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NSW Lighting Market Impact Evaluation

Impacts of NSW Government
energy efficiency programs

FINAL REPORT, 1 November 2017

NSW Lighting Market Impact Evaluation Study – Impacts of NSW Government energy efficiency programs

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Executive Summary

This report sets out the findings and recommendations from an extensive quantitative and qualitative study into the impacts of the NSW energy efficiency policy on the lighting market. Our research found that since 2011, the Energy Savings Scheme (ESS) has delivered energy saving upgrades of over **3.7 million lights**, to **over 10,000 NSW business sites in NSW**. This has achieved around:

- \$671 million** net economic benefit to NSW
- 8,226 GWh** of energy savings for NSW businesses
- \$1.6 billion** in energy bill savings for NSW businesses
- \$600 million** in new investment in NSW

This activity occurred against the backdrop of a global transformation of the lighting market through the shift to LEDs as the dominant technology. The ESS brought forward energy saving technologies and upgrades to NSW much earlier than would have occurred without the Scheme.

The ESS has also changed the structure and dynamics of the lighting market, in a way that has the potential to drive savings beyond the individual projects it has funded. It has **driven innovation in lighting product design and business models that break down split incentives by putting customers first**. These innovations are now being adopted by the mainstream lighting market, outside the ESS. They have enabled the growth of commercial energy saving retrofit markets in South Australia and the Australian Capital Territory, with potential to expand nationally. These provide a platform that can be built on to drive deeper energy efficiency retrofits in NSW beyond the lighting market. However, for these impacts to persist, the ESS policy settings need to be managed carefully to transition these business models and structures to sustain without incentives.

We recommend that the Government adjust the policy settings for the ESS and other energy efficiency programs to more **systematically pursue and manage their potentially greater market transformation benefits**. For these benefits to continue, the current **ESS Rule also needs to be updated to reflect the eventual but inevitable upgrade of almost all NSW lighting to LEDs** that the ESS has helped bring forward.

This research, our findings and recommendations are expanded on in the following Summary for Policy Makers section and detailed in the report.

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Summary of Findings

The ESS delivered energy saving lighting retrofits to over 10,000 NSW business sites between 2011 and 2016:

- This provides \$671 million in economic benefits to all of NSW and a combined \$1.6 billion in avoided energy bill costs for thousands of NSW businesses, and drove around \$600 million in investment in NSW, from \$250 million in ESS incentives
- These savings are from helping NSW lead the world in the wide scale adoption of efficient lighting and by continuing to accelerate the retirement of legacy energy wasting technologies
- The ESS has driven down the cost and improved the quality of LEDs in Australia through new product standards, market competition, and innovation
- However, efficient lighting is becoming the norm for new product sales and the incremental benefits of retiring legacy technology early will gradually decline over the next decade

The ESS is helping transform market structure and dynamics to drive and potentially extend these outcomes:

- Before the ESS, there were major structural barriers to the sale and retrofit of energy saving efficiency lighting in NSW
- The ESS has driven commercial innovations that are reshaping the lighting market to overcome these barriers, upgrading around 20% of NSW commercial lighting stock
- Investor confidence and regulatory clarity are essential to supporting the competition and innovation behind these transformations
- Other NSW programs may be having more targeted impacts on market structure that we were unable to detect

These findings are expanded on in the following Summary of Policy makers and detailed at the end of each part of this report.

Key Recommendations

Our central recommendation is that:

Energy efficiency policy, operations and evaluation should be adjusted to account for historical and future market transformation, particularly:

- the policy, administration and objectives of the ESS and other energy efficiency programs should systematically pursue and support market transformation benefits
- the current ESS Rule also needs to be updated to reflect the eventual but inevitable upgrade of almost all NSW lighting to LEDs that the ESS has helped bring forward

These findings are expanded on in the following Summary of Policy makers. A schedule of detailed of policy, administrative recommendations is provided at Chapter 26.

Summary for Policy Makers

Report Overview

This report is a summary of the findings and recommendations from a Common Capital study into the impacts of the NSW energy efficiency policy on the lighting market, for the NSW Office of Environment and Heritage (OEH). These findings and recommendations have implications for ongoing policy and operations of the NSW Energy Savings Scheme (ESS), the evaluation of the NSW Energy Efficiency Action Plan (EEAP), and the proposed Plan to Save NSW Energy and Money.

Research Objectives

This study set out to assist the OEH in answering three questions:

1. What impacts did NSW Government energy efficiency programs have on energy efficiency of the NSW lighting market?
2. To what extent were these impacts transitory (dependent on continued policy interventions) or transformative (likely to persist after programs ended)?
3. What are the broader energy efficiency policy, operational, and evaluation research implications of these findings?

Research Scope

The findings presented in this report are based on extensive qualitative and quantitative research using a market impact evaluation framework. We considered how the structure, dynamics, and performance of the lighting market influence the adoption of energy efficient technologies and practices. The programs in scope were the ESS, the Energy Efficiency Business Program (EEB) lighting guide, and the Government Resource Efficiency Policy (GREP). We considered market structure in terms of the mainstream and niche roles, interrelationships, segments, routes to market, and business models in the lighting supply chain network. We considered dynamics in terms of the social practices, technology infrastructure inertia, capabilities, opportunities, and motivations that drive and inhibit the adoption of efficient lighting.

Methodology

We undertook desktop research to qualitatively understand the likely baseline structure and dynamics of the lighting market before the ESS. Beletich Associates developed a quantitative model of the stock and sales of lighting products over the last ten years in the commercial, residential, industrial, and public lighting end uses. We developed an integrated theory of change and program logic to develop a series of hypotheses and research questions relating to how NSW Government programs influence the lighting market.

We then conducted thirty interviews with a cross section of mainstream and niche actors encompassing a diverse range of roles across the lighting supply chain. The interview results were used to refine our understanding of baseline market trends and program impacts. We also used the interviews to refine the assumptions and update the model for the quantitative analysis.

Key Findings and Recommendations

The ESS has delivered energy saving lighting retrofits to over 10,000 NSW business sites

This provides \$671 million in economic benefits to all of NSW and a combined \$1.6 billion in avoided energy bill costs for thousands of NSW businesses

From 2011 to 2016, the commercial and industrial lighting upgrades represented 70% of activity under the ESS as a share of energy savings delivered. Over this period, the ESS provided around \$250 million in incentives for energy saving lighting projects, representing around \$600 million in new investment in the NSW economy. These projects replaced over 3.7 million lights with energy saving at over 10,000 sites. This represents approximately 20% of inefficient NSW commercial lighting stock, that has been retired early and replaces with high efficiency alternatives through the ESS.

These projects resulted in around 4.6 million megawatt hours (MWh) of energy savings¹. Using a NSW Treasury approved cost benefit framework, this represents a \$671 million

¹ These savings estimates include discounting that we applied to avoid overstating benefits. Our model conservatively assumes 33% of these upgrades would have happened anyway; however, our qualitative research suggests that actual figure is much lower.

net benefit to all of NSW². This benefit reflects economic benefits of lower electricity prices from avoided and deferred generation and network investment. It also reflects the economic benefits associated with the avoided health and pollution impacts of electricity generation.

Those businesses that took advantage of incentives to upgrade their lighting also saved a combined \$1,633 million on their energy bills. These businesses have been able to improve their productivity through avoided energy waste with the help of the ESS. They are able to reinvest these bill savings in building their businesses, employment or passing on cost savings to their own customers.

Table 1 below shows the split of savings by industry segment.

Table 1: Lighting savings by industry segment

Industry Segment	Energy Savings (MWh)
Residential	6,555
Office	270,960
Non-office Commercial	4,058,350
Public Lighting	-
Industrial	3,889,703
TOTAL	8,225,568

These savings are from helping NSW lead the world in the wide scale adoption of efficient lighting and by continuing to accelerate the retirement of legacy energy wasting technologies

This activity coincided with a once-in-a-generation transformation of the lighting market internationally and in Australia, due to a transition to LEDs as the dominant technology. This activity also coincided with national changes in electricity prices and consumer attitudes, and significant residential and commercial lighting activity under the Victorian Energy Efficiency Target Scheme (VEET).

When lighting upgrades began *en masse* in the ESS in 2011, high efficiency technologies were niche in Australia and internationally. The ESS helped bring high efficiency products to NSW at scale 2 to 3 years before they would have without, leading to likely spill over benefits through the adoption of these technologies in the new-build market outside the

² Public benefit net of program costs, net present value in 2018 Australian dollars

ESS. By 2015, LEDs were well on their way to becoming the dominant global lighting technology for new sales. However, outside the new-build and refurbishment market, inefficient legacy lighting products are largely locked-in until buildings are refurbished (occurring every ten to twenty years, depending on type and sector).

From 2015 through to today, retrofit projects driven by the ESS deliver savings by bringing forward the early retirement of legacy technologies. For most building and lighting types, these projects are brought forward 7 to 10 years earlier they would otherwise occur. An exception is downlights where LED substitutes are rapidly replacing halogen lamps at end of life in the maintenance market, without the need to retrofit existing infrastructure.

The ESS has driven down the cost and improved the quality of LEDs in Australia through new product standards, market competition, and innovation

Niche and mainstream lighting suppliers (including brand managers, wholesalers, electrical contractors, and designers) all pointed to sharp increases in the quality of LEDs in the ESS following reforms in 2014. The vertically integrated Accredited Certificate Providers (ACPs) we interviewed attributed this to both the product testing standards and ESS co-payment requirements, which ensured customer engagement with product quality and warranties.

Beyond this point there was much nuanced and subjective disagreement over what relative quality meant, and it was beyond the scope of this project to assess.

Every lighting supplier we interviewed asserted that their products were superior to their competitors. Mainstream brands asserted that they and their mainstream competitors' products were better than ESS product. However, they noted that ESS product was significantly better than high volumes of the product imported by builders direct from Original Equipment Manufacturers (OEMs).

Mainstream lighting designers we interviewed acknowledged the quality of ESS product in terms of lifetime, lighting output, and efficiency. However, they took issue with the way they had observed that these products were used, when installed without the experience of mainstream lighting designers and specifiers. The vertically integrated high efficiency lighting firms we interviewed argued that customers were satisfied with installation quality and warranties.

The majority of the large lighting wholesalers and contractors we interviewed considered ESS and mainstream product quality to be generally at the same level. Several lighting

wholesalers and national property companies we interviewed went as far as to say that the ESS/VEET schedule had become a national quality standard in the absence of an official Australian standard.

However, efficient lighting is now becoming the norm for new sales and the incremental benefits of retiring legacy technology early will gradually decline over the next decade

When the ESS lighting method was developed in 2009, energy efficiency upgrades and LEDs were incredibly rare. From 2014 onwards, in part thanks to LEDs becoming mainstream, and at current trends, LEDs will eventually replace almost all legacy lighting technologies.

Based on average building refurbishment rates, this means that the vast majority of NSW buildings will eventually be upgraded to LEDs over the next 7 to 15 years (depending on lighting and building type). The ESS can continue to deliver significant public benefits and private bill savings by accelerating the rate at which inefficient legacy technology is retired through retrofits. However, with each year that passes, the period that retrofits are brought forward also diminishes by a year on average.

In the case of downlights, based on current trends, we estimate that this period is closer to 2 to 4 years, because they can and are increasingly likely to be upgraded when bulbs fail, rather than when buildings are refurbished. In part due to the ESS and VEET, there are now low cost, high quality LED substitutes that are increasingly being installed when old bulbs fail. Imports of legacy halogen downlights have fallen by nearly 70% since 2010. Downlights have also had steadily fallen in their significance in the ESS over this period, from a height of 31% of lighting ESC creation in 2011–12, when LED downlights were a niche technology to 5% of lighting ESC creation in 2015–16.

The ESS needs to be updated to reflect these changing market conditions which it has helped bring about. Otherwise, over-incentivising lighting upgrades risks crowding out other energy efficiency savings technologies, and eroding the future economic benefits they could deliver.

The ESS is helping transform market structure and dynamics to drive and potentially extend these outcomes

Before the ESS, there were major structural barriers to the sale and retrofit of energy saving efficiency lighting in NSW

Before the ESS, the mainstream NSW Lighting market had two main segments: the new build and refurbishment segment, and the maintenance segment. The same is generally the case for other markets without energy efficiency schemes. The structure and dynamics of these segments were characterised by significant barriers to the adoption of energy efficient lighting.

Historically, the major brands were resistant to the introduction of LEDs. Initially, LEDs did not perform significantly better than traditional products and so were valued as a low volume, high margin design product. Moreover, LEDs are a very different technology from traditional lighting. They are more closely related to consumer electronic products, with rapid lifecycles driven by chip innovations. They did not fit well with the capabilities, supply chains, and product development cycles of the dominant lighting brands. This can be seen through the restructuring of Australian and global lighting brand management firms following the mainstream emergence of LEDs. An explosion in the number of LED suppliers has also seen many builders bypass mainstream lighting brands and wholesalers to source their own product direct from Original Equipment Manufactures (OEMs).

In the dominant new build and retrofit segment (which is some actors estimated accounts for around 60% of the market value) lighting end-users are typically very removed from decision making. The dominant business models involve major brands designing and selling products through either lighting designers or wholesalers. These in turn work with architects, builders, and electrical contractors to develop and meet the specifications of property developers, as a small component of large building projects. Property developers then typically sell to investors, who lease commercial spaces to the actual lighting users and bill-payers. The decision-makers in these processes are typically focussed on maximising aesthetic values while minimising upfront capital costs. Through no ill-intent, occupant benefits concerning product lifetimes and running costs are far removed from decision-making. There are notable exceptions, particularly when investors are property trusts who are concerned about the NABERS rating of their assets. However, this only applies to base building office lighting for premium and A-grade buildings, and major retail.

In the traditional maintenance segment, lighting users and bill-payers are more closely involved with decision-making around lighting purchases. These transactions typically cover *ad hoc* replacement of failed lamps and ballasts. These decisions are usually made by buildings managers, based on options and advice provided by electrical contractors in consultation with occupants. However, lighting efficiency options are greatly constrained by the types of fittings that are already installed. The notable exception to this is downlights; now, a wide range of high efficiency LEDs can be installed in most downlight fittings.

The ESS has driven commercial innovations that are reshaping the lighting market to overcome these barriers

Our research found a high level of consensus, amongst both mainstream and ESS lighting market actors, that the ESS has driven the emergence of a new and significant market segment in NSW. There was near universal agreement amongst interviewees that before the ESS (and VEET), there was no real market for energy saving lighting retrofits.

The retrofit market is dominated by a small number of new NSW and Victorian firms which were established purely to target the ESS and VEET markets. These firms are vertically integrated, from product design and manufacturing through to sales, installation, and certificate creation. The remainder of ESS activity is spread between smaller certificate aggregators working with lighting suppliers and contractors using a mix of established brands and OEM direct product.

These vertically-integrated firms dominate the ESS-driven retrofit market, and have developed new customer direct business models. These business models involve three main innovations: lower costs through customers cutting out middle men, lower costs through small³ product ranges focussed on energy efficiency and lifetime, and leads generation and sales functions focussed on customers rather than intermediaries. Elements of these models have now begun to be adopted by two mainstream firms we interviewed.

The vast majority of mainstream actors we interviewed concur on the role the ESS has had on the emergence of the retrofit segment. They also noted the very positive impact that the ESS and VEET product approval processes have had on lamp quality since 2014, particularly compared with non-brand imports favoured by builders. However, the mainstream lighting brands and designers emphasised what they believed to be the superiority of their products. They also emphasised what they saw as the importance of

³ One such firm we interviewed had around 30 products compared with 66,000 of a major lighting brand we interviewed.

lighting designers in selecting the right technologies for a space. However, several executives of major lighting firms we interviewed acknowledged that the mainstream market had been slow to understand the significant customer demand for energy saving upgrades.

In contrast, the actors we interviewed in the retrofit market emphasised the different priorities for lighting product and design when end-users were directly involved in decision-making. They emphasised that in contrast to the design-focussed new-build and refurbishment market, end-users were focussed on optimising capital and operating costs while maximising product lifetime and lighting output.

Four of the large ACPs we interviewed reported early stage planning or initial ventures beyond the ESS and lighting. These included initiatives to work in the mainstream lighting market outside the ESS, and in cases outside NSW. One of these companies is already delivering energy efficiency services in South East Asia that were developed under the ESS. It included early stage planning to expand lighting to a range of other energy savings services inside and outside the ESS. All stakeholders interviewed noted the 4 to 5 year timeframes it took to establish their current successful businesses under the ESS. While these platforms would reduce the time required to launch new offerings or transition out of lighting, most companies indicated it would still take 2 to 3 years of business planning to do so.

Investor confidence and regulatory clarity are essential to supporting the competition and innovation behind these transformations

The vertically integrated customer direct firms we interviewed noted that they would not exist without NSW and Victorian Government policy settings. All reported taking 4 to 5 years to develop and refine these now successful business models. They also noted that significant changes to their business models (such as moving beyond lighting or the ESS) would take at least 2 years of planning and implementation. In contrast, changes to product mix would need to account for 2 to 6 month sales cycles (depending on customer type and size).

All of these firms identified four elements of ESS design which were required to make this possible:

- the availability of transparent incentives for energy savings
- the long-term investor certainty provided by ESS targets

- mandatory requirements for customer co-payments in NSW
- product quality approval processes in NSW and Victoria

A key difference between the vertically-integrated certificate creators and some of the pure aggregators was the perspective on certificate values and co-payments. The vertically integrated firms argued that high certificate values were not the primary driver of sales. They saw the ESS incentive as essential to covering the higher cost of establishing customer direct sales models. Incentives also play a crucial role in customer engagement, providing government credibility to claims of energy savings and proving a reason to retrofit now (rather than in the indefinite future). The vertically-integrated firms also saw co-payments as essential to establish market competition based on lighting quality and financial returns. They cited the dominance of poor quality product due to low customer engagement that they argued characterised the giveaway driven markets. This was supported by mainstream lighting firms who noted sharp improvements in ESS product quality post 2014. It also aligns with broader behavioural economics studies.⁴

Other NSW programs may be having more targeted impacts on market structure that we were unable to detect

The GREP program also appears to be driving a material increase in the adoption of energy efficiency lighting by major government agencies. It was not possible within the scope of this research to detect whether GREP or EEB had transformative impacts on underlying market structures and dynamics, due to the relatively small and narrow scope of program participants, and the broad focus of this research.

Energy efficiency policy, operations and evaluation should be adjusted to account for historical and future market transformation

The policy, administration and objectives of the ESS and other energy efficiency programs should systematically pursue market transformation benefit

The transformation of the NSW lighting and energy markets has the potential to drive ongoing lighting retrofits for certain sectors and customer classes, beyond the ESS. There are potential energy market and economic benefits to NSW, from the expansions of NSW-headquartered energy efficiency companies expanding interstate and internationally. The large customer bases and service delivery frameworks established to

⁴ Ariely 2008, *Predictably Irrational*, Dan Ariely, HarperCollins, February 2008, p.54

deliver lighting upgrades in the ESS provide a platform to rapidly scale the delivery of the many other potential cost-effective energy efficiency activities beyond lighting.

However, this market transformation has occurred as much by accident as by design. Market transformation was an explicitly goal of the now completed 2013 NSW Energy Efficiency Action Plan. Market transformation is arguably an implicit goal of the ESS and current proposed Plan to Save NSW Energy and Money. However, these policy frameworks don't explicitly define what market transformation is or how its success will be measured and delivered. For these market transformation objectives to succeed, we strongly recommend that they be codified and systematically monitored and managed as part of energy efficiency program policy, operations and evaluation.

At a policy-level, we recommend that achieving the co-benefits of market transformation be explicitly factored into energy efficiency program objectives, design and enhancements. Operationally, the potential to help and hinder market transformation needs to be considered and codified in the processes for staging and communicating changes to the market. From an evaluation perspective, market transformation objectives, baselines and impacts need to be built into program evaluation, monitoring and reporting frameworks.

In the context of the ESS policy and operations, there are five main areas where codification of market transformation objectives is particularly important:

1. **The timing of regulatory changes needs to align with the timing of the business cycles that those changes hope to constructively influence**, for example:
 - The Scheme's long-term targets and legislative framework are essential to provide the market with the regulatory clarity to invest the many years it takes to develop and refine new products and business models
 - The annual rule change time table provides notice, in-line with the timeframes of sales cycles and supply chains, and is appropriate for modest changes that can be delivered without major changes to business models
 - More than one year's notice is likely to be required for changes that aim to drive new business model innovation or open up new market segments, commensurate with the size of the change required
2. **Government needs to document, communicate and adhere to a clear and consistent policy basis for changes**, for example:

- Amendments to certificate calculation methods should be based on maintaining appropriate and relative accuracy of savings estimates between the different methods
- Cost-effectiveness impacts of certificate prices should be considered through the target-setting and adjustment processes; and the penalty price a safety valve mechanism that ensures certificate prices stay well below cost-effectiveness limits

These principles are not clearly or universally understood by market participants. This could lead to second guessing and feedback loops in policy and market activity, which in turn could cause price volatility. Floating prices are essential to the functioning of the scheme, but short-term volatility due to speculation or confusion can undermine confidence of the ultimate stakeholders – those undertaking energy saving retrofits.

3. **Policy and operational settings need to be adaptively designed and managed based on an understanding of the technology, structure and the dynamics of the entire supply chain network for each market segment a program is impacting.**

For example:

- The positive role mandatory customer co-payment requirements have had in the ESS, due to the behavioural economics of suppliers and customer of lighting upgrades
- The crucial role the post 2014 ESS and VEET lighting processes have had in focusing innovation on product efficiency and quality, in the absence of national standards

These elements should be preserved. Co-payments should be potentially extended to other methods.

4. **Policymakers and the market should take a long-term view of the Scheme's role and potential to grow and breakdown split incentives in other NSW energy services market segments.**

It is important to remember that before 2011, the ESS market was dominated by efficient showerhead retrofits that saved households energy through reduced hot water use. Lighting incentives remained almost dormant until a few companies innovated successful business models, which the rest of the market then copied and refined.

Lighting is but one segment of the energy efficiency market, representing only around 10% of the total savings opportunity. There are significant barriers and unrealised benefits in many other segments. For example: air-conditioning, refrigeration, industrial processes, and smart homes. The customer relationships, business models, capabilities

and business intelligence developed for lighting retrofits can be leveraged for many other savings opportunities.

The potential for certificate prices to rise higher is an essential mechanism to give the market the incentive to invest in new technologies and business models, which once deployed at scaled will drive prices back down.

Energy efficiency policy should include co-ordination with industry productivity, investment, and jobs policy. It should consider both the direct employment and investment potential of the energy services sector. It should also consider the indirect economic and employment benefits from improved business productivity due to reduced energy waste.

There is also an important role for complementary programs such as rating systems and minimum standards for products, home and commercial buildings, and targeted direct purchasing of certificates.

With patience and careful management of ESS policy settings, it is likely the scheme will drive similar levels of supply chain efficiency and product innovation in other energy efficiency segments, as lighting upgrade opportunities diminish.

5. **More data gathering and research be undertaken and published to assist with policy and evaluation.**

This should include ongoing periodic monitoring of the lighting market. Moreover, it should include developing a deeper understanding of other energy services markets. This covers energy efficiency performance, supply chain networks, business models, social network analysis, and market drivers and barriers to energy efficiency. The existing ESS data collected on the activities and savings delivered by the ESS should be made publicly available, to assist the quality and cost of ongoing monitoring and evaluation of the Scheme. This includes de-identified data on post codes, industry types, retrofit activities, cost, and savings.

The current ESS Rule also needs to be updated to reflect the eventual but inevitable upgrade of almost all NSW lighting to LEDs that the ESS has helped bring forward

The current ESS method for calculating savings assumes that without the ESS, the existing lights would not be upgraded to energy efficient alternatives. This was a reasonable assumption when it was developed in 2009, as both energy efficiency retrofits and LEDs were extremely niche. However, this assumption is now plainly out of date, in part due to

the transformation the ESS has helped accelerate. This study has shown, and is supported by international trends, that high efficiency LEDs are now the dominant lighting technology.

For most building and product classes, it is now a matter of time before they are upgraded to LEDs, mostly depending on building refurbishment cycles. The ESS is delivering, and can continue to deliver, significant energy savings by accelerating the rate at which the wasteful legacy lighting technologies are retired. However, these benefits can only reflect the length of time these upgrades are brought forward. At the moment, this period is very close to the 10 years currently deemed by the ESS for most lighting upgrade types. However, with each year that passes, the savings that can be attributed to the ESS will decrease by a year.

In light of this, and the market transformation considerations outlined above, the ESS Rule lighting method needs to be updated as follows:

- a once-off recalibration to bring deeming periods for lighting activities in-line with current trends
- the staggered phase-in of this calibration over two years to provide regulatory transparency for investors and provide time business planning
- amend the lighting method to gradually but automatically reduce deeming each year, to align with business-as-usual refurbishment cycles and to give the market a clear term to start planning for a medium-term transition to new activities

The structure of this report

The rest of the report is structured into 5 Parts:

Part 1 – Policy and research context

Part 2 – Structure of the NSW lighting market

Part 3- Dynamics of the NSW lighting market

Part 4 – Performance of the NSW lighting market

Part 5 – Implications for policy and evaluation research

Part 1

Policy and Research Context

CHAPTER 1

Introduction

1.1. Project Scope and Objectives

This document is the final report of a broad study into the lighting sector and its operation in NSW, in the context of NSW energy efficiency policy. The findings and recommendations from this study will inform evaluation and ongoing policy development of the NSW Energy Efficiency Action Plan (EEAP) and the NSW Energy Savings Scheme (ESS).

This study set out to assist the NSW Office of Environment and Heritage (OEH) in answering three questions:

1. What impacts did NSW Government energy efficiency programs have on energy efficiency of the NSW lighting market?
2. To what extent were these impacts transitory (dependent on continued interventions) or transformative (likely to persist after programs ended)?
3. What are the broader energy efficiency policy, operational, and evaluation research implications of these findings?

The project scope included the following NSW Government programs which are part of the Energy Efficiency Action Plan (EEAP):

- Energy Savings Scheme (ESS)
- Government Resource Efficiency Policy (GREP)
- Energy Efficient Business (EEB information provision and training)

This report documents a market-level theory of change and research for the project, tested through extensive quantitative and qualitative methods. It uses a market impact evaluation (MIE) framework, so as to formulate findings and recommendations relating to these policy questions.

1.2. Project Background

This project builds on previous Common Capital research for OEH to characterise the NSW energy efficiency market and best practice approaches to the evaluation of market

transformation Government programs.⁵ It is focussed on the NSW lighting market, which is one of the most important energy savings opportunities in the NSW context.

In this context, several government programs have focussed on transforming the energy efficiency of the NSW lighting market to capture these savings. This project aims to establish the impact of these interventions on the market.

1.3. Methodology

This study used a range of quantitative and qualitative analytical methods to develop and verify the structure, performance, and dynamics of the NSW lighting market, from which findings, conclusions, and recommendations on the key policy questions were developed. The stages of the study were as follows:

- We undertook desktop research to establish a baseline of the structure and dynamics of the lighting market, and the context for the NSW Government's policies that relate to energy efficient lighting
- Beletich Associates developed a quantitative model of the stock and sales of lighting products over the last ten years in the commercial, residential, industrial, and public lighting end-uses
- We established a conceptual framework for market transformation and tested this against a number of past Government energy initiatives
- We developed an integrated theory of change and program logic to develop a series of hypotheses and research questions relating to how NSW Government programs influence the lighting market
- We conducted thirty interviews with a cross section of mainstream and niche actors that provide a diverse range of roles across the lighting supply chain
- With findings from the stakeholder interviews, we validated the framework to explain the structure of the NSW lighting market, including supply chain networks and interactions

⁵ Common Capital (2014). *Characterising the NSW Energy Efficiency Market*

- We also used the findings from the stakeholder interviews to validate the framework to describe the dynamics of the NSW lighting market
- We then used the findings from the stakeholder interviews, together with quantitative analysis, to report on the performance of the lighting market in NSW
- From this, detailed findings were documented and conclusions reached over the extent to which NSW government policies have influenced the NSW lighting market
- Recommendations were developed on future policy direction and future market impact evaluation

CHAPTER 2

Policy Context

This study aimed to inform evaluation and ongoing policy development of the NSW Energy Efficiency Action Plan (EEAP) and the NSW Energy Savings Scheme (ESS). The EEAP has explicit policy goals to transform the NSW energy efficiency market. Two EEAP programs include the high efficiency lighting market in their scope: the Government Resource Efficiency Policy (GREP), and Energy Efficient Business (EEB). The ESS in particular has supported a significant number of energy saving lighting upgrades.

2.1. Energy Efficiency Action Plan (EEAP)

The EEAP supports goal 5 of the NSW 2021 state plan, which is to place downward pressure on the cost of living. The EEAP supports this goal by establishing programs that intend to contain electricity costs through efficient energy use. This includes a target annual energy savings of 16,000 GWh by 2020 compared to business-as-usual trends.

The EEAP commenced in 2013, building on previous energy efficiency programs to focus on using the market to deliver sustained energy efficiency improvements across NSW. Within the EEAP there are thirty actions in five streams:

1. Strengthening the energy efficiency market – providing information, tools and incentives to address market barriers and support the growth and maturing of the market for energy efficiency products and services
2. Energy efficient homes – make energy efficiency more accessible for households through expansion of activities within the ESS, delivery of targeted programs and development of innovative policy to address market barriers
3. Energy efficient business – working with industry to expand the scope and accelerate the uptake of energy efficiency opportunities, through both the ESS and other market actors
4. Energy efficient government – through the GREP and a range of actions to improve energy management practices and retrofit buildings
5. State-wide delivery – providing access to these initiatives across NSW, recognising that energy costs and market barriers can be greater in regional areas

2.2. Market Transformation in the EEAP Context

A central element of the EEAP is a focus on delivering energy savings through transformation of the energy efficiency market, rather than interventions at a customer-by-customer level.

The energy efficiency market is diffuse and complex. It covers the supply and demand for goods and services that directly provide energy efficiency, as well as energy efficiency as a by-product or characteristic of other goods and services. This concept of an *energy efficiency market* was described by the International Energy Agency in 2013, in the first Energy Efficiency Market Report. Prior to 2013, international research on the energy efficiency market had mostly focussed on tracking the level of investment in energy efficient technologies, and the level of latent demand (technical or economic potential) for further investment to improve energy efficiency.

OEH has developed the EEAP to drive market transformation in NSW, and has based this on the new way of thinking about an energy efficiency market – covering both the capability and capacity of the demand and supply sides of the market, as well as the context in which supply and demand interact and the transactions occur. The EEAP aims to drive growth in both the demand and supply sides of the market, and therefore stimulate the growth of transactions and capability in this market.

The EEAP includes several programs focussed on transforming the lighting market that were included in this project: the Energy Savings Scheme (ESS), the Government Resource Efficiency Policy (GREP), and Energy Efficient Business (EEB). The following sections outline these programs in the context of the lighting market.

2.3. The Energy Saving Scheme (ESS)

The ESS creates incentives and provides a mechanism for financing and delivery of energy efficiency improvements. It is both a key program for the NSW Government and a facilitation mechanism for realising many of the actions set out in the EEAP. The ESS supports a range of energy saving activities in homes and businesses. The EEAP is working to expand both the range of activities within the ESS and the uptake of these activities by both the supply and demand sides of the market.

Since 2010, the vast majority of ESS subsidies have gone towards commercial and industrial lighting upgrades. If the ESS has performed as designed, these projects should

have delivered significant energy savings through upgrades that are additional to a base case (without the ESS).

Prior to this study, there was also anecdotal evidence from ESS stakeholders to suggest that the ESS has helped accelerate the mass adoption of LED lighting technology in NSW. However, no empirical studies had yet been undertaken to understand the actual savings delivered or qualitative impacts that the ESS is having on the lighting market in NSW. This study begins to answer these questions.

This study includes analysis to both understand the historical performance of the ESS, and to inform the appropriateness of continued subsidies for lighting. This analysis considered free riding (i.e., projects that received funding but would have happened anyway), and spill-over (i.e., projects that did not receive funding but happened due to market changes catalysed by the ESS).

2.4. The Government Resource Efficiency Policy (GREP)

The GREP was introduced in 2014 to reduce the NSW Government's operating costs and lead by example in increasing the efficiency of the resources it uses. It requires government agencies to implement energy efficiency projects at sites representing 90% of their billed energy use by 2023/24, with interim targets of 55% for Health and 45% for other NSW agencies by the end of 2017/18. The policy includes support and finance for the identification and implementation of energy efficiency upgrades.

While there are few public reports on actions taken under the GREP to date, those that exist show that agencies are undertaking lighting projects as part of this policy. For example, the Roads and Maritime Service reported that lighting comprises 13% of their energy use, and identified street lighting and traffic signal lighting as opportunities for energy savings.

Alongside the general requirement to implement energy efficiency projects, the GREP requires agencies to meet minimum lighting energy efficiency standards in office tenancies.

2.5. Energy Efficient Business (EEB)

The EEB provides support for businesses to identify, implement, and verify energy saving actions. The program targets priority sectors and technologies, and produces case studies and guides to support broader adoption of energy saving actions in the broader market.

Energy efficient lighting has been a priority technology, and OEH has developed a range of materials to support the adoption of energy efficient lighting through the EEB program, including:

- a detailed technology report
- simple factsheets on efficient lighting opportunities
- an online calculator designed to help businesses identify energy efficient lighting opportunities and compare them by cost, energy savings, and financial payback
- a two-day energy efficient lighting training course to help businesses decide on the best energy efficient lighting options for their organisation
- up to \$3000 worth of expert guidance to help people that have completed the energy efficient lighting training to implement opportunities after completing the course

CHAPTER 3

Market Transformation

3.1. What is Market Transformation?

Seeking a standard by which to judge market interventions in a regulatory environment, the University of California Berkeley pioneered studies into the transformation of the energy efficiency market in 1996.⁶ They defined market transformation as:

A reduction in market barriers due to a market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced or changed.

Market transformation is the lasting change induced by a market intervention. It is evidenced by market effects, which are increases in the adoption of energy efficiency products, services, or practices due to the market intervention. In a transformed market, market effects continue after the intervention is withdrawn.

3.2. Why Seek Market Transformation?

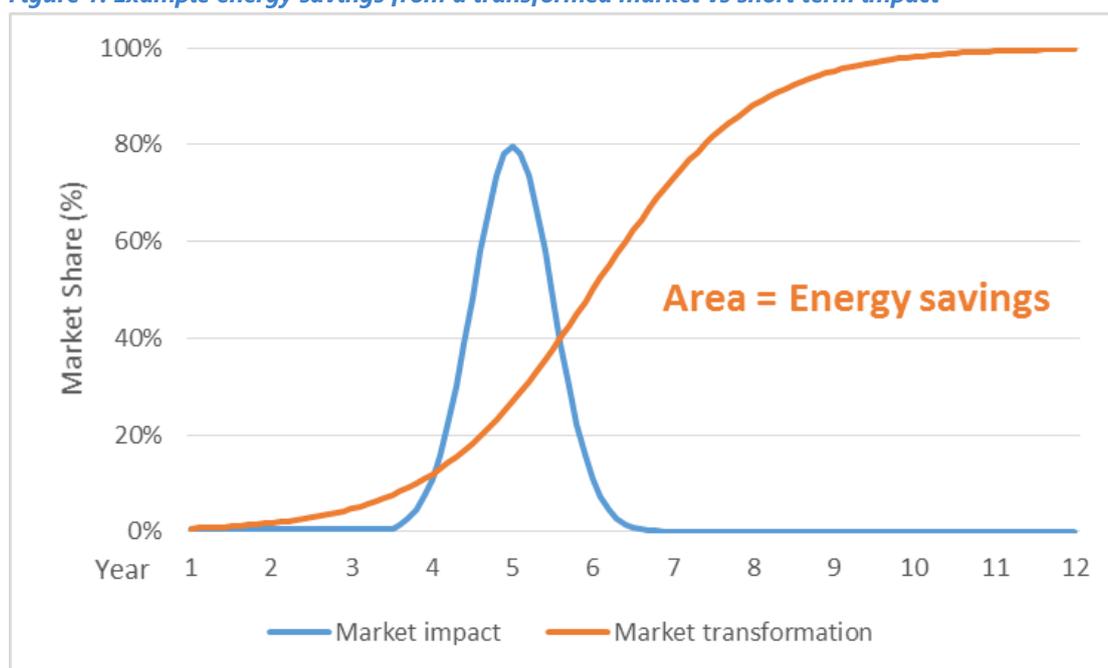
Market transformation is a desirable effect for government programs. Clearly, government interventions that induce a lasting change in the market even after the intervention is withdrawn are preferable to temporary solutions.

The NSW EEAP notes that government programs that lead to a transformed market benefit all energy customers, even those that do not directly participate in the government programs, through lower costs for high efficiency products and services. The plan includes an action to identify pathways for market transformation for the energy efficiency market.

Interventions that lead to a transformed market can deliver far greater outcomes at a lower cost to government. In many cases, government interventions can deliver significant energy savings through market effects that do not persist beyond the intervention. For example, product subsidies may drive a short-term increase in adoption of that product that is not maintained when the subsidy ends. Energy savings persist in a transformed market after the government intervention is withdrawn, leading to longer term savings in the market beyond the life of government investment. This cumulative benefit is demonstrated in Figure 1.

⁶ Eto et al. (1996)

Figure 1: Example energy savings from a transformed market vs short term impact



The blue line in this figure shows a significant, short term market effect arising from a government intervention. The government intervention is withdrawn in year 5, and the market promptly returns to the base case. In this instance, there are no ongoing energy savings, and the total benefit from the government intervention (represented by the area under the curve) is relatively small. In contrast, the orange line shows a transformed market in which the market effect is persistent. In this transformed market, the market has permanently shifted, and energy savings continue beyond the removal of the intervention.

The short-term market effect shown is typical of a *boom-bust intervention*, in which new providers have entered the market to take advantage of the government intervention, only to exit the market once the intervention ends. Several recent energy savings programs have demonstrated this effect.

The following section discusses market transformation in the context of a number of Australian government policy initiatives.

3.3. Case Studies

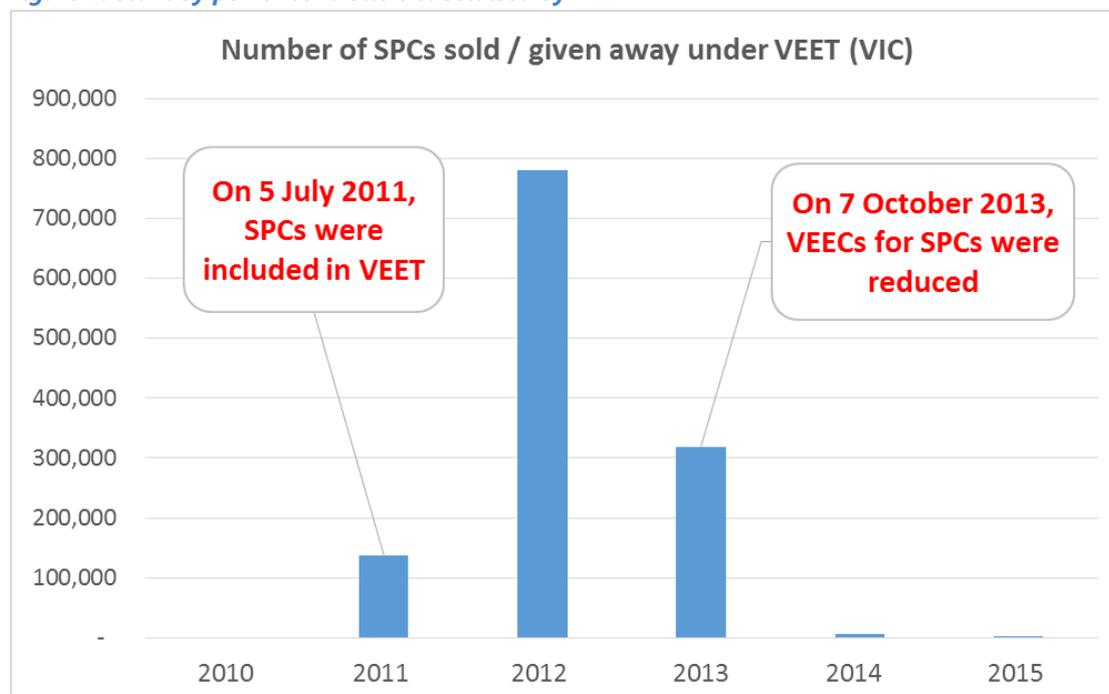
Standby Power Controllers

Standby power controllers were included in the Victorian Energy Efficiency Target (VEET) scheme on 5 July 2011. When originally introduced, the subsidies provided matched or

exceed the cost of purchase and installation. This meant that providers were able to sell the controllers at a very low cost, or give them away to householders.

Figure 2 shows the adoption rate of standby controllers in the VEET scheme.

Figure 2: Standby power controllers subsidised by VEET



Source: Energy Efficient strategies

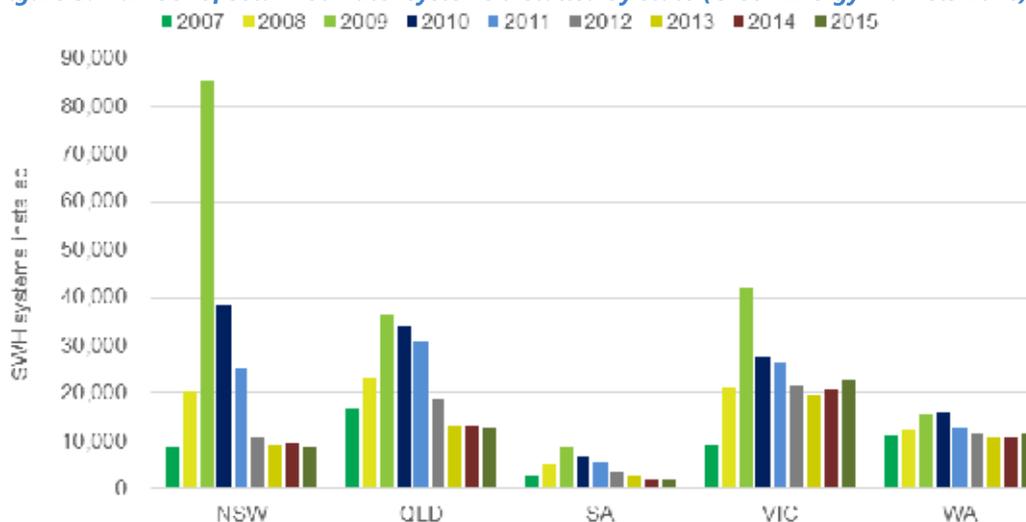
This chart shows the installation rates of SPCs takes the shape of the boom-bust cycle depicted in Figure 1. From the introduction of subsidies in 2011, more than a million standby power controllers were installed on the basis of VEET in just over two years. Once the subsidy available from VEET was reduced in 2013 (below the point that give-way programs were uneconomic), the market swiftly dropped away. A more comprehensive study would be required to be certain, but in this example it appears that the government intervention may have resulted in an impact as intended. However, the near cessation of activity once the intervention was reduced, suggests the additional benefits from a transformed market do not appear to have occurred.

Solar Hot Water

Figure 3 below shows the same short-term market effect in the solar hot water industry across Australia. Government interventions in the solar hot water industry include Renewable Energy Certificates (RECs), which reduce the up-front cost of the system, and,

between 2007 and 2012, rebates that increase this up-front subsidy.⁷ NSW had the most generous rebate scheme, investing \$160 million through the Home Saver Rebates program between 2007 and 2011. The market effect induced by these interventions is shown below.

Figure 3: Number of solar hot water systems installed by state (Green Energy Markets 2016)



The effect of rebates in NSW was very significant in the short term. The combined subsidy available through RECs, Commonwealth, and state government rebates led to a very large spike in solar hot water installations in 2009. The NSW rebate was reduced from \$1200 to \$300 on 1 January 2010, and the Commonwealth rebate reduced from \$1600 to \$1000 in February 2010. Figure 3 clearly shows a large market effect in 2009, with the market growing from 20,000 to 80,000 installations. The market effect halved after reduction of subsidies in 2010, and returned to the pre-subsidy levels immediately after the rebates were withdrawn in 2012.

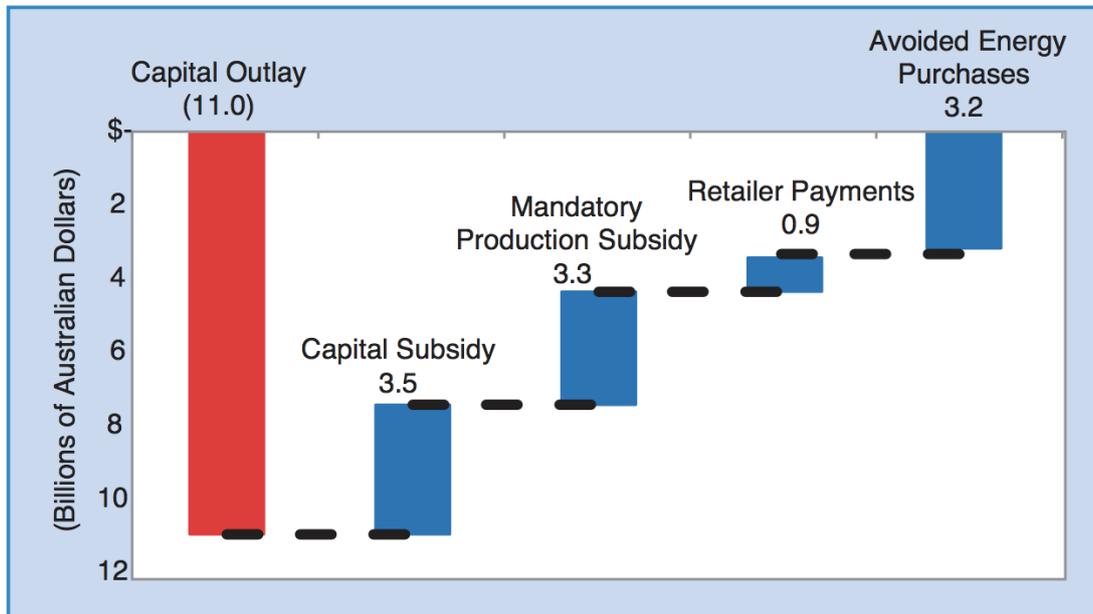
Solar Photovoltaics

Conversely, the market transformation is apparent in the solar photovoltaic (PV) market for households. Commonwealth, state and territory governments have made significant interventions to drive the uptake of solar PV. This has included capital subsidies under the Renewable Energy Target and rebate programs, and production subsidies under state-based feed in tariffs. As Figure 4 below illustrates, the combined value of these subsidies has been estimated at \$6.8 billion in 2015.⁸

⁷ Urbis (2012)

⁸ Mountain & Szuster (2015) *Solar, Solar Everywhere*, IE Power and Energy magazine, Jul/Aug; P57

Figure 4: Discounted present value (to households) of their investment in PVs (in billions of Australian dollars)

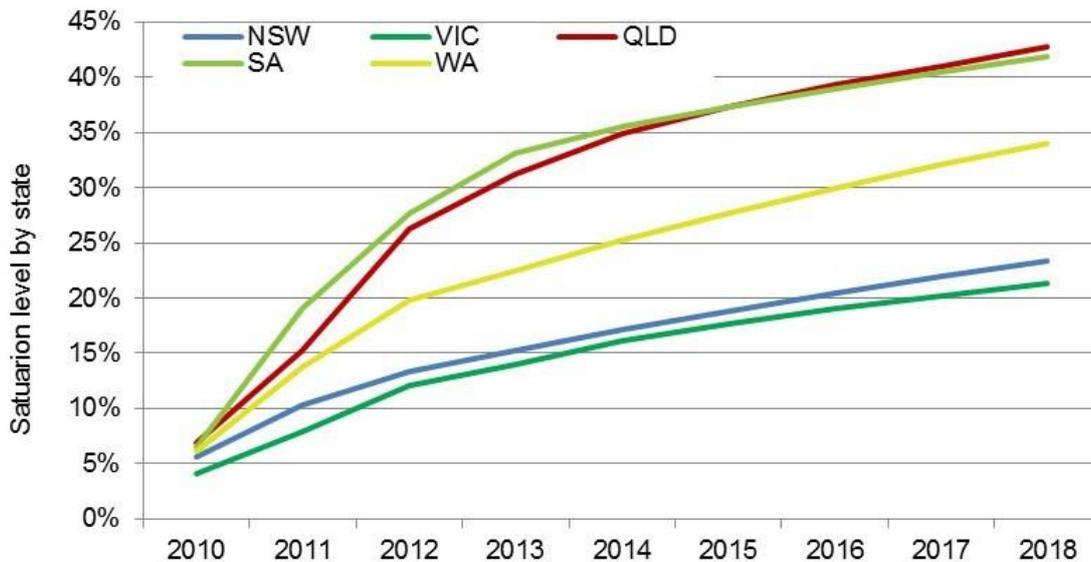


Source: Mountain & Szuster⁹

State-based feed in tariffs have been removed and the renewable energy target subsidies are now being steadily reduced each year. As Figure 5 shows, the increasing uptake of solar PV is forecasted to continue in each state.

⁹ Mountain & Szuster (2015)

Figure 5: Solar PV saturation level by state



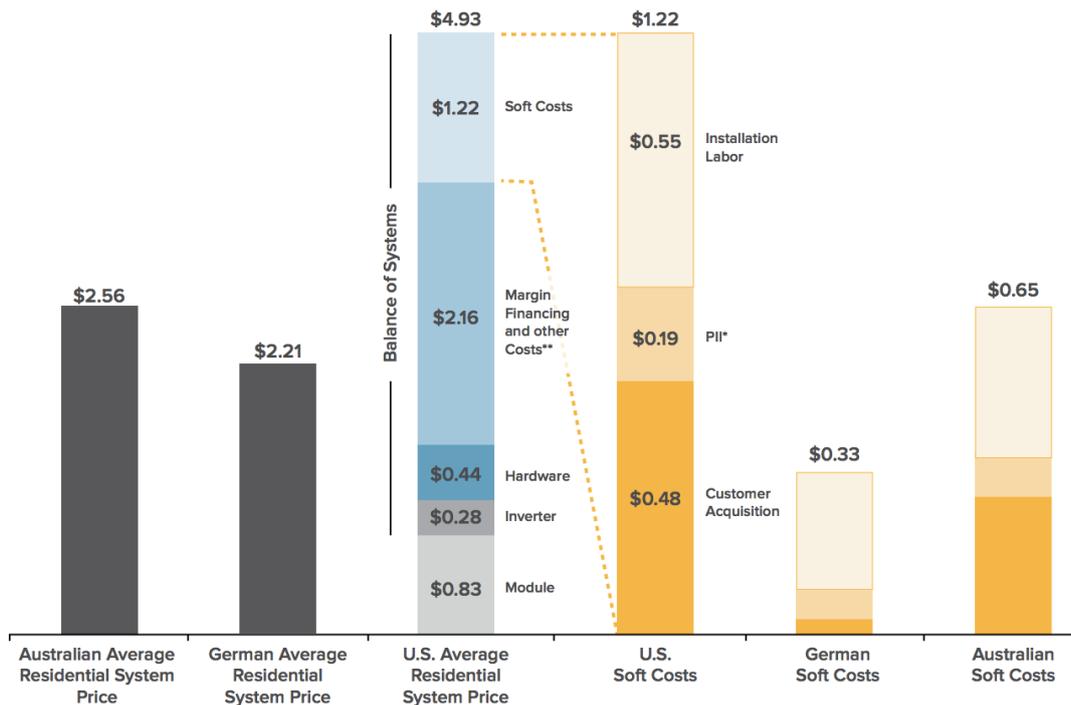
Source: Green Energy Markets¹⁰

This steady increase in uptake is in stark contrast to the boom-bust cycles seen for standby power controllers and solar water heaters. Not only has uptake continued, but the underlying structures of the market have been markedly transformed.

As Figure 6 illustrates, the Rocky Mountain Institute has found the cost of solar PV in Australia has been reduced dramatically below international levels. This reduction is beyond the significant international falls that have been seen on panel prices. The study found that a combination of process improvements and economies of scale through market saturation have seen the non-panel “soft costs” dramatically reduced.

Figure 6: Residential PV *Soft Costs in the US vs. Australia

¹⁰ Green Energy Markets (2016) *Small-scale technology certificates Data modelling for 2016 to 2018- Report to the Clean Energy Regulator*; P. 21
<http://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/Green%20Energy%20Markets%20-%20February%202016.docx>



* Permitting, inspection, and interconnection costs

** Includes installer and integrator margin, legal fees, professional fees, financing transactional costs, O+M costs, production guarantees, reserves, and warranty costs.

Source: Adapted from Rocky Mountain Institute (2014)¹¹

In this way, the solar PV market can be considered an example of a market that has been transformed following the introduction and reduction of Government policy interventions. Further analysis would be required to empirically demonstrate the extent to which this transformation can be attributed to the interventions, but such analysis is out of scope for this study. However, this provides a useful example for considering what a transformed lighting market may look like.

3.4. Approaches to Understanding Market Transformation

There is a range of theoretical frameworks for the analysis, understanding and evaluation of market transformation. These theories and concepts include Systems Innovation

¹¹Rocky Mountain Institute (2014) *Lessons from Australia: Reducing Solar PV Costs Through Installation Labor Efficiency*; P.4

Transitions (SIT) theory, multi-level perspective (MLP)¹², COM-B (Capability Opportunity Motivation – Behaviour)¹³, and others.

The traditional model to understand a changing market is to measure innovation diffusion, a model that has been critiqued as unrealistically linear. In this model, the innovation process is viewed as a relatively simple, one-directional process from “invention to commercial development to diffusion into the market place.” Twomey & Gaziulusoy argue that in practice, diffusion and innovation involve loops and feedbacks.¹⁴

More recent models understand that market transformation is more involved than this simple linear process. These approaches reflect the importance of networks, institutions, social practices, and business strategies in driving change.

The SIT approach combines an innovation systems approach, which analyses innovation in the context of an entire system, with the socio-technical transitions approach, which analyses innovation in the context of transformative societal processes.

Innovation Systems (IS) theory suggests that technologies, actors, and institutions are mutually dependent, and need to be analysed together to understand innovation and market change. When applied to a technology such as lighting, IS analysis considers the actors, institutions, and infrastructures involved in the supply, diffusion, and use of that technology. This approach has been criticised for being too heavily focussed on supply side concerns and dominant actors, and neglecting demand side forces, smaller actors, and disruptive technologies.¹⁵

The socio-technical transitions approach takes a broader perspective for analysing system innovation. The best example of this approach is the MLP, which considers broad societal processes, and understands market change using a three-layered perspective: the landscape (macro) level of cultural, economic, and political factors; the regime level of the prevailing practices and rules driving behaviours; and the niche (micro) level of individual behaviours and innovations to challenge the prevailing regime.¹⁶

This approach allows for a nuanced view of market transformation to reflect the interactions and context for market change. However, there are limitations. MLP works

¹² Twomey & Gaziulusoy (2014). *Review of System Innovation and Transitions Theories Concepts and frameworks for understanding and enabling transitions to a low carbon built environment*; CRC for Low Carbon Living

¹³ Michie, van Stralen, and West (2011). *The behaviour change wheel: A new method for characterising and designing behaviour change interventions*. Implementation Science.

¹⁴ Twomey & Gaziulusoy (2014)

¹⁵ Ibid

¹⁶ Ibid

best with markets for a single product, in which the levels can be identified and classified. The NSW lighting market is a complex market, with multiple product classes and actors that cannot be classified as purely *niche* or *regime*. This raises analytical challenges for an MLP approach.

For this study we adapted a simplified SIT methodology, as it can capture broad concepts (such as supply chain networks) and incorporate other methodologies.

We have also incorporated elements of the COM-B framework to better categorise the theory of change for individual actors. Details of this framework are described in Section 12.1.

The COM-B model has been shown to be effective at the individual level, and has been used in the UK to analyse behaviour change from direct actions including tobacco control and obesity programs. In the context of this analysis, one can broadly categorise how the NSW programs may be influencing actors, but it is important to note that the forces acting within businesses in an economic market are much broader and more complex than those in individual decision making. For this reason, COM-B should be treated as a guide within the broader market analysis.

3.5. The NSW Lighting Market

This study considers the concepts of market transformation in the context of the NSW lighting market and NSW government energy efficiency policies.

The NSW lighting market includes lighting-related goods and services, and consists of four broad segments:

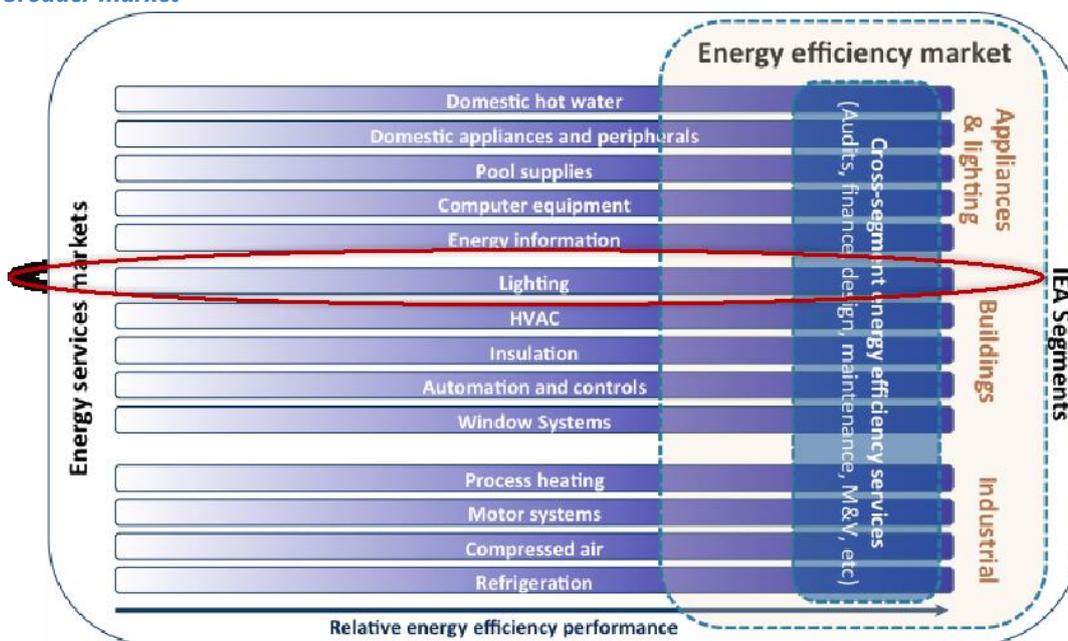
- Residential – including lighting for both detached and multi-dwelling buildings
- Commercial – lighting for businesses in a variety of settings, including retail and offices
- Industrial – lighting for industrial sites such as factories
- Public – lighting in public spaces, primarily street lighting

A complex supply chain network delivers lighting products from manufacturers to their final customers. The main roles in this network are manufacturers, brand managers, distributors, retailers, specifiers, certificate aggregators, electrical contractors, developers, property owners/managers, and end users. The market comprises over 800 companies with very different business structures and varying degrees of vertical integration.

The high efficiency end of the NSW lighting market is a key component of the broader NSW energy efficiency market, and is a target for NSW Government market transformation policies. Our previous report, *Characterising the NSW Energy Efficiency Market*¹⁷, noted that the NSW energy efficiency market is diffuse, and includes the delivery of energy efficient products through a broader range of end-use energy goods and services markets. These markets include products that directly consume energy (such as lighting), as well as products that can passively influence energy consumption (such as insulation).

An overview of the NSW energy efficiency market and its segments is illustrated in Figure 7 below.

Figure 7: Major and minor segments of the NSW energy efficiency market showing lighting as a part of the broader market¹⁸



Parts 2 and 3 of this report describe the structure and dynamics for the NSW lighting market in greater detail.

¹⁷ Common Capital (2014), *Characterising the NSW Energy Efficiency Market*

¹⁸ Ibid

CHAPTER 4

Policy Framework for Lighting Market Transformation

4.1. What is a Theory of Change and a Program Logic?

A *program logic* describes how a program is intended to work. It links program activities to the program aims and intended outcomes.¹⁹ The program logic explains how the program will result in an improvement to the policy problem that the program is trying to address. A program logic approach tends to take a linear view of the change that will theoretically arise from a particular program.

A *theory of change* similarly seeks to link program activities to intended outcomes, focussing on the causal mechanisms that will bring them into effect. The theory of change “maps out the logical sequence of changes that are anticipated as being necessary amongst stakeholders and in the contextual conditions to support the desired long-term change.”²⁰

The primary difference between the two approaches is that a theory of change approach requires justification of the causal link of each step in the process; it arguably focuses more on *why* a change will occur, not just *how*. The theory of change also maps out all the possible pathways that might lead to the desired outcome, including those that are not related to the program.

Both these models are useful in understanding how a program intends to drive market change, and form an important part of program evaluation. However, care needs to be taken when using either of these models to measure the success of a program. Neither program logic or theory of change models are deterministic, and the causal links driving the models are rarely proven. Once the model is documented, we should not assume that it accurately reflects the overall impacts of a program. In particular, evaluations should not be based solely on the outputs of a program (such as the number of ESCs created, subsidies granted, or training courses delivered), and an assumption that these outputs caused market-level outcomes, simply because that’s what the model suggested.

Program logic and theory of change models are an important component of good program design and evaluation. They form a hypothesis of what will happen, and why, as

¹⁹ NSW Evaluation Toolkit (2016)

²⁰ ESPA (2016)

a result of a particular set of government interventions. For evaluation and continuous improvement in policy implementation, it is good practice to continually test and validate these hypotheses, and to identify and implement changes to both the theory of change for the program, and the program itself, to bring about the desired outcomes.

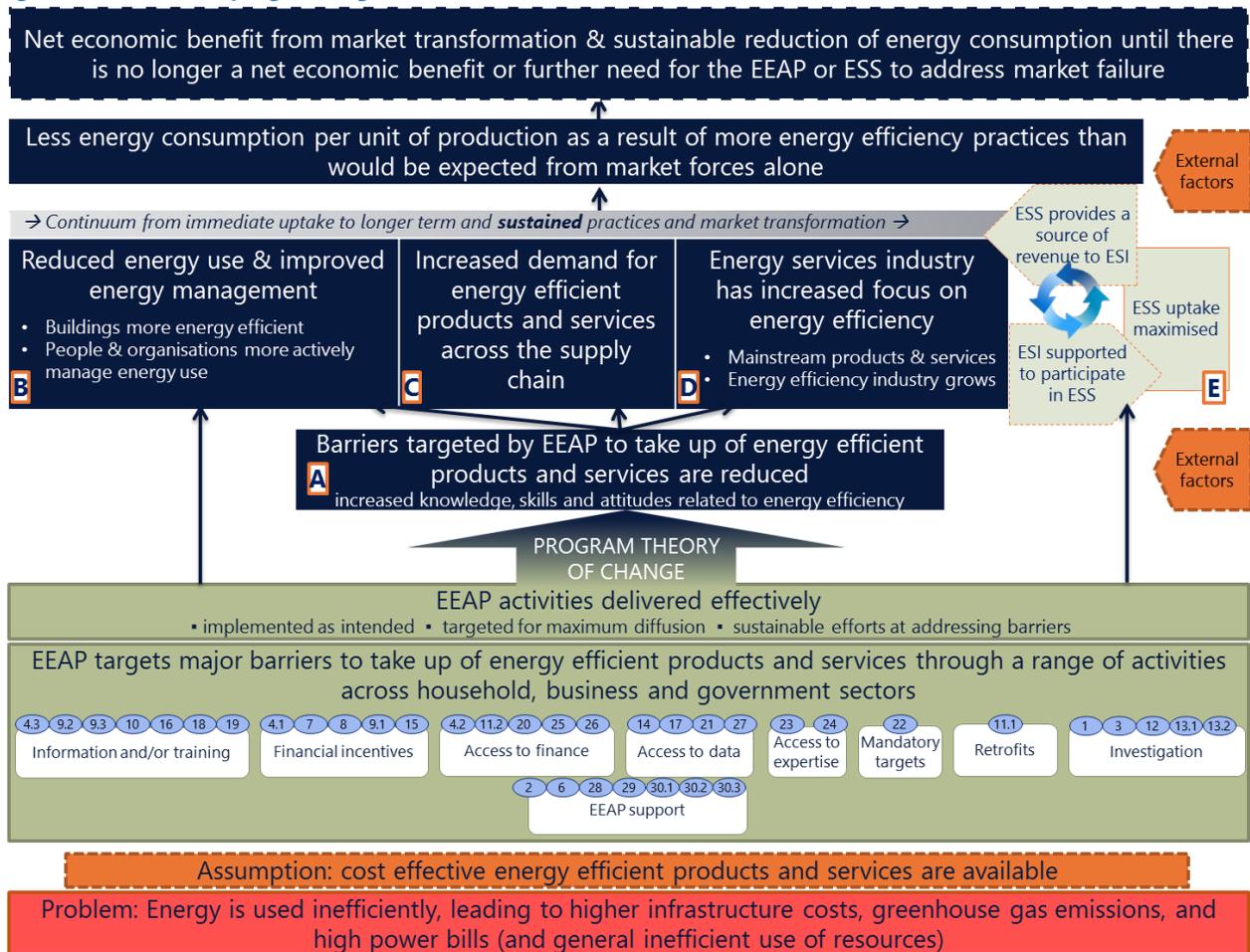
This study used a program logic and theory of change approach to develop hypotheses and research questions that shaped subsequent qualitative and quantitative research stages.

4.2. EEAP Program Logic and Theory of Change

At present, there is not a formal program logic or theory of change for the EEAP from which we can adapt a lighting market specific framework. The closest that exists is a draft theory of change developed for the EEAP Evaluation²¹, which is shown as Figure 8 below.

²¹ ARTD (2016) "Draft formative evaluation", *Evaluating the NSW Energy Efficiency Action Plan*, OEH – Unpublished

Figure 8: Draft EEAP program logic



This draft program logic takes a simplistic view of the energy efficiency market, with no differentiation between actors in the market or understanding of the systems in which they act. The basic logic states that energy efficient products exist, but that market failures prevent their adoption by the market, such as information gaps, lack of skills and time, data as a public good, split incentives, and high upfront costs for high-efficiency products and services.

The theory suggests that the EEAP addresses these market barriers through a combination of financial support, information support (such as access to data, training, and facilitated access to experts), and government demanding energy services as a user.

This program logic is incomplete and unclear, and does not address the complexity of the energy efficiency market stemming from the multitude of actors, institutions, and systems that determine the operation of the market. This program logic groups all programs and

issues together, and does not explain either the effect of these programs or the causal link between the program outputs and higher-level objectives. The program logic lacks a clear understanding of how each intervention will actually work; there is no detail of what programs actually do, or a theory of how these will drive any market change.

Clearly, a new framework is needed to understand how the NSW energy efficient lighting market works, and the extent to which NSW Government programs have changed this market.

4.3. An Integrated Approach to Program Logic and Market Transformation

A new approach to program logic and theory of change is required to analyse the impact of the ESS and EEAP programs on the lighting market. We have developed such a framework, based on OEH's preferred template for outcomes hierarchy, but also incorporating analysis of the direct and indirect impacts of actors in the market. This framework draws on a simplified approach to COM-B to understand the nature of the impacts. It also draws on the a simplified MLP framework to understand how these impacts vary by niche energy efficiency actors versus mass market regime actors. Seen as a whole, this hierarchy shows the various drivers and barriers a program has on a market, from a landscape perspective.

We have applied this framework to develop hypotheses about the impacts of the ESS, GREP, and EEB programs on the efficiency of the NSW lighting market. Each of the following sections provides a diagram that visually represents the anticipated impacts of each program on actors, and an explanation of how these forces combine at a landscape (or market-wide) level. Each diagram reads from bottom to top, with the scheme inputs, activities, and outputs at the bottom, moving through a series of intermediate outcomes until the final outcome of energy savings is achieved.

We have also identified secondary activities that may have impacts on the market, which are worthy of investigation through the subsequent project research phases. The program logic then looks at the immediate outcomes of these activities, in terms of the impacts on actors that are directly affected. It also looks at the outcomes on other actors as a result of the actions taken by the actors who were directly impacted.

Each diagram incorporates elements of the COM-B and MLP frameworks for analysis. COM-B allows us to broadly see what the key influence on each actor may be, whether it is increasing their capability (for example, through enhanced understanding of HE lighting products), increasing their opportunity (by creating opportunities to sell or install lights that may not have existed without the EEAP programs), or motivating them to act (for example, through financial incentives). However, there are limitations in applying the COM-B framework, which has primarily been developed to look at behaviour change programs targeting specific actions and individuals, to an economic market, where the scale of the participants and influences upon them are much larger and more diverse. In our context, COM-B provides us with a guide to describe what may be happening to each actor, but is by no means a complete analysis tool.

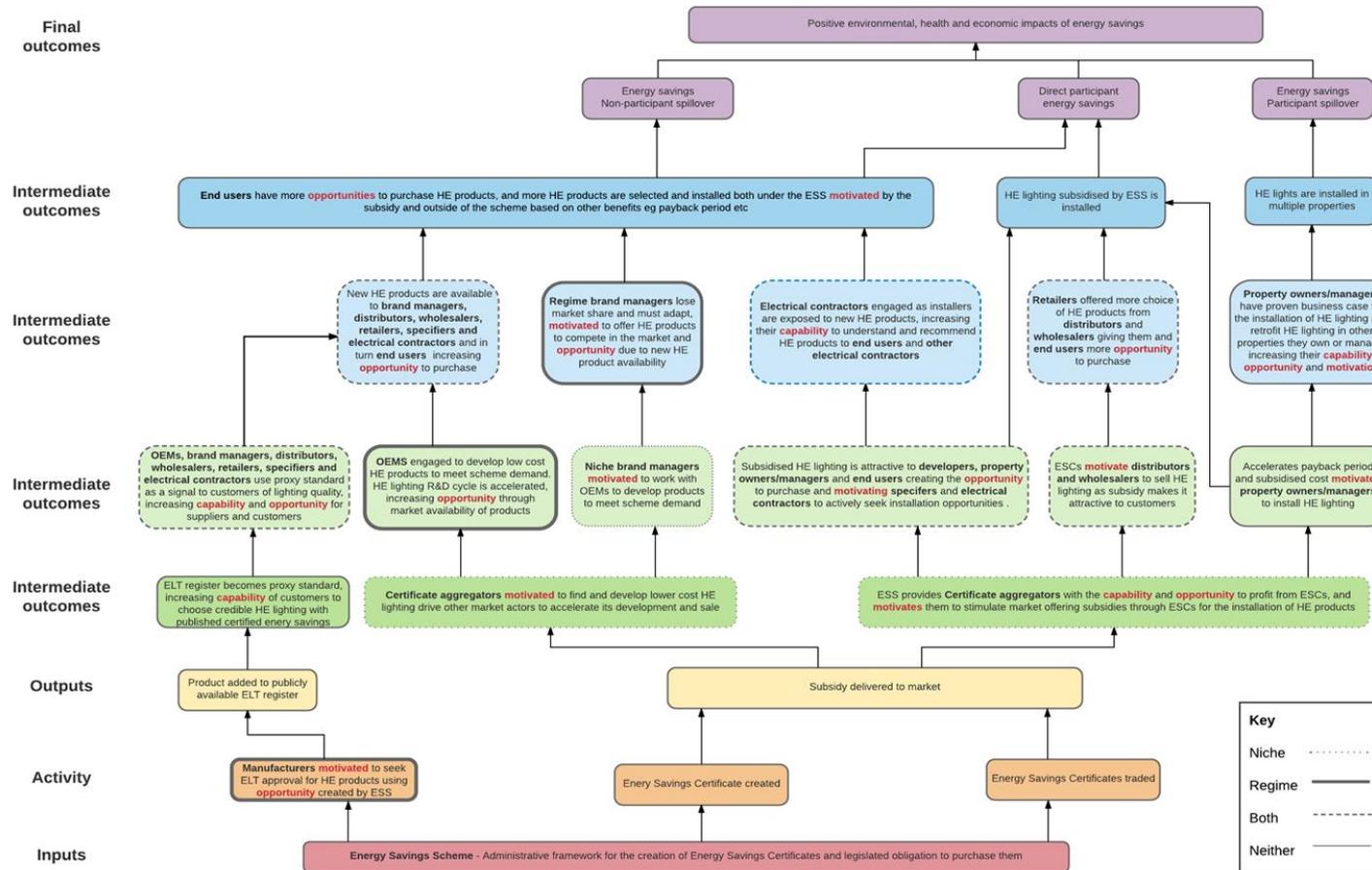
Similarly, MLP theory provides us with language to describe the bigger picture: are the actors participating in our schemes niche or regime, and how do they collectively create the NSW lighting market landscape? Answering these questions is critical in order for our research to determine how these influences are transforming this landscape, if at all. Each program outcome within the diagrams is categorised as either niche, regime, both, or neither, depending on the actors within it.

4.4. The Expected Impacts of the ESS on the Lighting Market

As a market-based policy mechanism, the ESS potentially has a broad range of direct and indirect impacts on actors through the lighting market supply chain. The ESS program logic, shown in Figure 9 below, is a high-level overview of how the ESS may be influencing key actors in the NSW lighting market. It explores how niche actors involved in the ESS may drive HE lighting development and sales influencing the regime actors and in turn transforming the market landscape.

The ESS program logic provides us with a starting point to explore the NSW lighting market in relation to the ESS. It will be informed and developed by the future stages of this research project, including the full analysis of the actors in the market, quantitative analysis of the market, and the interviews with key market actors.

Figure 9: ESS program logic



Broadly, the program logic shows that the ESS is affecting the market at a landscape level in three key ways. Firstly, certificate trading is influencing both the supply and demand sides of the HE lighting market. The subsidy makes the lights an attractive, low risk option for customers, and drives actors involved in the installation of lighting and sale of certificates to actively seek installation opportunities, rather than wait for customer demand.

Secondly, the ESS creates a legislated demand for HE lighting, driving niche market actors to develop product to meet this demand, accelerating the R&D cycle and the availability of new HE products to the market as a whole.

Thirdly, and in parallel, the market adoption of the ELT approval for HE lights as a proxy for another standard is also increasing the profile and availability of credible HE lighting to actors throughout the supply chain, and therefore end users.

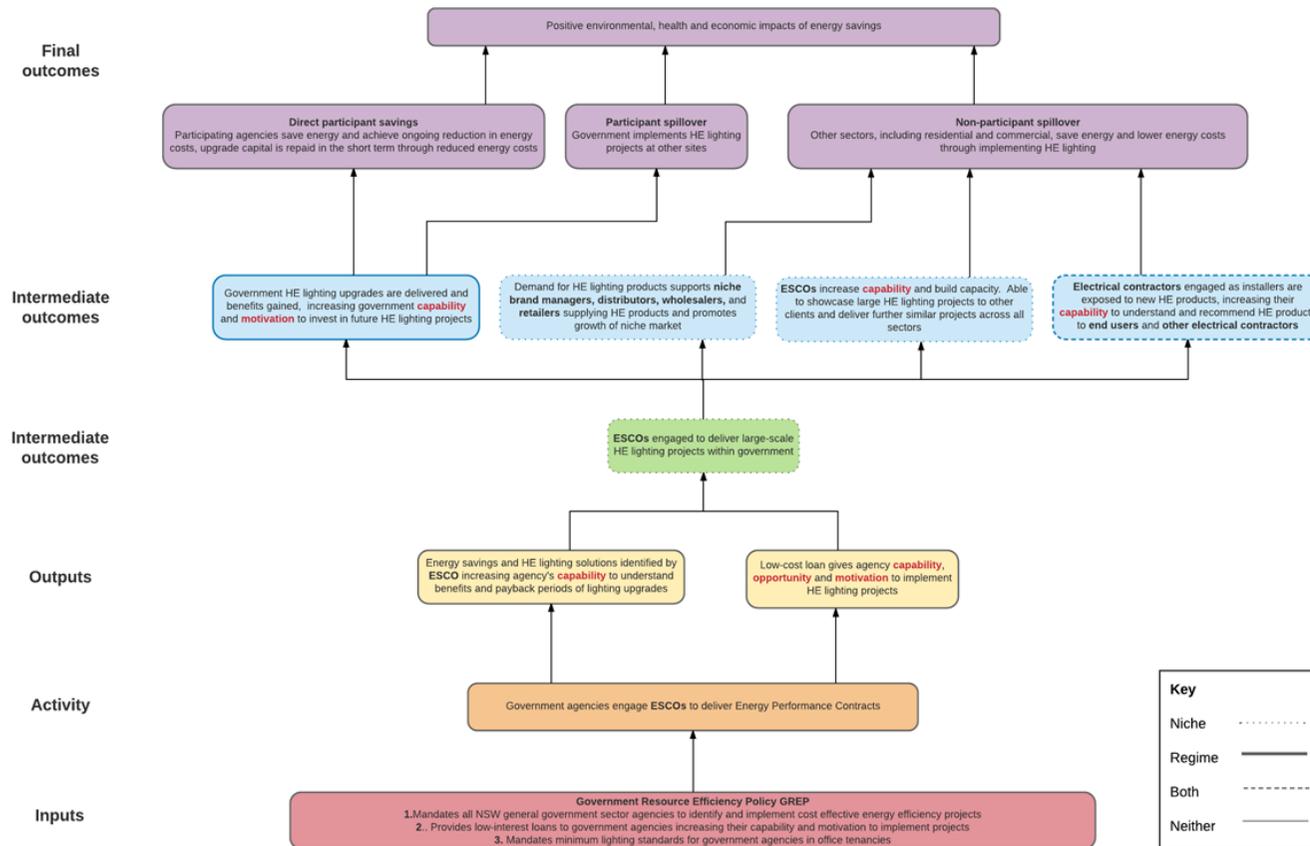
The program ultimately achieves three outcomes: direct energy savings for ESS participants, spill-over energy savings for participants (where the scheme has motivated them to implement other lighting projects outside of the scheme), and non-participant spill-over (where the ESS influence on the market, e.g. as a driver for OEMs developing new low cost HE lighting, is diffusing through the market and leading to the adoption of HE lighting by end users outside of the ESS).

4.5. The Expected Impacts of the GREP on the Lighting Market

Compared with the ESS, GREP is a much simpler program, as only a small number of actors are directly involved in large projects. However, as set out below, there is theoretical potential for these interventions to have indirect flow-on impacts on other actors in the market.

The GREP program logic (Figure 10 below) shows that while the program may be comparable to the ESS in terms of investment, its impact on the lighting market is much smaller, with a small number of large-scale projects affecting a small number of niche actors.

Figure 10: GREP program logic



The diagram shows that the GREP's chief influence is adding credibility to the benefits of high efficiency lighting within government, through mandating energy savings for government agencies, promoting energy performance contracting, and increasing the capability of agencies to achieve these savings through the low-cost loan availability. The GREP's key outcome is direct energy savings within government.

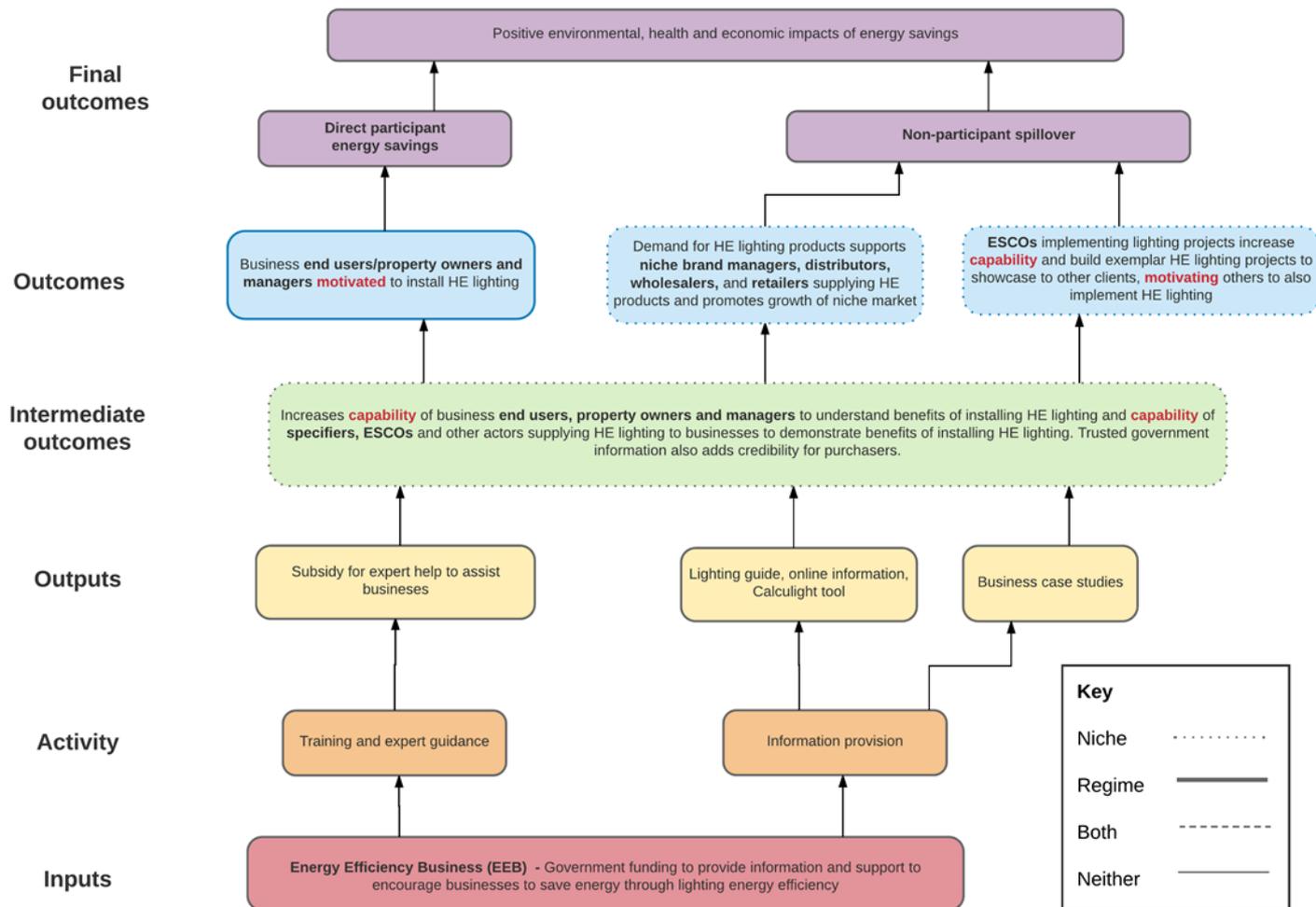
GREP's impact on the broader lighting market is mainly through the opportunity it provides Energy Service Companies (ESCOs) to deliver large-scale HE lighting projects, increasing their expertise and experience. ESCOs are then able to showcase these proven case studies to other clients, motivating them to also implement HE lighting upgrades.

Demand for high quality HE lighting to fulfil the government projects may increase sales for the niche suppliers of HE lighting, which, depending on the size of the contracts and the size of the business supplying the products, may or may not be significant.

4.6. The Expected Impacts of EEB on the Lighting Market

The Energy Efficient Business (EEB) program is primarily focussed on providing information and advice to businesses, in order to remove the knowledge gaps that may be a barrier to implementing HE lighting upgrades. Information is provided online, including a downloadable lighting guide, an online lighting calculator, and business case studies, with additional support available through training and expert advice.

Figure 11: EEB program logic



The EEB program logic (Figure 11 above) shows that the main and intended outcome is that businesses are motivated to install HE lighting; however, it is likely to have very limited market diffusion, due to its size and the small number of actors in the supply chain involved. Similar to GREP, it may influence some niche actors, but it unlikely to be transformative in this market.

4.7. Research Questions and Hypotheses

This study used the program logics described in Sections 4.4 through 4.6 to develop hypotheses for the market impacts of the programs to be analysed, as well as research questions to test these hypotheses. The hypotheses were used to inform questions in the interview phase of the study, and were incorporated into structured interview guides for each role in the market. The hypotheses for actors, categorised by the major roles played in the lighting market, are set out in Table 2 below. These roles are described in Chapter 7.

Table 2: Key program logic hypotheses for actors

Role	Hypotheses
All Roles	<ul style="list-style-type: none"> <li data-bbox="614 1144 1406 1227">• Awareness of ESS, GREP, and EEB will be limited to a very small number of niche actors <li data-bbox="614 1283 1406 1462">• Other actors may have no knowledge of the scheme, and no awareness of potential market diffusion caused by it (e.g. increased supply of HE lighting products)
OEMs	<ul style="list-style-type: none"> <li data-bbox="614 1520 1369 1653">• OEMs will be engaged by brand managers and certificate aggregators to make niche low cost HE lighting products, accelerating the R&D cycle <li data-bbox="614 1709 1390 1841">• OEMs will then sell these products to regime brand managers, wholesalers, and distributors, as well as HE lighting niche market actors

Role	Hypotheses
	<ul style="list-style-type: none"> Manufacturers will test and improve products with customers and regulators for ESS product registration
Niche brand managers	<ul style="list-style-type: none"> Demand from ESS for HE products will drive niche brand managers to source low cost HE products direct from OEMs, accelerating the R&D cycle
Regime brand managers	<ul style="list-style-type: none"> Will face competition from the accelerated development of HE products being offered by niche brand managers and developed with OEMs
Distributors/ wholesalers	<ul style="list-style-type: none"> Will see increased opportunities to sell HE products, made attractive by the subsidies Will see increased availability of new HE products from niche and regime brand managers
Regime retailers	<ul style="list-style-type: none"> Will have more choice of HE lights from wholesalers and distributors, through the HE lighting being developed for ESS by OEMs working for niche brand managers, and products on ELT register filtering through the market
Niche retailers	<ul style="list-style-type: none"> A small market will exist of niche retailers that chiefly sell HE products online
Specifiers / ESCOs	<ul style="list-style-type: none"> ESS will create opportunities for ESCOs working as specifiers to sell HE products, driving supply rather than waiting for customer demand Large-scale government HE lighting projects through GREP and possibly EBB will provide ESCOs

Role	Hypotheses
	<p>with valuable experience and case studies they can showcase to other clients</p>
Certificate aggregators	<ul style="list-style-type: none"> • Will drive the HE lighting market, as they are funded purely through the installation of HE lighting • Will drive the development of low cost HE lighting to meet demand, working with niche brand managers • Will drive the supply of HE lighting in the market through ESCOs, electrical contractors, etc. Installations are offered to customers, not driven by customer demand
Electrical contractors	<ul style="list-style-type: none"> • ESS will expose them to HE products they may not otherwise install, making them more likely to recommend HE products to customers and install them in the future
Developers	<ul style="list-style-type: none"> • ESCs will make HE lighting a lower cost (and thus viable) option for new lighting in major renovation projects
Property owners/managers	<ul style="list-style-type: none"> • Accelerated payback period of ESS installations will make HE desirable • Completed ESS projects will prove business case for property owners/managers with multiple properties, and motivate them to complete further lighting upgrades outside of the ESS
End users	<ul style="list-style-type: none"> • Will be motivated by subsidy to install HE lighting

A total of thirty interviews were conducted, spanning a broad range of key players in the NSW lighting market. These are listed in a de-identified form in Table 3. Twenty-nine of the actors interviewed performed at least one of the roles described in **Error! Reference source not found.** The remaining interview (interviewee 24 in Table 3) was with a body that regulates an aspect of the lighting industry. For the purposes of this study, regulation is not considered a direct role in the lighting industry. Rather, as described in Chapter 10, it serves as a hard social practice that influences the lighting industry.

Table 3: Roles of actors interviewed

Roles performed by interviewee's organisation	Interviewee (Anonymized interview identifier)																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
OEM	✓																													
Brand Manager	✓	✓	✓	✓	✓	✓	✓																			✓				
Distributor								✓	✓	✓													✓							
Retailer								✓	✓	✓													✓							
Specifier			✓					✓	✓	✓	✓	✓	✓	✓	✓	✓						✓	✓		✓			✓	✓	
Electrical contractor														✓	✓	✓				✓						✓				✓
Developer																											✓	✓		✓
Property owner/manager																					✓						✓	✓		✓
Certificate aggregator			✓											✓	✓	✓	✓	✓												
End user																						✓					✓			✓

Interviewees were asked in detail about the roles their organisation play, as well as their observations on other roles in the market that their organisation interacts with. Interviews were conducted on the condition of strict confidentiality, with only synthesised findings to be shared with OEH. Because of this, actors provided very detailed and frank information into their commercial models and drivers with respect to the lighting market and impacts of government programs.

The interviews provided valuable insights into the extent that the niche is influencing the mainstream, and how transformational the ESS has been for the NSW lighting market to date. The interviews also highlighted opportunities within the market for future focus of programs to foster energy efficient lighting. The interviews provided limited information on the performance of the GREP.

These insights have been used to test, refine, and update the preliminary findings of draft working papers on market structure performance and dynamics. They have been integrated with the findings of our desktop research and incorporated into the following sections of this paper.

Part 2

The Structure of the NSW Lighting Market

CHAPTER 5

A Framework for Understanding Market Structure

5.1. Supply Chain Networks

Market structure refers to the participants in a market, the buyers and sellers, and their commercial relationships with each other. At a high level, market structure can be described in terms of the supply chain network for a market. In a supply chain network, the actors in the network are linked upstream and downstream through the supply of products, or indirectly as facilitators of that supply chain. Altogether, the actors perform the different processes and activities that produce value in the form of products and services for end users.²²

Under this framework, a given type of actor refers to the organisations that carry out a particular *role* in the supply chain network. Industry associations and other organisations (e.g. lobbyists, lawyers) that represent and work for a given set of actors are considered to be agents of those actors, and are dealt with as part of the role of that actor type.

In practice, individual organisations may play several roles in a supply chain network, based on their organisational structure and level of vertical integration. The supply chain network does not cover those actors who can influence the supply of lighting, but are not involved in its delivery as a core activity. This includes regulatory bodies, subsidy programs, and aligned industries (e.g. logistics, warehousing, advertising). The role of these actors on the market is addressed in the concept of *regimes*, discussed below.

For this study, we have simplified the lighting supply chain network to more generally understand the major types of actors and relationships involved in the diffusion (or otherwise) of high efficiency lighting. More technical market studies might take a granular look at the supply chain network, in terms of the different roles and routes involved in the design, manufacture, assembly, and sale of each sub component of an individual lighting product. Such a level of detail is excessive given the objectives and scope of this project. To help understand the potential impacts of NSW Government programs, we are only interested in the diffusion of finished products to the end customers who ultimately use the lighting.

During a market transformation, market structures may change. For example, this may be observed through the entry of new buyers or sellers (*actors*) into the market, and particularly the entry of new categories of actors (i.e. new *roles*). Or, there may be new relationships formed between existing actors.

²² Harland (1996). *Supply Chain Management: Relationships, Chains and Networks*, British Journal of Management

5.2. Mass Market vs High Efficiency Lighting: Regimes and Niches

In addition to looking at market structure from a supply chain network perspective, we also considered how the structure varies for the supply of high efficiency versus mass market lighting products. To do so, we have drawn on the System Innovation and Transitions (SIT) theory²³ concepts of regimes and niches. SIT theory draws upon the multi-level perspective (MLP) framework for describing how niche actors can catalyse a market transition. MLP analyses the market as being made up of a sociotechnical landscape, regimes, and niches.²⁴

The **landscape** is the environment within which the market operates, including macro-economics, cultural patterns, and politics.

A **regime** is a dominant market trajectory. It is characterised by routines, sunk costs, infrastructure, dominant competencies, aesthetics, contractual agreements, regulations, and standards.

A **niche** is a small sub-market where new technologies are incubated. They are unstable, low performance, and with dedicated actors.

Figure 12 shows the relationship between the landscape, regimes, and niches.

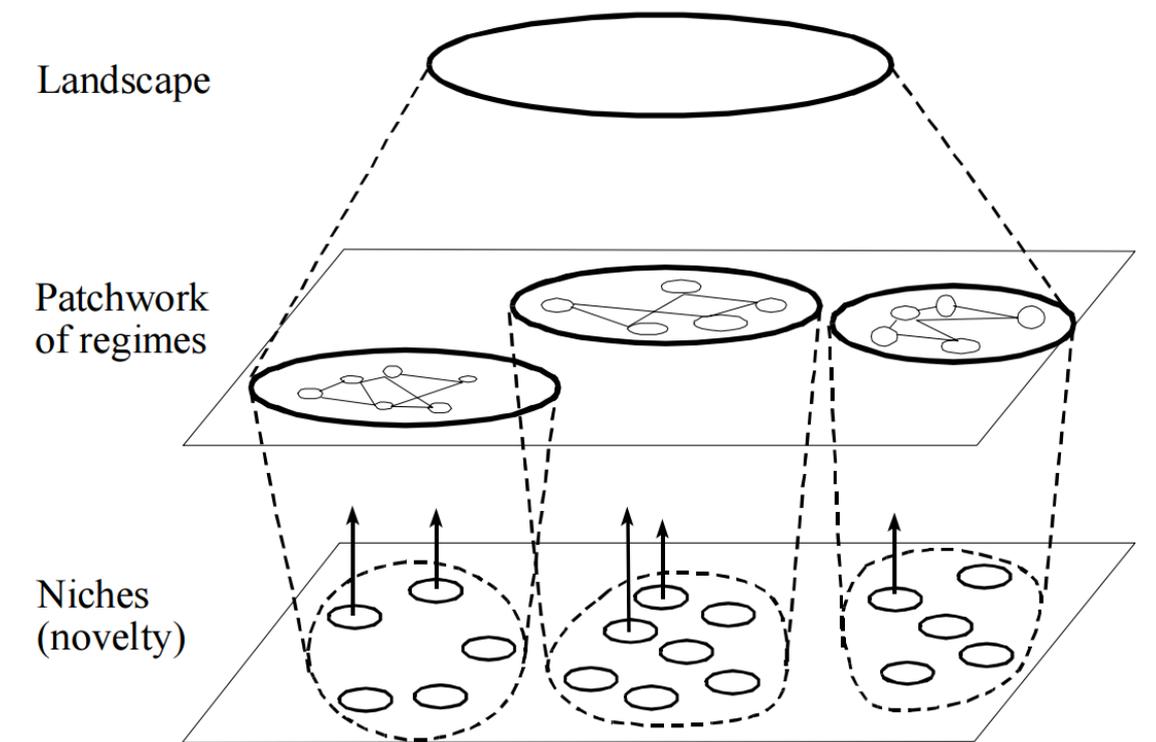
Niches are the level at which there is space for radical innovation and experimentation. This level is less subject to market and regulation influences, and can facilitate the interactions between actors that support product innovation.²⁵ Niche actors are often enabled by government subsidies, assistance, or requirements.

²³ Twomey & Gaziulusoy (2014). *Review of System Innovation and Transitions Theories: Concepts and frameworks for understanding and enabling transitions to a low carbon built environment*, CRC for Low Carbon Living

²⁴ Geels & Schott (2007). *Typology of sociotechnical transition pathways*, Research Policy 36, pp 399–417

²⁵ Nelson, R.R., Winter, S.G. (1982). *An Evolutionary Theory of Economic Change*, Cambridge (MA), Bellknap Press

Figure 12: Landscape, regimes and niches²⁶



Although distinct, regime actors may compete directly with niche actors. Regime actors may provide a range of products that includes some high efficiency niche products, which, depending on context, could be either a barrier or a driver towards the wider adoption of these niche products. Mass market regime actors dominate the practices, rules, and technologies that provide stability and reinforcement to the prevailing socio-technical systems.²⁷ As a market transition occurs, the distinction between niches and regimes begins to disappear.

Systems Innovation Transitions (SIT) theory provides a more holistic and nuanced view of market transformation than other methodologies, which often model transitions as a simple technology diffusion curve. However, in a complex market with multiple product classes and actors that cannot be classified as purely niche or regime, there are many challenges in analysis. In its purest form, SIT theory deals with markets for a single product. We have taken key concepts from SIT and adapted it to the needs of the lighting Market Impact Evaluation (MIE).

²⁶ Geels & Schott (2007). *Typology of sociotechnical transition pathways*, Research Policy 36, pp 399–417, 2007.

²⁷ Nelson, R.R., Winter, S.G. (1982). *An Evolutionary Theory of Economic Change*, Cambridge (MA); Bellknap Press

Figure 13 below provides a simplified illustration of how cycles of diffusion can lead to the mainstream adoption of initially niche technologies and/or practices.

Figure 13: Cycle of diffusion and adoption²⁸



In the NSW lighting market, we are interested in the high efficiency lighting niche and how the market is transitioning to adopt that niche into the mainstream regime. For example, niche high efficiency lighting actors may have been brought into the market through the NSW Energy Efficiency Scheme (ESS). These are characterised as Accredited Certificate Providers (ACPs) under the ESS. They are able to access the incentives available through the ESS, and either directly participate in the market themselves or facilitate other market actors to drive uptake of high efficiency products. There are also niche high efficiency lighting actors internationally.

²⁸ Xu (2016). *Systems Innovation and Transition Study*, OEH

CHAPTER 6

Market structure overview

6.1. Segmentation and Product Types

By *lighting market*, we refer to the commercial actors involved in the purchase and supply of technologies that use electricity to produce artificial light. There are a broad range of different lighting technologies for different applications, with differing levels of energy efficiency.

Lighting and Energy Efficiency

An installed lighting system normally consists of the lamp (where light is generated), control gear (e.g. switches, timers, and/or sensors), and luminaire (the fixture that hosts both the lamp and the control gear into a unit). The main types of lamps currently in use include:²⁹

- Incandescent (e.g. halogen)
- Fluorescent lamps (e.g. CFLs, T8s, T5s)
- High Intensity Discharge (HID) lamps (e.g. mercury vapour, sodium vapour, and metal halide)
- Light-Emitting Diodes (LEDs)

The energy efficiency of lighting products is typically measured in terms of the amount of light output (measured in lumens) per the amount of energy used to produce it (measured in watts), i.e. lumens per watt. Once installed in a building, lighting efficiency can also be measured in terms of the amount of energy used to produce the required lighting output for the given size of the lit space, i.e. watts per square meter of floor area that is lit.

Energy efficiency in this technology segment is achieved by either upgrading equipment to a more energy efficient source appropriate to the user's requirements, or by installing lighting control systems that reduce usage (e.g. light sensors or motion sensors).

According to OEH modelling, the lighting market is the third most important energy savings opportunity in NSW.³⁰

²⁹ Office of Environment and Heritage, NSW (2014). *Energy Efficient Lighting Technology Report*

³⁰ Common Capital (2014). *Characterising the New South Wales Energy Efficiency Market*

The lighting market is a complex supply chain network consisting of several different classes of actors that deliver lighting products from their manufacturer to their final customers. The NSW lighting market is part of a national market, and many of the actors in this market are national and international. For the purposes of this report, the NSW lighting market boundaries are defined where the final lighting product has been installed in a building in NSW.

We have split this market into four broad segments:

- Residential
- Commercial (Office and Non-office commercial)
- Industrial
- Public

Each segment is characterised not only by different customer types, but also by different lighting product types that service those different customers. These segments can be analysed more granularly based on industry, building, space, and lighting technology type. There are a wide variety of lighting applications, even within individual customer segments. This means that the overall lighting market is complex, with a huge variety of lighting products, and suppliers that often specialise in a particular segment or lighting type.

The **residential** segment consists of lighting for residential buildings ranging from detached houses to high-rise apartment buildings. Each home normally contains a number of different lighting product types, depending on the use of each room. The emphasis is usually on the aesthetics of the product, its colour, its price, and its light output, and efficiency is often a secondary consideration. Traditionally, general lighting service (GLS) and downlight fittings dominated this segment. In the past two decades, there has been an increased uptake of recessed halogen downlights, as well as compact fluorescent lamps (CFLs) and halogen overheads (known as GLS lamps).

The office commercial lighting segment services predominantly office-based businesses, and the main product in this sector has traditionally been linear fluorescent luminaires. However, there may be different lighting types in some service areas such as kitchens, bathrooms, and lift lobbies. Generally, offices are leased rather than owner-occupied, and the owners manage large portfolios of office buildings.

The **non-office commercial** lighting segment services businesses that include retail, education, health, accommodation, hospitality, and leisure. The main product in this sector has also traditionally been linear fluorescent luminaires, but it is supplemented by a wide variety of specialty lighting, such as spot lighting for retail. Apart from shopping

centres, this sector is largely composed of owner-operators or small leased buildings, requiring specialist lighting solutions.

The **industrial** lighting segment services industrial sites such as factories. It includes specialised *high bay* and *low bay* lighting, depending on ceiling height. Generally, these lights are high output, efficient, and have long lifetimes to minimise maintenance costs. Often, these lamps are HID lamps.

The **public** lighting market segment primarily consists of street lighting, which are specialised lights associated with significant maintenance costs. The technologies used are similar to industrial lighting.

The established lighting technologies in each of these segments have significant potential for energy savings if replaced by high efficiency alternatives. In particular, LED lamps have been developed for every lighting application. Though LEDs were, until recently, a high efficiency niche innovation, they now form a significant technology share in every category of lighting and market segment.

6.2. Lighting Supply Chain Network

High efficiency lighting products are delivered to end users through a supply chain network that can involve different roles and relationships. The nature of the relationships between actors and routes to market vary, depending on the nature of the transaction and the size and business models of the individual firms involved. There are many hundreds of firms involved in the delivery of lighting to end users in NSW. There are also many combinations of different business models based on goods, services, target segments, and level of vertical integration. For the purposes of this analysis, we have generalised these into ten different types of “role” involved in the supply chain network. These are:

- Original Equipment Manufacturer (OEM)
- Brand manager
- Distributor
- Retailer
- Specifier
- Electrical Contractor
- Developer
- Property owner/manager
- Certificate aggregator
- End user

These roles reflect distinct sets of responsibilities and activities, rather than actual firms (or *actors*). In practice, the activities of individual organisations tend to resemble a combination of several roles, through vertically integrated business models.

Roles in this market can be characterised as mass-market regime or high efficiency niche. The mass-market regime are those firms who dominate market dynamics and performance through their established relationships, size, infrastructure inertia, brand presence, distribution channels, market power, industry organisations influence, and other sources of market power.

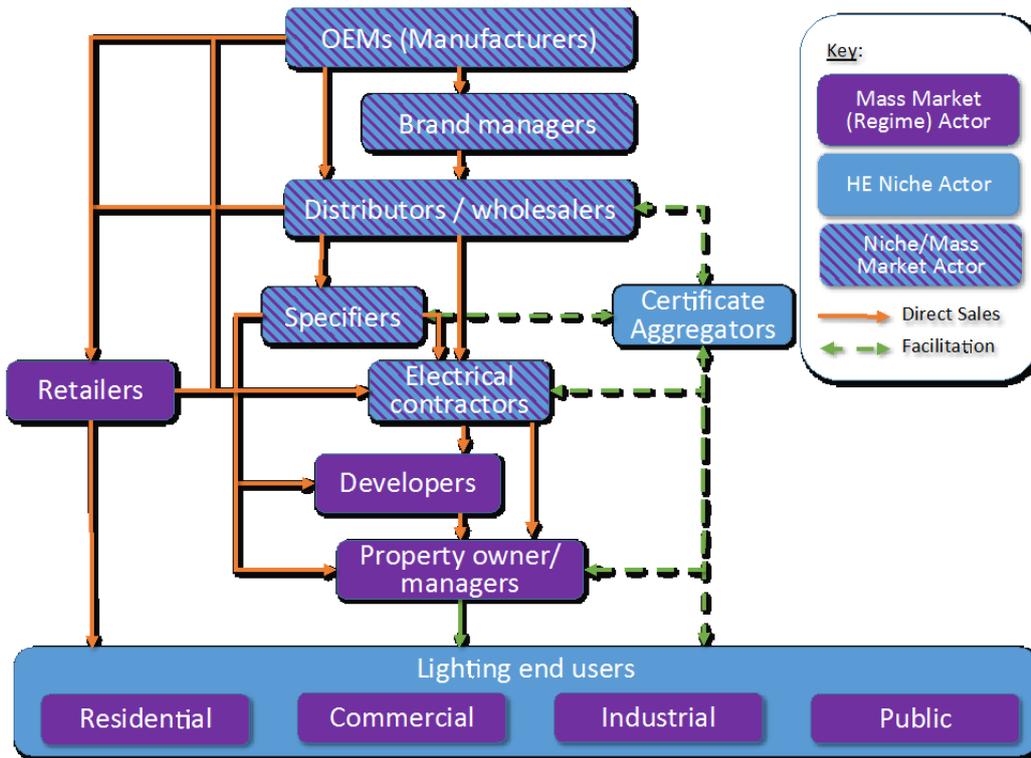
Our research identified several inter-related niches with respect to high efficiency lighting and the impacts of Government programs. Over the time period of this study, niche technologies and practices have been, or begun to be, adopted by mainstream actors, and become part of dominant regimes.

The first niche is high efficiency LED lights. This technology was initially sold by regime lighting companies for its novel aesthetic, as a premium high-margin product. In contrast, niche actors embraced LEDs for their efficiency, particularly those actors involved in the ESS and VEET schemes. Niche energy efficiency firms promoted LEDs (and other, earlier efficient lighting products) on the basis of lifetime bill savings.

There are two main practices for the distribution of LEDs under ESS and VEET. Initially, distribution under the ESS was based on giveaway programs, enabled by high subsidies and no co-payment requirements. In VEET, commercial lighting had lower subsidies, and business models focussed on demonstrating quality and lifetime value with price reductions achieved through customer-direct business models. A reversal of policy settings between VEET and the ESS saw VEET business models adopted by niche actors in NSW, and giveaway models rendered value-based business models in VEET uncompetitive. More recently, LEDs have been embraced as the dominant mainstream technology from all product segments across regime actors, in line with international trends. In addition, the niche customer-direct retrofit business models, pioneered by niche VEET and ESS firms, have begun to be adopted by regime lighting companies.

The nature of the lighting market actors, their relationships, and the dominant routes to market vary depending on which segment the end users are in. This study started with a generic high-level market structure which was refined (based on stakeholder interview findings) to incorporate the segment-specific differences.

Figure 14: High-level supply chain network for the lighting market



As illustrated in Figure 14 above, actors in many of these roles involve a combination of niche and regime firms. Also illustrated are the many different types of relationships between actors. The roles and their inter-relationships are described in Chapter 7, which simplifies these relationships by exploring the dominant routes to market from the Original Equipment Manufacturer (OEM) to end user.

6.3. Dominant Business Models

The business models for actual companies typically involve a combination of different roles. To support the development of this supply chain network for the NSW lighting market, we conducted desktop research of a cross-section of different companies. This section summarises the findings of this research with respect to the trends in business models.

We benchmarked companies by the types of markets and market segments they target, the range of products and services they offer, their involvement with the ESS and similar schemes, and their market roles. The sample is not exhaustive nor necessarily representative; however, it provides a good cross-section of the types of actors and business models currently present in the NSW lighting market. All information is taken

from publicly available sources on the companies' websites, and may not be completely accurate. Market segments targeted are based on the range of products displayed.

Specialisation and preference for new builds or retrofits is inferred based on how the company presented itself. Similarly, supply chain network roles are inferred based on the range of products and services provided, and how the company self-identified.

From this research, several basic conclusions can be drawn. The most notable is that all lighting market actors now deal in high efficiency lighting products (LEDs, higher efficiency fluorescence lamps, and any other product identified as being energy efficient).

Many actors, particularly the larger actors, still sell mainstream lighting products (that is, non-HE lighting). Actors typically specialise in either commercial and residential lighting or commercial and industrial lighting, although there are many variations, and some companies provide products to all market segments. The difference largely comes down to whether the lighting is required to have a high aesthetic standard or not. Public lighting is almost always provided by companies that also supply industrial lighting. A large proportion of companies provide in-house design services, and some companies provide other services such as maintenance and finance.

Typically, only higher efficiency specialists mention or promote the ESS, and it is usually presented alongside information about other schemes such as the VEET. This is because most actors do not confine themselves to the NSW market, with most being Australia-wide and some even offering their services overseas.

Interviewees noted that LEDs were a niche product five years ago, when the ESS first saw large amounts of lighting activity. However, the mainstream adoption of LEDs is not confined to NSW.

CHAPTER 7

Major Roles and Inter-Relationships

7.1. Original Equipment Manufacturers

Role Overview

Original Equipment Manufacturers (OEMs)³¹ manufacture and assemble components and finished products of lighting solutions (e.g. lamps, control gear and luminaires, and subsidiary components of each). OEMs are almost entirely overseas. Their core customers are established brands who purchase product to their specifications and resell it under their label. Traditionally, OEMs sold only through established brands. However, as with many technologies these days, OEMs now also sell directly to distributors, retailers, and large electrical contractors, under their own label. The ESS has seen ACPs and niche distributors bypass brands and source high efficiency lighting products directly from OEMs.

Insights from Stakeholder Interviews

Interviews identified a mix of actors involved in and with the OEM role. Some actors serving primarily as OEMs are large, high-tech firms. These are typically Chinese owned and based, but with global supply chains and multinational customers. There are also many small manufacturers who sell directly to wholesalers and niche brand managers. They typically meet customers and establish relationships through trade fairs in China.

We interviewed representatives from one³² large Chinese lighting OEM. This OEM manufactures a broad range of lighting technologies covering both LEDs and conventional technologies. They reported a turnover of around \$1 billion, with four major factories and over 30,000 employees in China. Of these, one main factory specialises in LEDs made to specification and label for a range of major Australian and international lighting brands. This OEM also made LEDs to specification and label of niche high efficiency brand managers/aggregators that operate in the ESS and VEET. Additionally, this particular OEM has now established a subsidiary in the United States, Europe, and Australia that sells its LEDs under its own brand. This brand is based on a low price, high volume value proposition. This OEM was not aware of the ESS before entering the

³¹ Note that there are two distinct meanings for the term *OEM* in common use. The firms that manufacture original equipment and components are also sometimes referred to as *manufacturers*. In this latter application, the term *OEM* is instead applied to the firms that purchase and resell the finished product under their own brand. We have chosen to adopt the more literal of the two applications of *OEM*, and are referring to the latter type of actors as *brand managers*.

³² Access to more OEMs proved challenging within project time frames, as they are typically based overseas, and lighting industry actors closely guard the identity of their OEM(s) and their relationships as commercial secrets.

Australian market. Rather, the Australian market was seen as attractive due a general reputation of rapid adoption of new technologies.

Other parties interviewed, such as brand managers and distributors, observed that in recent years there has been significant transition in the businesses of manufacturing and assembling lighting. With the advent of LED technology, lighting has transitioned to a technology centred around electronics and solid-state componentry. This has seen electronics companies entering the lighting manufacturing business.

7.2. Brand Managers (“Manufacturers”)

Role Overview

Brand managers are responsible for the specification, branding, and marketing of finished lighting products. Examples of well-known market actors that undertake this role include GE³³, Philips³⁴, OSRAM³⁵, and Sylvania³⁶. In practice, actors in this role typically describe themselves as *manufacturers*, *suppliers*, or even *OEMs*. However, for the avoidance of ambiguity, we are describing this role in terms of the primary activities it involves.

Brand managers work with OEMs to manufacture products under their label, to their design and specification. They engage in broad-based marketing activity to customers across the supply chain network. They coordinate the sale and distribution of their product through a network of distributors.

Brand managers tend to involve a degree of vertical integration with other elements of the supply chain network. For clarity, we are distinguishing between those roles and the specific roles of brand management. The term *supplier* is used by such a broad range of companies, from manufacturers to electrical contractors, that it is too ambiguous for analytical purposes.

Some brand managers may contract international OEMs to assemble finished products under license for them. Some may import components from OEMs and conduct light assembly in Australia (e.g. HPM Legrand³⁷). Many major lighting companies also have vertically integrated distribution businesses that sell product to large end users and

³³ <http://www.gelighting.com/>

³⁴ <http://www.lighting.philips.com.au/>

³⁵ http://www.osram.com.au/osram_au/

³⁶ <http://www.sylvaniaighting.com.au/>

³⁷ <http://hpm.com.au/>

electrical contractors. Some also have dedicated service businesses with integrated (or sub-contracted) specifiers and electrical contractors.

The NSW ESS and VEET schemes have seen several firms grow from importing white label product from OEMs to become niche high efficiency brand managers. For example, Optitech International is the sister company of a large ACP, the Green Guys Group. Ledified and Shine-on have similar vertically integrated structures.³⁸ EcoMatters³⁹ and Emerald Planet⁴⁰ are both niche integrated brand managers and distributors that have emerged, and grown to provide high efficiency lighting and other products to ACPs under the ESS and VEET.

Insights from Stakeholder Interviews

We interviewed five regime and niche high efficiency lighting actors whose core business was in the role of brand manager.

The regime brand managers were mostly multi-national companies. All had long international supply chains with lamp and luminaire design, component manufacture, and assembly across many countries. Generally, lamps are manufactured in China, with luminaires either made in China or assembled in Europe or Australia from predominantly Chinese components. All regime brand managers supplied product across all customer end-use segments. Their primary markets are the specification market for luminaires and lamps, and the replacement market for lamps. In the specification market, they primarily design for, market, and sell to architects and designers, or wholesalers who in turn sell to smaller architects and designers. These actors also have wholesale teams that sell directly to large customers and developers.

All of the niche actors were involved primarily with the ESS and other state energy efficiency schemes. The nature of the role was very similar between the five niche actors in the role of brand manager, and quite different from regime actors in the same role. This covers their activities, business models, products, value propositions, market segments, and routes to market.

Niche brand managers now focus exclusively on LEDs for the energy efficiency retrofit markets driven by the ESS and VEET (and for some, the SA and ACT schemes). Some

³⁸ <http://optitech.com.au/>

³⁹ <http://www.ecomatters.com.au/>

⁴⁰ <http://emeraldplanet.com.au/>

previously developed lighting products, like T5 Adaptor and CFLs, were high efficiency at the time but are now superseded by LEDs. Niche brand managers oversee the production and supply of products for a wide range of end uses in the commercial and industrial sector. Some develop their own residential products; however, these are only sold in Victoria under VEET. None of the niche brand managers interviewed catered to the public lighting sector.

All niche brand managers reported the same key differences between their products, and the regime products that were available when they began to develop product. These niche LEDs are designed for an end-user market, with value proposition based on high energy bill savings, low cost, and ease of retrofit. This contrasts with the more aesthetic based value propositions of regime actors, who typically sell through specifiers (architects and designers) and larger electrical contractors. For niche brand managers, all products are designed specifically with both ESS and VEET accreditation in mind, and minimisation of warranty claims. The customers that niche brand managers target are typically either decision makers in finance or facilities management roles.

Niche actors in the brand manager role had very different business models from their regime counter parts. Most were vertically integrated with their own leads generation, direct sales, and installation teams. They sell directly to end users, including building owners, managers, occupants, and tenants. None of the interviewed niche brand managers sold through the traditional channels of specifiers, wholesalers, and large contractors. None sold into the new build/refurbishment market, as they believed that this was not permitted in ESS rules.

Niche brand managers carry a smaller range of products and focus on volume and low prices. Price savings are achieved in part by selling straight to end customers, and cutting out the margins typically added on by wholesalers, specifiers, and contractors. Some actors said they also achieved cost savings through their narrower product range, and not needing to provide large back catalogues of replacement lamps for a wide range of fluorescent, incandescent, and HID products.

7.3. Distributors

Role Overview

Distributors manage the wholesale purchase and resale of large quantities of lighting products. They typically purchase product from brand managers. They sell to retailers, larger electrical contractors, specifiers, and potentially directly to developers and large commercial and industrial end users who purchase wholesale quantities.

Some distributors wholesale a broad range of lighting products and brands, as well as other non-lighting electrical equipment (e.g. Rexel⁴¹). Others may be dedicated lighting distributors supplying either a range of lighting products (e.g. LSB Lighting⁴²) or one brand exclusively (e.g. LED Australia⁴³).

Insights from Stakeholder Interviews

The interviews conducted clarified the role of lighting distributors. Three parties were interviewed that had a significant lighting distribution role (with some using the term *wholesaler* to describe this role). In this role, the majority of the lighting sales from those interviewed were to electrical contractors. In some cases, this was as high as 90%, with end-users being the other significant customer base.

All distributors identified lighting maintenance and retrofits as significant parts of their business.

The involvement of distributors in supplying the new build market varied. Some distributors we interviewed noted that new builds form a small part of their business, as lighting for new builds is often directly sourced from brand managers. From interviews with specifiers, it's clear that this is typically the case when the lighting design is provided by a party that has a direct relationship with a brand manager.

Other distributors identified new builds as a significant part of their business. Interviews with specifiers clarified that such arrangements occur when the performance of lighting is specified instead of a specific model, or where equivalent products to those specified are

⁴¹ <http://www.rexel.com.au/>

⁴² <http://www.jsblighting.com.au>

⁴³ <http://www.ledaustralia.com.au>

permitted. In such cases, distributors assist builders and/or electrical contractors in sourcing light fittings to meet the specifications.

All the distributors noted that LED lighting is forming an ever-growing proportion of their sales. They also noted that the quality of LED lighting has improved in recent years, and at the same time, the price of quality LED products has fallen.

One distributor estimated that LEDs make up 40% of its lighting sales. The remaining 60% of less efficient lighting is being sold to parties such as small-medium businesses that focus on upfront capital, and facility managers that have negative attitudes to LEDs. Another distributor estimated that 85% of its sales were LEDs.

All distributors that were interviewed were aware of the ESS. In the case of one person interviewed (a store manager), this awareness arose only recently. All those interviewed have direct engagement in the ESS.

One distributor set up a dedicated unit in 2011 to provide energy efficiency solutions to electrical contractors, as a means of supporting its customers and accessing the retrofit market. Whilst this was a national initiative, 80% of its business was in NSW, and of this, 80% was for lighting retrofits – an indication of the importance of the ESS incentive in this business model. After operating for three years, the unit was discontinued. The distributor cited the reason for this discontinuation as the emergence of niche parties providing lower quality products, which undercut the product they were able to offer.

Another distributor interviewee promotes the ESS to its electrical contractor customers, and then supports the electrical contractors in creating retrofit opportunities from their existing client base.

Two of the distributors also had experience in registering lighting products to the ESS and VEET lighting registers. Each noted the challenges associated with providing the documentation required by the scheme's regulator, and the time taken to gain product approval. These challenges were typically greater with the VEET scheme. One distributor, noting the difficulties that established parties face in meeting the documentation requirements, questioned how new-entrant niche parties would be able to meet these requirements.

Whilst the majority of lighting sold through distributors is sourced from parties such as brand managers, some distributors (especially those associated with international companies) do provide their own range of lighting.

7.4. Retailers

Role Overview

Retailers purchase lighting product wholesale, and resell it in small batches directly to end users and smaller electrical contractors. Retailers typically purchase their products from distributors. Larger retailers may source their product directly from distribution arms of vertically integrated brand managers.

Retailers may be general retailers that stock lighting products, such as Bunnings⁴⁴, or specialist lighting retailers, such as Eurolight⁴⁵. They range from large chains to single high street stores.

Insights from Stakeholder Interviews

One retailer that was interviewed operated a national lighting retail business. This retailer works with parties it described as “agents” to source lighting products. It stocks a mix of off-the-shelf products and luminaires that its agents source to meet the retailer’s design specifications.

This retailer’s market was mainly domestic maintenance and replacement lighting, which accounted for around 80% of its sales. Lighting for residential new builds and commercial sites account for the remainder of their sales. The retailer’s main customers are domestic end-users and electrical contractors that install in the domestic market.

Around one-third of this retailer’s product range is LED lighting. LEDs are more prevalent in the more “functional” lighting types, and less prevalent in decorative lighting, such as chandeliers. Over the last few years, the company has trained its sales teams on LEDs so that they can educate customers.

This retailer is active in getting lighting products registered on the ESS and VEET lighting registries. This has involved identifying lighting from its existing catalogue that meets the scheme requirements (sometimes with some modification), rather than sourcing specific

⁴⁴ <https://www.bunnings.com.au>

⁴⁵ <http://www.eurolight.com.au/>

products for this purpose. The retailer considered these schemes to be an “extra” to its core business.

The retailer noted that the product requirements for the energy efficiency schemes are on-par with the product range the retailer stocks. The schemes, however, are a “step-up” in terms of the documentation and testing requirements. As an example, the retailer undertakes similar product testing to that required by the schemes, though this is conducted in-house. The independent testing requirements of the schemes add costs.

7.5. Specifiers

Role Overview

Specifiers design lighting solutions for developers or end users. These solutions determine the qualitative combination and configuration of lighting products (lamps, luminaires, and control gear) involved to produce the final lighting service. Specifiers can be specialist lighting designers, as well as architects, interior designers, and Energy Service Companies (ESCOs) who provide advice and make decisions for end users on which products are installed.

As discussed in Section 0 below, specifiers play a critical role in influencing the quantity, type, and brand of the lighting products that end users and developers ultimately purchase. For this reason, many companies across the supply chain network tend to offer vertically-integrated specifier capabilities.

We consider ESCOs as a business model rather than a specific role for the purpose of our supply chain network model. ESCOs provide a range of solutions relating to energy services, including lighting projects focussed on energy savings. Other services include energy audits, energy performance contracts, energy monitoring and management, and broader energy efficiency retrofit projects.

As discussed above, ESCOs sit in the role of specifiers. They are also a prominent feature of many ACP business models, alongside that of certificate aggregator.

Insights from Stakeholder Interviews

We interviewed six parties that provide specifier roles. In addition, each of the distributors and the retailer interviewed offered specifier services.

One specifier that was interviewed provided energy efficiency service for large businesses, often packaged under an energy performance contract. It is noteworthy that for this specifier, the benefits of lighting energy efficiency improvements were used to cross-fund other energy efficiency improvements, such as chiller upgrades—making the payback for the overall project acceptable to the client.

Another energy efficiency service provider, offering services to government and large corporations, has established a partnership with a vertically integrated lighting business. This lighting business specifies lighting and provides installation and maintenance services, a model which is viable when providing large scale lighting retrofits. In this case, the lighting business sources lighting directly from manufacturers in China, Korea, and Taiwan, working with the manufacturers to ensure that products meet the desired requirements, which include compliance with ESS and VEET product requirements. The business is then directly involved in registering products to the energy efficiency schemes.

It is noteworthy that not all lighting specifiers have fully embraced LED technologies. One specifier, which provides lighting design services as part of the energy efficiency services for large retail, office, and aged care building owners and managers, did not consider LEDs to be a mature technology, and questioned whether LEDs were able to produce a sufficient quality of light that would satisfy end-users such as office workers. This same specifier considered LED applications as limited to situations where there are long operating hours or where there are higher maintenance costs.

For new builds and major refurbishments, architects and lighting designers have a key role in specifying lighting.

We interviewed one architect that provides services for medium size office, retail, and industrial buildings. They explained that the typical process of specifying lighting involves the architect engaging a lighting designer to provide a first-pass lighting design. The designers, often an electrical engineering consultancy service, provide a design that meets the relevant Australian standards and the Building Code. This is reviewed by the architect to incorporate any necessary design elements before finally being signed-off by the lighting designer. Whilst the designers often have an understanding of LED lighting, there can still be a tendency to specify less efficient lighting, especially if this will provide a lower-cost solution to the developer.

Another architect that was interviewed clarified that some lighting designs will specify particular luminaires, especially where the designer is associated with a lighting brand or

distributor. Even where a specific luminaire is identified, the specification may note that an equivalent can also be considered. This provides an opportunity for builders bidding for the job to identify alternate, and typically lower cost, solutions.

One specifier interviewed, a significant vertically integrated lighting business, uses its intimate knowledge of LED lighting to develop competitive LED-based lighting solutions. It considers that as recently as mid-2016, lighting designers were still specifying HID and T5 lighting, and those that still do are either “not forward thinking” or have a relationship with a supplier. This specifier considers that 85% of lighting designers are now specifying LEDs.

A number of specifiers flagged that there is often a disconnect between the lighting specified and that which is installed. This can be driven by builders and/or electrical contractors installing lower-cost products that do not comply with the specifications. One specifier cited the example of a major shopping centre car park that was specified for LEDs, but fitted out by the builder in fluorescent lighting in an attempt to rein-in their costs for the project. Many specifiers cited a lack of compliance checking (such as by local councils) and split incentives (where developers have little motivation to consider the running costs of lighting) as contributing to this disconnect.

Several lighting specifiers are engaged in the ESS. This can range from simply connecting clients with other parties that provide the incentives and handle the scheme paperwork, to specifiers that are part of a vertically integrated lighting business and can also be involved in getting products on the ESS lighting register and/or working with other parties to create scheme certificates for lighting installations.

7.6. Certificate Aggregators

Role Overview

Certificate aggregators are responsible for obtaining subsidies for lighting projects from the NSW ESS. Certificate aggregators are not a traditional role in the lighting industry, but these niche actors currently play a role in a large number of NSW lighting projects.⁴⁶ In practice, all certificate aggregators are accredited certificate providers (ACPs). However, there is a range of different ACP business models that influence the nature of the

⁴⁶ The market performance stage of this project will quantify the significance of the ESS as a share of NSW lighting projects. However, early indications are that the share of non-office commercial and industrial lighting that involves the ESS, and thereby aggregators, is significant.

relationships that aggregators have with other actors in the market. There are three main ACP business models: pure aggregator, aggregator-ESCO hybrid, and vertically integrated ESCO.

Pure aggregators tend to interact only with electrical contractors, and potentially large end users. They obtain the information and consents required to create and trade certificates for an energy saving lighting upgrade. They provide their customers with ESS subsidies, minus the fees they charge for creation. Their income is based purely on certificate creation and trading charges.

Other ACPs can be characterised as aggregator-ESCO hybrids. They act as aggregators for third party projects as well ESCOs, and originate their own sales to customers. In this latter role, the ACPs act most closely to the role of specifier in our supply chain network model. These ESCOs typically source products from niche distributors and sub-contract installations to electrical contractors. They may take overall responsibility for project execution, and derive additional revenue as a margin on product and service sales. Or, ACPs under this model may simply facilitate sales from distributors and contractors and derive additional revenue as a sales commission. Most ACPs fall into this category.

The third business model involves full vertical integration. These ACPs take complete responsibility of all aspects of a lighting project, from end user sales, wholesale product purchase, specification, implementation, and after sales support, in addition to certificate creation and trading. These ACPs derive revenue as a margin from each element of the project. These ACPs may also offer aggregation services for third party projects. For example, one major NSW ACP is presently focussed solely on high efficiency lighting, and is notable for also developing a brand management and product distribution role with its sister company. Another provides ESCO services across a broad range of industrial energy efficiency and management solutions, one of which lighting.

Insights from Stakeholder Interviews

We interviewed three businesses that operated primarily as certificate aggregators. All certificate aggregators interviewed focused completely on commercial lighting. One of these was a pure aggregator, with the ESS accounting for 60-70% of its business. It provided aggregation services to up to one hundred lighting suppliers with installers, with some being established retailers and others being start-ups. The aggregator noted that many rely completely on the ESS for their business. The aggregator has developed digital apps for its customers to streamline the data collection process to determine that

the lighting activities meet ESS requirements. The aggregator noted that there are risks to its business in being too dependent on energy efficiency schemes. As such, it considers itself a financing company for energy efficiency and renewable energy, and is exploring innovative financing products it may be able to offer, including leasing arrangements for lighting services.

Another certificate aggregator that we interviewed also operated primarily as a pure aggregator, though with a much narrower client base. Its main client is a major vertically integrated lighting business with large corporate end-user customers. The aggregator described its role as providing project management and support, working with its clients in the front and back end of ESS certificate creation. This aggregator has also developed digital apps to support ESS certificate creation. It noted that energy efficiency schemes are a dominant driver for retrofits, and as such, it does very little work outside of NSW and Victoria.

The third aggregator we interviewed was a vertically integrated business, initiating its own lighting projects and operating as a sub-contractor to other parties. It operated mainly in the retrofit market, with limited success in extending into the architectural specifier market. This aggregator noted that the high-end specifiers and suppliers had little interest in ESS incentives, as their business was more focused on lighting aesthetics than price.

Being close to the energy efficiency schemes, certificate aggregators flagged elements of the schemes' designs that present challenges to them and their clients. Elements raised included the evidence requirements around co-contributions (which can be particularly challenging for large corporate end-users), the duplicative nature of documentation required at different stages of a lighting project, and the approaches taken to product and installation audits.

One of the aggregators interviewed noted the highly favourable paybacks that LED lighting retrofits now provide. Given this, it questioned why such energy efficiency activities remain in the ESS and suggested that it may be time for the scheme to bring forward other energy saving opportunities, such as through project-based methodologies.

7.7. Electrical Contractors

Role Overview

Electrical contractors physically install the lighting products, and typically involve licensed electricians. Their role varies depending on the nature of the transaction. Electrical contractors may sell the lighting solution directly to end users, purchasing product from either distributors or retailers (depending on the size of the contractor and the project), or they may simply be engaged by specifiers, end users, or property owner/developers who purchase products wholesale directly from a distributor.

As outlined in Section 0 below, this latter type of relationship is more likely in the maintenance and retrofit market, where the transaction is solely lighting related. In this market, electrical contractors may also subcontract to ESCO specifiers who originate lighting upgrade projects.

In the new build and refurbishment market, where lighting projects are conducted as part of a broader building development project, electrical contractors are more likely to subcontract to the specifiers who hold the head contract with the developer or property owner.

Insights from Stakeholder Interviews

One interview was conducted with an electrical contractor role. This contractor noted that there are many thousands of electrical contractors operating in NSW, and up to 80% of these operate out of small businesses. They noted that electrical contractors servicing the domestic market have an influence in swaying customers towards energy efficient lighting, and that they typically source lighting for such work from lighting distributors. Electrical contractors also source lighting from distributors for small commercial jobs.

For larger commercial work, the electrical contractor is typically engaged by a builder to install lighting as per a design that has been developed by a lighting designer. In some instances, the builder sources the lighting for the electrical contractor. Where the electrical contractor needs to source lighting for a large job, they source this directly from brand managers.

It was noteworthy that none of the vertically integrated businesses we interviewed directly employed electrical contractors. Rather, they engage them on a contract basis. One such business vetted the electrical contractors they use to ensure they meet work health and safety standards, and are technically competent with new lighting technologies.

The party we interviewed noted that electrical contractors servicing the residential market are not engaged with the ESS. This is consistent with the current low uptake of residential activities.

The contractor also considers that electrical contractors typically don't know about the ESS. The view put to us was that small business electrical contractors would not be attracted to such a scheme, because of the paperwork involved. As mentioned above, a number of distributors have developed business models to work with their electrical contract customers to drive lighting retrofits supported by ESS incentives.

7.8. Developers

Role Overview

Developers are typically only involved in the lighting market for new build or major refurbishment projects. They are responsible for the construction, refurbishment, and/or maintenance of the lighting in buildings used by lighting end users. Developers are likely to engage specifiers to design the lighting project, and electrical contractors to install it. The actual lighting products could be purchased by either the specifier, electrical contractor, or developer, depending on the business models of the parties involved. Developers then sell the building or building retrofit to the property owner, with the lighting only a very small component of the overall transaction.

Insights from Stakeholder Interviews

The two developers that we interviewed were also property owners/managers. Details of their role is discussed below.

Architects and specifiers that we interviewed commented on the tension between some developers' desire for low cost lighting solutions and the need to meet the lighting

requirements of the Building Code. Other parties, such as distributors, noted that high efficiency LED lighting is now common for new developments.

7.9. Property Owners/Managers

Role Overview

Property owners/managers are responsible for maintaining the buildings in which the lighting is installed. A property manager may be the property owner or an agent contracted by the property owner to manage the building on their behalf.

Depending on the nature of the building, the area which is lit, and the building leasing arrangements, the property owner may or may not be the end user of the lighting, or responsible for owning and maintaining the lighting. Typically, property owners are responsible for common area lighting whether they are the occupants or not. Lighting in tenancies is the responsibility of the tenant, although the end user may still engage the building manager to maintain lighting for them.

The role of property owners/managers varies depending on the nature of the transaction. In the new build/refurbishment market, their role in the lighting market is indirect, with lighting provided as a small component of the broader property transaction by the developer. In the maintenance/retrofit market, their role is more significant, and they are more likely to directly engage specifiers or electrical contractors to procure integrated lighting solutions. In cases where the end user engages the specifier or electrical contractor, the property owner/manager is still likely to play a role in mediating transactions, either by managing projects on behalf of end users or as a decision maker/co-customer in project elements relating to common care lighting.

Insights from Stakeholder Interviews

Five property owners/managers were interviewed, each of which were large property businesses with national presence. One business was a property manager on behalf of investment funds. Two provided property management services for property owners, tenants, and investors. The remaining two owned and managed substantial commercial property portfolios.

One of the businesses discussed its approach to base-building lighting upgrades. Given its size, the business maintains a panel of preferred lighting suppliers. By calling for tenders for the supply of lighting, the business has been able to source lighting from agents of brand managers that meets its quality requirements and comes with attractive warranties. The lighting is installed by electrical contractors associated with the agent, a necessary step for the warranty. The business has also negotiated upgrade agreements with its energy provider as a means of securing upfront capital for the project, which is repaid through energy cost savings. The energy retailer obtains the financial value of ESS certificates created from the upgrades, to assist with the economics of the lighting upgrade. Under these arrangements, the business is able to undertake lighting upgrades with paybacks many years less than the lighting's warranty period.

This same property manager also seeks to influence the sustainability practices of its tenants. It has lighting guidelines for office building tenants which set a maximum electrical power density, expressed as watts per square metre. They also seek to influence industrial tenants through minimum design standards.

Another property manager, as part of its services, develops proposals to building owners for base building lighting upgrades. The value proposition of such upgrades for building owner, building manager, and tenant can vary depending on the contractual relationships that the parties have. This makes such retrofits more challenging than for owner-occupier circumstances. Where the building owner approves the retrofit, the property manager develops the lighting specifications and engages a contractor to undertake the work. The contractor is responsible for dealing with parties to capture the ESS incentive for the upgrade.

Whilst this property manager was not involved in many major refurbishments, it was able to note that such projects involve much more than lighting. As such, the incentives from the ESS are not considered, as they would be insignificant to the overall project. Where the budget is tight for such refurbishments, T5 fluorescent lighting may be installed. For higher cost refurbishments, higher quality LEDs are used.

Another property manager provides total asset management for building owners. It has formed a partnership with a vertically integrated lighting business to provide lighting upgrades that incorporate financing, design, installation, and maintenance.

For two property owners/managers that were interviewed, corporate sustainability goals were a key driver for lighting upgrades. One owner/manager noted that the quality improvements and price reductions of LED lighting now allows for extensive upgrades of

common areas, even where tenants capture some of the benefits through reduced outgoings. This business will also, at times, upgrade tenant lighting as a strategy to retain them through a lease renewal process. The other owner/manager provided a perspective on the retail sector. The business, which owns a number of shopping centres, requires its tenants to meet lighting design guidelines. The motivations for this are to ensure tenancies meet the centre's design standards and to contribute to sustainability goals. The lighting guidelines were developed by a specialist lighting design business.

7.10. End Users

Role Overview

End users use or benefit from the lighting solution. They can be grouped into the four broad segments that are the focus of this study: residential, commercial (office and non-office), industrial, and public. The first three segments are all building occupants, but can be divided into tenants and property owners. The role of property owners in the market is discussed above, and the role of tenants is in the use and maintenance of the lighting in their exclusive use areas. Their role in the lighting market is typically only in maintenance/retrofit transactions. In commercial, industrial, and multi-dwelling residential properties, these exclusive use areas are the tenancy or individual unit/lots that the end user occupies. In single dwelling residential, all lighting is exclusive use.

For all three segments, the role of the end user will depend on whether they own or rent the property they occupy. If they rent, their decision making may be limited. Under residential leases, end users are typically only responsible for replacing lamps, without changing any other elements of the lighting solution. There are niche high efficiency lighting products designed for this purpose.

Under commercial and industrial tenancies, end users typically have more freedom to change all aspects of a lighting solution within their tenancy. However, it may not be financially viable for them to invest in more efficient lighting solutions, depending on the length of their tenancy and financial position.

In maintenance transactions, the decisions are often constrained by the existing technology, where failed lamps are typically replaced with new equivalent products. In retrofit transactions, they may engage a specifier or an electrical contractor to conduct a

lighting upgrade of all elements of the lighting solution (lamp, luminaire, and control gear). End users may engage these actors directly or indirectly via the property manager.

For public lighting, the end users are the public, but they have little or no direct role in the lighting market supply chain. Public lighting purchasing decisions may be made by the property owner or by a separate actor responsible for managing the lighting assets for the property owner. For example, most street lighting in NSW is owned and managed by the local electricity distribution network on behalf of councils, who pay for the energy costs of the lighting. The main exception to this is the City of Sydney council, which owns its own street lighting. Public lighting in train stations is owned and managed by the state-owned rail corporation. End user decisions are taken into consideration based on reported or perceived expectations of lighting service levels.

Insights from Stakeholder Interviews

We interviewed three large national end users. Two of these were also property managers, discussed above.

The third, a large national retailer, has an active program of lighting retrofits. It is of sufficient size to employ an energy management team, which brings with it the capability to directly engage in the lighting market. They tender for lighting suppliers and installers, giving preference to regime businesses that can provide lighting functionality and warranty, rather than businesses that have emerged due to the ESS scheme. They also engage energy efficiency scheme certificate aggregators.

CHAPTER 8

Routes to Market and Transaction Types

8.1. Overview

There are many different ways in which finished lighting goods and services can make it from OEM to end users. As discussed, the precise routes to market vary depending on the size and structure of the individual firms involved in specific transactions. However, transactions can be grouped into three broad categories, which enables a more simplified understanding of the dominant routes to market and the impact the ESS may have on market structure. These categories are:

1. New build/refurbishment market
2. Maintenance market
3. Retrofit market

8.2. New Build/Refurbishment Market

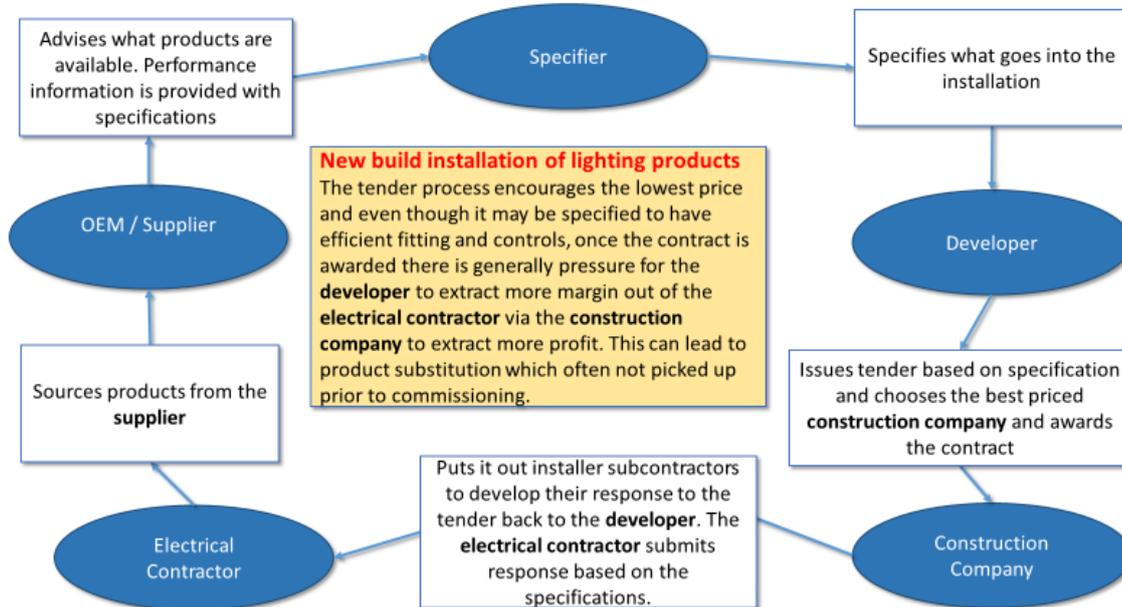
The largest lighting market segment by volume and value is the new build/refurbishment market. This market is often referred to as the *specification* market or sometimes *architectural lighting* market. Despite its significance to the lighting industry, lighting transactions in the new build/refurbishment market are generally incidental purchases for customers, bundled up as part of a larger property development project. As a result, transactions are typically highly mediated through one or several specifiers (e.g. an architect, then a subcontracted lighting designer).

Projects in this market segment focus on the construction of a new building, or a major refurbishment of an existing building, by a developer. These are then sold to property owners, with the lighting only one of many internal fittings and features involved. The property developer is unlikely to use the lighting services, and may face significant split incentives when it comes to the operational cost-savings delivered by high efficiency lighting.

There are exceptions to this in commercial buildings, where National Australian Building Energy Ratings Scheme (NABERS) and Green Star ratings are reported to provide strong incentives to developers to invest in energy efficient features. Similarly, Building Sustainability Index (BASIX) provides regulatory incentives for developers to install efficient lighting in new residential dwellings.

Figure 15 below illustrates the large number of actors involved in deciding and implementing the lighting design.

Figure 15: The new building/refurbishment lighting installation process⁴⁷



The complexity of this process and the split incentives for developers pose barriers to the entry of niche high efficiency actors in these transactions. Note that the role of OEM/supplier in this graphic encompasses the roles of brand manager and distributor in our taxonomy of roles.

These types of transactions are also effectively excluded from the ESS. Under the ESS commercial lighting method rules, new build and refurbishments must use the Building Code of Australia (BCA) lighting requirements as the baseline from which savings are calculated. This means that the subsidy provided is generally too low for certificate aggregators to target these projects.

⁴⁷ Commonwealth of Australia (2015). Product Profile: Commercial Lighting, E3: Equipment Energy Efficiency Program

Figure 16: Typical routes to market for new build/refurbishment transactions

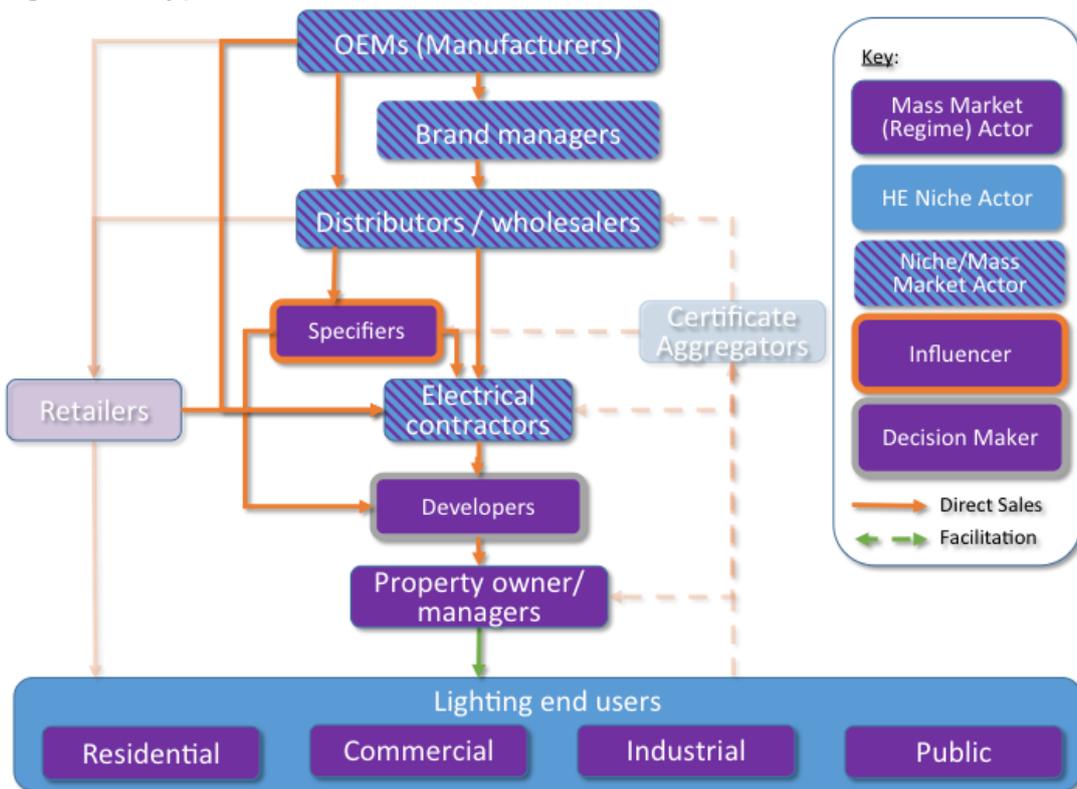
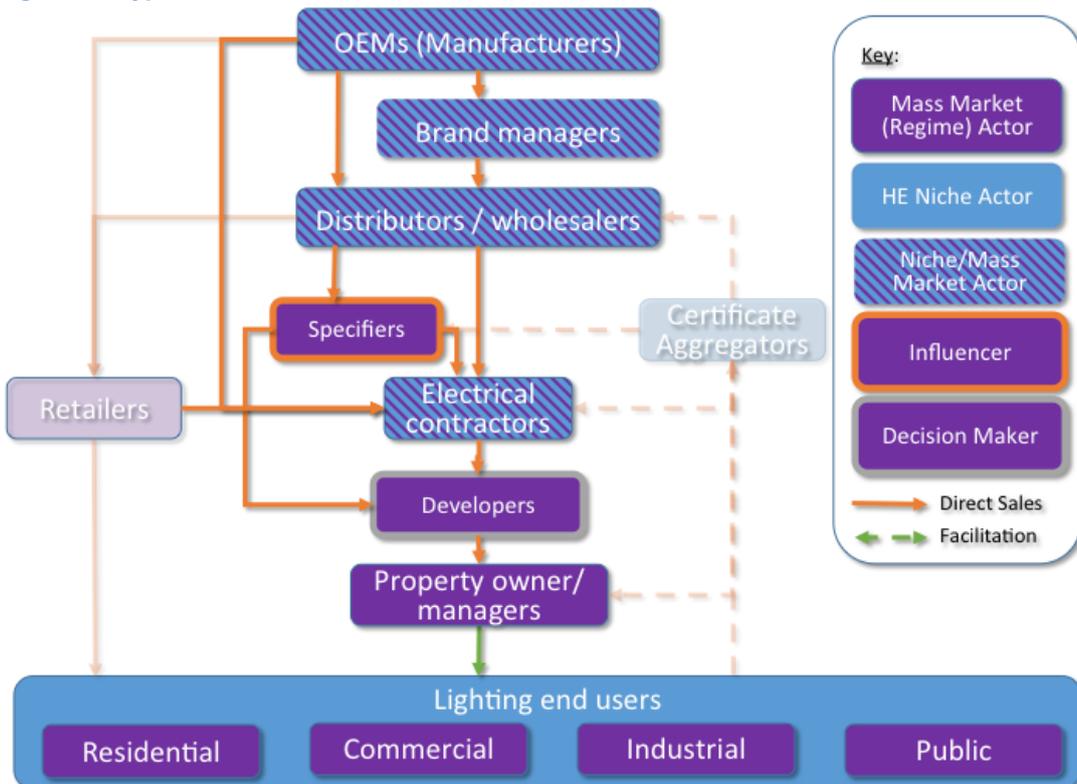


Figure 16 illustrates the major routes to market through the supply chain network for high efficiency technologies for new build/refurbishment transactions.

Figure 16: Typical routes to market for new build/refurbishment transactions



These routes to market also vary depending on the nature of the firms involved in a transaction. However, Figure 16 illustrates the key roles that specifiers and developers have in these transactions. Specifiers are the key influencers of the number, configuration, type, and ultimate efficiency of the lighting solution installed. They develop and provide options to the ultimate decision maker, the developer. Depending on the nature of the firms involved, the specifier may purchase and on-sell the lighting products themselves, or simply advise on the products which are purchased by the electrical contractor or developer directly.

The developer sells the completed property to the property owner, who may also be the lighting end user, or lease the property to the end user. The needs of the lighting end users who pay the bills are only very indirectly considered in these transactions, due to the split incentives discussed above.

Figure 16 also shows that the ESS and certificate aggregators essentially have no role in these transactions, for the reasons discussed above.

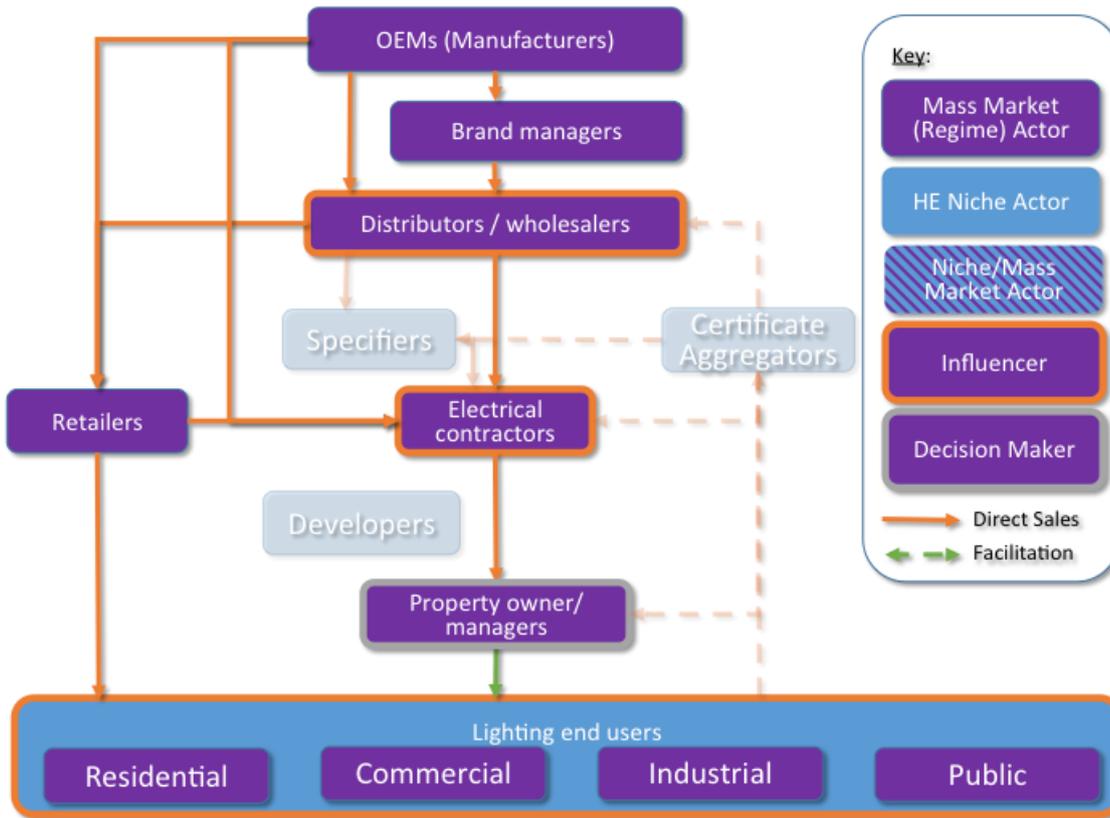
8.3. Maintenance Market

The next largest segment by volume and value is the maintenance market; however, this market appears to be in gradual decline. Maintenance transactions involve routine maintenance and replacement of existing lighting solutions. These typically involve replacing failed lamps and other individual components, based on the same type of equipment already in place. These transactions are characterised by a high level of infrastructure inertia, with the opportunities for high efficiency upgrades limited by the existing equipment types and configuration. These transactions are typically carried out by electrical contractors directly for the property manager or end user (depending on who is responsible for the specific lighting in question). They do not typically involve engagement of lighting specifiers. Depending on the size of the electrical contractor, they may purchase product from an OEM, a distributor, or a retailer.

As illustrated in Figure 17, the electrical contractor often has a great deal of power to control the choice of product. They are key influencers in these transactions, although property managers are the main decision makers.⁴⁸ The distributors who sell product to the installers also have a degree of influence in the pricing and options that contractors have to select from.

⁴⁸ Commonwealth of Australia (2015). *Product Profile: Commercial Lighting, E3: Equipment Energy Efficiency Program*

Figure 17: Typical routes to market for maintenance/retrofit lighting transactions



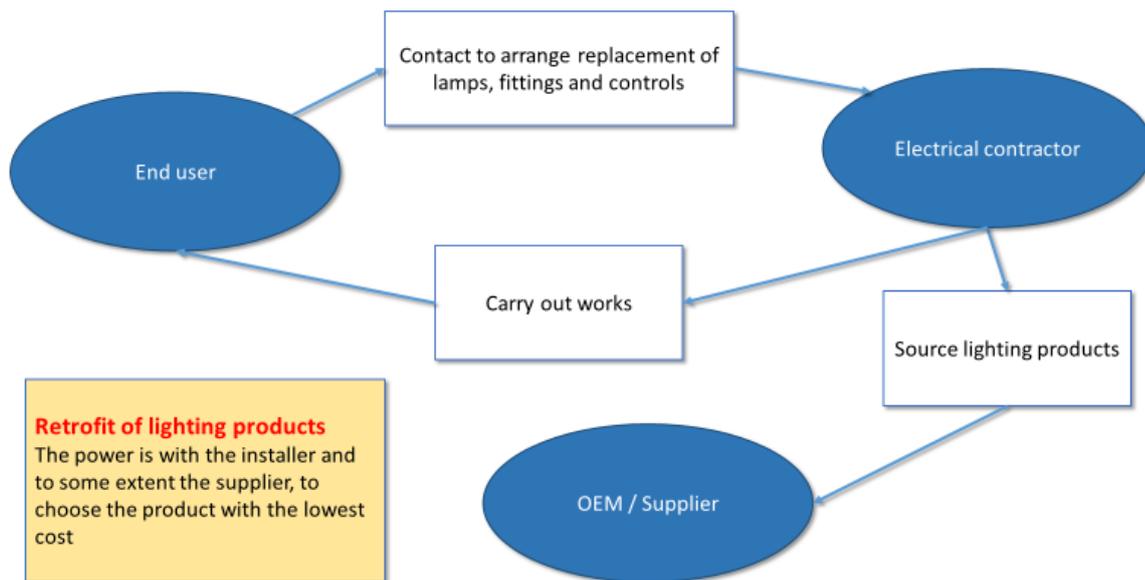
While LEDs dominate new product sales, a significant amount of building stock across sectors has pre-LED lamps, which require regular replacement. However, the importance of this market is gradually diminishing as a result of the global transition to LEDs. For most lighting product types, LEDs are sold as integrated luminaires and lamps, with nominal lifetimes much greater than conventional lamps.

8.4. Retrofit Market

Historically, the retrofit market was a small segment related to the maintenance market, with retrofits occurring if a majority of luminaires reached end-of-life before a building was due for refurbishment. The retrofit market segment has been significantly transformed by the ESS and VEET. It is beginning to emerge from a program-driven niche to a significant regime segment in its own right, albeit smaller than the maintenance and new build segments.

Figure 18 below shows a baseline structure of this market. As illustrated, retrofit transactions involve fewer actors and are much more closely connected to the lighting end user.

Figure 18: The retrofit lighting installation process⁴⁹



As earlier, this graphic uses the terms *OEM* and *supplier* to refer to our definitions of *brand manager* and *distributor*, respectively.

As with the maintenance market, electrical contractors often have a great deal of power to control the choice of product in retrofit transactions, but property managers are the main decision makers.⁵⁰ The distributors who sell product to the installers also have a degree of influence in the pricing and options that contractors have to select from.

Also as in the maintenance market, property managers are the role most directly influenced by the requirements of the end users. End users may or may not be the same organisations as the property manager. Their requirements may include efficiency and running costs, but are also likely to be driven by other considerations such as lowest upfront cost, aesthetics, and the level of disruption associated with the retrofit.

As discussed in Section 0, the ESS and VEET have driven the emergence of a niche energy efficiency retrofit market segment. Until recently, this niche involved mostly new actors with new business models, products, value propositions, and routes to market. In the last year, regime actors have become more actively involved in the ESS niche; however, it is

⁴⁹ Commonwealth of Australia (2015). *Product Profile: Commercial Lighting, E3: Equipment Energy Efficiency Program*

⁵⁰ Ibid

still dominated by the newer specialised actors. The customer-direct business model innovations and new routes to market have also begun to be adopted by regime actors.

There was general qualitative consensus that the ESS niche now dwarfs the traditional retrofit market. Many regime actors reported underestimating the significance of the ESS and the potential size of the energy efficiency retrofit market until recently. There are two main business models in this ESS driven energy efficiency niche.

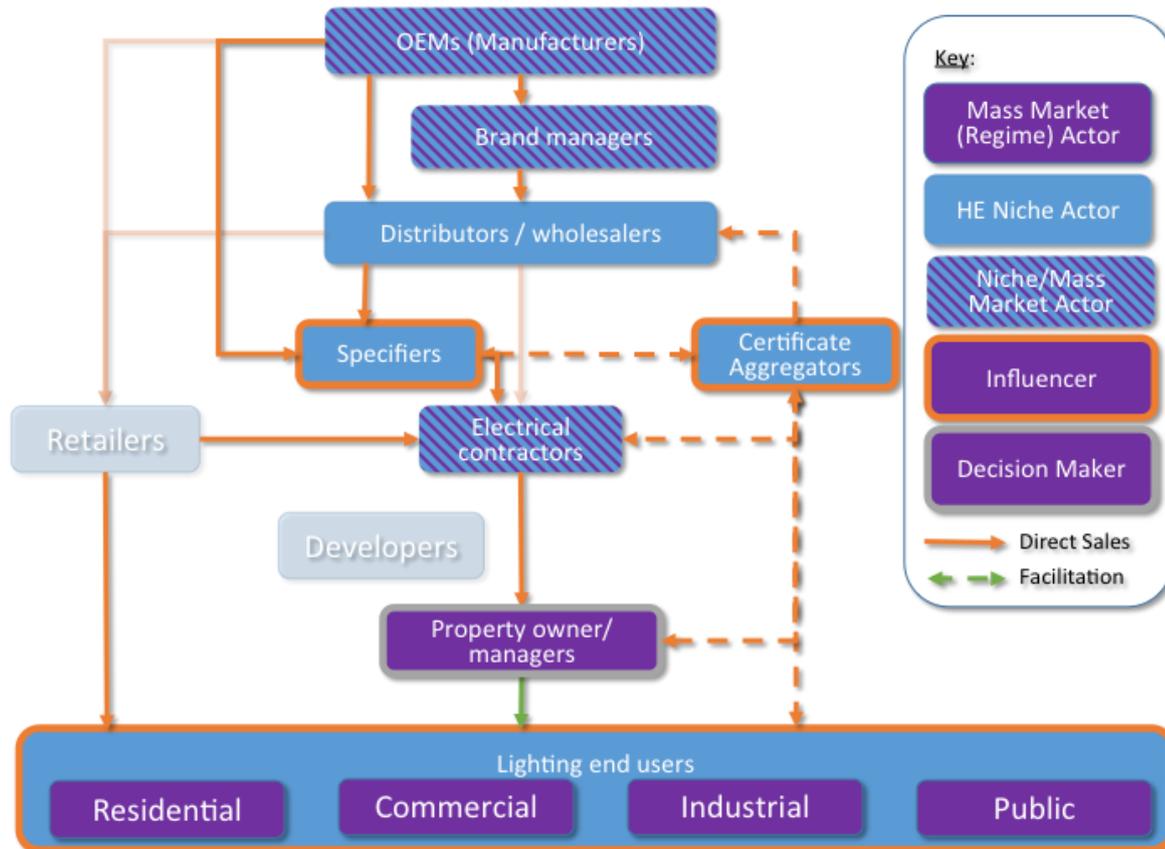
The first is customer-direct business models by the vertically integrated brand managers and certificate aggregators. In this model, the route to market is typically from a vertically integrated firm that performs the roles of brand manager, specifier, and certificate aggregator, direct to the building manager or lighting end user. The vertically integrated firms work with OEMs to develop product which they sell under their own label or a subsidiary brand. They have lead generation and sales teams that actively seek out and engage customers, and persuade them to retrofit their lighting. They then typically subcontract to electrical contractors, who are primarily or exclusively engaged by the firm.

This business model cuts out specifiers and wholesalers and the impact of their margins on final price. Regime actors raised concerns about installation quality due to the elimination of specifiers. Niche brand managers with this business model argued they have in-house lighting designers and design and install products for customer demands, rather than those of the specifier gatekeepers. Elements of this business model and the brand-manager-to-customer route to market are being adopted by regime brand managers, who have now identified this as an important market segment, even without subsidies.

The second business model is that of pure aggregator ACPs. This involves a range of routes to market, with the aggregator facilitating access to subsidies. The main routes to market involve specifiers, electrical contractors, wholesalers, or property managers initiating transactions. Some of these transactions are initiated in response to the impact of subsidies, and others are likely to involve routine maintenance upgrades which obtain subsidies anyway.

As illustrated by Figure 19 below, the typical routes to market for these ESS associated projects are very similar, but not quite the same, as for traditional retrofit projects. In ESS associated projects, the distributors and specifiers tend to be niche specialised energy efficiency players. The brand managers and OEMs from whom product is sourced can involve either niche high efficiency specialists or mainstream regime players selling their niche products.

Figure 19: Routes to market with for ESS facilitated projects



Compared with the maintenance segment, retrofit transactions involve more comprehensive upgrades of existing lighting, as the project is driven by aesthetic and/or energy savings objectives. Importantly, there is strong evidence that the ESS has been the dominant driver of the retrofit market in NSW and, along with VEET in Victoria, has spawned the emergence of niche players with a business model focused around energy efficiency rather than lighting.

As such, retrofit transactions involve fewer split incentives to the adoption of high efficiency lighting. However, split incentives tend to remain in leased properties and public lighting, due to a degree of separation between ownership, control of some lighting types, and the related energy bills.

Retrofit transactions offer more opportunities for the entry of high efficiency actors. Interviews found that the ESS has had its greatest impact in these types of transactions, with most retrofits being driven historically as part of a separate niche market of energy savings retrofits. Regime players have only entered this market in recent years.

The vast majority of ESS facilitated projects to date have been under the ESS Commercial Lighting Formula method for calculating energy savings. This primarily covers commercial and industrial end user markets with limited public lighting. Figure 19 above illustrates that under ESS facilitated transactions, specifiers and certificate aggregators are the key influencers. This contrasts traditional maintenance/retrofit projects where electrical contractors and distributors have more significant roles.

As discussed in Section **Error! Reference source not found.**, ACPs leverage ESS funding to facilitate these high efficiency retrofit projects through three main business models: pure aggregator, aggregator-ESCO hybrid, and vertically integrated ESCO. Under each of these models, ACPs act as the influencers on decision making. This can be either as a pure certificate aggregator or a specifier, based on the subsidy and ESS accepted products that they offer. Alternatively, the ACP may have complete control of the product options offered to customers by acting as both certificate aggregator and specifier.

ACPs often import products directly from overseas manufacturers, bypassing suppliers/distributors. The lighting is installed by electrical contractors, who may be high efficiency specialists, but may also operate in the mass market. The ACPs work directly with customers, who will usually be sold lighting products on a highly discounted basis (e.g. free or payback within one to two years post subsidy). The subsidy is paid as a rebate, promised at time of sale, so there is some uncertainty for the customers. There is a limited role for structured finance providers on a minority of projects.

This subsidy is provided through ACPs who create Energy Savings Certificates (ESCs) to subsidise projects. Some ACPs are vertically integrated with installers, whereas others are pure aggregators who just create and sell certificates for independent installers. Some pure aggregator ACPs also create ESCs for mass market players, selling business-as-usual retrofit projects. There are also auxiliary services associated with certificate creation provided by auditors, brokers, traders, energy retailers (compliance buyers of certificates), and scheme administrators (registration, product test approval).

8.5. Emerging Trends and Sectorial Variations

Emergence of LED Lighting as a Mainstream Technology

Underpinning much of the current and emerging structures in the lighting market is the profound transition that has accompanied the maturing of LED lighting technology. A common theme raised by many stakeholders with considerable experience in the lighting market is that in the last three years, the quality of LED lighting has improved and, at the same time, price has fallen considerably. We are at the point where LEDs are now the best lighting choice, in terms of price and functionality, for many if not most mainstream lighting applications.

A number of stakeholders observed that as a result of this trend, the manufacturing of lighting is moving from companies with expertise in the past dominant lighting technologies (such as fluorescent tubes and electro-mechanical componentry) to solid-state electronics companies. To some stakeholders, this is leading to lighting being produced by companies with little appreciation of the science of lighting. To others, it has opened the door for non-regime businesses to access lighting products outside of the regime industry pathways.

Many stakeholders pointed to the emergence of standards to measure the performance of LED lighting as a key step in gaining the confidence to use this technology. In particular, the standards developed by the Illuminating Engineering Society of North America's (IESNA's) Solid-State Lighting Subcommittee of the Testing Procedures Committee were seen by many to be de-facto international standards.⁵¹

Main Market Categories

The interviews we conducted confirmed the three broad categories of lighting transactions discussed above: the new build/refurbishment market, the maintenance market, and the retrofit market. However, within these categories, the interviews revealed

⁵¹ As an example, many stakeholders interviewed noted that registration of LED products to the ESS's Emerging Lighting Technology register requires submission of test reports to IESNA's LM7-9 and LM-80 test methods.

a wide range of approaches taken by different players in the lighting market, including many innovative approaches which have only recently been established.

New Build/Refurbishment Market

Many stakeholders that were interviewed (spanning the full lighting supply chain) noted that LED lighting is now the norm for new builds, and in particular, integrated LED luminaires. One large vertically integrated regime specifier was able to provide detailed information demonstrating that LED lighting costs significantly less than fluorescent for new builds. However, this stakeholder argued that the only situation where fluorescent lighting would be cheaper than LED would be where the lighting installation does not comply with the requirements set out in the BCA. In contrast to this dominant view, one large property manager noted that it still uses T5 fluorescents for refurbishments (especially where there is a tight budget), as T5s can provide similar light power density than LEDs.

The larger corporate developers and property owners/managers that were interviewed identified corporate sustainability policies and the desire to attract good tenants as key drivers for the installation of high efficiency lighting.

Stakeholders confirmed the practice of lighting for new builds being specified through architects engaging lighting designers. As such, the lighting designer can have a significant influence over the type of lighting installed. A number of stakeholders interviewed noted that lighting designers may be slow to embrace new technologies—either because they are associated with regime lighting suppliers, or because they rely on established work practices.

Many stakeholders noted that even where high efficiency lighting is specified, less efficient lighting may be installed where the builder and/or electrical contractor sources non-complying lamps and/or fittings. These same stakeholders noted the lack of compliance checking by building regulators as contributing to this situation.

Many stakeholders also confirmed the split incentives that limit high efficiency lighting refurbishments. For small and medium sized tenants, there is a reluctance to invest in lighting improvements, especially where this involves investing in the building owner's assets.

There were some exceptions to this:

- One property owner noted that during lease renegotiations and in oversupplied markets, it offers upgraded tenancy lighting as a strategy to retain tenants
- Large corporations with corporate sustainability policies will upgrade lighting, especially where paybacks for the investment are within the lease period
- A shopping centre owner that was interviewed requires tenants to meet lighting design guidelines to contribute to sustainability objectives, and ensure a consistent lighting standard across the centre

Maintenance Market

A number of stakeholders that were interviewed noted that the maintenance market is a significant source of ongoing demand for older technology lighting. Reasons offered for this were:

- A lamp replacement is cheaper than a full luminaire upgrade
- A reluctance to replace luminaires one at a time, as this would lead to inconsistent look and lighting

Retrofit Market

Many stakeholders noted that the ESS was a significant driver of lighting retrofits in NSW. However, the degree of that influence varied for different end user types.

For the residential market, the ESS has no material influence. Stakeholders noted that the ESS rules surrounding residential retrofits act as barriers to this activity. Accordingly, residential lighting retrofits are largely limited to the lighting components of owner-initiated home renovations. In these cases, the builders and/or electrical contractor, together with the distributors they source lighting from, are key influencers in lighting choice.

Many stakeholders noted that the ESS is a key driver for retrofits to small-to-medium sized businesses. Also, they noted that the businesses typically do not initiate these retrofits. For example, regime lighting distributors that we interviewed discussed how they worked with their electrical contractor customers to identify small to medium businesses that could be offered retrofit proposals, supported by ESS incentives.

Interviews with those involved in the large business retrofit market identified that the market is served by large regime organisations, often with vertically integrated

capabilities. We interviewed a number of these businesses and discovered several innovative retrofit products that they offer their customers. These include:

- Energy performance contracts
- Lighting service contracts, where a lighting retrofit is supplied, installed, and maintained for a fixed (multi-year) period, and paid for through a percentage of energy cost savings over the period

Many large property owners interviewed had sufficient scale to have in-house capability to drive their lighting retrofit program. One such business used a tendering process to establish a panel of approved lighting suppliers and installers. It used this approach to achieve quality lighting products with warranty periods that exceeded the typical payback period for their retrofit projects.

Typically, these larger businesses sourced lighting from regime brand managers or their agents. One property manager noted that it was open to considering newer entrants to the market, though these still needed to be reasonably established (at least ten years old), so as to provide some confidence that they would be around over the warranty period of the lighting (typically five to seven years).

CHAPTER 9

Market Structure Key Finding

Findings

Our research concludes that the ESS has had significant impacts that helped improve the efficiency of the NSW lighting market, in addition to background conditions. These impacts continue to materially influence the structure of the lighting market in NSW. Some of these impacts appear to be driving a lasting transformation.

This activity coincided with a once-in-a-generation transformation of the lighting market, internationally and in Australia, due to a transition to LEDs as the dominant technology. It also coincided with national changes in electricity prices and consumer attitudes, and significant lighting activity under the Victorian Energy Efficiency Target (VEET) scheme.

The GREP program also appears to be driving a material increase in the adoption of energy efficiency lighting by major government agencies. Within the scope of this research, it was not possible to detect whether GREP or EEB are having transformative impacts on underlying market structure and dynamics. Both involve relatively small numbers of participants, and more focused studies on the impacts to those participants would be required.

The key findings include:

- Before Government intervention, the NSW and national lighting market was characterised by two main segments, in which end users generally have little direct role in decision making
 - In the new build/refurbishment specification segment, brand managers or wholesalers typically sell products at a premium to specifiers, who make decisions on the developer or building owner's behalf. These decisions are within agreed parameters determined by the overall project budget, aesthetic objectives, and building code requirements, with lighting as only a small portion of the overall project costs and considerations
 - In the lower value maintenance segment, wholesalers typically sell to contractors, who make decisions on the building manager's behalf until buildings are refurbished. These decisions are within agreed parameters determined by budget and constraints of the existing luminaires

- Government interventions have occurred against the baseline of a massive disruption to the lighting market, as part of a global transition to LEDs in all end user sectors
 - This transition was driven globally through step improvements on quality, efficiency, and price of LED lighting
 - Having belatedly embraced LEDs, the historically dominant lighting brands continue to struggle against more agile and efficient new entrants
 - LEDs are more like electronic products than traditional lighting, having similar market dynamics and short product lifecycles due to constant improvements
 - The lamp replacement market is declining as LEDs typically involve integrated lamps and luminaires, eroding revenue while maintaining costs of legacy product lines for established actors
 - Warranty periods for LED lighting now typically exceed the payback period for lighting upgrades. Along with the integrated nature of LED lighting, this is resulting in some facility managers and lighting service contractors using warranty (rather than maintenance) to manage their lighting assets
 - Long warranty periods have also caused the emergence of new financing models for lighting upgrades, especially for services provided to large corporate clients
 - The long multi-national supply chains of major brands are high-cost and slow compared with easily accessible, finished products direct from hundreds of thousands of original equipment manufacturers (OEMs) in China
 - Niche actors have conducted considerable research and development into integrating lighting systems with the Internet of Things (IoT), creating value prospects potentially far greater than the value of the lighting service alone
- The ESS has a material impact on the structure of the lighting market in ways that are likely to be transformative for the adoption of energy efficient lighting in the medium term

- The ESS has had significant impacts on the structure of the lighting market, driving the emergence of a new retrofit market segment and new customer-direct business models that drive down costs and are significantly accelerating the baseline transition to high efficiency lighting
- These impacts appear to be transformative, as niche practices
- have begun to be adopted by regime lighting suppliers
- are likely be sustainable for large customers without subsidies and have the potential to become sustainable for medium customers
- are beginning to be extended to non-lighting energy service markets such as heating, ventilation, and air conditioning (HVAC) and control systems
- No evidence was found as to the impact of EEB or GREP on the structure of the lighting market

The next Part examines the market dynamics, in terms of drivers and barriers for energy efficient lighting, behind and resulting from these structural trends.

Part 3

Dynamics of the NSW Lighting Market

CHAPTER 10

Institutions and Social Practices

10.1. What are social practices

Social practices refer to a set of dominant behaviours, attitudes and norms within a social group. These behaviours are more than simply habits or passive tendencies; rather, social practise are those behaviours (or avoided behaviours) which are reinforced (or discouraged) by the attitudes and actions of other members of the group.⁵² In this instance, the group we are considering consists of the people who are professionally involved in the lighting market, through their work for actors in the supply chain network or associated institutions.

Social practices include both hard practices and soft practices. Hard practices include formal regulatory frameworks and codes of practice. Compliance with these is formally managed and enforced by institutions, and is informally enforced through social norms by other members of the group. Examples include lighting standards and the Building Code.

Soft practices are those less formal conventions that can be observed, and are enforced by the responses and attitudes of other members of the community. For example, these might include a preference to deal with the same individuals or brand names year after year, rather than try the goods and services of a new (niche) entrant. Individuals are notionally free to changes suppliers; however, they may face informal pressure not to, such as the perceived risk, social or transaction costs, or simply social awkwardness of changing. These can also include information barriers among customers and other actors about the costs and savings associated with adopting a new technology.⁵³

10.2. Lighting market hard social practices

The major hard practices that provide drivers and barriers to the adoption of high efficiency lighting, and the institutions which administer them for the NSW lighting market, are set out in Table 4 below.

⁵² Esfeld (2003). *What are Social Practices?* Indaga, Revista Internacional de Ciencias Sociales y Humanas 1, pp. 19–43

⁵³ Common Capital (2014). *Characterising the New South Wales Energy Efficiency Market*

Table 4: Hard social practices

Practice	Instrument	Institution	Driver/Barrier	Enforcement
Minimum standards for the efficiency of illumination in a new commercial building	Building Code of Australia (BCA), Section J	Australian Building Codes Board (ABCB)	Weak driver – prevents lowest efficiency solutions, while not requiring highest efficiency	Through planning approvals under the Environmental Planning and Assessment Act 1979 (NSW)
Minimum standards for new residential buildings	Building Sustainability Index (BASIX)	NSW Department of Planning	Weak driver – prevents lowest efficiency solutions, while not requiring highest efficiency	Through planning approvals under the Environmental Planning and Assessment Act 1979 (NSW)
Minimum levels of illumination for interior lighting	Australian Standard (AS) 1680	Standards Australia	Neutral (efficiency agnostic) – requires only minimum light output levels	Not mandatory, but widely used as guidelines by specifiers and referenced through other instruments, including the BCA and ESS

Practice	Instrument	Institution	Driver/Barrier	Enforcement
				Commercial Lighting Formula (CLF)
Minimum levels of illumination for public lighting (roads and public spaces)	Australian Standard (AS) 1158	Standards Australia	Neutral (efficiency agnostic) – requires only minimum light output levels	Not mandatory, but widely used as guidelines by specifiers and referenced through other instruments, including the ESS Commercial Lighting Formula (CLF)
Minimum performance standards for luminaires for road and street lighting	Standards Australia TS 1158.6	Standards Australia	Neutral (efficiency agnostic) – requires only minimum light output levels	Not mandatory, but widely used as guidelines by specifiers and end users
Product energy efficiency standards for	Greenhouse and Energy Minimum Standards	GEMS Regulator, (Australian Department	Driver – effectively bans least efficient technologies, transitioning niche products into	Controls on the import and sale of selected products

Practice	Instrument	Institution	Driver/Barrier	Enforcement
incandescent lamps, linear fluorescent lamps, compact fluorescent lamps, ballasts, transformers, and converters	(GEMS) Act 2012	of the Environment)	mainstream regimes	formally monitored (industry reporting) and enforced by the Australian Government GEMS Regulator
Energy performance ratings for commercial buildings	National Australian Building Energy Ratings Scheme (NABERS)	NABERS administrator (NSW Officer of Environment and Heritage)	Driver – provides incentive for property owners/managers to adopt high efficiency lighting	Widely voluntarily adopted by NSW (and national) commercial building owners, with energy performance ratings formally (voluntarily) considered in property valuations and investment decisions Referenced in Commercial Building

Practice	Instrument	Institution	Driver/Barrier	Enforcement
				Disclosure Program
Mandatory disclosure of commercial building energy efficiency	Commercial Building Disclosure Program (CBD)	Australian Department of the Environment	Driver – provides incentive for property owners/managers to adopt high efficiency lighting	Building Energy Efficiency Certificates (BEEC) based on NABERS ratings and tenancy lighting efficiency assessments legislatively required to be disclosed at the sale or lease of property over 2,000 m ² (1,000 m ² from 1 July 2017)
Subsidies for lighting upgrades	NSW Energy Savings Scheme (ESS) Commercial Lighting Formula (CLF) and Home Energy Efficiency Retrofit	ESS Administrator (NSW Independent Pricing and Regulatory Tribunal (IPART))	Driver – provides incentive to promote/undertake high efficiency lighting retrofits	Many lighting retrofit projects are eligible to access subsidies for energy savings by creating and selling certificates under the \$100

Practice	Instrument	Institution	Driver/Barrier	Enforcement
	(HEER) methods			million per annum ESS
ESS register of accepted emerging lighting products	NSW Energy Savings Scheme (ESS) Emerging Lighting Technology (ELT) product acceptance	ESS administrator or ESS mutual recognition of acceptances by the Victorian Energy Efficiency Target (VEET) scheme administrator (Victorian Essential Services Commission)	Both – seen as either driver or barrier by different actors in the market	Products not subject to an existing Australian Standard (predominantly LEDs) must be accepted by the ESS administrator to be eligible for ESS subsidies
Corporate policies	Corporate policies relating to risk management, sustainability, and corporate profile	Large corporations	Drivers – risk management, corporate profile, business attraction, and retention	Public reporting, and board and shareholder accountability

Interviews with stakeholders identified five of these hard social practices—Building Code of Australia requirements, GEMS, ESS incentives, ESS lighting product registration, and corporate policies—have a significant influence on the type and quality of lighting currently being installed in NSW.

Each of these is discussed below.

Building Code of Australia (BCA)

Architects, specifiers, developers, and property owners all identified the BCA's lighting energy efficiency requirements as key influences in the type of lighting installed in new builds and refurbishments that trigger the requirements. A number of stakeholders, however, noted that this did not always translate to efficient lighting being installed. The two main reasons identified were:

- The installation of lighting products different to and less energy efficient than those specified
- The lack of compliance checking that as-built work is consistent with the approved design

One architect we interviewed explained that some lighting designs have specific luminaires specified, especially in cases where a lighting designer is chosen because they have a relationship with a trusted lighting supplier. In other cases, the term “or equivalent” is specified, allowing builders tendering for the job to propose alternate products, opening up the potential for lower performing lighting. The split incentive between developers and those who will own or tenant the building adds to this.

Another common theme raised by stakeholders was the lack of compliance checking for new builds/refurbishments. One architect noted that this can occur internally, when the architect is not retained to oversee the building work. Other stakeholders noted the lack of compliance checking associated with government planning and building approval processes. One stakeholder recounted a recent shopping-centre car park upgrade, where the builder installed inefficient lighting, counter to the specifications, in order to rein-in overall project costs.

Two stakeholders interviewed noted that there is a current proposal to halve the BCA's lighting power density requirements for commercial buildings from 2019. Given the improvements in LED quality and reduction in price, the stakeholders considered this a

realistic proposal, one which would be sufficient to see the end of fluorescent lighting installed in new builds.

Greenhouse and Energy Minimum Standards (GEMS)

Greenhouse and Energy Minimum Standards (GEMS, formerly referred to as Minimum Energy Performance Standards, or MEPS) have played an important role in improving lighting energy efficiency for many years. There have been GEMS requirements for linear fluorescent lighting, and the GEMS for incandescent and compact fluorescent lighting were the instruments that drove Australia's incandescent lighting phase out.

A GEMS is currently being developed for commercial lighting. Interviews with stakeholders involved in this highlighted the following points:

- The maturity of LED lighting now offers the potential to achieve significant energy savings benefits from more stringent energy efficiency requirements, and to apply these to a wider range of lighting products and systems
- The emergence of integrated LED luminaires, with the potential for specialised designs and features, presents a particular challenge to setting workable product-level efficiency standards

The original GEMS proposal explored the potential for setting GEMS for luminaires as well as lamps, and for phasing out linear fluorescent tubes. Following stakeholder consultation, the goal of setting GEMS requirements for luminaires is being pared down to integrated recessed downlights. A GEMS for non-integrated luminaires is not considered feasible, and progress on integrated luminaires (beyond downlights) is being deferred. At the lamp level, GEMS proposals for phasing out halogens and setting LED performance standards are in progress. The proposal to phase out linear fluorescent lamps is being revisited in 2019, as regime stakeholders argued that it is a product class already on the way out.

Stakeholders identified that the biggest gains from this revised proposal will come from the phase-out of halogen lamps and improving the efficiency of LEDs that will replace them.

From our interviews, we did not get a sense of strong coordination across the parties setting regulatory requirements for lighting. (specifically, the Building Code of Australia, ESS, VEET, and the GEMS program). Whilst there is dialogue amongst the parties responsible for these initiatives, we did not observe any strategic coordination.

ESS Incentive

The ESS creates financial incentives for the delivery of energy efficiency activities. The amount of financial incentive is related to the level of energy saving that an activity provides, and the energy savings are measured against a business-as-usual baseline. End users typically experience this financial incentive as a discount or rebate on an energy efficiency activity.

Interviews with a wide variety of lighting industry stakeholders identified that the importance of this incentive varies significantly across different classes of end users. Large corporate end users of lighting often described the ESS incentive as a bonus, rather than the central factor governing a decision to upgrade lighting.

Interviewed stakeholders presented a very different story for ESS activity in small to medium businesses. For these, the ESS incentive associated with a lighting retrofit is often necessary to gain the end user's agreement to the retrofit. Further, such businesses may not even consider lighting upgrades unless they are contacted by a party offering them a discounted service. Many stakeholders noted that the rules surrounding residential activities are precluding lighting improvements in this sector.

The interviews exposed a considerable range of views over the quality of lighting retrofits associated with the ESS. There was a reasonably broad agreement that quality was particularly a problem in past years, with a number of stakeholders noting improvements since 2014. With regards to current installations, many stakeholders held the view that, in general, the quality of ESS lighting is superior to that installed in new builds (which are mostly, if not completely, outside of the scope of the ESS).

Some stakeholders noted some spill-over of the ESS into non-ESS lighting activities. This was most notably the case in large corporate end users, where it was common to use the ESS product standards and installation standards as standard practice across the country.

The vast majority of interviewed stakeholders utilised the ESS Commercial Lighting method, which involves upfront deeming for lighting activities. Only one stakeholder, a large national property owner and manager, used the NABERS method to obtain ESS credits for its building upgrades. This stakeholder argued that using the NABERS method avoided the potential for double counting of individual activities. As mentioned above, the ESS is typically a weak incentive for such large corporations, making the option of obtaining annual credits (rather than upfront) viable.

Niche brand managers emphasised that the ESS co-payment requirements was one of the most important features of the Commercial Lighting method. Regime actors were also strongly opposed to giveaway models, but seemed less aware of the precise ESS requirements that have prohibited giveaways. Some interviewees reported instances of ACPs trying to find ways around co-payment requirements. However, the major niche brand managers reported that the co-payment requirement had, and continues to have, a very pronounced and transformative impact on the nature of the NSW retrofit market. They argue that free product creates competition based solely on lowest cost, with no customer concern for quality. They contrast the NSW market to the Victorian commercial lighting market, which is based on giveaways. They say a small or large customer co-payment requires customers to engage with quality, and allows the development of sustainable business models which can survive on low-to-no subsidy and expand to other technologies. Those actors that support co-payments believe that the residential retrofit market is too hard to reach unless product is free.

ESS Lighting Product Accreditation

Niche and regime brand managers identified ESS and VEET product accreditation requirements as having significant impacts on the actors and products involved in the retrofit market. Niche brand managers who design product specifically for ESS and VEET accreditation are strongly in support of these processes, and argued that these requirements were more stringent than fair trading approval processes. They also argued strongly that they should be retained if a national standard for LEDs were to be introduced.

In contrast, regime brand managers had reservations about these processes. They faced obstacles accessing the ESS market due to scope and time frame of product approval processes, especially given the practicalities of accrediting their extensive product range. Unlike niche actors, regime brand managers tended to see a possible national standard as superseding ESS and VEET requirements. One major distributor that works exclusively with regime brands argued that IPART/ESC approvals would still be required due to the lack of enforcement for national standards.

Regime actors also expressed concerns with restrictions on non-energy related features (such as colour temperature) as adding barriers to obtaining product accreditation. They argued that ESS approvals focused on the wrong aspects of lighting technologies, and

didn't consider quality with respect to the appropriateness of a given product for an end use.

However, regime actors also acknowledged that the quality of products in the ESS and VEET has grown significantly over recent years, and attributed this to the approvals process. Both regime and niche actors complained of cheap, low-quality competition from new small actors bringing in small shipments of product straight from OEMs.

Niche actors (particularly ESS focussed brand managers and aggregators) reported that ESS approval is used by brand managers as a de facto certification of quality in the absence of an official Australian standard for LEDs, and is driving higher quality product. Regime actors also recognised the ESS requirements as a de facto standard.

Despite complaints with the scope and process, even some regime actors identified ESS approval as a (temporary) point of competitive advantage when selling to wholesalers.⁵⁴ Regime brand managers who focussed on high priced products for the architectural lighting market did not share this view for their products.

Several brand managers (niche and regime) noted that product lifecycles for LEDs are typically six months, and that approvals of up to eleven months mean products can be out of date by the time they are accepted into the ESS.

Actors consistently noted that IPART was generally better than the Victorian Essential Services Commission in terms of length of time to accredit product. It was noted that VEET has additional restrictions on approvals linked to aggregators that aren't barriers in NSW.

Corporate Policies

For the large corporate end users interviewed, corporate policies were a key driver of energy efficient lighting upgrades. Corporate policies identified included:

- Attaining GreenStar and/or NABERS ratings for policies
- Attaining targets against international sustainability benchmarks, such as GRESB⁵⁵

⁵⁴ The interviewed OEM noted that they had decided to make all products that they sold in Australia ESS and VEET compliant, despite concerns with the process. This was due to the perceived short-term advantage when selling their low-cost product to wholesalers who may be ESS market participants. This OEM has one full time employee to manage product approvals.

⁵⁵ <https://www.gresb.com/>

- Investing in lighting and other building improvements to attract good tenants. One property owner noted that they sometimes invest in lighting upgrades as a strategy to retain tenants

There was a consistent view across corporate end-users that factors such as corporate policies and rising energy costs were significant drivers of energy efficiency improvements, with ESS incentives being weaker (and often described as a bonus).

10.3. Soft Social Practices

The dominant soft practices that provide drivers and barriers to the adoption of high efficiency lighting in NSW are set out in Table 5.

Table 5: Soft social practices

Practice	Actor(s)	Driver/Barrier	Enforcement
Customer preference for like-for-like replacement	End user, and throughout supply chain network	Barrier – unless/until overcome, at which point it becomes a driver of continued practice if the experience is positive	Internal and external institutional pressure to avoid risk, discomfort, and effort through changing practices
Perceived aesthetic merits of downlights	End user (residential)	Barrier – result in over lighting, and use of inefficient halogens	Self and social group enforcement of fashion norms
Reluctance of regime actors to innovate	Brand managers	Barrier – without external competitive pressure and/or strong customer	Self-enforcement based on perceived/actual financial risk of lost

Practice	Actor(s)	Driver/Barrier	Enforcement
		demand, regime actors have little incentive to reduce cost of niche high efficiency products, lest they cannibalise their sales of mass market products	revenue/share through change

Stakeholder interviews identified that soft social practices in the new build market, which is heavily focused on regime brand managers and specifiers, have had significant negative influences on this sector’s rate of LED lighting adoption. Interviewed architects noted that some specifiers have been slow to embrace LED lighting, and where LEDs are specified, some builders substitute them for lower efficiency lighting.

The counter situation was found in the retrofit market. The ESS, and the retrofit businesses it has spawned, have served as an important positive influencer, raising the profile of the benefits of retrofits to end-users.

Larger end-user interviewees also identified NABERS base building ratings as a driving force in upgrading commercial building lighting, although this influence is limited to common area lighting (and ACPs and niche brand managers reported significant unrealised potential in office tenancies). The Commercial Building Disclosure (CBD) program tenancy requirements were perceived as only covering very large tenancies, and not having a significant impact on this market.

CHAPTER 11

Technology and Infrastructure Inertia

Technological and infrastructure inertia is a characteristic widely observed in complex systems that follow an evolutionary dynamic. It is often the outcome of rational behaviour by utility-maximising individuals, at least in the short term.⁵⁶ Technology and infrastructure inertia is caused by the additional cost, materials, and skills required to adopt a new technology. There are also costs inherent in any risks that an actor takes when moving to a new product. Changing to high efficiency lighting products can result in significant long-term energy bill savings for the end user, but at a short-term cost for them and all other actors in the market.

Some examples of technological and infrastructure inertia in the NSW lighting market are detailed in Table 6 below.

Table 6: Examples of technological and infrastructure inertia in NSW lighting market

Role	Technological and Infrastructure Inertia
OEMs	<ul style="list-style-type: none"> • Costs of retraining staff on how to design, manufacture, and assemble new products • Costs of purchasing or retooling manufacturing equipment • Costs of new quality control processes
Brand managers	<ul style="list-style-type: none"> • Additional costs of research and development, market research, marketing, and training • Market risk of new products
Distributors	<ul style="list-style-type: none"> • Costs of travelling overseas to find and evaluate new manufacturers • Risks of taking on new manufacturers • Costs of testing the performance of new products • Costs of ensuring that new products comply with Australian standards and regulations
Retailers	<ul style="list-style-type: none"> • Costs of retraining staff on how to sell new products
Electrical contractors	<ul style="list-style-type: none"> • Costs of retraining staff how to install new products • Risks of losing business if new products fail, customers are not satisfied, or if price is too high

⁵⁶ Mokyr (2000). *Innovation and Its Enemies: The Economic and Political Roots of Technological Inertia in a Not-so-Dismal Science*. Oxford University Press

Role	Technological and Infrastructure Inertia
Specifiers	<ul style="list-style-type: none"> • Costs of learning about the performance of new products • Reputational risks associated with specifying new products if those products lead to poor customer outcomes
Aggregators	<ul style="list-style-type: none"> • Costs of accreditation and compliance in the ESS • Costs of sourcing and evaluating new products • Costs of acquiring customers and/or installer partners
Developers/property owners	<ul style="list-style-type: none"> • Higher construction costs for specifying high efficiency products • Risks of failure, poor aesthetics, or customer non-acceptance from new products
End users	<ul style="list-style-type: none"> • Costs of replacing a lamp much lower than the costs of replacing the entire luminaire • Costs of maintenance increase where there are different lighting products • Costs of retraining maintenance staff to maintain new products • Upfront costs of less efficient lighting can be less than efficient lighting

Regime brand managers were initially reluctant to embrace LED lighting, due to the legacy value of their capabilities in fluorescent, HID, and incandescent technologies. Their business models were also based around high margin luminaries for the specification market with a long tail of replacement lamps. The challenges of rapid product development in the electronics industry, long product lifetimes, and integrated products without replacement lamps all proved barriers to regime adoption of LEDs. Whilst these barriers have been overcome, regime brand managers are struggling to compete on price due to the costs of their long supply chains.

The other main issue of infrastructure inertia is the lack of interchangeability between LEDs and existing luminaires and control gear. In addition, different policy settings see much greater prevalence of lamp-only upgrades to LED downlights and LED tubes. Lamp-only replacements don't face the same technology inertia issues, as they are able to reuse existing luminaires. Niche brand managers and certificate aggregators typically argue that these products are of good quality, whereas regime actors argue that LEDs are a different technology and only complete, purpose-built retrofits are appropriate.

From our interviews, we came across a number of cases of inertia in embracing new lighting technologies. These included:

- Legacy issues for regime brand managers, as discussed above
- Reliance on information from specifiers who had not yet fully embraced the opportunities of LED lighting
- Poor experiences of the first wave of LED lighting and a lack of awareness of the product improvements that have occurred since
- A reluctance for end users to revisit recently retrofitted sites, even where more efficient technology is now available

At the same time, we came across numerous cases of businesses that are not bound by these inertias. This demonstrates that the driving force for these cases rests more in capabilities, opportunities, and motivations, as discussed in the following section.

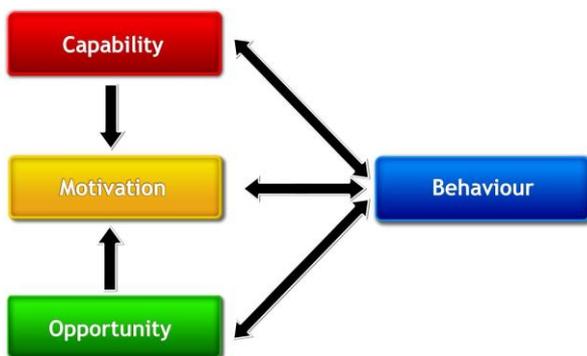
CHAPTER 12

Capability, Opportunity, and Motivation

12.1. COM-B Overview

Another way of assessing market dynamics is with the Capability, Opportunity, and Motivation Behaviour (COM-B) model. In this model, an interaction of capability, opportunity, and motivation gives rise to behaviour, and behaviours in turn influence those three components. These interactions are shown in Figure 20, with arrows indicating that a component affects another component of the system. Notice the feedback system between the behaviours and the drivers of behaviour.

Figure 20: The COM-B model⁵⁷



In this model, capability, opportunity, and motivation are defined as follows:⁵⁸

Capability is the individual's psychological and physical capacity to engage in the activity concerned, which includes having the necessary knowledge and skills.

Motivation is all the brain processes that energize and direct behaviour, not just goals and conscious decision-making. This includes habitual processes, emotional responding, and analytical decision-making.

Opportunity is all the factors that lie outside the individual that make the behaviour possible, or prompt it.

⁵⁷ Michie et al. (2011). *The Behaviour Change Wheel: A new method for characterising and designing behaviour change interventions*, Implementation Science, 6:42

⁵⁸ Michie et al. (2011)

12.2. Actor motivations, capabilities, and opportunities

In addition to using elements of COM-B in the program logic and theory of change, we took the concepts for motivations, capabilities, and opportunities to understand the baseline dynamics of the market. Table 7 **Error! Reference source not found.** below summarises the motivations, capabilities, and opportunities of the main roles in the NSW lighting market.

Table 7: Motivations, capabilities, and opportunities of the main roles in the NSW lighting market

Role	Motivations	Capabilities	Opportunities
Brand managers	<ul style="list-style-type: none"> • Want to retain or maximise market share • Want to maintain or increase profit margins • Need to include offerings of new products if they become emergent, but do not want to unnecessarily cannibalise existing product market 	<ul style="list-style-type: none"> • Existing distributor/retailer/OEM/specific relationships • Well-known brand names 	<ul style="list-style-type: none"> • Minimum performance standards may require products to be redesigned • Contract renewals may involve new stock or pricing
Distributors	<ul style="list-style-type: none"> • Want to retain or maximise market share • Need to include offerings of new products if they become emergent • Want to maintain relationships with retailers and installers 	<ul style="list-style-type: none"> • Tend to trust existing relationships with manufacturers, installers, and retailers 	<ul style="list-style-type: none"> • Contract renewals may involve new stock or pricing • New manufacturers may offer new products
Retailers	<ul style="list-style-type: none"> • Want to retain or maximise market share 	<ul style="list-style-type: none"> • Existing distributor relationships 	<ul style="list-style-type: none"> • New products available from new or existing distributors

	<ul style="list-style-type: none"> Want to attract customers to retail store with the types of products they want 	<ul style="list-style-type: none"> Existing customer relationships 	<ul style="list-style-type: none"> Contract renewals may involve new stock or pricing
Electrical contractors	<ul style="list-style-type: none"> Want simple, repeatable jobs to allow profit maximisation Not typically motivated by customer's future energy savings 	<ul style="list-style-type: none"> Electrical trade expertise General understanding of lighting performance for existing products 	<ul style="list-style-type: none"> Renewing contracts with suppliers Walk-in to retailers Customers may ask installers for recommendations on new products
Specifiers	<ul style="list-style-type: none"> Want to enhance building aesthetics Want to improve building user experience through high quality lighting Want to minimise costs for client 	<ul style="list-style-type: none"> Lighting design expertise Architectural expertise Possibly limited understanding of performance of latest technologies 	<ul style="list-style-type: none"> New products may provide lighting performance that is not available in existing products, especially on projects where architecture/design is more important than price
Aggregators	<ul style="list-style-type: none"> Business revenue (ESC revenue) solely and directly relies on sales of high efficiency products 	<ul style="list-style-type: none"> Direct relationships with customers who are engaged with energy efficiency 	<ul style="list-style-type: none"> Business model doesn't require direct participation in the supply chain – can partner with existing lighting installers Use of door-knocking to acquire customers

**Developers
/Property
owners**

- Want good quality lighting to attract buyers
- Want to minimise installed costs to maximise profits
- There may be an advantage in distinguishing new building offerings by incorporating latest technologies
- Negotiating lowest cost, quality installations with installers
- Clearly specifying lighting product requirements
- New buildings allow a transition to new technologies at relatively low cost

End users

- Want good quality lighting
- Want to minimise capital costs
- Want to minimise maintenance costs
- Want to minimise energy bills
- Usually maintain lights themselves (or manage subcontractors)
- Limited ability to move to new technologies
- Limited ability to differentiate between lighting performance when refurbishing, renting, or purchasing buildings
- When lamps fail, there is an opportunity to replace with better products
- Routine maintenance could plan to upgrade lights
- Refurbishments and rebuilds could also be customer-controlled in terms of lighting specifications
- Renting or purchasing a building could be an opportunity for informed customers to choose better lighting performance

12.3. Emerging Trends and Sectoral Variances

Brand Managers

Of all roles in the market, brand managers are where the most pronounced differences between regime and niche actors can be observed. There are two major trends driving what interviews suggest is a permanent transformation of the lighting market structure for this role.

Foremost of these trends is an international transition to LEDs from incandescent, fluorescent, and HID technologies. However, interviews with regime and niche actors suggest that there appears to be a consensus that the ESS has catalysed the emergence of new actors (in the role of niche brand manager) and new routes to market (which have changed types of lighting products and the way they are sold).

Niche and regime actors saw that regime brand managers are under pressure from several factors relating to a global transition to LEDs. LEDs are seen by niche and regime actors and relatively independent observers as very different from all other lighting technologies. LEDs are far more like consumer electronic products than lighting technologies. As such, they are subject to far more rapid product development cycles and more complex component supply chains.

In pre-LED lighting technologies, lamps remained technologically similar and interchangeable for decades. Product development focused on the design elements of the luminaires, and luminaire product life cycles either took years or involved short-run, high-margin custom solutions for architectural lighting.

In contrast, LEDs generally have lamps, control gear, and luminaires all integrated in one product. The chips and drivers which control the LEDs are constantly being improved and superseded by new developments in the consumer electronics component markets (interviewees reported that products can become obsolete within six months). These changes have challenged regime brand managers' product development processes. They have also resulted in new competition with some builders purchasing low cost product direct from OEMs, bypassing regime brand managers and their wholesaler and specifier

supply chains. These issues are discussed further in Section 0. Uptake of LEDs is also seen to be eroding sales in incandescent, fluorescent, and HID lamps. However, regime brand managers have still had to carry the costs of maintaining large product ranges to cater to their remaining customers of these products.

Interviewees pointed to developments in the lighting market as evidence of this. Examples include GE exiting many lighting product segments⁵⁹, the sale of OSRAM's international LED lamp business⁶⁰, the attempted sale of Philips' international lamp business⁶¹, and the reported financial challenges of Sylvania's parent company, Gerard, in Australia⁶². Several regime brand managers acknowledged being too slow to engage with both LEDs internationally and the ESS in NSW.

Niche brand managers saw the ESS as an essential force in driving transformation of the lighting market. This is perhaps to be expected, as all actors interviewed had built and grown new business in response to or based on the ESS and VEET. Regime actors also clearly identified major contributions.

In particular, actors reported that the ESS had driven the emergence of a new market for large scale lighting retrofits which previously did not exist. Prior to the ESS and VEET, the non-new build market was focussed on replacing lamps and luminaires as they failed. Major upgrades were typically only undertaken as part of complete refurbishment of all building interiors. ESS and VEET subsidies demonstrated significant untapped end-user demand for stand-alone lighting retrofits focussed on energy savings. Niche, regime, and independent interviewees noted that regime brand managers were slow to recognise the significance of this market, and most regime brand managers have only entered the ESS and VEET markets in the last few years. This market remains dominated by niche brand manager products.

All five niche brand managers reported building their businesses over the last four to five years, in response to an inability to source product for the ESS and VEET. Niche brand managers all reported that, previously, regime LEDs were either far too expensive or too low quality to sell as mass market, and sometimes both. The price gap has now narrowed;

⁵⁹ Mattioli & Gryta (2017). *Lights Go Out as GE Focuses on Future*, The Wall Street Journal, 7 April 2017. <http://www.theaustralian.com.au/business/wall-street-journal/lights-go-out-as-ge-focuses-on-future/news-story/92e547fb8fca6a7d3dec4acc0f8123cb>, accessed 4 July 2017

⁶⁰ Halper, M (2017). *Osram completes LEDvance sale to Chinese consortium for €500 million (UPDATED)*, LEDs Magazine, 3 March 2017. <http://www.ledsmagazine.com/articles/2017/03/osram-completes-ledvance-sale-to-chinese-consortium-for-500-million.html>, accessed 4 July 2017

⁶¹ Reuters (2017). *Osram says gets German government approval for Lamps sale*, 30 January 2017. <http://www.reuters.com/article/osram-licht-lamps-idU5L5N1FK3SN>, accessed 4 July 2017

⁶² Carter & Murdoch (2017). *Will lenders turn off Gerard lights?*, The Australian, 15 February 2017. <http://www.theaustralian.com.au/business/dataroom/will-lenders-turn-off-gerard-lights/news-story/60ab57c2d4990da8afb116f50b33d9f3>, accessed 5 July 2017

however, niche brand managers are now confident in their ability to compete with regime actors. Some niche brand managers saw their narrower product range as part of their competitive advantage, as it reduces their overheads and allows them to focus on rapid product development. Regime brand managers identified their large product range as a barrier to participation in the ESS. For example, one regime brand manager reported that, of 66,000 products in their range, only 20 were accredited with IPART. Regime brand managers identified their long supply chains as challenging in maintaining low costs in the face of new cheap competition. Premiums that previously existed for LEDs have been eroded, as customers now expect them to be the same price; this makes maintaining quality and competitiveness a challenge.

All niche brand managers that we interviewed emphasised the significant ongoing investments they make in R&D. Some brand managers now report that products they develop with OEMs are later sold by regime actors who have purchased those OEMs. These brand managers reported that they typically had a more advanced product out by the time variations of their product had been repacked through regime actors.

Niche and regime brand managers were all highly critical of the product giveaway business models that dominated the ESS before co-payments were required in the 2014 Rule Change. In contrast, pure aggregator ACPs were strongly supportive of giveaways, and opposed to co-payments. Brand managers argued that giveaway models are detrimental to both the quality (and associated savings) of product installed, and the sustainability of the businesses without subsidies. Giveaways are only possible due to ESS and VEET subsidies, and when the deemed certificates are high compared with upfront costs and there are no requirements for customer co-payments.

The ESS and VEET commercial lighting markets have been characterised by both giveaway and co-payment markets. From 2011 to 2014 the ESS niche was dominated by commercial lighting giveaways. These ended when deeming factors were reduced and co-payments were required in 2014. In the VEET niche, the commercial lighting market was much smaller, with low deeming values requiring customer co-payments. A significant increase in deeming values in 2016 made commercial lighting giveaways possible.

Niche brand managers, the majority of whom were vertically integrated with ACPs, all reported that giveaways change both the structure and dynamics of the ESS and VEET niches. All niche brand managers reported significant shifts in the market associated with these changes. In Victoria, customer-direct business models with value propositions based on quality and payback couldn't compete on price, as end-user dynamics were

dominated by demand for free product, with little engagement in quality. This changed the types of sales staff and business models involved in the market, as competition was driven by speed to market. Declining certificate prices increased demand for lower cost product, putting greater reliance on product approval processes to maintain quality and detect non-compliance. Regime brand managers, specifiers, and distributors all reported similar market dynamics over these periods, without an understanding of the nuanced differences in scheme rules behind these dynamics.

Niche actors are careful to emphasise that the vast majority of their ESS funded projects are still highly additional. Several actors reported conversion rates of around 10% of proposals, despite high ESS subsidies. They emphasised that the size of the subsidy was less important than having one at all. Niche brand managers reported that having a government program, as well as the potential temporary nature of the subsidy, was essential to get customer attention on making upgrade decisions now, rather than deferring them indefinitely. However, niche actors argued strongly that when products are free, customers have no interest in quality, and it is not possible to sell quality product, even with paybacks as low as six months, when there is a free low-quality alternative.

Niche brand managers were highly supportive of IPART's product approval processes and argued it was essential, even if a national LED standard were to be developed. In contrast, regime brand managers saw this approval process as a barrier to accessing ESS subsidies, due to their very large product ranges.

All niche brand managers reported having little-to-no involvement in the specification market, or with traditional lighting supply chains. Their business models and competitive advantage are based on direct customer relationships. They are largely too focussed on growing this core business to explore additional distributional channels. Some niche brand managers intend to begin promoting their product in the mainstream market, through either contractors or specifiers. Interviewed wholesalers saw these vertically integrated brand managers as competitors.

Many interviewees reported that it was very common for inexperienced individuals to bring in a shipping container of LEDs from China and sell directly to contractors and builders (one interviewee reported that there are over one million lighting suppliers in China). Niche and regime brand managers criticised the poor quality of product that they attributed to such businesses. However, niche brand managers also identified quality issues with regime product, specifically with respect to lifetime and efficiency, and regime actors identified quality issues with niche products, specifically with respect to glare.

Niche brand managers see themselves as energy efficiency companies rather than lighting companies. Several are looking at other opportunities once they see the ESS and VEET markets saturated, including HVAC and control systems.

Distributors

For the three distributors we interviewed, we spoke with a head-office senior product developer, an energy management specialist, and a store manager. The product developer and energy management specialist demonstrated that lighting distributors have the capability to engage issues associated with emerging lighting technologies, although a common theme was the importance of established standards to benchmark a lighting product's performance.

All three distributors demonstrated a good understanding of the ESS, though it was interesting to note that, in some cases, distributors have only become involved in the ESS in recent years. This is an indication that in the past, regime players have either not been aware of the scheme, or not seen its potential for their business.

Two of the three distributors identified opportunities they have taken to further their business interests through engaging in the ESS retrofit market. The motivations for these steps were:

- To open up new opportunities for lighting sales
- To support their electrical contractor customers (their main customer base) by providing them the tools and support needed to initiate lighting retrofits in buildings owned by the contractors' customers
- To promote own-brand lighting products

All distributors indicated that they place high importance on supplying quality lightings for ESS installations. Two distributors noted that this has resulted in the distributor losing business to niche businesses that undercut on quality and price.

As with other lighting industry actors, the distributors noted that the complexities associated with getting products approved to the ESS is a barrier to participation in the scheme.

Whilst the interviewed distributors were all aware that LED lighting is now mainstream, a number reported that a significant amount of the stock they sell is still older technology (in some cases, over half). This demonstrates the ongoing legacy of the maintenance

market, i.e., small-to-medium sized customers that are focused on upfront costs and customers that have negative perceptions to LED lighting. The interviewed distributors have taken steps to educate their sales teams on LED lighting and its benefits.

Retailers

The one retailer we interviewed was actively involved in the ESS and VEET, as a supplier of products approved on the schemes' product registers. The retailer was able to source product from its existing product range to meet the requirements of the schemes. The retailer noted that the international standards that the schemes use have become de facto methods of assessing product quality.

It is noteworthy that, while the retailer is involved in the energy efficiency schemes, it sees the business created from them as an "extra," indicating the schemes present a small part of the regime retail sector's business.

Electrical Contractors

Several consistent themes about electrical contractors emerged from the interviews with this sector, and with other players in the lighting industry:

- Electrical contractors typically have limited, if any, influence in the choice of lighting installed. Their influence appears to be mainly limited to residential and small business maintenance and retrofit markets. In other markets, the electrical contractor is either engaged by another party to install a designed lighting system, or is an employee of a vertically integrated business
- Smaller electrical contractors typically source lighting products from electrical distributors or retailers. These are places where they can obtain information about new lighting technologies
- Smaller electrical contractors are typically not involved in the ESS. It was pointed out to us that such contractors find the administrative work associated with the schemes a significant barrier to participation (it is noteworthy that some of the ESS certificate aggregators interviewed mentioned that they have developed electronic tools to assist installers with the documentation required to generate ESS certificates)
- Electrical contractors are often responsible for sourcing the lighting products to meet a design they have been engaged to install. They typically source the products directly from a lighting supplier (if one is specified on the design), from

brand managers (for larger jobs), or from electrical distributors/retailers (where they often seek assistance from the distributor/retailer in sourcing a product that meets the job's requirements)

Specifiers

From our interviews with specifiers, we broadly found the motivations of this sector were to meet the needs of their developer and building owner clients. As an example, an architect we interviewed, who provided services to small-to-medium businesses, noted that the new build sector has a tendency towards conformity and risk-averse design. The architect also noted the significant split incentive, where developers give greater attention to the upfront costs of a building than to its operating costs. The lighting designers that they engage as part of their design work typically provided lighting designs consistent with these factors.

The architect did note that the Building Code of Australia (BCA) has provided an opportunity to overcome these barriers to efficient lighting in new builds, though there is scope for it be strengthened.

Another regime specifier we interviewed, servicing the larger corporate sector, demonstrated considerable reluctance to embrace LED lighting to the extent that other specifiers have. This specifier identified corporate policies and the desire to attract good tenants as the main drivers they are seeing for high efficiency lighting. In their own tenancy, the specifier noted that T5s were installed over LEDs, as the business case did not stack up. They considered that LEDs were not a proven technology, provide lighting quality that was unacceptable to end-users, and are unable to deliver the paybacks required by their clients.

In contrast, we also interviewed several specifiers that have embraced LED lighting as a mainstream lighting product that is highly cost-competitive with older technologies. Across these specifiers, we found the emergence of innovative lighting management and financing arrangements.

One such specifier that we interviewed partners with a specialist vertically integrated lighting specifier business that provides lighting design, product sourcing, installation, and maintenance services. By sourcing quality LED products with long warranty periods, the lighting specifier is able to offer financing products that avoid the need for upfront capital from the client. The key opportunity that makes this possible is the emergence of

LED lighting warranty periods that are longer than the payback periods for the lighting project. The lighting specialist business is fully engaged with the ESS, taking advantage of the incentive to improve the business case for lighting upgrades. As a sign of spill-over, this specifier noted that they use ESS compliant lighting products across the country. They noted that ESS product requirements are driving higher quality lighting being installed for retrofits compared with new builds.

Another progressive specifier we interviewed, a vertically integrated lighting business, demonstrated a high degree of insight into the LED lighting market. It noted that the vast majority of the lighting specifiers it engages with are now specifying LED lighting for new builds, noting that the “tipping point” for LED over T5 lighting occurred as recently as 2016. Those that are still specifying T5 are, in this specifier’s opinion, not “forward thinking,” or have established relationships with specific lighting suppliers. As a vertically integrated business, this specifier is quite involved in the ESS. It strongly supports the stringent product requirements set by the scheme, and expressed concerns over whether start-up businesses involved in the scheme will be around long enough to honour the lengthy warranty periods that they offer for lighting installations. Whilst it is involved in the ESS, the company does not rely on the scheme for its business. Rather, it seems to generate demand through strong relationships with large lighting end users. During the interview, the specifier noted that companies that started up because of the ESS have taken business away from it.

A number of parties interviewed provided insights into the future of lighting, with some actively working in these areas. Of particular note is the emerging opportunities to use luminaires and lighting systems as platforms for introducing distributed intelligence systems and the Internet of Things into buildings, including:

- Motion sensing, which can be used for market research (e.g. supermarkets can monitor where customers spend the most time and use this data to market these locations as premium shelf rent for product suppliers)
- Changing lux levels and lighting colour in response to, or to influence, spending patterns and consumer behaviour
- Particle detectors as part of security systems
- Biometric recognition

These intelligence features offer the potential to become a, if not the, dominant driver for future lighting upgrades, with the lighting benefits possibly only a small part of the value proposition.⁶³

Certificate Aggregators

All certificate aggregators that we interviewed noted that their business depends to a high degree on the NSW and Victorian energy efficiency schemes. One identified the risks this poses, and is exploring alternate business arrangements to position itself as a financier of energy efficiency and renewable energy projects.

Two of the aggregators have taken the initiative to develop software tools (apps) to assist its clients with the data gathering requirements needed to create certificates under the NSW and Victorian schemes. This is a tangible example of the role that certificate aggregators play in reducing the administrative burden that their clients face in accessing incentives through the schemes. One aggregator noted that it is looking to extend the functionality of its app to make it useful for a wide range of activities, rather than just those within the scope of the energy efficiency schemes.

All three aggregators interviewed are, in NSW, predominantly engaged in the commercial retrofit market. They noted that the type of retrofits occurring are heavily dependent on scheme rules. For example, the commercial LED tube replacement and residential retrofits that occur in Victoria do not occur in NSW, because of ESS scheme rules. Some aggregators argued that such restrictions in NSW should be relaxed, whilst one aggregator suggested that the time has come for the scheme to move away from lighting and open up other energy efficiency opportunities.

Developers/Property Owners/Managers

One property manager we interviewed noted that the ESS incentives are not sufficient to have an influence in major refurbishments, as lighting is typically only a small part of the overall project. As a result, the consultants involved in major refurbishments are typically not aware of the ESS.

⁶³ As an example of a discussion on this emerging trend, see: <https://techcrunch.com/2015/12/20/how-intelligent-lighting-is-ushering-in-the-internet-of-buildings/>

This property manager regularly develops lighting retrofit proposals for its building owners. Whilst it is open to sourcing products from parties other than regime suppliers, it still tends to use established businesses (those that are ten or more years older). One reservation the property manager has with LED lighting is the use of poorly designed luminaires. It considers that product quality control that focuses on LED chips and lamps is insufficient, and that focus should instead be on light output.

This property manager noted the challenges faced by the split incentives in the commercial building sector. However, even with these, the property manager notes that rising energy costs are having a significant influence over the business case for retrofits.

Another property owner/manager, who owns retail shopping centres nationally, noted the influence of the BCA's energy efficient lighting requirements and its own lighting design guidelines as the main influencers of lighting in its shopping centres. The company's motivations are a desire to create retail spaces that attract customers and corporate sustainability policies. The lighting design guidelines are mandatory for tenants, and so directly influence the lighting choices made by tenants, overcoming split incentive issues. These arrangements can work because the tenancy periods are long enough to justify the investment in efficient lighting.

A national property owner/manager that we interviewed reinforced the importance of corporate sustainability drivers, especially for large national and international corporations. They also noted that rising energy costs are becoming a significant driver for energy efficiency improvements, to the extent that ESS incentives are becoming far less significant. The business case for lighting upgrades is typically so strong that this business is able to secure unplanned capital for the projects. Where a clear payback is not evident, other benefits, such as improved security, often assist in securing funding. It is noteworthy that past positive experiences with LED lighting upgrades (and favourable feedback from executives) are paving the way for the business to be planning a major national lighting upgrade. A feature of future upgrades will be the engagement of a specialist lighting consultant to advise on preferred suppliers and installers, and to utilise the lengthy warranty period now offered for LED lighting to eliminate the need for a maintenance budget (and leaving any maintenance work to the installers as a warranty job). This business, having a significant retail portfolio, noted the important role that lighting plays in safety and security for customers and tenants.

One major property manager we interviewed, which acts on behalf of investment funds, uses its corporate size to engage quality lighting providers (by means of tenders) for lighting upgrades to building common areas. These are typically agents of regime brands

that provide their own installers, so as to obtain long warranty periods on the lighting products and their installation. With these arrangements, the property manager has been able to negotiate with their energy provider an innovative finance arrangement, wherein the energy provider funds the upgrade, which is repaid through bill savings. This arrangement works for all parties because the payback period for the investment is shorter than the warranty period for the installed lighting. Whilst ESS incentives are incorporated into these arrangements, there are cases where projects proceed even where these incentives are not available.

End Users

Most of the property managers interviewed were also property owners. As such, many of their perspectives were those of a lighting end user.

One large national retail organisation that we interviewed considers the incentive offered through the ESS as one of a number of factors influencing the business case for a lighting upgrade. The business targets its lighting upgrades to where the business case is strongest. Factors such as energy costs, energy efficiency scheme incentives, the value of avoided maintenance costs, and time since last upgrade (noting that a number of T5 upgrades occurred within the last ten years) are key factors in these decisions. Significant increases in electricity costs in many parts of the country now make this a more significant factor. Of note, the lighting products that they use nationally for retrofits are products approved for the ESS and VEET. Also, the business requires the same level of documentation required for these schemes for retrofits across the country. This end-user sees a full LED roll out potentially occurring across its stores nationally over the next three to five years.

In addition to the end users we interviewed, many other parties provided views on the motivations of end-users. Those that were consistently reported include:

- The payback period that end-users will accept varies by the size of the business. Larger businesses typically accept two year paybacks, medium sized businesses want lesser payback periods (six to eighteen months), and small businesses and households are reluctant to invest in energy efficiency, and many expect energy efficiency to be a free service
- Larger tenants are more open to retrofitting lighting, especially when this is driven by corporate policies. For medium and small businesses, split incentives and a

reluctance to invest in assets that become the property of the building owner are significant barriers, even when the payback is within the timeframe of the lease

- The ESS rules for residential activities are prohibiting activity in this sector. Similarly, the decision to not permit lamp-only replacements in office buildings has seen retrofit activity in this sector dry up

The ESS co-payment requirement for lighting upgrades is seen by many in the lighting industry as a positive step to discourage free giveaway practices. Still, the administration of this arrangement has presented difficulties for larger end users

CHAPTER 13

NSW Lighting Market Dynamics

Key Findings

Key findings

Our research concludes that the ESS has materially influenced the lighting market in NSW, and is continuing to do so. The GREP program also appears to be driving a material increase in the adoption of energy efficiency lighting by major government agencies. Within the scope of this research, it was not possible to detect whether GREP or EEB were having transformative impacts on underlying market structure and dynamics. Both involve relatively small numbers of participants, and more focused studies on the impacts to those participants would be required.

These impacts have occurred against the backdrop of a global transition to LEDs, which has changed both the structure of the market (as discussed above) and the dynamics. Both the ESS and global transition to LEDs are driving changes to market dynamics, many of which are transformative. The transition to LEDs by regime actors was initially delayed, due to social practices and technology infrastructure inertia. With some product exceptions, LEDs have fundamentally changed long-established dynamics with respect to technology inertia. Once legacy luminaires are replaced by integrated LED lamps and luminaires, there will no longer be a significant market for replacement lamps. For many product segments, this is having disruptive impacts on the financial viability of previously dominant regime actors.

The ESS encouraged niche actors to promote LEDs two to three years earlier than what would have occurred through business-as-usual. The new customer-direct business models that developed radically changed the opportunities of end users, who have different motivations from the specifiers that were previously gatekeepers on purchasing decisions. These models also identified previously unrealised opportunities for lighting suppliers to drive early energy saving retrofits of lighting systems, without waiting ten to twenty years for major refurbishments. These business models are beginning to be adopted by regime actors, and appear to be having transformative impacts on the soft social practices of the mainstream market.

As end users were motivated more by price and bill savings than aesthetics compared with the specifier market, this new market has very different dynamics and different products. Changes in the global lighting market saw increased opportunity to service this demand with low-quality and low-price products, both in the retrofit market and by builders in the regime specification market. The new hard social practices developed by ESS and VEET to regulate product quality have improved outcomes in the retrofit market. Previous hard social practices, particularly product and building standards regulations, are

lagging significantly behind soft social practices and the hard practices of ESS and VEET product regulations.

The key findings with respect to market structure include:

- The ESS and GREP have had a material impact on the dynamics of the retrofit segment of the lighting market, some of which may be transformative depending on future policy reinforcement
 - New customer-direct business models of the retrofit market have shifted dynamics from aesthetics to upfront and lifetime costs
 - More stringent ESS and VEET product approvals are used as proxy quality standards by niche and new market entrants, in the absence of a national standard for LEDs
 - ESS co-payment requirements have allowed the dynamics in the retrofit market to balance customer demand for product quality and warranties with upfront cost
 - Under the co-payment market, the primary impacts have been developing customer awareness and opportunities to undertake upgrades by subsidising customer acquisition and installation of solutions, rather than improving already attractive project paybacks
 - GREP has material impacts on the motivation and retrofit opportunities for government end users, but more research is required to understand whether these impacts are transformative
 - More research is required to understand the implications of these new dynamics on installation quality
 - Changes in end user decision making appear to be transformative for the decisions of large energy customers in the retrofit market, as evidenced by the use of ESS accredited lighting products and documentation as national practice by some large end users

- These impacts may be transformative if the retrofit market is able to persist for medium to large sized customers in the absence or phasing down of incentives, by creating a critical mass of awareness to change social practices
- By opening up energy efficiency improvements in the retrofit market, the ESS and VEET have reached into lighting applications that other government policies cannot or have not reached
- There is a general view across lighting stakeholders that lighting installed as part of retrofits is of superior performance to that being installed in the new build market, flagging the need for improvements to the Building Code requirements
- The changes to the lighting market, such as the growth in niche suppliers and growth in the supply of integrated luminaires, present significant challenges for future Greenhouse and Energy Minimum Standards (GEMS)
- There is scope for greater coordination across these government initiatives

The next part considers the performance of the NSW lighting market, with respect to the update energy efficient lighting by lighting type and end-user sector.

Part 4

Performance of the NSW lighting market

CHAPTER 14

Approach to Measuring Market Performance

14.1. Introduction

This part of the report summarises the approach and findings understand NSW program impacts on the energy efficiency performance of NSW lighting stocks and sales.

It is are based on a market model developed for OEH, which estimates:

- Stocks and flows of high efficiency lighting products across various market sectors of the NSW lighting market
- Actual performance, including historical trends before and over the period of the interventions in question, to the present
- A counterfactual scenario against which to compare actual performance
- A theoretical, retrospective baseline based on the counterfactual

14.2. Technical nomenclature

The following terminology is used throughout this report:

- “Bay/road” refers to highbay, lowbay and road lighting luminaires commonly used in industrial and road lighting applications.
- “Downlight” refers to a small, recessed ceiling luminaire.
- “General purpose” lighting refers to conventional screw-cap or bayonet-cap light bulbs.
- “HID” refers to high intensity discharge lighting, such as mercury vapour, metal halide and sodium lighting.
- “Lamp” refers to a light bulb or fluorescent tube.
- “LED” refers to lighting emitting diodes.
- “Linear” refers to elongated linear fluorescent style luminaires commonly found in offices and commercial premises.
- “Luminaire” refers to a light fitting / fixture.

- “Niche” products refer to lighting products installed as part of the niche market, which is a small sub-market where new technologies are incubated. These are typically more efficient than regime products.
- “Regime” products refer to lighting products installed as part of the dominant market trajectory, which is characterised by routines, sunk costs, infrastructure, dominant competencies, aesthetics, contractual agreements, regulations and standards.
- “T12”, “T8” and “T5” refer to linear fluorescent lamps. They are listed here in order of increasing efficiency.
- CFL refers to compact fluorescent lamps, with integrated ballast as typically used in households.
- CFLn refers to compact fluorescent lamps with non-integrated ballast as typically used in office and commercial buildings (e.g. bathrooms, foyers).
- CLF refers to the ESS commercial lighting formula.

Other terminology and acronyms can be found in the Glossary.

15.1. Modelling background

Lighting is a complex area. In Australia, there are around half a billion lights installed. There are many different types of lighting technology, and we are in the middle of an unprecedented period of change in the available types, efficiencies and costs of lighting technologies.

It is of course not physically possible to count the numbers of lights installed in Australia or NSW, nor is it cost effective to even count a representative sample. Also, the types of lights installed is changing rapidly, meaning that counts become obsolete very quickly. It is similarly not possible to monitor just how lights are used by consumers, and this also varies widely from user to user.

Given these realities, we are forced to rely on modelling, which requires a number of reasonable assumptions to be made, and these should be supported by references and

sound logic. The purpose of this section of the report is to describe the modelling undertaken for this study, and the nature of the assumptions used.

To calculate the energy used by lighting, and the energy savings from lighting upgrades, we need to examine the lighting stock, i.e. the quantities of products actually installed and operating. However, for the reasons outlined above, very little stock data exists. Limited counting of stock is occasionally undertaken by various parties, but rarely does it exist as a time series.

Good data does however exist for lamp sales (for example ABS lamp import data as a proxy for sales) and this exists as an extensive time series. To take advantage of the availability of this data, we need to convert sales data into stock, and this is done using a Microsoft Excel stock-and-sales model built specifically for this study. Where possible, we also take advantage of the stock-and-sales modelling undertaken for the recent national consultation RIS for lighting (E3, 2016a).

The model constructed for this study is considered to be the best available lighting dataset ever devised for NSW, although input data limitations mean that it is by no means perfect. It is intended that the model remain malleable, and be improved over time, made possible by improved data collection processes. It is also intended that the model be as flexible as possible, with the ability to model multiple scenarios, technologies and end-use categorisations. With these objectives in mind, the model was constructed to strike a balance between simplicity/coherence and granularity.

15.2. Modelling scope

The market sectors covered by this report, and the model devised for it, are:

- Residential: the residential segment consists of lighting for residential buildings ranging from detached houses to high-rise apartment buildings. Each home normally contains a number of different lighting product types, depending on the use of each room. The emphasis is usually on the aesthetics of the product, its colour, price and its light output, with efficiency often a secondary consideration. General purpose lamps and downlights dominate this segment. In the past two decades there has been an increased uptake of recessed halogen downlights, as well as compact fluorescent lamps (CFLs).
- Office commercial, or simply "office": the office commercial lighting segment services predominantly office-based businesses, and the main product in this sector has

traditionally been linear fluorescent luminaires. There are often different lighting types, e.g. downlights, in service areas such as kitchens, bathrooms and lift lobbies. Generally, offices are leased rather than owner-occupied, and the owners manage large portfolios of office buildings.

- Non-office commercial: non-office commercial lighting services businesses that include retail, education, health, accommodation, hospitality and leisure. The main product in this sector has also traditionally been linear fluorescent luminaires, but it is supplemented by a wide variety of specialty lighting such as spot lighting for retail. Apart from shopping centres, this sector is largely composed of owner-operators or small leased buildings, requiring specialist lighting solutions.
- Industrial: industrial lighting services industrial sites such as factories. As well as linear fluorescent, it includes specialised “highbay” and “lowbay” lighting, depending on ceiling height. Generally, these lights are high output, efficient and have long lifetimes to minimise maintenance costs. Often these lamps are high intensity discharge lamps.
- Public (outdoor/road lighting): the public lighting market segment primarily consists of road lighting, which are highly specialised lights. Maintenance costs are also significant for street lighting. Technologies are similar to industrial lighting.

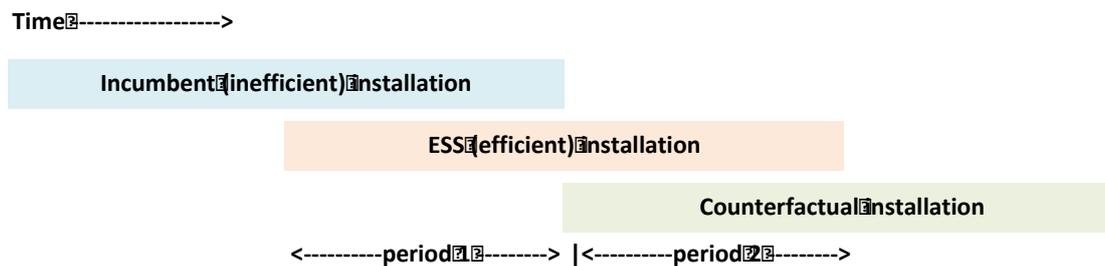
The model deals primarily with the impacts of ESS lighting measures. EEB and GREP installations are dealt with separately (refer to Chapter 24).

15.3. Modelling approach

Fulfilling the objective of this study requires the development of a counterfactual baseline. In the absence of any control group data, the approach developed for this study involves assessing the ESS lighting installations and comparing them against the “incumbent” installations (the inefficient lighting systems that were replaced) and also the future “counterfactual” installations.

The counterfactual installations are the lighting installations that *would have* replaced the incumbent installation that the ESS replaced - as shown in Figure 21. In other words, the counterfactual installation is the sales-weighted average of inefficient and efficient installations that *would have* been installed at the end of the life of the incumbent lighting.

Figure 21 - sequence of lighting installations



The incumbent and ESS installations shown in the figure above are essentially known from ESS ACP data. The energy savings of the ESS installation are then calculated for period 1 and period 2 shown in the figure above. The total ESS energy savings are the sum of savings from these two periods. Spill over and free riders are then dealt with separately.

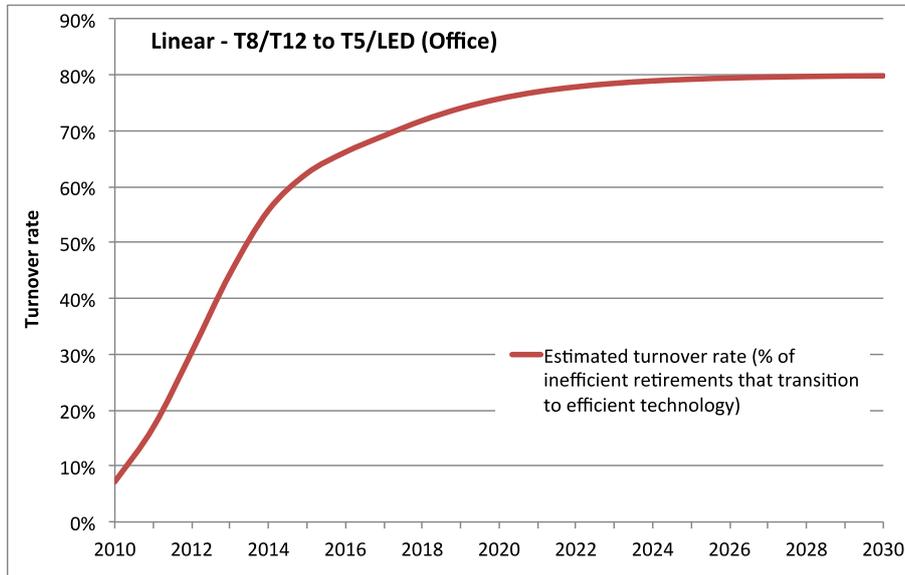
The text below describes the methodology used for the model, which has the following sequential sub-models:

1. **First pass stock model.** Lamp sales data from the ABS is used as the basis to convert lamp sales into luminaire stock. These calculated stocks typically represent a rough approximation, due to the fact that sales data is volatile.
2. **Sectoral model.** Luminaire stocks from #1 are split into the 5 market sectors listed above, typically using floor area data and estimated luminaire densities (numbers of luminaires fitted per unit of floor area). Where luminaire stock levels are available from other data sources (e.g. the recent national RIS for lighting and various road lighting studies; E3, 2016b) these supersede the stocks calculated by sub-model #1. Finally, some normalisation and smoothing using floor area data is applied.
3. **Turnover model.** Data from sub-model #2 is used to derive “turnover rates” for lighting products, by market sector. These are the baseline rates at which inefficient lighting (in the baseline scenario) is turning over to efficient lighting. Their key turnover types are:
 - General purpose - incandescent/halogen to CFL/LED
 - Downlight - halogen/CFLn to LED
 - Linear - T8/T12 to T5/LED
 - Bay/road - HID to LED

The turnover model distils the lighting market down into these 4 turnover types, with parameters for each essentially being weighted averages, split across the 5 market sectors, and these data are also dynamic over time. Using these 4 distilled turnover types allows us to talk in simple terms about what is occurring in the lighting market, which is a key advantage when we are dealing with such a complex area.

An example of turnover can be seen in Figure 22, which is essentially an S-curve showing the estimated proportion of *inefficient (incumbent) luminaire retirements* that transition to efficient technology at the end of their service life, over time (in the baseline scenario).

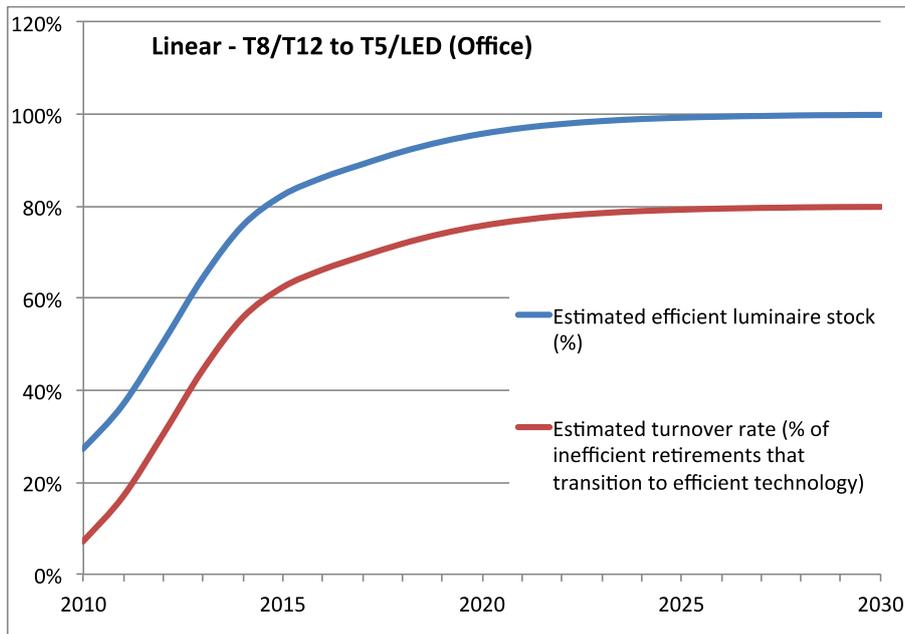
Figure 22 - example of turnover rate S-curve for inefficient technology



Note that the derivation of the baseline S-curves for the various turnover types does involve some uncertainty. Essentially each S-curve is derived from the lighting stock S-curve, with a percentage deducted to “strip out” ESS and VEET installations from the baseline, and also to take account of new build installations and also any “stickiness” of incumbent technologies (inertia for users to change technologies which applies especially in the case of incandescent lamps).

This derivation can be seen in the same example in Figure 23 below. For linear luminaires in the office market, 20% has been deducted from the stock curve, in order to remove ESS installations, VEET installations and new build from the baseline. The red S-curve in the figure below shows the estimated *baseline* rate at which linear fluorescent T8/T12 luminaires are turning over to T5/LED in existing buildings.

Figure 23 - example of turnover rate S-curve for inefficient technology along with stock S-curve



4. **Energy model.** The energy model calculates weighted average energy savings from each type of ESS upgrade, taking into account the baselines calculated at #3. In other words, the energy model uses a dynamic baseline. Note that the power usage of various luminaire types is sourced from E3 2016b and the supplied ACP data.

Example outputs from the energy model can be seen in the two figures below. Figure 24 shows the estimated power draw of linear fluorescent luminaires over time:

- The incumbent (inefficient) (or regime) luminaire that is replaced or upgraded by an ESS installation.
- The counterfactual - the sales-weighted average of inefficient and efficient luminaires that would have been installed (for all replacements) when the incumbent reaches the end of its life. The sales weighting is based on the S-curve shown in in Figure 22.
- The installed ESS (or niche) luminaire, which is assumed to be somewhat more efficient than the baseline efficient luminaire.

Figure 24 represents a key assumption and these (multiple figures) should be tested with market participants (visually if possible).

Figure 24 - example of luminaire power over time

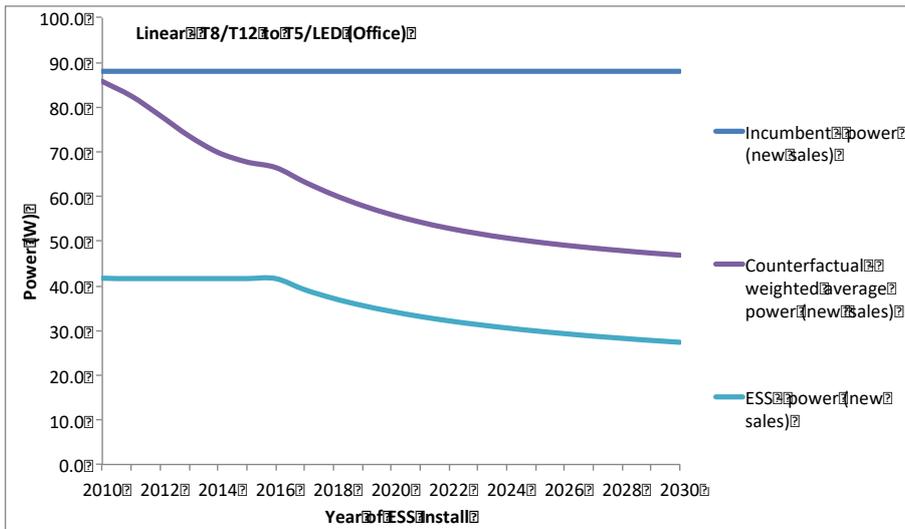
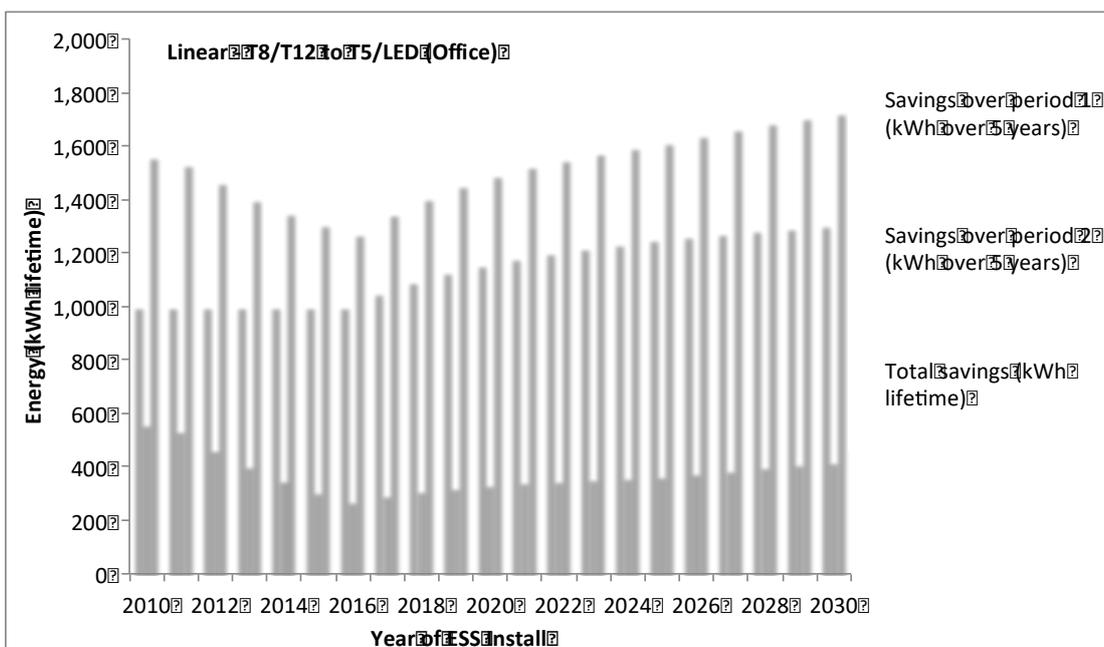


Figure 25 then shows the calculated energy savings results for this example, made up of energy savings in period 1 and period 2 (periods as described in Figure 21). We can see the energy savings for each of the two periods changing over time, as does the total (blue columns). In Figure 25 we can see that the total energy saving dips and then rises. The dip is due to energy savings in period 2 reducing - the counterfactual luminaire is becoming more and more efficient. The rise is due to the power of the ESS-installed luminaire improving.

Figure 25 - energy savings for linear fluorescent luminaire changeover



This calculation is performed for 10 different turnover types and market sectors:

- General purpose - incandescent/halogen to CFL/LED (Residential)
 - Downlight - halogen/CFLn to LED (Residential)
 - Downlight - halogen/CFLn to LED (Office)
 - Downlight - halogen/CFLn to LED (Non-Office Commercial)
 - Linear - T8/T12 to T5/LED (Office)
 - Linear - T8/T12 to T5/LED (Non-Office Commercial)
 - Linear - T8/T12 to T5/LED (Industrial)
 - Bay/road - HID to LED (Industrial)
 - Bay/road - fluorescent/HID to LED (Public)
 - Bay/road - fluorescent/HID to LED (Non-Office Commercial)
5. **Impact model.** Calculations of total energy savings from ESS installations are performed, including estimates of free riders and spill over.

15.4. Key formulae

The key formulae used by the model are as follows:

- Product stock = sum of all sales for previous Y years, where Y = the average lifetime of the product in years.
- Annual energy consumed by a type of lighting product = stock × average annual operating hours × average electrical input power.
- Efficacy = light output divided by electrical input power.

15.5. Datasets

The key data sources used in construction of the model are:

- ACP data supplied by OEH:
 - ACP CLF installation data (See below in this section for details).
- ESC creation data for CLF projects:
 - ESC creation volumes for CLF projects.
 - Downloaded from the ESS/IPART website on 6 January 2017.
- Sustainable Public Lighting: The current state of play and future developments, Paul Brown, 2005 (Brown 2005):
 - Road lighting stock.
- IPWEA, 2016, Street Lighting and Smart Controls (SLSC) Roadmap, for Department of the Environment and Energy, Australian Government, by Strategic Lighting Partners and Next Energy (IPWEA, 2016):
 - Road lighting stock.
- Consultation Regulation Impact Statement - Lighting, Regulatory reform opportunities and improving energy efficiency outcomes, Energy Efficient Equipment Committee, November 2016 (E3, 2016b):
 - Lighting stock and product efficiency data.
- ABS Import Data, purchased from the ABS for lamp imports:
 - Lamp imports.
- Commercial Building Disclosure data, downloadable dataset, downloaded on 15 December 2016:
 - Lighting power density.
- Commercial Building Baseline Study, downloadable dataset, downloaded on 15 December 2016:
 - Building floor area.
- National Exposure Information System (Nexis) Building Exposure Local Government Areas Aggregated Metadata, downloaded on 25 January 2017:
 - Building floor area.
- Residential Energy Baseline Study (DIS 2015):

Housing stock and floor area.

ACP datasets

The ACP data was provided by OEH. The key attributes of this data were as follows:

- Data provided by 5 ACPs. The 5th dataset was of traffic signal projects and is dealt with separately below. The remainder of this section deals with the conventional lighting upgrades, with data sourced from the remaining four ACPs.
- Total ESC creation of four ACPs: 1.6 million ESCs. This represents a 13% subset of the grand total ESC CLF creation (all ACPs) of 12.4 million (to end 2016). Refer Figure 26 and Figure 27 and for ESC creation volumes from the four ACPs.
- Around 10,000 records supplied, representing 256,000 luminaires upgraded.
- ESC creation, by sector
 - Residential: 1%
 - Office: 3%
 - Non-office commercial: 57%
 - Industrial: 38%
 - Public: 0%

Note that assignment of sectors to each record is considered imperfect, based on manual inspection of "BCA classification", "operating hours" and "area" fields.

Figure 26 - ESC creation volumes for supplied ACP data (3 ACPs) (stacked)

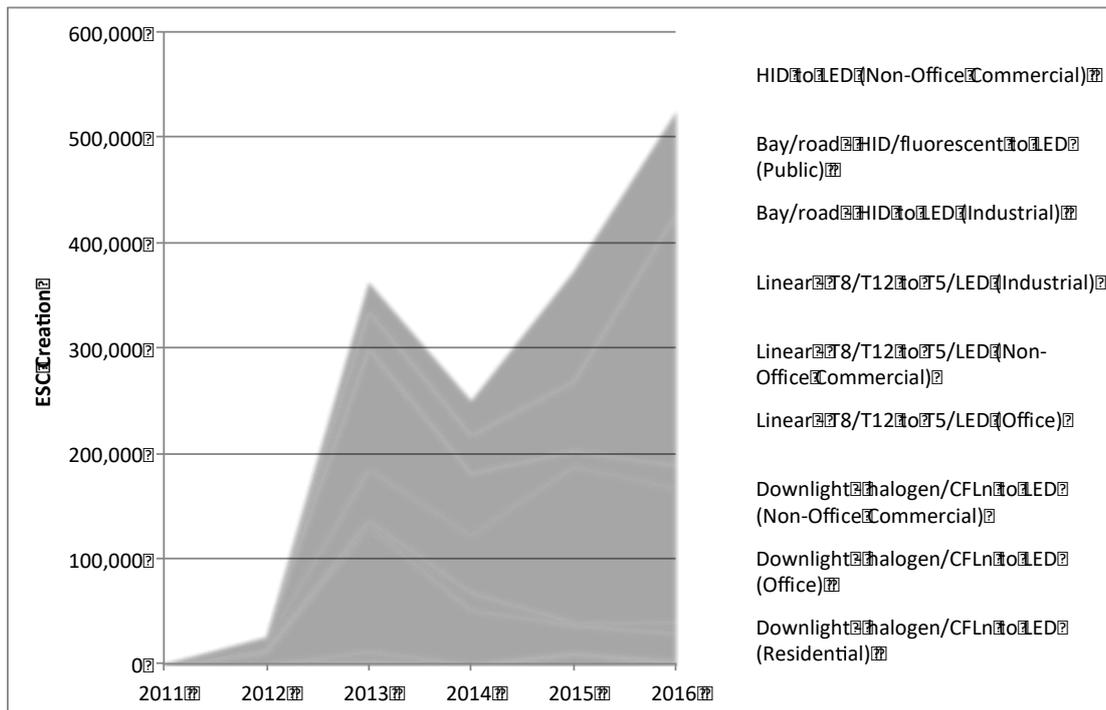
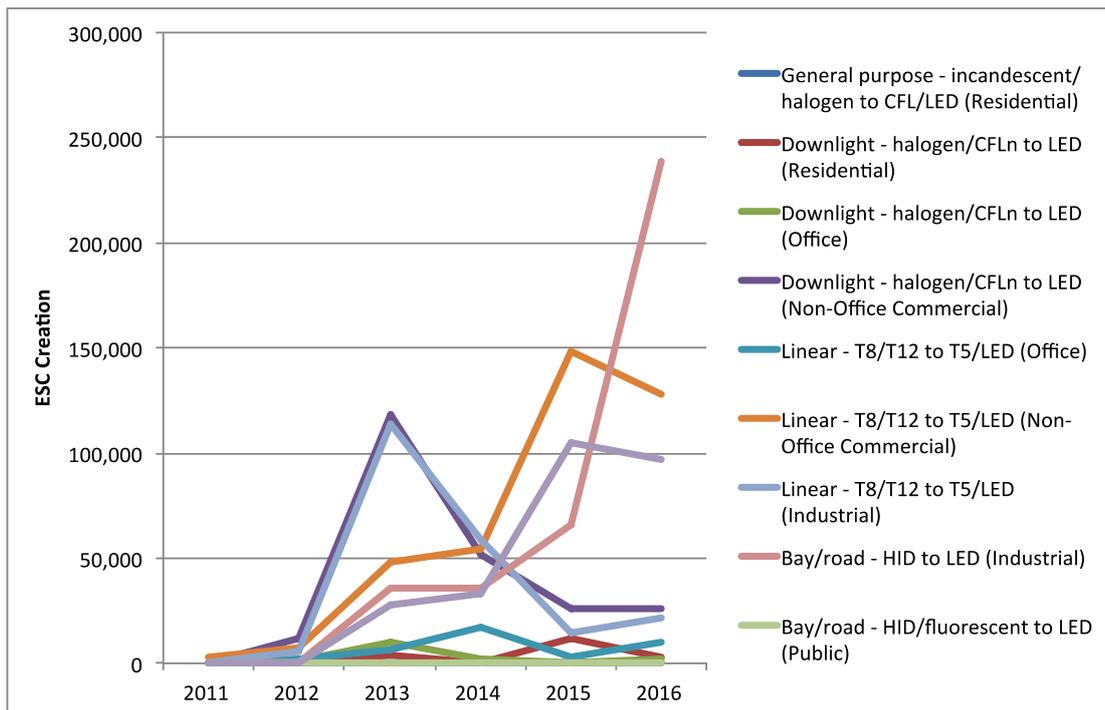


Figure 27 - ESC creation volumes for supplied ACP data (3 ACPs) (not stacked)



The supplied ACP data (3 ACPs) was extrapolated to match total annual ESC creation rates for CLF projects, with totals as follows (from ESS registry download):

- 2010: 19,739
- 2011: 320,896
- 2012: 1,413,907
- 2013: 3,183,465
- 2014: 3,131,455
- 2015: 1,626,399
- 2016: 2,709,430
- **Total: 12,405,291**

The supplied ACP data was analysed in order to track lighting projects by sector and upgrade type. This analysis was then fed into the model.

Traffic signal ACP data

One dataset was received, containing an ACP's data on installation of LED traffic signals. This dataset contained the calculations for around 116,000 ESCs, which is around 1% of total ESC creation from commercial lighting. This is not a significant proportion. Given

that, anecdotally, the vast majority of NSW traffic signals are now LED, OEH may wish to consider removing traffic signals as an allowable measure from the ESS CFL.

15.6. Data Issues and Uncertainty

As outlined in section 15.1, lighting is a complex area and understanding lighting markets necessitates significant modelling and a wide range of assumptions, resulting in some uncertainty. In the model developed for this study, the key areas of uncertainty are currently:

- Treatment of free riders and spill over.
- Representativeness of the ACP data collected for this study (covers only around 15% of total ESCs created).
- Forecast baseline turnover rates for market transition to efficient lighting.
- Lifetimes of lighting installations.

The areas where the model may be currently considered to be *optimistic* (over-estimate ESS energy savings) are as follows:

- Modelled product lifetimes of 10-15 years. This is based on the results of interviews with market participants. Refer Annex B for the lifetimes used for each sector, which are based on interviews. Note that it is possible that some installed ESS products will not last 15 years, although it has been assumed that a like-for-like replacement regime will occur, as each luminaire fails. Sensitivity testing was undertaken on installation lifetimes.

The areas where the model is considered *conservative* (under-estimate ESS energy savings) are as follows:

- The baseline turnover S-curves for market transition to efficient lighting.
- ESS (niche) products having longer lifetime than regime products - this is not currently modelled.
- Modelled run hours of lights is considered to be slightly lower than those used by ACPs.
- Modelled power savings of lighting upgrades is considered to be slightly lower than those used by ACPs.
- Modelled air conditioning energy savings and savings from any lighting control systems installed are considered to be slightly lower than those used by ACPs.

Recommendations for improved data collection processes, and modelling, are covered in Chapter 26.

15.7. Comparison with international data

The forecasts of LED stock penetration used in this model are based on the recent regulatory impact statement for lighting (E3, 2016b) which in turn bases many of its forecasts on US and European Studies. For comparison, Figure 32 shows a US forecast, where LED stocks in the US are expected to dominate by 2030, in line with the forecasts used in this study (refer Figure 36).

Figure 28 - forecast installed stock of lighting technologies in the US (source: USDoE, 2016)

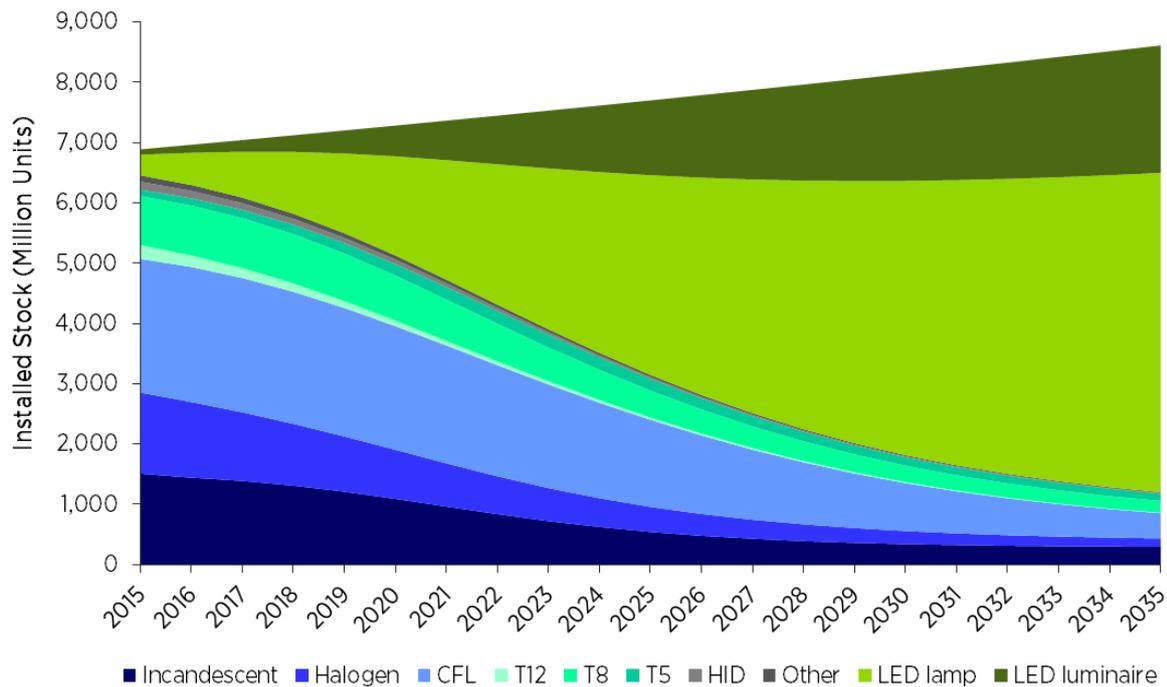


Figure 33 shows the same forecast for Europe (LEDs shown in orange).

Figure 29 - forecast installed stock of lighting technologies in the EU (source: EC, 2015)

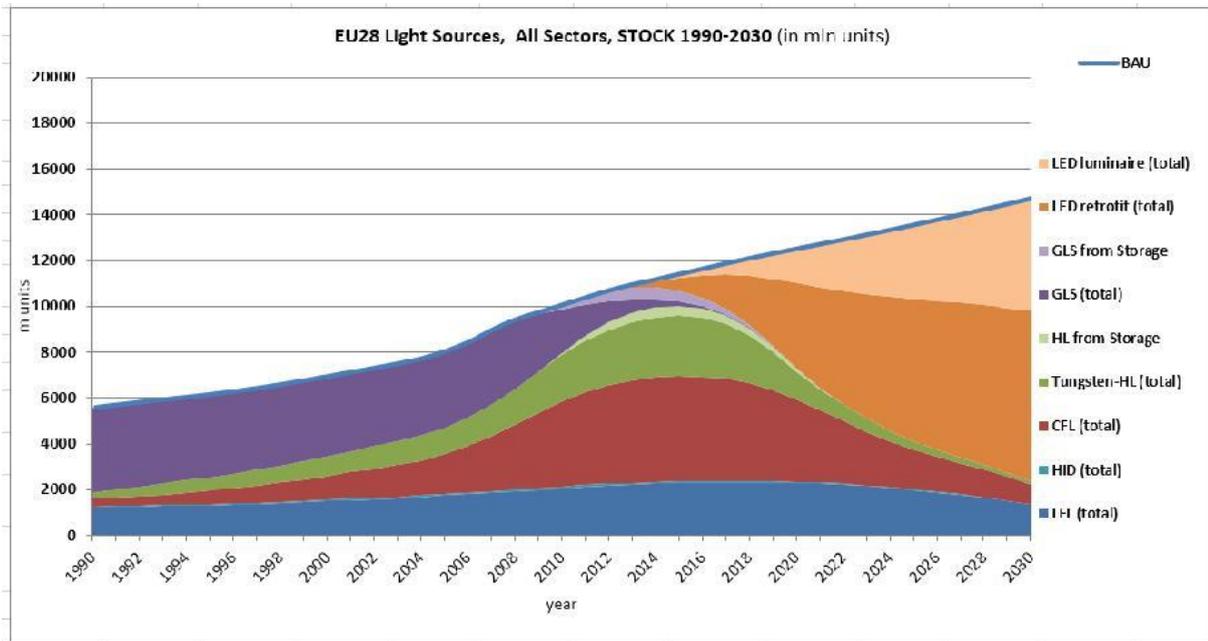


Figure 34 shows a related forecast - for US LED price and efficiency to 2020.

Figure 30 - forecast US LED price and efficiency relationship (source USDoE 2014)

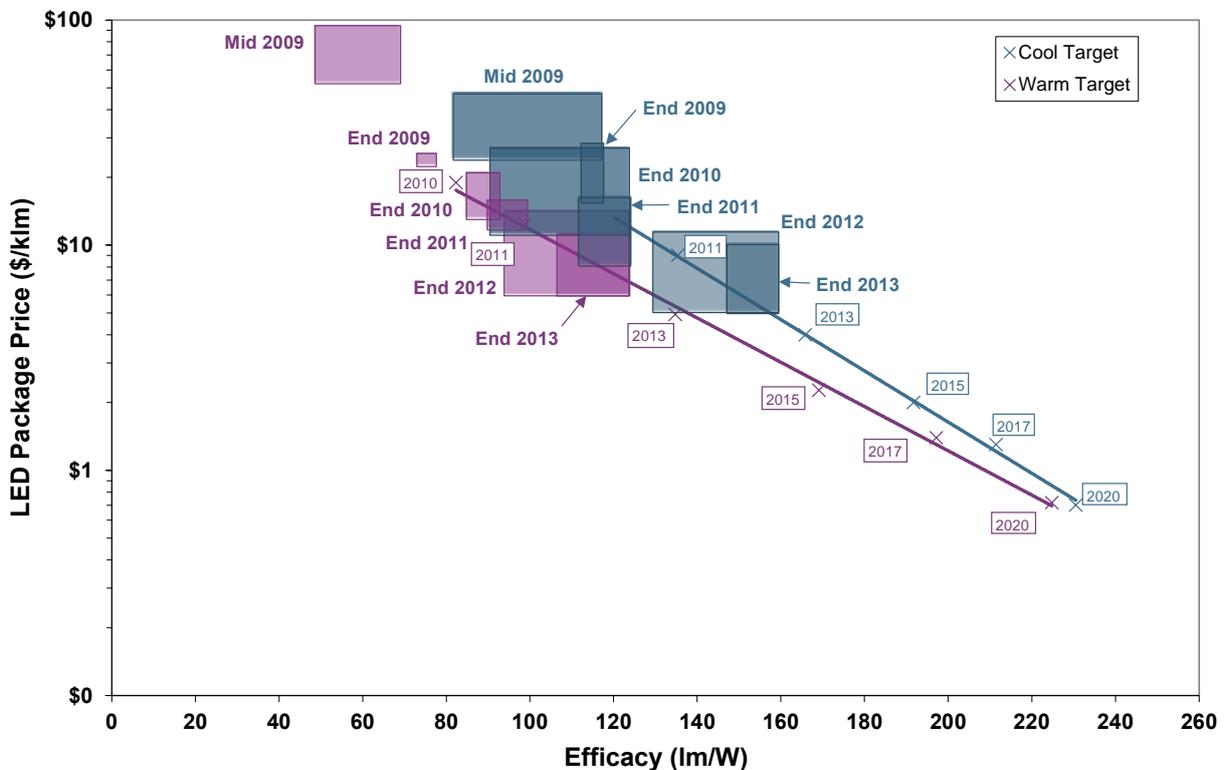
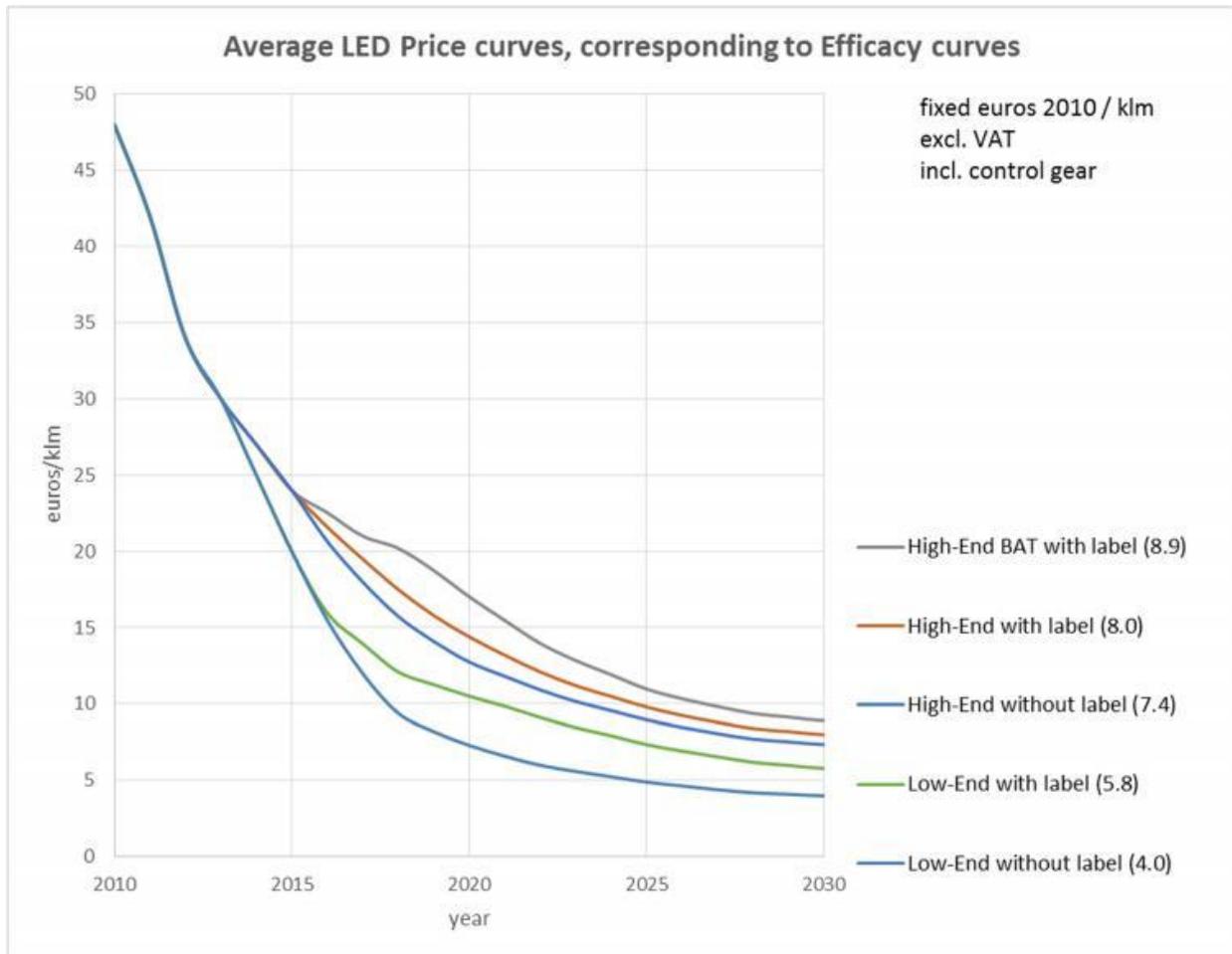


Figure 35 shows the LED price forecast for Europe, to 2030.

Figure 31 - forecast European LED price (source EC 2015)



The US and European forecasts are in line with the baseline forecasts for this study.

The forecasts of LED stock penetration used in this model are based on the recent regulatory impact statement for lighting (E3, 2016b) which in turn bases many of its forecasts on US and European Studies. For comparison, Figure 32 shows a US forecast, where LED stocks in the US are expected to dominate by 2030, in line with the forecasts used in this study (refer Figure 36).

Figure 32 - forecast installed stock of lighting technologies in the US (source: USDoE, 2016)

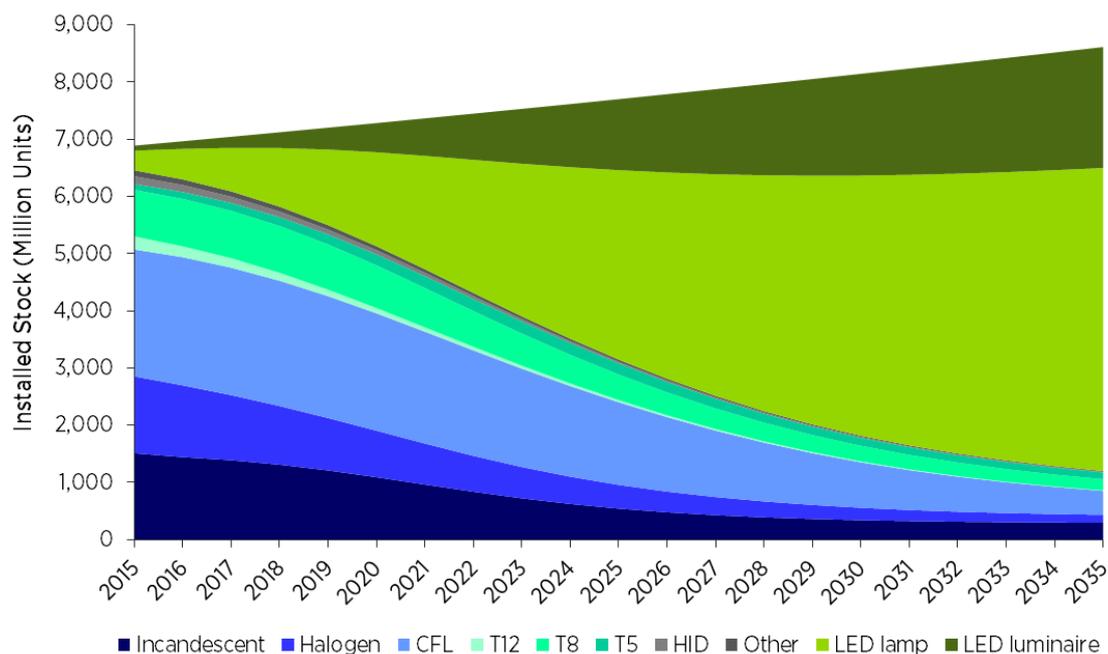


Figure 33 shows the same forecast for Europe (LEDs shown in orange).

Figure 33 - forecast installed stock of lighting technologies in the EU (source: EC, 2015)

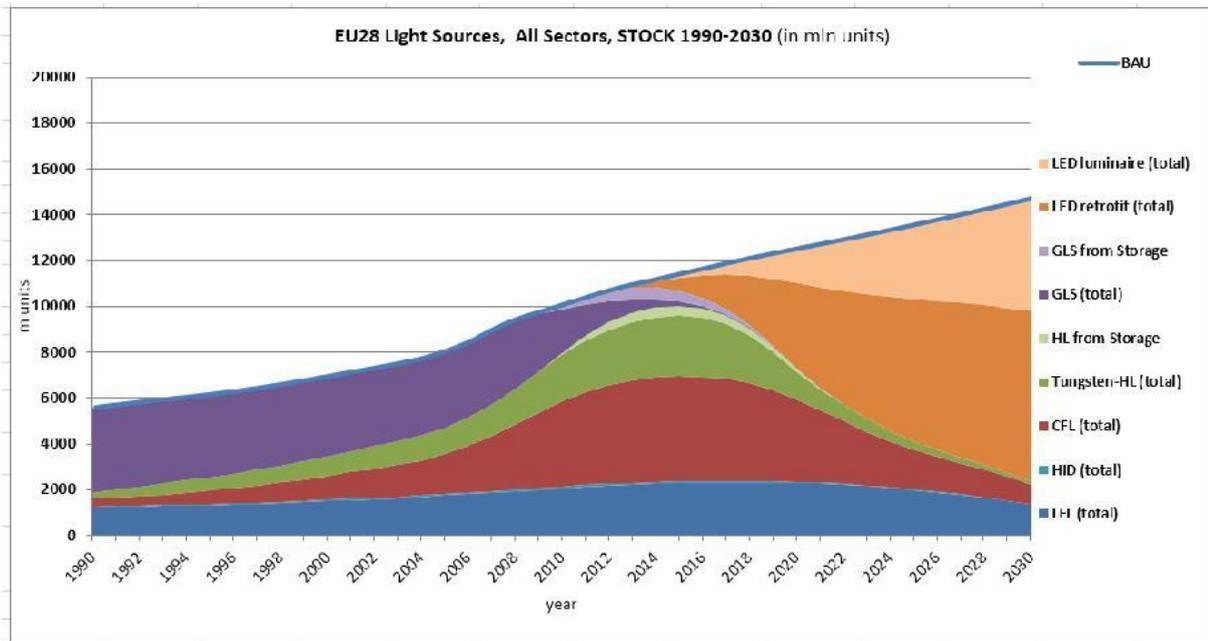


Figure 34 shows a related forecast - for US LED price and efficiency to 2020.

Figure 34 - forecast US LED price and efficiency relationship (source USDoE 2014)

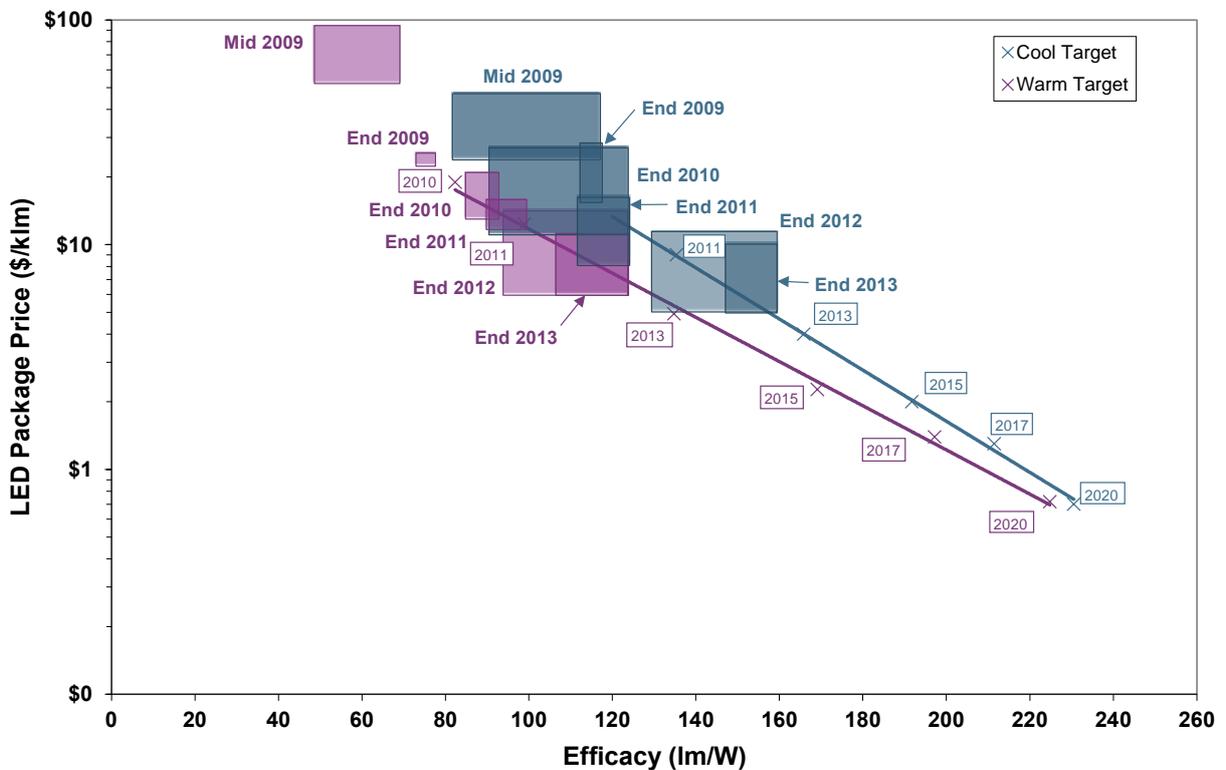
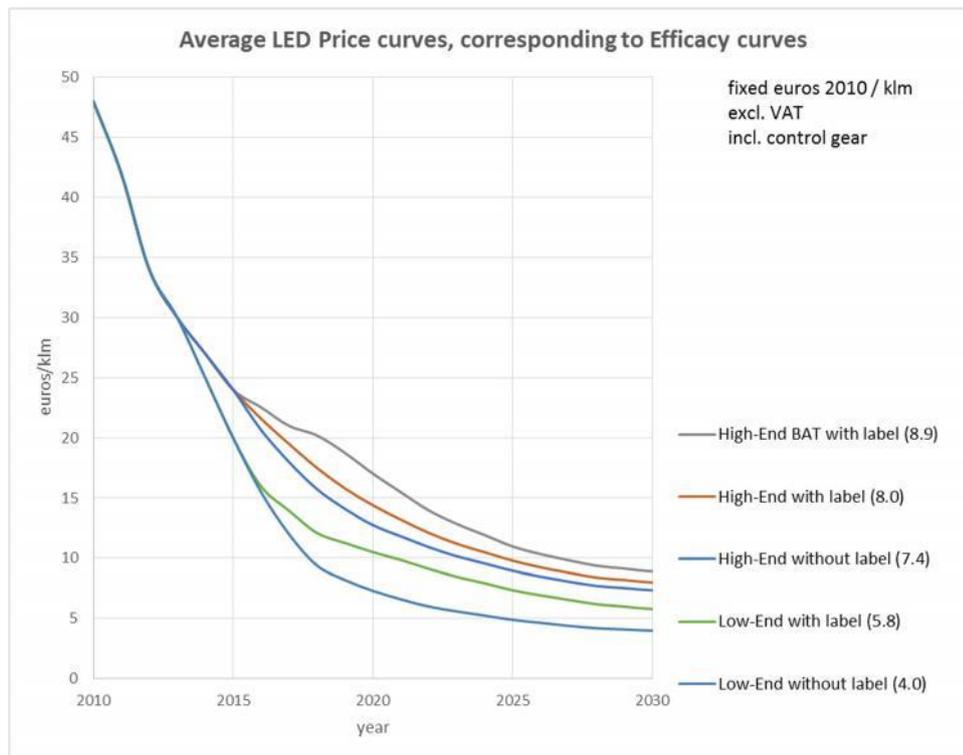


Figure 35 shows the LED price forecast for Europe, to 2030.

Figure 35 - forecast European LED price (source EC 2015)



The US and European forecasts are in line with the baseline forecasts for this study.

CHAPTER 17

Overview of Market Performance

The NSW lighting market sectors covered in this report are residential, office commercial, non-office commercial, industrial and public. Detailed findings for each of these are outlined in report Chapter 18 to Chapter 23.

This Chapter of the report summarises findings for the entire NSW lighting market.

17.1. Technology overview

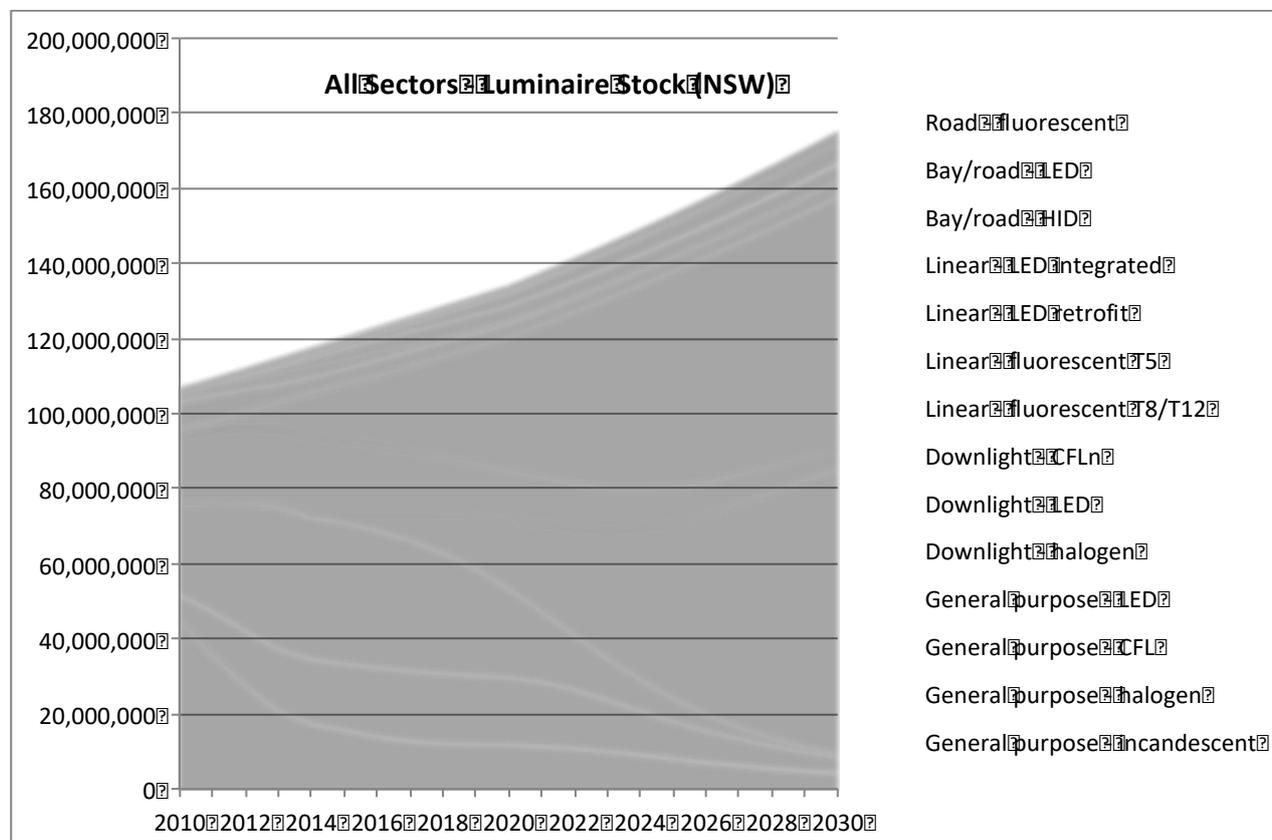
The lighting technologies and their application, by market sector, are listed in Table 8. In this table we can see also the key upgrade types (i.e. the technologies in column 3 upgrade to the technologies column 5). Note that the niche technologies, installed as part of the ESS, are assumed to be slightly more efficient than the market average equivalents. i.e. an LED installed by an ACP is slightly more efficient than the mass-market LED, as it is subject to a stringent quality specification and has an incentive to be more efficient (more ESCs will be created if more efficient).

Table 8 - lighting technologies and their application to market sector

Lighting type	Regime technologies (inefficient)	Mass market technologies (efficient)	Niche technologies (ESS)	Applicable market sectors
General purpose	Incandescent / halogen	CFL / LED (lower efficiency)	CFL / LED (higher efficiency)	Residential
Downlight	Halogen / CFLn	LED (lower efficiency)	LED (higher efficiency)	Residential / office / non-office commercial
Linear	T8 / T12	T5 / LED (lower efficiency)	T5 / LED (higher efficiency)	Office / non-office commercial / industrial
Bay / road	HID	LED (lower efficiency)	LED (higher efficiency)	Industrial / non-office commercial
Bay / road	Fluorescent / HID	LED (lower efficiency)	LED (higher efficiency)	Public

Figure 36 shows estimated stocks of all luminaire types, for all sectors.

Figure 36 - estimated stocks of major luminaire types in NSW



17.2. Sectoral overview

In the NSW **residential sector**, lamp sales exceeded 18 million in 2016 and the key upgrades are for general purpose lamps (incandescent/halogen to CFL/LED) and downlights (halogen to LED). A baseline transition to CFL/LED lighting is already well underway, thus energy savings from ESS activity in this sector would be relatively low. There was no significant ESS activity in the residential lighting sector (only around 8000 downlights) however some spill over effects may be occurring, due to ESS activity in other sectors.

In the NSW **office commercial sector**, lamp sales of around 1.5 million in 2016 were estimated, with the key upgrades being downlights (CFLn/halogen to LED) and linear luminaires (T8/T12 to T5/LED). Again, a baseline transition to efficient lighting technologies is already well underway in this sector, particularly for downlights. From the supplied ACP data, ESS activity in this sector represented only 3% of total ESS activity. The

baseline transition to efficient lighting is well and truly underway for downlights, and that this is predicted to continue (E3, 2016b).

In the **non-office commercial sector**, lamp sales are estimated at around 4 million in 2016. The key upgrades in this sector are for downlights (CFLn/halogen to LED) and linear luminaires (T8/T12 to T5/LED). The ACP data also showed significant upgrades of HID luminaires to LED in the retail sub-sector - these are HID "shop lights" and also highbay luminaires used in "big box" retail). A baseline transition to efficient lighting technologies is already well underway, particularly for downlights. From the supplied ACP data, ESS activity in this sector represented around 57% of total ESS activity.

In the NSW **industrial lighting sector**, lamp sales are estimated at around 1.3 million in 2016. The key upgrades in this sector are for linear luminaires (T8/T12 to T5/LED) and highbay / lowbay luminaires (HID to LED). A baseline transition to efficient lighting technologies is already underway. From the supplied ACP data, ESS activity in this sector represented around 38% of total ESS activity. The industrial sector is undergoing a relatively slow transition to efficient lighting (presumably as highbay lights are more difficult to change).

In the **NSW public lighting sector**, lamp sales are estimated at around 300,000 in 2016. The key upgrades in this sector are for HID/linear luminaires converting to LED. A baseline transition to efficient lighting technologies is already underway, although this some way behind the other sectors. The supplied ACP data did not show any ESS activity in this sector. However perusal of the ESS registry (examining activity names) shows that some 200,000 ESCs appear to have been created for street lighting projects.

17.3. General trends and findings

Across all sectors analysed, the following general trends and findings were observed:

- There is a significant baseline trend towards replacement of general purpose incandescent and halogen lamps with CFLs and LED lamps. This trend has been underway for some time.
- There is a significant baseline trend towards replacement of halogen downlights with LED. This is supported by ABS lamp import data which reveals a 70% downturn in the imports of halogen downlight lamps from 2010 to 2016.

- For linear and highbay / lowbay lighting, the trend towards efficient lighting has been slower to commence, but is now well and truly underway. ABS lamp import data reveals a 62% downturn in the imports of linear fluorescent lamps from 2010 to 2016.
- For public (road) lighting, upgrades trends to LED have been slowest.

Taking into account these trends and associated dynamic baselines, the estimated additional energy savings for lighting upgrades will be significantly lower than if a static baseline is used.

CHAPTER 18

Residential Market Performance

18.1. Overview

This Chapter of the covers the NSW residential lighting sector (refer section 15.2 for a definition). It describes the types of lighting products found, the “niche” and “regime” products, the major upgrade types and the estimated size of the market. Also discussed are the baseline scenario, including the baseline transition to efficient products, and the estimated impacts of the ESS.

The key findings for the NSW residential lighting sector are:

- Lamp sales in the NSW residential sector exceeded 18 million in 2016.
- The key upgrades in this sector are for general purpose lamps (incandescent/halogen to CFL/LED) and downlights (halogen to LED).
- A baseline transition to these lamp types is already well underway, and this will result in energy savings from any ESS activity in this sector being relatively low.
- There was no significant ESS activity in the residential lighting sector (only around 8000 downlights) however some spill over effects may be occurring, due to ESS activity in other sectors (to be tested in market participant interviews).

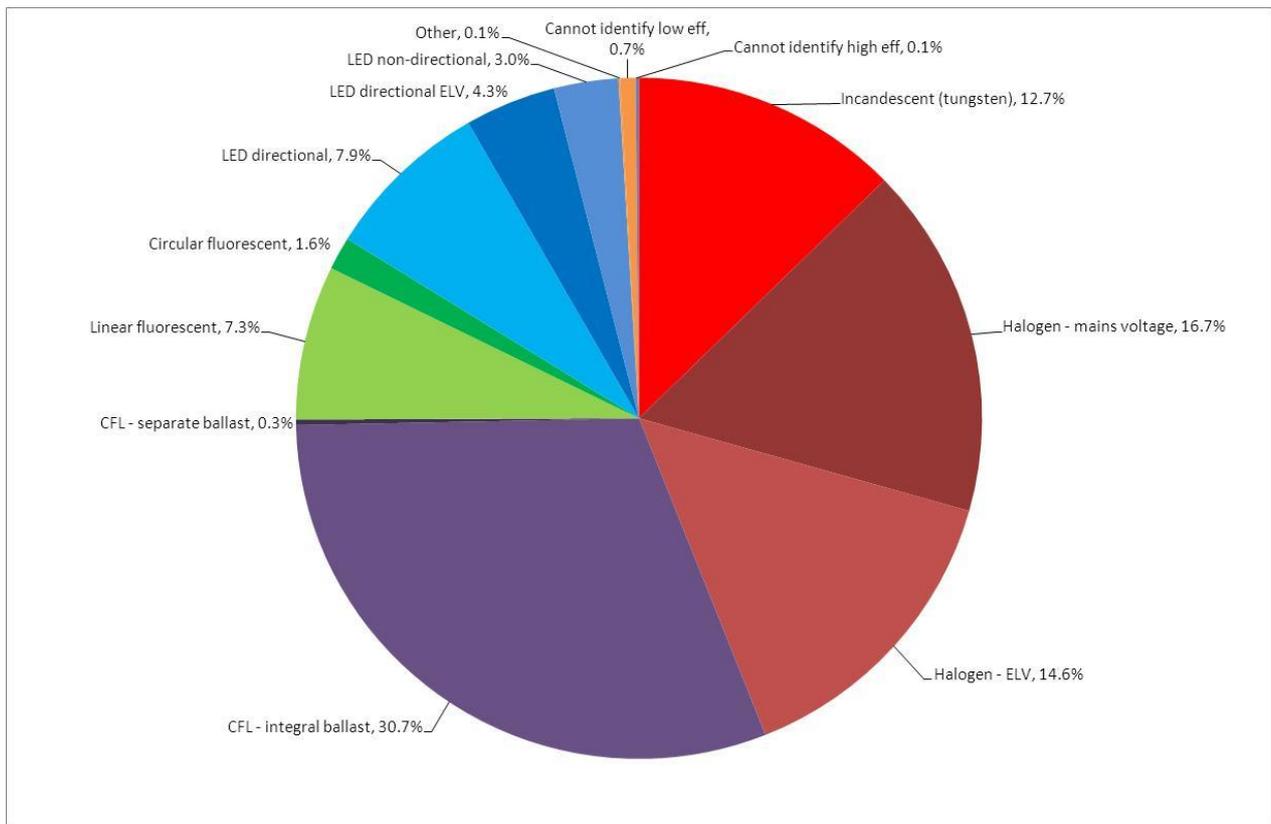
18.2. Sector Overview

The primary types of lighting technologies found in NSW homes are:

- General purpose - incandescent (regime)
- General purpose - halogen (regime)
- General purpose - CFL (regime + niche)
- General purpose - LED (regime + niche)
- Downlight - halogen (regime)
- Downlight - LED (regime + niche)

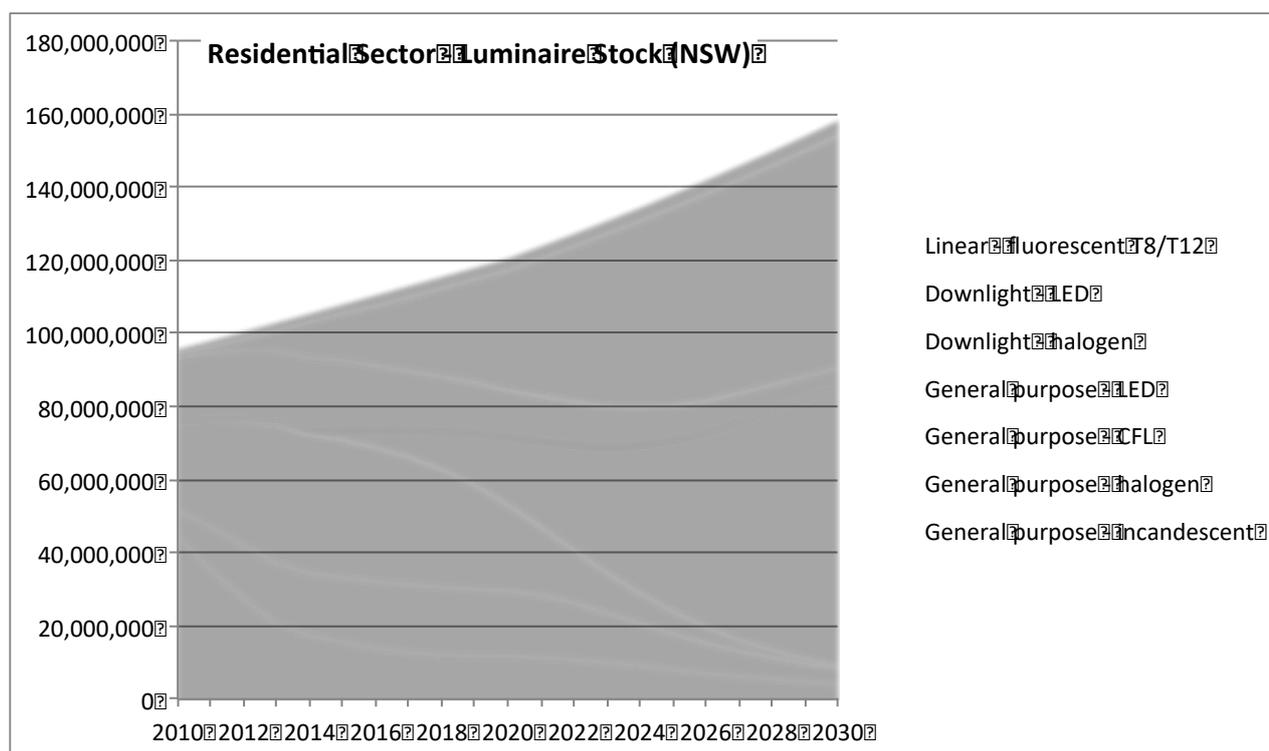
Fluorescent (linear and circular) lights also can be found in households, along with various other technology types in small quantities, however these are not a large part of the installed base, and not currently a significant target for upgrade. For information, the estimated shares of residential lighting types, for Australia, can be seen in Figure 37. In this figure it can be seen that directional LED lamps (downlights) already represent 12.2% of residential lamp stock, which is almost half of the share of total downlight stock, the other half being halogen ELV (extra low voltage) (14.6%). For general purpose (mains voltage) lamps, CFLs hold a significant share of lamp penetration.

Figure 37 - share of Australian residential lighting technologies (E3, 2016a)



The estimated sales of lamps in the NSW residential sector exceeded 18 million in 2016. The resultant estimated baseline of NSW stocks of luminaires are shown in Figure 38. Here we can see total stocks of lights growing over time, as the housing stock and average dwelling size increase, and the prevalence of downlights also increases (more lights used per m²). As predicted by E3 2016b, the prevalence of LEDs is predicted to increase significantly from around 2020 onwards, with LED downlights leading this trend.

Figure 38 - estimated stocks of residential luminaires in NSW



18.3. Baseline scenario

This section describes the estimated baseline scenario for the NSW residential sector. This is couched in terms of the baseline turnover of inefficient lights to efficient products. The major turnover types in this sector are:

- General purpose - incandescent/halogen (regime) to CFL/LED (niche)
- Downlight (regime) - halogen to LED (niche).

Figure 39 shows the predicted turnover rate for general purpose lamps - essentially an S-curve for these products. Note that this is the estimated percentage of lamp retirements that turn over to CFL or LED at the end of their life. The formulation of these turnover curves is discussed in section 15.3 and does contain some uncertainty.

As can be seen in Figure 39, there is a high rate of turnover to CFL/LED that pre-dates the ESS, and to date this is predominantly a transition to CFLs rather than LEDs. The curve flattens somewhat over the period 2013-2020 and then increase after 2020, as the price and availability of LEDs is predicted to improve considerably (E3, 2016b).

Figure 39 - estimated turnover rate - general purpose lamps (residential)

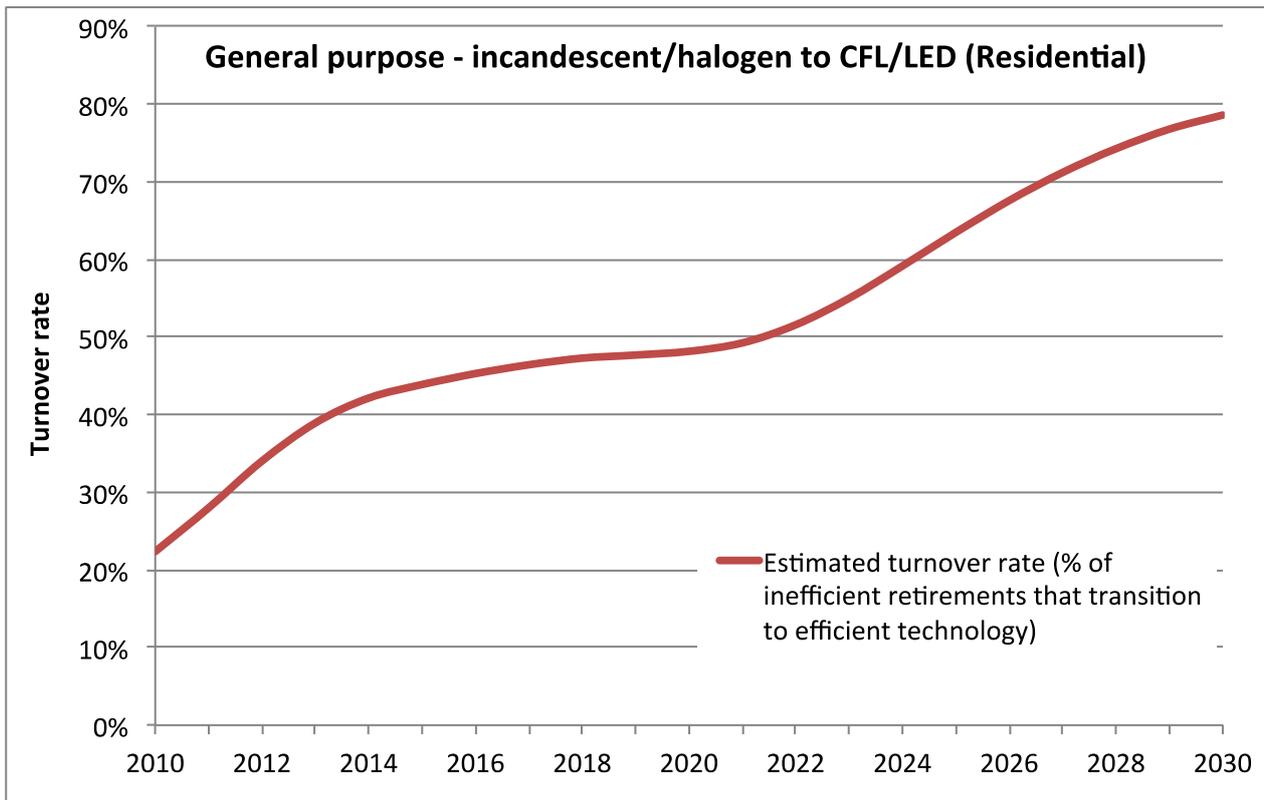


Figure 40 shows the turnover S-curve for downlight lamps - the estimated percentage of lamp retirements that turn over to LED at the end of their life. This does not start until around 2012 but increases rapidly - in Australia LED downlights lead the market trend towards LED products.

Figure 40 - estimated turnover rate - downlights (residential)

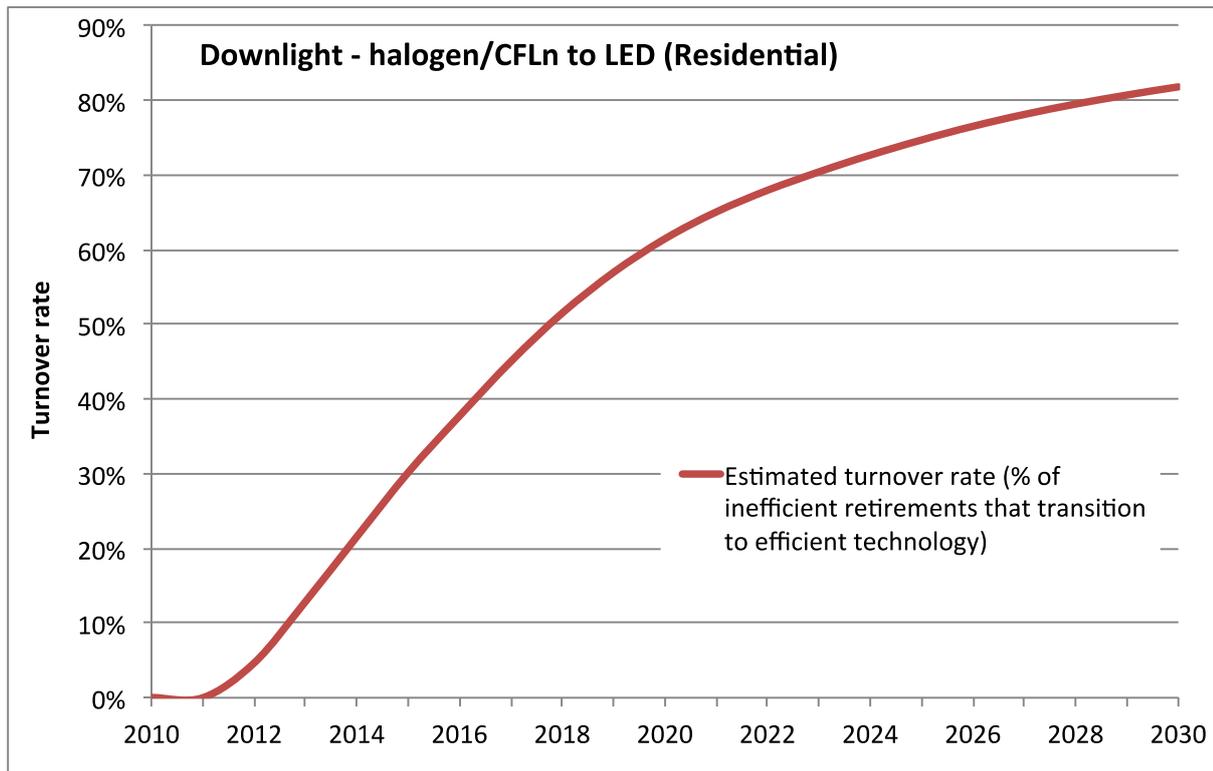


Figure 41 shows the estimated power of general purpose lamps in the residential sector, as follows:

- Incumbent: the lamp that is upgraded, in this case an incandescent or halogen lamp.
- ESS: the (niche) lamp that is installed as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) lamps, and are assumed to transition from CFLs to LEDs in around 2015.
- Counterfactual: the weighted average baseline lamp that is installed to replace incumbent lamps at the end of their life. These include incandescent, halogen, CFL and LEDs lamps. As the sales share of CFL and LED lamps increases, the weighted average power of this counterfactual lamp decreases.

In Figure 41, for general purpose lamps, we can see the power of the counterfactual, efficient and ESS lamps decreasing over time, with the incumbent lamp power remaining static.

Figure 41 - estimated general purpose lamp power (residential)

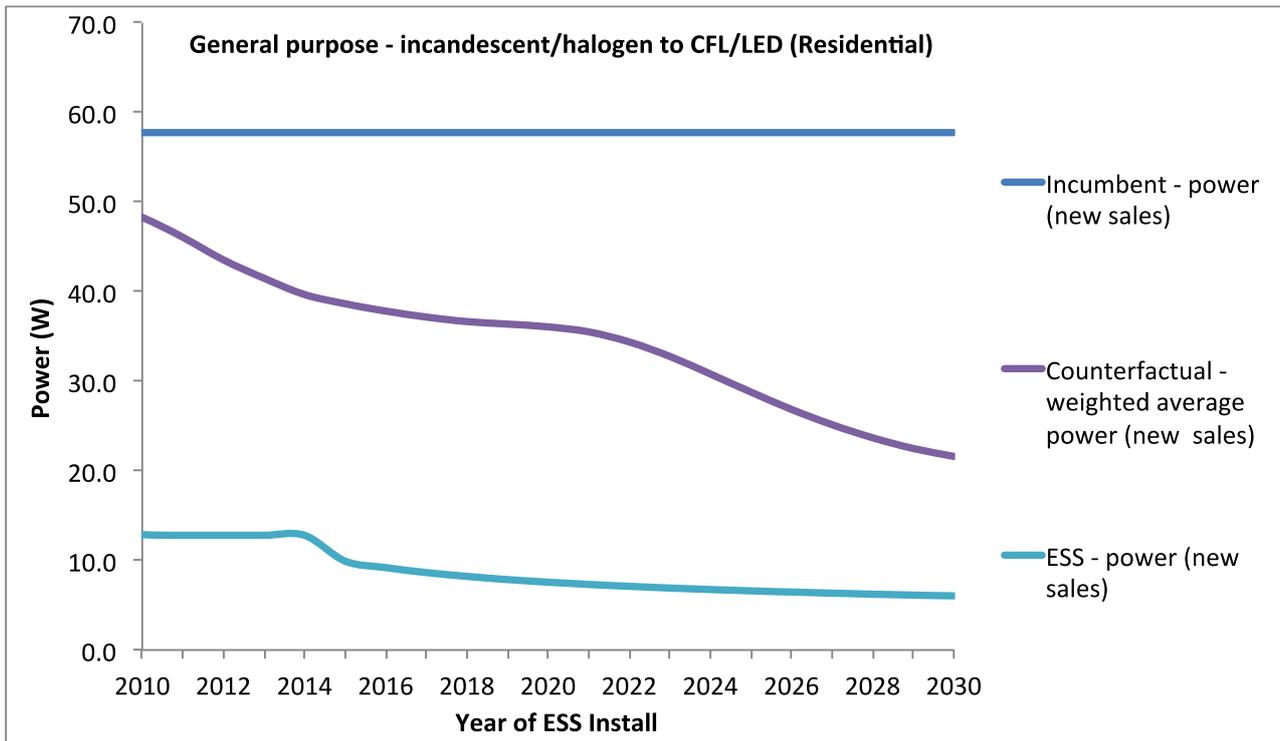
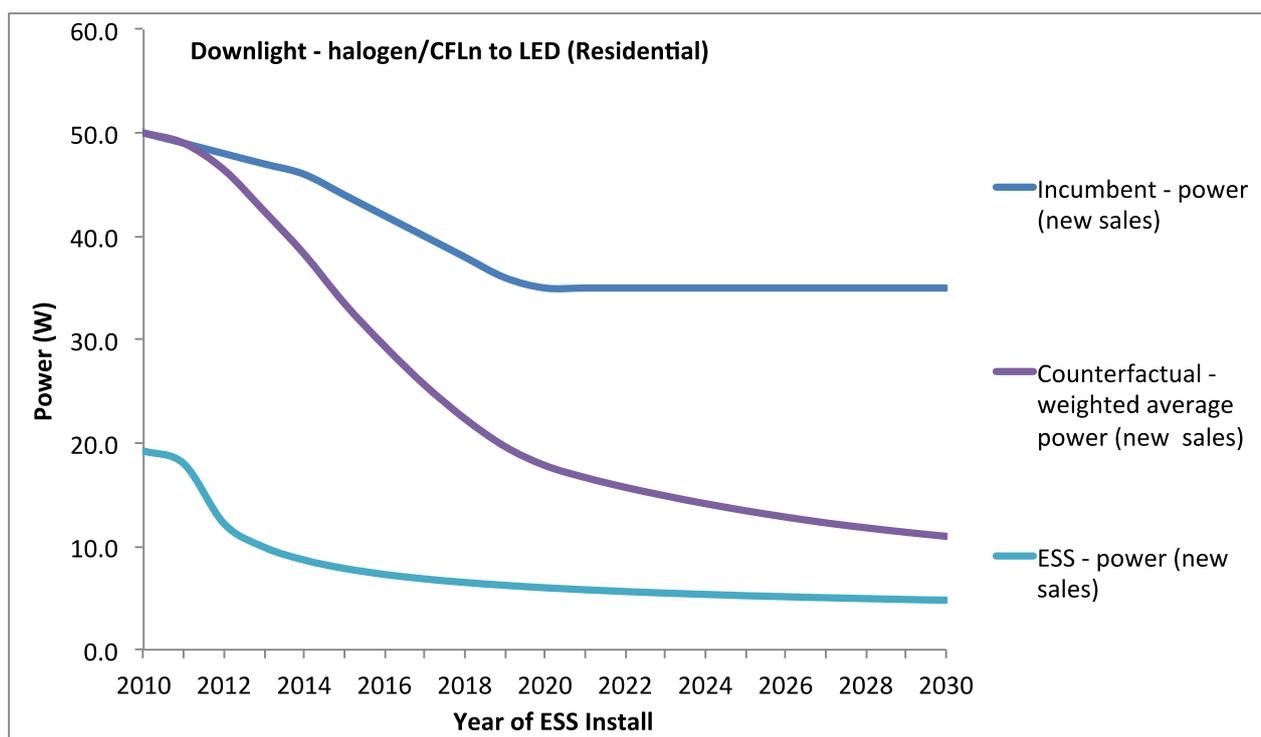


Figure 42 shows the same for residential downlights. In this figure we can see a steeper reduction in the power of the counterfactual lamp, reflecting the baseline transition of halogen downlights to LED. Also, the power of incumbent luminaires decreases due to government phase out of 50W halogen downlight lamps in favour of 35W.

Figure 42 - estimated downlight lamp power (residential)



The curves shown in the previous two figures are used as the basis for deriving energy savings from replacing incumbent lamps with ESS lamps, with the counterfactual lamp being the lamp that would have replaced the incumbent lamp, in the absence of the ESS (refer section 15.3 for more detail on the methodology). The results of this calculation are described in the following section.

18.4. ESS impacts

Although there was only a very small amount of ESS activity in the residential lighting sector (around 8000 downlights to date, presumably in common areas of multi-unit apartment buildings) the model calculates potential energy savings from upgrades in this sector, summing energy savings over the two periods described in section 15.3. Figure 43 shows estimated savings for general purpose lamp upgrades and Figure 44 shows the same for residential downlights. The relatively low energy savings of both of these types of upgrades reflects the fact that the baseline transition to efficient lighting is well and truly underway for general purpose lamps and downlights in the residential sector, and that this is predicted to continue (E3, 2016b).

Figure 43 - estimated lifetime energy savings from replacement of general purpose lamps (residential)

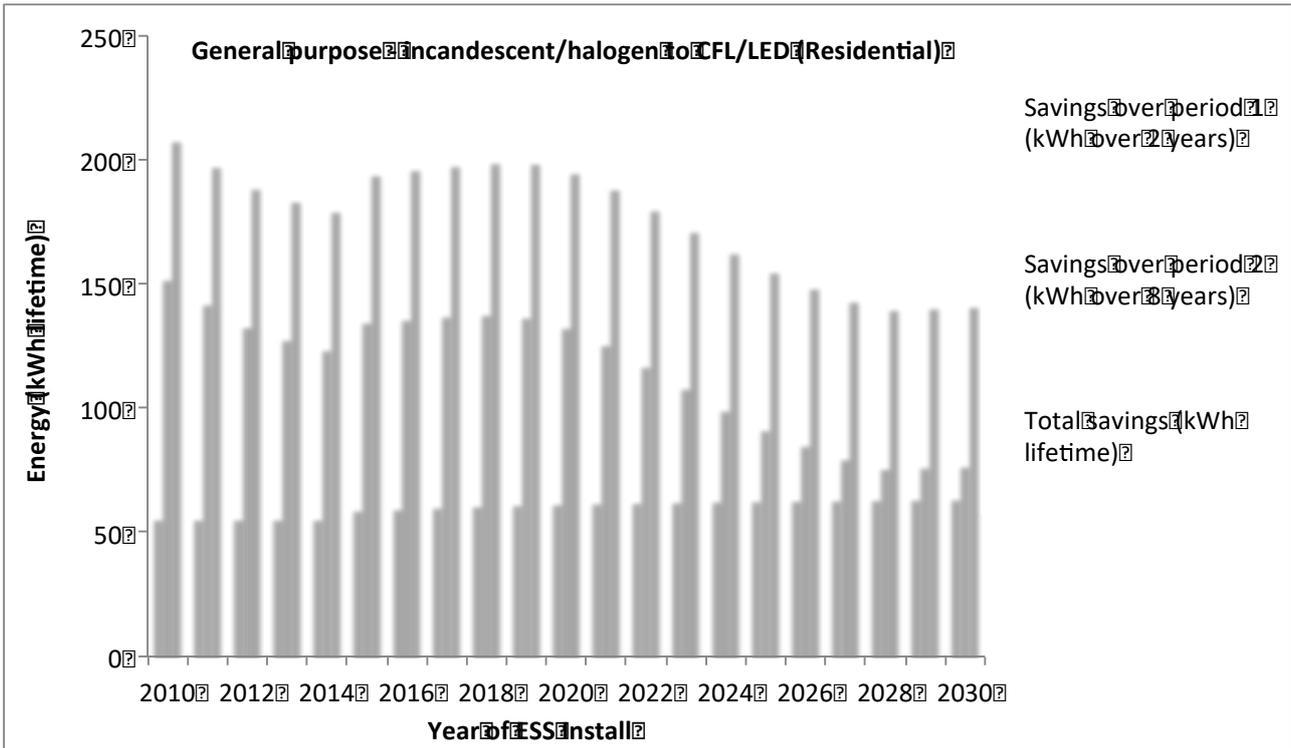
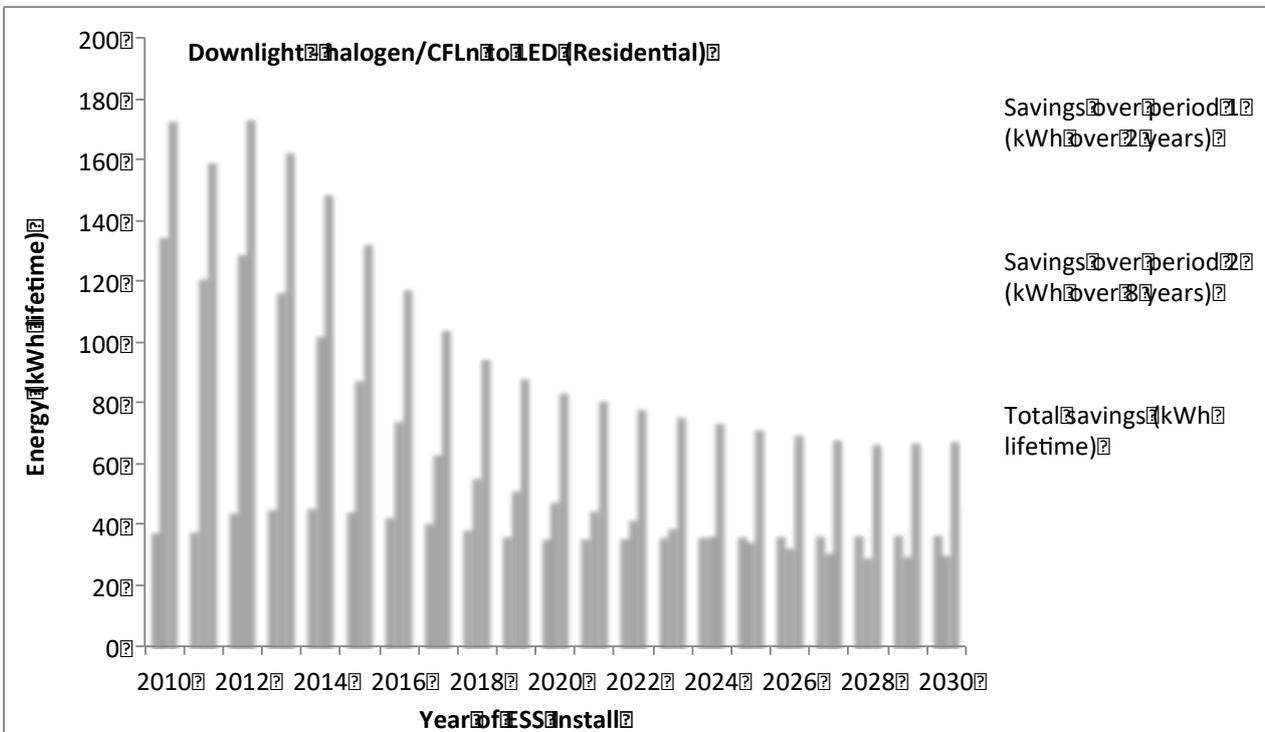


Figure 44 - estimated lifetime energy savings from replacement of downlight lamps (residential)



18.5. Transformative Nature of ESS Impacts

There was only a very small amount of ESS activity in the residential lighting sector. The ESS's and VEET's contribution to accelerating adoption of LED downlights in the commercial market may have contributed to accelerated availability of affordable LEDs for NSW households (directly and via wholesalers to residential electrical contractors). However, we were unable to test this hypothesis as our interviewees focussed on commercial and industrial actors, due in line with ESS impacts.

CHAPTER 19

Office Commercial Market Performance

19.1. Overview

This section of the report covers the NSW “office commercial” (or simply “office”) lighting sector (refer section 15.2 for a definition). It describes the types of lighting products found, the “niche” and “regime” products, the major upgrade types and the estimated size of the market. Also discussed are the baseline scenario, including the baseline transition to efficient products, and the estimated impacts of the ESS.

The key findings for the NSW office lighting sector are:

- Lamp sales in the NSW office sector are estimated at around 1.5 million in 2016.
- The key upgrades in this sector are for downlights (CFLn/halogen to LED) and linear luminaires (T8/T12 to T5/LED)
- A baseline transition to efficient lighting technologies is already well underway, particularly for downlights.
- From the supplied ACP data, ESS activity in this sector represented only 3% of total ESS activity.

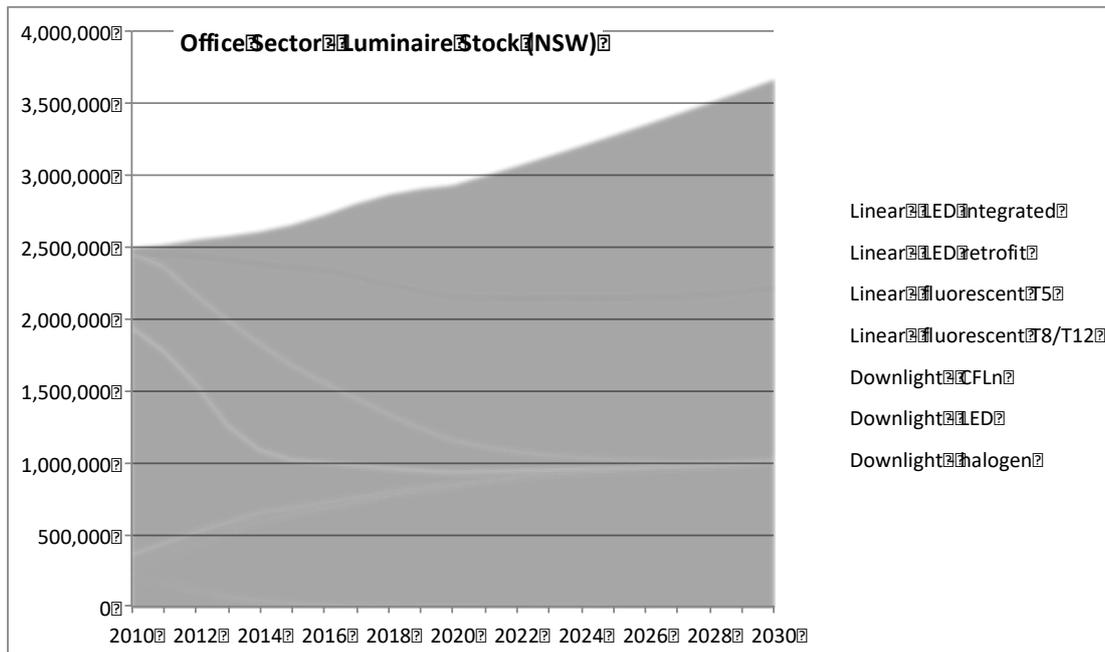
19.2. Sector Overview

The primary types of lighting technologies found in NSW offices are:

- Downlight - halogen (regime)
- Downlight - CFLn (regime)
- Downlight - LED (regime + niche)
- Linear - T8/T12 (regime)
- Linear - T5 (regime + niche)
- Linear - LED (regime + niche)

The estimated sales of lamps in the NSW office sector is estimated at around 1.5 million in 2016. The resultant estimated baseline NSW stocks of office luminaires are shown in Figure 45. Here we can see total stocks of lights growing over time, as the office floor area increases, as well as increases in stocks of T5 and LED lights (noting that T5 stocks eventually decrease and are replaced with LED).

Figure 45 - estimated stocks of office luminaires in NSW



19.3. Baseline scenario

This section describes the estimated baseline scenario for the NSW office sector. This is couched in terms of the baseline turnover of inefficient lights to more efficient products. The major turnover types in this sector are:

- Downlight - CFLn or halogen (regime) to LED (niche)
- Linear - T8 or T12 (regime) to T5 or LED (niche)

Figure 46 shows the predicted turnover rate for downlights - essentially an S-curve for these products. Note that this is the estimated percentage of downlight luminaire retirements that turn over to LED at the end of their life. The formulation of these turnover curves is discussed in section 15.3 and does contain some uncertainty.

As can be seen in Figure 46 the transition to LED downlights is estimated to occur very rapidly in offices from 2010 onwards, supported by ABS data which reveals a 70% downturn in the imports of halogen downlight lamps from 2010 to 2016.

Figure 46 - estimated turnover rate - downlights (office)

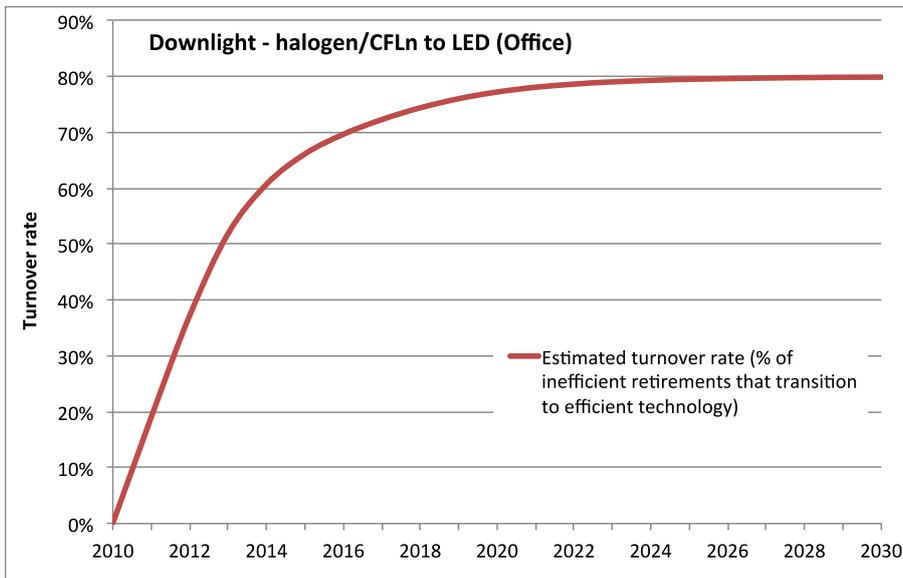


Figure 46 shows the turnover S-curve for linear luminaires - the estimated percentage of T8/T12 luminaire retirements that turn over to T5 or LED at the end of their life.

Figure 47 - estimated turnover rate - linear luminaires (office)

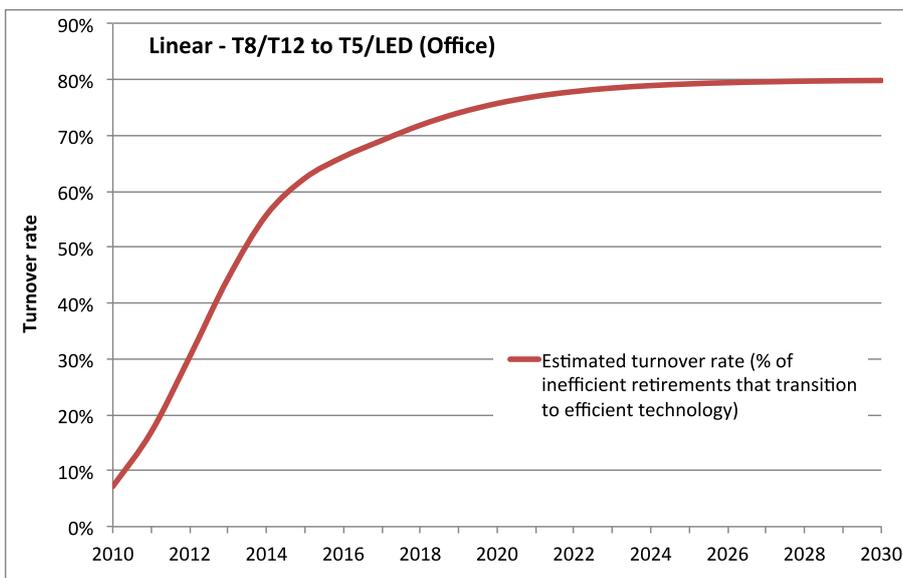


Figure 48 shows the estimated power of downlights in the office sector, as follows:

- Incumbent: the luminaire that is upgraded, in this case a CFLn or halogen.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) LED luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These are halogen, CFLn or

LED and as the sales share of LEDs increase, the weighted average power of this counterfactual luminaire decreases.

In Figure 48, for downlights, we can see the power of the counterfactual, efficient and ESS luminaires decreasing over time. The incumbent luminaire power also decreases due to government phase out of 50W halogen downlight lamps in favour of 35W.

Figure 48 - estimated downlight power (office)

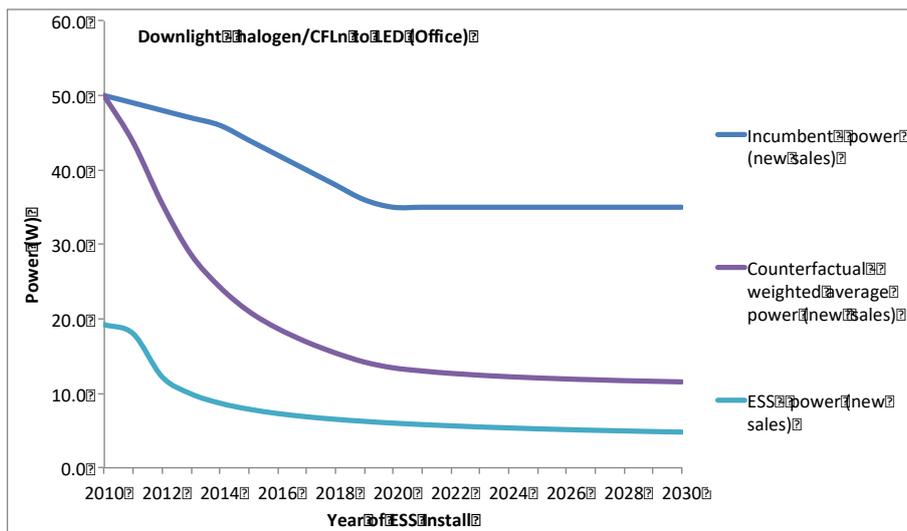
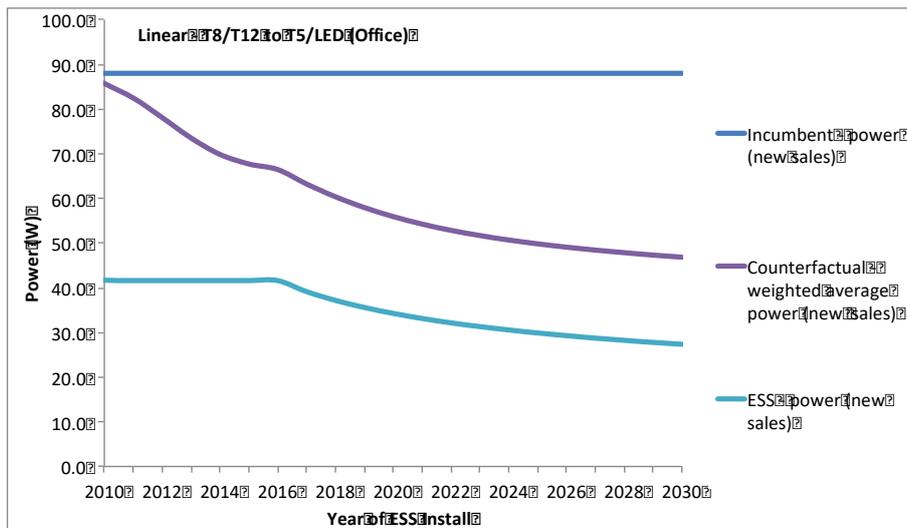


Figure 49 shows the same for office linear luminaires, as follows:

- Incumbent: the luminaire that is upgraded, in this case a T8/T12.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include T8, T5 and LED. As the sales share of T5s and LEDs increase, the weighted average power of this counterfactual luminaire decreases.

Figure 49 - estimated linear luminaire power (office)



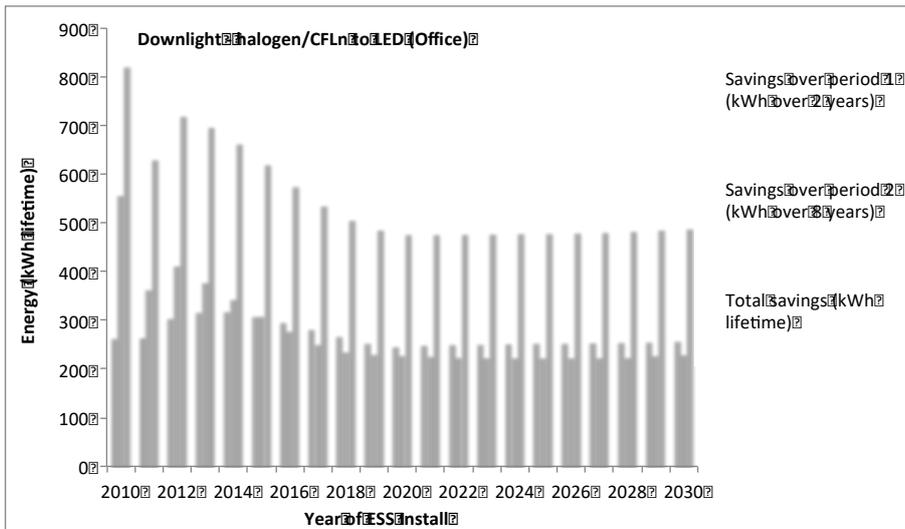
The curves shown in the previous two figures are used as the basis for deriving energy savings from replacing/modifying incumbent luminaires with ESS luminaires in offices, with the counterfactual being the unit that would have replaced the incumbent luminaire, in the absence of the ESS (refer section 15.3 for more detail on the methodology). The results of this calculation are described in the following section.

19.4. ESS impacts

The model calculates potential (direct) energy savings from upgrades in this sector (not including free riders or spill over), summing energy savings over the two periods described in section 15.3. Figure 50 shows estimated savings for downlight upgrades and Figure 51 shows the same for linear luminaire upgrades.

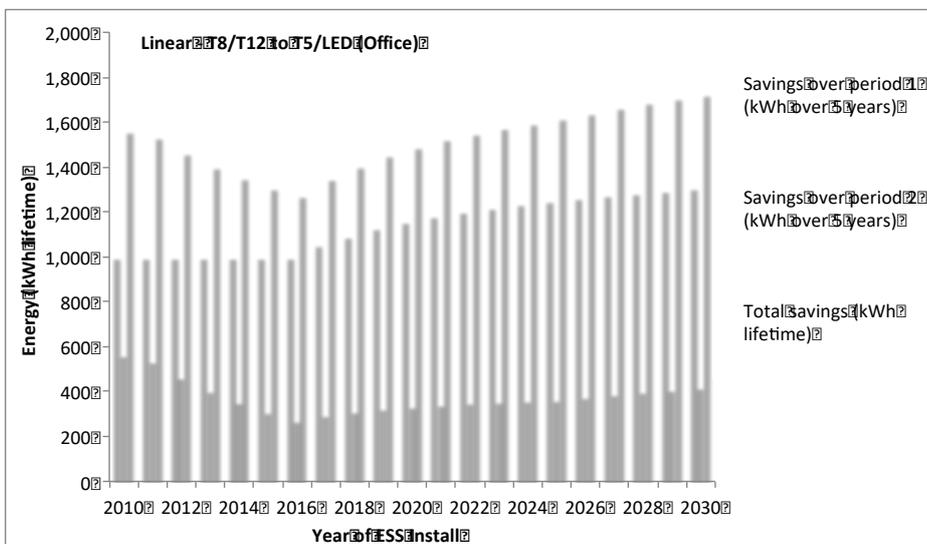
The relatively low energy savings for downlights reflects the fact that the baseline transition to efficient lighting is well and truly underway for downlights, and that this is predicted to continue (E3, 2016b).

Figure 50 - estimated lifetime energy savings from replacement of downlights (office sector)



The lifetime energy savings calculated in Figure 51, for office linear luminaires range from around 1.3 to 1.6 MWh⁶⁴. By comparison, the CLF assigns 2.3 MWh⁶⁵.

Figure 51 - estimated lifetime energy savings from replacement/upgrade of linear luminaires (office sector)



The per-luminaire energy savings calculated above are then used to estimate total impacts of the ESS in the office sector.

⁶⁴ Using average of 4300 hours p.a. (av of ACP data), 15 years LED life, no A/C effect

⁶⁵ Using 35W LED luminaire to replace 88W luminaire, average of 4300 hours p.a. (av of ACP data), 10 years LED life, no A/C effect

19.5. Transformative nature of ESS impacts

There was ESS activity in the NSW office lighting sector, but this was only around 3% of the total ACP supplied data. However, there may be some spill over occurring, due to ESS activity in other sectors, i.e. structural and product changes that effect all sectors.

CHAPTER 20

Non-Office Commercial Market Performance

20.1. Overview

This section of the report covers the NSW “non-office commercial” lighting sector (refer section 15.2 for a definition). It describes the types of lighting products found, the “niche” and “regime” products, the major upgrade types and the estimated size of the market. Also discussed are the baseline scenario, including the baseline transition to efficient products, and the estimated impacts of the ESS.

The key findings for the NSW non-office commercial lighting sector are:

- Lamp sales in the NSW non-office commercial sector are estimated at around 4 million in 2016.
- The key upgrades in this sector are for downlights (CFLn/halogen to LED) and linear luminaires (T8/T12 to T5/LED).
- The ACP data also showed significant upgrades of HID luminaires to LED (likely “shop lights” and highbay luminaires used in “big box” retail outlets).
- A baseline transition to efficient lighting technologies is already well underway, particularly for downlights.
- From the supplied ACP data, ESS activity in this sector represented around 57% of total ESS activity.

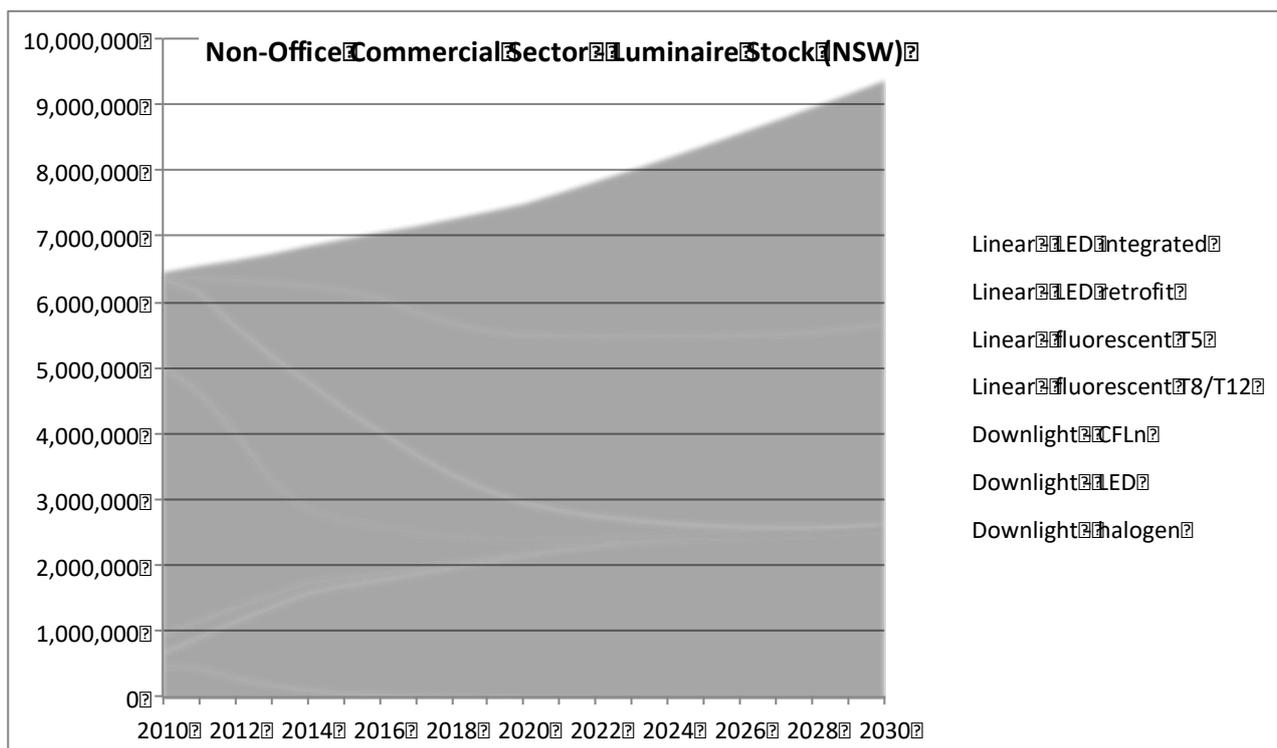
20.2. Sector Overview

The primary types of lighting technologies found in NSW offices are:

- Downlight - halogen (regime)
- Downlight - CFLn (regime)
- Downlight - LED (regime + niche)
- Linear - T8/T12 (regime)
- Linear - T5 (regime + niche)
- Linear - LED (regime + niche)
- HID to LED (shop lights and highbay)

The estimated sales of lamps in the NSW non-office commercial sector is estimated at around 4 million in 2016. The resultant estimated baseline NSW stocks of non-office commercial luminaires are shown in Figure 52. Here we can see total stocks of lights growing over time, as floor area increases, as well as increases in stocks of T5 and LED lights (noting that T5 stocks eventually decrease and are replaced with LED). Note that no sales or stock data was available specifically for HID lights used in retail.

Figure 52 - estimated stocks of non-office commercial luminaires in NSW



20.3. Baseline scenario

This section describes the estimated baseline scenario for the NSW non-office commercial sector. This is couched in terms of the baseline turnover of inefficient lights to more efficient products. The major turnover types in this sector are:

- Downlight - CFLn or halogen (regime) to LED (niche)
- Linear - T8 or T12 (regime) to T5 or LED (niche)
- HID to LED (shop lights and highbay) - no data available to demonstrate the baseline turnover rates.

Figure 53 shows the predicted turnover rate for downlights - essentially an S-curve for these products. Note that this is the estimated percentage of downlight luminaire retirements that turn over to LED at the end of their life. The formulation of these turnover curves is discussed in section 15.3 and does contain some uncertainty.

As can be seen in Figure 53 the transition to LED downlights is estimated to occur very rapidly in this sector from 2010 onwards, supported by ABS data which reveals a 70% downturn in the imports of halogen downlight lamps from 2010 to 2016.

Figure 53 - estimated turnover rate - downlights (non-office commercial)

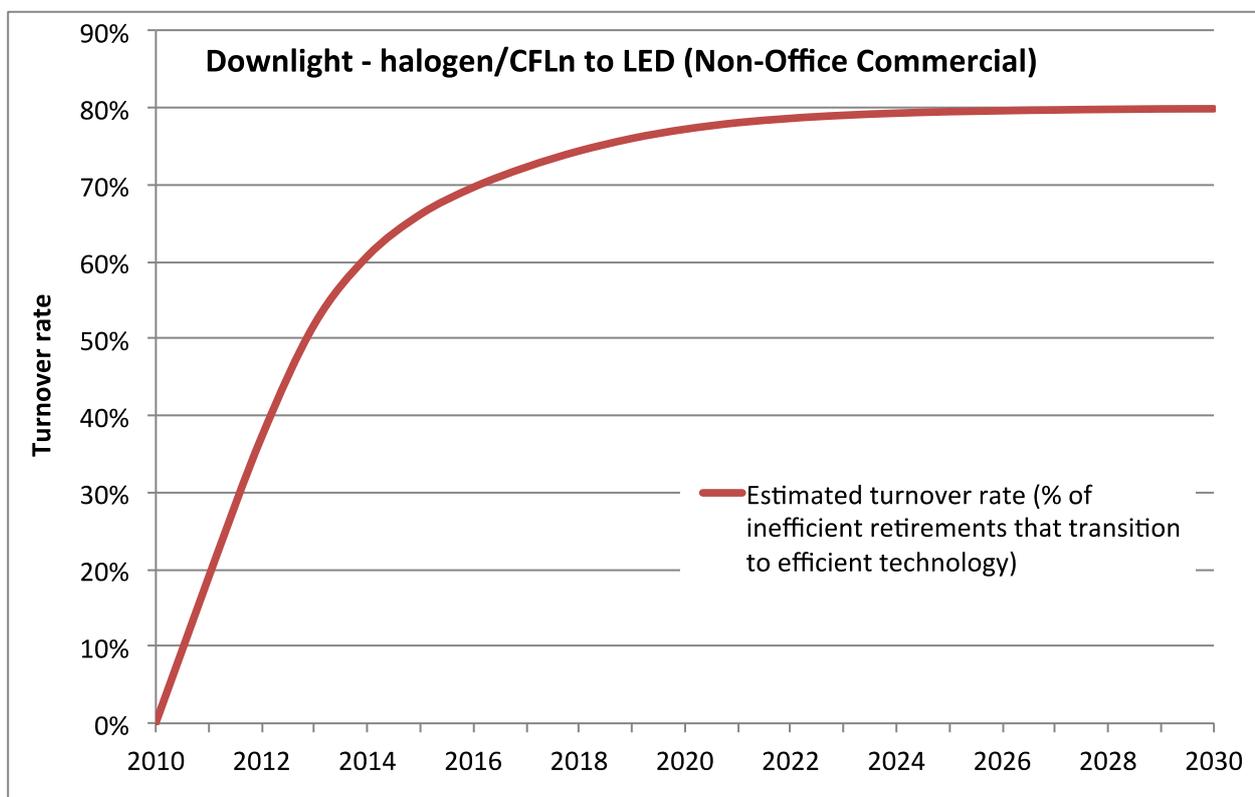


Figure 54 shows the turnover S-curve for linear luminaires - the estimated percentage of T8/T12 luminaire retirements that turn over to T5 or LED at the end of their life.

Figure 54 - estimated turnover rate - linear luminaires (non-office commercial)

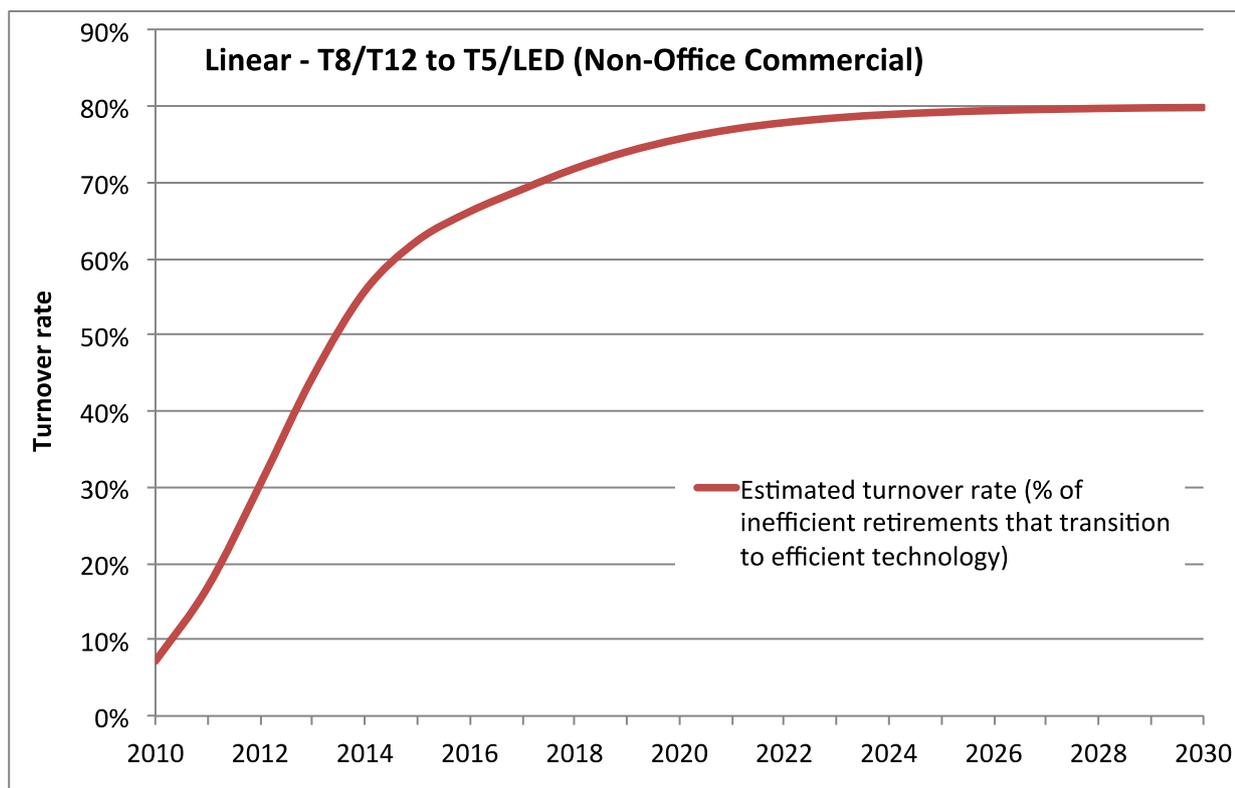


Figure 55 shows the estimated power of downlights in the non-office commercial sector, as follows:

- Incumbent: the luminaire that is upgraded, in this case a CFLn or halogen.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) LED luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These are halogen, CFLn or LED and as the sales share of LEDs increase, the weighted average power of this counterfactual luminaire decreases.

In Figure 55, for downlights, we can see the power of the counterfactual, efficient and ESS luminaires decreasing over time. The incumbent luminaire power also decreases due to government phase out of 50W halogen downlight lamps in favour of 35W.

Figure 55 - estimated downlight power (non-office commercial)

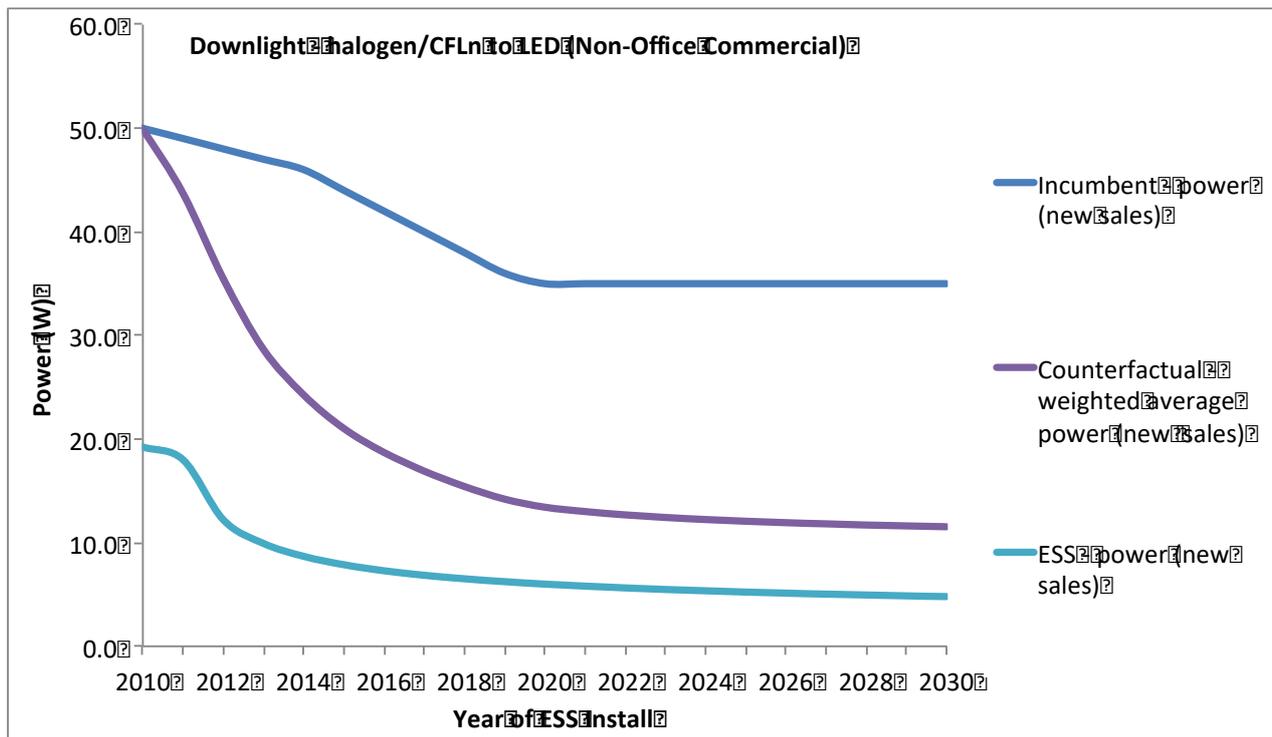
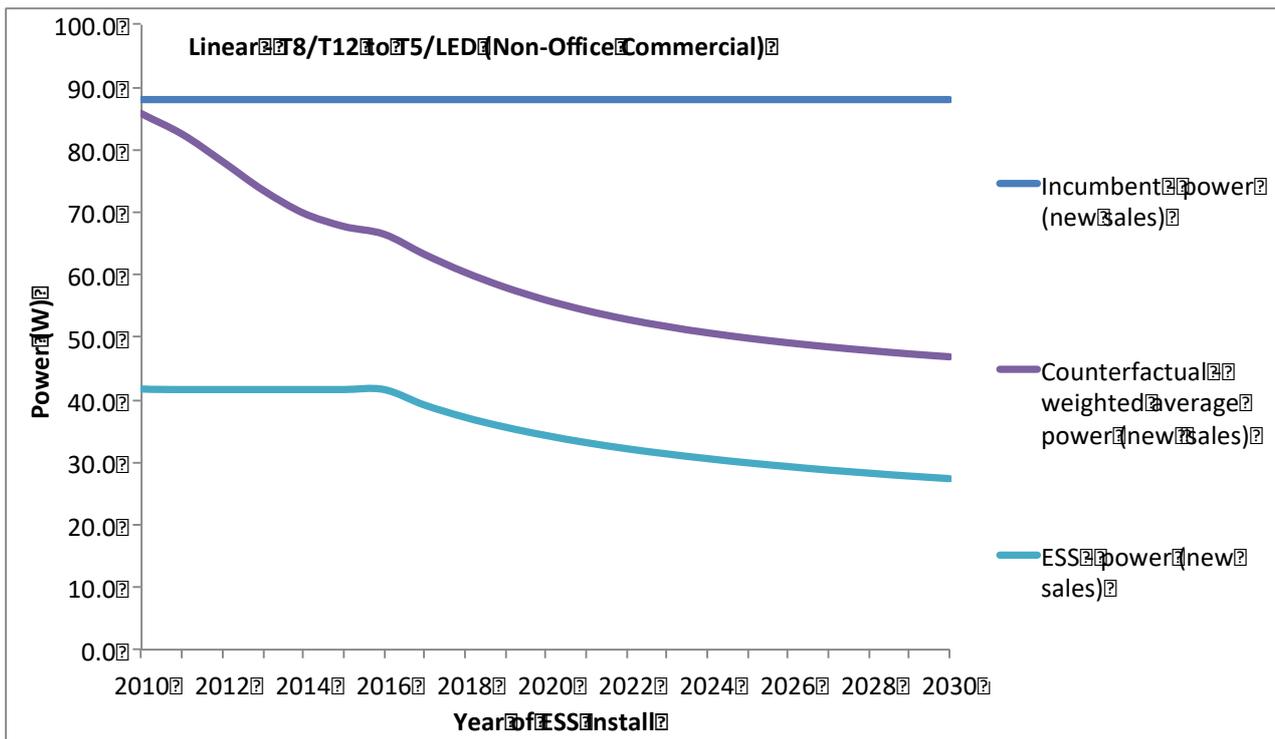


Figure 56 shows the same for linear luminaires, as follows:

- Incumbent: the luminaire that is upgraded, in this case a T8/T12.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include T8, T5 and LED. As the sales share of T5s and LEDs increase, the weighted average power of this counterfactual luminaire decreases.

Figure 56 - estimated linear luminaire power (non-office commercial)



The curves shown in the previous two figures are used as the basis for deriving energy savings from replacing/modifying incumbent luminaires with ESS luminaires in the non-office commercial sector, with the counterfactual being the unit that would have replaced the incumbent luminaire, in the absence of the ESS (refer section 15.3 for more detail on the methodology). The results of this calculation are described in the following section.

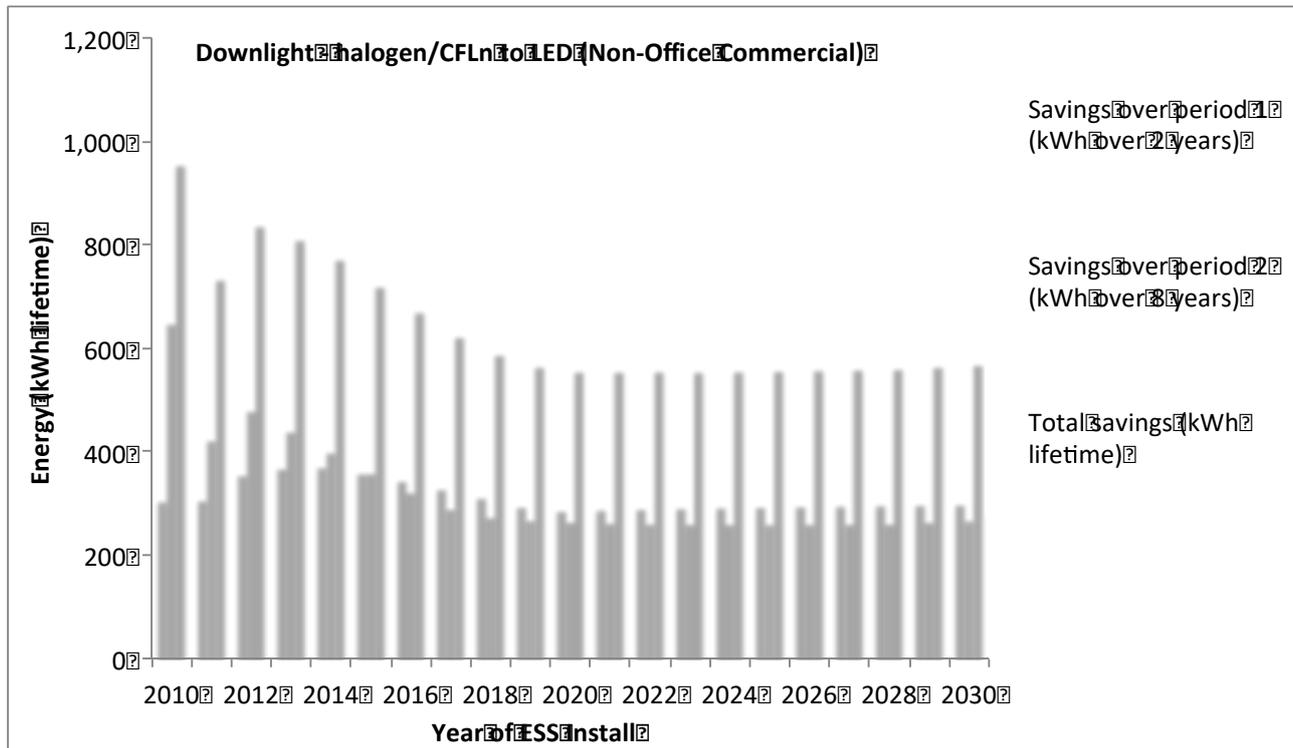
Note that no data was available for specific stock or sales of HID shop lights and highbay luminaires in the retail sector. Thus these are assumed to turn over to LED at around the same rate as HID luminaires used in other sectors.

20.4. ESS impacts

The model calculates potential (direct) energy savings from upgrades in this sector (not including free riders or spill over) summing energy savings over the two periods described in section 15.3. Figure 57 shows estimated savings for downlight upgrades and Figure 58 shows the same for linear luminaire upgrades.

The relatively low energy savings for downlights reflects the fact that the baseline transition to efficient lighting is well and truly underway for downlights, and that this is predicted to continue (E3, 2016b).

Figure 57 - estimated lifetime energy savings from replacement of downlights (non-office commercial sector)

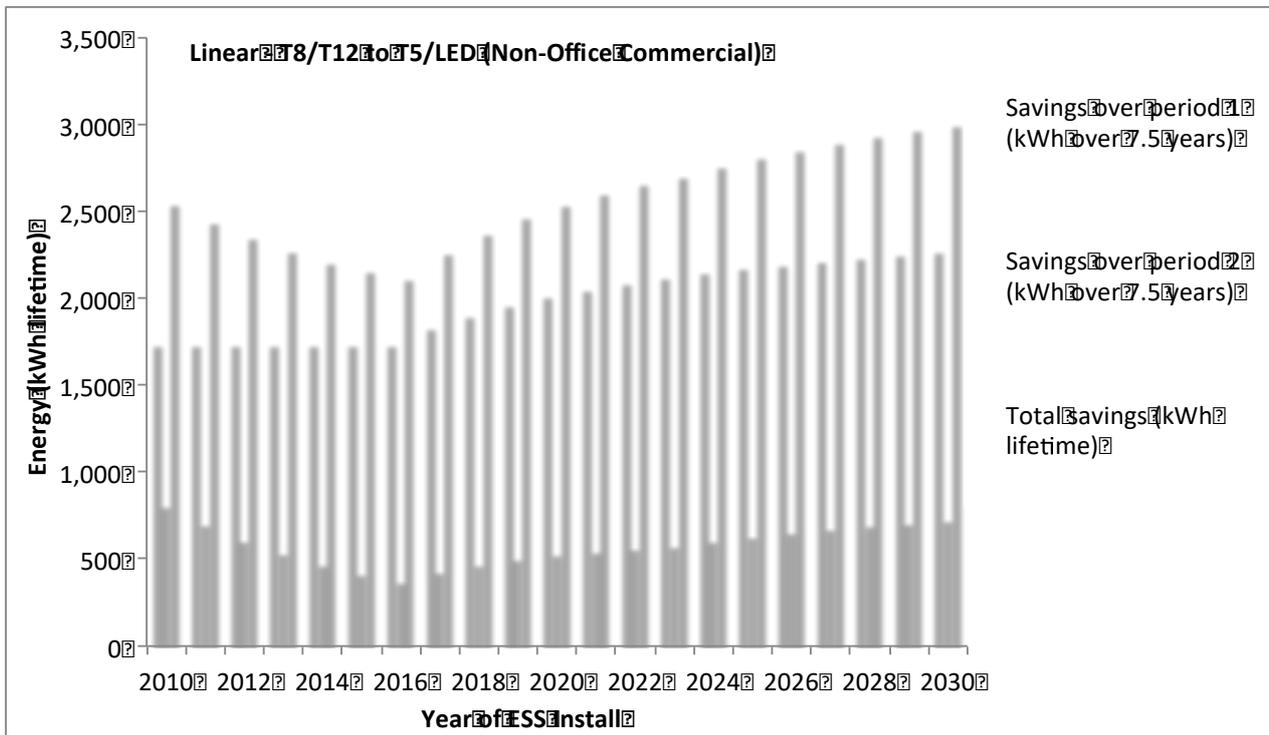


The lifetime energy savings calculated in Figure 58, for non-office linear luminaires range from around 2.1 to 3.0 MWh⁶⁶. By comparison, the CLF assigns 2.7 MWh⁶⁷. The key reason that these compare (relatively) favourably, even though the ESS assumes a static baseline and our model uses a dynamic baseline, is that we use a lifetime of 15 years for the installed ESS product (refer section 15.6 for more discussion of this figure).

⁶⁶ Using average of 5000 hours p.a. (av of ACP data), 15 years LED life, no A/C effect

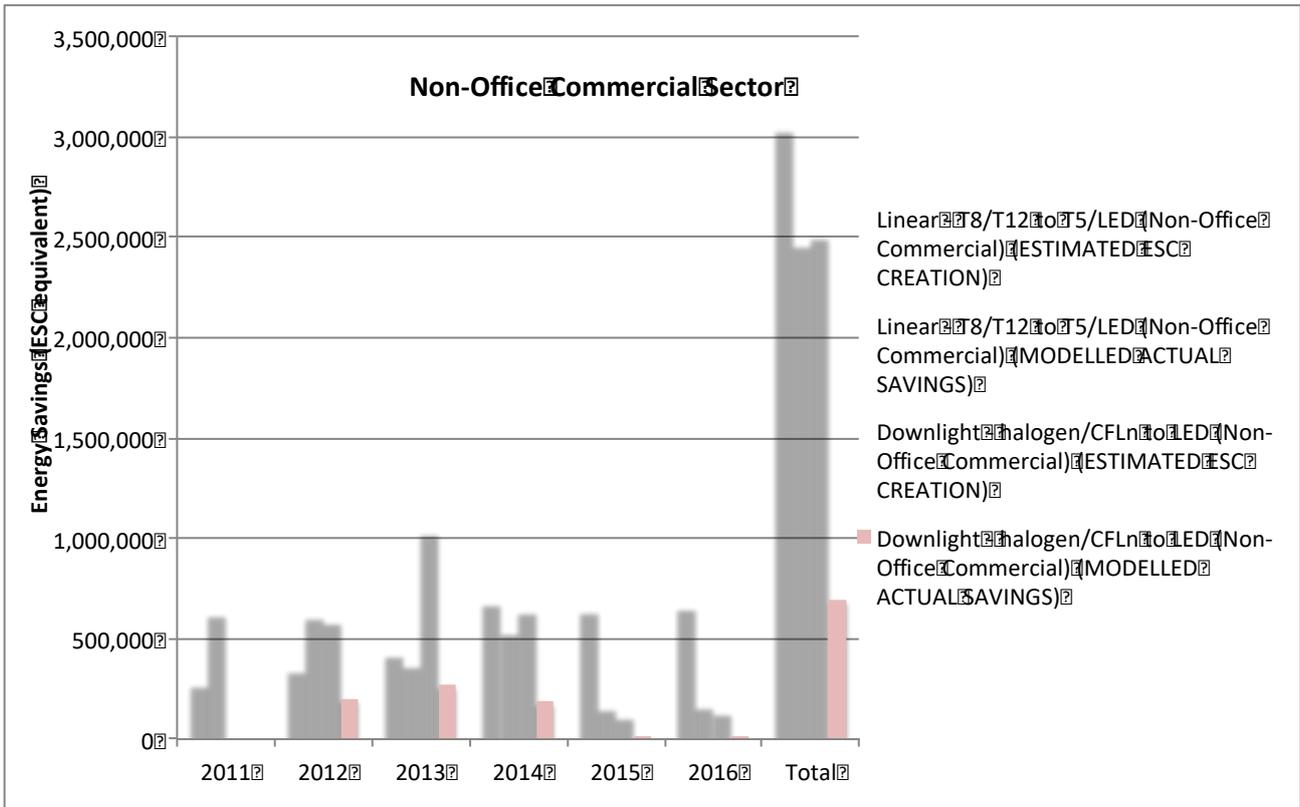
⁶⁷ Using 35W LED luminaire to replace 88W luminaire, average of 5000 hours p.a. (av of ACP data), 10 years LED life, no A/C effect

Figure 58 - estimated lifetime energy savings from replacement/upgrade of linear luminaires (non-office commercial sector)



The per-luminaire energy savings calculated above are then used to estimate total impacts of the ESS in the non-office commercial sector, including free riders and spill over.

Figure 59 - comparison of modelled non-office commercial sector energy savings (units=ESCs) and estimated ESCs from supplied ACP data (extrapolated)



20.5. Transformative nature of ESS impacts

There was significant ESS activity in the NSW non-office commercial lighting sector - around 57% of the total ACP supplied data. However, there may be some spill over occurring, due to ESS activity in other sectors, i.e. structural and product changes that effect all sectors.

This section of the report covers the NSW “industrial” lighting sector (refer section 15.2 for a definition). It describes the types of lighting products found, the “niche” and “regime” products, the major upgrade types and the estimated size of the market. Also discussed are the baseline scenario, including the baseline transition to efficient products, and the estimated impacts of the ESS.

The key findings for the NSW industrial lighting sector are:

- Lamp sales in the NSW industrial sector are estimated at around 1.3 million in 2016.
- The key upgrades in this sector are for linear luminaires (T8/T12 to T5/LED) and highbay/lowbay luminaires (HID to LED)
- A baseline transition to efficient lighting technologies is already underway.
- From the supplied ACP data, ESS activity in this sector represented around 38% of total ESS activity.

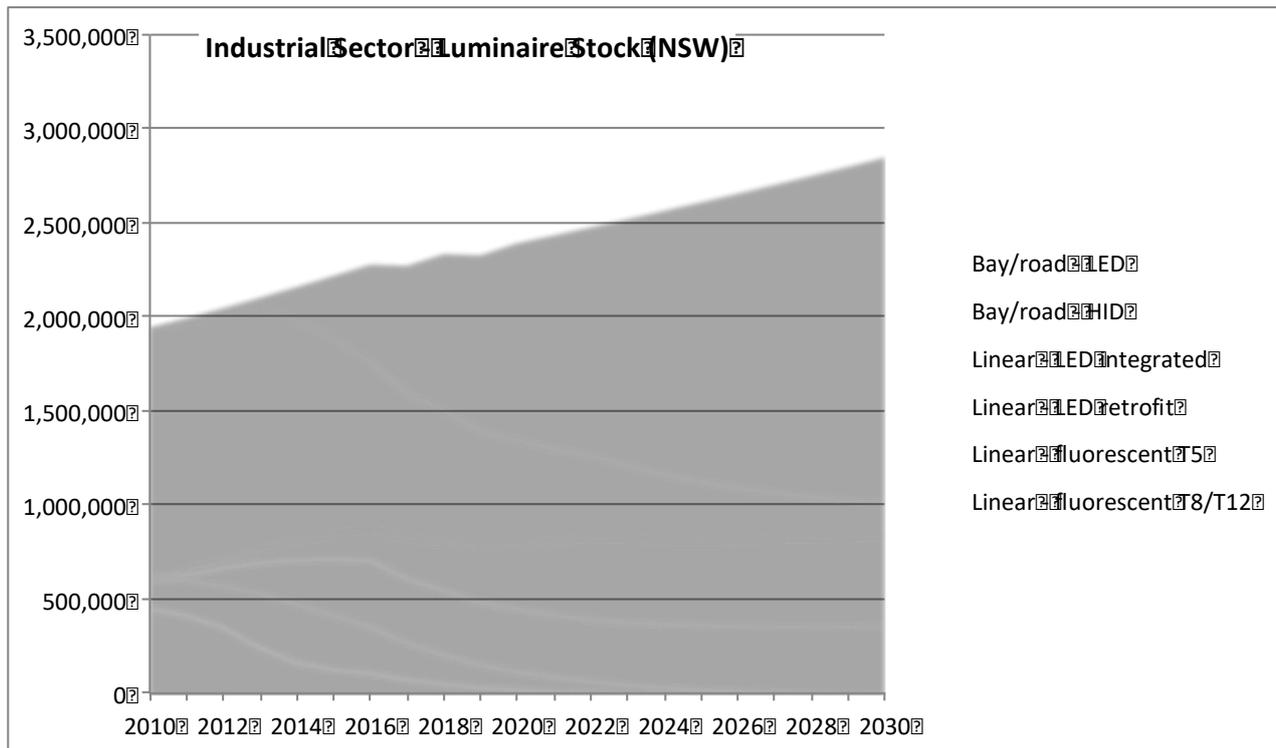
21.1. Sector Overview

The primary types of lighting technologies found in NSW offices are:

- Linear - T8/T12 (regime)
- Linear - T5 (regime + niche)
- Linear - LED (regime + niche)
- Highbay/lowbay - HID (regime)
- Highbay/lowbay - LED (regime + niche)

The estimated sales of lamps in the NSW industrial sector is estimated at around 1.3 million in 2016. The resultant estimated baseline NSW stocks of industrial luminaires are shown in Figure 60. Here we can see total stocks of lights growing over time, as floor area increases, as well as increases in stocks of T5 and LED lights (noting that T5 stocks eventually decrease and are replaced with LED).

Figure 60 - estimated stocks of industrial luminaires in NSW



21.2. Baseline scenario

This section describes the estimated baseline scenario for the NSW industrial sector. This is couched in terms of the baseline turnover of inefficient lights to more efficient products. The major turnover types in this sector are:

- Linear - T8 or T12 (regime) to T5 or LED (niche)
- Highbay/lowbay - HID (regime) to LED (niche)

Figure 61 shows the predicted turnover rate for linear luminaires - essentially an S-curve for these products. Note that this is the estimated percentage of T8/T12 luminaire retirements that turn over to T5 or LED at the end of their life. The formulation of these turnover curves is discussed in section 15.3 and does contain some uncertainty.

Figure 61 - estimated turnover rate - linear luminaires (industrial)

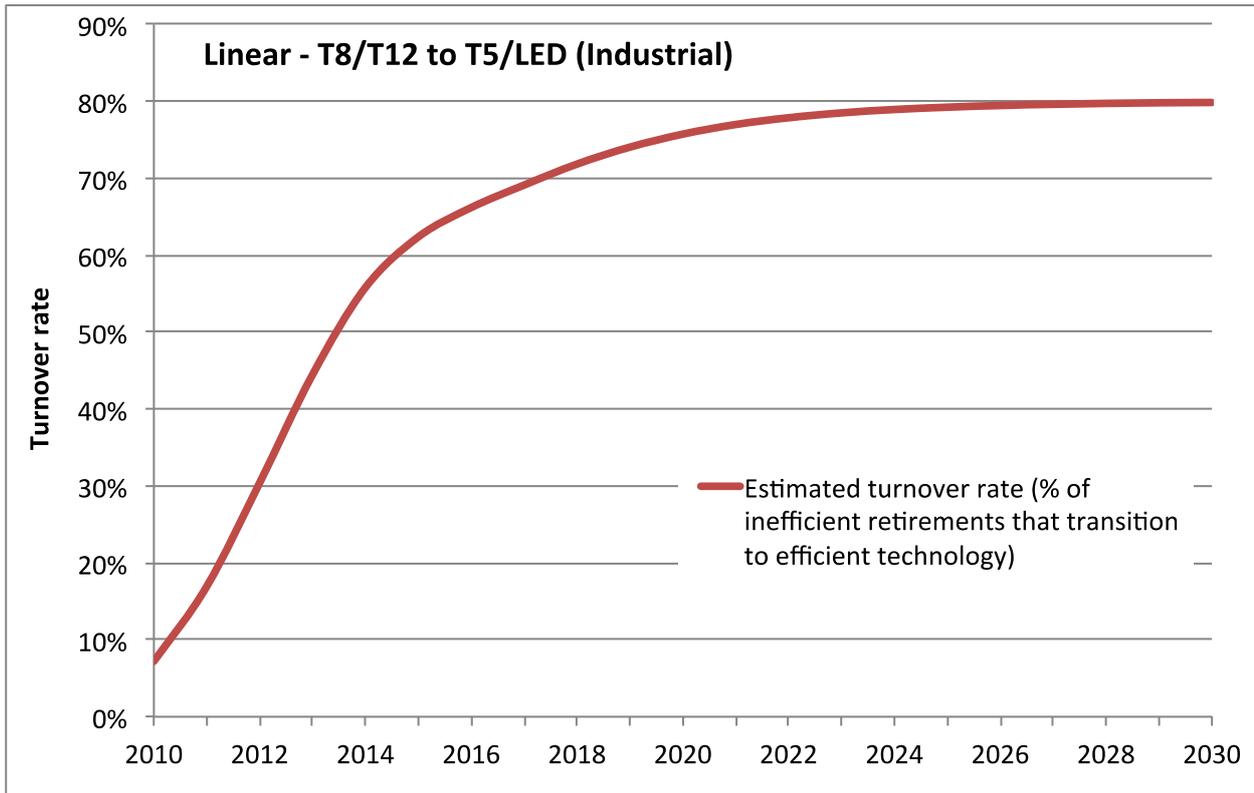


Figure 62 shows the turnover S-curve for HID luminaires - the estimated percentage of HID luminaire retirements that turn over to LED at the end of their life.

Figure 62 - estimated turnover rate - HID luminaires (industrial)

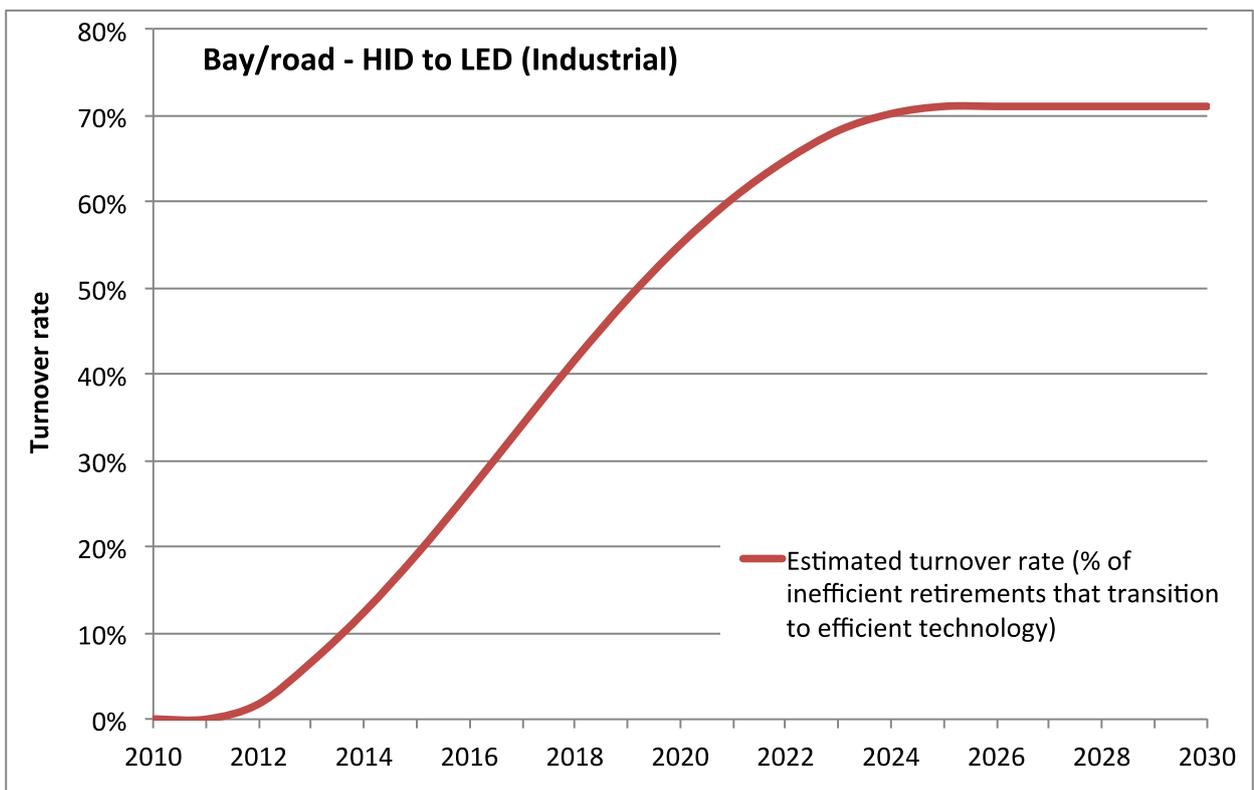


Figure 63 shows the estimated power of linear luminaires in the industrial sector, as follows:

- Incumbent: the luminaire that is upgraded, in this case a T8/T12.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include T8, T5 and LED. As the sales share of T5s and LEDs increase, the weighted average power of this counterfactual luminaire decreases.

Figure 63 - estimated linear luminaire power (industrial)

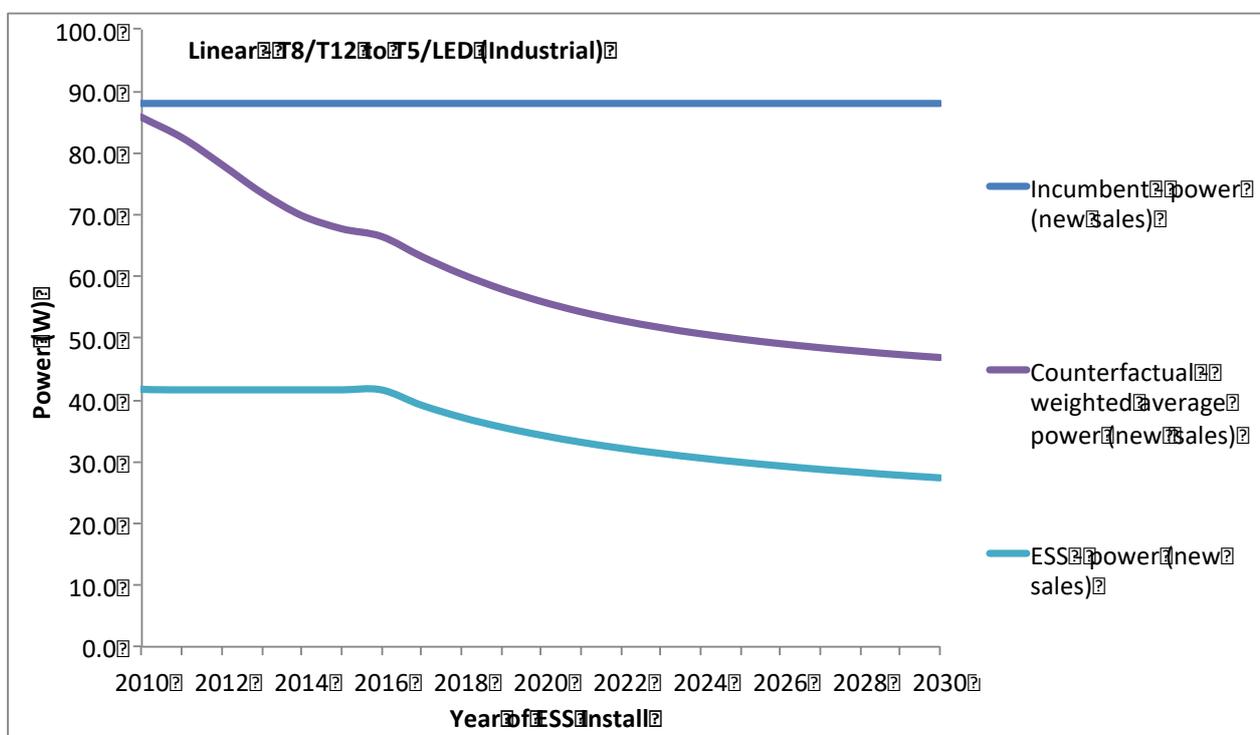
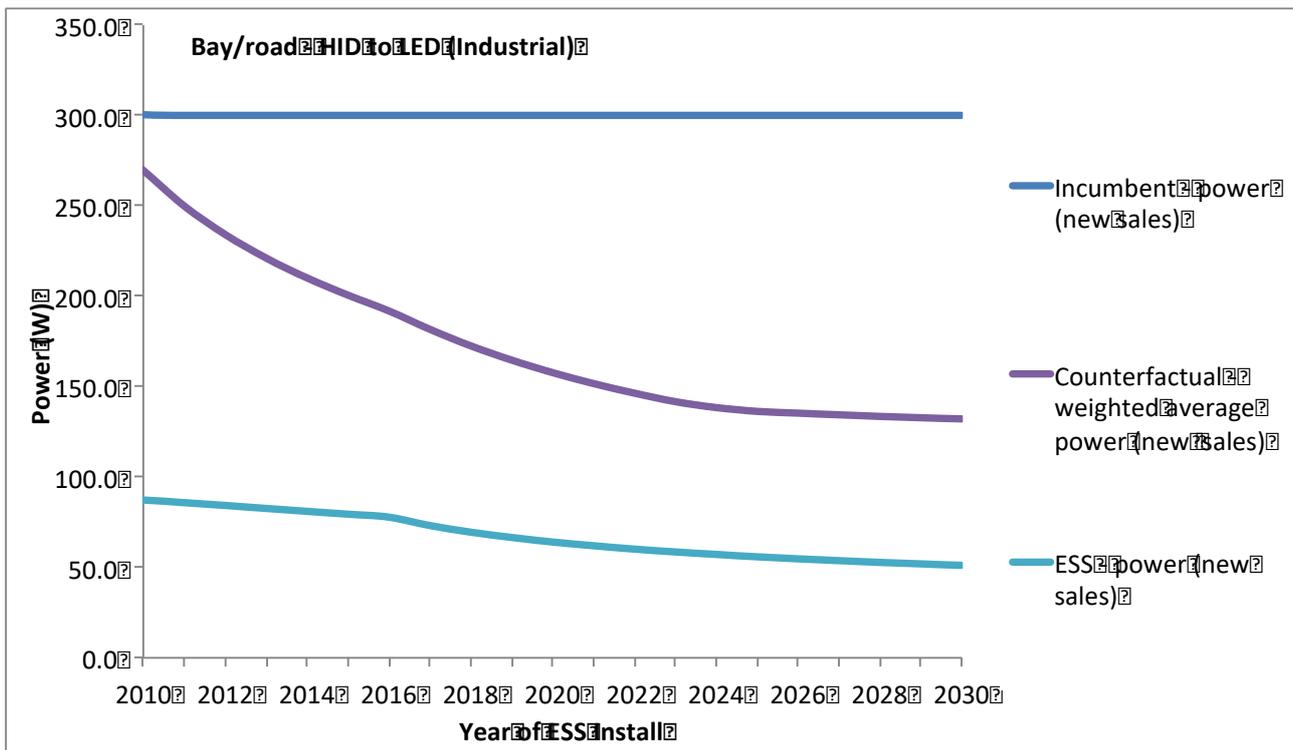


Figure 64 shows the same for industrial HID luminaires, as follows:

- Incumbent: the luminaire that is upgraded, in this case an HID.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include HID and LED. As the sales share of LEDs increase, the weighted average power of this counterfactual luminaire decreases.

Figure 64 - estimated HID luminaire power (industrial)



The curves shown in the previous two figures are used as the basis for deriving energy savings from replacing/modifying incumbent luminaires with ESS luminaires in the industrial sector, with the counterfactual being the unit that would have replaced the incumbent luminaire, in the absence of the ESS (refer section 15.3 for more detail on the methodology). The results of this calculation are described in the following section.

21.3. ESS impacts

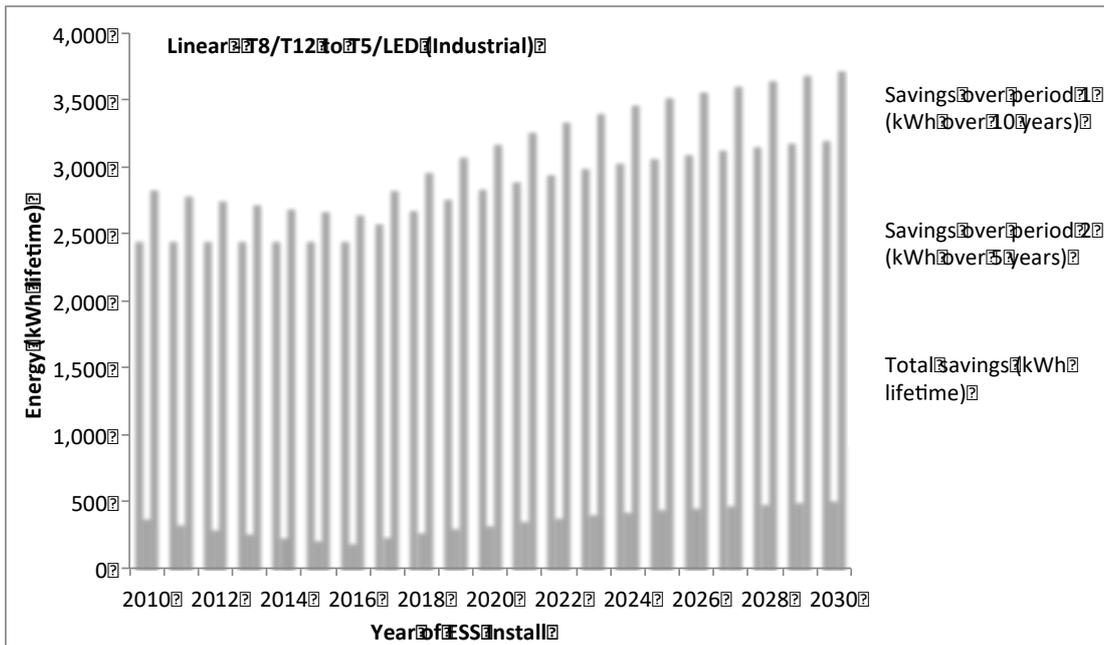
The model calculates potential (direct) energy savings from upgrades in this sector (not including free riders or spill over), summing energy savings over the two periods described in section 15.3. Figure 65 shows estimated savings for linear luminaire upgrades and Figure 66 shows the same for HID luminaire upgrades.

The lifetime energy savings calculated in Figure 65, for industrial linear luminaires range from around 2.7 to 3.7 MWh⁶⁸. By comparison, the CLF assigns 2.5 MWh⁶⁹. The key reason that these compare favourably, even though the ESS assumes a static baseline and our model uses a dynamic baseline, is that we use a lifetime of 15 years for the installed ESS product (refer section 15.6 for more discussion of this figure).

⁶⁸ Using average of 5300 hours p.a. (av of ACP data), 15 years LED life, no A/C effect

⁶⁹ Using 35W LED luminaire to replace 88W luminaire, average of 5300 hours p.a. (av of ACP data), 10 years LED life, no A/C effect

Figure 65 - estimated lifetime energy savings from replacement of linear luminaires (industrial sector)

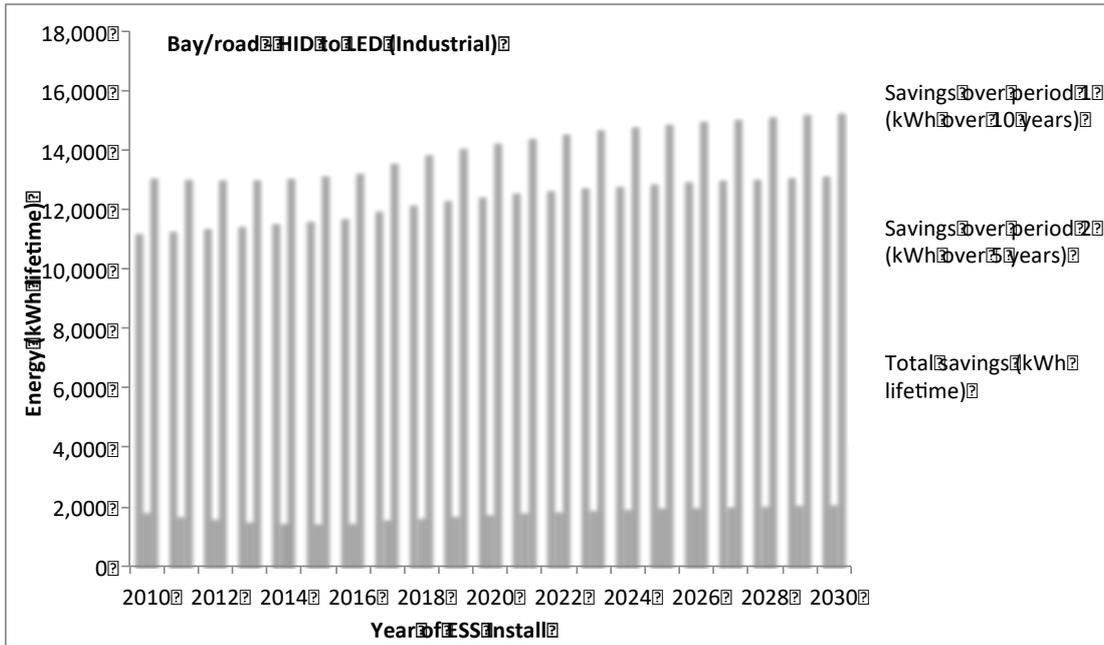


The lifetime energy savings calculated in Figure 66, for industrial HID luminaires range from around 13 to 15 MWh⁷⁰. By comparison, the CLF assigns 15 MWh⁷¹. The key reason that these compare favourably, even though the ESS assumes a static baseline and our model uses a dynamic baseline, is that we use a lifetime of 15 years for the installed ESS product (refer to section 15.6 for more discussion of this figure).

⁷⁰ Using average of 5300 hours p.a. (av of ACP data), 15 years LED life, no A/C effect

⁷¹ Using 100W LED luminaire to replace 380W luminaire, average of 5300 hours p.a. (av of ACP data), 10 years LED life, no A/C effect

Figure 66 - estimated lifetime energy savings from replacement/upgrade of HID luminaires (industrial sector)



21.4. Transformative nature of ESS impacts

There was significant ESS activity in the NSW industrial lighting sector - around 38% of the total ACP supplied data. However, there may be some spill over occurring, due to ESS activity in other sectors, i.e. structural and product changes that effect all sectors.

CHAPTER 22

Industrial Market Performance

22.1. Overview

This section of the report covers the NSW “industrial” lighting sector (refer section 15.2 for a definition). It describes the types of lighting products found, the “niche” and “regime” products, the major upgrade types and the estimated size of the market. Also discussed are the baseline scenario, including the baseline transition to efficient products, and the estimated impacts of the ESS.

The key findings for the NSW industrial lighting sector are:

- Lamp sales in the NSW industrial sector are estimated at around 1.3 million in 2016.
- The key upgrades in this sector are for linear luminaires (T8/T12 to T5/LED) and highbay/lowbay luminaires (HID to LED)
- A baseline transition to efficient lighting technologies is already underway.
- From the supplied ACP data, ESS activity in this sector represented around 38% of total ESS activity.

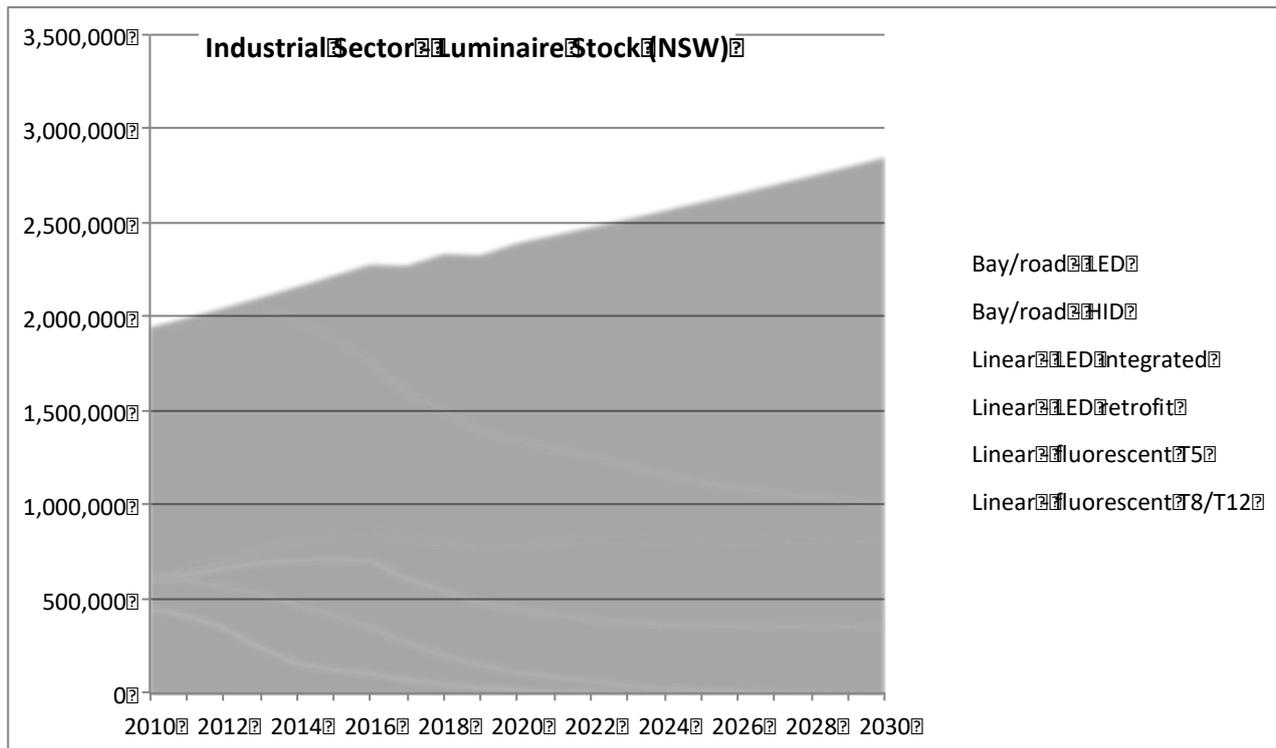
22.2. Sector Overview

The primary types of lighting technologies found in NSW offices are:

- Linear - T8/T12 (regime)
- Linear - T5 (regime + niche)
- Linear - LED (regime + niche)
- Highbay/lowbay - HID (regime)
- Highbay/lowbay - LED (regime + niche)

The estimated sales of lamps in the NSW industrial sector is estimated at around 1.3 million in 2016. The resultant estimated baseline NSW stocks of industrial luminaires are shown in Figure 60. Here we can see total stocks of lights growing over time, as floor area increases, as well as increases in stocks of T5 and LED lights (noting that T5 stocks eventually decrease and are replaced with LED).

Figure 67 - estimated stocks of industrial luminaires in NSW



22.3. Baseline scenario

This section describes the estimated baseline scenario for the NSW industrial sector. This is couched in terms of the baseline turnover of inefficient lights to more efficient products. The major turnover types in this sector are:

- Linear - T8 or T12 (regime) to T5 or LED (niche)
- Highbay/lowbay - HID (regime) to LED (niche)

Figure 61 shows the predicted turnover rate for linear luminaires - essentially an S-curve for these products. Note that this is the estimated percentage of T8/T12 luminaire retirements that turn over to T5 or LED at the end of their life. The formulation of these turnover curves is discussed in section 15.3 and does contain some uncertainty.

Figure 68 - estimated turnover rate - linear luminaires (industrial)

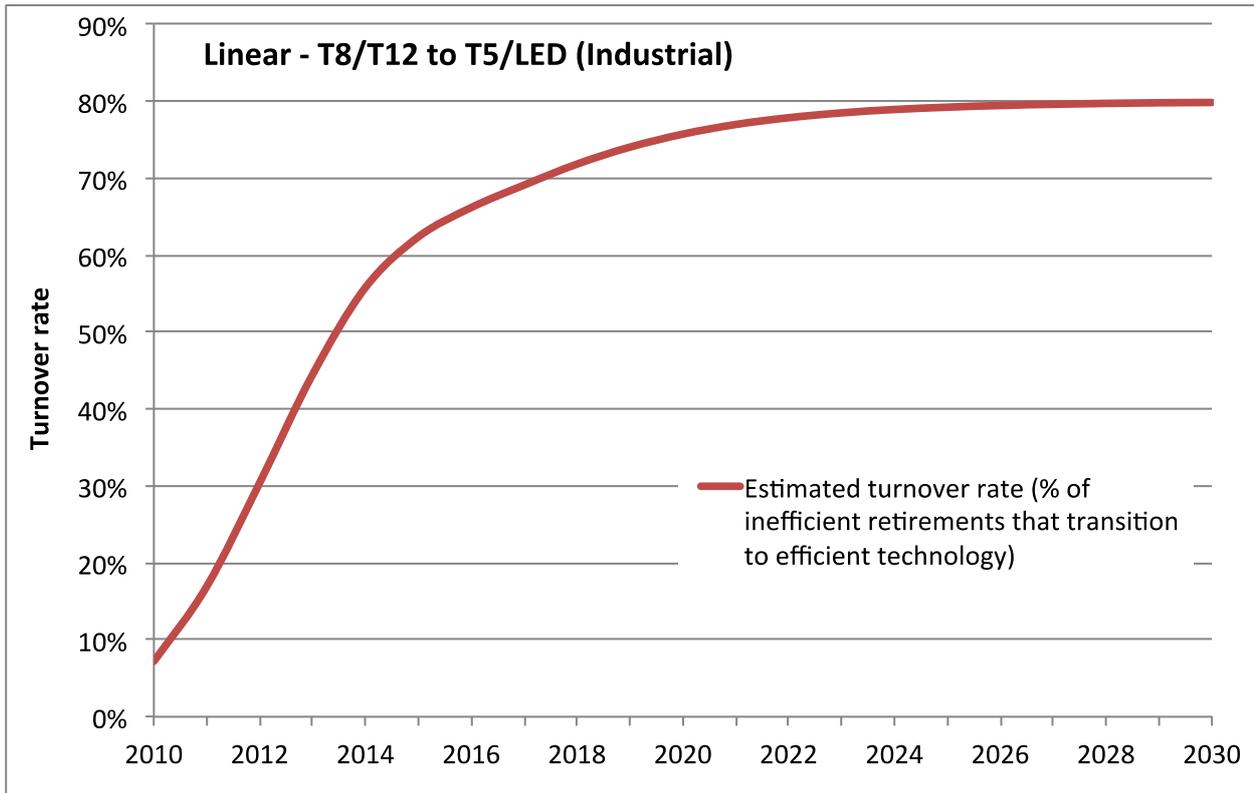


Figure 62 shows the turnover S-curve for HID luminaires - the estimated percentage of HID luminaire retirements that turn over to LED at the end of their life.

Figure 69 - estimated turnover rate - HID luminaires (industrial)

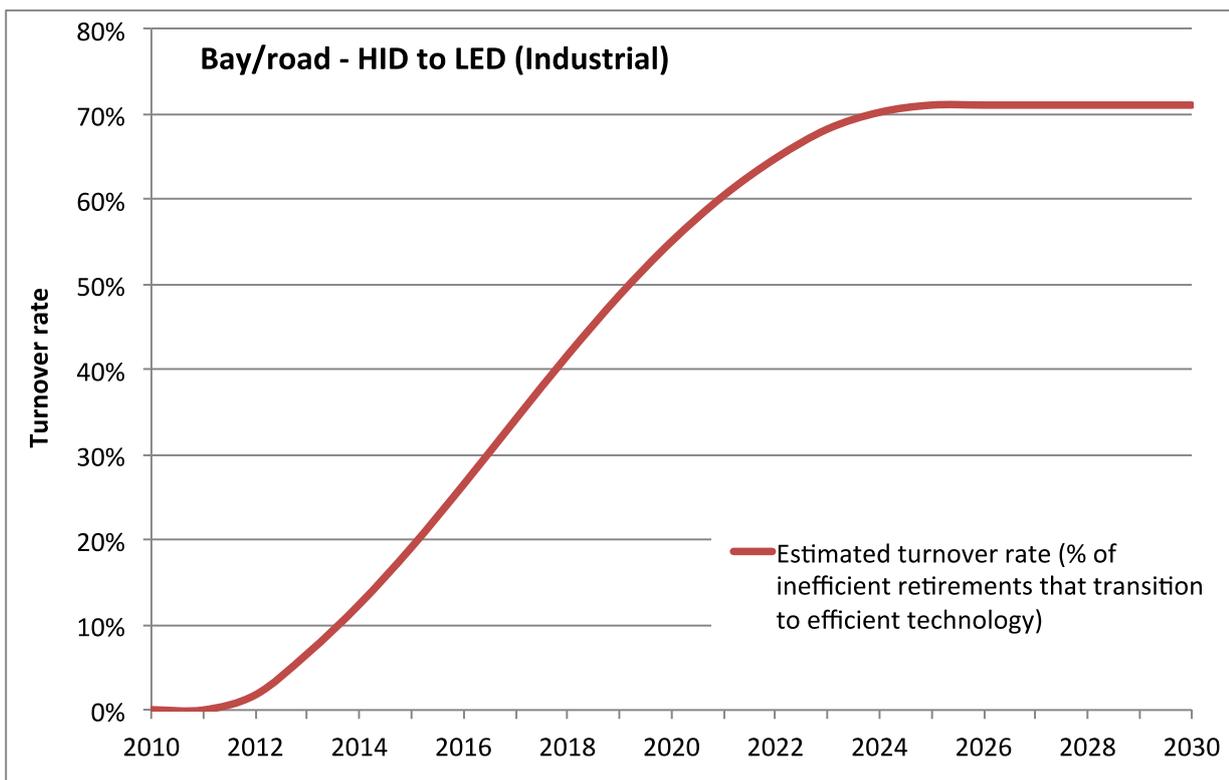


Figure 63 shows the estimated power of linear luminaires in the industrial sector, as follows:

- Incumbent: the luminaire that is upgraded, in this case a T8/T12.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include T8, T5 and LED. As the sales share of T5s and LEDs increase, the weighted average power of this counterfactual luminaire decreases.

Figure 70 - estimated linear luminaire power (industrial)

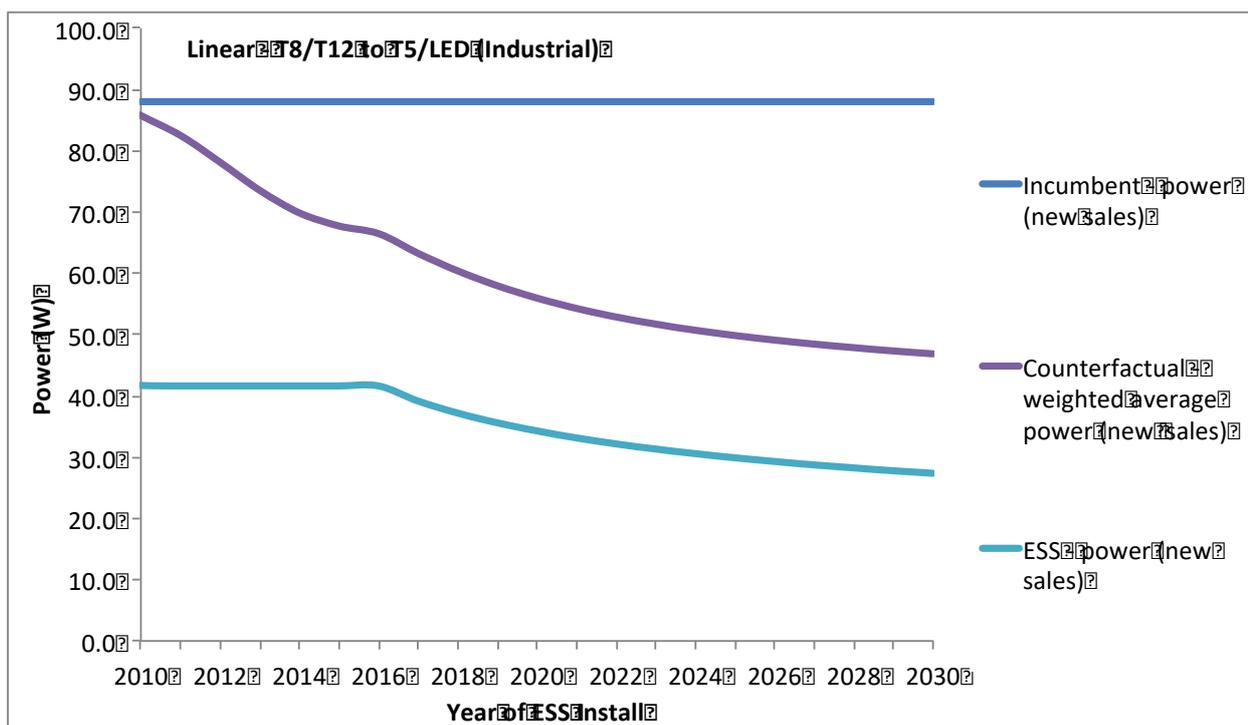
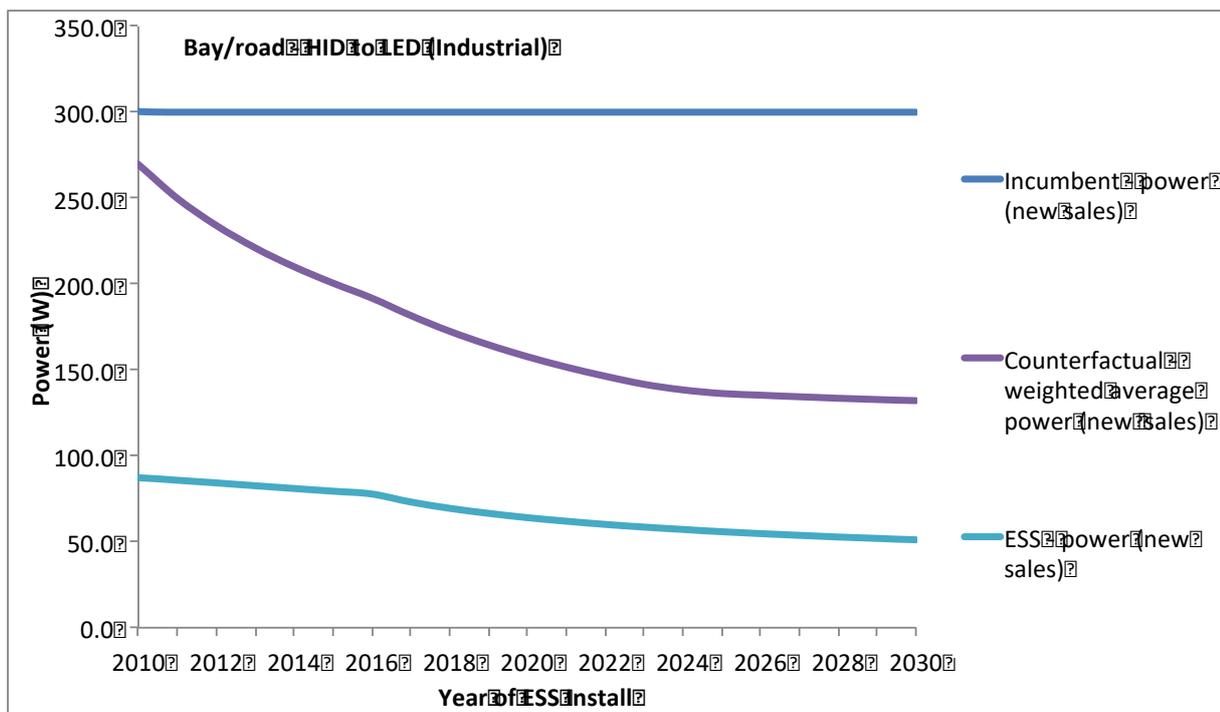


Figure 64 shows the same for industrial HID luminaires, as follows:

- Incumbent: the luminaire that is upgraded, in this case an HID.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.

- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include HID and LED. As the sales share of LEDs increases, the weighted average power of this counterfactual luminaire decreases.

Figure 71 - estimated HID luminaire power (industrial)



The curves shown in the previous two figures are used as the basis for deriving energy savings from replacing/modifying incumbent luminaires with ESS luminaires in the industrial sector, with the counterfactual being the unit that would have replaced the incumbent luminaire, in the absence of the ESS (refer section 15.3 for more detail on the methodology). The results of this calculation are described in the following section.

22.4. ESS impacts

The model calculates potential (direct) energy savings from upgrades in this sector (not including free riders or spill over), summing energy savings over the two periods described in section 15.3. Figure 65 shows estimated savings for linear luminaire upgrades and Figure 66 shows the same for HID luminaire upgrades.

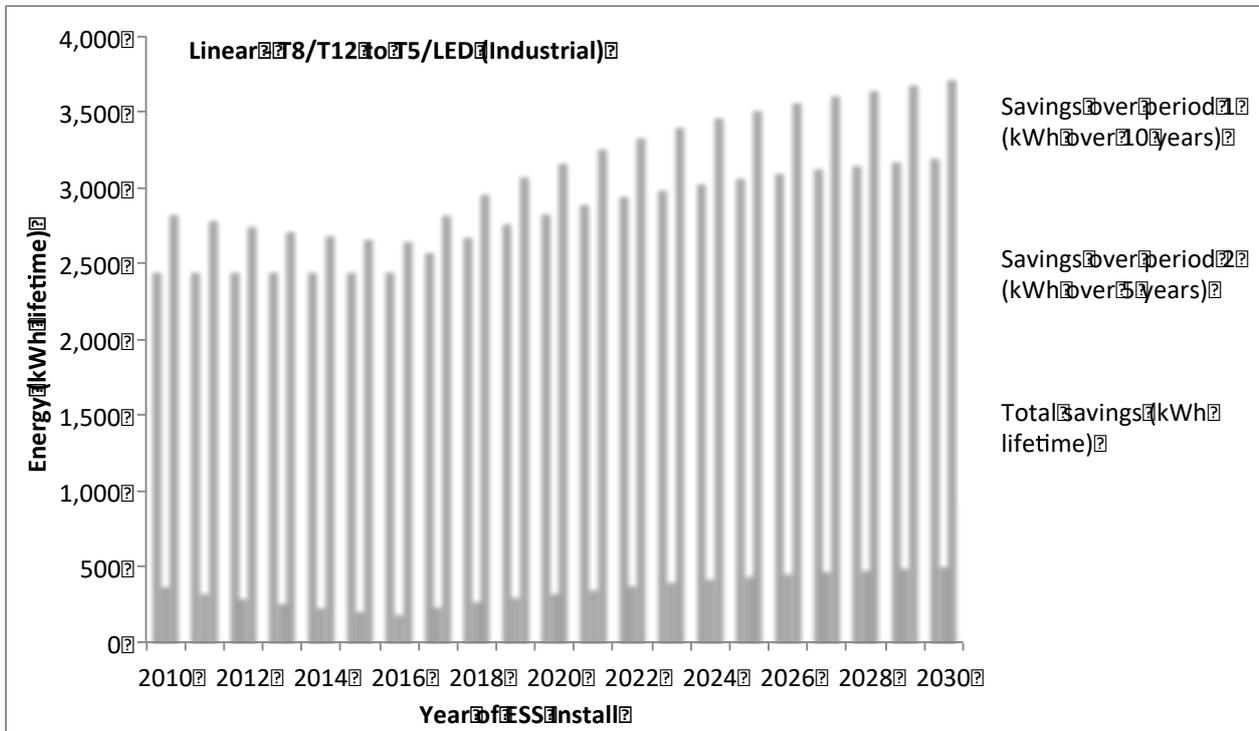
The lifetime energy savings calculated in Figure 65, for industrial linear luminaires range from around 2.7 to 3.7 MWh⁷². By comparison, the CLF assigns 2.5 MWh⁷³. The key reason that these compare favourably, even though the ESS assumes a static baseline and

⁷² Using average of 5300 hours p.a. (av of ACP data), 15 years LED life, no A/C effect

⁷³ Using 35W LED luminaire to replace 88W luminaire, average of 5300 hours p.a. (av of ACP data), 10 years LED life, no A/C effect

our model uses a dynamic baseline, is that we use a lifetime of 15 years for the installed ESS product (refer section 15.3 for more discussion of this figure).

Figure 72 - estimated lifetime energy savings from replacement of linear luminaires (industrial sector)

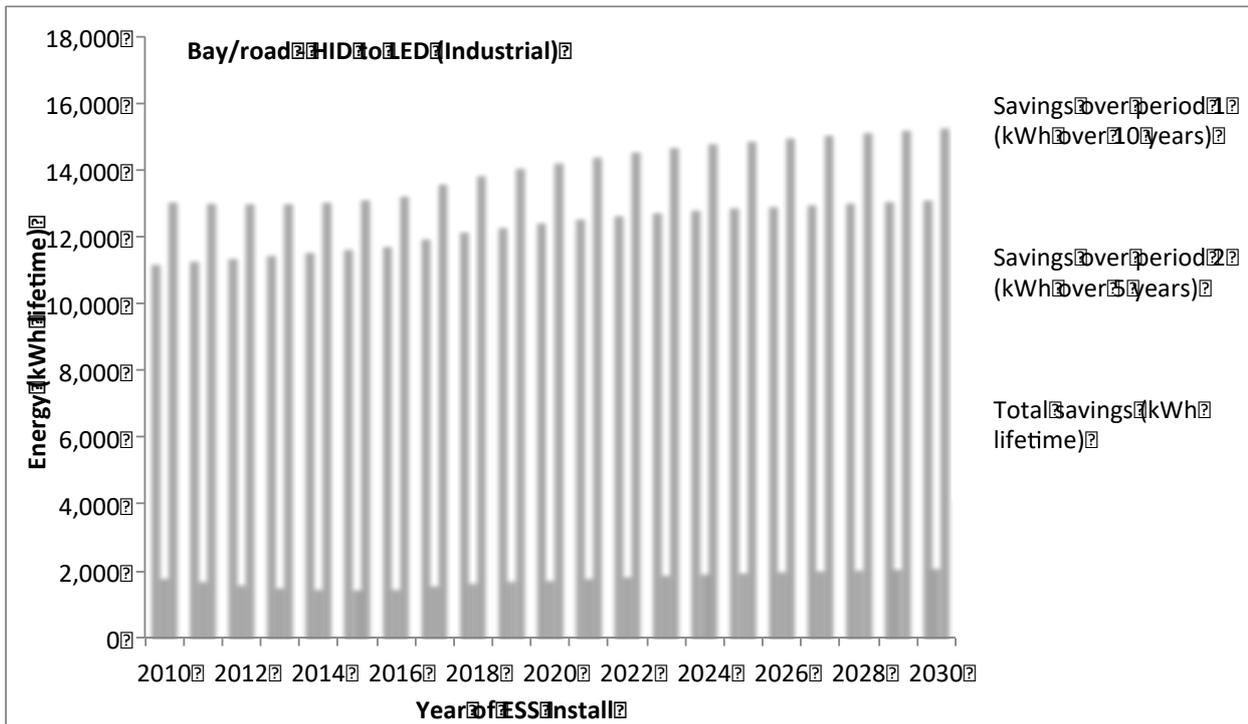


The lifetime energy savings calculated in Figure 66, for industrial HID luminaires range from around 13 to 15 MWh⁷⁴. By comparison, the CLF assigns 15 MWh⁷⁵. The key reason that these compare favourably, even though the ESS assumes a static baseline and our model uses a dynamic baseline, is that we use a lifetime of 15 years for the installed ESS product (refer section 15.3 for more discussion of this figure).

⁷⁴ Using average of 5300 hours p.a. (av of ACP data), 15 years LED life, no A/C effect

⁷⁵ Using 100W LED luminaire to replace 380W luminaire, average of 5300 hours p.a. (av of ACP data), 10 years LED life, no A/C effect

Figure 73 - estimated lifetime energy savings from replacement/upgrade of HID luminaires (industrial sector)



22.5. Transformative nature of ESS impacts

There was significant ESS activity in the NSW industrial lighting sector - around 38% of the total ACP supplied data. However, there may be some spill over occurring, due to ESS activity in other sectors, i.e. structural and product changes that effect all sectors.

CHAPTER 23

Public Lighting Market Performance

23.1. Overview

This Chapter covers the NSW “public” lighting sector (refer section 15.2 for a definition). It describes the types of lighting products found, the “niche” and “regime” products, the major upgrade types and the estimated size of the market. Also discussed are the baseline scenario, including the baseline transition to efficient products, and the estimated impacts of the ESS.

The key findings for the NSW public lighting sector are:

- Lamp sales in the NSW public lighting sector are estimated at around 300,000 in 2016.
- The key upgrades in this sector are for HID and linear luminaires converting to LED
- A baseline transition to efficient lighting technologies is already underway, although relatively behind the other sectors.
- The ESS registry (examining activity names) shows that some 200,000 ESCs appear to have been created for street lighting projects.

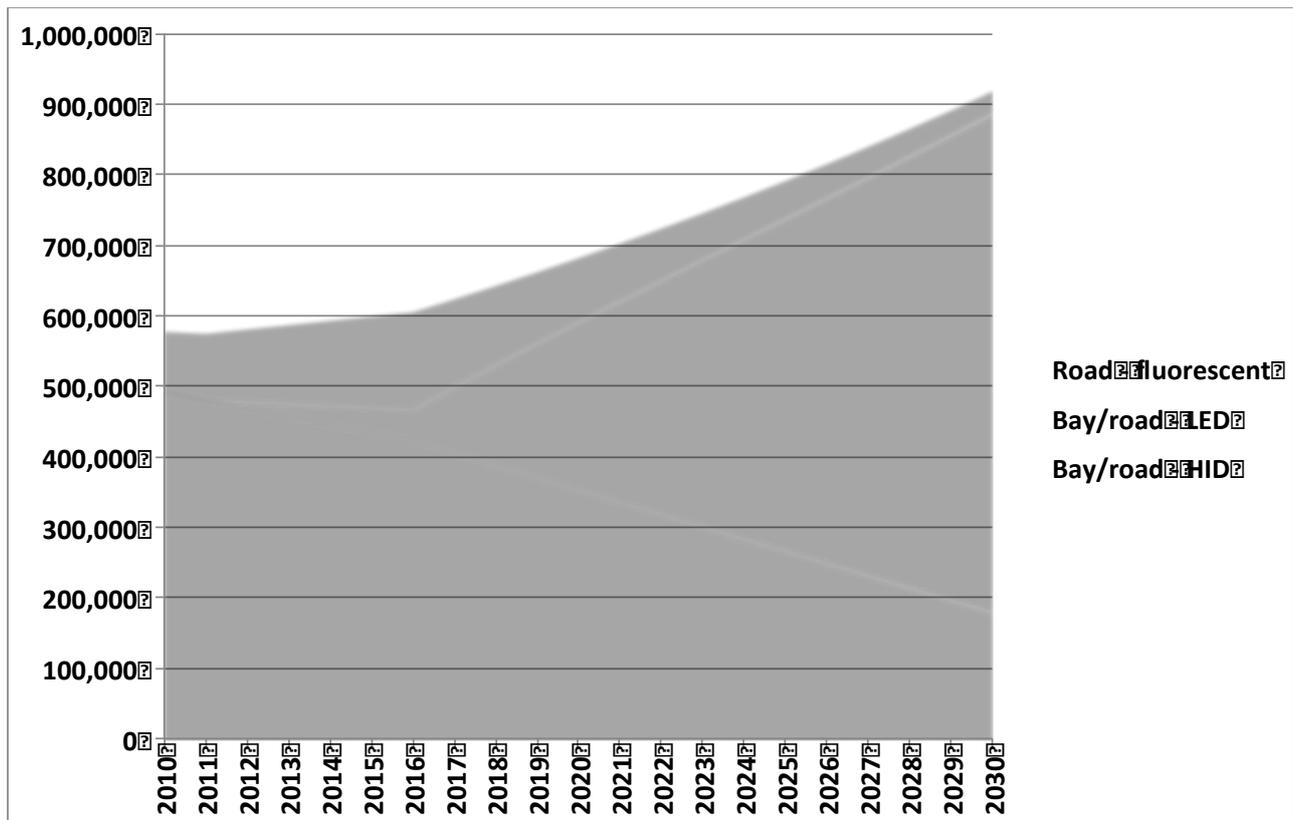
23.2. Sector Overview

The primary types of lighting technologies found in NSW offices are:

- Linear - T8/T12 (regime)
- HID (regime)
- LED (regime + niche)

The estimated sales of lamps in the NSW public lighting sector is estimated at around 300,000 in 2016. The resultant estimated baseline NSW stocks of public luminaires are shown in Figure 74. Here we can see total stocks of lights growing over time, as well as increases in stocks of LED lights).

Figure 74 - estimated stocks of public lighting luminaires in NSW



23.3. Baseline scenario

This section describes the estimated baseline scenario for the NSW public sector. This is couched in terms of the baseline turnover of inefficient lights to more efficient products. The major turnover types in this sector are:

- HID (regime) to LED (niche)

Figure 75 shows the predicted turnover rate for road lighting luminaires - essentially an S-curve for these products. Note that this is the estimated percentage of luminaire retirements that turn over to LED at the end of their life. The formulation of these turnover curves is discussed in section 15.3 and does contain some uncertainty.

Figure 75 - estimated turnover rate - linear luminaires (public)

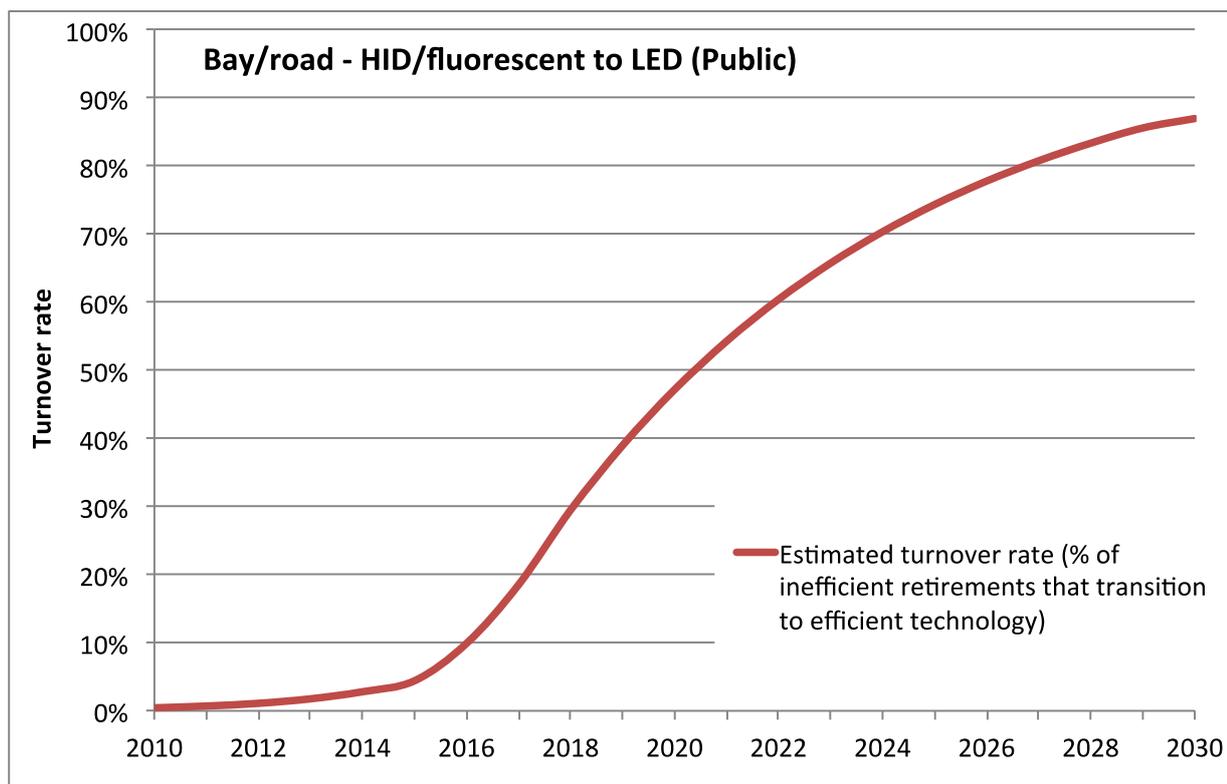
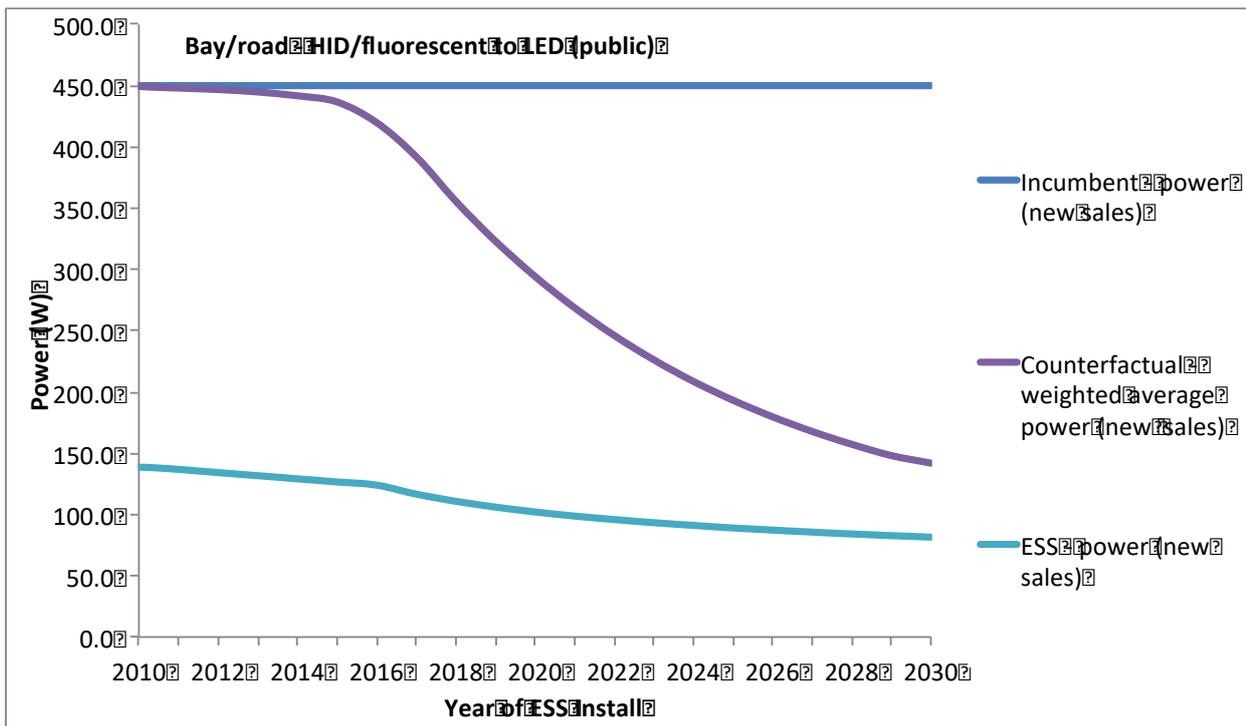


Figure 76 shows the estimated power of road lighting luminaires in the public sector, as follows:

- Incumbent: the luminaire that is upgraded, in this case primarily HID.
- ESS: the (niche) LED luminaire that is installed/modified as part of the ESS. These are assumed to be slightly more efficient than the efficient (regime) luminaires.
- Counterfactual: the weighted average baseline luminaire that is installed (or modified) to replace incumbent luminaires at the end of their life. These include HID and LED. As the sales share of LEDs increase, the weighted average power of this counterfactual luminaire decreases.

Figure 76 - estimated linear luminaire power (public)



The curves shown in the previous two figures are used as the basis for deriving energy savings from replacing/modifying incumbent luminaires with ESS luminaires in the public sector, with the counterfactual being the unit that would have replaced the incumbent luminaire, in the absence of the ESS (refer section 15.3 for more detail on the methodology). The results of this calculation are described in the following section.

23.4. ESS impacts

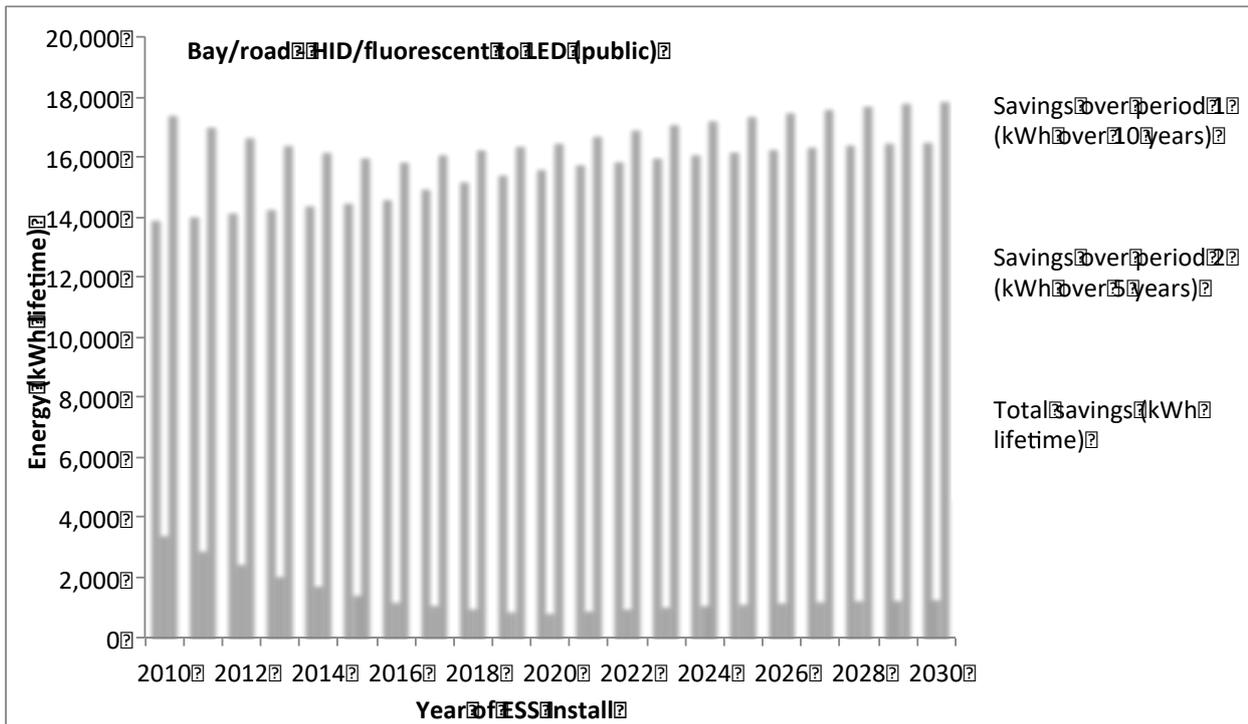
The model calculates potential (direct) energy savings from upgrades in this sector (not including free riders or spill over), summing energy savings over the two periods described in section 15.3. Figure 77 shows estimated savings for luminaire upgrades.

The lifetime energy savings calculated in Figure 77, for public HID luminaires range from around 16 to 18 MWh⁷⁶. By comparison, the CLF assigns 16 MWh⁷⁷. The key reason that these compare favourably, even though the ESS assumes a static baseline and our model uses a dynamic baseline, is that we use a lifetime of 15 years for the installed ESS product (refer section 15.3 for more discussion of this figure) whereas the ESS CLF assumes 12 years.

⁷⁶ Using 4500 hours p.a., 15 years LED life, no A/C effect

⁷⁷ Using 150W LED luminaire to replace 450W luminaire, 4500 hours p.a., 12 years LED life, no A/C effect

Figure 77 - estimated lifetime energy savings from replacement of linear luminaires (public sector)



CHAPTER 24

Market Performance Key Findings

Overview

The NSW ESS commercial lighting method has led to significant energy savings, from the replacement of inefficient lighting products with significantly more efficient units.

When the ESS was conceived in 2009, the transition to LED technology was not foreseen. Indeed, the ESS framed LEDs as “emerging technology.” We estimate that the “tipping point” for LED was not reached until around 2013-14, when it became clear that LEDs would begin to dominate the lighting market. Since then, the transition to LED technology has led to an altered baseline for lighting (which this report attempts to quantify), and new baseline results in lower energy savings than the current ESS method would predict (as the ESS baseline is static).

Market-wide trends

The NSW lighting market sectors covered in this report are residential, office commercial, non-office commercial, industrial, and public. This section of the report summarises findings for the entire NSW lighting market, and subsequent sections report on findings for each sector.

Across all sectors analysed, the following general trends and findings were observed:

- There is a significant baseline trend towards replacement of general purpose incandescent and halogen lamps with CFLs and LED lamps. This trend has been underway for over a decade
- There is a significant baseline trend towards replacement of halogen downlights with LED. This is supported by ABS lamp import data, which reveals a 70% downturn in the imports of halogen downlight lamps from 2010 to 2016
- For linear and highbay/lowbay lighting, the trend towards efficient lighting has been slower to commence, but is now well and truly underway. ABS lamp import data reveals a 62% downturn in the imports of linear fluorescent lamps from 2010 to 2016
- For public (road) lighting, upgrade trends to LED have been slowest

EEB and GREP

Energy audit data was provided by OEH for the Energy Saver Program, which lists lighting upgrade opportunities for some 1500 spaces. However, it is not possible to assess any energy savings from this data, as no data was available relating to the implementation of the opportunities assessed.

An evaluation report for the OEH Energy Efficient Technology Lighting Report was provided (dated August 2014) which showed that a total of sixteen business had planned or started a lighting upgrade, with anticipated savings ranging from \$300 to \$60,000 (with an average of \$20,675).

No further data or evaluation was available for OEH EEB training or for the GREP program.

Market Transformation

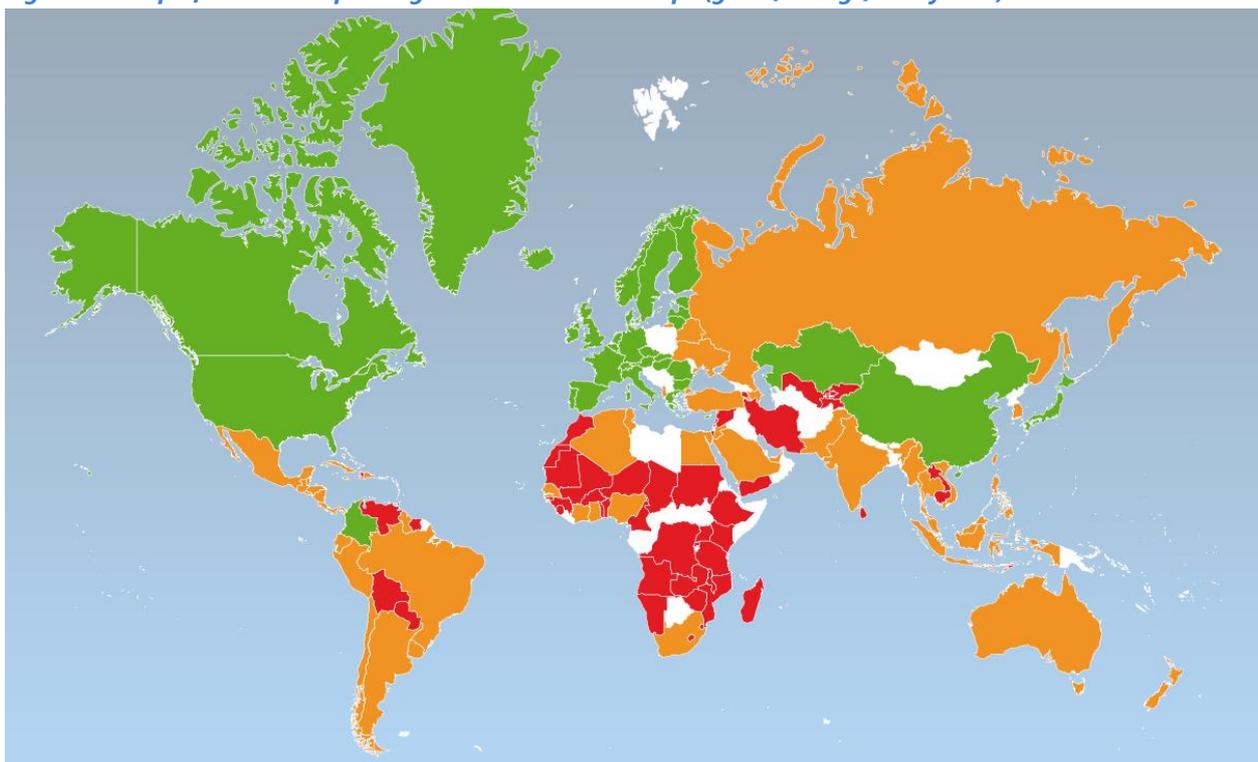
The impacts of the ESS on the performance of that market are likely to persist, in that LEDs are unlikely to be replaced by less efficient products. However, this is because the baseline for the mainstream market has caught up to performance of niches driven by the ESS. It is unclear whether the impacts of the ESS would have been as transformative without international changes in the baseline, or regulatory changes (such as GEMS and BCA) to reinforce the gains driven by the ESS and VEET.

Spill-over within NSW is now near zero, but the ESS is attributed with bringing LED lighting into NSW two to three years early. Qualitatively, the research indicated that high levels of spill-over in other states can be attributed to the ESS and VEET. This covers high levels of lighting activity in the South Australia Retail Energy Efficiency Scheme (REES) and ACT Energy Efficiency Incentive Scheme (EEIS), which participants report would be unlikely without the scale achieved through ESS and VEET. It also covers spill-over into unsubsidised upgrades in other states by large national energy customers, based on the commercial success of initial ESS and VEET projects.

There is anecdotal evidence to suggest that the ESS (and its predecessor, the Greenhouse Gas Abatement Scheme, GGAS) lead to the creation of several other government initiatives/regulations, such as:

- The phase out of incandescent lamps in Australia, announced in 2007, which was in turn emulated by most developed economies (refer to **Error! Reference source not found.** below)
- VEET commercial lighting methodology (emulating the ESS)
- REES commercial lighting methodology (emulating the ESS)
- Commercial lighting component of the Australian Emissions Reduction Fund (emulating the ESS)
- Commercial building disclosure - mandatory tenancy lighting assessment (assessment based on ESS methods)

Figure 78: Map of economies phasing out incandescent lamps (green/orange/red system)⁷⁸



If spill-over into these initiatives were to be assessed, energy savings would be very large. This has not been undertaken; however, qualitatively, the ESS (and GGAS) should take some credit for the creation of these programs and policies.

⁷⁸ From UNEP EnLighten initiative

Key findings

The key findings with respect to performance include:

- The ESS had a material impact on the performance of the lighting market in a way that is likely to be transformative in the medium term, but is without policy changes to reflect improving baselines the future incremental benefits will slowly diminish each year
 - The ESS is likely to have delivered an estimated 8,266 GWh of savings from lighting projects (discounting for estimates of potential free-riding and including and spill over within NSW)
 - When lighting upgrades began en masse in the ESS in 2011, high efficiency technologies were niche. We estimate that by 2015, LEDs had begun to account for more of the installations in the new build and refurbishment market.
 - Without the ESS retrofit market, existing technologies would not be converted to LEDs until building refurbishment (occurring every ten to twenty years, depending on type and sector). The exceptions to this are downlights and general-purpose lamps, which are increasingly likely to be converted to LEDs at the point of lamp failure
 - The ESS continues to drive additional energy savings by bringing forward retrofits to LEDs significantly sooner than would happen under typical refurbishment cycles
 - The average period for which refurbishments are brought forward is now typically less than the ten years for which savings are deemed. As each year passes, these benefits diminish as the ESS impacts converge with business as usual
 - The ESS has not influenced the residential lighting market and is unlikely to do so in the future, with future GEMS better positioned to contribute to this sector

- This has facilitated spill over energy savings for large national energy customers in other Australian jurisdictions, and potentially spill over into the lighting specification market through accelerating LED adoption
- New retrofit business models appear poised to facilitate spill over energy savings in the non-lighting markets of Building Management Systems (BMS) and HVAC, if future ESS policy facilitates an orderly transition out of lighting

Part 5

Policy Implications and evaluation research

CHAPTER 25

Implications for policy, administration and evaluation

25.1. Implications for Policy and Program Administration

Our research concludes that the ESS has had significant impacts that helped improve the efficiency of the NSW lighting market, in addition to background conditions. These impacts have and continue to materially influenced the structure, dynamics and the energy efficiency performance of lighting market in NSW. Some of these impacts appear to be driving a lasting transformation.

The GREP program also appears to be driving a material increase in the adoption of energy efficiency lighting by major government agencies. Within the scope of this research it was not possible to detect whether GGREP or EEB were having transformative impacts on underlying market structure and dynamics. Both involve relatively small numbers of participants, and more focused studies on the impacts to those participants would be required.

The key policy findings include:

- Overall the ESS has successfully delivered against its policy objectives, although policy changes are required to maintain the level of benefits
 - ESS lighting upgrades between 2011-2016 delivered a net benefit of around \$671 million
 - From 2011 – 2014 the scheme drove savings from upgrades that were unlikely to occur at all without the scheme, energy efficient retrofits and lighting products were very niche
 - From 2015 through to today, retrofit projects driven by the ESS deliver savings by bringing forward the early retirement of legacy technologies. For most building and lighting types, these projects are brought forward 7 to 10 years earlier they would other-wise occur
 - The commercial lighting formula calculates savings assuming that there is a static baseline, with inefficient technology continuing without ESS incentives. In practice, this baseline is dynamic and gradually improving.
 - This means that the link between deemed lifetimes and the lifetime of savings has begun to decouple. This is not yet an issue for the dominant lighting activities,

such as industrial, but will begin to gradually erode benefits if default savings factors aren't adjusted to account long run improving efficiency of lighting stock

- ESS lighting calculation methods need to be updated to reflect this improving baseline.
- Dynamic baselines should also be considered for other methods, if an activity is occurring against a background of market transformation.
- Changes to the ESS rule to address dynamic baseline issues should be made in a way that sends clear long-term signals to the market about the value of future lighting projects
- To encourage sustainable business models and allow for orderly transitions, the Government should provide the market proportional notice for changes. It also means providing a clear and consistent policy basis for changes.
- ESS and VEET Emerging Lighting Technology⁷⁹ (ELT) product approval processes play a crucial role in maintaining quality in the absence of a national standard for LEDs, with possible spill over benefits outside the ESS
- National action is required to strengthen and enforce the Building Code of Australia (BCA) and Greenhouse and Energy Minimum Standards, to lock in product and installation quality in the absence of the ESS and for market segments the ESS does not readily reach
- Further consideration is required to understand the case for maintaining ESS ELT product approvals if a national standard for the quality and performance of LED lighting is developed

The key administration findings include:

- ESS administration has had a material impact on the quality of lighting products in NSW, but there is opportunity to improve operational efficiency and a case for investigating installation quality

⁷⁹http://www.ess.nsw.gov.au/Projects_and_equipment/Lighting_Technologies/Commercial_Lighting_Requirements

- There is a case for investigating whether ESS assurance and compliance processes can be improved with respect to verifying consistency of installations with the BCA and veracity of pre-upgrade lighting claims
- ESS ELT product approval processes are widely considered to be much faster than VEET, though time frames can vary significantly between Accredited Certificate Providers (ACPs)
- ELT product approval processes are still too burdensome for regime product suppliers to accredit more than a very small portion of their large product ranges, although these ranges are designed for the new build market

CHAPTER 26

Implications for Market Impact Evaluation Research

MIE and Evaluation research

Market impact evaluation (MIE) proved to be a powerful suite of analytical tools to understand not just program impacts, but the underlying forces behind them.

From the outset, a key challenge with this research was understanding retrospectively what the impacts on the market were, without access to state-level baseline stock or sales data on market performance. As such, we had to combine a series of national and state-level data sets, and rely on a number of assumptions to derive modelled estimates. Qualitative analysis of the underlying market structure and dynamics was of critical importance in two main ways: it allowed us to refine assumptions and validate findings for the quantitative analysis.

MIE allowed the development and testing of hypotheses across a detailed theory of change, to systematically understand not just what happened, but why. In doing so, this provided more robust results than conventional program logic evaluation research, which relies overly on measuring outputs and assuming outcomes. It also provided far more meaningful insights to improve future policy and program administration than a purely quantitative analysis of measured or modelled outcomes.

We considered market structure in terms of the regime and niche roles, interrelationships, segments, routes to market, and business models in the lighting supply chain network. We considered dynamics in terms of the social practices, technology infrastructure inertia, capabilities, opportunities, and motivations that drive and inhibit the adoption of efficient lighting. These analytical lenses were complimentary, and ensured a disciplined and comprehensive consideration of the program impacts, causes, and intermediate outcomes.

These benefits notwithstanding, this research and its findings still have limitations. In particular, findings would have been more empirically valid had quantitative and qualitative baseline studies been conducted very early into program impacts on the market, and at an intermediate point. Quantitative analysis would have been more efficient and revealing if research data gathering strategies had been developed and integrated with program administration. Finally, had appropriate participant consents been obtained, quantitative research could have considered not just estimates of intermediate outcomes (additional efficient lighting installed), but statistically valid

measurements of final outcomes (energy saved). Obtaining such consents should be a foundational element of every energy efficient program.

These lessons are relevant and important for the evaluation and continuous improvement of the ESS, and for market based programs in general.

The key findings with respect to future MIE strategy are:

- Market impact evaluation proved to be an insightful analytical framework for understanding the impacts of government programs on a market
 - The quantitative performance analysis helped understand what occurred
 - Qualitative analysis of market structure and dynamics provide insights into how and why impacts occurred, significantly beyond what is possible through quantitative analysis alone
 - The staged desktop, then interview based, research worked effectively to efficiently target the actors and questions required for interviews
 - The quantum of interviews was right for clear and consistent messages to emerge within different roles
 - The broad based approach to interview subjects, required to detect market wide impacts, and was not suitable to sufficiently understand impacts from programs with narrowly targeted impacts
 - As anticipated in the research design, a quantum of interview numbers was insufficient to quantitatively understand program impacts. However, interview results now enable a better targeted and designed approach to future quantitative survey work
- Limitations of data that is requested and held by the ESS Administrator results in avoidable cost, complexity, and limitations in evaluation research data gathering
 - ACPs already collect and hold a much broader range of data than was used to calculate energy savings, but the ESS Administrator generally only requires data if is specifically referred to by the ESS Rule

- The OEH were able to obtain some of this data (around 15%) directly from ACPs, but with significant cost and time delays
- More robust, frequent, and lower cost analysis would be possible if ACPs were required and able to readily provide project baseline and operating data, for all projects, to the ESS Administrator or OEH
- The analysis involved cleaning costs and data gaps which could be avoided due to non-standardised entry of industry and building codes by APCs
- The absence of customer consent to obtain billing data from retailers for analysis of de-identified, aggregated savings prevents Government from understanding the actual rather than modelled energy savings attributable to the ESS and other programs
- Further research would allow a more precise understanding of ESS additionality, spill-over, and installation quality, and GREP and EEB benefits
 - A larger scale survey of the experience and satisfaction of the lighting end-users and purchasers in ESS projects would help verify that the concerns that some actors have about installation quality are material
 - A larger scale survey of the lighting end-users and purchasers would provide a more representative and granular understanding of spill-over and additionality, to support the synthesised perspectives of suppliers from the interviews in this study
 - While GREP has a comparatively large impact, it is spread across a small number of participants and does not appear to have impacts across a market level; in-depth research with GREP participants is needed to understand program-level benefits
 - EEB has involved a relatively small number of participants compared to the size of the lighting market, and does not appear to have impacts across a market level; in-depth research with EEB participants is needed to understand program-level benefits
- Future MIE baseline studies should ideally commence before transformation has occurred

- More conclusive findings would have been possible if baseline MIE research on performance, structure, and dynamics had been undertaken before the ESS began to impact the market at scale, at an earlier mid-point in the last eight years since the ESS commenced
- Policy makers should monitor the ESS activity to identify likely high-volume energy savings activities
- Early into the growth of new high-volume activities (but not necessarily before), identify emerging technologies and develop structure, dynamics, and performance baselines with respect to mainstream and high efficiency niche products and practices

CHAPTER 27

Recommendations

Based on these findings, we have recommendations with respect to ESS policy and administration, GREP, energy efficiency program evaluation research, and Council of Australian Governments (COAG) energy efficiency policy. These recommendations separately address responsibilities of the ESS Policy Maker, the ESS Administrator, OEH GREP administration, OEH program evaluation and research, and OEH and NSW Department of Industry (DoI).

We recommend that the NSW Government:

- Develop a formal policy position on the objectives and role of the ESS with respect to driving sustainable market transformations, including specific consideration given to the inconsistency of subsidy dependent giveaway⁸⁰ programs to such objectives
- Systematically review and revise the strategy, process, and ESS Rule to better incorporate dynamic baselines and spill over benefits
- Review and update the ESS commercial lighting formula method to incorporate an updated baseline
- Investigate administratively efficient and auditable ways to differentiate savings by end user size, to account for potentially different levels of additionality by user type
- Consider developing default assumptions/limits for baseline lighting energy consumption
- Amend the ESS Rule review timetable to ensure twelve to eighteen months of notice is provided for changes to methods in active use that are likely to have material impacts on sustainable business models, unless equivalent notice or automatic adjustment mechanisms are already in place⁸¹
- Amend ESS Rule clause 6.8 to require National Meter Identifier (NMI) meter number(s), a meter read at time of installation, and energy saver consent for OEH to request NMI data for the purposes of aggregated analysis of savings

⁸⁰ I.e. business models based on the giving away of free product, where incentive levels are higher than the cost of hardware and installation. Our definition of "Giveaway programs" specifically exclude structured finance products that enable zero upfront costs, with capital costs spread over time. These loan or lease payments should be considered as valid co-payments.

⁸¹ This does not preclude incremental changes within methods, unless those changes are likely to distort the overall market (e.g., by driving new giveaway models for a given product that crowd out other activity). This excludes changes which are built into current rule, regulatory, or legislative mechanisms. For example, price changes are part of the market design and are already factored into business models and investment decisions. Dynamic or automatically adjusting baselines would similarly provide sufficient notice.

- Review and amend ESS Rule clause 6.8 to require the Administrator to collect and share the broader range of already available ACP data for research and evaluation proposes
- Clarify and codify the roles and responsibilities of the ESS Policy Maker and Administrator with respect to evaluation research and data sharing
- Incorporate co-payment requirements for all ESS rule methods
- Review the eligible lighting technologies to potentially remove general purpose lamps, downlights, and traffic signals
- Conduct a review of ESS administrative efficiency to identify and implement improvement opportunities across the ESS regulations, ESS Rule, and administrative processes to reduce costs while maintaining outcomes
- Amend accreditations nomination forms to ensure adequate consents are obtained for the gathering and sharing of installation and NMI data with the policy maker for evaluation research
- Amend lighting and other certificate calculation tools to require standardised entry of business classification data by ANZSIC code and building use by BCA code, including multi-unit apartment buildings
- Establish systems to allow the streamlined capture of all the project input and output data, from lighting and other methods, that is already collected by ACPs, and provide the Policy Maker access for analysis and reporting
- Consider incorporating the ESS product register into Government lighting procurement policy
- Consider undertaking further participant research as part of program-level evaluation, to understand whether market impacts are, or could be, transformative for agencies and energy service companies beyond the life and scope of the program
- Prioritise a co-ordinated engagement with COAG Greenhouse and Energy Minimum Standards (GEMS) program and the Building Code of Australia (BCA) Section J review, to lock-in and extend ESS lighting efficiency impacts to the new build, refurbishment, maintenance and domestic markets

- Monitor the ESS activity to identify likely high-volume energy savings activities, and undertake MIE baseline studies of these activities early into their growth trajectory, to be updated bi-annually
- Continue to gather data and update lighting market performance analysis bi-annually
- Undertake annual statistical analyses of post implementation energy consumption against appropriate baselines, using de-identified aggregated energy saver NMI data for all methods

Key terms and references

List of abbreviations

ABS	Australian Bureau of Statistics
ACP	Accredited certificate provider under the NSW Energy Savings Scheme
CLF	Commercial lighting formulae measure of the NSW Energy Savings Scheme
EEB	NSW Energy Efficient Business program
ELT	Emerging Lighting Technology
ESC	Energy Savings Certificate
ESCO	Energy Service Company
ESS	Energy Savings Scheme
ESS Rule	Energy Savings Scheme Rule of 2009
GEMS	Greenhouse and Energy Minimum Standards
GGAS	Greenhouse Gas Abatement Scheme
GLS	General Lighting Service
GREP	Government Resource Efficiency Policy
HE lighting	High Efficiency lighting
HEER	Home Energy Efficiency Retrofit
HID	High Intensity Discharge
HVAC	Heating, Ventilation, and Air Conditioning
IoT	Internet of Things
IPART	Independent Pricing and Regulatory Tribunal
IS	Innovation Systems
LED	Light-Emitting Diode
MEPS	Minimum Energy Performance Standards
MIE	Market Impact Evaluation
MLP	Multi-Level Perspective
NABERS	National Australian Building Energy Ratings Scheme
NMI	National Meter Identifier

NSW	New South Wales
OEH	Office of Environment and Heritage
OEM	Original Equipment Manufacturer
PV	Photovoltaic
REC	Renewable Energy Certificates
REES	South Australia Retail Energy Efficiency Scheme
RIS	Regulatory impact statement
SIT	Systems Innovation Transitions
VEET	Victorian Energy Efficiency Target

Glossary

Bay/road	Highbay, lowbay and road lighting luminaires commonly used in industrial and road lighting applications
CFL	Compact fluorescent lamps, with integrated ballast as typically used in households.
CFLn	Compact fluorescent lamps with <u>non</u> -integrated ballast as typically used in office and commercial buildings (e.g. bathrooms, foyers)
Downlight	A small, recessed ceiling luminaire.
General purpose lighting	Conventional screw-cap or bayonet-cap light bulbs.
HID	High intensity discharge lighting, such as mercury vapour, metal halide and sodium lighting.
Lamp	Light bulb or fluorescent tube
Landscape	In the MLP framework, refers to the environment within which the market operates, including macro-economics, cultural patterns, and politics (see also: niche, regime)
LED	Lighting emitting diodes – a class of integrated lamps and luminaires, which are now typically high efficiency
Lighting market	The commercial actors involved in the purchase and supply of technologies that use electricity to produce artificial light
Linear	Elongated linear fluorescent style luminaires commonly found in offices and commercial premises.
Luminaire	A light fitting / fixture
Niche	In the MLP framework, refers to a small sub-market where new technologies are incubated; they are unstable, low performance, and with dedicated actors (see also: landscape, regime)
Program logic	A model that describes how a program is intended to work, linking program activities to the program aims and intended outcomes (see also: theory of change)
Regime	In the Multi-Level Perspective (MLP) framework, refers to a dominant market trajectory characterised by routines, sunk costs,

infrastructure, dominant competencies, aesthetics, contractual agreements, regulations, and standards; in the report, regime is used more or less interchangeably with the more common term mainstream

Role	Refers to distinct sets of responsibilities and activities pertaining to the NSW lighting market. In this MIE report, ten roles were identified: OEMs, brand managers, distributors, retailers, specifiers, electrical contractors, developers, property owners/managers, certificate aggregators, and end users
Free riding projects	Projects that received funding from the ESS, but would have happened anyway (see also: spill over projects)
Multi-Level Perspective	A theoretical framework for analysing system innovation. It considers broad societal processes, and understands market change using a three-layered perspective: the landscape (macro) level of cultural, economic, and political factors; the regime level of the prevailing practices and rules driving behaviours; and the niche (micro) level of individual behaviours and innovations to challenge the prevailing regime. ⁸²
Spill-over projects	Projects that did not receive funding from the ESS, but happened due to market changes catalysed by the ESS (see also: free riding projects)
“T12”, “T8” and “T5”	Linear fluorescent lamps. They are listed here in order of increasing efficiency
Theory of change	A model that seeks to link program activities to intended outcomes, focussing on the causal mechanisms that will bring them into effect (see also: program logic)
Transformative impacts	Impacts likely to persist after programs ended
Transitory impacts	Impacts dependent on continued interventions

⁸² Twomey & Gaziulusoy (2014)

Bibliography

ARTD (2016) "Draft formative evaluation", *Evaluating the NSW Energy Efficiency Action Plan*, OEH – Unpublished

Brown 2005, *Sustainable Public Lighting: The current state of play and future developments*, Paul Brown, 2005

Common Capital (2014) *Characterising the New South Wales Energy Efficiency Market*, unpublished paper for NSW Office of Environment and Heritage

Commonwealth of Australia (2015) *Product Profile: Commercial Lighting*, E3: Equipment Energy Efficiency Program

Commonwealth of Australia (2015) *Product Profile: Light Emitting Diodes (LEDs)*, E3: Equipment Energy Efficiency Program

Department of Energy, United States (2013) *SSL Pricing and Efficacy Trend Analysis for Utility Program Planning*, PNNL-22908

Department of Energy, United States (2014) *Solid-State Lighting Research and Development Multi-Year Program Plan*

Department of Energy, United States (2016) *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*

DIS 2015, *Residential Energy Baseline Study: Australia*, prepared for Department of Industry and Science on behalf of the trans-Tasman Equipment Energy Efficiency (E3) Program, August 2015

E3 2016a, *2016 Residential Lighting Report, Results of a lighting audit of 180 Australian homes*, Energy Efficient Equipment Committee, June 2016

E3 2016b, *Consultation Regulation Impact Statement - Lighting, Regulatory reform opportunities and improving energy efficiency outcomes*, Energy Efficient Equipment Committee, November 2016

EC 2015, *Preparatory Study on Light Sources, for Ecodesign and/or Energy Labelling Requirements, Final report, Task 7, Scenarios - Energy*, European Commission, prepared by VITO in cooperation with VHK, October 2015

Esfeld (2003). *What are Social Practices?* Indaga, Revista internacional de Ciencias Sociales y Humanas, 1, pp. 19–43

Eto J, Prael R, and Schlegl J (1996) *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*, University of California Berkeley, <https://emp.lbl.gov/publications/scoping-study-energy-efficiency>

Geels and Schott (2007) *Typology of sociotechnical transition pathways*, Research Policy 36, pp 399–417

Gerke, Ngo, Alstone, and Fisseha (2014) The evolving price of household LED lamps: Recent trends and historical comparisons for the US market, Lawrence Berkeley National Laboratory

Green Energy Markets (2016) *Small-scale technology certificates data modelling for 2016 to 2018*, http://greenmarkets.com.au/images/uploads/GEM%20Reports/Industry%20Reports/GEM_Report_on_STC_modelling_2016-18_Dec_2015V0_6_Final_web_compliant.pdf

Harland (1996) *Supply Chain Management: Relationships, Chains and Networks*, British Journal of Management, Volume 7, Issue s1, December 1996, Pages S63–S80

IPWEA 2016, Street Lighting and Smart Controls (SLSC) Roadmap, for Department of the Environment and Energy, Australian Government, by Strategic Lighting Partners and Next Energy

Michie, van Stralen, and West (2011) *The behaviour change wheel: A new method for characterising and designing behaviour change interventions*, Implementation Science, <https://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-6-42>

Mountain & Szuster (2015) *Solar, Solar Everywhere*, IE Power and Energy magazine, Jul/Aug

Nelson and Winter (1982) *An Evolutionary Theory of Economic Change*, Cambridge (MA), Bellknap Press

McKinsey and Company (2012) *Lighting the Way: Perspectives on the Global Lighting Market*

Office of Environment and Heritage, NSW (2014). *Energy efficient lighting Technology report*, Second Ed., <http://www.environment.nsw.gov.au/resources/business/140016-energy-efficient-lighting-tech-detail.pdf>

Rocky Mountain Institute (2014) Lessons from Australia: Reducing Solar PV Costs Through Installation Labor Efficiency; P.4 https://d231jw5ce53gcq.cloudfront.net/wp-content/uploads/2017/04/2014-11_RMI-AustraliaSIMPLEBoSFinal.pdf

Twomey and Gaziulusoy (2014) Review of System Innovation and Transitions: Theories Concepts and frameworks for understanding and enabling transitions to a low carbon built environment, CRC for Low Carbon Living, http://www.visionsandpathways.com/wp-content/uploads/2014/06/Twomey_Gaziulusoy_Innovation-and-Transition-Theory.pdf

Urbis (2010) *Evaluation of the NSW Home Saver Rebate program: Evaluation Report*, <http://www.environment.nsw.gov.au/resources/actionmatters/evaluation/home-saver-rebates-evaluation-2012.pdf>

USDoE 2014, Solid-State Lighting Research and Development, Multi-Year Program Plan, April 2014 (Updated May 2014), Prepared for: Solid-State Lighting Program, Building Technologies Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

US DoE 2016, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, Prepared for the U.S. Department of Energy Solid-State Lighting Program, September 2016, Prepared by Navigant

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