



Discussion Paper

Smart street lighting in Australia

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EXECUTIVE SUMMARY

Infrastructure such as new technology smart street lighting devices are being enabled to act as sensor networks, collecting and communicating data relevant to transport, environment, city management, energy, safety and security service applications. Smart street lights are being recognised as a platform for the collection of smart cities data because they are ubiquitous, provide good visibility for various sensors and wireless communications devices and are already connected to a reticulated electricity supply, thereby helping to reduce rollout cost.

Street lighting asset owners, road authorities and governments at all levels are considering the potential for smart technology street lighting to deliver increased safety, efficiencies, productivity and services.

The Lighting Council Australia Smart Street Lighting Stakeholder Forum (SSLSF) held on 12 May 2016 in Sydney heard from electricity utilities, road authorities, local governments and regulators about how they would like to use smart street lighting and the current Australian regulatory frameworks for street lighting. An Australian standards committee member also presented a view of the current standards (including gaps) in this area.

This discussion paper summarises the views presented and discussed at the SSLSF and tries to identify the areas where regulatory reforms, standards developments and other market actions may be needed to facilitate the smart street lighting market in Australia.

Appendix A is included to provide some context around how smart street lighting may be used within smart cities.

Stakeholders at Lighting Council's forum agreed the following issues will require resolution before smart street lighting networks can be widely rolled out:

1. Business cases need to be developed
 - Quantifying benefits and providing investment assurance is needed to justify capital outlay.
 - Collaboration/coordination/partnerships between all levels of government in Australia, government agencies, regulators, industry and researcher stakeholders may be needed to develop the business cases, regulations, systems and markets.
2. Regulations will require amendment
 - Agreement on how smart street lighting will be used is needed.
 - Regulators require accurate descriptions of smart street lighting systems.
 - Regulations will likely require amendment to accommodate discrete and adaptive smart street lighting systems.
3. Standards and specifications are required
 - Standards and specifications are needed that can be referenced in regulations and tender documents to reduce technical barriers and bridge the current knowledge gaps.
4. Transformation of electricity networks
 - The incorporation of smart street lighting into the existing infrastructure needs to be considered.
5. Smart cities and data
 - The use of smart street lighting within the context of smart cities needs to be considered and planned.

Recommendations

1. Roads authorities and local government develop smart street lighting business cases. Lighting Council Australia can assist in providing information on smart street lighting capabilities.
2. All stakeholders provide feedback on how they would like to use smart street lighting systems through comments to this discussion paper.
3. Suppliers of smart street lighting agree an accurate description of the components that make up a smart street lighting system. Lighting Council Australia can coordinate.
4. Lighting Council Australia, relevant regulators and other key stakeholders develop detailed proposals to amend the National Electricity Act and the National Measurement Act.
5. The National Measurement Institute coordinate the development of a smart street lighting metering standard.
6. The Institute of Public Works Engineering Australasia (IPWEA) through its Street Lighting and Smart Controls (SLSC) Program to develop a smart street lighting specification.
7. Energy Networks Association include smart street lighting systems (e.g. standby power, dimming, control system communication, etc.) in its Electricity Network Transformation Roadmap.
8. The Australian Government's Smart Cities Plan as well as smart cities research organisations consider the capabilities of smart street lighting systems within smart cities.
9. Lighting Council Australia host a second Smart Street Lighting Stakeholder Forum seeking agreement on regulatory and standards development proposals.
10. Lighting Council Australia develop this paper through the incorporation of stakeholder feedback and the inclusion of detailed regulatory proposals.
11. Lighting Council Australia strongly recommends that any upgrades of traditional street lighting incorporate smart-ready LED luminaires.

Next steps - your feedback is sought

Lighting Council Australia welcomes your input on any aspects of this discussion paper. Please send any comments to David Crossley, Technical Manager dcrossley@lightingcouncil.com.au by **Friday 5 August, 2016**.

1 Introduction

Lighting Council Australia's Smart Street Lighting Stakeholder Forum (SSLSF) on 12 May 2016 in Sydney heard from electricity utilities, road authorities, local government and regulators about how they would like to use smart street lighting and the current Australian regulatory frameworks for street lighting. An Australian standards committee member also presented a view of the current standards (including gaps) in this area.

This discussion paper summarises the views presented and discussed at the SSLSF and seeks to identify the areas where regulatory reforms, standards developments and other market actions may be needed to facilitate the smart street lighting market in Australia.

Appendix A is included to provide some context around how smart street lighting may be used within smart cities.

The discussion paper also mentions other possible infrastructure allied to smart street lighting such as electric vehicle charging stations. However this project will not be considering the developments that may be needed to facilitate electric vehicle charging infrastructure.

2 What is smart street lighting and new technology LED street lights?

The term 'smart street lighting' refers to street lighting infrastructure that performs the role of traditional street lighting and has additional features designed to increase efficiencies, productivity and services.

Smart street lighting infrastructure consists of (at least) LED luminaires (able to be dimmed if needed), data collection sensors and communication technology. Other features could include digital signage, CCTV, speakers, 'push to talk' emergency system and electric vehicle charging.

The combination of the pole, data collection, data sharing, analytics and application development has the capacity to significantly increase services.

New technology LED street lights offer increased energy efficiency, reduced maintenance costs and longer lifetimes over traditional street lighting technology. Street lighting infrastructure owners (electricity utilities) are now starting to install this new technology.

Lighting Council Australia strongly recommends that any upgrades of traditional street lighting incorporate smart-ready LED luminaires. Smart-ready LED luminaires include cabling and connectors able to accommodate the connection of sensors and communication devices at a later date.

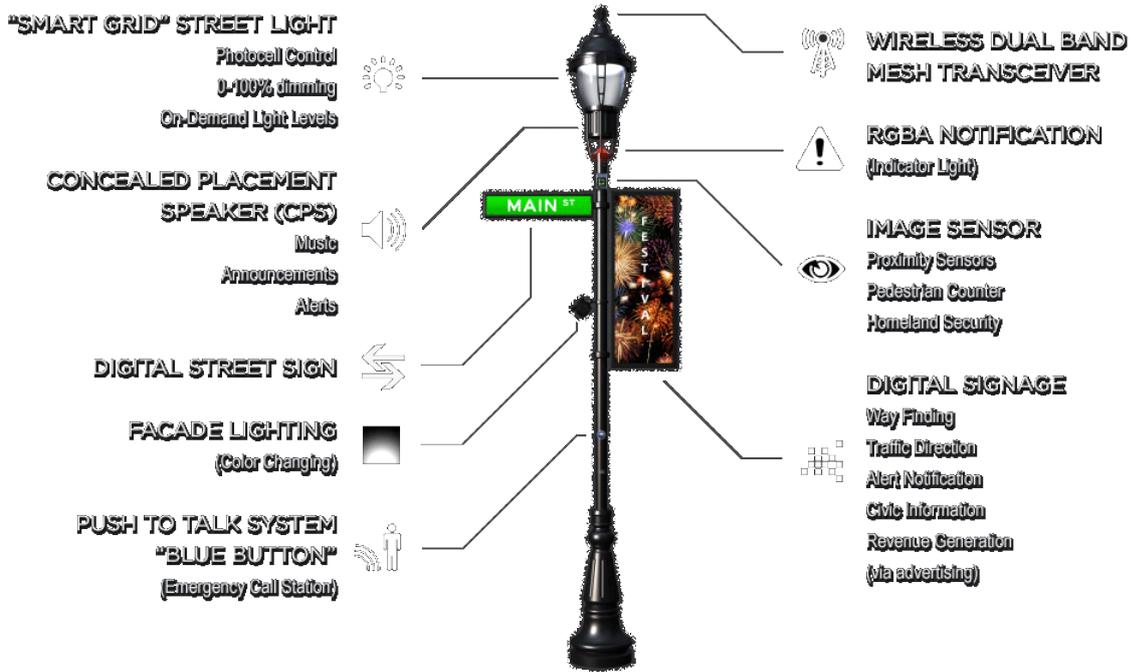


Figure 1: Smart street lighting pole. ¹

3 Thoughts on smart street lighting by infrastructure owners, customers and regulators

3.1 Local government

Background and context

Governments, including local government, are moving towards a new framework – that of service providers. Local government is becoming aware of the service possibilities offered by smart street lighting. However there are knowledge and information gaps as well as a lack of standards and aligned specifications available to local government.

Our cities and their services and systems are smarter now than decades ago. In future they will be driven, in large part, by increased data collection, data analysis and service-orientated applications. Data will be used to create new economic services and business opportunities. Public agencies will want to access essential data and business will benefit from access to data for appropriate purposes.

Street light poles are likely to become valuable real estate as the space used and data collected can be leased or on-sold to service providers. In future the light pole may be considered as part of a new eco system providing improved lighting, increased service efficiencies, data collection and additional service provisioning.

Some city areas may want to encourage a night economy and so they would want to increase lighting levels at particular times or for events. Smart lighting systems will provide the right amount of light in the right places at the right times.

Cities acknowledge the need to consult with their communities on the use and management of smart street lighting. Providing value to the community and enabling self-funding of smart street lighting

¹ Image from <http://www.illuminatingconcepts.com/intellistreets/>

infrastructure will be primary goals of cities as part of upgrades. A focus of smart street lighting business cases will be revenue generation (e.g. via value capture through access leasing arrangements or sale of data to third parties).

There is inertia to retain the existing infrastructure. The capital cost to upgrade mean that business cases have to be developed to obtain funding for infrastructure upgrades.

Smart street lighting assets should be resilient, flexible and modular. They should be capable of enhancement over time.

Local government potential use of smart street lighting

Cities may want to use the following features of smart street lighting and smart poles:

- Variable lighting levels:
 - to increase light levels around event precinct areas and create night economies; and
 - to decrease light levels and save energy when vehicles and pedestrians are not on the streets.
- Increased control, centralised monitoring, outage detection, fault prediction, maintenance planning and asset management improvements.
- Image sensing (CCTV, photography, traffic and pedestrian movements).
- Parking vacancy sensing to support smarter parking and payment applications.
- Digital signage for way-finding, alerts, announcements, entertainment and revenue generation.
- Speakers for music, alerts and announcements.
- Façade lighting (colour changing) for entertainment and ambience.
- Electric vehicle charging stations.

Issue 1: Develop business cases

Work is needed on developing the business cases, quantifying the benefits and providing the investment assurance to justify capital outlay.

Issue 2: Regulatory reform

There is a need to accommodate the metering of adaptive (variable output) loads. Current regulations will require amendment to accommodate this requirement.

Issue 3: Develop standards and specifications

- a. A smart street lighting metering standard has to be developed and referenced in regulations. Are suitable international metering standards available (e.g. OIML R46, IEC, ANSI), can they be adopted or modified for use in Australia or do we need a national standard developed?

- b. There is a lack of market knowledge of suitable smart street lighting specifications. A smart street lighting luminaire brings together a large number of components and cooperation/collaboration is needed to produce and agree an overall standard or specification for a smart street lighting luminaire/ pole/ system.
- c. International light pole standards are being developed now and Australia should consider involvement.

Issue 4: Transformation of electricity networks

- a. We need to work with the existing infrastructure (wooden poles). The cost to run telecommunications cabling is expensive so wireless communication may be the best option initially.

Issue 5: Smart cities and data

- a. Considerable data capacity is needed to cater for the collection of data from different sensors for use by applications. Big data and cloud solutions exist now that can cater.
- b. Data ownership, sharing and security may require clarity and agreements.

3.2 Road authority

Background and context

Road authorities in Australia are keenly interested in how smart street lighting works and the possible improvements to safety, efficiencies, productivity and other benefits. They want to be an active participant in this discussion and the development of smart street lighting systems.

Maintained or increased safety is of primary importance to road authorities in their consideration of upgrading their road lighting infrastructure. Pedestrian deaths are increasing. The cost of serious accidents to the NSW economy is \$5 Billion/year. Good street lighting is needed so that drivers can see pedestrians when natural light conditions are poor.

The increased asset management capabilities of smart street lighting systems is of interest to road authorities, as faulty luminaires can be detected immediately upon failure. In addition the data logging capabilities of smart street lighting enables efficient maintenance planning, thereby reducing the incidence of failures. As well, the relatively long lifetimes of LED luminaires compared to traditional lighting are now reducing maintenance costs.

Cost reductions over time due to decreased energy usage from more efficient and dimmable luminaires are being explored now by road authorities.

Road authorities should aim for a consistent approach to smart street lighting across the state road networks of Australia. Freight doesn't recognise state borders, road freight traffic is increasing and the freight industry is demanding consistency across all states and territories.

Other countries are already implementing smart road lighting systems. In the United Kingdom, approximately 1.5 million out of a total of 6 million road lighting luminaires are using some increased smart functionality. Road authorities in Australia point to the inevitability of smart road lighting implementation.

Maintained or increased pedestrian and driver safety, increased asset management capabilities and cost reductions over time are all fundamentally important issues for road authorities.

NSW Roads and Maritime Services has a wave of infrastructure development and building due for delivery in the next few years. Consideration should be given now to the implementation of new technology road lighting systems or at least lighting products that can be adapted relatively easily in future (i.e. smart-ready luminaires).

Road authorities believe there is value and opportunity in smart street lighting and are looking for potential improvements in the following areas when considering new smart road lighting systems:

- An increase in pedestrian and driver safety.
- Asset cost reductions over time due to decreased energy usage, reduced maintenance costs and improved lifetimes.
- Asset management due to increased efficiencies in scheduled maintenance.
- Contract administration and other potential benefits.
- Other benefits may include: traffic sensors and CCTV to be used for active traffic management systems; parking vacancy sensing to support smarter parking and payment applications; environmental sensors to monitor factors such as temperature, rain, flooding and air quality.

Other applications will inevitably be developed when new data streams become available.

There are commercial issues around the implementation of new infrastructure and a cooperative approach is needed. Government ministers are starting to realise the potential value of smart street lighting on major road routes and internal state government committees (e.g. the NSW Government 'Street Lighting Forum') are currently discussing smart street lighting.

Issue 1: Develop business cases

Work is needed on developing the business cases, quantifying the benefits and providing the investment assurance needed to justify capital outlay.

Issue 2: Regulatory reform

There is a need to accommodate the metering of adaptive (variable output) loads. The current regulations will require amendment to accommodate this requirement.

3.3 Electricity utilities

Background and context

Electricity utilities own the majority of street and road lighting infrastructure and are moving to LED street and road lighting. Electricity utility customers are the roads authorities and local governments. For utilities such as Ausgrid this translates to a street lighting network comprising 70% residential lighting and 30% road lighting.

Utilities now use websites to allow the public to report faulty street lighting. Night patrols also identify street lighting faults.

The business case for new or upgraded infrastructure is critically important. Benefits need to be quantified. Removing the need for night patrols is relatively easy to assess but other benefits may not be easy to initially identify and quantify. Stakeholders need to make important decisions on who will pay to upgrade street lighting infrastructure.

Utilities need to identify the features and systems that are available and are being demanded by their customers (i.e. the road authorities and local governments).

Other electricity network considerations include the network transformation currently underway to accommodate a more distributed generation profile as well as new and significant loads. For example, smart poles incorporating electric vehicle charging may result in a large change in the electricity load because electric vehicles draw considerable power during fast charging. The impact of smart lighting system standby power also needs to be considered. We will also need to work with the existing infrastructure (wooden poles).

A business case approach similar to the examination conducted by the Energy Networks Association (ENA) and CSIRO needs to be developed in the smart street lighting area. Key questions such as how smart street lighting will affect the grid of the future and whether smart street lighting will be a distributed energy resource need to be considered as part of the electricity network transformation roadmap. The incorporation of control and communication systems currently used within the grid and used by smart street lighting systems needs to be considered along with variable load prediction.

Drivers of the future grid include: regulation; tariffs; standards; grid design and operation including transformation; technology development and innovation.

Future mergers of electricity distribution companies may provide an opportunity to discuss policy approaches to smart lighting infrastructure.

Issue 1: Develop business cases

Work is needed on developing the business cases, quantifying the benefits and providing the investment assurance needed to justify capital outlay.

Issue 4: Transformation of electricity networks

- b. We need to work with existing infrastructure (wooden poles). The cost to run telecommunications cabling is expensive so wireless communications may be the best option initially.
- c. Smart street lighting's effect on the grid (e.g. Standby power used by smart controls) and its use as a distributed energy resource needs to be considered as part of the electricity network transformation roadmap.
- d. Can a common platform for the network also control smart street lights?
- e. Smart street lighting demand prediction is needed for optimal network control.

3.4 Australian Energy Market Operator

The Australian Energy Regulator (AER), Australian Energy Market Commission (AEMC) and Australian Energy Market Operator (AEMO) enforce, develop policy and operate the National Electricity Market (NEM) in Australia.

AEMO operates the NEM by maintaining the market operating principles, coordinating electricity dispatch instructions, overseeing responsible parties and arranging energy settlements/financial contracts/settlement payments.

The responsible parties within the NEM include generators, retailers, local network service providers, responsible persons, metering and data providers. Metering Service Providers must comply with the accreditation and quality management requirements of the National Electricity Rules (NER).

Street lighting in Australia is mainly installed and operated as *Type 7 unmetered supplies* and classified as *market* loads. Type 7 installations require the load pattern to be predictable and reasonably calculated. The NEM load table, inventory tables and on/off times table determine the billing values.

Different installation types require accuracy of metering to range from 0.5% to 1.5%. An appropriate accuracy needs to be determined for street lighting if it becomes metered.

Discrete control of adaptive street lighting (e.g. lighting levels adjusted to a particular level at the same time each night) is easier to accommodate within the current arrangements. The load has to be predictable and reasonably calculated.

Full adaptive control (e.g. a range of dimmed lighting levels, no specific times for dimmed operation, no specific duration of dimmed operation, not able to reasonably calculate metering data) will require metering of the street lighting.

Under the National Electricity Rules metering requires the following five components: measurement element, clock, energy data storage, display, communications device (to enable the collection of metering data). If smart street lighting requires full adaptive control the required metering installation components and their arrangement/placement have to be determined and agreed.

Smart street lighting systems including adaptive lighting controls can be installed now by installing systems behind a pattern approved meter.

Issue 2: Regulatory reform

Items to be resolved to facilitate integration of discrete smart lighting control systems into the metrology framework:

- a. Detailed description of operation of smart lighting control systems.
- b. Owner/operator of smart lighting control systems.
 - i. Accreditation required?
 - ii. Operate under the auspices of the Metering Data Providers?
- c. Standardisation of data/information provided by smart lighting control systems to Metering Data Providers.
- d. Agreement on the level/s of dimming, dimming times and durations.

Additional issues needing resolution to facilitate integration of adaptive smart street lighting control systems into the metrology framework:

- e. Location of all metering installation components within smart lighting control systems. The current rules require meters to contain a display. An appropriate place/s where the customer can access smart street lighting energy consumption information needs to be determined.
- f. The accuracy class for smart street lighting metering needs to be determined.

- g. Detailed descriptions of data security provisions facilitated by smart lighting control systems.
- h. Recognition of “metering” components of smart lighting control systems in the National Electricity Rules.
 - i. New class of metering device?
 - ii. Is system metering possible?
 - iii. Approvals required for these metering devices?
 - iv. Communication methods?
 - v. Changes to National Electricity Rules?
- i. Installation and routine testing of “metering” components of smart lighting control systems by accredited Metering Provider.
- j. Identification of luminaires operated by smart lighting control systems.
- k. Inventory table management and coordination with Local Network Service Providers.

3.5 National Measurement Institute

The National Measurement Institute (NMI) is the regulator overseeing metering used for trade in Australia. The National Measurement Act is the relevant legislation. The Act requires measuring instruments used for trade to be pattern approved and verified. The pattern approval process is about verifying an instrument is accurate under a different range of expected use conditions including electricity supply specifications and tolerances, impulses, magnetic induction, vibration, shock, environmental conditions, electromagnetic fields.

The NMI represents Australia internationally to support Australia’s interests and reduce technical barriers to trade. The International Organisation of Legal Metrology (OIML) and the International Electrotechnical Commission (IEC) are both international standards setting bodies in this area. There are multiple international electricity metering standards.

NMI has recently lifted the exemption for electricity meters (< 750MWh per year) and now require pattern approval and verification. The OIML R46 test standard or the NMI M6 test standards are approved for the meter impulse voltage test and IEC standards (e.g. IEC 62052) are approved for other meter tests. Further consultation on pattern approval standards is currently ongoing with an options RIS in development.

Issue 2: Regulatory reform

Items requiring resolution to facilitate integration of smart street lighting systems into the metrology framework:

- I. Location of all metering installation components within smart lighting control systems. The current rules require meters to contain a display. We will need to determine an appropriate place/s where the customer can access smart street lighting energy consumption information.

- m. The accuracy class for smart street lighting metering will need to be determined. What accuracy is required and possible to deliver?
- n. Recognition of “metering” components of smart lighting control systems in the National Electricity Rules.
 - vi. New class of metering device?
 - vii. Is system metering possible?
 - viii. Approvals required for these metering devices?
 - ix. Communication methods?
 - x. Changes to National Electricity Rules?

Issue 3: Develop standards and specifications

- a. A smart street lighting metering standard needs to be developed and referenced in regulations. Are suitable international metering standards available (e.g. OIML R46, IEC, ANSI), can they be adopted or modified for use in Australia or do we need a national standard developed?
- d. There is a Standards Australia project starting on advanced metering. Does a smart street lighting metering project need to be included?
- e. Other physically close applications that may need to be metered may be photovoltaic arrays mounted on the street lighting pole and electric vehicle charging points.

3.6 Standards

Smart street lighting standards are currently fragmented and not well integrated.

The marketplace is changing quickly. There are many standards for the individual components that make up a smart pole and smart street light but there may not currently be any standards for an entire smart street lighting luminaire or pole. The IEC, ISO and CIE are currently working on terminology standards for smart lighting.

Smart street lighting and smart poles will bring together areas that have not previously co-existed including street lighting, dimming, communications, metering, controls, sensors, displays, photovoltaic systems, connection sockets, EV charging and potentially other components.

Various protocols exist to control lighting systems including international standards (e.g. DALI, LonWorks, TCP/IP), consortia projects (e.g. TALQ and others) and proprietary systems.

The NEMA ANSI C136.41 standard is gaining acceptance as a 7 pin connection base standard for mounting sensors and other accessories.

Issue 3: Develop standards and specifications

There is a lack of market knowledge regarding suitable smart street lighting specifications. A smart street lighting luminaire brings together a large number of components and

cooperation/collaboration is needed to produce and agree an overall standard or specification for a smart street lighting luminaire/pole/system.

3.7 Other matters raised during the Forum

- Many current street lighting installations do not conform with lighting standards requirements (in terms of lighting levels) and the transition to LED and smart lighting provides an opportunity to bring compliance of installations up to the requirements of current standards.
- A local government considers it difficult to make decisions about assets it does not own. Some local governments are considering owning street lighting assets in certain areas.
- Governments should provide the lead in expenditure on smart street lighting infrastructure. The capital cost is high and the benefits inter-generational.
- It is important to provide smart ready infrastructure even when lighting upgrades do not initially include smart lighting systems. It is considerably more costly to upgrade systems that are not smart ready.
- Anyone may propose a rule change to the National Electricity Rules.
- The energy retailer perspective should be included in any discussions and proposals.
- Smart street lighting assets should be considered as part of the larger smart city infrastructure.

4 Conclusions and recommendations

Stakeholders at Lighting Council's forum identified the following issues requiring resolution before smart street lighting networks can be widely rolled out:

- **Develop business cases:** More work is needed on developing the business cases, quantifying the benefits and providing the investment assurance needed to justify capital outlay. Collaboration/coordination/ partnerships between all levels of government in Australia, government agencies, regulators, industry and researcher stakeholders may be needed to develop the regulations, systems and markets. Smart street lighting infrastructure will require an initial capital outlay but have significant inter-generational benefits. Smarter investment through value capture should be considered for inclusion in business cases as smart pole real estate and data streams will likely have value for some businesses and service providers.
- **Regulatory reform:** The current regulations may not easily accommodate new smart lighting technology (e.g. there will be a need to meter the new variable output loads and the new devices that will be included in the street lighting network). Regulators stated they are willing to develop the regulatory solutions to enable the development of this market.
- **Develop standards and specifications:** Standards and specifications are needed that can be referenced in regulations and tender documents to reduce technical barriers and bridge the current knowledge gaps.
- **Transformation of electricity networks:** The incorporation of smart street lighting into the existing infrastructure needs to be considered.

- **Smart cities leveraging smart street lighting data:** The use of smart street lighting within the context of smart cities needs to be considered and planned.

Recommendations

1. Roads authorities, local government and electricity utilities develop smart street lighting business cases. Lighting Council Australia can assist in providing information on smart street lighting capabilities.
2. All stakeholders provide feedback on how they would like to use smart street lighting systems through comments to this discussion paper.
3. Suppliers of smart street lighting agree an accurate description of the components that make up a smart street lighting system. Lighting Council Australia can coordinate.
4. Lighting Council Australia, relevant regulators and other key stakeholders develop detailed proposals to amend the National Electricity Act and the National Measurement Act.
5. The National Measurement Institute coordinate the development of a smart street lighting metering standard.
6. The Institute of Public Works Engineering Australasia (IPWEA) through its Street Lighting and Smart Controls (SLSC) Program to develop a smart street lighting specification.
7. Energy Networks Association include smart street lighting systems (e.g. standby power, dimming, control system communication, etc.) in its Electricity Network Transformation Roadmap.
8. The Australian Government's Smart Cities Plan as well as smart cities research organisations consider the capabilities of smart street lighting systems within smart cities.
9. Lighting Council Australia host a second Smart Street Lighting Stakeholder Forum seeking agreement on regulatory and standards development proposals.
10. Lighting Council Australia develop this paper through the incorporation of stakeholder feedback and the inclusion of detailed regulatory proposals.
11. Lighting Council Australia strongly recommends that any upgrades of traditional street lighting incorporate smart-ready LED luminaires.

5 Consultation - your feedback is sought

Lighting Council Australia welcomes your input on any aspects of this discussion paper. Please send any comments to David Crossley, Technical Manager dcrossley@lightingcouncil.com.au by **Friday 5 August, 2016**.

Appendix A: Smart cities and smart street lighting

Australian Government Smart Cities Plan

The Australian Government has released its Smart Cities Plan focusing on building an agile, innovative and prosperous nation through action around the opportunities for our cities. Cities need a clear vision for their economic future. Only with such a vision and the accompanying policy framework can cities deploy technology in the smartest ways possible.

The Australian Smart Cities Plan seeks to improve the economic, social and environmental lives of people living in cities. Smart city policies are being driven by the move towards a knowledge based economy, population growth, urbanisation, planning principles, technology improvements, innovation, productivity, congestion and human well-being.

An overview of a smart cities approach

To succeed, our cities will need to be productive, accessible, liveable and serve their citizens. Human well-being as well as economic activity indicators should be used as the metrics for smart cities.

Collegiate approaches and collaborations between a diverse range of businesses, all levels of government and diverse communities will lead to success. A web of diverse influences and experiences will be needed to challenge ourselves and promote growth in ideas.

Policies and culture that enable and reward innovation should be encouraged. A governance structure is needed that has credibility with industry and encourages private partnerships. Governments should collaborate with citizens, industry and academia by nurturing a collaborative ecosystem and connecting without dominating. Governments should review and reform their own structures to support the required level of agility, efficiency, flexibility and effectively manage change.

Innovation hubs will supercharge economies and underpin city culture. New developments will need to be connected to existing infrastructure and communities with an important digital overlay. Smart cities use technology to enhance the lives of the people inhabiting cities.

Smart cities will require a high capital outlay but have inter-generational benefit.

Businesses and employees may need to be more nimble in future. Artificial Intelligence and automation will reduce the amount of jobs in certain professions. Humans will not be entirely replaceable in the foreseeable future workforce but they will likely be liberated from mundane jobs and left with creative jobs. Nimble market players are gaining market share.

The criteria for the success of a smart city includes:

- Economic composition – a diverse mix of economic activity is needed.
- Human capital – Smart cities and nations need to attract and retain a base of talented human capital. Perks beyond salaries will be important to retain the best employees. We need to encourage the brightest people to stay in Australia and innovation hubs will help to retain the brightest people. Risk and entrepreneurship should be encouraged and rewarded.
- Physical and virtual infrastructure – to facilitate connectivity and movement of goods, services and labour.
- Regulatory and cultural environment – Smart cities need policies and culture that reward innovation.

- Identity and brand – Smart cities need to be places where people want to be.

Smart, energy efficient technology and sensor networks will be increasingly used to gather real time data that can be analysed and used to provide innovative services within smart cities.

Views on technology solutions

A smart city could be defined, at least in part, as a city in which information and communications technology is merged with traditional infrastructures, coordinated and integrated using new digital technologies. Smart cities use technology to enhance the lives of the people inhabiting cities. Twenty-first century technologies offer new promise for the future of cities: more efficient resource usage and greater connectivity between people and places. Smart cities should facilitate the process of people living meaningful and fulfilled lives, enabled seamlessly by technology and offering opportunities for all.

Technology should enable us to live more sustainably and comfortably by enabling new services. Example services such as 'space' as a service (co-working and co-living spaces) and ride-sharing are becoming more common. An example application could automatically coordinate pollution monitoring and road toll levels to deter traffic if pollution levels increase above set points. Such services enabled by real time data collection can reduce pollution and road congestion.

The forecast web of machine-processed data is starting now. The internet of things will include sensor networks collecting, disseminating and using data. Individuals, businesses and governments will be empowered through greater situational awareness provided by data collection, analysis and real world applications.

Communications will need to be enabled via high speed broadband infrastructure, wireless broadband for public access, pervasive connectivity for sensors, open data and co-creation of new services.

Views on leveraging open and real time data

Data collection undertaken by the Australia Bureau of Statistics (monthly data) and the Australian Government Sensis (five yearly) will continue to be important. However an increase in the collection, analysis and use of real-time data will drive further efficiencies, services and solutions.

Networks of sensors and smart devices will collect real-time data. Mobile phones and their applications already collect, disseminate and use data streams. Other city infrastructure such as new technology smart street lighting devices are being enabled to act as sensor networks, collecting and communicating data relevant to transport, environment, city management, energy, safety and security service applications.

Smart street lights are being recognised as a platform for the collection of smart cities data because they are ubiquitous, provide good visibility for various sensors and wireless communications devices and are already connected to a reticulated electricity supply, thereby helping to reduce rollout cost.

The opening of data streams and an understanding of data patterns are leading to new services and new applications. Data is not useful until it is used so sharing anonymised, validated data is important and will continue to lead to innovation, reliable service delivery and more efficient use of infrastructure. Public agencies could access essential sensor data and private enterprise could share agreed data.

Using data from a variety of sources, analytics and communication systems will enable new services in the following areas:

- Environment and water: waste and water treatment; pollution control.

- Built environment and city management: green buildings; urban design; urban services; smart use of buildings.
 - Urban mobility: last mile solutions; urban logistics; intelligent transport systems (e.g. transport journey planning applications provide real time travel information to help commuters better plan their journeys).
 - Energy: smart energy management; energy efficiency; renewables.
 - Safety and security: public safety; command and control systems.
 - Smart health care services.
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About Lighting Council Australia

Lighting Council Australia is the peak body for Australia's lighting industry. Its members include manufacturers and suppliers of luminaires, lighting control devices, lamps, solid state lighting and associated technologies. Lighting Council's goal is to encourage the use of environmentally appropriate, energy efficient, quality lighting systems.