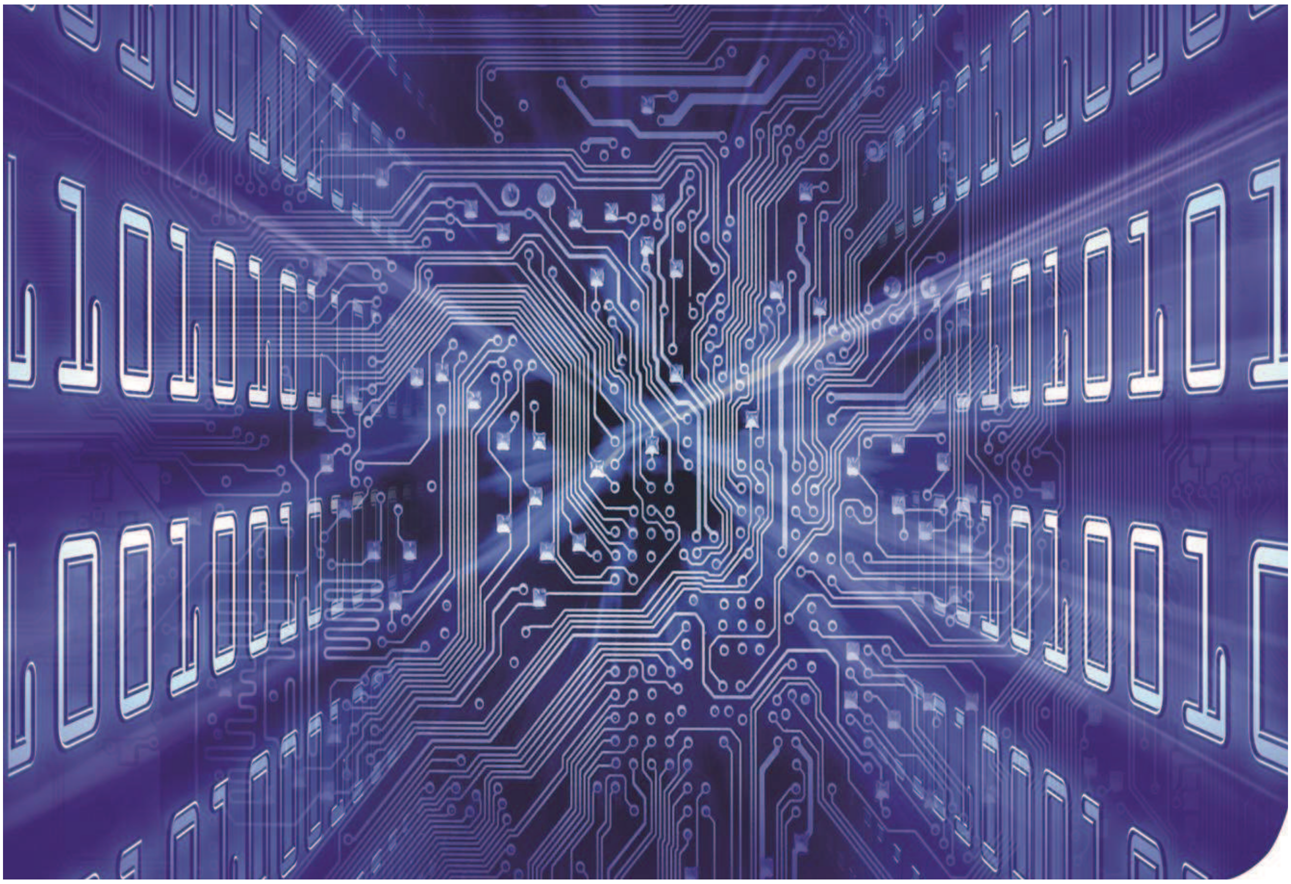
SP AusNet

Assessment of AMI Communication Options



Presented by DNV KEMA

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Version 1.1

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Disclaimer

All due care and diligence has been taken by DNV KEMA, in the preparation of this report within the time constraints allowed.

In reaching its conclusions DNV KEMA has relied upon information provided by SP AusNet and SP AusNet's legal representatives, as well as information derived from KEMA's expertise and experience in AMI and Smart Grid projects worldwide. The facts and matters taken from this information were supplemented by a process of discovery with SP AusNet staff and legal representatives. DNV KEMA's corporate experience with, and recorded and unrecorded knowledge of, other AMR/AMI projects and the individual knowledge of the consultants performing the assignment formed the basis of DNV KEMA's assessment. Some of this knowledge and information may have been made available to DNV KEMA under confidentiality agreements. In some cases, these agreements may limit our ability to disclose some information should it be requested.

To the extent this report relies upon information provided by third parties, DNV KEMA does not guarantee or warrant the accuracy of this report. Furthermore, neither DNV KEMA, nor its Directors or employees, will accept liability for any losses related to this report.

1. Executive Summary

The AER's final determination on SP AusNet's 2012-2015 AMI budget on the 31st October 2011 disallowed part of SP AusNet's planned expenditure. SP AusNet appealed the AER's determination to the Australian Competition Tribunal on the 30th November 2011. The Tribunal decided that the AER had made a material error in determining the $72.2 of WiMAX related expenditure was not prudent. The Tribunal directed the AER to further consider SP AusNet's Submitted Budget on the basis that the commercial standard required SP AusNet to carefully reconsider its various options and determine the extent to which incurring the proposed expenditure is not prudent.

DNV KEMA has been requested to provide expert analysis, given the information available to SP AusNet at 14th February 2011. This requires a 15 year cost benefit assessment of SP AusNet continuing with a WiMAX communication solution in comparison to adopting an RF Mesh solution. DNV KEMA has also been requested to review the assumptions made in the Energeia report prepared for the AER in August 2012[1].

DNV KEMA's approach is to break the examination of costs down into three main areas:

- Costs of continuing with the WiMAX solution – This has primarily been based on contractual obligations for SP AusNet with input from DNV KEMA in calculating some of the costs that should apply.

- Costs of adopting a RF Mesh solution – The cost and requirements for the RF Mesh solution suitable to meet the Victorian AMI requirements are based on the construction of a high level design for the RF Mesh network with benchmark information used to estimate the capex and opex of the solutions.

- Transition Costs – DNV KEMA has first reviewed, based on our experience in other markets, the likely timing over which transition would take place. We have made an estimate of the costs of the different transition activities based on this timetable and benchmark information from other projects. The model assumes that SP AusNet's AMI project would still meet the mandated rollout completion date of 31 December 2013.

[1] Energeia, Review of SP AusNet's WiMAX Related Expenditure, August 2012.

Key Differences to the Energeia Assessment (August 2012)

DNV KEMA has taken a bottom up approach to estimating the costs of the Mesh Solution based on the resources and costs estimates we have experienced in other markets applied to SP AusNet's circumstances. The approach involves an assessment of Capex and Opex for individual systems, resources and components to build up the total costs we expect to be incurred over a 15 year period. DNV KEMA's approach also includes the development of a high level network design for the RF Mesh system based upon SP AusNet's service territory and characteristics to produce the list of equipment necessary to meet the AMI minimum functional specification.

This approach contrasts with Energeia who have estimated many of its costs using other distribution businesses in Victoria as a proxy. The use of Powercor as a proxy for RF Mesh design does not reflect the different geographical, topographical or density differences between the utilities. The use of other proxies for IT systems does not reflect SP AusNet's costs as other distribution businesses have the ability to share costs where a single solution has being utilised by two utilities (i.e. Citipower / Powercor and Jemena / UED). DNV KEMA also has a concern that the other distributors, which are used as proxies, may have different cost allocation methodologies that makes direct comparison of individual line items difficult. This emphasises the importance of focussing on the total cost of the solutions in making any comparisons.

The key areas of difference between the DNV KEMA and Energeia assessments are:

- **Transition timescale and cost –** Energeia's report indicates that they expect the Mesh system to be operational within 10 months of the 28th February. Unlike the assumption in the Energeia report, DNV KEMA experience suggests that a number of months will be required for procurement so that even with an efficient delivery of the system it will be 16 months before the Mesh system is operational. There will also be a further time period to complete the retrofit/installation of Mesh NICs, an activity which is not factored into Energeia's modelling. Energeia has also suggested that no additional manpower would be required to manage the transition process, whereas DNV KEMA suggests that this is not the case as a number of additional activities will be required to run in parallel with the main program.

- **NMS Costs –** Network Management is a crucial component of a Mesh Radio system and is a continual ongoing process of tuning network operation. DNV KEMA have estimated the cost of the solution and operational cost based on our experience of quotations in a number of other markets from vendors of NMS solutions for Mesh. These costs reflect our experience of the costs with either an in-house service or a service hosted by the NMS Vendor. DNV KEMA's estimates are significantly higher than the Energeia numbers.

- **Communication Operation Costs –** The DNV KEMA Communication operation costs for WiMAX now comprise of a number of separate elements including labour resources (33%), sites leases (23%), Spectrum costs (24%), Motorola costs (9%) and training (6%). This revised list of activities results in a PV of $60.4m against $27.4 estimated by Energeia. Site leases, spectrum costs and Motorola costs do not apply to the Mesh option and DNV KEMA have only applied a conservative field services cost, which results in a $15.1m PV. This is fairly close to the Mesh Communication Operations PV of $15.9m used by Energeia.

Results of the Cost Benefit Analysis

The DNV KEMA cost benefit analysis found that continuing with WiMAX would result in higher Capex than the Mesh Option. However, this would be offset by lower Opex and no transition costs, which would collectively make the switch to mesh a more expensive option. This contrasts with the Energeia analysis which states than both the Opex and Capex from a full roll out of Mesh are lower than the continued roll out of the WiMAX Solution. The main areas for difference are set out above. These costs are summarised in the table below:

Table 1-1: Costs by Option

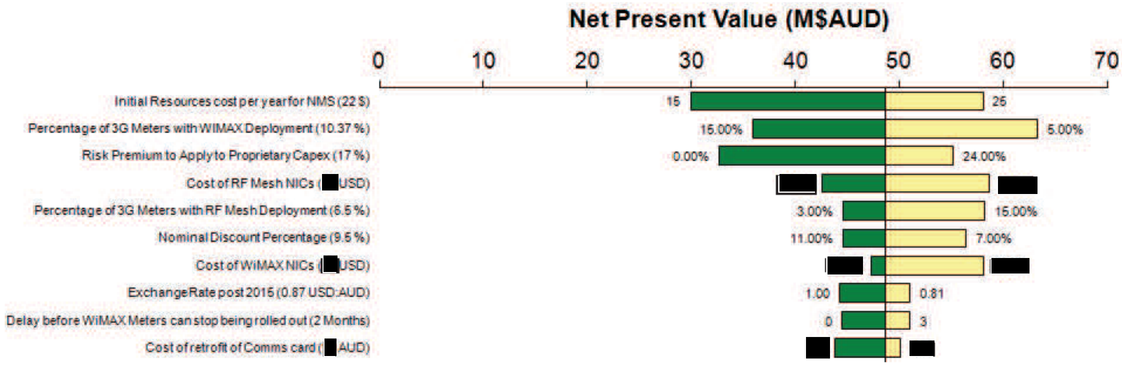
Cost	DNV KEMA PV Cost of Continuing with WIMAX ($M)	DNV KEMA PV Cost of Adopting Mesh ($M)	Energeia PV Cost of Continuing with WiMAX ($M)	Energeia PV Cost of Adopting Mesh ($M)
Capex	$183.5	$152.5	$208.5	$126.8
Opex	$122.8	$145.5	$110.1	$74.4
Transition Costs	$0	$56.8	$0	$ small amount included above
Total Costs	**$306.3**	**$354.9**	**$318.6**	**$201.2**

The DNV KEMA analysis, based on a bottom up assessment of cost, shows the overall impact is a PV benefit of $48.6m for retaining WiMAX rather than switching to Mesh. This includes all the activities associated with a transition to a Mesh network, for which only a very small allowance has been made in the Energeia numbers. The Energeia allowance for 15 years of Opex for the Mesh network is much lower, primarily due to different assumptions about the complexity of operating an NMS.

Sensitivity Analysis

It is important to note that whilst the central projection of the NPV of retaining WiMAX is estimated at $48.6m, this is sensitive to a number of key parameters. Figure 1-1 below indicates the impact on the NPV of moving a single parameter from its expected value to the high or low point that were considered feasible.

Figure 1-1: Sensitivity of NPV (Tornado)



The key observation from this analysis is that no single parameter (or combination of two parameters) if changed to the low end of the feasible range would be sufficient to make the NPV of retaining WiMAX negative.

2. Background to the Project

2.1 Background

In 2006 the Victorian Government announced the rollout of AMI for all customers and that electric distribution companies (Distribution Network Service Providers – DNSPs) would be given an exclusive mandate for AMI implementation. The recovery of costs related to the AMI program is subject to regulatory oversight by way of an Order in Council. Relevantly, the regulatory arrangements require the Australian Energy Regulator (AER) to approve a Submitted Budget unless it establishes that the expenditure (or part thereof) is outside scope or is not prudent.

The AER made a final determination on SP AusNet's 2012-2015 AMI budget on the 31st October 2011 and disallowed part of SP AusNet's planned expenditure. SP AusNet appealed the AER's determination to the Australian Competition Tribunal on the 30th November 2011. The appeal was based on a number of material errors of fact, which included expenditure in relation to foreign exchange, contracts, WiMAX communications, maintenance, IT and communications backhaul expenditure, project management and customer service costs.

The Tribunal decided that the AER had made a material error in determining that $72.2 of WiMAX related expenditure was not prudent. The Tribunal required that that AER revise its determination to reflect agreed changes to foreign exchange contracts, meter supply expenditure and labour costs. In respect of the WiMAX related expenditure ($72.2m), the Tribunal directed the AER to further consider SP AusNet's Submitted Budget on the basis that the commercial standard required SP AusNet to carefully reconsider its various options and determine the extent to which incurring the proposed expenditure is not prudent.

The reconsideration of the technology choice as directed by the Tribunal should include the communication technology and systems architecture, cost of network interface cards, network management systems as well as the incremental cost of changing out the technology to Mesh Radio including the associated delays, and program management costs.

The AER engaged an independent consultant, Energeia, to advise on the prudency of SP AusNet's proposed expenditure on its WiMAX based telecommunications solution as part of its AMI solution. In particular, Energeia provided advice on whether SP AusNet's proposal to incur WiMAX related expenditure during 2012-2015 represented a substantial departure from the commercial standard that a reasonable business would exercise in the circumstances.

Energeia conducted a study that included a commercial assessment of the relative costs and benefits of WiMAX compared to alternative telecommunication solutions as of 28th February 2011 over a 15 year period. Energeia found that a prudent company would not have incurred more than the amount required for the Mesh telecommunications solution over the 2012-2015 period, and since SP AusNet's WiMAX AMI solution was in excess of those costs, it was not prudent expenditure. Energeia's study included a number of technical and financial references from sources such as Citipower / Powercor and Jemena / UED rather than the bottom up cost estimates.

SP AusNet have provided further information to the AER in June 2012 to assist in its further reconsideration and provided information that indicated continuing with a WiMAX solution was the lowest cost option. The preliminary view from the AER did not accept these arguments and disallowed much of the SP AusNet WiMAX expenditure. SP AusNet have engaged DNV KEMA as an independent consultant to re-assess these costs to consider what the impacts would have been from a switch to Mesh, based on information available in February 2011.

DNV KEMA has been provided with a copy of the *Practice Note CM 7: Expert Witnesses in Proceedings in the Federal Court of Australia* Federal Court Guideline issued by PA Keane, Chief Justice on 1st August 2011. The authors of this report have read, understood and complied with the Expert Witness Guidelines.

DNV KEMA has made all the inquiries that we believe are desirable and appropriate and no matters of significance that DNV KEMA regard as relevant have, to DNV KEMA's knowledge, been withheld from the report.

3. Experience and Qualifications of the Consultant

3.1 Overview of DNV KEMA

DNV KEMA Energy & Sustainability has more than 2,300 experts in over 30 countries around the world and is committed to driving the global transition toward a safe, reliable, efficient, and clean energy future. With a heritage of nearly 150 years, we specialize in providing world-class business & technical consultancy, testing, inspections & certification, risk management, and verification in the energy and energy-consuming industries. DNV KEMA is an independent, objective and impartial knowledge-based company and we advise and support organisations along the energy value chain: producers, suppliers and end-users of energy, equipment manufacturers, as well as government bodies, corporations and non-governmental organisations.

DNV KEMA brings unmatched global power system experience to each of our client projects. This global experience is applied with regional knowledge and insight to develop solutions to the power system problems of today, and to create opportunities for our clients within the competitive marketplace of tomorrow. We remain abreast of the latest developments in the power industry and the effects of these developments on specific market segments and technologies.

3.2 Expertise in AMI and Associated Communications Technologies

DNV KEMA's AMI and Smart Grid team is a worldwide leader in planning, designing, and implementing advanced communications, Advanced Metering Infrastructure (AMI), distribution and substation automation and Smart Grid utility systems. We also provide project management experience to oversee the integration of these automation and change management efforts into utility operational systems. DNV KEMA is the only independent firm of its size with deep AMI and AMI communications experience. DNV KEMA is not aligned with AMI meter, service, or software suppliers, and as a result, provides unbiased assessments of system architecture and enabling technologies.

Our services include (but are not limited to) the following processes, for both the electric and gas utility industries:

- Strategic planning and financial studies (e.g., business case development)
- Technical and business requirements analysis and development
- System design, specifications and integration for Information Technology, distribution automation, and telecommunications systems
- Enterprise Architecture and Data Integration
- Program management

- Business process redesign
- Change management
- Procurement support including issuance and support of applicable RFP's and vendor liaison
- Supplier Quality Assurance and risk assessments
- Acceptance testing
- Meter type testing and forensic analysis
- "Utility of the Future" thought leadership forums and book series.

To date, DNV KEMA's consultants have implemented numerous AMI projects and are presently supporting the implementation of some of the largest initiatives in Europe, North and South America, Australia, and Asia. Samples of relevant projects are listed below.

Table 3-1: Samples of Relevant AMI Projects

Client	Project Description	Performance Period
[redacted]	KEMA developed plans to implement an AMI solution that would improve the management of the electric and water distribution grids, improve operational efficiencies, and serve as the foundation for future SG initiatives.	2011
[redacted]	KEMA is providing operational analysis and logistics support, developing business process flows for operational support, and supporting various technical activities related to the engineering and deployment of AMI: liaison between engineering, operations and systems integration teams for the integration between Customer Care and Billing and UIQ management team; providing AMI deployment support and technical/engineering consulting services.	2010 - present
[redacted]	Technical review of proposed AMI technology solutions, Desk-top review of QA Systems of potential meter and technology vendors; and On-Site QA Assessment of the potential technology vendor.	2008-09
[redacted]	KEMA developed an overall strategy, business case, and procurement documentation for AMI/MDM (electric and water customers), and that aligned with the overall smart grid vision. Ongoing PMO for Proof-of-Concept and overall implementation.	2008 - present
[redacted]	KEMA assisted in defining and documenting the processes and systems required to support an AMI pilot project; emphasis was placed on minimizing the impacts of current business processes. KEMA led the process to select and hire an AMI installation vendor and the AMI technology itself. KEMA developed business process models covering customer management, revenue management, work management, maintenance and support processes. KEMA also developed a comprehensive audit program for supply chain vendors that incorporates ISO 31000 and ISO 9001 quality standards.	2009 - 2011

[redacted]	KEMA is assisting Duke Energy in evaluating communication technologies for a wide variety of smart grid applications, incl. metering and distribution automation. The two principal technology options evaluated are nodal systems and the RF mesh systems; a set of solutions optimized for various environments is being developed.	2010 - present
[redacted]	KEMA is conducting a Feasibility Study for smart metering across EEHC's 9 operating companies serving over 26 million customers. This includes the development of a strategic plan and business case, a system and network architecture, a technology assessment, an implementation plan and cost estimates for the deployment.	2011 - present
[redacted]	KEMA is assisting in the formulation of a strategy and roadmap for the preparation and implementation of a 3,000 meter AMI pilot system in Cyprus. KEMA documented the objectives of the pilot AMI program objectives and analyzed the prospective benefits that could be delivered by deploying the technology.	2012 - present
[redacted]	Various reports on AMI technology, , Expert Opinion Report, December , Assistance with the SmartNet financial model; and Due Diligence Reviews,	2007-2010
[redacted]	KEMA is providing comprehensive PMO services for LADWP's Smart Grid Regional Demonstration Project. This is an ARRA funded endeavor which includes smart meters (AMI) and demand response, Electric Vehicle (EV) charging and impact studies, customer behavior in adopting, using and understanding the Smart Grid and Cyber Security for the pilot program which includes 52,000 meter points.	2010 - present
[redacted]	Business Requirements Work group Leader, NSSC development of National Smart Meter Functional specification.	2009-11
[redacted]	KEMA provided a security assessment of various elements associated with OGE's Smart Grid deployment, including the evaluation and testing of network security aspects of the Wireless Communications Radios (WCR) from several leading vendors selected for AMI and DA systems deployments.	2010-2011
[redacted]	In collaboration with Chulalongkorn University in Bangkok, KEMA is conducting a feasibility study of PEA’s smart grids and AMI project, including formulation of smart grid policies and strategies, roadmap development, and implementation plan development...	2011 - present
[redacted]	KEMA performed quality assurance reviews for SMUD/s AMI Project, incl. meters, communications systems, back-office systems, installation & testing, business process transition, and project management.	2009 - 2011
[redacted]	Technical Due Diligence Assessment of AMI Program	2009

[redacted]	Technical Review of RFP for the AMI Pilot procurement and assistance with the evaluation of vendor responses to the procurement specification. Development of Smart Grid Strategy, Road Map and Business Case	2009-10 2010-11

These projects include diverse communications solutions that cover the range of options that are considered in this report.

Specifically, DNV KEMA has had detailed involvement in over 15 projects that have included Mesh radio solutions [redacted]

3.3 Qualifications of the Individual Consultants

Mr. Ronald Chebra: Mr. Chebra is DNV KEMA's Vice President responsible for the North American Advanced Metering Infrastructure (AMI) practice. He has an extensive background in communication systems and telemetry services, with a specialty in business requirements and strategy. He is involved in a number of client engagements where they are evaluating strategies, technical options, and economic considerations for SmartGrid and Advanced Metering.

Mr. Chebra has been a long-standing member of the Board of Directors of Utilimetrics (formerly AMRA) and has been actively involved with the leadership of this organisation for over 14 years. During 2001 and 2002 he served as President of this association. In 2006, Ron was awarded their "Outstanding Achievement Award" for his contributions to the association and for leading their efforts developing, organising and chairing their Public Policy Committee. He has taught detailed courses on communication technologies at many venues, has published many papers on advanced metering, given keynotes at leading conference and is quoted frequently in leading trade industry journals.

Mr. Mark Burke: Mr. Burke has over 20 years of experience in engineering and management consulting. As Vice President of Intelligent Networks and Communications, he leads the DNV KEMA business practice involved with the business case development, design, procurement, test and operations of utility communications and automation systems. He has been successful in management of engineering, consulting and change management engagements for utility companies, telecommunications firms, and governments in the North America, South America, Europe, the Middle East, and Asia. Efforts under his direction have included economic and market analyses, regulatory development, enterprise valuation, network planning, engineering and implementation, and management, as well as organisational development and project financing.

Mr. Jeffery Polan: Mr. Polan has 30+ years experience in wireless and telecomm systems research, analysis, modelling, design, architecture, engineering and test, with emphasis on advanced broadband wireless communications (1xRTT/EVDO, WCDMA/HSPA, MIMO-OFDM, LTE, WiMAX, Mesh), TDM SDH/PDH and packet networks (including Connection oriented Ethernet and ip/MPLS), smart handset and vehicular mobile devices, space-time/space-frequency signal processing, partition-kernel/EAL secure operating systems, strong encryption/authentication and related information- and cyber- security; expert in RF channel- and multi-cell modeling and prediction, and advanced network architectures including cognitive radio, MANET and dense femtocell/picocell; expert in mission-critical LMR and Public Safety Radio Systems (APCOA P25, TETRA, P34/TIA-902, DMR). Extensive experience in systems analysis, requirements definition/specification, technology trade-off studies, technology planning, and related network design and architecture.

Mr. Polan holds nine US Patents in broadband wireless communications and wideband data networks, as well as author of numerous technical papers. He has deep experience in design, development, test, verification and validation of secure, mission-critical, high-availability communications networks.

Mr. Didier Stom: Mr. Stom is a telecommunications engineering and operations specialist with a diversified technical background and over twenty years of experience in the industry, primarily in a managerial or executive capacity. Technical expertise in landline and wireless transmission technologies and systems supporting voice and data services. Experience in mobile and fixed network planning, engineering, construction, implementation and operation, as well as in business planning, product development, program management, supply and service agreement negotiation, and vendor relations.

Mr. Afshin Tajian: Mr. Tajian has more than 10 years experience in Advanced Metering Infrastructure (residential, C&I, high-end); design of metering systems and circuits, programming meters, AMR, AMI, field test, calibration, and troubleshooting of electric metering system. Experienced in Metering Standards, test equipment, test boards, instrument transformers (CT, PT), and recorder applications. Familiar with ANSI, IEC, and IEEE standards on electric metering. Familiar with ANSI C12 tests on electric meters, and criteria to approve/reject meters based on test results. Familiar with preparing RFP's for AMI projects. He has served as "meter engineer" function at Con Edison, one of the most unique utilities in the world in terms of the population and diversity of electric meters, and challenges with meter reading.

More than six years experiment in T&D, power systems, design and test of substation systems, high voltage testing, substation equipment, and insulator design.

Mr. David Lenton: Mr Lenton is an economist who has worked in the electric power sector since 1992. He joined KEMA in 2004 and worked for four years in our London office before transferring to KEMA's Sydney office in 2008. Recent AMI assignments include cost benefit assessments for [redacted] and [redacted] as well as work on AMI enabled tariff options for [redacted] Mr Lenton led the financial analysis of the Due Diligence Reviews of the [redacted] carried out in 2009 and 2010 and before this worked on a benchmark of AMI network benefits for [redacted]

Mr. Don Bonnitcha: Mr Bonnitcha is an Operational Technology specialist and power systems engineer who has worked with a broad range of power utility companies in Australia, New Zealand and Asia in large procurement and implementation projects for technology solutions over a period of 35 years. Mr Bonnitcha has worked on projects with electricity distribution companies in every state of Australia and is well-versed in the practices appropriate to, and the complexities associated with, major technology procurements.

3.4 Disclosure of Pre-Existing Relationships

DNV KEMA has performed consultancies for SP AusNet and other electric power utilities in Australia and worldwide. Recent consultancies within Australia addressing advanced metering are identified below:

- [redacted]:
  - Various reports on AMI technology;
  - Expert Opinion Report;
  - Assistance with the SmartNet financial model;
  - AMI Program Due Diligence Reviews;
  - AER Determination Opinion.
- [redacted]:
  - Business case study of options for deployment of advanced metering with and without direct load control.
- [redacted]
  - Technical Due Diligence Assessment of AMI Program;

- AER 2011 Revised Budget Application Opinion April 2011.

- [redacted]
  - Technical review of proposed AMI communications technology solutions;
  - Desk-top review of QA Systems of potential meter and communications vendors;
  - On-Site QA Assessment of the potential communications vendor.
- [redacted]
  - Business requirements workstream lead, National Smart Meter Program.
- [redacted]
  - AMI RFP Review;
  - AMI RFP Evaluation;
  - Smart Grid Strategy, Road Map and Business case.
- [redacted]:
  - Smart Grid Value Assessment.
- [redacted]:
  - Intelligent Network strategy.

4. Scope of the Project

4.1 Terms of reference

DNV KEMA has been requested to provide expert analysis, given the information available to SP AusNet at 14th February 2011, by way of a 15 year cost benefit[2] assessment of SP AusNet continuing with a WiMAX communication solution in comparison to adopting an RF Mesh solution. This information would then have been used to reach a decision by the 28th February 2011 and all costs incurred or committed before 28th February 2011 are to be ignored for the purposes of this analysis.

DNV KEMA has also been requested to review the assumptions made in the Energeia report prepared for the regulator in August 2012[3]. The Energeia assessment concluded that there were net benefits from switching to RF Mesh and was based on a number of modelling assumptions. DNV KEMA in undertaking its assessment was requested to highlight where it disagrees with the assumptions made by Energeia, focussing in particular on the suitability of Powercor as a proxy for the cost of RF Mesh in SP AusNet's region and the transition program in any switch to RF Mesh.

4.2 DNV KEMA Approach

DNV KEMA's approach is to break the costs down into three main areas:

- Costs of continuing with the WiMAX solution;
- Costs of adopting a RF Mesh solution; and
- Transition (switching) costs in moving from WiMAX to RF Mesh.

The costs of WiMAX have primarily been provided by SP AusNet and are based on contractual obligations they have for components and resource expectations to deliver against the requirements in the AMI Minimum specification. DNV KEMA estimated the WiMAX costs that may be required for a replacement MDMS based on our industry experience with many such projects as part of AMI deployments.

The cost and requirements for the RF Mesh solution are based on the construction of a high level design for the RF Mesh network. This produces a view on the number of access points and relays

[2] Whilst additional benefits do arise from the deployment of the WiMAX solutions, these have not been reviewed within this analysis.

[3] Energeia, Review of SP AusNet's WiMAX Related Expenditure, August 2012.

required and the optimal level of coverage for the Mesh network (with the remainder using 3G). This allows infrastructure and NIC costs to be calculated for the Mesh deployment. Benchmark information has then been used to estimate the Capex and Opex of the solutions required to operate the Mesh network.

The third area of assessment relates to transition costs. DNV KEMA has first reviewed, based on our experience in other markets, the likely timing over which transition will take place. We have then made an estimate of the costs of the different transition activities based on this timetable and benchmark information from other projects. The model assumes that the AMI project will still meet the mandated rollout completion end date of 31st December 2013 with no project extension required.

Comments on each of the Energeia cost assumptions are provided in DNV KEMA's review of the expected approach and costs for the different solutions.

4.3 Solutions Impacted by Adoption of Mesh

DNV KEMA's assessment is focussed solely on the AMI Costs that would have been impacted by the choice of communication solution. This includes the Capex and Opex associated with communications infrastructure, NICs (WiMAX, NMS and 3G), antennas, NMS, Communication Operations and transition activities.

Costs that are independent of the choice of communication solutions have generally not been assessed. This includes:

- Meter costs – same for both solutions;
- Other IT system costs – Not impacted by choice of communication solution.

The MDMS should be independent of the communication options selected. However, as this has been included in the Energeia assessment it is also recorded in DNV KEMA's cost analysis. DNV KEMA expects these costs to be independent of the communication solution chosen.

4.4 Cost Benefit Modelling Approach

4.4.1 Background to the Model

DNV KEMA's Cost/Benefit model is built in Microsoft Excel and provides a central tool to assess the benefits of introducing the new infrastructure and technologies. It breaks down all costs and benefits in fine detail, allowing the user to identify which variables drive the more significant elements and therefore take steps to further validate this data.

The model has been applied in Australia for Smart Metering, Smart Grid, DMS, Substation Automation, Communications assessments and Generation business cases.

4.4.2 Comparison in the Model

The model has been set up to allow the user to assess a number of costs covering:

- WiMAX Capex and Opex; [4]
- Mesh Capex and Opex; and
- Switching costs.

Combining these costs allows a comparison of whether the costs of rolling out a Mesh Network, including all switching costs, will exceed the costs of retaining WiMAX.

4.4.3 Key Parameters of the Model

Within the model there are key parameters that either impact on a number of costs, or are significantly material in their impact for some range of values to be assessed. Each of these key parameters has a central (most likely), minimum and maximum values that can be individually switched to demonstrate the effect of value ranges, or to cover off differences of opinion that may need to be assessed. The minimum and maximum values reflect the impact of the parameter on the NPV, so some of the smaller numerical values will be captured in the maximum column.

A table of all the key parameters applied in the model is shown below. A number of these parameters are discussed in the assessment of the individual costs sections (8-10) with the source for all parameters in Appendix A.

[4] - WiMAX costs include the cost of WiMAX and 3G using WiMAX as the primary solution. Correspondingly RF Mesh Costs means the cost of Mesh and 3G using Mesh as the primary solution.

Figure 4-1 Key Parameters in the Model

Parameter description	Min	Central	Max
Project Assessment Period (years)	15	15	15
Inflation Rate (%)	2.00%	2.55%	3.00%
Nominal Discount Percentage (%)	11.00%	9.51%	7.00%
Percentage of 3G Meters with WIMAX Deployment (%)	15.00%	10.37%	5.00%
Percentage of 3G Meters with RF Mesh Deployment (%)	3.00%	6.50%	15.00%
Cost of WiMAX NICs (USD)	[redacted]	[redacted]	[redacted]
Cost of RF Mesh NICs (USD)	[redacted]	[redacted]	[redacted]
Cost of 3G NICs(USD)	[redacted]	[redacted]	[redacted]
Exchange Rate post 2015 (USD:AUD)	1.00	0.87	0.81
Date for Deployment of 3G Meters (Year)	2012	2012	2013
Cost of installation of Comms card (AUD)	[redacted]	[redacted]	[redacted]
Cost of retrofit of Comms card (AUD)	[redacted]	[redacted]	[redacted]
Cost of standard antenna (AUD)	[redacted]	[redacted]	[redacted]
Cost of extended antenna (AUD)	[redacted]	[redacted]	[redacted]
Cost of antenna installation (AUD)	[redacted]	[redacted]	[redacted]
Delay before WiMAX Meters can stop being rolled out (Months)	0	2	3
Delay before RF Mesh Meters can start being Rolled out (Months)	7	9	13
Initial Resources cost per year for NMS ($)	15	22	25
Delay before Meters are retrofitted/installed with RF NICs (Months)	13	10	9
Min timescale before the RF Mesh Network starts to be operational (Months)	12	16	20
Months to complete retrofit/installation of NICS (Months)	24	20	12
Number of meter per access point - High Density Urban (Meters)	367	334	301
Number of meter per access point - Suburban (Meters)	1111	1010	909
Number of meter per access point - Rural (Meters)	1048	953	858
Risk Premium to Apply to Proprietary Capex (%)	0.00%	17.00%	24.00%

4.4.4 Sensitivity of the Model

A key concern with cost benefit analysis is the sensitivity of the end results to changes in each parameter and the risk of one small alteration having a significant impact on the overall result. The use of this range of values for key parameters within the model allows the testing of sensitivities, which are described later in this section. To demonstrate this sensitivity DNV KEMA's model assesses each individual key parameter for its impact on the NPV when the maximum and minimum values are tested.

DNV KEMA suggest that some form of sensitivity analysis is an important part of long term cost benefit models as uncertainty must exist around some of the assumption in all long-term models and such a sensitivity analysis may highlight the key parameters of any differences in models and assumptions. DNV KEMA note that a sensitivity analysis was not undertaken by Energeia.

DNV KEMA's sensitivity analysis showing this calculation for each of the key parameters is included in section 12 of this report.

5. Tasks and Schedule for AMI Technology Transition Program

5.1 Transition Approach

The following section describes the estimated transition schedule based on the level of effort required to execute the activities required for the switch of communication solution to RF Mesh. This entails the abandonment of the existing WiMAX-based AMI infrastructure deployed as of 1st March 2011 in favor of an RF Mesh AMI solution.

SP AusNet's underlying assumptions to the overall approach to switching to Mesh are considered sound by DNV KEMA. These are, assuming a decision to replace WiMAX with Mesh radio communications on 1st March 2011, that:

1. For March and April 2011 SP AusNet would continue to roll out WiMAX enabled meters because of the OIC requirement that installed meters be capable of remote reading as required by the OIC
2. During those months, SP AusNet would hold discussions with the AER and Victorian Government with the following expected outcomes:
    a. Those discussions lead to regulatory and Government support for changing to Mesh so that the roll out of WiMAX-enabled meters can be stopped, but
    b. Whilst there may be some relaxation of the subsequent interim milestones[5] for remotely read meters this will not lead to a relaxation of the final roll out target
3. Hence, according to 2b. above, there will be a requirement to roll-out meters out without any NIC cards until Mesh enabled meters are available from the factory
4. Also in support of 3 above, if SP AusNet did not continue to roll-out meters until Mesh enabled meters were available from the factory, it would lead to a loss of the trained installation workforce over that period.
5. Once Mesh enabled meters are available from the factory, rollout would be recommenced.

[5] The expectation of some relaxation of the interim milestones is important in minimising the activities required and cost of any transition. If the interim milestones were all retained then this would require the continued deployment of WiMAX meters for many months and the parallel operation of WiMAX systems to meet these milestones. There would then be a very significant cost in converting a much larger number of WIMAX meters to Mesh (change of the NIC) and cutting over the WiMAX systems to Mesh systems.

Hence, the transition program, with respect to meter deployment, is assumed to occur in four streams:

a. Initial continued roll-out of WiMAX enabled meters for a period, to meet the OIC June 2011 interim milestone
b. Roll out of meters without NICS for a subsequent period, until
c. Roll out of mesh enabled meters when available from the factory
d. Retrofit the WiMAX enabled meters installed in the initial period with Mesh NICs and revisit and install Mesh NICs in the meters initially installed without any NICs

The underlying assumptions with respect to duration are derived from experience and information that DNV KEMA has gathered over the years during the course of executing numerous AMI-related consulting engagements, primarily in North America, South America and Australia, in addition to a huge number of other power utility technology procurement and implementation projects. This includes proprietary information from 4 specific implementations in California, New York, Indiana and Brazil (ranging from a pilot program of ~100K smart metering end-points to a large deployment of over 2M meters), and information extracted from confidential BAFOs issued by various vendors / integrators, as well as actual deployment timelines observed by utility operators. DNV KEMA adapted the assumptions to the scope of the change-out scenario envisioned by SP AusNet, using interpolated or extrapolated data from real-world green-field deployments of RF mesh technology AMI systems.

It is further assumed that the IT systems already deployed can be readily adapted to the new AMI systems; for example, the MDMS remains largely unchanged but the existing NMS cannot be used for the Mesh network systems.

An important consideration is that the NMS functionality provided for the management, monitoring, and configuration of meters interconnected by a proprietary meshed network is designed to handle only meters (and other devices) which are part of the RF mesh (e.g. security certificate to validate commands). This means that most of the functionality and safeguards related to other functions than basic meter data retrieval will not be available for meters equipped with cellular modems, i.e. those not integral to the meshed environment. These cellular meters will require additional external management systems and security measures to fill the gap. This is not the case with a WiMAX infrastructure approach, where a single external management system platform can accommodate meters covered by the AMI WiMAX network as well as those equipped with cellular modems. This would result in both additional Capex and Opex to manage the cellular modems with a NMS build to manage Mesh solution. These have not been quantified at this time

5.2 Activities required for Transition

The following activities and tasks are applicable to this endeavor (each implying time and Capex and/or Opex expenditures):

- Requirements Definition
- Procurement Process (Engineer Furnish and Install agreement; h/w and s/w for communications gear and support systems, engineering / installation / integration services etc.)
- Logistical Planning & PMO (contract management; deployment management; schedule and budget tracking, etc.)
- Installation / configuration / commissioning of Communications and Support systems
- Communications Systems and Facilities Integration & Testing / RF Optimization
- IT systems Integration and Testing
- Performance / Security / Regulatory Compliance Verification
- Systems Acceptance Testing / Punch-list Items' Resolution
- Additional Manual Reading of a Subset of Meters
- As-built / Baseline System Documentation
- Utility Staff Training
- O&M Procedures Development

The estimated timeline developed for those activities is presented below, showing the major requisite categories and phases of activities, many of them occurring concurrently.

5.3 Duration of Transition

As documented below, the duration for completing the procurement of the necessary AMI infrastructure, metering end-points and entering into a contractual agreement with a provider is estimated at 5 months following the presumed date for initiating a switch in AMI technology.

This is a conservative estimate for the time needed to (1) develop the tender documentation (specifying the functional technical and performance requirements, the scope of the engagement, the timeline for the agreement's execution, and the contractual terms and conditions), (2) analyse the bids and proposals from the respondents, (3) request best and final offers and select the best suited provider of the optimal solution, and (4) negotiate and finalise a contract for the requisite equipment, systems, and services for the installation and deployment of the procured systems as well as for the requisite integration, testing, optimization, and ongoing post-acceptance support and maintenance services. Those sourcing activities require skilled technical and contracts personnel.

Following the placement of an initial order, a lead time of 90 days after receipt of order would have been expected prior to receiving and staging the first shipment of product. This is a standard lead time that a manufacture would require to process an order, place an order for components with suppliers and manufacture/integrate the product prior to delivery.

Based on the resources that could have been brought to bear by SP AusNet during 2011, up to 30,000 new meter installations could have been accomplished in a month, utilising an accelerated rate of deployment target. By the end of CY'2011, a total of 308K smart meters could have been deployed, of which fewer than 15,000 would have been equipped with an RF mesh NIC (less than 5%).

A period of approximately 19 months would be needed to deploy the requisite RF mesh infrastructure with an additional 341K smart meters, for an aggregate total of over 648K smart meters by YE2012. Concurrently, the timeframe required to equip smart meters already deployed with the requisite RF NIC would extend over a period of 18 months.

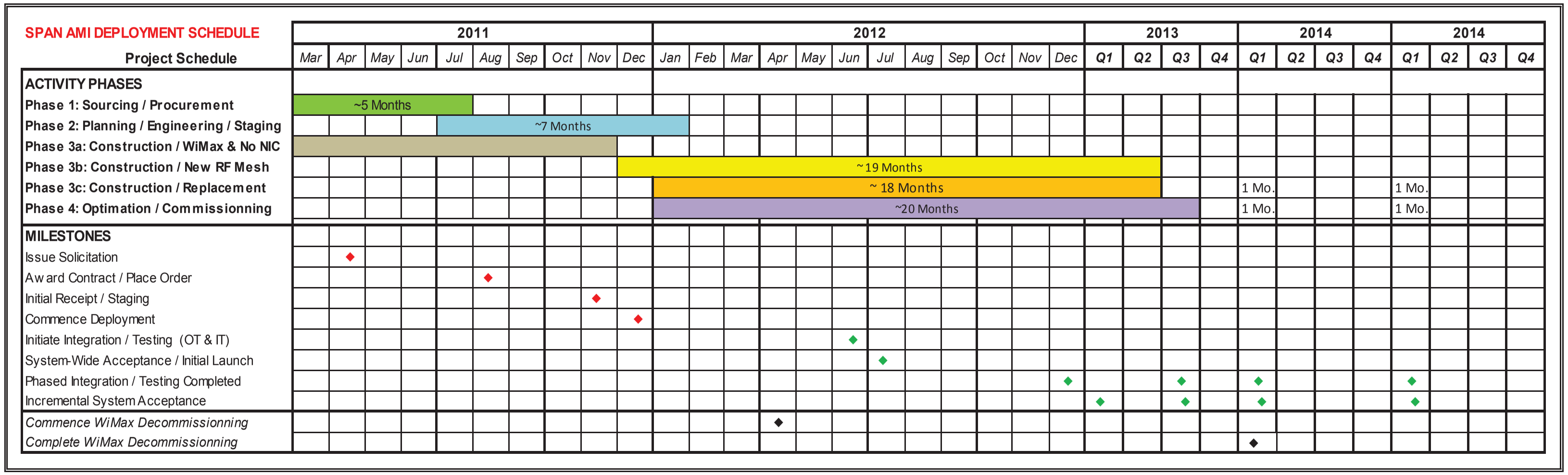
It is assumed that NIC replacement can be performed in the field, which may or may not actually be feasible (nor acceptable to the equipment vendor with respect to honoring the "standard" contractual warranties).

It should be noted that the time required to swap a smart meter's NIC on site and to change-out the external antenna needed at the vast majority of locations can take twice as long as installing a pre-configured meter and its attending antenna. However, this schedule and the costing approach has taken a relatively conservative allowance for the time required using a best case scenario for the ease of replacement/installation.

By mid 2013, i.e. 28 months after the 1st March 2011, close to 700,000 smart meters could have been installed, integrated, and operational using an RF mesh AMI. The first commercial launch of the new operational partial AMI system encompassing some 180,000 meters would have occurred in mid-2012 at the earliest, some 16-17 months into the process, to allow for the requisite Operational Technology and IT integration and to complete the acceptance testing process for the initial system.

Estimates of the costs associated with the large scale deployment utilizing the new AMI technology and for changing-out the system components already deployed through 2011 are addressed in Sections 8 and 10.

The following picture provide an overview of this timeline broken down into the main activities and showing key milestones.



	2011										2012												2013				2014				2015				Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Additional WiMax Meters *(in 1,000s)*	30.1	27.9																																	
Meters w/o NIC *(in 1,000s)*			30.6	29.3	14.3	14.3	14.3	14.3	14.3																										
New RF Mesh Meters *(in 1,000s)*										14.3	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	29.3	29.3			14.7				15.1				
Total Meters during Period	117,891				42,837			42,838			85,179			85,179			85,179			85,179			58,668				14,743				15,131				
Cummulative # of Smart Meters	222,339				265,176			308,014			393,193			478,372			563,550			648,729			707,397				722,140				737,271				
Replacement by RF Mesh NICs											12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	73.4	73.4											
New Access Points											*152*			*135*			*135*			*135*			*222*				*16*				*16*				
Total APs											***152***			***287***			***422***			***557***			***779***				***795***				***811***				
New Relays											*1,520*			*1,350*			*1,350*			*1,350*			*2,220*				*160*				*160*				
Total Relays											***1,520***			***2,870***			***4,220***			***5,570***			***7,790***				***7,950***				***8,110***				
Sites Requiring Installation Work *(in 1,000s)*	30	28	31	29	14	14	14	14	14	14	29	29	29	29	29	29	29	29	29	29	29	29	30	30	30	1	15	0	0	0	15	0	0	0	670
Monthly Manual Meter Readings *(in 1,000s)*	0	0	31	60	74	88	103	117	131	146	175	203	232	261	290	319	290	261	232	203	175	146	116	15	15	0	7	0	0	0	8	0	0	0	3,698

5.4 Timeline Estimated by Energeia

In its Review prepared for the AER in August 2012, Energeia concluded that "…a reasonable commercial business in the circumstances would have planned on a 10 month timeframe for implementing a proven mesh based telecommunications solution…". As pointed out by Energeia, however, this timeframe "… does not include the time required for mobilization, procurement or technology delivery…". As Energeia's analysis ignores procurement it presumably hinges upon a rapid sole source approach. This would expose SP AusNet to a high risk of non-competitive pricing. In such a situation, a prudent business should seek competitive pricing via a well managed procurement process.

The timeline described under subsection 5.3 above accounts for a period of 9 months prior to commencing deployment and integration activities, allowing for a competitive procurement process, contract negotiation, and customary lead times for the initial delivery of goods and services from the winning AMI vendor. Energeia's approach also took no account of any technology delivery lead times. In DNV KEMA's view a prudent business would plan for the customary lead times in delivery.

This requisite sourcing, planning and acquisition phase precedes the initiation of the period of 10 months estimated by Energeia for an initial launch of an RF mesh solution by SP AusNet; an aggregate timeline of 19 months would thus be required for the reference date of 1st March 2011, to implement the first phase of the alternate AMI Mesh system and complete its installation, integration, optimization, testing and acceptance.

The schedule laid out above for SP AusNet calls for a duration of 8 months following the equipment deployment's initiation, to achieve the launch of an RF mesh AMI system encompassing some 180,000 meters, i.e. within an aggregate timeframe of 16-17 months rather than the 19-month window (9 months for procurement + 10 months for implementation) which would follow if procurement activities were added to the implementation activities in Energeia's assumptions.

DNV KEMA note that Energeia's reference to PG&E as a "relevant case" is a qualitative and highly subjective statement regarding PG&E's situation, as there is no foundation established to enable a comparison at any level; no comparative statistics are offered in terms of customer densities and distributions over the service area and as a fraction of total customer population and it is specifically stated that the PG&E timeframe was from after "contract award". Therefore there is no basis for comparing PG&E's mesh experience with SP AusNet, with respect to deployment costs, coverage, or performance, and no established predictive value in doing so.

6. RF Mesh Infrastructure Requirements for SP AusNet

6.1 DNV KEMA Approach to Calculation of Mesh Requirements

In order to estimate the cost of an RF mesh network for SP AusNet, DNV KEMA developed a series of models that estimated the design of the systems that would accommodate the minimum performance requirements as stipulated in the Minimum AMI Functionality Specification for Victoria published by the Department of Primary Industries in September 2008. The models specifically estimated the bill of materials and quantities of network devices including RF mesh NIC cards, access points, relays and repeaters and back haul facilities. The analysis yielded predictions of the necessary facilities to deliver the adequate capacity, latency and reliability of the system to support the requirements.

The model included an analysis of the characteristics of the service territory, including terrain, density of meters, and characteristics of ad hoc mesh networks in the frequency band appropriate for the area. The methodology leveraged theoretical models such as Hata-Okagura models to estimate the mean propagation loss to which the fading models, and expected range coverage as well as project experience with such systems. The results of the effort yielded a number of outputs for various level of confidence. The minimum required systems to support requirement 4.1 *Performance levels for collection of daily meter readings* was selected as the minimum compliant system requirement in the development of costs. The Details of the approach, methodology and references are provided in Appendix B.

6.2 Number of Meters Per Access Point

The number of meters per access point varies across the service territory driven by several factors which include the need to complete the mesh with adequate density in order to ensure reliable communications, the customer density and the terrain of the services territory. DNV KEMA models included an analysis of meter density per square km across the services territory and the access to either utility owned or cellular based back haul communications. The average of the meter density across the entire service territory of the minimum compliant system yielded 823 meters per access point. The details of the analysis are provided in Appendix B.

6.3 Number of Access Points

To minimally meet the DPI's Requirement 4.1 of 99% meters read within 4 hours the use of 811 access points is initially expected by 2013 under assumptions of independent Gauss-Markov process with intelligent continuous re-queuing of unsuccessful reads after the first hour. The breakdown of access points in the three categories of density yielded the following:

- Urban: 225 Access Points
- Suburban: 490 Access Points
- Rural: 96 Access Points

The numbers of Access Points will expand over time in line with the growth in the meter population.

6.4 Costing information applied to Mesh Network

The cost of the Mesh Network was driven by the number of access points and relays required (with a ten to one ratio assumed). Based upon our experience with a number of similar projects, the cost of the access points (ToPs) were taken as $[redacted] USD (including battery backup, installation kit, and installation labour), and the cost of each relay was taken as $[redacted] (including battery backup, installation kit, and installation labour). These costs estimates break down as follows:

Table 6-1: Cost Breakdown Access Point and Relay

Item	Access Point	Relay
Purchase Cost	[redacted]	[redacted]
Battery Backup	[redacted]	[redacted]
Mounting Kit	[redacted]	[redacted]
Installation	[redacted]	[redacted]
Total	[redacted]	[redacted]

6.5 Suitability of Powercor as a Proxy to SP AusNet

Energeia in their report have made the simplistic assumption that Powercor (with broadly the same number of customers) would be a suitable proxy for SP AusNet for deriving RF Mesh Costs. DNV KEMA does not believe this to be a valid assumption for a number of reasons.

Many of Energeia's conclusions are based on little more than presumption that experience at Powercor, Jemena, and even PG&E shall serve a valid and useful basis of comparison, and predictor of SP AusNet's mesh costs. No such basis is ever established, nor is a methodology for comparing the indicated Utilities with SP AusNet described.

The systems design associated with radio communications are critical to evaluating the cost of AMI systems. Drivers of the design include the customer densities, the topography and foliage of the service territory. Ad hoc RF Mesh networks require a certain density to form the mesh and reliable and predictable communications performance. If the customer density is very low, repeaters or relays must be put in place to form an adequate mesh. If the densities are too large, the mesh must be segmented to avoid interference and achieve the required capacity. Terrain, foliage and buildings affect the performance of the networks as well and must be accommodated in the design. The designs include the number and location of access points, repeaters relays and back haul nodes. Finally the performance in the form of capacity, latency and reliability must be designed with the knowledge of the all these technical characteristics of the services territory.

In SP AusNet's case, less than 7.8% of the customer population is spread out over more than 79% of the service area (defined as that area with at least 1 customer per Km^2) – about 15,700 Km^2 of 19,856 Km^2 – and less than 20% of the customer population is spread out over 94% of the service area. Such a low-density rural/open area disposition shall pose significant economic challenges for any AMI solution, including WiMAX, Cellular, or Mesh. In addition, more than 43% of the customer population occupies less than 2.2% of the service area (deployment densities greater than 500 meters/Km^2). Such high density urban deployment shall pose economic difficulties especially for mesh solutions, where subnet capacities shall be severely constrained due to interference conditions.

There is no technical basis presented to accept that the indicated Utilities' experience should carry over to SP AusNet. There are no comparisons of differences in service area, analysis of customer densities and distributions, geography, structures or terrain. There are in fact significant differences in geography, topology and foliage between PowerCor and SP AusNet's service territories and such technical characteristics can have a great effect on the various separate radio frequency AMI solution costs. The 15-year Total Lifecycle Cost (TLC) models are suspect on numerous assumptions and factors not considered including estimated number of Access points (and associated backhaul requirement) versus customer density, number of required relays per Access point, expected subnet delivered capacities and range coverage per customer density, and assurance of meeting AER AMI requirements.

Hence, due to the issues discussed above, Energeia's report has provided no established basis for assumptions, such as:

- The Mesh Radio deployment for SP AusNet requiring 'less than 433' Access points (ToPs) to deliver the capacity to achieve the required meter read throughput;
- The ability of a Mesh solution to achieve 97% coverage in SP AusNet's territory.

Rather than rely on the presumption of the suitability of Powercor data, DNV KEMA has produced its estimates of required number of access points from the actual customer distribution data (GIS data) provided by SP AusNet utilising appropriate models to derive expected RF single-hop transmission availability, expected number of required re-transmissions, and average subnet hop counts to arrive at expected capacities and coverage in each of the dense urban, medium-density suburban, and low-density rural deployments. DNV KEMA expects that a significantly greater number of access points are required to fully-meet the AER requirements.

7. Network Management Systems for Mesh Radio

7.1 Mesh Radio NMS overview

Network Management is a crucial component of a Mesh Radio system as the nature of the system requires a continual on-going process of tuning network operation. Network management systems associated with RF Mesh networks play a crucial role in the data collection and operation of the system. The functions that network management provide include the following:

- Network monitoring
- Provisioning
- Fault management
- Configuration management
- Security management
- Data collections
- Control order management
- Software/firmware management.

7.2 Network Management System Components

The roles and tasks of the network management function are expanded below:

Fault Management detects, fixes, logs, and reports network problems; involves determining symptoms through monitoring and measurements, and isolating the problem; it may also initiate controlling functions, e.g. recovery, work-around, and backup.

Configuration Management involves maintaining an inventory of the network and system configuration information. This information is used to assure inter-operability and problem detection. Examples of configuration information include device/system OS name and version, types and capacity of interfaces, types and version of the protocol stacks, type and version of network management software, etc.

Accounting Management keeps track of usage per account and ensures resources are available according to the account requirements.

Performance Management involves measurements of various metrics for network performance, analysis of the measurements to determine normal levels, and determination of appropriate threshold values to ensure required level of performance for each service. Examples of performance metrics include network throughput, user response times, and line utilisation. Management entities continually monitor values of the performance metrics. An alert is generated and sent to the network management system when a threshold is exceeded.

Security Management controls access to network resources according to security guidelines. The security manager partitions network resources into authorized and unauthorized areas. Users are provided access rights to one or more areas. Security managers identify sensitive network resources (including systems, files, and other entities), determine accessibility of users and the resources, and monitor access points to sensitive network resources and log inappropriate access.

NMS Infrastructure Support provides operational support for the NMS systems itself. That includes database maintenance, rule base generation, script editing and alarm and alert definitions, and renewal; as well as application management. The NMS system is a system of subsystems that must be maintained for the proper functioning of the NMS system.

7.3 Approaches to Mesh Network Management

The approach to network management varies among vendors, however, in order to estimate the cost of the Network Management Systems we have focused on those approaches most common among the leading vendors serving this service territory.

There are two principal modes of operating the RF Mesh network. The **"Utility Owned"** mode involves the utility owning and licensing the RF Mesh AMI system and operating the system with internal resources. The **"Managed Service "** model involves the vendor providing as service meter reading (data collection) and network management. To model and apply the costs of the NMS we have estimated an attribution of NMS costs for initial set-up and recurring costs in the two principal modes of operations.

Typically the NMS includes a number of support elements for each environment. The environments include Development Environment, Test Environment, User Acceptance Environment and, Production Environment. In all environments the following elements are required: Database Software, Operating Systems, Network Servers, Web Server, Application Servers, Database Servers, Security Servers, Installation hardware, Test Harnesses, Device Clients, Geographic Displays and Messaging infrastructure.

As part of the NMS deployment considerable systems integration must take place including, configuration, integration, migration, testing and change management. The NMS systems require considerable ongoing support to update the device clients, firmware updates, security management as well as systems training and documentation.

7.4 NMS Cost Estimates for Different Approaches

The basis of estimating the costs of the elements, and total costs, are drawn from numerous projects of a similar nature in North America, South America and Australia. Specific references cannot be provided since they are proprietary to the utilities involved. However, these estimates are substantiated by actual past projects.

Managed Service

[redacted]

[redacted]

[redacted]

Utility-Owned and managed NMS

[redacted]

[redacted]

- [redacted]

[redacted]

- [redacted]

[redacted]

[redacted] [redacted]

[redacted]

7.5 Approach to NMS for SP AusNet

DNV KEMA has applied the costings for the Utility Owned in-house service as this is more commonly applied in Australia.

8. Comparison of Capex

8.1 Overview of Results

DNV KEMA's assessment of the Capital costs has broken down into the areas shown in the table below, which is consistent with the previous Energeia analysis. In the case of WiMAX this includes savings after 1st March 2011 of costs that would not be subsequently incurred if WiMAX had been cancelled. The Mesh Costs includes all costs from 1st March 2011, but the installation of NICs/antennas to meters without Mesh devices initially fitted is covered in the transition section.

Table 8-1: Overview of Costs (2011 dollars)

Cost Item	PV of WiMAX Costs ($M)	PV of Mesh Costs ($M)	Difference in Costs ($M)
NIC Costs	$76.1	$47.5	$28.6
Antenna Cost	$19.7	$10.1	$9.6
Network and Backhaul Costs	$56.8	$46.8	$10
NMS Costs	$13.3	$30.5	$17.2
MDMS Costs	$17.7	$17.7	$0
Total Capex	**$183.5**	**$152.5**	**$31**

8.2 NIC Capital Costs

In this area the costs of the WiMAX solution are significantly higher than the costs of the RF Mesh solutions due partly to the differential cost of the NIC cards. The difference in this particular section is exacerbated by the allocation of NIC installation for Mesh meters rolled out without NICs as a transition cost. This means that a different number of NIC cards are recorded for implementation in this section for WiMAX and Mesh. However, this has no impact on the overall NPV in the model.

DNV KEMA's modelling of the NIC Costs is based on the following assumptions[6]:

- Cost of WiMAX NICs ($[redacted] USD) – This is consistent with the cost in the Energeia assessment and reflects the information available to SP AusNet in February 2011. This includes the cost of a Zigbee chip.

[6] One general assumption is that all NICs (WiMAX, Mesh and 3G) are assumed to be contracted and have a fixed price for 5 years with inflation applied after this point.

- Cost of RF Mesh NICs ([redacted] USD) – This cost is based on SP AusNet's 2009 submission to the AER and reflects the information available to SP AusNet at February 2011 for the cost of NICs. Energeia have a slightly cheaper cost at $54 USD per RF NIC, which is based on other distributors in Victoria who would have benefited from economies of scale and therefore would expect to achieve a lower price. Energeia state that this is substantial difference in cost[7]. In DNV KEMA's modelling whilst this is a material impact the difference on the NPV is just over $6m, so it will not fundamentally alter the business case. This includes the cost of a zigbee chip.

- Cost of 3G NICs – [redacted] USD - This is based on costs available to SP AusNet in February 2011 and is the cost adopted by Energeia in its modelling. It includes the cost of a Zigbee chip.

It is assumed that the WiMAX network can cover 89.4% of the SP AusNet network and DNV KEMA's high level design indicates that RF Mesh would optimally cover 93.5%. WiMAX NIC costs are assumed to start from 2 months after the 1st March 2011 as WiMAX NICS would continue to be deployed for a period of time even after the decision was made to switch to RF Mesh. This assumption was made in order to allow SP AusNet to continue complying with the OIC milestones as discussed in section 5.

The difference in costs for NIC Cards and coverage assumptions resulted in an incremental NIC cost for the WiMAX solution of $28.6m. This is broken down as follows:

Table 8-2: Differences in Costs for WiMAX and Mesh

	WiMAX ($M)	**Mesh ($M)**
PV Installed WiMAX NICs[8]	$60.0	Not applicable
PV Installed 3G NICs	$16.1	$10.1
PV Installed RF Mesh NICs	Not applicable	$37.4
Total	**$76.1**	**$47.5**

[7] Energeia, Page 29 of 41.

[8] This cost includes the inventory of WiMAX NICs that exist at February 2011 and which will be used in the deployment. This approach is also taken for WiMAX antenna.

8.3 Antenna Costs

The modelling makes a number of differential assumptions that result in the WiMAX Antenna costs being higher than the cost for the Mesh antennas. These were:

- Percentage of meters needing a standard antenna – Set at 91% for WiMAX and 3G against only 70% for Mesh;
- Percentage of meters needing an extended antenna – Set at 9%[9] for WiMAX and 3G with no requirement for RF Mesh meters.

These variables contrast with the Energeia modelling that assumes 100% of Mesh meters requiring a standard antenna.

There is a relatively low cost for standard antennas of $[redacted] with extended antennas significantly more expensive at $[redacted]. The installation cost for all antennas is $[redacted] The Energeia modelling included the same purchase price, but assumed that no charge would be made for the antenna installation. Despite this activity being done at the same time as the NIC installation or meter installation we would expect there to be a charge for this service.

This assessment resulted in an additional PV cost of the WiMAX solution of $9.6m. However, there are some costs for Mesh Antenna that are not fitted in the standard installation, but are included in the transition processes.

8.4 Network and Backhaul Costs

The WiMAX network and backhaul Capex has been provided by SP AusNet and utilised by DNV KEMA in its modelling. These costs are consistent with those applied in the Energeia model with two exceptions:

- Energeia has assumed the full costs for 2011. However, DNV KEMA has assumed that the project would only be cancelled from the end of February 2011. DNV KEMA has therefore reduced the 2011 costs by 1//6th to reflect a linear estimate of the costs incurred in January and February 2011. The net impact of this change is to reduce the WiMAX 2011 costs that could have been avoided by $2.9m out of a total expenditure in 2011 of $17.3m.

[9] This is a conservative estimate.

- DNV KEMA agree with SP AusNet's opinion that limited additional infrastructure should be needed post 2014 as the existing number of WiMAX towers should be able to handle some growth in customer numbers. However, some additional towers may be needed for Greenfield sites and DNV KEMA has adopted SP AusNet's approach of one tower every two years. Energeia by contrast have continued to include capital costs post 2014 and at a rate of between $1.7m and $2.1m nominal dollars per annum.

These assumption differences results in a PV for the Energeia costs of WiMAX of $68m compared to the DNV KEMA estimate of $56.8m.

The infrastructure costs for the Mesh Network have been built up using the number of access points and relays required multiplied by the cost of this equipment. In addition until the end of the AMI project (December 2013) much of the NMS resource will be focussed on creation of the design and optimisation of the Mesh network infrastructure and this cost has therefore been included in network infrastructure The PV of the DNV KEMA approach was $46.8m compared to $38.5m in the Energeia model. Although there are similar costs between Energeia and DNV KEMA these have been derived in different ways and are not based on the assumption that one company is similar to another.

The overall difference in network and backhaul infrastructure Capex between Mesh and WiMAX is a PV of $10m.

8.5 NMS Costs

The NMS Capex for WiMAX is provided in SP AusNet's AMI IT Capex Detail covering Network Management and Data. This is the same source used by Energeia, although Energeia have applied the figure for MDMS Capex in 2011, rather than the NMS Costs, which were considerably lower. The PV of DNV KEMA calculation over 15 years for WiMAX NMS Capex is $13.3m compared to $16.2m by Energeia. This is based on the replacement cost of $15.0M incurred in 2019/20.

The NMS Cost for Mesh are based on the parameters set out in the previous section with the Capex covering a perpetual licence, hardware and software licences and initial set up costs. In addition $4.5m has been included as the project management and solution services costs being the middle of the range we normally observe for this type of project. Consistent with the WiMAX NMS a system replacement is assumed to be required in year 9 with the initial costs of deployment repeated. This results in a PV for the NMS Capex for Mesh above the WiMAX costs at $30.5m including a risk premium.

8.6 MDMS Costs

DNV KEMA's expectation is that the MDMS solution would be independent of the choice of communication solutions. The only difference in costs should relate to the interfaces to the NMS. Discussions with SP AusNet indicate that at the assessment date of February 2011 these interfaces had already been developed for WiMAX, but would need development for the RF Mesh solution. However, these costs have been captured in the transition costs section.

Energeia and DNV KEMA for consistency have assumed that the replacement of the MDMS solution and interfaces will occur after 7 years. Energeia have applied a differential cost for the new system with a nominal cost of $40.8m for the WiMAX MDMS against $11.2m for an RF Mesh MDMS. DNV KEMA believe this should be an equivalent costs for the same system and have estimated the cost based on industry benchmarks as a nominal cost of $17m. This includes training, hardware, software, integration, O&M and facility costs.

DNV KEMA's PV for MDMS Capex is $17.7m for both communication solutions as the MDMS adopted should be the same. Energeia have assumed that a different MDMS would be adopted if there was a move to RF Mesh, although no clear reason is given for this decision. They believe this MDMS would be significantly cheaper with a PV of the Capex for the Mesh solution of $13.6m against a PV of $25.5m for WiMAX.

If it could be demonstrated that a lower cost solution could provide the same service that the SP AusNet's MDMS currently provides, then SP AusNet could adopt this system regardless of the communication solution deployed. However, it should be noted that the other utilities in Victoria have the benefit of being able to share the costs of one system between two organisations (Jemena/UED and Powercor/Citipower), which may reduce the cost for the individual business units below the level that SP AusNet could achieve on its own.

Switching to an alternative MDMS is a non-trivial exercise. If SP AusNet adopted Jemena's MDMS it would require the operation of parallel systems until every AMI meter is managed by the new MDMS. This would result in higher integration costs and additional OPEX to maintain parallel systems for a period of time. In addition it should be noted that SP AusNet currently operates a single MDMS for all meters, which contrasts to Jemena who operate both a legacy and new system.

9. Comparison of Opex

9.1 Overview of Results

KEMA's Cost Benefit Assessment of Opex has broken down into the areas shown in the table below. In the case of WiMAX this includes costs from 1st March 2011 that would not have been incurred if WiMAX had been cancelled. The Mesh Costs includes all costs from 1st March 2011.

Table 9-1: Comparison of Opex

Cost Item	PV of WiMAX Costs ($M)	PV of Mesh Costs ($M)	Difference in Costs ($M)
Backhaul Communications	$28.4	$17.5	$10.9
Communication Operations	$60.4	$15.1	$45.3
NMS Costs	$19.0	$98.0	$79
MDMS Costs	$15.0	$15.0	$0
Totals	$122.8	$145.5	$22.8

9.2 Backhaul Communications

In the Energeia assessment there were no backhaul costs associated with the WIMAX network. This is not realistic given the number of 3G meters that are deployed as part of this rollout (10.5% of the population). In addition SP AusNet has now included Netstar (MPLS), Radio Licences and 3G VPN Costs in their backhaul cost estimate. The requirement to transfer data back from the WiMAX towers has not been included, as this uses network facilities with no incremental Opex.

The RF Mesh Networks has backhaul costs associated with a smaller percentage of the meter population (6.5%) and backhaul costs for data being transmitted by 3G from access points.

All 3G meters are assumed to cost $[redacted] per meter per annum, which was a charge by Telstra for SP AusNet in February 2011. This cost is the same regardless of whether the primary solution is WiMAX or Mesh with no further discounts assumed for volume. A cost of $[redacted] per month has been applied for backhaul from the access points, based on Telstra pricing for SP AusNet. DNV KEMA has assumed that 10% of the access points will be conveniently placed on the SP AusNet communication network and therefore be able to use the existing SP AusNet communication network. This reduces the annual average cost for backhaul from an access point to $[redacted] per year.

The PV of the backhaul communications for WiMAX was $28.4m, which was $10.9m higher than the cost for Mesh of $17.5m. This contrasts with the Energeia assessment that had $0m for WiMAX and a PV of $26.4m for Mesh.

9.3 Communications Operations

It appears from previous review that there was some overlap in the activities that different organisations have included in Communications Operations. As an example Energeia's inclusion of no costs for backhaul communications for SP AusNet's WiMAX solution, suggests these costs had previously been captured in communications operations.

SP AusNet has produced revised costs for Communication Operations with WiMAX with major element including:

- Site Leases of WiMAX (23%)
- Motorola Costs (9%)
- Spectrum Costs (24%)
- Training (6%)
- Labour resources (33%)

Despite the removal of any backhaul cost SP AusNet's WiMAX costs for Communication Operations costs are significantly higher their previously estimated. The costs now have a PV of $60.4m against the previous estimate of $27.5m by Energeia. This primarily reflects some reallocation of costs by SP AusNet.

Some of the equivalent communication operation activities associated with RF Mesh may partly be included in the NMS Opex listed below and any comparison should therefore consider both elements. However, there are additional costs for field service personnel to maintain the Mesh Infrastructure. This has been estimated at an average of 2 hours per access point/relay and results in a slightly lower, but broadly equivalent, communications labour resource costs for Mesh of $15.1m against $19.4m for WiMAX.

There is insufficient actual accumulated operating and maintenance data over a long enough period, over enough operating environments, and as the networks continue to be built out, to draw any firm conclusions on the field costs that will be required with RF Mesh. However, from first principles, and hardware/software failure rates equal, we expect operation and maintenance costs to be greater for serving a given number of customers with mesh than point-to-multi-point solution including WiMAX, but it is impossible to be more specific without extensive modeling or actual accumulated expenditure histories.

The difference in the DNV KEMA model between the communication operations costs for the two solutions primarily reflects the different activities that are included for WiMAX and is $45.3m.

9.4 NMS Costs

WiMAX NMS costs based on SP AusNet's budget were provided to DNV KEMA by SP AusNet. This includes costs for GridNet Maintenance and resources, SP AusNet Resources, 24*7 labour costs, training and MMS maintenance. The costs were significantly lower than previously applied by Energeia as those costs included other costs that were not strictly related to the WiMAX NMS. These cost items have now been further broken down. The PV of these costs was $19m.

The NMS Cost for RF Mesh is based on DNV KEMA's experience with other implementations. The main cost is a calculated annual resource cost per meter as described in section 7. The cost of utility personnel undertaking network management is modelled to drop over time (reflecting reducing numbers of FTEs) as the Mesh Network evolves into one of more stable growth. This charge and smaller costs for maintenance and vendor's fees results in a PV of $98m, which is broken down into:

- Cost of SP AusNet resources - $69.1m
- Mesh Vendor's annual charges - $10.6m
- Software maintenance charges - $18.3m

9.5 MDMS Costs

DNV KEMA anticipates that the choice of MDMS solution should be independent of the communication solution deployed. The modelling has therefore assumed that the costs that SP AusNet forecasted in February 2011 for WiMAX should apply to the Mesh solution. This results in a PV cost for both communication options of $15m.

Energeia's assumptions were that the PV of Opex should be $15m for the WiMAX solution and slightly higher at $16.6m for the Mesh solution.

10. Transition Costs for RF Mesh

10.1 Overview of Costs

DNV KEMA has assessed a number of costs that would be incurred by SP AusNet due to any decision to switch to RF Mesh. These break down as follows:

Table 10-1: Cost Overview of Switching to RF

Item	PV of Cost ($M)
Replacement of WiMAX NICs	$25.9
Replacement and fitting of Mesh Antenna	$2.4
Mesh NICs for Meters fitted with no Comms Cards	$16.6
Termination and remediation costs for WiMAX network	$3.7
Additional IT Costs	$1.1
Additional Meter Reading Costs	$3.5
Additional PM costs	$2.3
Additional Industry Costs	$0.2
Additional IT Opex	$1.1
Total	**$56.8**

Additional detail on how each of these costs has been derived is provided below.

10.2 Replacement of WiMAX NICs

This is the cost for purchase and replacement of the Mesh NICs in meters that had a WiMAX NIC. The analysis assumes that it will take a couple of months before WiMAX NICs cease to be rolled out with a total of 162,403 NICs deployed. This is a larger number than was envisaged in the Energeia assessment due to the transition assumptions that DNV KEMA has made in section 5.

The cost of the NIC is explored in section 8.2. The SP AusNet resource cost for the retrofit of the NIC is an area of diverging views between Energeia and SP AusNet. DNV KEMA has provided SP AusNet with a list of task that would be required for a retrofit. This includes:

- Access (open metal box, remove NIC, antenna/antenna lead/antenna connection);
- Remove and Replace NIC, attach new antenna captive lead;
- Mount new antenna and secure/dress RF cable:;
- Provision NIC for required ID, subnet, and crypto keys using FS tool and record results/documentation:;
- Network Integration/Test/Confirmation that network has discovered and authenticated new NIC, check NIC has discovered at least two routes, verify received Signal Level/Hop counts, test traffic OK, all indications need to be good prior to conclude installation.

SP AusNet's process maps result in 1.25 hour estimate for these activities. On the basis of $[redacted] an hour this results in $[redacted] per retrofit (assuming no travelling time).

Energeia had made the assumption that this retrofit activity could be done for $[redacted] which is the cost quoted by one contractor for the installation of a NIC. DNV KEMA view is that this activity is more complex as stated in the transition section of this report the time required to swap a smart meter's NIC on site and to change-out the external antenna needed at the vast majority of locations can take twice as long as installing a pre-configured meter and its attending antenna.

The DNV KEMA modelling has assumed the cost of $[redacted] AUD for each replacement of the NIC based on the process mapping by SP AusNet of tasks required for a retrofit. This resource retrofit costs combined with a Mesh NIC cost of $[redacted] USD results in a PV of $25.9m for the retrofit of these cards.

10.3 Replacement and fitting of Antenna

This covers both meters where WiMAX NICs are replaced and meters where no NICs are initially deployed. The antennas that may have been fitted for WiMAX are not suitable for Mesh so will need to be replaced. It is assumed that antennas will be fitted to these meters at the same time the NICs are deployed.

DNV KEMA's modelling suggested that 70% of the Mesh meters may require a standard antenna, which contrasts to WiMAX where the assumption was 91% required a standard antenna and 9% an extended antenna.[10] The modelling has assumed that the installation will be undertaken at the same time that the Mesh NIC is installed so no incremental installation cost has been applied, but the purchase cost of $[redacted] has been included. .

[10] This is a conservative estimate.

No incremental cost is assumed for the removal of the WiMAX antenna (even where no Mesh antenna is fitted). This is assumed to be done with the replacement of the NIC, which is required at all WiMAX meters.

The total PV of purchasing antenna for these meters is $2.4m.

10.4 Mesh NICs for Meters fitted with no Comms Card

This is the cost for purchase and installation of the NICs, which is assumed to be slightly simpler than the retrofit.

DNV KEMA has adopted the SP AusNet process modelling cost of $[redacted] based on 0.75 hours to undertake the tasks associated with installation. There is a risk that installing these devices in the field may not be straightforward, which could results in significant additional costs. This risk equally applies to the retrofit of MESH cards where WiMAX NICs were previously applied. The PV of this cost based on a $[redacted] USD purchase price and $[redacted] AUD installation price based on SP AusNet process maps is $16.6m.

10.5 Termination and Remediation Costs for WiMAX Network

These are the costs associated with stopping deployment of the WiMAX network. It is composed of termination fees due under the contract with Motorola and the cost to remove towers that will have been constructed prior to 28th February 2011.

The termination cost of $[redacted]m is based on the SP AusNet Contract with Motorola that allows SP AusNet to terminate a contract with 30 days notice, but does make SP AusNet liable for all Work in Progress at this date. The cost was based on acquisition and design services being undertaken for around 30 sites and is largely accepted by Energeia.[11]

The remediation cost relates to the obligation to demolish towers that have been constructed. DNV KEMA has made this a general cost to either demolish towers, or to remove equipment (which we believe applies to the majority of the 13 towers existing if the project was cancelled at the 28th February 2011.) This has been estimated at 6% of the construction cost, which results in a total cost of around $[redacted] to demolish towers and remove equipment. This activity is assumed to take place in 2012 as it would not have been a priority. The total termination and remediation costs are estimated at a PV of $3.7m. This is slightly below Energeia's estimate of $4.2m.

[11] Energeia, Page 30 of 41.

10.6 Additional IT Costs

As indicated under Section 4, a dedicated network management system is needed to monitor and control a proprietary RF mesh metering infrastructure; the functionality can be outsourced and acquired and operated in-house, and thus treated as either Opex or Capex. This cost is addressed in the modelling of the RF AMI network described in Sections 7 and 8. In addition special accommodations will be needed to accommodate the metering of end-points which are not included in the meshed communications network, i.e. connected via a cellular modem.

There are a number of costs related to basis systems implementation, custom software development and system integration services that will be required with any decision to switch to Mesh including the need to integrate the existing MDMS. This is estimated at a PV of $1.1m.

10.7 Additional Meter Reading Costs

The modelling assumes that at February 2011 it was expected that all WiMAX meters would be remotely read by 1st January 2012. However, the move to RF Mesh would result in the WiMAX systems being decommissioned (to avoid the costs of running parallel systems) and meter readings would not be available until the Mesh infrastructure was operational. Including procurement and delivery timescales this is estimated to take 16 months from the decision date, which is 6 months from the 1st January 2012.

During this 6 month period there is an additional cost of manually reading all the RF Mesh meters that could have been read remotely using WiMAX. In addition to the delay for all Mesh meters being operational the recommended transition plan has the period for installation/retrofit of meters spread over 20 months in order to create a manageable workload alongside the continued installation of meters. This creates a delay before all these meters are remotely read and an additional requirement for manual reads.

The cost estimate is based on $[redacted] per meter reading[12] including meter reading and meter data management costs, with 99% of meters read quarterly. This results in an additional cost of $3.5m occurred in 2012 and 2013.

No additional meter reading costs for switching were assumed by Energeia as the assumption was that there was no delay to the cut over of AMI services[13]. DNV KEMA's concerns with this

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[12] Figures derived from SP AusNet meter reading and meter data management costs for 2009 and 2010 divided by the number of meter readings.

assumption have already been highlighted in section 5. DNV KEMA suggests that a prudent approach to transition, as discussed in Section 5, would result in a delay before any Mesh meters are remotely read and, hence, an additional requirement for manual reads.

10.8 Additional Project Management Costs

As described under Section 5, the management of the new procurement activities, entailed engineering and contracts/legal expertise, requires a level of effort extending over a period estimated at 5 months. Furthermore, the level of effort for the PM / CM functions for the incremental deployment of RF mesh infrastructure is higher than for a WiMAX deployment since there are more AP and relay sites to requiring installation work, and many more location requiring backhaul connectivity than there would be WiMAX base-station sites; additionally, the replacement effort of NICs and antennas for nearly 300K smart meters already also necessitates coordination, tracking and administration.

Energieia's review stated:

> " that the project and technical resources that would otherwise have had to be used on SPA's WiMAX-3G solution could have managed the market delivery of a proven mesh-3G solution without a significant increase in cost."

DNV KEMA does not agree that the additional activities, described above, can be executed by the same resources that will be required to execute parallel activities for WiMAX roll-out and wind-up.

The supplemental Project Management level of effort is estimated at an average of 5 FTE over a continuous period of 30 months. In addition to the Project Management effort there is also a requirement for additional training of meter installers. This cost is less than $100,000.

This results in a relatively small incremental PV of $2.3m.

[13] Energeia report, Figure 6, Page 12.

10.9 Additional Industry Costs

This is a relatively small cost reflecting the additional regulatory and legal costs associated with the move to a new solutions and the requirement to agree some revised milestones with the AER. Energeia suggested that there were no additional costs attributable here.

This was estimated at $200,000 by SP AusNet, which appears reasonable to DNV KEMA and has been included as 2011 cost.

10.10 Additional IT Opex

DNV KEMA considers that there will be additional Opex from supporting the new NMS, interface to MDMS, changed NMS requirements for 3G meters and decommissioning the old solutions. Energeia suggested that there should be no additional IT Opex.

DNV KEMA estimated this cost at [redacted] FTEs for one year, which has a PV of $1.1m.

10.11 Transition Costs Estimated by Energeia

DNV KEMA's assessment of a feasible schedule for the transition program is discussed in detail in Section 5. It is DNV KEMA's view that a prudent business would plan a transition project with the schedule shown in Section 5.3.

Energeia's review suggested a schedule that excludes key transition activities. Hence DNV KEMA's assessment of costs that are closely related to assumed schedule, differ from those proposed by Energeia. These differences are highlighted in individual sub-sections above, but include:

- Replacement of WiMAX NICs and installation of NICs in meters without Comms cards
- Additional Meter Reading Costs
- Additional Project Management Costs
- Additional Industry Costs
- Additional IT Opex.

11. Risk Premium for Proprietary Solutions

Section 6.3 of SP AusNet's Reconsideration Submission of the 5th June 2012 identifies four sources of risk and uncertainty associated with AMI execution: contracts, technology, implementation, and management. In addition to these sources of risk, DNV KEMA submits that there are company-specific counterparty risks associated with firms offering non-standard proprietary solutions to narrow markets. This section explains company-specific risk and measures the implied risk premium using a common valuation exercise.

11.1 Nature of Company-Specific Risk

Selecting proprietary, non-standards based, non-interoperable solutions for a utility infrastructure present financial, technical and performance risk. In order to model the cost risk premium associated with switching to a proprietary Mesh network from the standards based WiMAX solution, a number of considerations are involved: Firstly, the mesh system is proprietary and the selected vendor is the only provider of terminal devices, take out points (ToPs), repeaters, and the required network management and data collection systems for the mesh ; Secondly, [redacted]; since this is a long term infrastructure, expected to function for 15 years or more, the vendor viability risk is a factor of prudence. A prudent business may set aside funds for acquiring the designs and specs in escrow, pre-establishing a suitable contract manufacturer, purchase of plant and equipment and legal efforts in the case the vendor may not be able to support the systems in the long term.

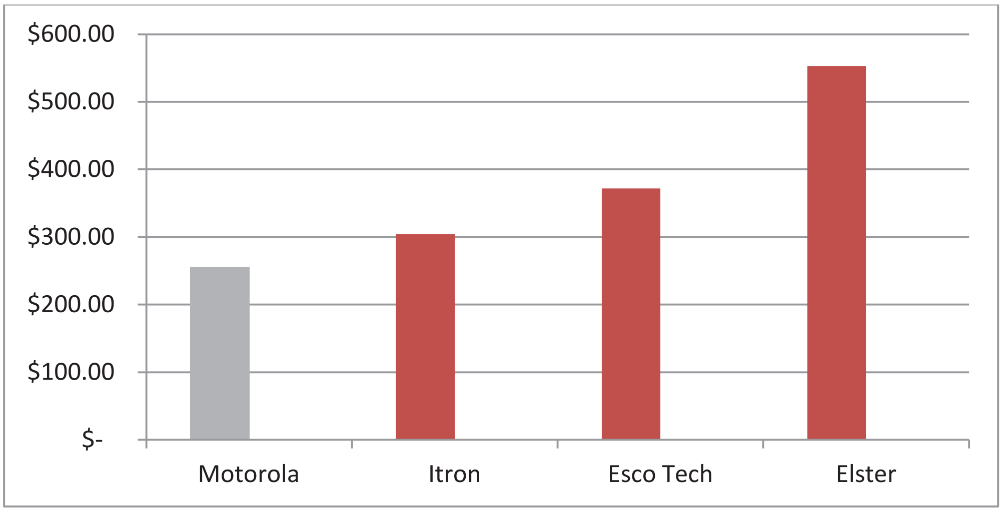
11.2 Measuring Risk Premium

Without access to proprietary pricing data from a selected vendor DNV KEMA proposes a standard asset price and options model to estimate company-specific risk. Using public pricing information to compare company-specific risk is a valid approach because the risk premium facing a utility customer would be equal or greater than that facing an equity investor.

This exercise validates the concern that there is more firm-level risk associated with a proprietary, non-inter-operable solution applied to a single industry (Utilities) than with standards-based vendors delivering inter-operable products to a broad set of customers in different industries. To confirm and illustrate this argument we value a hypothetical hedge against company-specific risk using a standard Black-Scholes model with 2011 data. A hypothetical asset cost of $700 for a system is used to value a $600 put option. In other words, the valued option would protect against the loss in system value equal to or greater than 15% over 15 years.

Using the volatility of listed securities between 28th February 2010 and 28th February 2011, a put option price for the following companies was calculated:

Figure 11-1: Put Option Price[14]



A prudent investor or utility customer in 2011 would note the greater company-specific risk associated with single-sector proprietary providers like Itron, ESCO Tech, and Elster compared to a ICT firm offering standards-base technologies to multiple sectors like Motorola. Using Itron as a proxy for the mesh supplier under consideration, the prudent company would likely add a **17 – 24 % risk premium** (the Black-Scholes fair value of a protective put) to protect a decline in value of 15% or more of the replacement cost less inflation of the investment over the 15-year lifecycle, using a 3% or 1% risk-free rate of return, respectively.

11.3 Application of the Risk Premium

DNV KEMA has applied the risk premium to the capital expenditure purchased from the Mesh Vendor. This covers:

- Mesh NICs;
- Access Points and Relays; and
- NMS System Costs related to the Mesh Vendor.

[14] Prices developed directly from published stock price volatility data and applying Black-Scholes model

The total impact of the Risk Premium is about $15m, so whilst significant would not change the results of the business case.

12. Qualitative Benefits of WiMAX

WiMAX is a flexible high-speed wireless MIMO-OFDM data communications technology designed to accommodate channel bandwidths from 1.5 – 20 Mhz and data rates to 70 Mbps (nearly 3.7 bps/Hz but available only at very short ranges) using either FDD or TDD in licensed (2.3 Ghz, 2.5 Ghz, 3.5 Ghz) or unlicensed bands. The system is highly resistant to multipath because of its OFDM design (which effectively eliminates inter-symbol interference), space-time coding (e.g. Almouti rate=1 coding), and available multi-way transmit and receive antenna diversity MIMO); in rich scattering environments the MIMO can also be used for spatial multiplexing, effectively doubling link capacity for the typically-implemented 2x2 (2 transmit and 2 receive antennas) MIMO when link conditions permit. It also adds resilience by supporting QPSK through QAM64 (downlink)/QAM16 (uplink) modulation alphabets on the OFDM subcarriers, scalable number of subcarriers, and a selection of various strength coding schemes to optimize delivered capacity in a wide range of dynamic link conditions.

Originally envisioned as a “last-mile” replacement for cable or DSL, the standardized (802.16d and 802.16e) system is designed as a point-to-multi-point cellular network with a central basestation (FDD or TDD); the WiMAX system can in principle support mesh-networks between subscriber units in TDD mode without use of a base station based on proprietary overlay software, similar to proprietary WiFi mesh networks. To date, virtually all trial deployments and the few actual commercial deployments have been of the macrocellular type employing omni-directional or multi-sectored base stations.

TDD (Time Division Duplex) mode offers advantages in macro-cellular applications where the forward and reverse link traffic is highly asymmetric. Mobile services are defined in the 802.16e as using TDD only.

Unlike point-point microwave systems, WiMAX does not require line of sight and can in many instances benefit from spatial-multiplexing in rich scattering environments. Of course, range coverage will ordinarily be reduced in non Line-of-Sight (NLOS) environments. WiMAX supports both fixed and mobile subscribers. Plug-in modems for laptop PCs are now available and Intel has announced PC chipsets with built-in WiMAX support.

For fixed applications typical of utility communications assets like substations and feederlines using WiMAX terminals with +24 dBm average transmit power and +17 dBi antennas, and 12 dBi 3-sector base stations using 3-way receive diversity, 5Mhz channel at 2.5 Ghz, typical ranges in dense urban environments using QPSK (approximately 2 bps/Hz or 8 Mbps) will be in the 1Km range for non-line-of-sight, with ranges increasing to 6Km (4 Km with Omni base station) in suburban to 10 Km or more in rural environments (near line of sight), depending on base station antenna height and terrain, and terminal height. Used with line of sight more than 50 Km range is possible.

WiMAX has found increasing interest and use as high-capacity point-multipoint backhaul and distribution for LAN solutions including WiFi as well as cellular; for cellular backhaul to/from base stations it can take advantage of near-line-of-sight or line-of-sight conditions available from basestation towers and high-gain directional antennas to achieve ranges of some 15 - 50Km or more.

Equipment vendors include Samsung, Motorola, Alcatel-Lucent, Huawei, and Nokia-Siemens.

The IEEE 802.16d/e standards for WiMAX also explicitly specify strong cyber-security methods and controls for authentication, message integrity, and privacy protection (encryption), unlike proprietary single-vendor solutions which may or may not incorporate any particular controls. Furthermore, the WiMAX radio NIC cards adopted by SP AusNet take this a major step further and incorporate exceptionally strong, hardware-based, tamper-resistant protection of critical security parameters (CSPs) and cryptographic operations using specialized security processor/secure memory devices verified to resist temperature, power supply and clock tampering attacks and Simple Power Analysis/Differential Power Analysis. In KEMA's knowledge and experience, this level of protection of CSPs and cryptographic processes is not currently available in mesh-based AMI systems.

The WiMAX NIC modules also incorporate advanced RF features including 2-antenna receive diversity with MRC (Maximal Ratio Combining) and switched transmit diversity, along with high-power transmit capability (+26 dBm), for improved performance approximately 4.7 dB in the downlink and 1.5 dB in the critical uplink.

13. Cost Benefit Results

13.1 Overview of Results

The DNV KEMA cost benefit analysis found that continuing with WiMAX would result in higher Capex than the Mesh Option. However, this would be offset by lower Opex and no transition costs, which would collectively make the switch to Mesh a more expensive option. This contrasts with the Energeia analysis which states than both the Opex and Capex from a full roll out of Mesh are lower than the continued roll out of the WiMAX Solution. These costs are summarised in the table below and are based on the information available to SP AusNet at the reconsideration date and a 15 year cost benefit analysis.

Table 13-1: Overview of Costs

Cost	DNV KEMA PV of Continuing with WIMAX ($M)	DNV KEMA PV of Adopting Mesh ($M)	Energeia PV of Continuing with WiMAX ($M)	Energeia PV of Adopting Mesh ($M)
Capex	$183.5	$152.5	$208.5	$126.76
Opex	$122.8	$145.5	$110.1	$74.4
Transition Costs	$0	$56.8	$0	$ marginal
Total Costs	**$306.3**	**$354.9**	**$318.6**	**$201.2**

DNV KEMA assessment based on a bottom up assessment of cost shows an overall impact is a PV benefit of $48.6m for retaining WiMAX rather than switching to RF Mesh. This includes all the activities associated with transition to a Mesh network, for which only a very small allowance appears to have been made in the Energeia numbers. The Energeia allowance for 15 years of Opex for the Mesh network is much lower, primarily due to different assumptions about the complexity of operating an NMS.

13.1.1 Breakdown of Costs and Benefits

A more detailed breakdown of the costs and benefits is shown in the table below.

Table 13-2: Breakdown of Costs and Benefits

Cost/ benefit item	Phase	Description	Total per CB-item	Distribution Capex	Distribution Opex
			48.6	**21.3**	**27.3**
1.A	Capex for WiMAX	WiMAX NICs	-76.10	-76.1	0.0
1.B	Capex for WiMAX	WiMAX Antenna Costs	-19.68	-19.7	0.0
1.C	Capex for WiMAX	WiMAX 3G Incremental Meter Costs	0.00	0.0	0.0
1.D	Capex for WiMAX	WiMAX Network and Backhaul Costs	-56.77	-56.8	0.0
1.E	Capex for WiMAX	NMS Costs from 2011	-13.28	-13.3	0.0
1.F	Capex for WiMAX	WiMAX MDMS Costs from 2011	-17.69	-17.7	0.0
2.A	Capex for RF Mesh	RF Mesh NICs	47.46	47.5	0.0
2.B	Capex for RF Mesh	RF Mesh Antenna Costs	10.13	10.1	0.0
2.C	Capex for RF Mesh	RF Mesh 3G Incremental Meter Costs	0.00	0.0	0.0
2.D	Capex for RF Mesh	RF Mesh Network and Backhaul Costs	46.79	46.8	0.0
2.E	Capex for RF Mesh	RF Mesh NMS Costs	30.49	30.5	0.0
2.F	Capex for RF Mesh	RF Mesh MDMS Costs	17.69	17.7	0.0
3.A	Opex for WiMAX	WiMAX and 3G Backhaul Communications	-28.43	0.0	-28.4
3.B	Opex for WiMAX	WiMAX Communication Operations	-60.41	0.0	-60.4
3.C	Opex for WiMAX	NMS Costs with WiMAX	-18.96	0.0	-19.0
3.D	Opex for WiMAX	MDMS Costs for WiMAX	-14.98	0.0	-15.0
4.A	Opex for RF Mesh	Backhaul Communications for Mesh and 3G	17.42	0.0	17.4
4.B	Opex for RF Mesh	Communication Operations for RF Mesh	15.14	0.0	15.1
4.C	Opex for RF Mesh	NMS Costs for RF Mesh	97.98	0.0	98.0
4.D	Opex for RF Mesh	MDMS Costs for RF Mesh	14.98	0.0	15.0
5.A	Capex and Opex for Switching	Replacement of WiMAX NICs	25.90	25.9	0.0
5.B	Capex and Opex for Switching	Replacement and fitting of Antenna	2.44	2.4	0.0
5.C	Capex and Opex for Switching	Mesh NICs for Meters fitted with No Comms Cards	16.63	16.6	0.0
5.D	Capex and Opex for Switching	Termination and Remediation Costs for WiMAX Network	3.70	3.7	0.0
5.E	Capex and Opex for Switching	Additional IT Costs	1.10	1.1	0.0
5.F	Capex and Opex for Switching	Additional Meter Reading Costs	3.46	0.0	3.5
5.G	Capex and Opex for Switching	Additional PM Costs	2.32	2.3	0.0
5.H	Capex and Opex for Switching	Additional Industry Costs	0.20	0.2	0.0
5.I	Capex and Opex for Switching	Additional IT Opex	1.08	0.0	1.1

Key costs and benefits differences between the 2 solutions include:

- NMS Opex – The justification for DNV KEMA's cost estimate for a Mesh NMS is provided in section 7. It is DNV KEMA's experience that the complexity of optimising a mesh network results in a much higher Opex due to the chaotic nature of the network. DNV KEMA estimates an Opex that is over $80m higher in PV terms than the WiMAX costs.

- Communication Operation Costs – The WiMAX networks has a $43.5m higher Communication operation PV than the Mesh network. There is an expectation that the

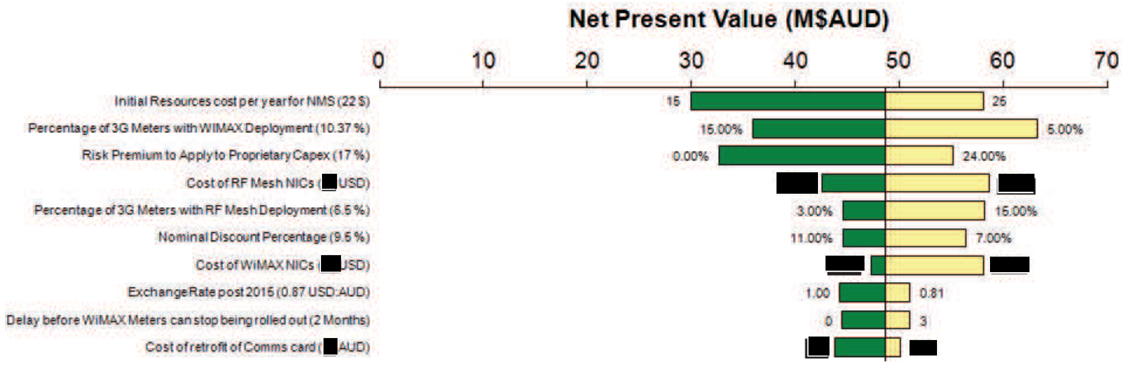
Mesh costs for the field service proportion of this activity should be higher than WiMAX, although it does include a number of other services. Some of the counteracting difference between communication operation and NMS Opex may reflect allocation of costs.

- NIC Costs –The headline comparison of NIC Costs (1.A and 2.A) shows an additional $28.6m cost for WiMAX NICs. However, if the cost of retrofitting NICs and installation of Mesh NICs was included then the Mesh NICs would outweigh the cost of WiMAX NICs by $14m.

13.2 Sensitivity Analysis

It is important to note that whilst the central estimate of the NPV of retaining WiMAX is estimated at $48.6m this is sensitive to a number of key parameters. The figure below indicates the impact on the NPV of moving a single parameter from its expected value to the high or low point that were considered feasible.

Figure 13-1: Sensitivity Analysis NPV



Key parameters that can impact on the sensitivity are:

- Initial Resouce costs per year for NMS – This has been set with a central value of $22 per meter per year based on DNV KEMA’s experience with international deployment. If this could be reduced to $15 this would reduce the NPV of retaining WiMAX by $18.7m to $28.2m.

- Percentage of 3G Meters with WiMAX Deployment –This has been set at 10.37%, which reflects the SP AusNet estimate in Febrary 2011. If WiMAX coverage was reduced to 85% this would reduce the NPV of retaining WiMAX by $12.7m to $35.9m reflecting the higher cost of 3G operations over WiMAX. Conversely if was possibel to expand WiMAX coverage to 95% this would increase the NPV of retaining WiMAX by $14.7m to $63.3m.

- Risk Premium to Apply to Proprietarty Capex – This has been set to 17% in line with DNV KEMA's view on an appropriate premium to apply. If this was removed it would reduce the NPV of retaining WiMAX by $15.9m, but an increase to the higher level of DNV KEMA's range would increase the NPV of the difference between the options of $6.5m.

An important point to make is no single parameter (or combination two parameters) if changed to the low end of the feasible range would be sufficient to make the NPV of retaining WiMAX negative.

Appendix A – Data Sources for Model Inputs

Appendix A Data Inputs and Assumptions List

Parameter	High	Central	Low	Justification	Evidence
Project Assessment Period (years)	15	15	15	Model needs to run for 15 years to be consistent with Energeia business case.	AER and Energeia focus on a 15 year assessment
Inflation rate (%)	3%	2.55%	2%	Based on Assumptions in AER model. For simplicity the model has assumed inflation of 2.55% for the entire period and ignored the 2.56 for 2012/13	Assumption sheet on AER Financial Model 130812
Nominal Discount Percentage (%)	7%	9.505%	11%	Central model from assumptions sheet in AER Model. AER model then uses different values (9.51% 2012 and 2013. 9.77% rest of the model). Single number applied for simplicity range can be assessed in the modelling	Assumption sheet on AER Financial Model 130812
Percentage of 3G Meters with WiMAX Deployment (%)	15%	10.37%	5%	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
Percentage of 3G Meters with RF Mesh Deployment (%)	3%	6.5%	15%	DNV KEMA estimate of economically efficient level of Mesh	DNV KEMA Model of RF Mesh based this number on percentage of customer below a defined meter density per sq KM
Cost of WiMAX NICs (USD)	[redacted]	[redacted]	[redacted]	Data used in Energeia assessment sourced from L&G contract – Includes Zigbee	Meter Costs in AER Financial Model 130812
Cost of RF Mesh NICs (USD)	[redacted]	[redacted]	[redacted]	Confidential source (SP AusNet to provide to the AER)	Confidential source (SP AusNet to provide to the AER)
Cost of 3G NICS (USD)	[redacted]	[redacted]	[redacted]	Data used in Energeia assessment sourced from L&G contract includes Zigbee	Meter Costs in AER Financial Model 130812
Exchange Rate post 2015 (USD:AUD)	0.81	0.87	1	Central figures based on AER Financial Model. High figure based on current exchange rate (scaled down) with low figure close to current hedged rate	Consistent with Energeia assumptions for 2015 in AER Financial Model 130812

Parameter	High	Central	Low	Justification	Evidence
Date for Deployment of 3G Meters (year)	2012	2012	2013	Based on AER Financial Model	Assumption consistent with AER Financial Model 130812
Cost for installation of Comms card (AUD)	[redacted]	[redacted]	[redacted]	Based on SP AusNet process maps of activities required identified by KEMA	Based on SP AusNet process maps of activities identified by KEMA
Cost of retrofit of Comms card (AUD)	[redacted]	[redacted]	[redacted]	Based on SP AusNet process maps of activities required identified by KEMA	Based on SP AusNet process maps of activities identified by KEMA
Cost of standard antenna (AUD)	[redacted]	[redacted]	[redacted]	Provided by SP AusNet	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
Cost of extended antenna (AUD)	[redacted]	[redacted]	[redacted]		
Cost of antenna installation (AUD)	[redacted]	[redacted]	[redacted]		
Delay before WiMAX meters can stop being rolled out (Months)	0	2	3	DNV KEMA estimate	Based on continuing to achieve milestone targets. See KEMA's Transition plan for description of process
Delay before RF Mesh meters can start being rolled out (Months)	7	9	13	DNV KEMA Estimate as Part of Transition Assessment	DNV KEMA's Transition plan – Section 5.3 Document
Initial Resources Cost per year for NMS ($)	15	22	25	DNV KEMA figures based on experience at many utilities	DNV KEMA's figure based on our experience. Further details are provided in section 7 of the report
Delay before Meters are retrofitted/installed with Mesh NICs (Months)	9	10	13	DNV KEMA Estimate as Part of Transition Assessment	DNV KEMA's Transition plan – Section 5.3 Document
Min timescale before the RF Network starts to become operational (months)	12	16	20	DNV KEMA Estimate as Part of Transition Assessment	DNV KEMA's Transition plan – Section 5.3 Document

Parameter	High	Central	Low	Justification	Evidence
Months to complete retrofit/installation of NICs (Months)	12	20	24	DNV KEMA Estimate as Part of Transition Assessment	DNV KEMA's Transition plan – Section 5.3 Document
Number of meter points per access points – High Density Urban (Meters)	301	334	367	DNV KEMA model results	DNV KEMA's modelling of requirement for RF Mesh Network using AMI Minimum Functional Specification
Number of meter points per access points – Suburban (Meters)	909	1010	1111	DNV KEMA model results	DNV KEMA's modelling of requirement for RF Mesh Network using AMI Minimum Functional Specification
Number of meter points per access points – Rural (Meters)	858	953	1048	DNV KEMA model results	DNV KEMA's modelling of requirement for RF Mesh Network using AMI Minimum Functional Specification
Risk Premium to Apply to Proprietary Capex (%)	0%	17%	24%	DNV KEMA estimates	DNV KEMA report section 11
Exchange rate pre 2015	0.8	0.8	0.8	SP AusNet exchange rate contracts	SP AusNet exchange rate contracts
Year to which hedged exchange rate applies	2015	2015	2015	SP AusNet exchange rate contracts	SP AusNet exchange rate contracts
Year when AMI Project Completes	2013	2013	2013	End data for AMI project	Consistent with OIC

Individual Parameter Estimates

WiMAX Capex

REF	Parameter	Number	Justification	Evidence
1.A	Months of inventory after WiMAX meters stopped	1	Based on expectation of 2 more months when WiMAX meter still get rolled out	DNV KEMA estimate as 2 month continued deployment of WiMAX meters reduces much of the WiMAX stock
1.B	Percentage of WiMAX Meters needing a standard antenna	91%	SP AusNet forecast (modified for inflation differences)	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
1.B	Percentage of WiMAX Meters needing an extended antenna	9%		
1.B	Percentage of 3G meters needing a standard antenna	91%		
1.B	Percentage of 3G meters needing an extended antenna	9%		
1.D	2011 Full year cost (WiMAX Network and Backhaul Costs)	17,264,567	SP AusNet forecast (modified for inflation differences)	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
1.D	2012 Full year cost (WiMAX Network and Backhaul Costs)	24,896,725		
1.D	2013 Full year cost (WiMAX Network and Backhaul Costs)	17,405,442		
1.D	2014 Full year cost (WiMAX Network and Backhaul Costs)	3,386,925		
1.D	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided. Assumes expenditure is linear.	Assumption of linear expenditure of costs
1.E	NMS Costs for 2011	1282380	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
1.E	NMS Costs for 2012	3847140		

REF	Parameter	Number	Justification	Evidence
1.E	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
1.E	Replacement Year for NMS	9 (equates to 2019)	DNV KEMA estimate consistent with AER Planned replacement timescales	Consistent with AER Financial Model 2019/20 – Systems potentially could last longer, but the same assumption is applied to Mesh and WiMAX
1.E	Time to replace NMS	2	DNV KEMA estimate	Consistent with AER Financial Model 130812
1.E	Cost of replacement NMS (include interfaces)	15.03	DNV KEMA has adopted the same approach as Energeia in summing all NMS Costs for initial implementation and applying this number. One small difference is that DNV KEMA adjusted the 2009 and 2010 nominal costs to convert into 2011 dollars.	Consistent with AER Financial Model 130812
1.F	MDMS Costs for 2011	5,116,287	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
1.F	MDMS Costs for 2012	3,061,817		
1.F	MDMS Costs for 2013	3,061,817		
1.F	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
1.F	Replacement Year for MDMS	9	DNV KEMA estimate consistent with AER Planned replacement timescales	Consistent with AER Financial Model 2019/20 – Systems potentially could last longer, but the same assumption is applied to Mesh and WiMAX
1.F	Time to replace MDMS	2	DNV KEMA estimate consistent with AER Planned replacement timescales	Consistent with AER Financial Model 130812

REF	Parameter	Number	Justification	Evidence
1.F	Cost of replacement MDMS (include interfaces)	13.75	DNV KEMA estimate from other deployments including hardware, software, integration, O&M and facility costs.	DNV KEMA estimate from international experience (specific deployments cannot be named)

RF Mesh Capex

REF	Parameter	Number	Justification	Evidence
2.B	Percentage of RF Mesh Meters needing a standard antenna	70%	DNV KEMA estimate used in modelling	DNV KEMA's expectation used in Mesh modelling for Sp AusNet based on number of meter cabinets
2.B	Percentage of RF Mesh Meters needing an extended antenna	0%		
2.B	Percentage of 3G meters needing a standard antenna	91%	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
2.B	Percentage of 3G meters needing an extended antenna	9%		
2.D	High Density Urban Customers	10.64%	Derived from KEMA Modelling	DNV KEMA's modelling using SP AusNet GIS data to split customers according to meter density per sq Km
2.D	Suburban Customers	69.92%		
2.D	Rural Customers that use Mesh (Others use 3G)	12.94%		
2.D	Cost per Access Point (USD)	[redacted]	Derived from KEMA Modelling	DNV KEMA's estimate of cost from international experience broken down in Section 6 of the report
2.D	Cost per Relay (USD)	[redacted]		
2.D	Relays per Access point	[redacted]	DNV KEMA Estimate	DNV KEMA estimate based on experience with Mesh Networks
2.E	Perpetual NMS Licence per meter (USD)	[redacted]	DNV KEMA Estimate	DNV KEMA's estimate based on other implementations
2.E	3rd Party hardware per meter (USD)	[redacted]	DNV KEMA Estimate	DNV KEMA's estimate based on other implementations
2.E	Set up costs per meter (USD)	[redacted]	DNV KEMA Estimate	DNV KEMA's estimate based on other implementations
2.E	Project Management and solution service cost (USD)	[redacted]	DNV KEMA Estimate	DNV KEMA's estimate based on other implementations

REF	Parameter	Number	Justification	Evidence
2.E	Replacement Year for NMS	9	DNV KEMA estimate consistent with AER Planned replacement timescales	Consistent with AER Financial Model 2019/20 – Systems potentially could last longer, but the same assumption is applied to Mesh and WiMAX
2.E	Time to replace NMS	2	DNV KEMA estimate consistent with AER Planned replacement timescales	Consistent with AER Financial Model 130812
2.E	Year when project management costs starts being incurred	1	DNV KEMA Estimate	DNV KEMA Assumption that model set up over 2 years – Consistent with other implementations
2.E	Years over which PM Costs applied	2	DNV KEMA Estimate	
2.F	MDMS Costs for 2011	5,116,287	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
2.F	MDMS Costs for 2012	3,061,817		
2.F	MDMS Costs for 2013	3,061,817		
2.F	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
2.F	Replacement Year for MDMS	9	DNV KEMA estimate consistent with AER Planned replacement timescales	Consistent with AER Financial Model 2019/20 – Systems potentially could last longer, but the same assumption is applied to Mesh and WiMAX
2.F	Time to replace MDMS	2	DNV KEMA estimate	Consistent with AER Financial Model 130812
2.F	Cost of replacement MDMS (include interfaces)	13.75	DNV KEMA estimate from other deployments including hardware, software, integration, O&M and facility costs.	DNV KEMA estimate from international experience (specific deployments cannot be named)

WIMAX Opex

REF	Parameter	Number	Justification	Evidence
3.A	Fixed Backhaul Cost for 2011	168,000	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
3.A	Fixed Backhaul Cost for 2012	249,025		
3.A	Fixed Backhaul Cost for 2013	773,267		
3.A	Fixed Backhaul Cost for 2014	852,742		
3.A	Fixed Backhaul Cost for 2015	833,840		
3.A	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
3.A	Backhaul Cost per year	$[redacted]	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011 (Telstra charge)
3.B	2011 Costs for Communication Operations	2,518,572	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
3.B	2012 Costs for Communication Operations	4,545,054		
3.B	2013 Costs for Communication Operations	6,590,177		
3.B	2014 Costs for Communication Operations	6,712,958		
3.B	2015 Costs for Communication Operations	6,867,831		
3.B	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
3.C	2011 Cost for NMS	541,020	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
3.C	2012 Cost for NMS	2,298,861		
3.C	2013 Cost for NMS	2,422,220		
3.C	2014 Cost for NMS	2,046,344		

REF	Parameter	Number	Justification	Evidence
3.C	2015 Cost for NMS	2,016,604		
3.C	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
3.D	2011 Cost for MDMS	1,237,376	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
3.D	2012 Cost for MDMS	1,434,214		
3.D	2013 Cost for MDMS	1,484,214		
3.D	2014 Cost for MDMS	1,535,712		
3.D	2015 Cost for MDMS	1,612,223		
3.D	Percentage reduction for 2011	16.66%	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs

Mesh Opex

REF	Parameter	Number	Justification	Evidence
4.A	Average 3G Backhaul Costs per Access point per year AUD	[redacted]	Based on $[redacted] per month ($[redacted] per year) with the assumption that 10% of sites could be on fibre network	DNV KEMA estimate that 10% of sites would be able to utilise existing backhaul facilities and therefore would not incur 3G charges based on expectation of overlap of Access Points with existing fibre network. The rest of the sites use 3G with monthly cost
4.A	Average 3G Backhaul costs per meter per year	[redacted]	Estimate provided by SP AusNet	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011 (Telstra charges)
4.B	Average hours of maintenance per access point/relay	2	DNV KEMA Estimate	DNV KEMA Estimate based on experience of Mesh technology – Limited information available as not many complete deployments – produces an estimate slightly lower than WiMAX Costs
4.B	Annual average hours per FTE	1700	Based on a 36-40 hour working week with around 7-8 weeks of annual leave, public holidays and sickness	DNV KEMA estimate agreed with SP AusNet as typical working year
4.B	Cost per FTE	[redacted]	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
4.C	Mesh Vendor Per meter per year cost (USD)	[redacted]	DNV KEMA estimate to be agreed	DNV KEMA's estimate based on other implementations
4.C	Software maintenance per meter per year cost (USD)	[redacted]	DNV KEMA estimate to be agreed	DNV KEMA's estimate based on other implementations
4.C	Proportion of initial labour resource cost allocated to network set up until end of project completion (%)	100%	DNV KEMA estimate cost should be associated with getting network infrastructure established	DNV KEMA's estimate to make network establishment costs consistent with other estimates

REF	Parameter	Number	Justification	Evidence
4.C	Annual percentage reduction in resource costs per meter post 2013	10%	DNV KEMA estimate as more efficient operation of NMS over time	DNV KEMA estimate
4.C	Min Cost per meter	$10	DNV KEMA estimate as cost cannot continue to fall	DNV KEMA estimate
4.D	2011 Cost for MDMS	1,364,028	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
4.D	2012 Cost for MDMS	1,557,778	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
4.D	2013 Cost for MDMS	1,557,778	Two months of the year have already gone so expenditure cannot be avoided.	Assumption of linear expenditure of costs
4.D	2014 Cost for MDMS	1,557,778		
4.D	2015 Cost for MDMS	1,557,778		
4.D	Percentage reduction for 2011	16.66%		

Capex and Opex Costs for Switching

(Add in note about still able to get installers)

REF	Parameter	Number	Justification	Evidence
5.B	Percentage of RF Mesh Meters needing an antenna	70%	Estimate used in DNV KEMA's modelling	DNV KEMA's expectation used in Mesh modeling for SP AusNet to meet minimum functional specification
5.E	Cost of termination of contracts (MAUD)	[redacted]	SP AusNet forecast	SP AusNet forecast as per Reconsideration submission 5 June 2012
5.E	Year when termination fees paid	2011	DNV KEMA assumption termination fees due in 2011	Payments would become due in 2011
5.E	Make good cost as a % of construction cost	6%	Estimate of around $40k for proportion needing demolition and less where equipment is removed	DNV KEMA estimate
5.E	Average tower construction cost	[redacted]	SP AusNet forecast	SP AusNet forecast as per Reconsideration submission 5 June 2012
5.E	Number of towers forecast at 1 March 2011	13	SP AusNet forecast	SP AusNet forecast as per Reconsideration submission 5 June 2012
5.E	Year when towers are demolished	2012	DNV KEMA Estimate – Not a priority	DNV KEMA assumption that it would take some time to organise demolition so model for 2012
5.F	Year when IT integration work starts	1	DNV KEMA estimate consistent with transition plan	Consistent with activities in transition plan described in Section 5
5.F	Years over which IT Costs incurred	2	DNV KEMA estimate consistent with transition plan	
5.F	Basic Systems Implementation	422,500	DNV KEMA estimate consistent with transition	DNV KEMA estimate consistent with transition plan
5.F	Custom Software Development	507,000		
5.F	System Integration Services	211,250		
5.G	Percentage of monthly read meters	1%	SP AusNet forecast	SP AusNet forecast as per Budget and

REF	Parameter	Number	Justification	Evidence
5.G	Cost of meter read and meter data management per read	[redacted]		Charges Application submitted 28 February 2011
5.H	Average Additional PM Resources During Transition period (FTEs)	[redacted]	DNV KEMA estimate based on additional activities in the work plan	DNV KEMA estimate based on activities described in the transition plan in section 5
5.H	Annual Cost of PM FTEs (AUD)	[redacted]	SP AusNet forecast	AER Final Determination, October 2011
5.H	Months of extra PM in 2011	10	DNV KEMA Estimate based on transition plan	Based on activities in DNV KEMA's Transition Plan
5.H	Months of extra PM in 2012	12		
5.H	Months of extra PM in 2013	8		
5.H	Hourly Rate of Training	[redacted]	SP AusNet forecast	SP AusNet forecast as per Reconsideration submission 5 June 2012
5.H	Hours of Training	1000		
5.H	Date for Training	2011	DNV KEMA assumption training is need in 2011	DNV KEMA assumption you need training in advance of deployment of Mesh Meters
5.I	SP AusNet estimate of additional Industry Costs (AUD)	200000	SP AusNet forecast	SP AusNet forecast as per Budget and Charges Application submitted 28 February 2011
5.I	Year costs start to be incurred	2011	DNV KEMA expectation (2011 costs)	KEMA Assumption that it is only 2011 when additional cost will be incurred
5.I	Year costs finish being incurred	2011		
5.J	Additional FTEs required for 1 year	[redacted]	DNV KEMA estimate	DNV KEMA Estimate based on activities in the transition plan
5.J	Cost per FTE	[redacted]	SP AusNet forecast for skilled resources required	SP AusNet forecast based on fully costed resource (as per 28 February 2011)
5.J	Year costs start to be incurred	1	DNV KEMA Estimate	DNV KEMA assumption that opex starts to be accrued in 2011
5.J	Year costs finish being incurred	3	DNV KEMA Estimate	DNV KEMA Assumption that at the end of 2013 the opex costs will be same independent of communication solution chosen

Data in Standing Data for Meters

Meter data (as per SP AusNet's Budget and Charges Application, 28 February 2011)

Pre 1 March 201	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
97271	218827	269825	282434	295467	308855	322598	336703	351180	366040	381292	396946	413015	429507	446435	463809
6908	45703	263452	297111	297111	297111	297111	297111	297111	297111	297111	297111	297111	297111	297111	297111
254	39710	73372	80782	82398	84046	85737	87474	89256	91085	92962	94889	96866	98896	100980	103119
6	3718	38293	43190	43225	43261	43297	43335	43374	43413	43454	43496	43539	43583	43628	43674
9	56	3786	3881	3939	3998	4058	4121	4185	4250	4317	4387	4457	4530	4605	4682
104447.8875	308013.53	648728.9	707397.4	722139.6	737271	752801.9	768742.9	785104.8	801898.7	819136	836828.4	854987.9	873626.9	892758.1	912394.3

2011 Roll Out schedule (as per SP AusNet's Budget and Charges Application, 28 February 2011)

FORECAST as per Feb 2011

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
9,334	19,090	30,086	27,868	30,616	29,320	14,279	14,279	14,279	14,279	14,279	14,279	231,991

Appendix B – RF Mesh Analysis Methodology

B.1 Mesh as a chaotic system

Self-organising ad-hoc mesh networks are described as "complex" and often "chaotic" systems; they are characterised by small changes in initial conditions - differences in terrain, exact placement of access points, relays, and meter mesh nodes – that in turn yield large changes in performance – availability, capacity, coverage, and cost. For this reason, predictability of Mesh network performance – and hence cost – is low; this low predictability extends as well to problems of adding an additional node or nodes to an existing Mesh, often requiring reconfiguring one or more entire subnets (networks associated with a single access point) to accommodate the new members; this in-turn leads to significant intervention of personnel to investigate and correct availability, coverage, and capacity issues, using first RF Mesh NMS (NMS and Mesh SCADA) and then truck rolls, FSU, and installations of additional equipment, etc.

Additional points to consider:

- Communications outages - insufficient communications availability – can be more important in driving field Operation & Maintenance costs – and therefore Opex – than outright hardware failures.
- Mesh networks are more brittle in that they exhibit good resilience and aggregate communications availability until they collapse suddenly based on some fraction of link- or node- outages (due to numerous causes, including propagation difficulties or inter-/intra-user interference), but predictions of that critical threshold are difficult to make, and depend sensitively on the operating environment and temporal/spatial correlations; this can make diagnosis and correction difficult, drive up field O&M costs, including costs to re-deploy or add additional take-out-points or relays.
- Similarly, predictions of mesh performance coverage, capacity, and latencies are generally more difficult to make than point-to-multipoint PLC, WiFi, WiMAX or cellular.
- It is hard to make the case that Opex should be less costly than a mesh network than point-to-multipoint solutions on a percentage total lifecycle cost basis, unless the acquisition costs (Capex) for the system and deployment were to go up. That is, in the limit of a single hop Mesh – basically a point-to-multi-point network – field O&M costs – in an absolute sense – should be similar to those of a cellular, WiMAX, or PLC AMI network serving the identical number of users – but of course acquisition costs would multiply radically as the full cost of the take-out-point is distributed over the

limited number of neighboring nodes, and the number of required take-out-points and backhaul costs for dictated network coverage goes up as well.

There are additional concerns regarding especially potential security vulnerabilities of mesh solutions:

- RF Mesh systems operate in unlicensed bands.
- RF Mesh is susceptible to interference and jamming, and is especially vulnerable to easily-constructed narrow-band repeater-jammers.
- Mesh networks have unique vulnerabilities because of the routed structure, which introduce more degrees of freedom, expose a larger number of elements to potential attack, and which allow in principle a successful attack on a single node to infect all users.
- Absence of cryptographic message integrity and confidentiality protection in some vendor's RF mesh systems may require compensating controls.
- NERC CIP requirements may potentially apply to RF Mesh.
- Both point-to-multipoint (WiMAX, cellular) and RF mesh systems can be made secure with proper architecture, design, and implementation, including application of compensating controls, which shall add costs.

B.2 Mesh Radio Analysis:

B.2.1 Assumptions:

The prominent vendors of RF Mesh AMI systems have never published design characteristics of their 902-928 Mhz[15] FHSS NIC radios, or of actual measured performance (including such basic characteristics as modulation and symbol rates, BER versus Eb/N0, adjacent channel selectivity, use of adaptive channel equalization, maximum hop rates, MAC, etc.), so we base our estimates and assumptions on the FCC Part 15 Subpart C ISM regulations in the US to which they are required to conform, as well as review/inspection of the NIC card. It is important to note that the NIC is a low-

[15] The unlicensed ISM band as defined by the FCC for the US; in Australia mesh operation for the same equipment shall be limited to 915-928 Mhz. This has no direct impact on modeling, but the potential for band congestion and therefore interference from other unlicensed users of the band and other AMI mesh subnets is increased, which may decrease single-transmit single-hop communications availability further and increase the number of re-transmissions required, that is, reduce network capacity. Our models are based on the indicated levels of single-transmit single-hop availability (50% or 70% for dense urban, 70% or 90% for suburban, and 90% or 95% for low-density rural), but these numbers may be further degraded by the reduced operating band available.

cost device, with an estimated manufacturing cost below $20, and therefore subject to meaningful design- and performance- compromises compared with FHSS radios not so constrained.

First, we know from Part 15 regulations that these are narrowband FHSS radios, without processing gain (the frequency hop rate is many times slower than the information rate – actually one hop per frame of data), with maximum average dwell at any frequency in the hopset fixed at no more than 400ms, and all frequencies from the pseudorandom hopset used equally on average. Ideally, hop dwell times would be made much shorter – on the order of 10s of milliseconds – forcing rapid scintillation of fade or interference levels (if the hop frequencies are sufficiently separated - more than the channel coherence bandwidth) which along with applied time-interleaving can improve the reliability of transmission (there is a tradeoff however in required LO synthesizer settling time versus cost). The frequency hopping (along with strictly limited EIRP/power-spectral density, and required spectral mask) serves the principal mechanism of interference and fade management. The maximum allowed 20-dB bandwidth of the hopping channel is 500 Khz, and the minimum hop frequency separation shall be 25 Khz or the 20-dB bandwidth, whichever is greater.

We also know that these radios use low-cost, high-efficiency constant-envelope (Class C) power amplifiers (ideal as well for "last-gasp" outage transmissions), limited by FCC to +30 dBm power input to antenna, and with limited (2-level: say +30 dBm and +24 dBm) or no closed-loop transmit power control that is achieved through power-supply voltage switching to the output amplifier; this last has consequences especially for high-density deployments such as urban where performance may be co-user interference limited. The radios do not utilise network time-synchronization or coordination for medium access control. As to EIRP, FCC limits strictly to +36dBm. The built-in (under-glass) antenna is a low-efficiency approximately omni-direction conformal metal radiator with estimated efficiency no greater than -1 dB; from this we can conservatively conclude no more than +30 dBm EIRP.

Second, the specified FCC spectral mask along with required constant envelope modulation lends itself to nFSK modulation alphabets with symbol rates to a maximum of about 250Ks/s at low modulation index of 1 in a 500 Khz 20-dB channel, or 125Ks/s at the same MI for a 250 Khz 20-dB channel; higher modulation indexes will reduce these symbol rates at the gain in SNR. We do not expect that the radio uses coherent FSK such as GMSK. The 250 Khz 20-dB channel is preferred in terms of number of non-overlapping frequently channels available in the band. Based on available data, the vendors's implementation provides around 100 Kbps raw throughput using binary FSK in a 250 Khz 20-dB bandwidth noise-limited channel; this figure discounts at least the full layer 3 communications overhead, if not some layer 2 (framing, synchronization, and error control) overhead as well; note that allowing for typical FEC and frame synchronization overhead likely consumes the 25kbps. Therefore, we would estimate practical ip-packet maximum throughput at around 25 - 30% less for 70 - 75Kbps, depending on a variety of factors including packet size, but discounting any communications availability issues (i.e. noise-limited case with very high SNR such that BER is very low compared with data rate).

Gaussian (non-nyquist) pulse shaping, if used, would produce an even better spectral mask, helping better avoid adjacent channel interference with other users, but would introduce another complication: inter-symbol interference or ISI from the pulse-shaping filtering itself, an impairment that, like multi-path induced ISI, limits maximum BER verus Eb/N0 or SNR (Es/N0). We assume that unlike GSM (which uses GMSK, or GFSK with modulation index =0.25), and uses an adaptive channel equalizer (Viterbi equalizer), NO adaptive channel equalization (decision feedback directed or other) is used in the receiver to compensate for ISI, because of complexity and cost (if it were incorporated it is also likely they would use GFSK instead of FSK). That is, we expect that the device uses Nyquist pulse shaping or dispenses with the pulse shaping entirely and simply uses binary FSK with MI=1 for data payload capacity of around 100Kbps less layer 3 overhead, and about 70-75 Kbps with all overhead accounted.

Based on the above characteristics, DNV KEMA would expect a receiver input sensitivity around -106dBm for a well implemented design in AWGN at a BER of 10E-6; vendors quote -102 dBm for a PER of 10E-03, which is consistent with BER of 10E-06 for a 1000 bit packet, so perhaps coding gains are less or impairments are 3-4 dB or so higher for the low-cost radio implementation, and which is not unreasonable, or vendors are simply being conservative. We shall use the figure of -102 dBm at an assumed BER of 10E-06 for the analysis.

In the case of the dense urban environment, we take as the limiting case for availability calculations Rayleigh fading (Rayleigh-distributed envelope), that is, absent dominant path, thanks to the low-gain omni-directional antenna employed in the NIC, low meter antenna height (2m), and low-gain omni antenna (6 dBi) employed well as at the ToP; in addition we consider the impacts of un-cancelled Inter-Symbol Interference (ISI) from multi-path (no equalizer), and co-user and inter-system interference; in the suburban and rural deployments we take the case of Ricean fading (dominant path present, not necessarily Line-of-Sight) with various K-factors considered (ratio of dominant path power to other power) for the availability calculations, along with adjusted ISI from multipath (fewer multipath components, with larger path delays and large rate of decay) and interference considerations.

B.2.2 Propagation Modeling:

We use standard Hata-Okagura models to estimate the mean propagation loss to which the fading models are applied, and expected range coverage

B.2.3 Path Hop distribution:

The average number of path hops required to service a subnet of N nodes is an important metric of mesh networks, but unfortunately, for self-organizing mesh networks, this average number of hops is very difficult to predict reliably, as it is a sensitive function of underlying path propagation conditions (itself a strong function of terrain, vegetation, and structures) as well as node density and distribution. Along with the average number of re-transmissions per hop required, this product strongly influences the average mesh data throughput (capacity), and therefore the number of meters which can be directly read in a fixed period of time.

The situation is further complicated by the fact that subnets serving N nodes with lower average hop counts, such as by having more available branches per node, assuming it is even possible in terms of propagation, tend as well to lower coverage (extent and area), necessitating an increase number of ToP s and subnets: for example, a binary tree (two branches per node) serving 1,023 user nodes will require an average 7.75 hops, whereas a 4-ary tree (4 branches per node except 3-ary from the eToP) serving the same number of 1023 user nodes require an average 4.66 hops. But the likelihood of each meter node reaching 4 other nodes is reduced by the square, and so simply may not form, or the availability per additional branch may be reduced so additional retransmissions shall be required. (The probability of finding n nodes within some range is the nth power of the probability of finding a single node within that same range.)

To elaborate, consider an urban deployment with Rayleigh fading (no dominant propagation path): with a 10 dB Rayleigh fade margin, adequate for a 90% single transmit availability, requiring 2.7 transmissions average (1.7 re-transmissions average) for 99.8% per path hop availability, estimates derived from the HATA model predict about 220m range, node-to-node range (using meters deployed at 2m height off the ground). The model predicts in this instance a $E(M_{transmission}) \times E(N_{hops})$ product of 18.9 for the binary tree mesh, and 12.6 for the 4-ary mesh; the corresponding average throughputs (subnet capacity) predicted are 2.65 Kbps and 3.96 Kbps respectively, and number of meter reads possible (1639 bytes compressed) in 1 hour to 99% probability at 560 and 838 respectively, or approximately 0.5 and 0.82 of the subnet population; this last would fail the requirement to complete direct meter reads on 99% of all installed and operational meters in 1 hour's time.

It must be remarked that the above example represents the likely “best case”; that is, assumes perfect cancellation of ISI from multipath which shall not impact per transmission availability, and no interference (co-user whether within the subnet or another subnet, or otherwise from unlicensed users).

B.2.4 Distribution of node separation versus node density:

We consider the case of customers uniformly distributed in both x- and y- dimensions over some rectangular area, and ask the question what the distribution of range separation between such customers versus the number of customers per the area;

BIN density definition: # meters/sq Km	# sq KM at BIN density	% of service area	Subtotals, % service area	Total meters	% of total population	Subtotals, % population	Avg density, meters/sq Km
1-9	15736	79.3%		50319.0	7.73%		3.19769954
10-19	1650	8.3%		21694.0	3.33%		13.1478788
20-29	460	2.3%		10945.0	1.68%		23.7934783
30-39	265	1.3%		9096.0	1.40%		34.3245283
40-49	144	0.7%		6314.0	0.97%		43.8472222
50-99	405	2.0%	94.0%	28099.0	4.32%	19.44%	69.3802469
100-199	358	1.8%		50929.0	7.83%		142.259777
200-299	181	0.9%		44690.0	6.87%		246.906077
300-399	121	0.6%		41663.0	6.40%		344.322314
400-499	95	0.5%		42794.0	6.58%		450.463158
500-999	381	1.9%	5.7%	274823.0	42.24%	69.92%	721.32021
1000-1999	60	0.3%		69198.0	10.64%		1153.3
2000-3999	0	0.0%		0.0	0.00%		#DIV/0!
4000-7999	0	0.0%		0.0	0.00%		#DIV/0!
8000-16000	0	0.0%		0.0	0.00%		#DIV/0!
>16000	0	0.0%	0.3%	0.0	0.00%	10.64%	#DIV/0!
Total	**19856**	**100.0%**		**650564.0**	**100.00%**		
1-4	11883	59.85%		25429	**3.91%**		
1-7	14794	74.51%		42369	**6.51%**		

B.2.5 Effect of metal meter enclosures/external antennas:

According to current calculations and models,

1. For urban deployment densities below 4,000 meters/sq KM, on average, ALL meters enclosed in full metal enclosures shall require the external (low-gain) antenna;

2. For suburban deployment densities below 500 meters/sq KM, on average, ALL meters enclosed in full metal enclosures shall require the external (low-gain) antenna;

3. For rural/open area deployment densities below 300 meters/sq KM, ALL meters enclosed in full metal enclosures shall require the external (low-gain) antenna;

AND

4. Assuming a high-gain omni antenna with net 5-6dBi gain, for all rural /open area deployments about ¼ of all meters in the rural/open area deployment are likely to require external high-gain antennas for deployment densities below 5 meters/sq KM.

These estimates are average based on uniformly distributed customers over the sq KM, assume 20 db increase in propagation loss due to each metal enclosure (i.e. a "leaky" RF enclosure), or total 40 dB impact on meter-meter communications with both meters in metal enclosures. The actual situation might be significantly worse, depending on the actual enclosure construction, but is impossible to determine without tests.

Wood-enclosed boxes should have little impact or need for external low-gain antennas.

B.2.6 Multi-phase (C+I) meters:

According to SP AusNet, approximately 134K meters, or 19% of the indicated 2015 quantity of customer meters (709K) shall be multi-phase (C+I) meters, requiring the C+I NIC ("commercial NIC") at $[redacted] each (rather than residential meter NIC); in addition, these NICs shall require the external $[redacted] antenna and approximate $[redacted] installation cost for a Capex total of approximately **$[redacted] each**.

B.2.7 Mesh Relays:

Estimating the number of relays (non-meter mesh nodes, used to provide coverage/routability in the mesh) required per ToP on average is quite difficult, and depends sensitively on local propagation conditions; however, Mesh vendors typically assumes 10 relays perToP; we shall do the same for budgetary estimates.

B.2.8 Access Points:

Mesh access points (equipped with cellular 3G modem and ethernet interface) are generally quoted at $[redacted] each, to which must be added battery backup of $[redacted] and mounting kit of $[redacted] for a total CapEx of $[redacted] each, along with expected installation, provisioning and test of 4 hours.

B.2.9 AMI Mesh Network Management System

Vendors typically quotes $1 per meter per month per environment for Network management (outsourced model – hosted on the vendors datacenter on the vendors owned machines) quantities of meters in the several 200K to 600K or 700K range; a minimum of three environments are required: production, disaster recovery, and test.

B.2.10 3G Cellular backhaul (ToP) costs:

Telstra cellular tariffs are taken at $[redacted]/month per ToP ($[redacted]per year). Although some small fraction of the ToPs are likely to be backhaul connected at substations or other SPAusnet facilities (without cellular), we assume that all ToPs are cellular connected for the cost estimates.

B.2.11 Costs for Cellular (3G) meters:

Telstra tariffs are quoted at $[redacted]/meter per year for 3G cellular-modem equipped AMI meters.

B.2.12 Analysis of SPAusnet service area and customer base:

Analysis of the approximately 650564 customer records and meter types from the GIS files provided indicates some important characteristics:

1. The service area extends to 19,856 Km^2, defined as that area with 1 or more customers per Km^2;
2. Approximately 79.3% of the service area has a customer density between 1 – 9 meters per Km^2, corresponding to 7.73% of the entire customer population, and an average customer density of 3.2 meters/Km^2;
3. Approximately 94% of the service area has customer density between 1 – 99 meters per Km^2, corresponding to 19.44% of the entire customer population;
4. Approximately 5.7% of the service area has customer density between 100 – 999 meters per Km^2, corresponding to 69.92% of the entire customer population;
5. The peak of the population distribution, or approximately 42.24% of the customer population, occurs at 500-999 meters /Km^2, but corresponds to 1.9% of the service area, with average customer density of 721 meters/Km^2;
6. Approximately 0.3% of the service area has customer density between 1,000 – 1,999 meters per Km^2, corresponding to 10.64% of the entire customer population, with average customer density of 1,153 meters/Km^2;
7. No customer densities are observed above 1999 meters/Km^2

Taken together, the very large proportion of the service area with very low customer density (79.3% of the 19,856 Km^2 service area with 1-9 meters/Km2, or average 3.2 meters/Km^2), nearly 16,000

Km2, but representing only 7.73% of the customer population, indicates considerable difficulty can be expected in obtaining the required mesh network service area coverage at economic rates.

1. **<u>High Density Urban , >1,000 meters/sq Km:</u>**

   Characterisation: ISI-limited, short delay spreads, channel coherence BW may exceed hop frequency extents causing flat fades; may need time-scheduling (e.g. polling or time-scheduled response to broadcast) to manage co-user interference

   Average 44m range separation between meters for uniform distribution;

   Rayleigh Fading, with availability further adjusted for ISI impairments

   In each case a direct meter read payload is 1639 bytes, compressed.

   The results assume no interference – including effective mesh co-user interference management - e.g. each meter is polled (requested and read) individually, or broadcast a request and scheduled read response so as to avoid co-user interference.

   The figures assume no backhaul throughput constraints and zero delays.

   Expect about 220m mean radio range without ISI or interference limitations (HATA, estimated 20 dB adjustment for 30m basestation -> 2m radios height, 10 dB Rayleigh fade margin); no further margin provisions are taken for standard deviation on adjusted HATA range. This shall serve as an upper bound on transmission range in the dense urban environment.

   Using a capacity requirement of 99% of all meters read successfully in 4 hours, ***we predict about 334 meters can be associated per access point (ToP), on average, in high-density urban deployment****, with an expected lower bound of about 63% of all such meters read within the same period (independent Gauss-Markov process with intelligent continuous queuing of re-read attempts after the first hour); with 205 meters per access point we can expect 98% of all meters read within 4 hours as an expected lower bound (independent Gauss-Markov process with 0.5 correlation, 50% single-hop, single transmit availability as above, with intelligent continuous queuing of re-read attempts after the first hour).*

2. **<u>Mid- Density Suburban , >100 - 1000 meters/sq Km:</u>**

Characterisation: ISI-limited, longer delay spreads, channel coherence BW fits within hop frequency extents causing independent fading per frequency dwell; may need time-scheduling (e.g. polling or time-scheduled response to broadcast) to manage co-user interference

Average 65m range separation between meters for uniform distribution, and N between 100 and 1000 equally likely (N_{avg} = 550 meters); max average range separation of 140m for uniform distribution at 100 meters/sq Km

Rayleigh to Ricean K=5 Fading, with availability further adjusted for ISI impairments

Expect about 440m to 610m mean radio range without ISI or interference limitations (HATA, estimated 20 dB adjustment for 30m basestation -> 2m radios height, 10 dB Rayleigh fade margin/5 dB Ricean K-5 fade margin); no further margin provisions are taken for standard deviation on adjusted HATA range. This shall serve as an upper bound on transmission range in the suburban environment.

Same notes apply as under dense urban.

*Using a capacity requirement of 99% of all meters read successfully in 4 hours, **we predict about 1010 meters can be associated per access point (ToP), on average, in mid-density suburban deployment**, with an expected lower bound of about 63% of all such meters read within the same period (independent Gauss-Markov process with intelligent continuous queuing of re-read attempts after the first hour); with 620 meters per access point we can expect 98% of all meters read within 4 hours as an expected lower bound (independent Gauss-Markov process with 0.5 correlation, 70% single-hop, single transmit availability as above, with intelligent continuous queuing of re-read attempts after the first hour).*

3. **Low Density Rural , <100 meters/sq Km:**

Characterisation: generally coverage-limited, ISI still but generally less of a factor, longer to very-long delay spreads, channel coherence BW fits within hop frequency extents causing independent fading per frequency dwell; may need time-scheduling (e.g. polling or time-scheduled response to broadcast) to manage co-user interference

Average 250m range separation between meters for uniform distribution, and N between 2 and 100 equally likely (N_{avg} = 50 meters); max average range separation of nearly 1000m for uniform distribution at 2 meters/sq Km; as much as 2.8 Km between adjacent cells.

Ricean K=5 Fading, with availability further adjusted for ISI impairments

Expect about 800m to 1100m mean radio range without ISI or interference limitations (HATA, estimated 20 dB adjustment for 30m basestation -> 2m radios height, 10 dB Rayleigh fade margin/5 dB Ricean K-5 fade margin); no further margin provisions are taken for standard deviation on adjusted HATA range. This shall serve as an upper bound on transmission range in the suburban environment.

Same notes apply as under dense urban.

Using a capacity requirement of 99% of all meters read successfully in 4 hours, ***we predict about 953 meters can be associated per access point (ToP), on average, in low-density rural deployment****, with an expected lower bound of about 63% of all such meters read within the same period (independent Gauss-Markov process with intelligent continuous queuing of re-read attempts after the first hour); with 585 meters per access point we can expect 98% of all meters read within 4 hours as an expected lower bound (independent Gauss-Markov process with 0.5 correlation, 90% single-hop, single transmit availability as above, with intelligent continuous queuing of re-read attempts after the first hour).*

B.2.13 Economic Coverage Analysis – approach to estimating 3G modem deployment:

The usual criteria for determining economic coverage – percentage of the total customer population that can be covered by a particular AMI technology – is that the *incremental* total lifecycle cost (TLC) over the period (in this case 15 years) attached to adding a single new customer AMI meter should not exceed the *incrementa*l TLC for the alternate AMI technology – the 3G cellular-modem AMI meter in this case. The incremental TLC for the mesh case is strongly dependent on whether the need exists to add an (expensive) relay node to support the additional customer meter; this need in turn is strongly dependent on the local customer density as well as expected (mean) radio propagation range in the circumstances. Apart from in-fill, where economic coverage is assumed for most customers and a cellular modem meter is deployed strictly for adverse propagation conditions to that particular customer, the situation is defined by the low-density rural/open area case.

In this instance, the man radio propagation range from the model is combined with the particular deployment density from 1 – 10 meters/sq Km and a triangular distribution for customer separation range to determine the probability of adding an additional relay for the given deployment density.

For example, the probability of needing one or more relays added for supporting an additional customer at 1 customer/Km^2 is about 52%, at 2 customers/Km^2 is about 59%, at 7 customers/Km^2 is 40% and at 10 customer/Km^2 is 15%, and peaks at about 63% at 3 customer/Km^2.

Because the predicted 15-year blended residential + commercial meter total lifecycle cost, at between $751 and $855 (less the physical meter itself) depending on deployment (rural/open area to urban), exceeds in every instance the 3G cellular modem AMI meter total lifecycle cost at $732 (less the meter itself); so provided that cellular coverage is available where the new meter shall be added, a modified criteria had to be employed.

DNV KEMA has chosen as the relevant criteria a 10% increment in total lifecycle cost over the nominal lifecycle cost for the deployment for adding one or more meters at the specified deployment density. Based on DNV KEMA modeling, this implies the added coverage is not economic for mesh for customer densities below about 8 customers /Km^2 – that is, incremental TLC cost of adding at least one relay at the probability of so-doing would raise the TLC for 8 meters deployed under the same density and deployment conditions by 10%.

Appendix C - CVs of Key DNV KEMA Personnel

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