Retrofitting public buildings for energy and water efficiency

Patrick X.W. Zou, Rodney Stewart,
Morshed Alam, Edoardo Bertone and Oz Sahin

Sustainable Built Environment National Research Centre

Final Industry Report, SBEnrc Project 1.43

Acknowledgement

This research has been developed and implemented with funding and support provided by Australia's Sustainable Built Environment National Research Centre (SBEnrc) and its partners.

Core Members of SBEnrc include Aurecon, BGC, Queensland Government, Government of Western Australia, New South Wales Roads and Maritime Services, New South Wales Land and Housing Corporation, Curtin University, Griffith University and Swinburne University of Technology.

We acknowledge the input provided by the following people for specific aspects of this research:

Dr Jay Sanjayan Professor and Director, Centre for Sustainable Infrastructure, Department of Civil and Construction Engineering, Swinburne University of Technology

Luke Menzel Chief Executive Officer, Energy Efficiency Council, Australia

Rob Murray-Leach Head of Policy, Energy Efficiency Council, Australia

Sam Burke Acting Director, Strategic Sourcing, Department of Treasury and Finance, Victorian Government, Australia

Susan Read Senior Team Leader, Sustainable Government Team, Office of Environment and Heritage, NSW Government, Australia

Robert Thomson Team Leader, Energy Efficient Government Programs, Office of Environment and Heritage, NSW Government, Australia

Anna Martinis Team Leader, Energy Efficient Government Program, Office of Environment and Heritage, NSW Government, Australia

Michele Leembruggen Senior Sustainability Officer, City of Melbourne, Australia

Dr Lihua Zhao Team Leader, Research & Analytical Services, Department of Planning and Environment, NSW Government

The important contributions by the participants of the two workshops in Brisbane and Perth are also acknowledged. The contribution of the Project Steering Group was of vital importance to our research.

Cover image courtesy of Trafikverket

Project Team

Research team members

Professor Patrick X.W. Zou, Project Leader, Swinburne University of Technology

Professor Rodney Stewart, Deputy Project Leader, Griffith University

Dr Morshed Alam, Research Fellow, Swinburne University of Technology

Dr Edoardo Bertone, Research Fellow, Griffith University

Dr Oz Sahin, Senior Research Fellow, Griffith University

Project Steering Group

Chris Buntine, Project Steering Group (PSG) Chair, Environmental Systems Design (ESD) Leader, Built Environment, Aurecon.

Carolyn Marshall, Principal Architect, Building Management and Works, Department of Finance, Government of Western Australia.

Evan Blair, Principal Advisor, Building Industry and Policy, Department of Housing and Public Works, Queensland Government.

Daniel Ellis-Jones, Policy Officer, Building Commission, Department of Commerce, Government of Western Australia.

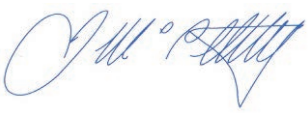
SBEnrc core members

ISBN 978-0-6480742-0-5 (Hard Copy)
ISBN 978-0-6480742-1-2 (Soft Copy)

Preface

The Sustainable Built Environment National Research Centre (SBEnrc), the successor to Australia's Cooperative Research Centre (CRC) for Construction Innovation, is committed to making a leading contribution to innovation across the Australian built environment industry. We are dedicated to working collaboratively with industry and government to develop and apply practical research outcomes that improve industry practice and enhance our nation's competitiveness.

We encourage you to draw on the results of this applied research to deliver tangible outcomes for your operations. By working together, we can transform our industry through enhanced and sustainable business processes, environmental performance and productivity.



John V McCarthy AO
Chair
Sustainable Built Environment
National Research Centre

Dr Keith Hampson
Chief Executive Officer
Sustainable Built Environment
National Research Centre

Executive Summary

Governments occupy a significant proportion of building stock, and their associated annual energy and water consumption costs can be substantial. Research has shown that significant reductions in energy and water consumption and carbon emissions can be achieved through retrofitting public buildings. However, in most countries, the current retrofitting rate is very low due to a number of barriers, including lack of supportive legislation, regulations, guidelines, industry capacity and financing mechanisms. This research aimed to address this issue through developing a best-practice guide to retrofitting public buildings, identifying the barriers to the uptake of retrofitting activities and developing strategies to overcome these. A number of research methods were applied, including literature reviews, interviews, numerical modelling, case studies and focused group workshops with stakeholders.

Through a comprehensive review of national and international literature and practices, this research identified five key components of a successful retrofitting project. Numerical models were developed to assess the influence of different financing options and procurement methods on public building retrofit outcomes. The modelling results indicate that a revolving loan fund (RLF) supporting an energy performance contract (EPC) procurement strategy can be the best option for retrofitting many government buildings in Australia. However, RLF may work best for projects with shorter payback periods. Also, for low-risk projects (for example, lighting replacement), the use of EPC may unnecessarily increase the project cost and time. Alternative procurement models may be used, depending on the project value, project complexity, project risk profile and project team skill and leadership.

Based on the review of relevant guidelines around the world, this research has developed a Public Building Retrofitting Guideline. It was found that effective implementation of retrofitting guidelines depends on the collective actions of four key stakeholders:

1. The government department in charge
2. The facilitation team
3. The Energy Service Company (ESCO)
4. The individual government department or agency which is the owner of the building asset that requires retrofitting

The government department in charge has the responsibility of introducing the appropriate policies, regulations and mandates. It is usually the one which holds and allocate the resources for retrofitting, e.g. Department of Treasury and Finance. The facilitation team is a central team which assists the individual government department or agency throughout the retrofitting process of their building. The ESCO is responsible for auditing, developing a business proposal, installing the selected retrofit measures and monitoring the performance of installed retrofit measures. Finally, the role of the individual government department or agency is to take necessary steps to retrofit the buildings under their portfolio by following the retrofitting guidelines and seeking necessary assistance from the facilitation team.

To identify the barriers hindering the uptake of building retrofitting activities and corresponding coping strategies, two focused workshops were conducted in two different Australian States with participants from relevant management roles in different government departments. From the workshops and key stakeholder consultations, lack of mandate was identified as one of the major barriers. Governments' willingness to introduce mandatory policies and financing mechanisms is mostly influenced by the 'net debt' over the forward estimate period. Retrofitting projects normally have longer payback periods which may result in an increase in this debt. As a result, the building retrofitting projects are seen as a cost rather than producing savings. Other barriers are lack of dedicated funding, lengthy and complex procurement processes, no incentives for the agencies to prioritise efficiency projects, and lack of knowledge and capability to manage retrofit projects. Possible solutions to overcoming these and other barriers are discussed.

The outcomes of this industry-led research can provide evidence-based support to policy-makers and help governments to develop and implement comprehensive public retrofitting policies and programs to achieve energy and water efficiency in their buildings.

1 Introduction

1.1 Industry challenges

The built environment accounts for about 40 per cent of the world's total energy consumption [1]. In Australia, governments occupy over 25 per cent of the commercial building stock, and the Australian governments collectively spend over AUD$1 billion each year on building energy and water bills [2]. The majority of those public buildings (e.g. offices, schools, libraries, hospitals, galleries and museums) are old and there are opportunities to improve the energy and water efficiency. In 2006, the Energy Efficiency in Government Operation (EEGO) policy was introduced to improve energy efficiency of Australian government operations [3]. In addition, several state governments have introduced their own retrofitting policies, targets and implementation strategies. Review of these state-level programs along with other international retrofitting programs revealed a number of barriers and challenges in retrofitting existing public buildings [4]. These barriers and challenges are resulting in lost opportunities for the governments to save in utility bills as well as contribute to achieving the national emission reduction target.

There is an urgent need for a comprehensive retrofitting guideline and strategy to help the Federal and State level governments to overcome the barriers and challenges and accelerate the building retrofitting rate.

1.2 Research objectives

This research project worked with industry partners to develop a best-practice guide for energy and water efficiency retrofitting of existing public building stock. Specific objectives were to:

1. Identify key components of a retrofitting project and analyse financing mechanisms
2. Develop comprehensive retrofitting guidelines and strategies
3. Identify barriers to retrofitting public buildings and suggest strategies to overcome these

The research methods and phases, as shown in Figure 1 were used to achieve the research aim and objectives.

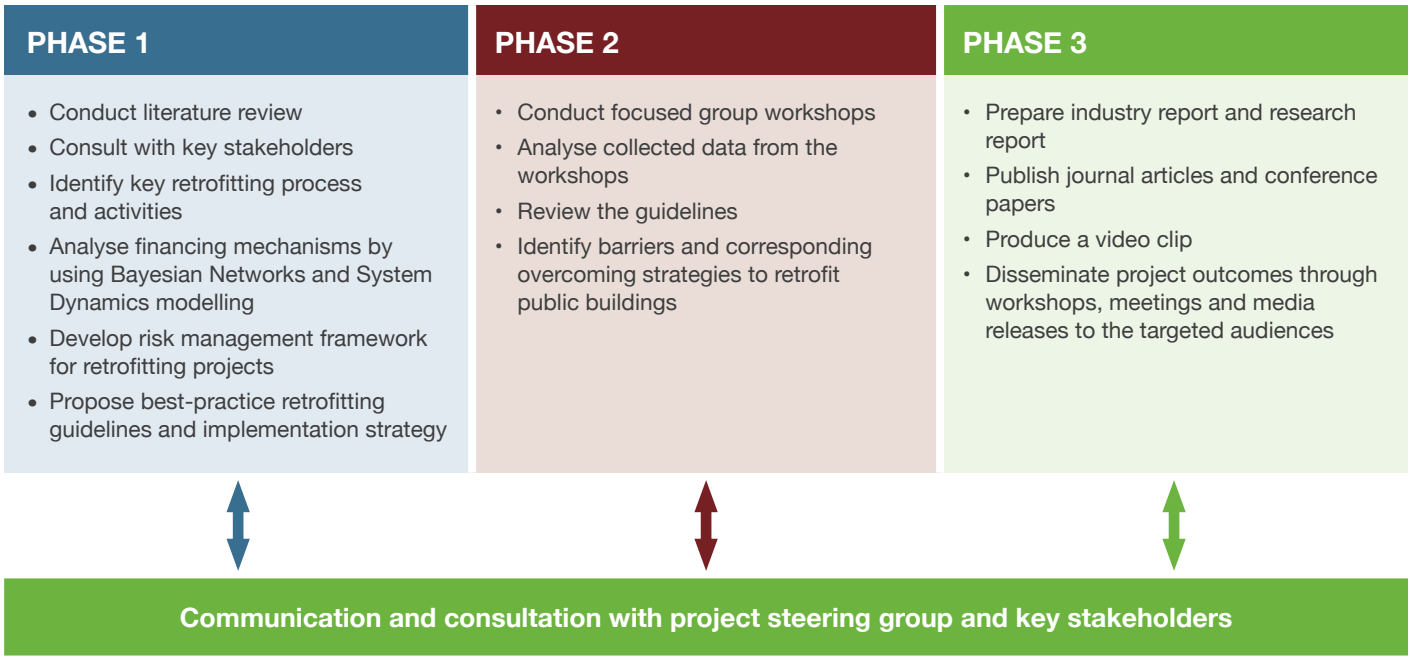


Figure 1 *Research methods and process*

2 Key components

Based on the Project's review of successful and unsuccessful examples worldwide [5], five key components of a retrofitting project were identified:

1. Efficiency assessment
2. Selection of retrofit options and risk assessment
3. Procurement methods
4. Project financing mechanism
5. Post-retrofit measurement and verification

The main reason for low retrofitting rates was the absence of one or more of these components or lack of specificity.

2.1 Efficiency assessment

Assessing the energy and water efficiency of an existing building is an intricate task, as it requires accurate and reliable monitoring and auditing, and proper benchmarking and certification schemes.

An efficient metering policy would be the first step towards a proper national-level public buildings efficiency assessment. Smart meters would help to identify the best ad-hoc retrofit option. In addition, if energy/water data for several buildings was collected, it would help with benchmarking and designing national energy/water efficiency policies. In Denmark [6], the data collected through a mandatory certification scheme were used to assess potential savings and develop policy actions.

Regarding auditing, in Australia and New Zealand there are three standard levels of building energy audit with increasing complexity, but no mandate on which level is required for specific tasks. Additionally, there is no standard for water audit.

With respect to performance benchmarking, there are several examples of certification schemes worldwide, both mandatory and voluntary. The Project's review [5] shows how both are useful, but the voluntary scheme is less effective, since owners of poorly performing buildings are wary of undertaking the certification which could subsequently display a negative rating and potentially affect the rental value. The issue with mandating a certification scheme is related to the metering barrier, as baseline data (to be collected through large scale metering programs) would be required to provide appropriate and meaningful benchmarking.

Example #1 - Sydney's Smart Green Apartments program

Launched in 2011, the Smart Green Apartments program in Sydney, Australia offers free water and energy audits for 20 large apartment buildings each year in order to seek tailored retrofitting opportunities. The program was successful in identifying up to AUD$89,000 of potential annual savings per building. One of the shortcomings of the program has been the lack of an appropriate benchmarking/rating system; the development of such a system would help increase the understanding of sustainability, and energy and water performance for the apartments sector. These and other similar programs help to showcase the potential benefits of energy/water retrofits, and the importance of a standardised, professionally-driven building efficiency assessment as the first step in the process. Further information and application instructions can be found on the program's website[1].

2.2 Selection of retrofit options and risk assessment

A large number of different retrofit options are available for energy and water efficiency, and therefore identifying the most suitable option for a specific building can be quite challenging. Often, the 'low-hanging fruit' options (e.g. LED lights, window sealing, taps, aerators) represent relatively inexpensive and quite effective solutions. However, for more extensive retrofits (e.g. Heating, Ventilation and Air Conditioning (HVAC) systems or hot water system replacement), rigorous monitoring and auditing activities are necessary to identify the best retrofit option.

> *While ranking different options, it would be beneficial to account for co-benefits, such as increased tenants' productivity, reduced carbon emissions or increased property value, which could increase the project's attractiveness;*

however, these may be difficult to quantify and compare in monetary terms. Adding to the complexity, there are a number of uncertainties (e.g. future energy/water price, climate change, equipment performance), increasing the risks for the building owner. The associated risks in a retrofitting project can be minimised through following a systematic risk assessment and management framework from a project life-cycle perspective [7]. The framework should include the following dimensions: communication and consultation with key stakeholders; establishing the context in terms of risk management objectives and risk acceptance criteria; identification of potential risks and their causes and sources; analysis and evaluation of the identified risks; identification of risk mitigation and treatment measures; implementation of risk mitigation and treatment measures; and monitoring and reviewing the risk management process as well as learning from the process through reflection.

[1] http://www.cityofsydney.nsw.gov.au/live/residents/sustainable-city-living/sustainable-apartments/smart-green-apartments

2.3 Procurement methods

Traditional procurement methods were found to be generally ineffective, because government agencies seek funding from the central government for retrofitting projects and funding options are rarely provided. An effective procurement option can be provided by 'Integrated Services Models', whereby a qualified service provider (for energy efficiency, called an Energy Service Company or ESCO) is selected for not only the retrofit installation, but also pre-retrofit auditing, project proposal and post-retrofit measurement and verification (M&V). In the case of Energy Performance Contract (EPC), the whole process is performance-driven, as the ESCO will not be paid up front but will get paid through a proportion of the achieved energy savings. In this way, it is important for ESCOs to accurately predict the savings and monitor them to achieve positive returns on investment. This procurement method also transfers risks away from the owner, who does not require in-depth technical knowledge. EPC has been widely used in the United States, Canada, Germany, Finland, Denmark and in some Australian States.

However, EPC is generally not suitable for small projects (< AUD$500,000) or remote locations, as it can deter ESCOs. Also, developing an EPC project is a lengthy process, and it drives up the project cost as all the risks are shifted to the ESCO. In the case of low-risk projects (e.g. lighting) with higher project value, the use of EPC unnecessarily increases the project cost, time and complexity. In this scenario, a different procurement model, such as 'Design and Install', can be used. To analyse the risks associated with a project, a multiple criteria analysis can be used, considering project value, project complexity, risk profile, etc., rather than only project value. After the multiple criteria analysis, projects with high-risk rating may be procured via EPC. Medium and low-risk projects may be procured using a Design & Install procurement model.

Example #2 - Empire State Building retrofit

In 2009, through an EPC-based procurement approach, the iconic building in New York was retrofitted with a number of integrated retrofits, in order to achieve an annual energy use reduction of 38 per cent with a payback period of three years. A 2014 M&V report stated that the guaranteed energy savings were exceeded by 16 per cent, leading to USD$2.5 million in energy savings each year. More information can be found on the program's webpage[2].

2.4 Project financing mechanism

Utilisation of an appropriate financing mechanism is critical to overcome the financing related barriers and ensure proper implementation of a retrofitting project. A number of different financing mechanisms were identified from around the world, which had achieved a wide range of success in overcoming financing related barriers, discussed briefly below:

- **Revolving Loan Funds (RLF):** This type of loan provides favourable financial terms and helps qualify for credit entities that otherwise would struggle to access funds. The ESCOs repay the loan through the energy savings of the retrofitted buildings and, due to the interest rates, the budget dedicated for the RLF will increase over time and can be used to fund further retrofits. It has been successfully used in more than 30 states in the USA. In Australia, the New South Wales (NSW) Government Finance Facility uses RLF for financing government building energy and water efficiency projects. The fund has been in place since 1998 and currently, has a cap of AUD$95 million.

However, the government need to seek funding sources first to set up an RLF. One way of doing it may be the use of Green bonds which has been explained later in this section. Also RLF may work better with shorter payback periods of up to four years. For projects with longer payback periods, the requirement to wait for paybacks from these will limit the rollout of new projects.

[2] http://www.esbnyc.com/esb-sustainability

- **On-bill financing:** This mechanism helps avoid upfront costs by allowing repayments through energy/water bills. The repayments are supposed to be lower than the savings, thus allowing for immediate positive returns for the owner. This is usually suitable for small projects. However, private lenders can potentially perceive the energy efficiency market as high risk and the utility companies themselves may have no desire for acting as lenders. Government agencies typically don't have the power to sign these agreements (they are now considered to be 'finance leases' rather than 'operating leases' and are considered a borrowing), so these are not an option unless governments make specific exemptions from borrowing Acts.
- **Environmental Upgrade Finance (EUF)**: In this situation, a long-term, low-interest rate loan is provided, which is paid back through municipal taxes. These can be transferred to the tenants, thus help avoid both upfront costs and split incentive issues. It requires a deep involvement of the local councils to facilitate the lending process. EUF has been applied in several states in Australia.
- **Green Bonds:** In this method, a government issues bonds to source the capital required for retrofitting. The collected fund is then used to provide the required money for a retrofitting project using the government's preferred financing mechanism. It is a low-risk and government-backed financing mechanism, and its use is increasing worldwide, including in Australia. Nevertheless, clearer rules are required, in particular around the definition of 'green', to avoid unrelated applications being submitted to take advantage of the financial benefits.

Other options (e.g. grants, green depreciation) were identified, but those above were considered more effective or less exclusive. It was found that the best solution would be a combination of a number of integrated financing options (e.g. on-bill financing for small remote projects, EUF or RLF for large projects) in order to overcome the limitations of each.

Example #3 - Modelling hospital retrofitting potentials

After identifying the revolving loan fund to be a potentially successful financial tool to increase the number of building energy and water efficiency retrofits in Australia [5], an integrated qualitative/quantitative prediction model was developed to estimate how many hospitals in Australia would be retrofitted over time. It assumed a revolving loan fund was set up for 'low-hanging fruit' retrofits, such as LED lights and tap aerators, and the projects were procured through an EPC. The results were stunning, but not surprising: with an investment of AUD$80 million; it is predicted that 29 per cent of hospitals would be retrofitted within five years and that approximately AUD$400 million in energy and water cost savings would be achieved in 10 years; five times the initial investment. As a co-benefit, more than 23 million tonnes of emitted carbon dioxide could be avoided annually through these simple retrofits, representing more than 1 per cent of the total greenhouse gases emissions of the overall Australian electricity sector.

2.5 Post-retrofit measurement and verification

Post-retrofit measurement and verification (M&V) is a component which is typically underestimated and not often considered. It is critical to verify that the measured savings match the predicted ones and important to implement M&V policies promoting cyclic feedback mechanisms. As an example, the 2007 US 'Energy Independence and Security Act' introduced a four-year cycle for project planning, implementation and verification [8].

Recently, the capability of the Australian energy efficiency industry in understanding and conducting measurement and verification has grown significantly. This is due to the introduction of training and certification for the relevant professionals to the International Protocol for Measurement and Verification (IPMV). This has resulted in the use of common language, protocols and expectations on how to demonstrate that the savings have been achieved.

3 Proposed Public Building Retrofitting Guideline

Drawing on the lessons learned from the review of different procurement methods and a number of national and international guidelines [9-15], an EPC-based Public Building Retrofitting Guideline is proposed and presented in Figure 2. The figure shows the required key components at each step of the proposed guideline.

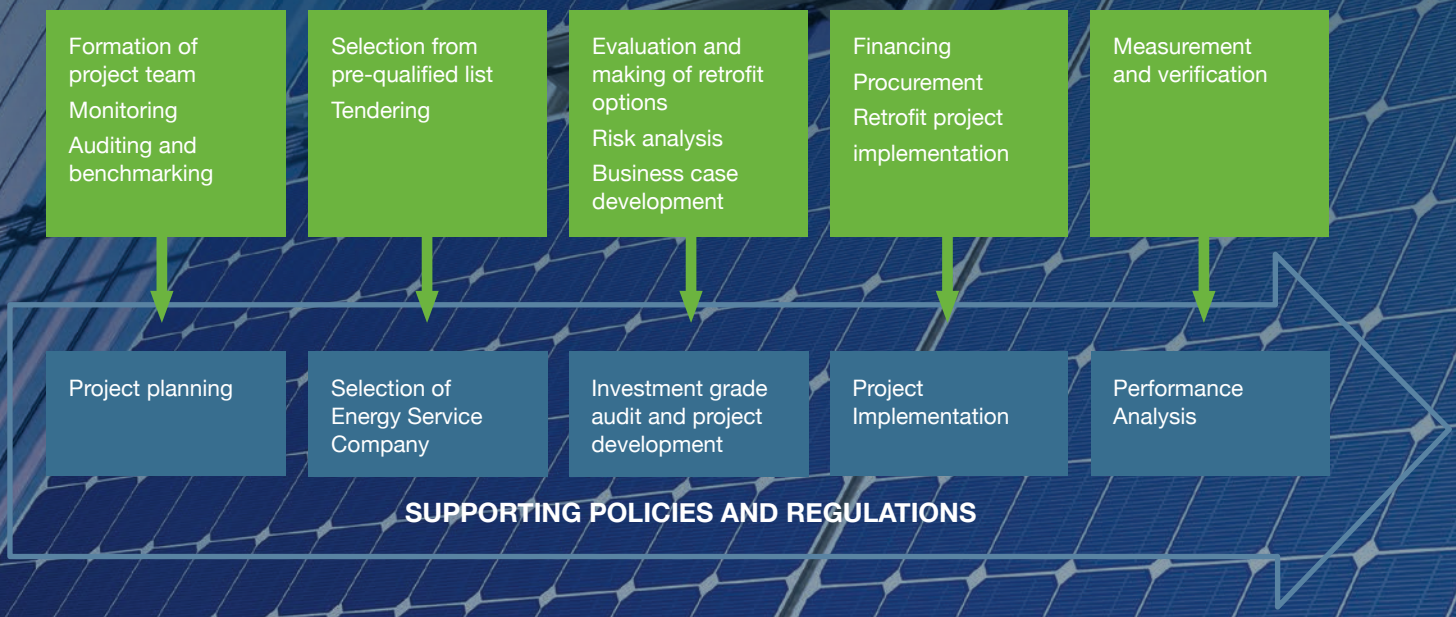


Figure 2 *Proposed Public Building Retrofitting Guideline for implementing energy performance contract (EPC)*

Project planning

The project planning stage includes formation of a project team, monitoring and exploring energy and water saving opportunities at the site and checking the feasibility of an EPC project. Experience from Canada's Federal Building Initiative program demonstrated that a competent project team should include all key personnel responsible for the management and operation of the facility and representatives from the procurement, human resources, finance, engineering and legal departments [10]. A preliminary energy and/or water audit should be carried out for exploring energy and water savings opportunities and preparing proposals.

Selection of Energy Service Company (ESCO)

Public building retrofitting programs that use an EPC should maintain a list of pre-qualified ESCOs to ensure that skilled and qualified professionals are selected by the government departments and agencies for their retrofitting projects. The ESCO selection criteria may include:

1. Capacity to comply with project requirements
2. Demonstrated experience in the provision of energy efficiency retrofit services
3. Company's methodology (auditing, selection and installation of retrofit measures and M&V) for undertaking an EPC project
4. Company's risk management strategies

If the potential for a project exists, a number of ESCOs could be invited to carry out a preliminary assessment including potential energy conservation measures and estimates of energy and cost savings. Based on their submitted proposals, one ESCO could be selected to conduct the detailed "investment grade" audit.

Investment grade audit and project development

At this stage, the selected ESCO should perform a detailed investment-grade audit, identify retrofitting options and submit a report that describes the basis for the project's contractually guaranteed savings. In the Victorian Government's Greener Government Building (GGB) program, the investment-grade audit is equivalent to a Level 3 energy audit [13]. The Level 3 audit is costly; it requires rigorous engineering and economic analysis and is recommended for major, capital intensive and high risk retrofitting projects to provide a high level of confidence [16]. For other retrofitting projects, a Level 2 energy audit may be appropriate which also includes a building survey and energy analysis, with detailed analysis of recommendations and cost effectiveness for each recommended energy efficiency measure [16]. Once the report is accepted, the project team proceeds with organising the fund and developing an EPC.

Project implementation

The implementation stage starts with organising the fund for retrofitting, either from government or private sectors. Once the funding is approved, an EPC is signed between the department/agency and ESCO. Then the ESCO proceeds with installing the proposed retrofit measures. According to USA guidelines, the best practice during the implementation stage is to keep the ESCO and department/agency in contact to avoid delays, unintended outcomes and backtracking [17].

Performance analysis

At this stage, the performance of the retrofitted buildings is analysed using a well-defined M&V plan. Sometimes the government agencies lack the capacity to perform M&V themselves and need assistance from ESCOs. In Australia (VIC and NSW), the ESCOs are required to develop a detailed M&V plan during the investment-grade audit and project development stage.

4 Lessons learned from State-level retrofitting programs

In Australia, different States have introduced different programs to retrofit public building stock for energy and water efficiency:

1. **Greener Government Building (GGB) and Efficient Government Building (EGB) programs – Victoria**
2. **Government Resource Efficiency Policy (GREP) – New South Wales**
3. **Government Building Energy Strategy (GBE strategy) – South Australia**
4. **Energy Smart Government (ESG) – Western Australia**
5. **Strategic Energy Efficiency Policy (SEEP) – Queensland**

Each of these retrofitting programs was studied regarding relevant policies and targets, implementation methods and current progress. These case studies provided important lessons which are listed in Figure 3 and described in the following sections:

Mandating targets

The Victorian Government's GGB program [18] had a mandate for implementing energy performance contracts in government departments and agencies. During 2009-2012, the program resulted in direct annual savings in utilities and maintenance bills of AUD$32.17 million [19]. In NSW, the average annual investment in energy efficiency projects at government sites increased fourfold from AUD$2.7 million to $10.3 million within the first year of implementing the mandatory GREP program [20]. These demonstrate the importance of mandating a target in building retrofitting programs.

Setting input and output targets

The Victorian Government's GGB program had an input-type target [18] that required the Government departments and agencies to identify and implement energy efficiency retrofits within certain timeframes. It was observed that the input type target has the potential to accelerate the retrofitting rate. On the other hand, the NSW GREP program [14] and the South Australia (SA) GBE strategy have both input and output type targets. The output type target ensures that a certain level of savings are achieved within the targeted period. For example, in SA's GBE strategy, the output type target (i.e. of achieving a minimum four-star NABERS[3] energy rating) resulted in having a NABERS energy rating of four stars or more in 80 per cent of the office floor space leased by the Government in Adelaide's Central Business District (CBD).

[3] National Australian Built Environment Rating System

Providing government funding

When the Victorian Government's GGB program was changed to the EGB program, no government funding was available for retrofitting projects, which resulted in a significant drop in public building retrofitting activities. Moreover, planned energy efficiency retrofits in a number of hospitals were cancelled due to the changes in the program. This incident demonstrates the need for having a suitable government funding arrangement for building energy efficiency retrofitting projects.

Reducing financial burdens of ESCOs

According to the 2009 GGB program [18], three ESCOs conduct initial auditing of the sites and submit a proposal outlining the possible savings and related costs. This is considered a major investment risk by the ESCOs because, if unsuccessful, they will not be reimbursed for their initial investment into auditing and developing the proposal. Even the winning ESCO is only compensated at the end of the investment grade auditing and such compensation could get further delayed if there are inefficiencies in parties involved in the program.

Developing a centralised facilitation team

A centralised facilitation team can assist the government and its agencies in different aspects of a retrofit project, reduce the time taken at different stages, and allow for better project outcomes.

Ensuring a stable long-term retrofitting program

A stable long-term building retrofitting program that does not change significantly with time is a pre-condition for achieving positive outcomes. When the Victorian Government's GGB program was changed to the EGB program in 2014, a number of building energy efficiency projects did not go ahead. The Queensland public building retrofitting strategy, introduced in 2007, was terminated after several years, due to a change in government.

Implementing mandatory annual reporting

A mandatory annual reporting scheme similar to the NSW Government's GREP program might have the potential to create peer pressure on the government departments and agencies to perform better and influence their retrofitting-related decision making.

Enhancing accountability

A lack of accountability may be one of the many reasons for not achieving the desired outcomes from the Government of Western Australia's ESG program. At the end of this program, two-thirds of the Government agencies did not achieve their retrofitting targets. There was no accountability or financial penalty imposed on the agencies for not achieving the targets [21]. There is a need for a mechanism to ensure that the departments and agencies are committed to improve energy efficiency through making them accountable for their actions.

Using EPC-based procurement methods

In the WA ESG program, many agencies did not implement the energy efficiency retrofit, despite the presence of energy saving opportunities and government funds, because of the risks associated with this type of project [21]. This barrier could have been overcome through using the EPC-based procurement methods, which shifts the technical and financial risks to the ESCO. However, as described previously, there may be situations where other types of procurement model will be more suitable, particularly when a single technology is used and the project is considered to be low risk.

Figure 3 *Lessons learned from the reviewed Australian retrofitting programs*

5 Implementation strategy

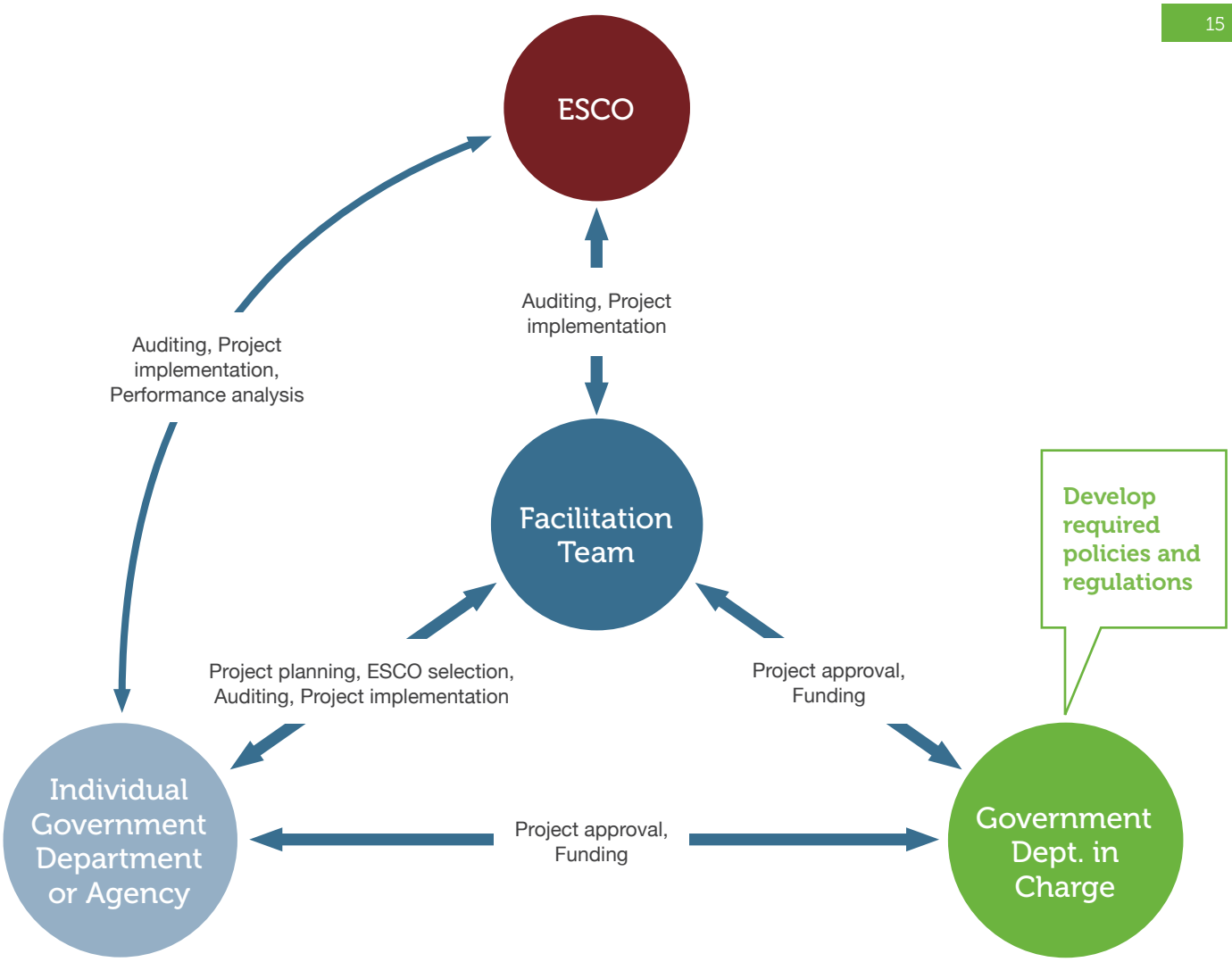


Figure 4 *Key stakeholders and their interactions in implementing the proposed Public Building Retrofitting Guideline*

From the review of different public building retrofitting programs and lessons learned from five Australian programs, it has been realised that the effective implementation of any retrofitting guidelines and achievement of desired outcomes depends on the action of four key stakeholders: (1) the government department in charge, (2) a facilitation team, (3) the ESCO and (4) the individual government department or agency which is the owner of the building asset that requires retrofitting. Figure 4 shows the key stakeholders and their interactions with each other at different stages of the proposed Public Building Retrofitting Guideline.

The government department in charge is the overarching policy-setting department which has the responsibility of introducing the appropriate policies, regulations and mandates; establishing a reasonable target, providing funds to the eligible projects and monitoring the progress towards the preset targets. The government department in charge is usually the one which holds and allocate the resources for retrofitting, e.g. Department of Treasury and Finance.

In most cases, the individual government department and agency may not have the expertise to manage an energy efficiency projects. The facilitation team is a team of experts which can help the departments and agencies throughout the retrofitting process, starting from project planning to implementation and completion. For example, this team can provide standardised contract forms and EPC procurement guidelines. In this way, they can also minimise the resourcing requirements of individual departments and agencies.

The ESCO performs a comprehensive energy audit and develops a business proposal for one, or a combination of retrofit measures. They are also responsible for monitoring and verifying the performance of installed retrofit measures and is paid by the building's owner through the energy savings that are generated.

Finally, the role of the individual government department or agency is to take necessary steps to retrofit the buildings under their portfolio by following the retrofitting guidelines and seeking necessary assistance from the facilitation team.

6 Barriers and coping strategies

Two focused group workshops were conducted to identify the most significant barriers and coping strategies for each of the following key factors in the proposed Public Building Retrofitting Guideline.

Over fifty participants from different government departments with various relevant experiences participated in these workshops on either side of Australia.

6.1 Building efficiency assessment

For the building efficiency assessment process, the identified barriers are related to governance and data/information. Regarding governance, the workshop participants identified a lack of understanding of the importance of M&V; this, in turn, leads to a lack of funding allocated to necessary monitoring activities, and thus a lack of data being available for verification of achieved efficiency savings. Where monitoring data is available, there are often not the qualified experts to interpret such data, as well as no appropriate key performance indicator for the baseline assessment of a particular building's efficiency.

Some of the solutions identified include the need for introducing mandates and standards, as well as education programs. Introducing mandatory energy/water consumption reporting as well as targets would necessitate investment in M&V activities and thereby ensure that estimated savings are verified or otherwise. Introducing clear regulations and standards for which kind of audit is required based on the project/building categorisation, as well as the responsible persons to undertake the audit, was considered another crucial requirement for better quantifying retrofitting opportunities. To ensure that skilled and experienced professionals are engaged to do the efficiency assessment and explore savings opportunities, certification schemes may be used. One such scheme is the Energy Efficiency Certification Scheme (EECS) developed by the Australian Energy Efficiency Council [22]. Another, the most frequently mentioned coping strategy, was related to educating staff to raise awareness about the benefits and opportunities from energy and water retrofits. Figure 5 displays the current cycle impeding a wider M&V implementation and the proposed effective M&V action plan.

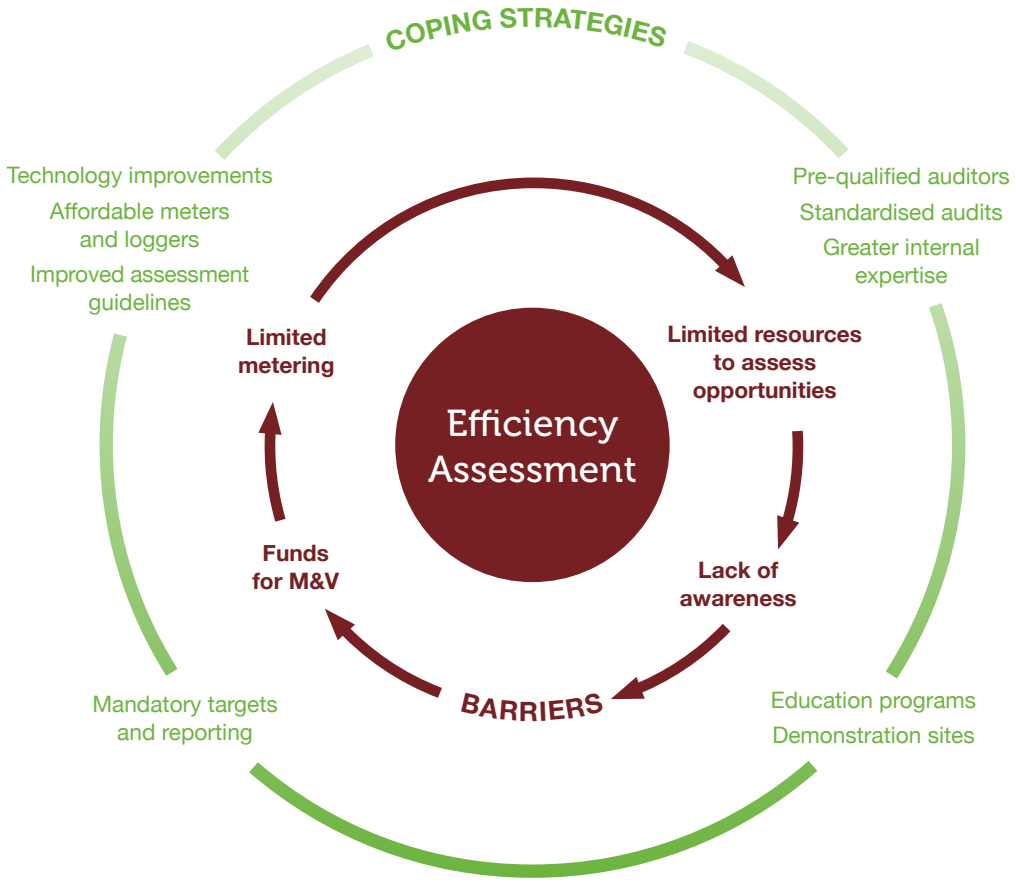


Figure 5 *Barriers and coping strategies for public building efficiency assessment*

Financing

BARRIERS	COPING STRATEGIES
Lack of knowledge in business case development	· Support from facilitation team · Sharing information between agencies and departments · Streamline process for business case development
No dedicated funding	· Policies targeting budget support · Retrofitting funding rules from Treasury departments · Use Revolving Loan Fund (RLF) and Green Bonds
Limitations in borrowing from private sector	Establish relevant funding schemes
Split incentives	Mechanism to keep savings in the departments and agencies
Associated risk	Use Energy Performance Contract

Figure 6 *Barriers and coping strategies during financing of public building retrofit projects*

6.2 Financing

Figure 6 shows the main financing barriers and coping strategies identified in the workshops for public building retrofitting projects. A lack of a dedicated long-term funding source for retrofitting projects was identified as a key barrier. Individual government departments have a constrained budget for each fiscal period and considered retrofit projects have to compete against other project priorities. In addition, governments have limited opportunities for borrowing from private sector lenders in order to fund public building retrofit projects. In cases where a particular government department successfully retrofits their buildings, the ongoing operational savings from reduced utility bills is often not retained in that department, providing a disincentive to invest in projects that will subsequently reduce their future budget allocations. This issue of split-incentive also arises in cases where public buildings are leased, especially when on a short-term basis. In those cases, there is little incentive for the government department tenant to retrofit the building, as the owner will reap the benefits. The financial risk associated with retrofitting, for example, not achieving the desired savings targets, also acts as a barrier to the financing of retrofitting projects. Finally, there is presently limited specialist knowledge and experience within governments for developing robust retrofit project business cases. As a result, only limited funding allocations are dedicated towards retrofit project opportunities within annual budgeting cycles.

In terms of coping strategies, governments could consider introducing targeted policies with allocated budget support for an ongoing retrofitting program. Treasury departments should establish retrofitting project funding rules. A revolving loan fund (RLF) or Green Bonds were considered as potential financing options in the workshops. Also, governments could consider introducing policies, regulations and funding schemes that enable departments with viable retrofit projects to access private sector funding. In order to encourage individual departments, there could be an internal reward structure and dedicated KPIs assigned to senior government executives. An incentive to government departments could be that building utility savings related to successful retrofit projects could be accumulated within their department and used to fund further retrofit projects (i.e. an internal RLF arrangement). In the case of leased public buildings, use of appropriate financing schemes (e.g. Environment Finance

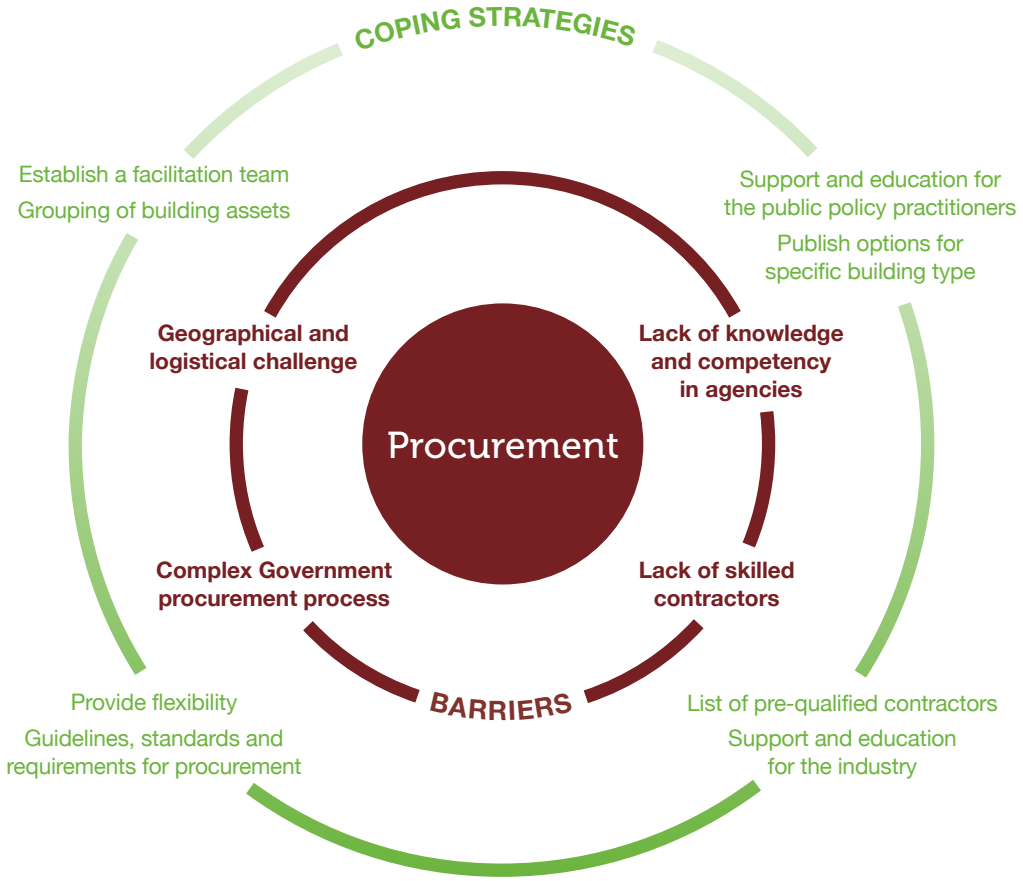


Figure 7 *Barriers and coping strategies during procurement of public building retrofit projects*

Upgrade) could help to resolve the split-incentives issue. To eliminate the financial risks associated with retrofitting projects, the government could introduce EPC procurement methods. Formation of an expert facilitation team was considered very important to support departments in developing a strong business case for retrofitting projects. Additionally, a dedicated knowledge repository and a streamlined process for business case development with information sharing between departments would be helpful for business case development.

6.3 Procurement

Building energy/water retrofit project procurement is challenging and requires extensive project management to achieve successful outcomes. There is currently a shortage of skilled contractors to suitably install building energy and water efficiency retrofits and a contractual means to ensure that contractors achieve estimated savings from those retrofits over the long term. Another identified barrier was the time-consuming government procurement process, which is too burdening for the smaller retrofit projects. The final major barrier identified for procuring retrofit projects was related to the geographical and logistical challenges associated with very large states like QLD and WA. These state governments have thousands of owned and leased public buildings located within capital and regional cities as well as remote country towns. Planning for and procuring retrofit projects in regional and remote locations is particularly challenging. Bundling of retrofit project works across each state is possible, but requires an expert procurement and facilitation team to be successful.

In terms of coping strategies, easy to follow procurement guidelines for various scales and categories of retrofit projects would help government officers championing building efficiency objectives. A list of pre-qualified contractors could help government departments and agencies to select the right contractor. Government may also consider establishing a specialist building retrofit procurement office that can provide assistance to departments implementing smaller retrofit projects, and completely manage the entire process for geographically spread, large-scale and bundled whole-of-government retrofit programs. Figure 7 summarises the main identified procurement barriers and coping strategies for public building retrofitting projects.

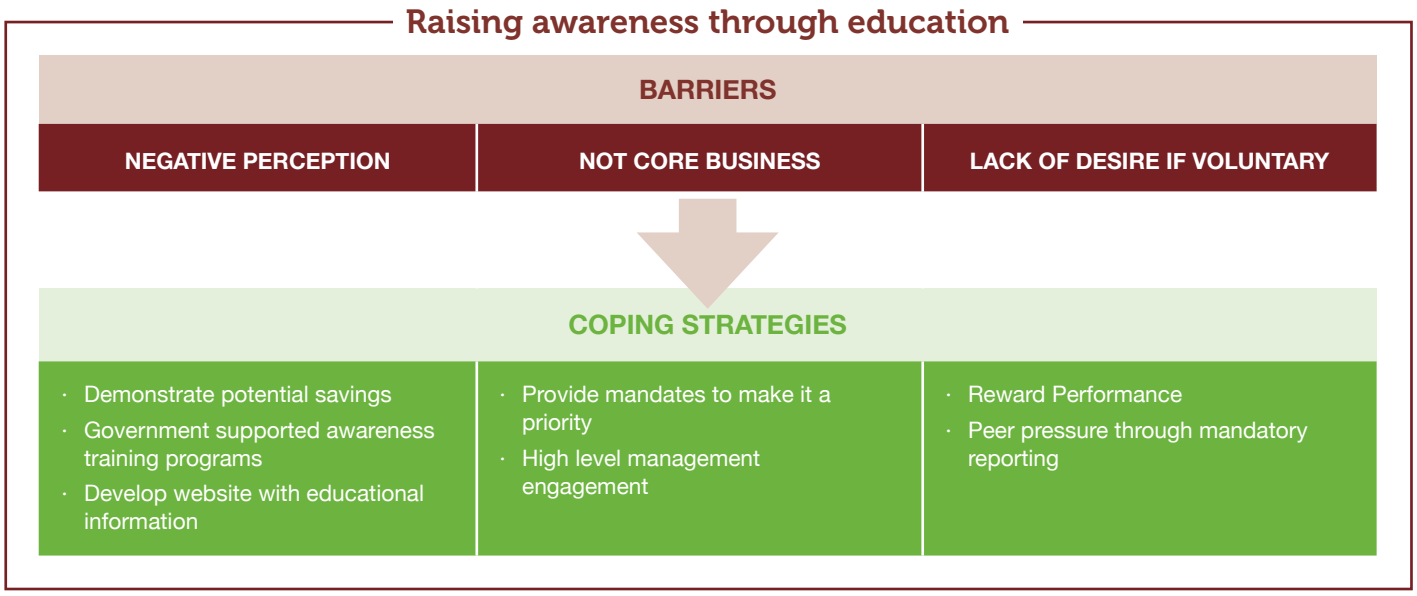


Figure 8 *Barriers and coping strategies for awareness raising educational programs*

6.4 Raising awareness through education

The identified main barriers to raising awareness through education and possible coping strategies are presented in Figure 8. A negative perception regarding the benefits of retrofitting was identified as a key barrier. Government facility managers may not fully understand the various possible retrofitting options available and the associated financial savings. The government's frequent changes in information dissemination and policy related to the energy/water efficiency priorities and targets also act as an impediment in this regard. Additionally, given that each government departments and agencies occupying a public building has a core business function, which is not building energy and water efficiency, the motivation to initiate and implement challenging retrofit projects will remain low in a policy context where such initiatives are voluntary and not mandatory.

To raise the level of awareness of water/energy retrofit opportunities and delivery methods, governments could consider the provision of training programs, dedicated information portals containing benchmarks, guidelines and case studies, as well as building assessment and procurement procedure manuals. Complementing awareness and training programs with executive leadership and well-defined and achievable mandates will ensure that viable retrofit projects are implemented. If compliance with building retrofit programs remains voluntary, the government could introduce performance rewards for those departments and agencies that have achieved savings targets. Mandatory government reporting of annual energy and water consumption for building stock with comparisons against best practice water and energy KPIs may also promote a greater diffusion of these types of projects.

6.5 Mandating energy/water efficiency targets

As shown in Figure 9, the three main barriers identified against mandating public building water/energy efficiency targets were 1) partisan government policy; 2) determining suitable targets; and 3) achieving acceptance by departments and agencies required to meet those targets. Whenever there is a change

Figure 9 *Barriers against imposing a mandate for public building water and energy efficiency targets and possible coping strategies*

in government at the State or Federal level, there are also significant shifts in sustainability-related policy, mandates and funding. Governments' willingness to take up energy and water efficiency projects is mostly influenced by 'net debt' over the forward estimate period (typically, this is four years in Australia).

It is impossible to retrofit public buildings without increasing government net debt.

The payback period of retrofitting projects is normally longer than four years and up to seven years, which means it will increase net debt over the forward estimates period. Although governments' acknowledge the long-term benefits of building efficiency retrofitting, they give higher priority to reducing the amount of net debt over the forward estimate period. As a result, building retrofitting projects are seen as a cost rather than savings. One possible solution is to limit the project payback period to less than four years; but this will restrict the scale of investment. Alternatively,

governments need to have firm determination and strong political will to impose appropriate policies and mandates to prioritise building efficiency upgrade projects.

Successful case examples demonstrating savings and short payback periods can be used to persuade governments.

Designing a workable retrofitting mandate with savings targets that is sufficiently versatile to handle a wide range of building types and categories is undoubtedly challenging and requires careful consideration, planning and committed funding before it will be accepted and successfully implemented by government facilities managers. However, any mandate must have realistic targets and implementation timeframes. As a first step, certain relatively easy retrofits that yield a predictable, rapid return of capital could be mandated. For example, installation of solar panels with maximum four years payback periods can be mandated. The available accreditation schemes can be used as a standard while setting a target. An update of the office fit-out standard accommodating the energy and water efficiency feature could also be a good way of achieving the retrofitting target in office buildings. It is important to note that any mandate set by government on its departments and agencies must be suitably resourced (i.e. funding, procurement support, guidelines, staffing, etc.) to ensure timely implementation.

Figure 10 *Barriers to establishing a skilled facilitation team for retrofit programs and possible coping strategies*

6.6 Facilitation team

Considerable cost and effort is required to establish a skilled retrofit program facilitation team. A whole of government approach is required where the central government creates the core team of project initiation and

procurement experts along with a network of dispersed energy/water efficiency champions within various departments and agencies. A second barrier is the lack of understanding about the importance and value of a facilitation team for the successful delivery of an ongoing building energy and water efficiency retrofit program. The delivery of some significant retrofit projects by the facilitation team will serve to demonstrate the value of their service. There is a possibility of having certain conflicts of interest where a person has a role within the central facilitation team and also within a department or agency. This can be overcome through a transparent internal appointment process, full-time secondment to the facilitation team and the use of contracted specialist consultants for specific periods (e.g. 3 years). The identified barriers to establishing a skilled facilitation team and possible strategies to overcome each of these are summarised in Figure 10.

7 Conclusions

The extensive review of national and international best practice retrofit programs identified five key components that are required for a successful building energy and water efficiency retrofitting project or program, namely: 1) building efficiency assessment; 2) selection of the best retrofit option(s) and risk assessment; 3) procurement methods; 4) project financing; and 5) post-retrofit measurement and verification.

Additionally, a state-of-the-art Public Building Retrofitting Guideline has been developed and the key components involved at each stage of the proposed guideline have been outlined.

The research showed that active involvement from four key stakeholders is an essential requirement for successful delivery of retrofit projects, namely: 1) the government department in charge of introducing the appropriate policies, regulations and mandates; 2) The individual government department or agency which is the owner of the building asset that require retrofitting; 3) ESCO(s); and 4) the central facilitation team.

Two successful workshops were conducted in two Australian cities to identify the barriers to implementing the retrofitting guideline and the possible coping strategies to overcoming those barriers. Integration and application of these workshop outcomes together with the outcomes of this research could help governments to develop and implement a comprehensive public building retrofitting strategy for energy and water efficiency.

8 References

[1] IEA, International Energy Outlook. 2011, International Energy Agency.

[2] ANAO, Audit Report no. 25 2008-09: Green Office Procurement and Sustainable Office Management. 2009, Australian National Audit Office, Canberra.

[3] Department of the Environment and Water Resources, Energy Efficiency in Government Operations (EEGO) Policy 2007, Australia.

[4] Alam, M., Zou, P.X.W., Sanjayan, J., Stewart, R.A., Sahin, O., Bertone, E., and Wilson, J., Guidelines for Building Energy Efficiency Retrofitting in Sustainability in Public Works, 24-28 August, 2016, Melbourne.

[5] Bertone, E., Sahin, O., Stewart, R.A., Zou, P.X.W, Alam, M., and Blair, E., State-of-the-art review revealing a roadmap for public building water and energy efficiency retrofit projects. International Journal of Sustainable Built Environment, 2016. 5(2): p. 526-548.

[6] IEA, Energy Performance Certification of Buildings: A policy tool to improve energy efficiency. 2010, International Energy Agency. p. 64.

[7] Zou, P.X.W., Alam, M., Sanjayan, J., Wilson, J., Stewart, R.A., Sahin, O., Bertone, E., Buntine, C., Blair, E., and Ellis-Jones, D., Managing risks in complex building retrofit projects for energy and water efficiency. in International Conference on Innovative Production and Construction, 29-30 September, 2016. Perth.

[8] USDE, Guidance for the Implementation and Follow-up of Identified Energy and Water Efficiency Measures in Covered Facilities. 2012, United States Department of Energy, USA

[9] Shonder, J., Morofsky, E., Schmidt, F., Morck, O., and Mervi, H., Best Practice Guidelines for Using Energy Performance Contracts To Improve Government Buildings, in IEA ECBCS Annex 46-Holistic Assessment Tool-Kit on Energy Efficient Retrofit Measures for Government Buildings. 2010, International Energy Agency.

[10] Federal Building Initiative, Energy Performance Contracting: Guide for Federal Buildings, Natural Resources Canada, Editor. 2013, Canada.

[11] Motiva Oy, IEA DSM Task 16, Competitive Energy Services, Country Report: Finland. 2009.

[12] Baechler, M. and Webster, L., A Guide to Performance Contracting with ESCOs, U.d.o. Energy, Editor. 2011, Washington, USA.

[13] GGB, Greener Government Buildings Guidelines, Department of Treasury and Finance. 2016, Victoria, Australia.

[14] GREP, NSW Government Resource Efficiency Policy, Office of Environment and Heritage, 2014, Sydney, NSW, Australia.

[15] GBE strategy, Government Buildings Energy Strategy 2013, Government of South Australia.

[16] Kilsey, J. and Pearson, D., Updated Procedures for Commercial Building Energy Audits. ASHRAE Transactions, 2011. 117, p. 374-381.

[17] FEMP, Best Practices and Lessons Learned for Federal Agency ESPC Projects. 2014, Federal Energy Management Program, Office of Energy Efficiency and Renewable Energy, USA.

[18] GGB, Greener Government Buildings Guidelines, Department of Treasury and Finance, 2011, Victoria, Australia.

[19] Greener Government Building Performance Report 2009-2012, Department of Treasury and Finance, Victoria, Australia.

[20] GREP progress report, Government Resource Efficiency Policy- whole of government progress 2014–15, O.o.E.a. Heritage, 2016, Sydney, Australia

[21] Murphy, C., Energy Smart Government - Western Australian Auditor General's Report. 2010, Perth, Australia.

[22] Energy Efficiency Council. Energy Efficiency Certification Scheme. 2013; Available from: http://www.efficiency certification.org.au/uploads/files/EECS%20Brochure.pdf.

Project Publications

The following journal articles and conference papers have been published as a result of this research:

1. Bertone, E., Sahin, O., Stewart, R.A., Zou, P., Alam, M., and Blair, E., State-of-the-art review revealing a roadmap for public building water and energy efficiency retrofit projects. International Journal of Sustainable Built Environment, 2016. 5(2): p. 526-548
2. Zou, P.X.W., Alam, M., Phung, V.M., Wagle, D., Stewart, R.A., Bertone, E., Sahin, O., and Buntine, C., Achieving energy efficiency in government buildings through mandatory policy and program enforcement. Frontiers of Engineering Management, 2017. 4(1): p. 92-103
3. Alam, M., Zou, P.X.W., Sanjayan, J., Stewart, R.A., Sahin, O., Bertone, E., and Wilson, J., Guidelines for Building Energy Efficiency Retrofitting, in Sustainability in Public Works Conference, 24-26 August 2016, Melbourne, Australia
4. Zou, P.X.W., Alam, M., Sanjayan, J., Wilson, J., Stewart, R.A., Sahin, O., Bertone, E., Buntine, C., Blair, E., and Ellis-Jones, D., Managing risks in complex building retrofit projects for energy and water efficiency in International Conference on Innovative Production and Construction, 29-30th September 2016, Perth, Australia (Keynote speaker)

A short YouTube video on the project is available on the Project Website[4].

Acronym list

RLF – Revolving Loan Fund

EPC – Energy Performance Contract

ESCO – Energy Service Company

IEA – International Energy Agency

EEGO – Energy Efficiency in Government Operation

EUF – Environmental Upgrade Finance

M&V – Measurement and Verification

GGB – Greener Government Building

GREP – Government Resource Efficiency Policy

ESG – Energy Smart Government

GBE – Government Building Energy

EEC – Energy Efficiency Council

Recommended Citation:

This report should be cited as

Zou, P. X.W., Stewart, R. A., Alam, M., Bertone, E., and Sahin, O., 2017. Retrofitting Public Building for Energy and Water Efficiency. Sustainable Built Environment National Research Centre (SBEnrc), Melbourne, Brisbane and Perth, Australia.

[4] http://www.sbenrc.com.au/research-programs/1-43-retrofitting-public-buildings-for-energy-and-water-efficiency/

Sustainable Built Environment National Research Centre

This research would not have been possible without the ongoing support of our core industry, government and research partners:

For further information:

Professor Patrick Zou Department of Civil and Construction Engineering & Centre for Sustainable Infrastructure, Swinburne University of Technology, VIC, Australia
pwzou@swin.edu.au

Professor Rodney Stewart, Griffith School of Engineering, Griffith University, QLD, Australia.
r.stewart@griffith.edu.au

Dr Keith Hampson, Chief Executive Officer
Sustainable Built Environment National Research Centre (SBEnrc), Australia
k.hampson@sbenrc.com.au

www.sbenrc.com.au
April 2017