigure the network
- equipment damage/stress on other, healthy, assets
- increased likelihood of equipment fire and physical impact from debris
- environmental impacts from equipment oil and gas leaks.

352. As at 30 June 2016, Western Power has 6,961 RMUs and 482 high voltage (**HV**) ground mounted metering units in the distribution network.

353. Overhead LV disconnectors can age due to normal and abnormal electrical and mechanical stresses or environmental factors. Typical impacts of ageing include corrosion, high resistance joints leading to hot spots, arcing, mechanical breakdown or deterioration of specific parts of the switchgear.

354. Failure of LV disconnectors can have the following impacts:

- potential equipment damage/stress on healthy assets due to undetected faults
- poor power quality due to voltage imbalance, flickers and voltage deviation
- increased likelihood of equipment/ground fire and electric shock

355. Switchgear replacement forecasts are based on historical failure rates and find rate of defects. Expenditure is consistent with investment levels during the AA3 period, and is predominantly to replace 39 RMUs per year.

Protective device management

356. During the AA4 period, Western Power will invest $19 million in protective device management.

357. This category contains distribution assets that provide protection to the primary assets. It includes drop-out fuses, sectionalisers, reactors and reclosers. Replacement of these assets is targeted at reducing the safety risk (ground fires, electric shock and physical impact) associated with failures of HV protective devices and associated components.

358. This equipment ages due to normal and abnormal electrical and mechanical stresses (switching load and short circuit currents) and environmental stresses. In addition, type defects may exist due to poor manufacturing, installation or past maintenance. Typical impacts of ageing include corrosion, loss of insulation (SF6 or oil), high resistance joints leading to hot spots, arcing, mechanical breakdown, mis-alignment of contacts or deterioration of specific components of the switchgear.

359. Reclosers provide the functionality to interrupt permanent faults and limit interruptions due to transient faults to a very short duration, thereby preventing asset damage and reducing the impact of potential network outages. The incorrect operation, failure, or absence of reclosers will have an adverse impact on reliability, power quality, safety and bushfire mitigation strategies. Following a targeted replacement program in AA3, only 17% of reclosers are the hydraulic (non-automated) type. Non-automated reclosers impede the bushfire mitigation plan in extreme and high fire risk zones because their settings cannot be remotely adjusted from the network control centre.

360. Expulsion drop-out fuses are used to protect transformers, cables and network spurs from overload and fault conditions. Under fault conditions, when the current flow exceeds the rating of the fuse, the fuse carrier 'drops out' of a fuse bracket. The hanging fuse carrier facilitates identification of a blown fuse and assists repair crews to identify faults quickly.

361. Sectionalisers operate as isolating devices. They count the number of operations of the recloser in the event of a fault. After a pre-set number of operations of the recloser, the sectionaliser will open its contacts whilst the network is in a de-energised state, so as to isolate the faulted section of the network. Surge arrestors limit surge voltages, protecting plant or line by diverting surge currents to ground.

362. The majority (three quarters) of the forecast investment is on replacement of reclosers. The remainder is on drop-out fuses, with only minor investment in sectionalisers and surge arrestors).

Cable management

363. During the AA4 period, Western Power will invest $8 million in cable management.

364. This expenditure category covers the underground cables distributing power from zone substations to customer load centres, as well as associated Henley cable boxes. Western Power's distribution network has 25,157 km of underground cables in service.

365. Underground cables can provide reliability benefits compared to overhead lines, as they are less likely to be impacted by inclement weather or vehicle accidents. However, they can develop defects over their service life from insulation deterioration (caused by oil or water ingress, termites, or fault overload), external damage (e.g. if they are struck when the ground is dug up), lightning, or electrical stress. These factors can lead to cable failure. The main impacts of failures of these assets are:

- customer supply interruptions
- electric shock to the public or the Western Power workforce through direct contact with the cable from drilling or excavation activities
- ground fires as a result of cable termination failures
- environmental damage as a result of ground fires.

366. Underground cables are subject to limited inspection and condition assessment due to the difficulty associated with accessing the buried assets. As a result, we replace or repair underground cables upon failure. Henley cable boxes are replaced opportunistically, i.e. whenever a pole on which a Henley cable box is mounted is replaced or a cable terminating in a Henley cable box is replaced.

Other replacement

367. This activity historically contains minor asset replacement works. The AA4 capital expenditure forecast now also includes the distribution component of transmission driven projects such as the replacement of transmission indoor switchboards in addition to an increase forecast in minor asset replacement works.

368. Forecast expenditure in this category for the AA4 period is $20 million.

1.2.2.3.2 Metering

369. Western Power currently installs basic meters at small use customers' premises. These meters are manually read every two months with only basic consumption and net generation data being recorded.

370. The capital cost of the meters is included in Western Power's RAB and the ongoing operational expenses, such as manual meter reading, are considered to be part of the cost of operating the network. As such, all customers pay for metering as part of their tariff.

371. Advanced meters are now routinely deployed by utilities around the world, and research indicates that the benefits across the electricity value chain outweigh the costs of deployment over the meter's life. Feedback from our customer engagement program indicated that customers support the adoption of advanced meters where efficient to do so.

372. Western Power proposes to change the default replacement meter from basic meters to advanced meters. Western Power plans to deploy advanced meters and associated communications infrastructure over the next 15 years, including 355,000 new and replacement meters during the AA4 period.

373. Benefits of the Advanced Metering Infrastructure (**AMI**) proposal include:

- the opportunity to defer network investment associated with peak demand reduction (from more cost-reflective tariffs, such as TOU and demand-based tariffs) and improved power factor and other programs;
- reduced capex and opex through service connection condition monitoring by advanced meters
- reduced back-office support costs (e.g. call centre) due to quicker access to better data
- reduced fieldwork costs as a result of fewer in-field scheduled and non-scheduled meter reads, re-energisation and de-energisation, power quality investigations[51] and unnecessary site visits
- reduced technical losses due to improved balancing between phases and voltage management

51 The Connections Management forecast in Regulatory Compliance expenditure category assumes the adoption of advanced meters.

- reduced non-technical losses (theft) as a result of access to near real time energy consumption data and tamper alarms.

374. Investment in AMI is forecast at $137 million. Metering capex also includes the associated communications infrastructure and ICT system costs to facilitate remote acquisition of interval data and meter alarms.

375. We efficiently minimise meter costs under section 6.52(a) of the Access Code by conducting open tenders to procure meters at market tested prices. An internal assessment concludes that the NFIT is satisfied and that the recommended investment will be assessed as approved expenditure and thus be subject to a regulatory return in the AA4 period. Cost and benefit modelling associated with the incremental expenditure to move to an AMI minimum specification maintains a positive NPV over 15 years.

376. There is the potential that demand for advanced meters may be greater/less than Western Power has forecast, particularly if future market reforms require a retailer-led implementation of advanced metering services. Therefore, we propose AMI investment be subject to the IAM.

1.2.2.3.3 Pole management

377. Western Power's distribution network consists mostly of wood poles (98 per cent of distribution power poles are wooden). During the AA3 period Western Power made significant improvements in its wood pole asset management practices, replacing/reinforcing approximately 270,000 wood poles. The AA3 pole replacement program was driven by Energy*Safety* Order 2009-01, which required Western Power to address the safety risk associated with its rural wood pole population.

378. During the course of satisfying the Energy*Safety* order, we have gathered more information on the condition and risk associated with wood poles and have used this to develop an efficient, risk based pole management program for AA4.

379. At the end of June 2016, asset condition data indicated approximately 253,000 wood poles remain in the network that require treatment (either replacement or reinforcement). However, not all of these poles require immediate treatment over the AA4 period. We have designed an AA4 works program that will treat around 125,000 wood poles, prioritising those that are in the poorest condition and/or pose the highest public safety risk.

380. For example, approximately 16 per cent (~40,000) of the 253,000 outstanding poles are located in extreme/high bushfire risk zones or in high risk public safety zones[52]. These highest risk poles are prioritised for treatment during the AA4 period.

381. The progress we have made in our risk based renewal approach, combined with better asset data, means we can maintain the overall network safety risk associated with distribution wood poles despite the lower replacement/reinforcement volumes compared to the AA3 period. This is because the majority of poles with the greatest identified risk will have been treated.

382. Further, the mixture of reinforcement and replacement forecast for the AA4 period is different to that of the AA3 period. During the AA4 period, around 61,000 (48 per cent) of the 125,000 poles identified for treatment will be replaced, and the remainder reinforced. During the AA3 period, approximately 82,000 (30 per cent) of the 270,000 treated poles were replaced. The high proportion of reinforcement during the AA3

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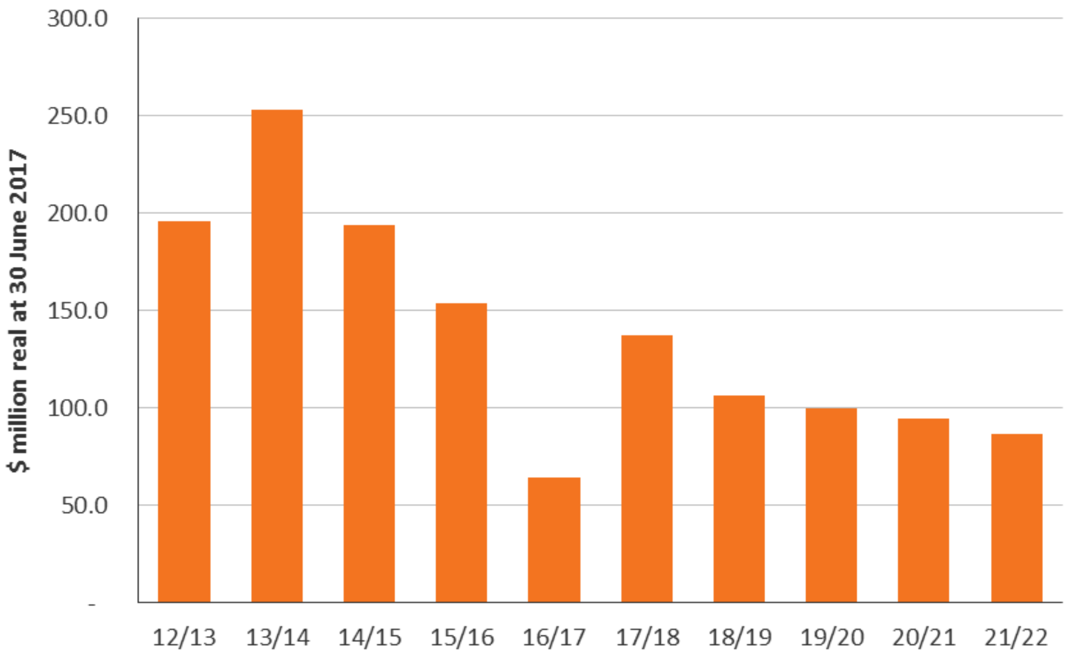
52 For example near to schools, bus stops, or other densely populated areas where there is a greater risk that the public may come in to contact with assets if they fail.

period was primarily due to the high volume of poles that required treatment under the Energy*Safety* order.

383. Though replacement is more expensive than reinforcement, it is a longer-lasting solution and a more prudent form of treatment for the highest risk/poorest condition assets. Increasing the proportion of replacements compared to reinforcement will allow Western Power to maintain the current overall safety risk associated with wood poles while treating a smaller total volume of poles at a lower overall cost than during the AA3 period.

384. Forecast expenditure on distribution wood pole replacement / reinforcement in AA4 is $525 million. This is 39 per cent less than incurred during the AA3 period (see Figure 1.18).

Figure 1.18: Comparison of AA3 actual and AA4 forecast pole management capex, $ million mean at 30 June 2017[53]



385. Key changes in the wood pole management capex for the AA4 period include reductions achieved by focusing on risk reduction per dollar spent. This is possible due to better asset data, and further understanding of risk, and a better risk management tool (NRMT).

386. Challenges for the AA4 period are listed below.

- Approximately 7 per cent of the distribution wood pole population has exceeded MRL. If replaced only on failure, this will reach 20 per cent in five years (by 30 June 2022) and 34 per cent in 10 years (by 30 June 2027).
- 19 per cent of poles that are operating beyond MRL are in high risk zones (7,303). This is 1% per cent of the entire pole population.
- 58 per cent of the distribution wood pole population is Jarrah. These poles often develop an internal rot that can remain undetected during inspection.

53 Excluding forecast labour cost escalation.

- Wood cross arms often deteriorate earlier than the poles they are attached to, thus creating a potential requirement to replace the pole-top-structures (cross-arm, insulators) mid-life of the main structures. Western Power's approach to asset creation in previous decades has not allowed for this requirement.

387. Refer to the Network Management Plan for more information on the reinforcement and replacement strategies.

388. AA4 distribution asset replacement expenditure has been assessed as meeting section 6.52(b)(iii) of the Access Code. Evidence from condition monitoring and inspections is used to demonstrate that there is a high likelihood that the safety or reliability of the covered network will not be maintained if not for the investment. This is documented in the Network Management Plan.

389. AA4 distribution asset replacement expenditure has been assessed as efficiently minimising costs under section 6.52(a) of the Access Code as described in chapter 8 of the AAI. The Network Management Plan outlines the risk management practices that are in place to manage network assets to ensure the safety and reliability of the covered network. Using wood pole management as an example, we have efficiently minimised costs by ensuring that:

- the management plan applies to a ten-year planning horizon, taking into account the lowest sustainable cost of providing the covered services forecast[54]
- poles are maintained or reinforced where possible and only replaced when this is no longer an option (efficiently minimising cost)
- only high risk poles are reinforced or replaced, based on serviceability defined through the inspection cycle
- work is bundled where possible so that all conditions existing on a pole are rectified at the same time, reducing the costs of crew mobilisation.

390. The AA4 plan is to monitor condition through routine inspections. Every structure in extreme and high fire risk zones or very high and high public safety zones, will be inspected at least once every year as a part of visual or vegetation inspection.

391. Consistent with customer feedback, capex during the AA4 period is designed to maintain the current network safety risk rather than improve the overall network wood pole risk rating. We will target expenditure on areas of the network where we achieve the highest risk reduction per dollar spent in order that the network safety risk level is maintained. The asset replacement and renewal selection also considers delivery efficiencies alongside risk reduction, to deliver the optimal asset replacement plan.

*1.2.2.3.4 The State Underground Power Program (**SUPP**)*

392. SUPP is an initiative where Western Power replaces overhead power lines with underground power infrastructure. The SUPP is a partnership between the State Government, Western Power and local governments.

393. Since it was initiated (in 1996), SUPP has converted around 87,000 households to underground power.[55] In January 2017 the State Government announced the sixth round of funding for SUPP. Of the 62 applications received, 17 projects were chosen. Works started in 2017 and are expected to be completed by the end of

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54 Access Code, section 6.52(a) (ii).

55 Western Power, as at November 2016 - available at: https://westernpower.com.au/community/projects/

2021. Western Power has forecast to invest $124 million in SUPP during the AA4 period. This compares to $73 million invested during the AA3 period. The increase is because more councils have approached Western Power requesting retrospective undergrounding, therefore Western Power is undertaking more projects than in the AA3 period.

394. New facilities investment in SUPP is expected to only partially satisfy section 6.52(b) (iii) of the Access Code, where the new facility is necessary to maintain the safety or reliability of the covered network or its ability to provide contracted services. As a result, we only partially contribute to the cost of the program, reflecting the expected benefits in reliability and avoided maintenance costs.

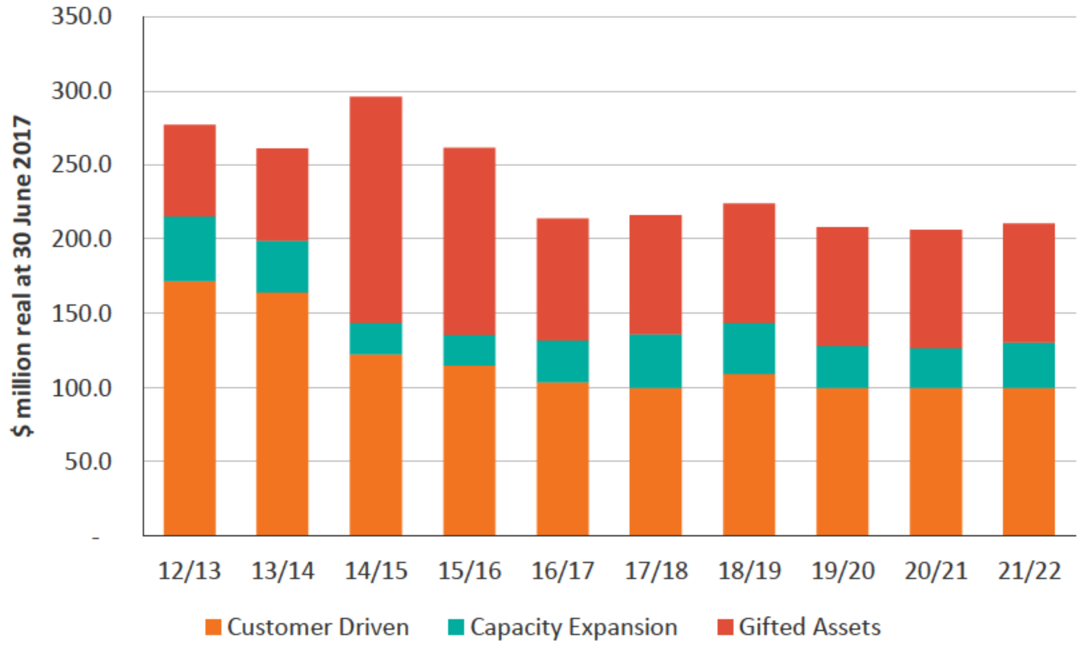
395. AA4 SUPP expenditure has been assessed as efficiently minimising costs under section 6.52(a) of the Access Code. In addition, we are able to leverage our existing contracting arrangements, which offer continuity of work to our contractors in exchange for a competitive fixed price contract, to ensure we are efficiently minimising costs.

1.2.2.4 Distribution growth capex

396. Growth capex (both distribution and transmission) is typically one of the largest components of forecast network expenditure, yet actual expenditure is heavily dependent on external factors. Therefore as per transmission, all distribution growth capex will remain subject to the IAM.

397. Western Power will invest $1,065 million in distribution growth projects during the AA4 period. Of this, $659 million will be recovered via customer contributions and gifted assets. Overall distribution growth capex investment is $245 million (19 per cent) less than that incurred during the AA3 period (see Figure 1.19).

Figure 1.19: Comparison of AA4 and forecast AA3 actual distribution gross growth capex by expenditure sub-category, $ million real at 30 June 2017[56]



398. Table 1.17 shows forecast distribution growth capex for the AA4 period.

Table 1.17: AA4 forecast distribution growth capex, $ million real at 30 June 2017[57]

Distribution growth capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Capacity expansion	36.2	34.7	28.3	26.6	30.7	156.5	4.2%
Customer driven	99.8	109.1	99.8	99.8	99.8	508.1	13.7%
Gifted assets	80.0	80.0	80.0	80.0	80.0	400.0	10.8%
Gross growth capex	**216.0**	**223.8**	**208.1**	**206.4**	**210.5**	**1,064.6**	**28.6%**
Less contributions	129.9	139.2	129.9	129.9	129.9	658.7	
AA4 distribution growth capex to be added to the RAB	**86.1**	**84.6**	**78.2**	**76.5**	**80.6**	**405.9**	

399. Distribution growth capex is split into three sub-categories:

- distribution capacity expansion

56 Excluding forecast labour cost escalation.

57 Excluding forecast labour cost escalation.

- distribution customer driven projects
- gifted assets.

400. Gifted assets are treated as a capital contribution and are not added to the regulated asset base (RAB). The distribution growth expenditure sub-categories are discussed below.

1.2.2.5 Distribution growth capex – capacity expansion

401. Western Power will invest $156 million to expand capacity in the distribution system. While transmission capacity expansion generally comprises a small number of large projects (see section 1.2.1.4.1), distribution growth projects tend to be small and high volume. Capacity expansion works augment the distribution network to ensure the growing demand for energy can be met.

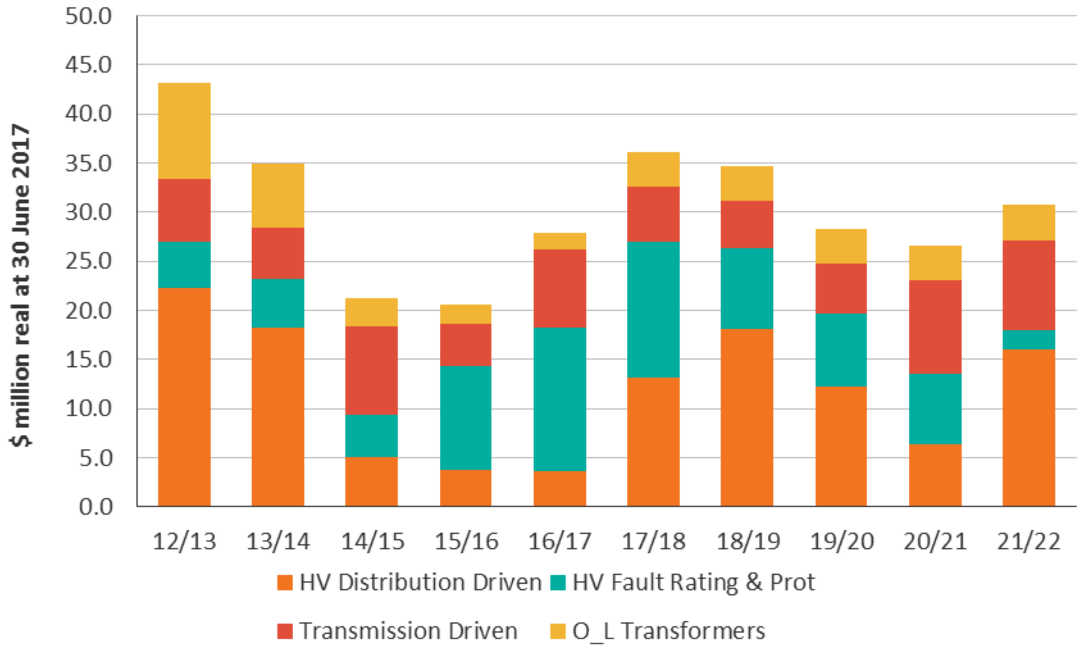
402. Works include constructing new distribution assets or upgrading existing assets such as feeders, distribution transformers and protection management. Distribution capacity expansion is also heavily influenced by economic activity, housing growth and the uptake of solar rooftop systems.

403. The transmission network can also be a driver of growth capex works on the distribution network such as where work requires complementary activity on the distribution network to ensure the transmission capacity can be delivered to the distribution network.

404. Although forecast peak growth is flat, there are some parts of the network that will require reinforcement to mitigate against feeders reaching voltage limits or thermal constraints. We have also introduced new risk based planning methodologies to target capacity expansion in the highest risk areas. This is consistent with feedback from our customer engagement program, where customers have indicated they would prefer Western Power to maintain overall network performance/security and only target improvement in poor performing areas.

405. Distribution capacity expansion capex for the AA4 period is expected to be $9 million (six per cent) more than that incurred in the AA3 period (see Figure 1.20).

Figure 1.20: Comparison of AA3 actual and AA4 forecast distribution capacity expansion gross capex, $ million real at 30 June 2017[58]



406. AA4 distribution capacity expansion capex is designed to:

- reduce the number of feeders with a utilisation rate above 80 per cent (from 114 to 52), and feeders with a utilisation rate above 100 per cent from (62 to 30). We expect that by the end of the AA4 period this will reduce the number of customers at risk of long duration outages by eight per cent
- reduce the number of country feeders at risk of supplying voltage below limits and potentially causing equipment damage from four per cent to half a percent
- target zone substation distribution networks that have been assessed as having conductors which are not adequately fault rated
- target transformers with a capacity greater than 100 kVA that are predicted to fail due to overload during consecutive days of high temperature
- invest in distribution projects planned to be undertaken in conjunction with transmission capacity expansion projects.

407. The AA4 distribution capacity expansion forecast increase is driven largely by an increase in HV distribution driven and HV fault rating and protection expenditure. Expenditure in these two subcategories is primarily focused on addressing increasing demand in Mandurah, Rockingham, Bunbury and Busselton, and follow a period of lower-than-expected investment.

408. During the AA3 period Western Power began undertaking a whole of business review, culminating in the Business Transformation Program. When developing the Business Transformation Program, capacity expansion was identified as an area where there were significant opportunities for optimisation and

58 Excluding forecast labour cost escalation.

improvements, particularly given the slowdown in peak demand growth and average customer consumption.

409. As a result, the entire capacity expansion portfolio was reviewed as part of the asset management work stream in the Business Transformation Program. During the review a number of planned capacity expansion projects, particularly HV distribution driven works, were re-evaluated or scaled back while forward capacity expansion requirements were reassessed.

410. As discussed above, risk based growth planning was introduced and applied to the distribution growth capex forecasts. Further information on the distribution planning and optimisation approach can be found in Western Power's Network Development Plan.

411. Table 1.18 shows forecast distribution capacity expansion capex for the AA4 period.

Table 1.18: AA4 forecast distribution capacity expansion capex, $ million real at 30 June 2017[59]

Distribution capacity expansion capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
HV distribution driven	13.2	18.0	12.3	6.4	16.1	65.9	1.8%
HV fault rating and protection	13.9	8.2	7.4	7.1	1.9	38.5	1.0%
Transmission driven	5.6	4.8	5.0	9.5	9.2	34.1	0.9%
O_L transformers	3.6	3.6	3.6	3.6	3.6	18.0	0.5%
Gross capacity expansion capex	**36.2**	**34.7**	**28.3**	**26.6**	**30.7**	**156.5**	**4.2%**
Less contributions	-	-	-	-	-	-	
AA4 distribution capacity expansion capex to be added to the RAB	**36.2**	**34.7**	**28.3**	**26.6**	**30.7**	**156.5**	

412. Distribution capacity expansion capex is discussed in further detail in the following sections.

1.2.2.5.1 HV distribution driven

413. During the AA4 period, Western Power will invest $66 million on high voltage (HV) distribution driven projects. HV distribution driven expenditure is designed to ensure the parts of the network that are experiencing growth have sufficient capacity, and also that the following requirements in the Technical Rules are met:

- the distribution feeders do not exceed optimal utilisation levels
- the voltage is within the required limits

59 Excluding forecast labour cost escalation.

- the load on the network is balanced across the three phases
- there is the required level of redundancy in the network.

414. Forecast investment is $13 million (25 per cent) more than that incurred during the AA3 period.

415. Despite overall reduced peak demand growth and the economic conditions in Western Australia, most of the increase in HV distribution investment is due to continued growth experienced in localised areas such Mandurah, Rockingham, Ellenbrook, Waikiki, Bunbury, Muja load areas, and pockets in the Metro North, which are expected to experience steady growth in peak demand.

Meeting voltage limits

416. Voltage limits are specified in the Technical Rules to ensure the safe and efficient operation of customer loads. The voltage on distribution feeders reduces as the load supplied by the feeder increases. As the load on a feeder increases, the voltage may reduce to a level that is outside the allowable range. This is predominantly seen on long feeders, mostly in the rural areas. If no action is taken to increase the voltage, it may reduce to the extent that connected equipment and appliances will not function correctly or even at all.

417. We analyse the performance of the distribution network and identify where the voltage may be too low using power simulation software and network peak loading data. Once LV feeders are identified, we plan for remedial measures to maintain voltage support of the feeders. Such measures include the reinforcement of distribution feeders, installation of capacitor banks, voltage regulators, or the transfer of load to other parts of the network.

Maintaining balanced loads

418. Western Power's distribution network is predominantly a three phase configuration (with three conductors per circuit). In certain rural areas we have established extensive single phase networks which are sufficient to support the electricity needs of the area or locality (and where a more costly higher capacity three phase network cannot be justified).

419. Single phase networks can lead to a load imbalance on the three phase network that supplies them. This will in turn lead to a voltage imbalance on the three phase network. This affects the quality of the supply to existing customers and can cause electrical interference with any nearby telecommunications circuits affecting their ability to function correctly. If the voltage unbalance is not corrected, it could lead to mal-operation of their equipment or prevent new customers from connecting.

420. Voltage unbalance is identified by power simulation software and network peak loading data or through customer complaints of poor power quality. Two options to resolve this issue are the installation or upgrade of isolation transformers at the three phase to single phase transition on the network, or the upgrade of the single phase networks to three phase.

421. Western Power will continue to aim to reduce the number of metropolitan distribution feeders that are loaded above 80 per cent[60], thereby significantly reducing the number of customers at risk from long duration outages. We will reduce the maximum utilisation of feeders in the Perth CBD under normal operating conditions to 50 per cent, to provide the higher level of network security required by the Technical Rules.

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60 The level of interconnection of distribution feeders in the Perth metropolitan area allows a target utilisation of 80 per cent which is higher than the national benchmark level of 66 per cent.

422. This ensures that if a fault occurs on a feeder, the affected load can be supplied by other feeders without exceeding their rating. Supply is able to be maintained after a brief outage during the fault event. Customers will be able to remain connected to the network, whilst repairs are being made to rectify the fault. The ability to resupply customers minimises the reliability risk on the network.

423. By the end of AA4 if we consider no network reinforcement is implemented, there will be 176 distribution feeders that are overloaded relative to these targeted utilisation levels, with 62 having a utilisation of 100 per cent or more. During the AA4 period, we will identify and utilise risk based planning techniques to address overloaded feeders as part of the annual planning process.

424. Typical network solutions to address overloaded feeders consist of:

- upgrading the existing feeder to a higher capacity cable (keeping within current standards)
- installing a new feeder
- rebalancing or transferring the loads to existing interconnected feeders
- demand side management solutions.

425. In total, approximately 209 km of conductor (combination of overhead conductor and underground cable) will be installed over the AA4 period to reduce the utilisation of high risk overloaded distribution feeders.

426. The majority of feeder utilisation projects are targeted in areas of the network that are experiencing load growth. Though overall network peak demand has flattened over the AA3 period, demand in areas including Mandurah, Rockingham, Busselton and Bunbury is still growing at a faster rate than the network average. Key feeder reinforcement projects scheduled for the AA4 period are shown in Table 1.19.

Table 1.19: Key feeder reinforcement projects, $ real at 30 June 2017

Project	Description	AA4 expenditure
Busselton East feeder reinforcement	New feeder required for additional capacity due to overloaded feeders in Busselton	$5.7 million
Waikiki feeder reinforcement	New feeder required for additional capacity due to overloaded feeders in the Waikiki area	$2.6 million
Henley Brook feeder reinforcement	New feeder required for additional capacity due to overloaded feeders in the Ellenbrook area	$0.9 million

427. Details of projects designed to meet voltage limits and maintain balanced loads are provided in the Network Development Plan.

428. Thermal and voltage limitations under peak demand conditions examples include the Mandurah, Muja, Metro North and Bunbury load areas.

1.2.2.5.2 HV fault rating and protection

429. During the AA4 period, Western Power will invest $38 million to address rising fault levels on the distribution network as a result of the connection of new generation, network upgrades and changes in network topology and the need for more sensitive protection settings, as the network grows. This is a similar level to that invested during the AA3 period.

430. When faults occur on the electricity network, a current path to earth is established. The current that flows is referred to as the fault current, and is generally much higher than the normal load current. The maximum fault current that may flow is referred to as the fault level.

431. The equipment in the distribution network is designed to withstand a certain fault level. If the fault current exceeds this fault level, the physical characteristics of the conductor will be adversely affected. This may lead to conductor failure or a permanent sagging, which is a public safety risk.

432. As the electricity network grows over time, the fault levels rise. If the fault levels rise to a level that exceeds the fault level rating of the equipment, action needs to be taken to reduce the fault levels, replace the equipment with equipment that has a higher fault level rating, or increase the level of protection on the relevant section of conductor to prevent damage.

433. There is an estimated 1,234 km of under fault rated conductor on the Distribution OH network. A large proportion of these conductors are on Rural Long feeders which tend to be constructed with smaller sized and lower fault rated conductors. As discussed, the majority of Rural Feeders traverse the lower risk zones for both fire and public safety.[61]

434. Sixty per cent of zone substation distribution networks have been assessed to have conductors which are adequately fault rated. During the AA4 period the remaining 40 per cent of zone substation distribution networks will be assessed and where under-fault rated conductor is identified, the appropriate remedial action will be taken on a case by case basis.

435. To ensure equipment is not damaged when faults occur, protection devices are set to isolate the fault. Many protection devices installed may no longer be sufficiently sensitive to detect (and initiate isolation of) faults in the extremities of the distribution network. If this occurs, faults may remain on the network until (for example) the conductor burns to break the circuit and isolate the fault. This presents a safety and fire risk.

436. This issue can be resolved by investing in additional protection devices on the network and/or adjusting the sensitivity of devices that are already in service. Detailed protection studies are undertaken periodically to confirm the extent of the issue.

437. Forecast AA4 expenditure on HV protection will be focused in the following load areas:

- North Country
- Eastern Goldfields
- East Country
- Muja
- Bunbury
- Mandurah
- Kwinana
- Southern Terminal
- South Fremantle
- Cannington Terminal

61 Network Management Plan (p. 144) EDM# 34159326

- East Perth and CBD
- Western Terminal.

1.2.2.5.3 Transmission driven

438. During the AA4 period, Western Power will invest $34 million on projects to be undertaken in conjunction with transmission capacity expansion projects. This is a similar level to that invested during the AA3 period.

439. The distribution capacity expansion projects arise out of the need to:

- provide distribution capacity to accommodate new zone substation capacity and interconnection
- provide distribution feeder load transfer capability that enables utilisation of existing zone substation capacity
- maintain clearances between distribution and transmission assets as transmission lines are developed or augmented
- reinforce the distribution network to cater for a change in voltage levels from the zone substation
- provide distribution capacity to take up load from a decommissioned zone substation.

440. Transmission driven network expenditure is directly linked to transmission investment and forecast feeder requirements in order to meet Technical Rules. Transmission work requires complementary activity on the distribution network to ensure the transmission capacity can be delivered to the distribution network.

441. The current distribution investment forecast includes the CBD ($15 million), which is driven by the transmission CBD substation. Depending upon new load forecast studies and the new risk based approach to managing assets, the transmission substation work is likely to be postponed until the next regulatory period.

442. Examples of specific projects that will be undertaken during AA4 are set out in Table 1.20.

Table 1.20: AA4 transmission driven distribution capacity expansion projects, $ real at 30 June 2017

Project	Description	AA4 expenditure
CBD substation	Installation of a new 132/11 kV CBD substation to resupply the Forrest Avenue and Wellington Street substation loads and decommission both 66 kV substations	$14.5 million[62]
Address sensitivity issue	Distribution work to resolve protection sensitivity issues caused by inadequate sensitivity of transformer LV protection to back up the feeder circuit breaker protection	$4.2 million

62 Likely to be deferred to AA5.

Project	Description	AA4 expenditure
Mandurah Transformers	Distribution work on 2 x 66MVA transformers	$3.0 million[63]
Nedlands voltage conversion	Distribution network upgrades to enable change in distribution voltage of 6.6 kV to 11 kV	$2.5 million
Mundaring Weir decommissioning	Decommission Mundaring Weir substation and resupply distribution loads from Sawyers Valley substation via distribution network extension	$1.5 million

1.2.2.5.4 Overloaded transformers and LV cables

443. During the AA4 period Western Power will invest $18 million to address overloaded transformers and LV cables to ensure that service levels are maintained in accordance with the Access Code. This is $5.1 million (22 per cent) less than that incurred during the AA3 period.

444. As distribution transformers and LV cables become overloaded, there is an increasing likelihood of failure resulting in public safety risk and disruptions to customer supply. In 2004, Western Power introduced the transformer overload mitigation strategy in response to a significant number of distribution transformer failures. Since inception of the program, we have reduced the number of catastrophic transformer failures from more than 50 per annum to five or less per annum.

445. The program targets transformers with a capacity greater than 100 kVA that are predicted to be loaded above 135 per cent of their cyclic rating during consecutive days of high temperature. In the AA4 period, we will replace approximately 150 distribution transformers via the overloaded transformer program. Low voltage cable upgrades are replaced following repetitive fuse operations.

446. New facilities investments in distribution capacity expansion are only undertaken where section 6.52(b) (iii) of the Access Code is met. Section 6.52(b) (iii) of the Access Code requires that the new facility is necessary to maintain the safety or reliability of the covered network or its ability to provide contracted services.

447. AA4 distribution capacity expansion expenditure has been assessed as meeting section 6.52(b) (iii) of the Access Code. The network development plan and distribution network planning guidelines indicate the extent to which contracted covered services cannot be provided if not for the investment.

448. AA4 distribution capacity expansion expenditure has been assessed as efficiently minimising costs under section 6.52(a) of the Access Code as described in chapter 8 of the AAI. In addition, we efficiently minimise costs by ensuring that more costly network augmentations are deferred when non-network alternatives, such as procurement of generation or demand side management, represent the lowest sustainable cost option.

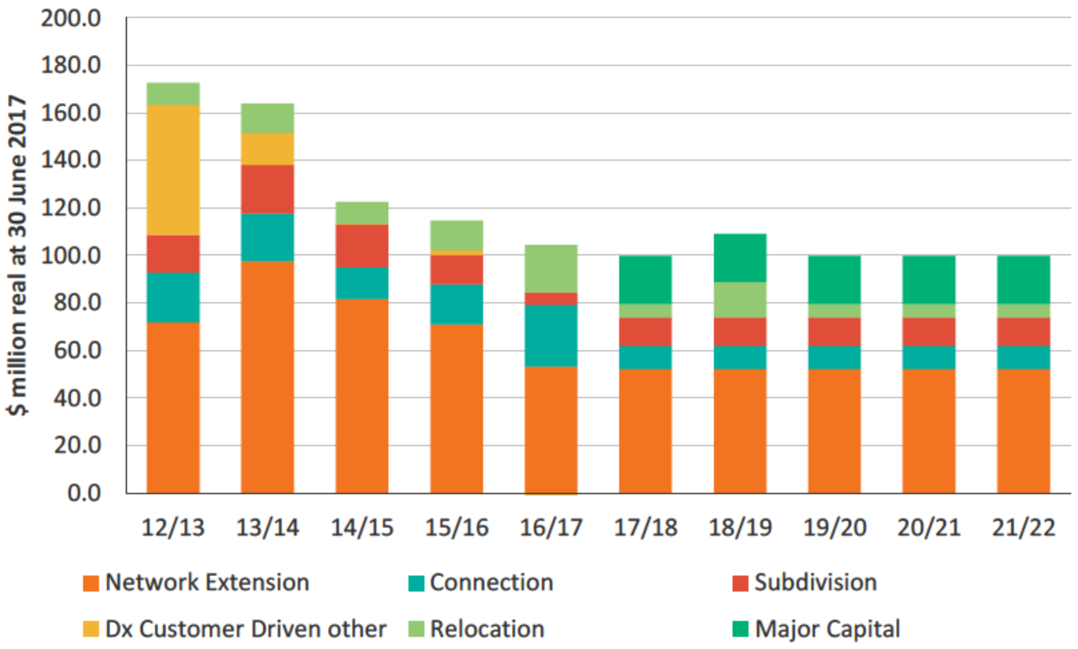
63 Likely to be deferred to AA5.

1.2.2.6 Distribution growth capex – customer driven

449. Distribution customer driven capex includes all work associated with connecting customer loads or generators, and the relocation of distribution assets at the request of a third party. Projects range from small residential connections (pole to pillar), through to network extensions to cater for large industrial customers. This category of investment generally includes high volumes of low cost works, thus historical expenditure tends to be a good indicator of future investment.

450. Western Power estimates it will invest $508 million (including capital contributions) during the AA4 period on customer driven distribution projects. This is $169 million (25 per cent) less than that incurred during the AA3 period (see Figure 1.21).

Figure 1.21: Comparison of AA3 actual and AA4 forecast distribution customer driven gross capex, $ million real at 30 June 2017[64]



451. For customer driven works, the connecting customer contributes the part of the investment that does not meet NFIT (typically the incremental revenue test in section 6.52(b)(i)(A) of the Access Code). The contribution is charged in accordance with Western Power's Contributions Policy.

452. Table 1.21 shows forecast distribution customer driven capex for the AA4 period.

Table 1.21: AA4 forecast distribution customer driven capex, $ million real at 30 June 2017[65]

Distribution customer driven capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Network extension	52.3	52.3	52.3	52.3	52.3	261.4	7.0%

64 Excluding forecast labour cost escalation.

65 Excluding forecast labour cost escalation.

Distribution customer driven capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Connection	9.6	9.6	9.6	9.6	9.6	48.1	1.3%
Subdivision	12.1	12.1	12.1	12.1	12.1	60.4	1.6%
Relocation	5.7	14.9	5.7	5.7	5.7	37.6	1.0%
Major capital	20.1	20.1	20.1	20.1	20.1	100.6	2.7%
Gross customer driven capex	**99.8**	**109.1**	**99.8**	**99.8**	**99.8**	**508.1**	**13.7%**
Less contributions	49.9	59.2	49.9	49.9	49.9	258.7	
AA4 distribution customer driven capex to be added to the RAB	**49.9**	**49.9**	**49.9**	**49.9**	**49.9**	**249.4**	

453. Annual connections capex during the AA4 period has been forecast at broadly similar levels to recent years. However, as previously outlined, customer driven capex levels directly reflect customer requirements, which can be subject to substantial change during an access arrangement period. Any variation to forecast will be adjusted via the IAM in the AA5 period.

454. New facilities investments in distribution customer access projects are only undertaken where section 6.52(b)(i) of the Access Code is met or the connecting customer contributes that part of the investment that does not meet section 6.52(b). Section 6.52(b)(i) of the Access Code requires that the anticipated incremental revenue for the new facility is expected to at least recover the new facilities investment.

455. The connecting customer contributes that part of the investment that does not meet the incremental revenue test, in accordance with the *Contributions Policy* developed under sections 5.12 to 5.17 of the Access Code.

456. Relocation of existing assets generally does not satisfy section 6.52(b) of the Access Code and hence contributions are generally sought from the party requesting the relocation for the full amount of the efficient investment in these works.

1.2.2.6.1 Distribution gifted assets

457. In some instances, a third party (for example a land developer or major industrial load) may pay for the construction of new distribution assets to distribute electricity to their premises. Once the assets have been constructed, the third party transfers the ownership, and operation and maintenance, to Western Power. These are known as gifted assets.

458. During the AA4 period, we expect Western Power will receive ~$400 million of distribution gifted assets. These assets are not added to the regulated asset base because we do not incur capital costs for their construction. However, the gifted assets forecast is a key part of Western Power's access arrangement proposal as the business must ensure it collects sufficient revenue to recover the cost of operating and maintaining the new assets.

Table 1.22 shows the forecast capex value of gifted assets for the AA4 period.

Table 1.22: AA4 forecast gifted assets, $ million real at 30 June 2017[66]

Distribution gifted assets	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Gifted assets	80.0	80.0	80.0	80.0	80.0	400.0	10.8%
Less contributions	80.0	80.0	80.0	80.0	80.0	400.0	
AA4 distribution gifted assets to be added to the RAB	-	-	-	-	-	-	

1.2.2.7 Distribution improvement in service capex

459. This expenditure category covers reliability driven capex and investment in SCADA and communications systems. Reliability driven capex is designed to achieve reliability and power quality service standard targets for the distribution network. This SCADA and communications capex is designed to improve monitoring and control of the distribution network.

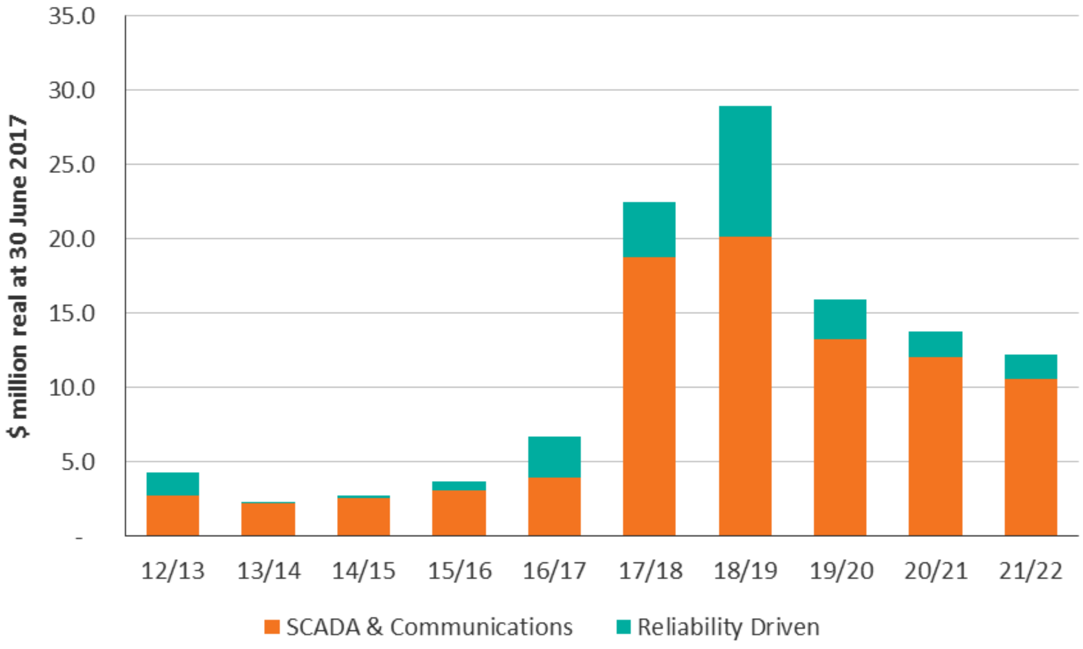
460. Feedback during our recent customer engagement program indicates that customers are generally satisfied with overall current levels of performance. As a result, Western Power's reliability driven expenditure during AA4 is designed to maintain service at the levels achieved at the end of the AA3 period, noting that service performance has improved over the past five years. While we will target parts of the network that are performing below service standards, we do not expect network-wide performance to improve.

461. The service standard targets and benchmarks in the regulatory incentive scheme for the AA4 period are set at more challenging levels than those set at the beginning of the AA3 period. As a result, distribution reliability driven capex will be greater during the AA4 period in order to achieve the service performance targets.

462. Western Power will invest $94 million in distribution improvement in service capex during the AA4 period. Of this, forecast distribution reliability driven expenditure during the AA4 period is $19 million. This is $14 million more than incurred during AA3 period. Forecast distribution SCADA and communications expenditure is around $75 million. This is $60 million more than in the AA3 period (see Figure 1.22).

66 Excluding forecast labour cost escalation.

Figure 1.22: Comparison of AA3 actual and AA4 forecast distribution improvement in service gross capex by expenditure sub-category, $ million real at 30 June 2017[67]



463. The increase in SCADA and communication investment is required to replace obsolete SCADA and communication equipment and maintain the performance of system monitoring and control. Approximately $17 million of proposed distribution SCADA and communication investment is required to upgrade the master station so that this essential system remains vendor supported. Approximately $21 million relates to infrastructure to support implementation of advanced metering.

464. The increase in reliability driven investment is required to maintain current levels of service performance. For example, Western Power proposes to install distribution automation systems in the Perth CBD to mitigate potential reliability issues resulting from ageing underground high voltage cables.

465. Failure rates of underground HV cables in the CBD are forecast to increase over the next 10 years. A cable replacement program will take considerable time to deliver, and will be very costly. In the meantime, to maintain reliability, we will install distribution automation equipment that remotely identifies, isolates and reconfigures the distribution network. The distribution automation equipment provides a cost effective short-term alternative to traditional network maintenance or upgrades, and can also help to reduce the time taken to partially or fully restore power to customers following a fault.

466. Distribution improvement in service investment also includes the Kalbarri microgrid project, which is designed to address the poor levels of reliability experienced by residents in the popular holiday town of Kalbarri.

467. Table 1.23 shows forecast distribution improvement in service capex for the AA4 period.

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67 Excluding forecast labour cost escalation.

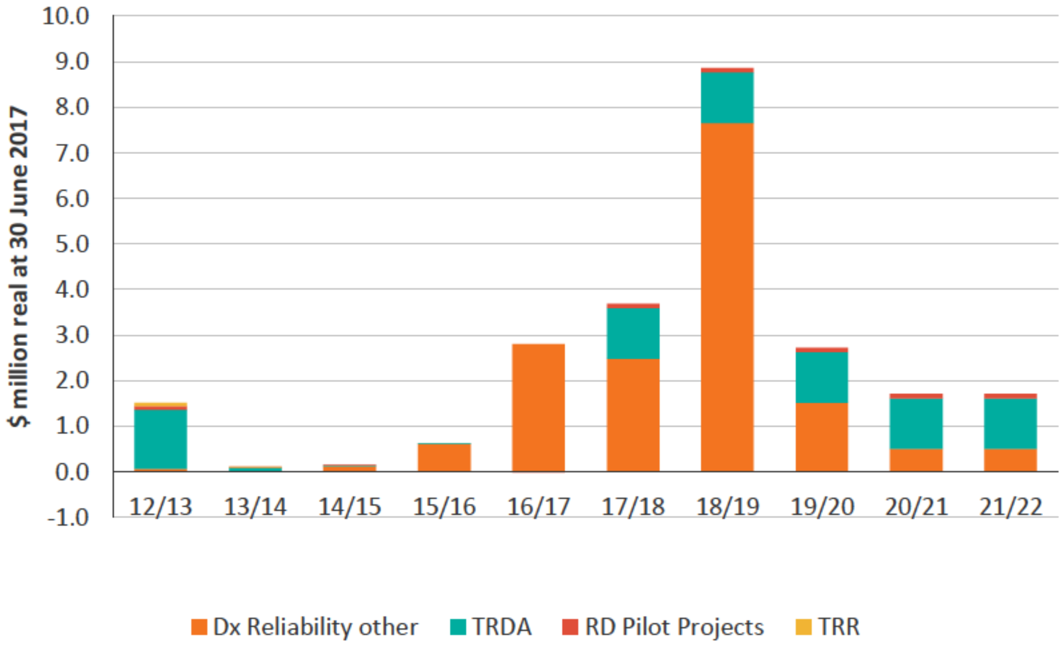
Table 1.23: AA4 forecast distribution improvement in service capex, $ million real at 30 June 2017[68]

Distribution improvement in service capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Reliability driven	4.2	8.9	2.7	1.7	1.7	19.2	0.5%
SCADA & comms	18.8	20.1	13.2	12.1	10.5	74.8	2.0%
Gross improvement in service capex	**23.0**	**29.0**	**16.0**	**13.8**	**12.2**	**94.0**	**2.5%**
Less contributions	-	-	-	-	-	-	
AA4 distribution improvement in service capex to be added to the RAB	**23.0**	**29.0**	**16.0**	**13.8**	**12.2**	**94.0**	

1.2.2.7.1 Distribution reliability driven

468. During the AA4 period, Western Power will invest $19 million in distribution reliability driven projects. This compares to the $5 million incurred in this expenditure category during the AA3 period (see Figure 1.23).

Figure 1.23: Comparison of AA3 actual and AA4 forecast distribution reliability driven gross capex, $ million real at 30 June 2017[69]



68 Excluding forecast labour cost escalation.

69 Excluding forecast labour cost escalation.

469. The increase in distribution reliability capex is primarily due to the Kalbarri microgrid project (discussed below), which accounts for $7.9 million of the 'distribution reliability other' expenditure category.

470. Other distribution reliability projects include:

- distribution fuse savers which will reduce the number of intermittent faults causing drop out fuse trips
- finalise battery storage to mitigate poor reliability issues in the Perenjori and Morawa areas
- self-healing networks.

471. These projects are all to address poor reliability performance experienced by customers in specific parts of the network. These works are not designed to improve overall network SAIDI or SAIFI performance.

472. Each of these projects involve trialling new or alternative technology. The sites chosen are on rural long feeders which have high value renewal costs. Alternative technology solutions present a cost effective option to address reliability issues as well as removing the need to invest highly on rebuilding the network supplying these areas. The projects will also provide valuable data and insights into how technology can be used as a substitute for traditional network solutions, and may lead to similar technologies being applied across the Western Power Network where efficient to do so.

473. Targeted reliability driven automation (**TRDA**) relates to investment in SCADA, protection and automation protection schemes, and is required to support the broader SCADA and communications investment described below.

474. In addition, around $0.5 million has been allocated for research and development pilot projects, undertaken by Western Power's network operations engineers. This includes a distance to fault wave travelling pilot project, and a network self-healing project which studies network topology and uses existing automated devices (telemetered RMUs, reclosers and load break switches) to quickly restore supply to customers under fault scenario. This self-healing project will benefit Western Power by maintaining / improving reliability in certain targeted areas in the network.

Table 1.24: AA4 forecast distribution reliability driven capex, $ million real at 30 June 2017[70]

Distribution reliability driven capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total	% of total WP gross capex
Distribution reliability other	3.0	7.7	1.5	0.5	0.5	13.1	0.4%
Targeted reliability driven automation	1.1	1.1	1.1	1.1	1.1	5.6	0.1%
RD pilot projects	0.1	0.1	0.1	0.1	0.1	0.5	0.0%
TRR	-	-	-	-	-	-	0.0%
Gross distribution reliability driven capex	**4.2**	**8.9**	**2.7**	**1.7**	**1.7**	**19.2**	**0.5%**
Less contributions	-	-	-	-	-	-	

70 Excluding forecast labour cost escalation.

Distribution reliability driven capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total	% of total WP gross capex
AA4 distribution reliability driven capex to be added to the RAB	**4.2**	**8.9**	**2.7**	**1.7**	**1.7**	**19.2**	**0.5%**

475. New facilities investments in distribution reliability driven are only undertaken where section 6.52(b)(iii) of the Access Code is met, or the anticipated benefits awarded under the service standard adjustment mechanism outweigh the cost. Section 6.52(b)(iii) of the Access Code requires that the new facility is necessary to maintain the safety or reliability of the covered network or its ability to provide contracted service.

476. AA4 distribution reliability driven expenditure has been assessed as meeting section 6.52(b)(iii) under the Access Code. This investment will enable future opportunities through innovation and new technology to efficiently minimise costs while achieving the service standard benchmarks. In the AA4 period, we will also rely on the financial incentive rates under the service standard adjustment mechanisms to determine the point at which the customer value placed on a desired service level outweighs the delivery cost.

1.2.2.7.2 Kalbarri microgrid

477. During the AA4 period, Western Power will invest $8 million to build and energise a microgrid to improve reliability in the town of Kalbarri.

478. Though overall network reliability is good, there are parts of the network that experience poorer reliability than elsewhere in the SWIS. These reliability hot spots are typically in regional WA and at the extremities of the Western Power Network.

479. Kalbarri has been identified as a reliability hot spot. It is supplied solely through a 140 km, 33 kV feeder from Geraldton. The feeder is exposed to environmental factors (wind-borne marine salt and dust pollution) that make it particularly prone to pole-top fires, which can lead to extended outages on the line. The feeder is one of the worst performing on the Western Power Network, and customers suffer a high frequency of outages.

480. In October 2016, Western Power conducted a feasibility study, which identified options for improving reliability for the residents and many tourists that visit Kalbarri each year.[71] Options were assessed against the following criteria:

- deliverability
- NFIT compliance
- contribution to reduction of rural long SAIFI
- alignment with the distribution network reliability performance strategy
- strategic value of investigating in new technologies.

481. The four options assessed were:

71 A summary of the Kalbarri microgrid is available on the Western Power website www.westernpower.com.au.

1. Building a backup diesel power station microgrid.
2. Building a Battery Energy Storage System (**BESS**) microgrid.
3. Building a new feeder to Kalbarri.
4. Maintaining the status quo.

482. Option 4 (status quo) has not been financially assessed as it would not deliver the desired reliability improvement.

483. Option 3 (new feeder) is financially prohibitive. Investment costs of building a new feeder would be in the region of $26 million. It would also be subject to the same environmental conditions as the existing line, which means there may not be any significant reliability improvement. It would not be economic to place a 140 km line underground.

484. Options 1 and 2 are technically and financially viable solutions. A microgrid solution offers the enhanced reliability desired by customers, while being considerably less expensive than a new feeder.

485. Increased maintenance activities such as insulator siliconing and more extensive vegetation clearance has had a positive impact on the reliability of the Kalbarri feeder but, ultimately, the radial nature of the Kalbarri supply means that short of duplicating or undergrounding the supply line to Kalbarri, the most impactful way to improve the reliability of power supplies at Kalbarri is to introduce local generation that can supply the town in the event of loss of supply from Geraldton.

486. Potential solutions where shared with local stakeholders and the community, with the preferred options being 1 and 2. Work is ongoing to determine whether the microgrid would be diesel or BESS powered, however, there is community support for a microgrid solution. The difference in net present cost between a diesel or a BESS microgrid is relatively small (less than 15 per cent). Therefore both of these options are being explored further in the planning phase of the Kalbarri microgrid project.

487. What makes Kalbarri particularly suitable for a microgrid solution is the potential for the microgrid to be powered by a mixture of generation types, including wind. The Kalbarri windfarm generates sufficient power to meet more than 50 per cent of Kalbarri's load more than 30 per cent of the time. Generation from the windfarm is currently not available when the interconnector between Kalbarri and Geraldton is out of service as the generator relies on the Western Power Network to operate.

488. Connecting the Kalbarri windfarm to a Kalbarri microgrid will mean the town can be supplied by mix of generation that is not dependent on the Kalbarri feeder being operational. The solution will also provide valuable information on how windfarms (and other non-dispatchable power sources) impact microgrids and how microgrids will interact with the main Western Power Network.

489. There has been broad support for a microgrid from the Kalbarri community. Investigation into the costs and technical solution has begun, and further consultation with Kalbarri stakeholders is planned for November and December 2017.

490. In summary, the anticipated benefits of the microgrid are:

- fewer and shorter duration outages for customer in Kalbarri
- improved rural distribution asset utilisation
- valuable data on the interaction of microgrids with the main network and feasibility of similar solutions for other regional networks.

491 The project is expected to commence in 2018.

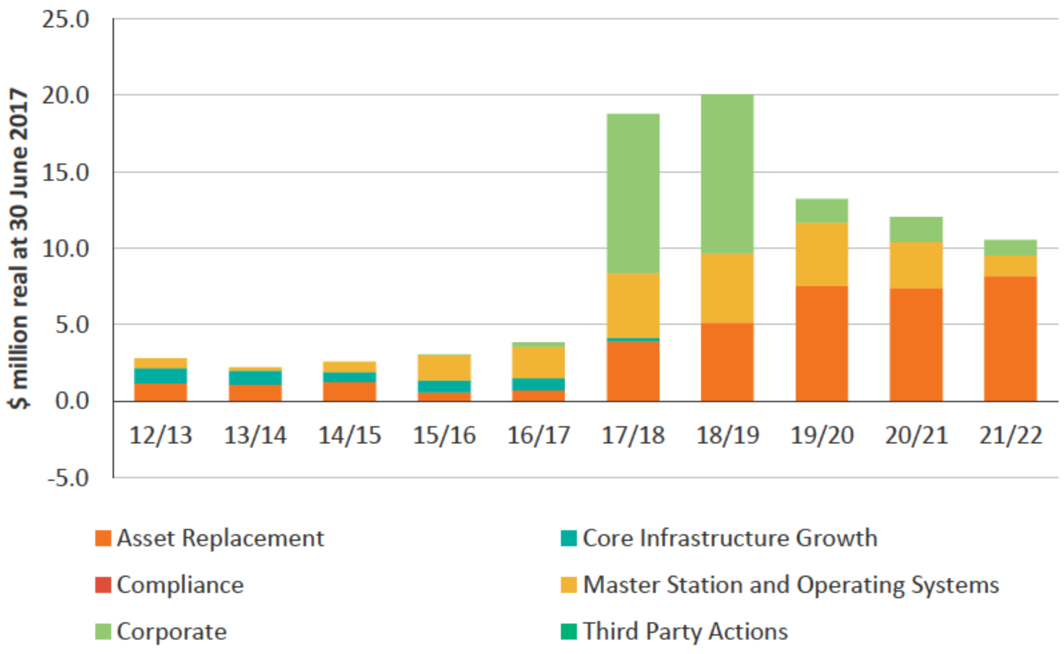
1.2.2.7.3 Distribution SCADA and communications

492. Western Power's SCADA and communications assets provide the information and technology services required to protect, operate and manage the transmission and distribution networks and the Wholesale Electricity Market.

493. Western Power forecasts a significant uplift in investment in SCADA and communications investment for the distribution network. The new SCADA and communication systems will provide the backbone to advanced metering infrastructure, and will allow more efficient operation and control of the distribution network.

494. Figure 1.24 shows how the AA4 forecast distribution SCADA and communications capex compares with that incurred during the AA3 period.

Figure 1.24: Comparison of AA3 actual and AA4 forecast distribution SCADA and communications capex, $ million real at 30 June 2017[72]



495. The increase in distribution SCADA and communication investment is required to replace obsolete SCADA and communication equipment and maintain the performance of network monitoring and control. Table 1.25 shows forecast distribution capex on the SCADA and communications network.

Table 1.25: AA4 forecast SCADA and communications distribution capex, $ million real at 30 June 2017[73]

Distribution SCADA and communications capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total	% of total WP gross capex
Asset replacement	3.9	5.2	7.6	7.4	8.2	32.2	0.9%

72 Excluding forecast labour cost escalation.

73 Excluding forecast labour cost escalation.

Distribution SCADA and communications capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total	% of total WP gross capex
Core infrastructure growth	0.2	-	-	-	-	0.2	0.0%
Compliance	-	-	-	-	-	-	0.0%
Corporate	10.5	10.5	1.6	1.7	1.0	25.1	0.7%
Master station	4.2	4.5	4.1	3.0	1.3	17.2	0.5%
Third party actions	-	-	-	-	-	-	0.0%
Gross SCADA and communications capex	**18.8**	**20.1**	**13.2**	**12.1**	**10.5**	**74.8**	**2.0%**
Less contributions	-	-	-	-	-	-	0.0%
AA4 transmission SCADA and communications capex to be added to the RAB	**18.8**	**20.1**	**13.2**	**12.1**	**10.5**	**74.8**	**2.0%**

496. Further detail on specific distribution SCADA and communications investment is provided below.

Asset Replacement

497. During the AA4 period, Western Power will invest $32 million on the replacement of obsolete SCADA and communications assets that are critical to operations. This is a $27 million increase on the AA3 period. Obsolete assets include:

- the distribution backhaul radio network
- mobile voice radio
- CBD SCADA
- the distribution automation communication network.

498. In many cases these assets are operating well beyond their design life. Deferral beyond the AA4 period poses a risk to safe and reliable performance of the distribution network, as well as compromising the ability to integrate new technology and alternative network solutions into the SWIS. Key distribution SCADA and communications asset replacement programs scheduled for the AA4 period are described below.

Distribution backhaul radio network

499. The distribution backhaul radio network is comprised of 88 communications sites (including communications towers, equipment shelters, power supplies and communication equipment). This forms a series of point-to-point UHF or VHF radio links that connect the mobile voice, distribution automation (DA) and last mile communications networks with the transmission backhaul communications network (which provides connectivity to the master stations). In certain situations, the distribution backhaul radio network also provides the necessary radio links for transmission protection and transmission SCADA.

500. Currently, the existing single/dual channel UHF radio links are deployed as the backhaul to provide the connectivity between mobile voice and DA. These analogue links are outdated, not compliant to technical

rules and have reached their capacity. All of these assets have reached the end of their product life cycle and key assets are displaying increasing failure rates.

501. A suitable upgrade path is available via IP radio technology, which will provide improved functionality and additional capacity to support future DA, SCADA, protection, advanced metering and IT connectivity as well as mitigating the risk of radio network failure due to obsolescence.

502. Replacement of the distribution backhaul radio network has already been deferred from the AA3 period. Given the increasing criticality of distribution SCADA services and the growing obsolescence risk of the assets that support these services, further deferral would pose a significant risk.

Mobile voice radio

503. During the AA4 period, Western Power will implement a staged replacement of the mobile voice radio network, with a larger investment deferred to the AA5 regulatory period. Work in the AA4 period will include replacing approximately 40 per cent of the existing obsolete 80 MHz analogue mobile voice radios installed throughout the country mobile radio network.

504. The country mobile radio network was installed 35 years ago. The network is the primary mobile field voice communication system designed to operate under post-disaster situations and is therefore critical for satisfying Western Power's legal obligation to ensure reliable communication for remote workers. The network is privately owned and operated by Western Power and is therefore immune to the shortcomings of mobile phone services provided by third parties. It is comprised of 84 radio base or repeater stations strategically located within the Western Power Network to provide network coverage over the majority of the geographic area. These radio assets have reached the end of their product life cycle and no longer receive manufacturer support.

505. This investment will migrate the analogue radio network to a digital one with increased functionality and reliability. The investment will mitigate the obsolescence risk and will also reduce safety risks to field workers by covering the entire geographic area of the Western Power Network and eliminating radio black spots.

CBD SCADA

506. Western Power will upgrade the CBD SCADA system. SCADA in the CBD is currently a low-speed proprietary Harris serial communications protocol. This system is at capacity and is nearing the end of lifecycle, with limited manufacturer support. CBD SCADA has increasing risks of not meeting the requirements of the Technical Rules and targeted CBD SCADA availability. The CBD SCADA network is currently operating at 97.90 per cent against a target of 99.98 per cent.

507. This investment is also required to meet forecast growth within the CBD (projected 46 per cent residential growth in from 2017 to 2036) over the AA4 period. We will adopt an optimisation strategy to not only support customer growth, but also reshape the network for emerging technologies such as intelligent distribution automation which will detect and rectify faults in support of performance requirements (utilisation of Clarity and Crossbow applications).

508. Stage 1 of the CBD SCADA upgrade was completed during the AA3 period. Stages 2 and 3 of this investment will complete the transition to an open standard model (DNP3), improving overall reliability and resilience of the self-healing loop within the CBD. The forecast expenditure will allow the targeted replacement of obsolescent CBD RTU assets (limited spares and no vendor support) and reduce the number of CBD SCADA failures.

Distribution automation communication network

509. Western Power will invest $9 million to upgrade the distribution automation communication network to a digital mobile platform.

510. The distribution automation communication network enables quick, automatic restoration or disconnection of electricity supply to customers in the event of a network disruption or fault (also known as self-healing). These services are critical to both safety and reliability outcomes for the SWIS. It is comprised of 104 radio base stations operating in a point to multipoint configuration strategically located to enable remote control and monitoring of distribution network electrical switchgear (roughly 2,700 remote devices).

511. As with the country mobile radio network, the DA communications network is obsolete, end of lifecycle and support, and at capacity. These data radio devices provide a communications medium for remote control and monitoring of pole-top distribution automation devices needed to safely and efficiently manage distribution switchgear.

Master station

512. During the AA4 period Western Power will invest $17 million in the master stations and head end information systems that enable the distribution SCADA and communications services. Investments in this category have been segregated to map to organisational responsibility for the SCADA and communications assets, which are divided between ICT (master stations) and asset performance (communications assets and SCADA field assets). Consequently, this activity includes elements of asset replacement, compliance, corporate and third party. The primary drivers for investment are obsolescence and cyber security risks, with additional funding required to support the advanced metering infrastructure program.

513. The key master station programs for the AA4 period are replacement of the distribution management system (**DMS**) and investment in new systems to support benefits realisation from the AMI program. These are discussed below.

Distribution management systems and supporting systems

514. The primary driver for investments in the DMS is the end of software and ICT hardware product life and ensuring continued cyber security assurance. The existing version of the DMS, PowerON Fusion went live in August 2013 with an expected product service life of 5 years. The vendor, GE, has indicated further product development on PowerON Fusion has stopped because a new advanced distribution management system called PowerOn Advantage has been released.

515. Western Power intends to migrate to PowerON Advantage, as this will maintain business functionality and provide support for as support for advanced metering. It will also enable convergence of the transmission and distribution control systems.

516. Other supporting systems such as the OSI Soft Data Historian, BT Control Centre Telephony and Operational Geographic Viewer that have reached or are forecast to reach end of life within the AA4 period. These too will be replaced.

Real-time systems

517. The planned deployment of advanced meters across the Western Power Network will result in increased data collection. Integration with the operational systems such as the DMS and business systems and analytical tools will be required.

Corporate

518. During the AA4 period, Western Power will invest $25 million to establish and expand the last mile communications (**LMC**) network using radio frequency (**RF**) mesh technology. This infrastructure will support the implementation of advanced metering and will also create a platform for other LMC services, such as condition monitoring and automation of the distribution network. This investment represents a significant portion of the overall distribution SCADA and communications expenditure, but is essential to support business initiatives that will deliver efficiencies in other areas.

519. Advanced metering and expansion of the LMC system are discussed below.

Advanced metering infrastructure

520. The SCADA and communications portion of the advanced metering infrastructure program is in final negotiations with a vendor, with design work proceeding in parallel. Investment in the LMC network cannot be deferred without impacting the timelines of the advanced metering program, with subsequent impacts on the benefits to be realised from advanced meters. This work will deliver the core of the LMC network, which is essential to the additional benefits available through expansion.

Last mile communications expansion

521. The investment planned for the expansion of the LMC for the automation of distribution electrical network which will enable quick, automatic restoration or disconnection of electricity supply to customers in the event of a network disruption or fault. These services are critical to both network safety and reliability. In particular, this investment will enable Western Power to remotely control distribution reclosers to mitigate bushfire risk and improve restoration times of the electricity network during outages.

522. New facilities investments in distribution SCADA and communications are only undertaken where section 6.52(b) (iii) of the Access Code is met. Section 6.52(b) (iii) of the Access Code requires that the new facility is necessary to maintain the safety or reliability of the covered network or its ability to provide contracted services.

523. AA4 distribution SCADA and communications expenditure has been assessed as meeting section 6.52(b) (iii) under the Access Code. Without this investment, the safety and reliability of our network is at risk because of the less than optimal remote visibility and control required to effectively manage distribution network assets. In addition, we would be at risk of not meeting service standard benchmarks and therefore would fail to provide acceptable levels of service to our customers.

524. AA4 distribution SCADA and communications expenditure has been assessed as efficiently minimising costs under section 6.52(a) of the Access Code as described in chapter 8 of the AAI. We invest in common SCADA and communications assets and systems across many projects in a centralised model to realise efficiencies of scale and scope when digital control, monitoring and communications functions are required for distribution primary network assets.

1.2.2.8 Distribution compliance capex

525. Western Power has a range of safety, environmental and service compliance obligations. Compliance requirements relating to non-growth investment on the distribution network include:

- **Section 25(1)(a) of the *Electricity Act 1945***

A network operator shall - at all times maintain all service apparatus belonging to the network operator which is on the premises of any consumer, in a safe and fit condition for supplying electricity.

- **Section 25(1)(d) of the *Electricity Act 1945***

  A network operator shall - declare the system pressure and/or frequency at which the network operator proposed to supply electricity to the premises of a consumer at the position thereon where electricity will pass beyond the service apparatus of the network operator, and maintain constantly the said pressure within the limit of ±6% and the said frequency within the limit of ±2½%.

- **Section 3.5(3) of the Electricity Industry Metering Code 2012**

  A network operator must, for each metering installation on its network, on and from the time of its connection to the network:

  (a) unless otherwise agreed between the network operator and a user, provide, install, operate and, subject to clause 3.5(7), maintain the metering installation in accordance with:

    i. this Code; and

    ii. good electricity industry practice; and

    iii. the metrology procedure for the network; and

    iv. the service level agreement between the network operator and the user in respect of the metering installation; and

  (b) ensure that the metering installation complies with clause 3.9; and

  (c) without limiting clause 3.5(3) (a) ensure that the metering equipment in the metering installation:

    i. is suitable for the range of operating conditions to which it will be exposed (e.g. temperature, impulse levels); and

    ii. operates within the defined limits for that metering equipment as specified in the approved metrology procedure.

526. The distribution regulatory and legislative obligations, and hence compliance expenditure, focus on the performance and management of distribution network assets, and is particularly centred on public safety, environmental management and power quality. Investment in this category often targets step changes, new obligations or identified issues with current compliance levels.

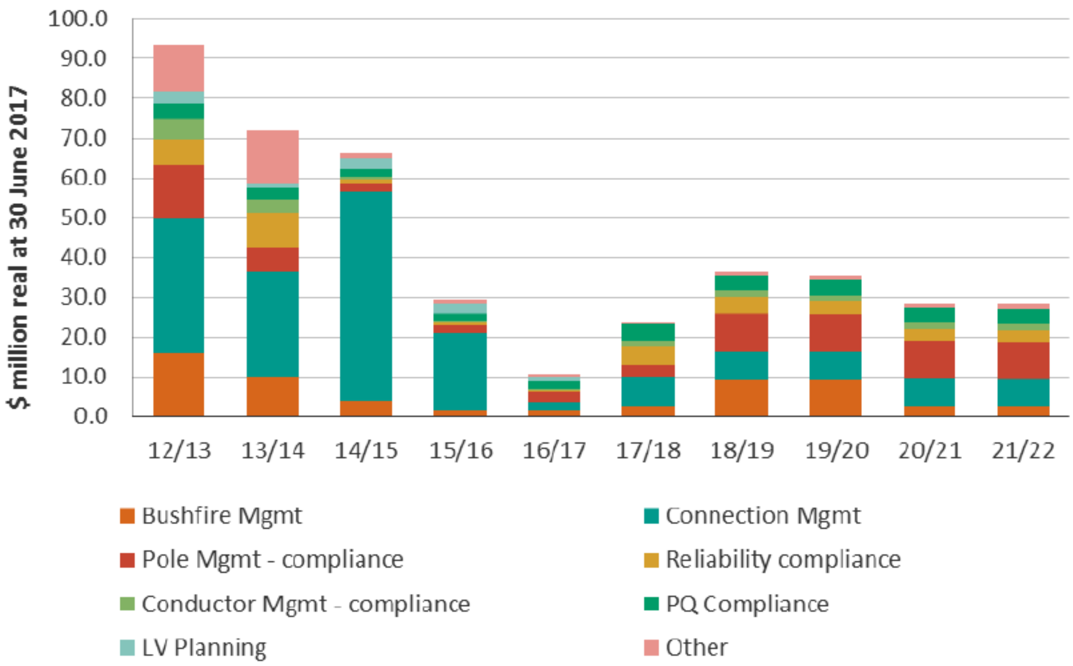
527. Forecast capex on distribution compliance requirements during the AA4 period is $150 million. This is $121 million (45 per cent) less than that incurred during the AA3 period (see Figure 1.25). This is due to progress made during the AA3 period to improve power quality and reduce the safety risk associated with customer service connections and conductor clashing.

528. New facilities investments in distribution regulatory compliance are only undertaken where section 6.52(b) (iii) of the Access Code is met. Section 6.52(b) (iii) of the Access Code requires that the new facility is necessary to maintain the safety or reliability of the covered network or its ability to provide contracted services.

529. AA4 distribution regulatory compliance expenditure has been assessed as meeting section 6.52(b) (iii) under the Access Code. Non-compliance with relevant codes and standards is evidence that there is a high likelihood that the safety or reliability of the covered network will not be maintained if not for the investment.

530. AA4 distribution regulatory compliance expenditure has been assessed as efficiently minimising costs under section 6.52(a) of the Access Code. We undertake our own cost benefit analysis when new legislation or industry standards are introduced, only changing practice where we are legally obliged or it is efficient to do so.

Figure 1.25: Comparison of AA3 actual and AA4 forecast distribution regulatory compliance capex, $ million real at 30 June 2017[74]



531. Table 1.26 shows forecast distribution regulatory compliance capex for the AA4 period.

Table 1.26: AA4 forecast distribution regulatory compliance capex, $ million real at 30 June 2017

Distribution regulatory compliance capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Bushfire management	2.4	9.1	9.1	2.6	2.6	25.9	0.7%
Connection management	7.6	7.1	7.1	7.1	6.6	35.4	1.0%
Pole management	2.8	9.5	9.4	9.3	9.5	40.5	1.1%
Reliability compliance	4.4	4.4	3.5	3.0	3.0	18.3	0.5%

74 Excluding forecast labour cost escalation.

Distribution regulatory compliance capex	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Conductor management	1.4	1.4	1.4	1.4	1.4	7.0	0.2%
Power quality	4.1	4.1	4.1	4.1	4.1	20.3	0.5%
Other	0.2	0.5	0.7	0.5	0.9	2.8	0.1%
Gross compliance capex	**22.9**	**36.1**	**35.3**	**28.0**	**28.1**	**150.3**	**4.0%**
Less contributions	-	-	-	-	-	-	
AA4 distribution compliance capex to be added to the RAB	**22.9**	**36.1**	**35.3**	**28.0**	**28.1**	**150.3**	

532. Proposed distribution compliance capex projects are below.

1.2.2.8.1 Bushfire management

533. Bushfire risk zones are aligned with Western Power's distribution maintenance zones. There are four categories of bushfire risk zone: extreme, high, medium and low. The current bushfire risk zone definition was developed in 2003 through discussions with the (then) Fire and Emergency Services Authority (**FESA**).

534. The primary bushfire management activity for the AA4 period is the high voltage conductor clashing program. The aim of the program is to mitigate the risk of overhead conductors coming into contact with each other and causing sparks, which could lead to ground fires. The various solutions to conductor clashing include installing longer cross arms, installing taller poles, re-tensioning the line or a complete redesign of the bay.

535. We target replacement of poor condition conductors, considering the risks presented by conductor failure (including fire risk) and the costs to remediate. Network segments with clashing issues are detected through telemetered protection device signatures. Light Detection and Ranging (**LiDAR**) surveys and helicopter inspections of these network segments are used to identify the clashing bays. Clashing bays also identified through reports from the public or Western Power workforce.

536. Enhancements made to the condition data during the AA3 period means we have better understanding of the risks posed by these defects. Remediation is prioritised by risk. Remediation options include installation of anti-swan cross arms, line -tensioning, installing mid-span poles, and installing LV spreaders.

537. The lower expenditure level during the AA4 period is due to a change in the mixture of asset treatment compared to the AA3 period, which will see a higher number of reclosers installed on the network. A recloser is a type of circuit breaker installed on the network that can automatically close the breakers after it has been opened due to a fault (such as clashing). During the AA3 period we found that installing reclosers is a more effective and efficient method of mitigating the bushfire risk associated with conductor clashing than re-designing long bays.

1.2.2.8.2 Connection management

538. During the AA4 period, Western Power will invest $35 million in connection management.

539. This category describes forecast expenditure for service connections – i.e. the connection that links the LV distribution network to the customer's premises or connection point. Connections can either be overhead, underground, or hybrid (supplied from the underground network but with overhead components). Western Power no longer installs hybrid connections, and a targeted AA2/AA3 program to remove a particular type of overhead connection (twisties), has significantly reduced the variety of overhead connections. Approximately half of Western Power's service connections are overhead and half are underground.

540. Forecast capex during the AA4 period is focused on:

- replacing overhead connections that are in poor condition
- reactively addressing underground pillars where they have developed a fault or been reported by either the public or Western Power personnel
- addressing hybrid connections where they present a safety risk.

541. Overhead connections can develop defects due to their exposure to environmental factors, ageing, and other threats such as third party damage, vegetation or poor work practices for example. Defects can result in corroded, lose or burnt connections, and/or insulation loss, leading to asset failure.

542. Failure of service connections can result in:

- localised outages (i.e. to a single customer)
- electric shock due to contact with live conductors or contact with normally safe parts of the customer property that have become live due to fault conditions (i.e. loss of neutral leading to energised household objects, such as taps)
- ground fires due to live conductors coming into contact with dry vegetation
- physical injury or property damage due to service connection equipment falling to the ground.

543. The main benefit of the early detection and remediation of failures is reduction in the expected number of electric shock incidents from service connections. To this end, underground connections are generally inspected on a reactive basis following a fault incident or an enquiry from the customer. For overhead connections, Western Power undertakes periodic inspections of these assets to assess their condition.

544. Implementation of condition monitoring equipment is also underway to achieve early detection of defects before they lead to electric shock. Approximately 12,000 overhead connections are planned to be fitted with these devices each year, or around a third of the overhead connection population by the end of 2026/27. This work is to be undertaken as part of the advanced metering infrastructure program.

545. The use of the communications backbone to monitor the condition of service connections is one of the major benefits of the advanced metering infrastructure program. Currently, the only way of assessing the condition of service connections is to manually inspect them. However, the cost of manual inspection is almost as much as replacing the asset, therefore it would be inefficient to inspect every asset.

546. By installing the remote monitoring devices, asset condition information can be provided at relatively low expense, while providing sufficient data to enable more accurate risk based replacement planning. As with the pole replacement program, we consider better information about asset condition will allow for a more efficient and targeted replacement plan at a lower cost to customers.

1.2.2.8.3 Pole management (compliance)

547. The compliance expenditure category includes elements of pole management expenditure, including stays and insulators, and cross arms. Western Power will invest $40 million on the treatment of these assets during the AA4 period.

548. The pole management activity includes cross arms, stays and insulators replacements.

549. The distribution network contains approximately 528,000 cross arms. Cross arms support the overhead infrastructure. Failure may lead to range of adverse safety impacts including ground fire, electric shock, physical injury and property damage. Failure of cross arms can also result in service disruption.

550. Cross arms are exposed to a range of environmental factors that can cause defects, such as corrosion and splits, that reduce the structural integrity of the cross arm.

551. Note that the cross arm replacement program was included the bushfire management expenditure subcategory in the AA3 period, but has been moved into the pole management activity for the AA4 period.

552. As replacement work can also result in service disruption, Western Power often replaces cross arms when the associated pole is replaced. We consider this approach to be efficient given that sending a work team to site is a significant component of the cost associated with asset replacements. This cost is included in the cost of the pole replacement, and is forecast under that expenditure category.

553. A substantial proportion of Western Power's 157,780 stay systems are in extreme and high fire risk zones and very high and high public safety zones. Due to the high risk consequences, corroded or unserviceable (under-rated) stays in are treated through condition-based replacement. For all other zones, condition based replacements of stay poles and stay systems are only carried out when the main pole is being replaced, while loose stays are repaired.

554. This activity involves replacement of missing, underrated or unserviceable stay wires and stay-insulators. Failure of stays may lead to failure of main poles, which may lead to consequences including ground fire, electric shock, physical injury, property damage and/or service disruption. Failure of stays can also cause physical injury or property damage without any failure of the main pole.

1.2.2.8.4 Reliability compliance

555. During the AA4 period, Western Power will invest $18 million to improve compliance with legislative and regulatory obligations relating to reliability and voltage. This is a $1.3 million increase from the amount invested in AA3. It is primarily to address South Country rural reliability compliance.

556. Western Power has an obligation under the Electricity Industry (Network Quality and Reliability of Supply) Code 2005 (**Supply Code**) and the *Electricity Act 1945* to supply customers in a reliable and safe fashion. Western Power can be liable for damages that result from poor power quality.

Improve voltage levels

557. Section 25(1)(d) of the *Electricity Act 1945* requires Western Power to

> *... declare the system pressure and/or frequency at which the network operator proposes to supply electricity to the premises of a consumer at the position thereon where the electricity will pass beyond the service apparatus of the network operator, and maintain constantly the said pressure within the limit of ±6% and the said frequency within the limit of ±2½%.*

558. The system pressure has been declared to be 240 V (single phase). There are currently 2,000 LV networks (out of a total 18,000) that are non-compliant with the requirement to maintain a voltage of 240V ±6 per cent. These have largely arisen from the subdivision of land in inner metropolitan and semi-rural areas. In addition, the rapid uptake of residential solar PV systems have caused an increase in voltage levels in the LV networks.

559. A program commenced in 2011/12 to manage the voltage on the LV network and, where required, upgrade the LV network to improve compliance with the Act. The works during AA4 will be prioritised based on a number of criteria, including number of complaints, asset age, conductor impedance, feeder lengths and separation between adjoining networks.

Reduce long duration interruptions

560. Section 12(2)(a) of the Supply Code requires that small use customers must not experience more than one twelve hour duration every ten years. Where Western Power is not compliant with this requirement, section 12(3) of the Supply Code requires Western Power to remedy the cause or causes of the interruption or enter into an alternative arrangement with the customer.

561. During the AA4 period we will aim to meet service standard targets and benchmarks. This means we will only invest in targeted service improvement activities where the benefit of delivering the service improvements outweighs the costs. The benefits are estimated based on the service standard adjustment mechanism financial incentives rates, which have been developed using the value that customers place on reliability. Growth driven investment and normal maintenance activities will contribute towards maintaining performance.

562. Western Power will continue to manage reliability performance by making investments in managing reliability performance and customer expectations in the worst performing areas (reliability hot spots).

1.2.2.8.5 Conductor management

563. AS/NZS 7000: 2010 and AS 6947 -2009 prescribe the minimum required ground clearances for safe and reliable operation of overhead conductors. This activity exists to rectify substandard clearances of distribution overhead lines and overhead customer service connections. The focus of this activity is on road, rail and river crossings, where the likelihood of contact with the conductors is increased. It does not cover vegetation clearances, which are addressed by the line easement vegetation maintenance opex program. It also does not include clearance to other overhead conductors, which is addressed by the HV conductor clashing program.

564. Bays that exhibit substandard clearances have an increased likelihood of coming into contact with vehicles, structures and livestock, with the potential to cause electric shock, property damage (due to collision impact or electrical damage) and service disruption. Contact with the conductors can also lead to conductor damage and failure.

565. The expected outcome of this program is to reduce the number of known substandard conductor clearances on the distribution network and a corresponding reduction in safety risk.

566. Forecast capex on this activity during the AA4 period is $7 million, a reduction of $2.9 million on the AA3 period. This reduction is primarily due to the completion of the known river crossings and slightly improved unit rate and a continuation of the conductor clearance work at historical levels.

1.2.2.8.6 Power quality compliance

567. During the AA4 period, Western Power will invest $20 million to address customers' power quality complaints. This is an increase of $8 million from AA3 investment levels, which largely reflects the increasing trend in the number of power quality complaints from customers as well as the prioritisation of limited resources during the high growth environment of the early AA3 period to address growth related projects.

568. Western Power has an obligation under the Supply Code and *the Electricity Act 1945* to supply customers in a reliable and safe fashion and can be liable for damages that result from poor power quality.

569. Under section 24 of the Supply Code, Western Power must investigate any complaints by customers in relation to the quality of their electricity supply impacting on their equipment. If the investigation identifies that we are not compliant with the Supply Code requirement or Technical Rules, we are obliged to rectify the non-compliance.

570. Western Power has an obligation under the *Electricity Act 1945* and Electricity Industry (Network Quality and Reliability of Supply) Code 2005 to monitor the quality of the power supply.

571. Western Power's distribution network is defined as all network assets outside the zone substations with voltage rating below 66 kV. Western Power currently maintains wide monitoring coverage of its distribution network, with 350 power quality monitoring devices fixed across the 415V/240V distribution networks.

1.2.3 Corporate capex

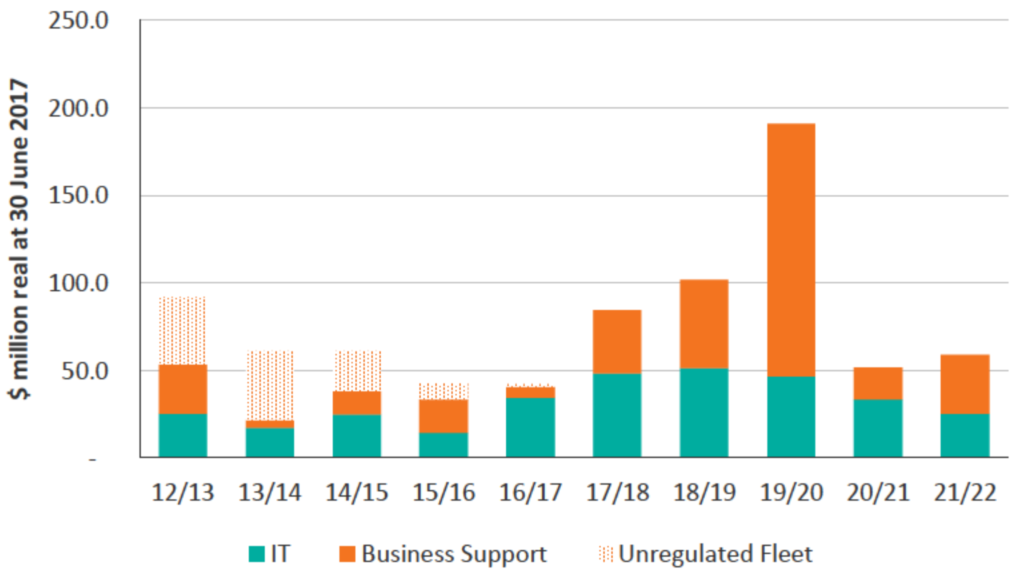
572. Western Power will invest $487 million of capital in corporate support during the AA4 period. This represents around 13 per cent of total capex. Corporate capex comprises business support investment and ICT investment. Table 1.27 shows AA4 forecast corporate capex by category.

Table 1.27: AA4 forecast corporate capex by regulatory category, $ million real at 30 June 2017[75]

Corporate capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Business support	36.0	50.2	144.3	18.4	33.7	282.5	7.6%
ICT	48.4	51.4	46.6	33.2	25.1	204.6	5.5%
Gross corporate capex	**84.4**	**101.5**	**190.8**	**51.6**	**58.7**	**487.1**	**13.1%**
Less contributions	-	-	-	-	-	-	
AA4 corporate capex to be added to the RAB	**84.4**	**101.5**	**190.8**	**51.6**	**58.7**	**487.1**	

573. Figure 1.26 shows how AA4 forecast corporate capex compares with that incurred during the AA3 period.

Figure 1.26: Comparison of AA4 forecast corporate capex and AA3 actual gross corporate capex by regulatory category, $ million real at 30 June 2017[76] [77]



75 Excluding forecast labour cost escalation.

76 Excluding forecast labour cost escalation.

77 Unregulated Fleet expenditure in AA3 has been included in this chart to enable like-for-like regulatory period comparison.

574. Forecast corporate capex for the AA4 period is $212 million higher than that incurred during the AA3 period. The primary driver for this capex increase is the need to modernise Western Power's portfolio of metropolitan and regional operational depots, many of which are in poor condition. Additionally fleet capital expenditure is proposed to be part of Western Power's regulated assets in AA4 whereas in AA3 fleet was unregulated.

575. Other corporate real estate projects proposed for the AA4 period include relocation of Western Power's network control centre to a new location. The primary driver for the relocation is that the current building is beyond its useful life, with wiring and roofing requiring substantial modernisation. The cost of relocation is seen as prudent compared to the cost of renovating/overhauling the existing aged building.

576. Another contributor to the increase in capex is the proposal to capitalise leased fleet from 2019 onwards. Business support projects investment is discussed in 1.2.3.1 below.

577. The other major component of AA4 forecast corporate capex is ICT. Forecast capex on ICT during the AA4 period is $205 million. This is $88 million (76 per cent) more than that incurred during the AA3 period.

578. Most of the relative increase in ICT capex relates to upgrades and replacements of existing ICT systems, which are designed to improve processes and help the business realise the efficiencies identified in our recent Business Transformation Program. As discussed in the AAI, Western Power's business transformation program commenced in 2015, with many initiatives having a direct or indirect ICT component.

579. A key outcome of the business transformation program is the business' greater dependence on automation and ICT systems, particularly in the asset management space. Therefore, to ensure the benefits of the business transformation are maintained over the long term, investment in these systems is required.

580. For example, Western Power's enterprise resource planning system, Ellipse, and geographical information system, Spatial Display and Analysis (**SPIDA**), require upgrades during the AA4 period. Ellipse has not been upgraded since 2010, while SPIDA requires enhancement to provide more accurate and timely analysis of the network – both of which will support the asset management improvements made during the business transformation program.

581. Expenditure directly related to the Business Transformation Program initiatives is ongoing, and we expect to complete the projects during 2017/18.

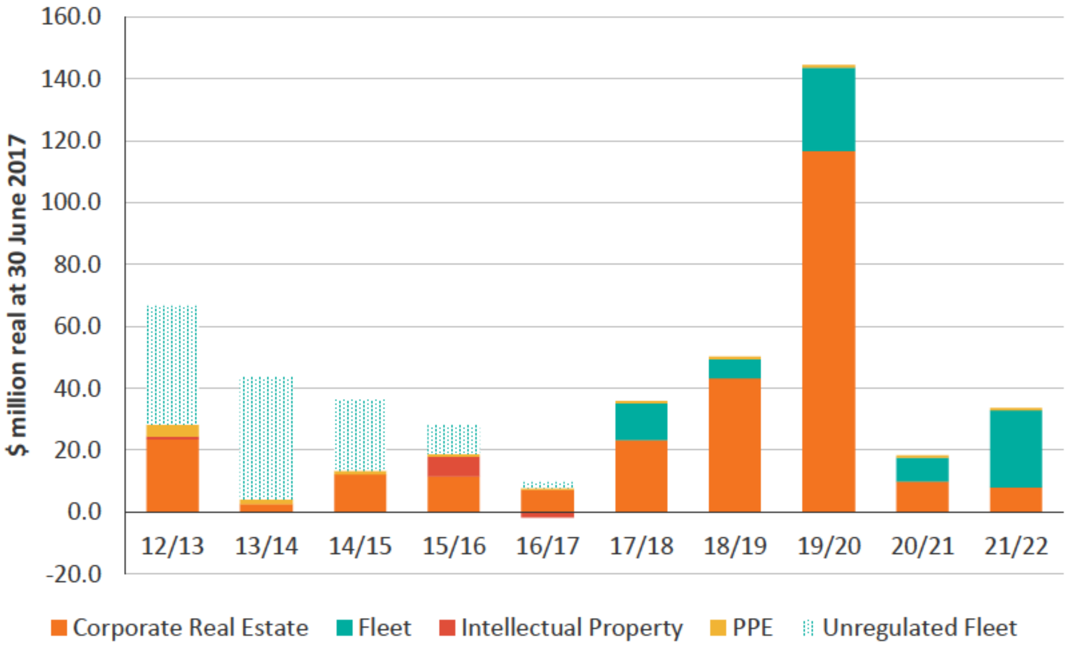
582. Western Power also proposes to invest in a new customer relationship management system (**CRM**) to replace the existing ten-year old system. During our customer engagement program, customers told us they believed that accurate and timely support is essential for a positive customer experience. The new CRM system will integrate customer quotations, fault reporting, meter reading, vegetation management, and work orders, providing a single view of customer requirements and improving the accuracy and retrieval of data.

583. ICT investment is discussed in 1.2.3.2 below.

1.2.3.1 Business support capex

584. Forecast business support capex includes expenditure on corporate real estate, heavy and light fleet, and property plant and equipment. Business support capex for the AA4 period is $282 million. This is $212 million more than incurred during the AA3 period (see Figure 1.27).

Figure 1.27: Comparison of AA4 forecast and AA3 actual gross business support capex by regulatory category, $ million real at 30 June 2017[78][79]



585. The expenditure increase is primarily due to the depot modernisation project, the inclusion of fleet and the establishment of a new network control centre, both of which are key components of Western Power's ongoing strategy to improve operational efficiency.

586. Table 1.28 shows forecast business support capex for the AA4 period by regulatory expenditure sub-category.

Table 1.28: AA4 forecast business support capex by regulatory sub-category, $ million real at 30 June 2017[80]

Business support capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Corporate real estate	23.3	43.2	116.6	9.9	8.1	201.1	5.4%
Fleet	11.8	6.1	26.9	7.6	24.7	77.2	2.1%
Property, plant & equipment	0.8	0.8	0.8	0.8	0.8	4.2	0.1%
Intellectual property	0.0	0.0	0.0	0.0	0.0	0.0	0.0%

78 Excluding forecast labour cost escalation.

79 Unregulated Fleet expenditure in AA3 has been included in this chart to enable like-for-like regulatory period comparison

80 Excluding forecast labour cost escalation.

Business support capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Gross business support capex	**36.0**	**50.2**	**144.3**	**18.4**	**33.7**	**282.5**	**7.6%**
Less contributions	-	-	-	-	-	-	
AA4 business support capex to be added to the RAB	**36.0**	**50.2**	**144.3**	**18.4**	**33.7**	**282.5**	

587. Forecast business support capex is discussed further below.

588. New facilities investments in property are only undertaken where section 6.52 (b) (iii) of the Access Code is met. This section requires that the new facility is necessary to maintain the safety or reliability of the covered network or its ability to provide covered services.

589. The investments proposed in AA4 have been assessed as meeting section 6.52(b) (iii) of the Access Code. The investments are required in order to meet the requirements of our safety and environmental regulatory obligations including. We effectively minimise costs by ensuring a competitive tender process is undertaken to secure the right services at the right price to undertake the build program. We prioritise our works in accordance with our corporate risk criteria and works program to ensure all network requirements are able to be met whilst the build program is occurring.

1.2.3.1.1 Corporate real estate

Depot modernisation

590. During the AA4 period, Western Power will invest $201 million in corporate real estate. The majority of this expenditure ($184 million) is on the depot modernisation program.

591. Western Power has implemented a new safety strategy for its entire workforce of employees and contractors. The depot modernisation program is designed not only to provide improved facilities but also address the serious safety issues present in a number of these existing depots. These issues include:

- site flooding in heavy weather
- poor separation of vehicle traffic and pedestrians on site
- asbestos issues
- temporary offices and accommodation, which in some cases is not fit for purpose
- constrained work environment, which leads to potentially unsafe practices.

592. Western Power currently owns and operates 14 depots in the Perth metropolitan area and south-west region of Western Australia, with a further 16 depots in regional locations. [redacted]

593. During the AA4 period we propose to deliver phase one of the depot modernisation program, which will focus on the Perth metropolitan and south-west depots. [redacted]

[redacted] The remaining depots will be re-designed and re-fitted to reduce health and safety risks and operating costs, as well as providing sufficient accommodation to meet future operational requirements. [redacted]

594. [redacted] The depot modernisation program has already seen the closure of Western Power's Fremantle Depot, Perth Airport Fleet Services and the Bentley Depot. These closures have generated $4.5 million in recurring opex savings.

595. Phase two of the program will commence at the end of the AA4 period and be completed during the AA5 period. Phase two will focus on improving the facilities at regional depots. [redacted]

Why now?

596. As a cost saving strategy, during the AA3 period Western Power adopted an essential care and maintenance strategy for its depot portfolio. This meant only essential repairs were carried out in order to keep the depots operational, and little or no investment was made on upgrading the depots, some of which are between 30 and 50 years old.

597. The majority of the depot portfolio has reached the end of its economic life. Western Power's depot network has been developed over time on an ad-hoc basis with no consistency in design. This lack of detailed and structured planning has resulted in the following challenges:

- the depot accommodation across the depot portfolio is in poor physical condition, is at end of life and requires a major rebuild or major refurbishment
- health and safety risks associated with occupying depots that are constrained in design and foster unsafe work practices
- many depots do not have designated areas for safe storage and movement of heavy and light fleet, and provide insufficient separation between vehicles and employees
- there are deficiencies in physical security for network assets, equipment and office space
- the need to lower operating costs and minimise future capital investment, whilst providing fit for purpose depot facilities.

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1.2.3.1.2 Fleet

632. During the AA4 period, Western Power proposes capital expenditure on fleet be added to the regulated asset base. During the AA3 period fleet was treated as unregulated expenditure, and not included in the RAB. The changes in treatment for the AA4 period means there is a fleet capex component in the AA4 corporate capex forecast.

633. Fleet capex for the AA4 period is $77 million. This compares with $112 million of unregulated fleet capex incurred during the AA3 period. However, it should be noted that the accounting treatment of light fleet will change in 2019/20. Currently, light fleet vehicles are leased and costs incurred as opex. It is only from 2019/20 onwards that light fleet leasing costs are to be capitalised and added to the regulated asset base. Heavy fleet vehicles are currently purchased, so there will be no change to the treatment of heavy fleet assets.

634. The new treatment of fleet capex in the regulated asset base is discussed in Chapter 10 of the AAI.

635. Capital expenditure over the AA4 period comprises the replacement of:

- light fleet capitalised from 1 January 2019 comprises $30 million of the total proposed capital expenditure
- heavy fleet such as trucks, trailers, elevated work platforms (**EWPs**) and cranes.

Light fleet

636. During the AA3 period, Western Power conducted an internal assessment of light fleet and rationalised the number of light fleet vehicles by 30 per cent. We also transitioned light fleet operations from an internal ownership structure, to an outsourced leasing arrangement.

637. Following an open tender process in 2015, Western Power entered into contractual arrangements with an external provider for the provision of:

- sale and leaseback of existing light fleet vehicles
- leasing of new light fleet vehicles
- fleet management services

638. The contractual arrangement is forecast to deliver Western Power a benefit of $35.9 million over a five-year period. The new light fleet contractual arrangement commenced in October 2016.

639. For the AA4 period all of Western Power's light fleet will be managed on an operating lease basis. From 1 January 2019 the *Accounting Standard AASB 16 – Leases* comes into force. This standard brings the accounting treatment for operating leases into line with that for finance leases where the capital value of the lease is capitalised. Western Power's capital expenditure forecast for fleet reflects the capitalisation of its light fleet operating leases in accordance with AASB 16.

Heavy Fleet

640. Since transferring light fleet from internal ownership to an outsourced lease, we have explored the potential to transition heavy fleet operations in the same manner. In 2016, Western Power engaged EY to undertake a market sounding to assess the viability of outsourcing heavy fleet activities. Following receipt of this advice, Western Power conducted an open tender process for outsourcing heavy fleet. However, based on the responses received, it was determined there would be minimal financial and operational benefits to Western Power outsourcing heavy fleet.

641. Following the decision to retain heavy fleet in-house, Western Power has commenced the implementation of an efficiency program which seeks to improve financial and operational efficiency. Program activities include:

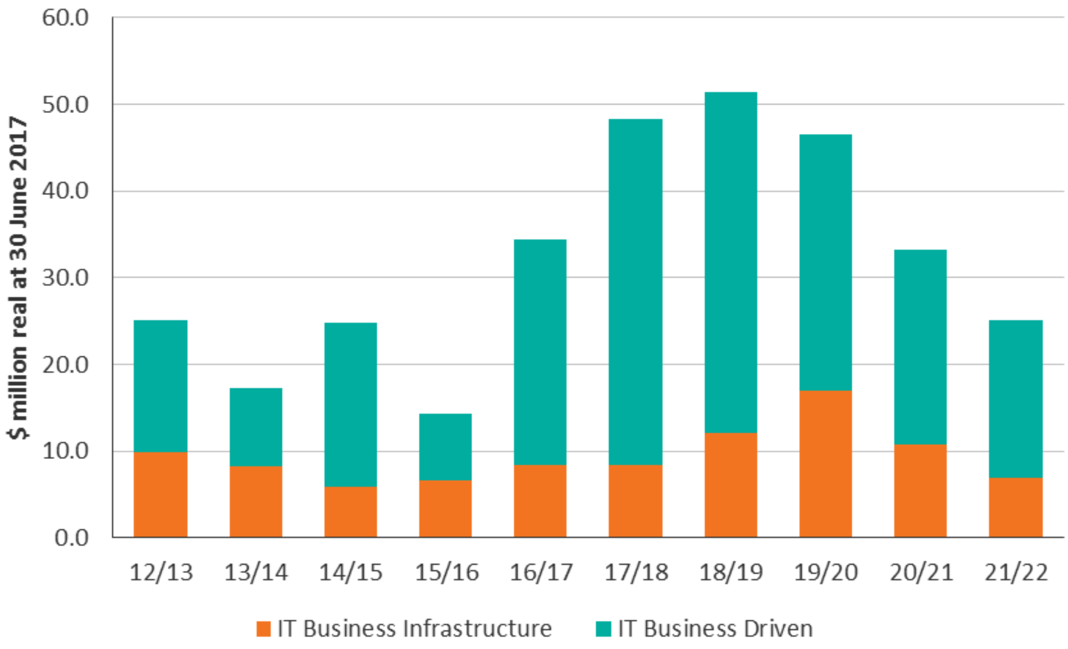
- service and maintenance scheduling improvements
- EWP refurbishment program
- a heavy fleet rationalisation and modernisation program.

642. Forecast expenditure on heavy fleet during the AA4 period is \$47 million. This forecast factors in expected improvements from the heavy fleet efficiency program, and covers the costs of replacing heavy fleet that has reached its MRL and cannot be efficiently maintained.

1.2.3.2 Information and communications technology

643. The other major component of AA4 forecast corporate capex is ICT. Forecast capex on ICT during the AA4 period is \$205 million. This is \$88 million (76 per cent) more than that incurred during the AA3 period (see Figure 1.28).

Figure 1.28: Comparison of AA4 forecast and AA3 actual ICT gross capex by regulatory category, $ million real at 30 June 2017[81]



644. ICT in the energy sector is evolving at a rapid pace. Technology such as battery storage systems, microgrids, and advanced metering means electricity networks are becoming more and more dependent on ICT, requiring sophisticated and robust ICT systems to help integrate this new technology into the network efficiently.

645. During the AA4 period, Western Power aims to make greater use of ICT to deliver safe, reliable and efficient electricity transmission and distribution, and to enable greater use of emerging technologies. As a result, we will invest significantly more in implementing new, or enhancing existing, ICT systems over the AA4 period than we have done in previous regulatory periods.

646. To ensure that this investment delivers the required return and effectively supports the achievement of our business objectives, the following specific goals have been built into Western Power's ICT Strategy:

- **Increase the business value from technology investments** - taking a portfolio approach making sure we focus on the most important things that will have the biggest impact on our objectives.
- **Increase agility and reduce time to benefits** – implementing in an iterative way, delivering releases incrementally and focusing on the highest value projects first.
- **Operate efficiently** – ensure that the availability and reliability of ICT systems is good enough to meet business and customer needs and our ongoing costs are as efficient as possible.
- **Effectively manage cyber security risk** – ensure that the increasing use of ICT to improve business operations and customer interactions does not create unacceptable level of cyber risk.

647. To achieve these goals Western Power will:

81 Excluding forecast labour cost escalation

- be a mainstream adopter of new ICT and digital technology, taking an early adoption position only where potential benefits are sufficiently compelling to justify the increased risk
- wherever possible use commercial off-the-shelf products and avoid modification and customisation
- prefer cloud based and as-a-service solutions to enable faster implementation, provide more flexibility and reduce on-going maintenance effort
- prioritise adaptable-for-change over built-to-last in systems selection and design
- prefer agile delivery over a waterfall approach to reduce risk and drive greater value from technology enablement projects
- make extensive use of external service providers to obtain specific skills and capabilities, access to low-cost delivery models, and provide flexibility to scale up and down quickly to deliver technology enablement projects
- elevate cyber security to be a business issue, increase the focus on operational technology systems, and consider survivability in addition to prevention.

648. These objectives apply equally to all services offered by the distribution and transmission networks. They underpin the design of the governance framework, the target operating model, the sourcing and delivery model, and the future ICT enterprise architecture.

649. To support the business' strategy a number of key technology investments are envisaged including:

- extending the use of ICT from traditional back office process automation to automated data acquisition, decision automation and digital connection with customers
- introducing advanced meters and associated meter management and billing systems to enable new services to customers and reduce operating costs
- rationalising and upgrading the distribution and transmission network management systems to reduce ongoing costs and enable more responsive network operations
- upgrading the enterprise resource planning (**ERP**) system, and potentially separating out the Finance and Human Resource components into new systems, to maintain systems at supported levels and enable improvements in these corporate services
- introducing a customer management system and integrating into other core systems to improve the level of service provided to customers
- further investing in asset management and network planning systems to enable network investment to be better targeted.

650. All of these investments are subject to a rigorous ICT governance framework, which is described in Western Power's ICT Strategy. ICT governance requires that ICT capex programs are considered against the requirements of the NFIT and where possible are directly linked to improving the efficiency of transmission and distribution networks.

651. Table 1.30 shows forecast ICT capex for the AA4 period.

Table 1.30: AA4 forecast ICT capex by regulatory sub category, $ million real at 30 June 2017[82]

ICT capex category	2017/18	2018/19	2019/20	2020/21	2021/22	Total AA4	% of total WP gross capex
Business driven	39.9	39.3	29.5	22.4	18.1	149.3	4.0%
Business infrastructure	8.5	12.1	17.0	10.8	7.0	55.3	1.5%
Gross ICT capex	**48.4**	**51.4**	**46.6**	**33.2**	**25.1**	**204.6**	**5.5%**
Less contributions	-	-	-	-	-	-	
AA4 ICT capex to be added to the RAB	**48.4**	**51.4**	**46.6**	**33.2**	**25.1**	**204.6**	

652. The ICT expenditure categories are discussed below.

1.2.3.2.1 Business driven

653. During the AA4 period, Western power will invest $149 million in business driven ICT projects.

654. The Business driven ICT capex category covers investment in the various enterprise systems used by Western Power, many of which require upgrade or replacement over the AA4 period. This includes investment in ICT projects that improve our customer management interface, provide a more robust employee management solution, and support a risk based approach to asset management.

655. We will invest $24 million implement a new customer management system. The existing system is over 10 years old and does not provide the capacity to meet the business' customer engagement and data requirements, particularly given the proposed implementation of time of use tariff structures and data/communications platforms.

656. Currently, Western Power's customer support systems have several disparate elements covering customer quotations, fault reporting, metering, vegetation management and work orders. The new customer management system will provide an integrated customer solution that provides a single view of customers, thereby improving our ability to interact with them efficiently.

657. In terms of employee management systems, Western Power will invest $7 million to adopt a cloud-based HRIS[83] and payroll solution. This will better support a self-service approach, offer a more comprehensive set of HR and payroll functions, and provide better value for money than enhancing the existing HR and payroll functions in Ellipse. The solution will be fully compliant with all legislative requirements relating to tax, superannuation and single touch payroll, including self-service capabilities, and with software upgrades and updates provided via automated update files.

658. We will also invest $30 million in ITC solutions that deliver, using a risk based approach, an efficient asset management strategy that delivers an optimised replacement and maintenance activities. These systems will enhance and complement the existing suite of ICT tools used in risk based distribution network planning.

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82 Excluding forecast labour cost escalation.

83 HRIS – Human Resource Information System.

659. We plan to enhance the processes of workflow management in particular:

- distribution construction workflow
- work planning and scheduling
- project management
- work process automation.

660. These ICT improvements will enable Western Power to deliver its works program in a more efficient, cost effective manner.

661. This expenditure category also includes $2.5 million of investment to cover ICT components of the depot modernisation program (discussed in the business support capex section above), and $5.5 million for the Network Control Centre move.

662. ICT systems to support advanced metering infrastructure also falls into this capex category. During the AA4 period, Western Power proposes all new and replacement meters be advanced meters, and that the associated telecommunications infrastructure be installed to enable the benefits of advanced meters to be realised.

663. The ITC component of the advanced metering infrastructure project comprises:

- implementation of the network management system (**NMS**)
- migration of the network billing system to the required platform
- integration of the NMS to the billing system
- modifications to the billing system to accommodate interval data
- integration with market systems
- implementation of tools to support the rollout of advanced meters.

664. Forecast AA4 ICT capex on advanced metering infrastructure is $15 million.

1.2.3.2.2 Infrastructure

665. During the AA4 period, Western Power will invest $55 million in upgrading and replacing business infrastructure ICT systems. The business infrastructure ICT capex category covers expenditure on core IT infrastructure including computers, operating systems, and desk top applications.

666. Two of the major systems that require upgrade during AA4 are Western Power's ERP system Ellipse and the GIS[84] system SPIDA along with associated systems that interface with these.

667. Ellipse has not been upgraded since 2010 and the version that is currently operating is now out of vendor support. Ellipse and associated systems will be upgraded during the AA4 period. This will be a major upgrade, bringing an enhanced level of functionality as well as ensuring that vendor support will be available to maintain the ongoing viability of Western Power's core enterprise and associated systems.

668. The upgrade to SPIDA and its associated systems will enable a more accurate and timely analysis of the network.

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84 GIS – Geographic Information System.

669. Capital expenditure in this category also relates to end of life asset refresh, organic network growth, end of life IT systems and new technology upgrades.