City of Karratha

City of Karratha Energy Efficiency Action Plan 2017-2022

Peer Reviewed by:

PERDAMAN ADVANCED ENERGY

(Previously Enigin WA)

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1 Introduction

The aim of this energy efficiency action plan is to set an outline for the City of Karratha (the City) to meet its vision below:

"For the City to utilise innovative, best practice energy saving initiatives and policies that ensure the ongoing provision of an environmentally sustainable, reliable and affordable energy source for generations to come."

With electricity prices increasing and the transition from carbon-based energy to renewables occurring around the country, the City's aim is to reduce energy consumption and take hold of clean energy opportunities.

The provision of strategies and actions within this plan have been devised to achieve the following overarching objectives:

- Develop policies that reduce the City's overall energy consumption and related operational costs based on clear measurable targets.
- Reduce the City's greenhouse gas emissions through effective energy management, improved energy efficiency and increased use of renewable energy sources.
- Interpret principles of environmental sustainability into design and construction of City owned buildings.
- Encourage and support the community to reduce their emissions through education and behaviour change programs.
- Establish a process to monitor City energy consumption and report annually to Council in regards to this consumption.

Figure 1 Process followed to develop Energy Action Plan

The process shown in Figure 1 has been followed to develop the Energy Efficiency Action Plan. Further details regarding the process are set out below:

- Current electricity use has been determined and recorded through an audit across all City facilities;
- High electricity use facilities have been identified as targets for energy efficient management actions;
- Electricity consumption for each high consuming site in the 2015/16 Financial Year has been used as benchmarks for future monitoring and assessment; and
- An action plan has been developed. The action plan includes an implementation schedule, assigns responsibility, and estimates cost and payback periods.

2 Current City of Karratha's Energy Use

The City of Karratha spent approximately $3.2 million on electricity use in the 2015/2016 financial year. Figure 2 details the highest energy consumers and carbon emitters of the 2015/2016 FY. Sites that aren't labelled contribute less than 1% each to the City's overall energy usage. This graphic clearly shows the largest electricity users. These users should be prioritised for energy saving initiatives.

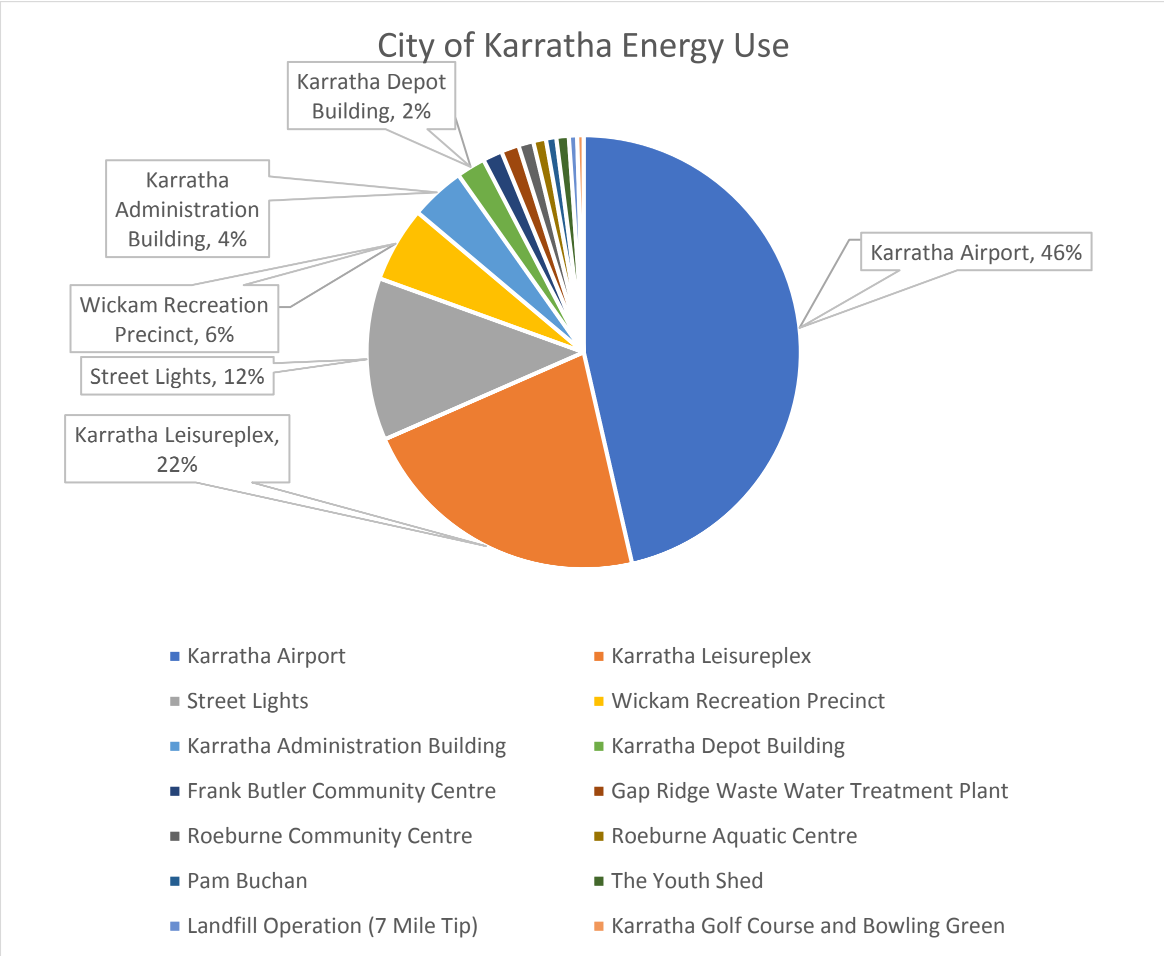


Figure 2 Percentage of Electricity and Carbon Emissions at the City's sites

The recent introduction of a solar farm at the City's Airport will see an approximate saving of $89,136 annually on electricity costs, which equates to the removal of 22.2 tonnes of carbon from the atmosphere (equivalent to removing approximately five cars off the road for a year).

Aside from the high-energy use sites, the City also spent an additional $110,000 in the 2015/2016 FY (see narrow slices of the pie chart) on the provision of electricity to essential services such as parks and gardens, Effluent Reuse Watering System Pumping Station maintenance, libraries, community buildings, oval maintenance and Cossack. This electricity use resulted in the release of approximately 28 tonnes of carbon into the atmosphere. Figure 3 depicts the additional areas of electricity use in the City.

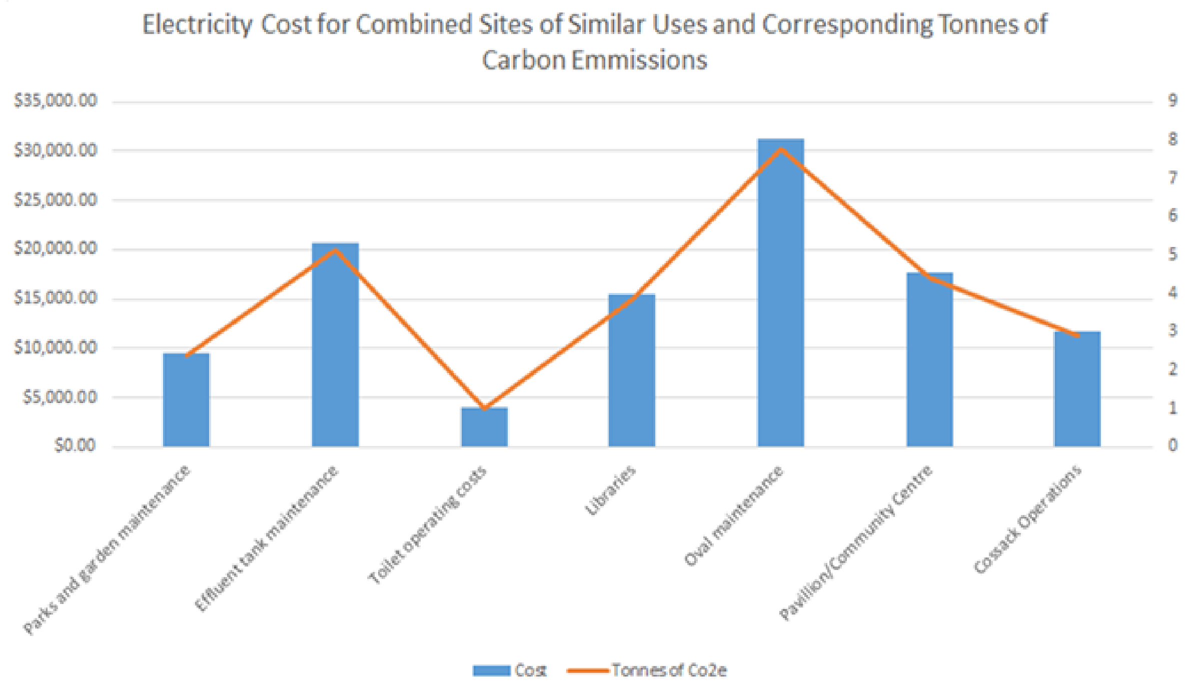


Figure 3 Additional Areas of Electricity Use

2.1 Current Energy efficiency initiatives

2.1.1 Solar Powered Pedestrian Lighting

The City is currently installing 32 solar powered street lights along two prominent pedestrian routes. These street lights use LED lighting as opposed to the far less efficient Mercury Vapour, and operate on solar powered energy. Mercury Vapour lights have been banned in the US and are being phased out in Europe due to their poor energy efficiency and safety issues in regards to the mercury content.

The comparative cost and payback period for these LED street lights is detailed in Table 1 below, indicating that installing LED street lights instead of Mercury Vapour lights will result in a savings of $49,000 annually and a payback period of less than 3 years in simple payback terms. This also equates to the removal from the atmosphere of 16 tonnes of GHG's annually.

Street Lamp	Cost of Installation	Annual Cost of Electricity	Payback Period
LED Luminaires (Solar Powered) x 32	$139,200	Nil	Approx. 3 years
Mains Powered (Mercury vapour) x 32	$143,475 (including trenching and cabling)	$49,223 (608 kWh per lamp per year on average)	Nil

Table 1 LED Street Light Installation Costs and Payback Period

Figure 4 Example of Solar Powered Street Lights

2.1.2 The Karratha Airport Solar Farm

The Karratha Airport Solar Farm as displayed in Figure 5 is a 1MW solar PV facility with Cloud Predicative Technology. This facility is designed to produce 1824MWh of energy a year, approximately one third of the airport's current energy needs. In addition, the infrastructure will reduce carbon emissions (CO2-e) by 1,200 tonnes annually, the equivalent of taking 260 cars of the road.

Figure 5 Karratha Airport Solar Farm

The Cloud Predictive Technology (CPT) reduces the level of energy storage required. Cloudy conditions can lead to a sudden drop in solar energy generation rate. Commercial solar power generation usually has costly storage requirements to 'smooth out' supply of a varying solar energy generation rate into the grid. Employing CPT reduces the need for this smoothing out, meaning large scale solar PV systems can be installed and operated at lower cost.

2.1.3 Solar PV system at the Youth Shed

The Youth Shed is an indoor play centre, which is open seven days a week. This centre requires the ongoing use of air-conditioning to keep ambient temperatures at a level required for indoor play. As a result, the building is one of the highest electricity consumers, with $30,000 spent in the 2015 financial year. The play centre has a 12kw array of solar panels, which offsets approximately 544kWh/day, 1606kWh per month, which equates to $5,760 in electricity savings annually based on the current tariffs.

Figure 6 Photo of the Youth Shed

2.1.4 Future PV systems for the City.

The City is installing a 15kw array in the new Wickham Community Hub building. This will provide 24,090 kWh of power to the building annually. In addition, the City is currently investigating the feasibility of installing a PV system with battery storage for the refurbishment of the City's Depot building. This system will potentially provide up to 80% of the City's electricity needs.

2.1.5 Waste to energy

The City in 2015 signed an agreement with waste to energy company New Energy to divert up to 60,000 tonnes of waste from landfill. Under this agreement, approximately 90% of all residential waste will be diverted to New Energy processing plants to be converted into energy. Energy supplied by the New Energy via this waste to energy process will reduce the City's carbon footprint by 84,000 t (CO^2), equivalent to taking 380 cars off the road for a year. A materials recovery facility will be in operation at the Seven Mile waste facility to separate any recyclable material.

2.1.6 Initiatives in the Pilbara region

The Pilbara Development Commission has an objective to diversify energy sources in the Pilbara into more sustainable and renewable energy sources by 2050 (Pilbara Development Commison, 2016). The Kimberley Development Commission has completed a study highlighting the opportunities for renewable energy in the region (Kimberley Development Commission , 2013). The Pilbara State of the Environment Report encourages the installation of energy efficient fittings in public buildings and the installation of solar PV panels (Regional Development Australia Pilbara, 2013).

3 Future City of Karratha Energy Use

The overarching objective of the EEAP is to achieve an overall reduction in energy consumption from the 2015/16 FY benchmarks of key community assets.

The City can achieve this objective and more by completing the initiatives set out in the action plan. The largest potential energy saving initiatives are listed below:

1. Installing solar on high use buildings, resulting in potential energy savings of 25%-35%, dependant on the size of the system installed in relation to the energy used at each facility (Perdaman Advanced Energy, 2015).
2. LED lighting upgrade, with potential energy savings from 15%-25% (Perdaman Advanced Energy, 2015).
3. Undertaking energy audits and acting on recommendations.
4. HVAC optimisation at sites where appropriate. Potential energy savings of 5-15% (Perdaman Advanced Energy, 2015).
5. Retrofit of streetlights to LED through discussion with Horizon.
6. Continue the installation of solar lighting for City owned pedestrian lights.

4 Recommendations

The priority for the City is to improve energy management across all of its operations. The key areas are:

- Infrastructure and Assets;
- Street Lighting;
- Parks and Gardens;
- Corporate Governance; and
- Community Education.

Proposed actions for each area have been detailed in the sections below. With all the below recommendations, the largest consuming sites will be targeted first.

With all recommendations and actions outlined below, a pre-project feasibility study will be undertaken first to ensure viability. There is a need to look at whole of life costs of infrastructure based on hot and cyclonic Pilbara conditions.

4.1 Infrastructure and Assets

4.1.1 Energy Audits on High Consuming buildings and Screening of Actions

An energy audit is an inspection, survey and analysis to find energy efficiency savings of a particular building. Descriptions of what each level of audit includes is detailed in Appendix A – Glossary of Energy Efficiency Options. The City has initiated energy audits to be carried out on the Karratha Administration Building, Wickham Recreation Precinct and Karratha Airport. Further auditing of other buildings should only be executed if the energy use of the building is large enough to produce enough return on investments from energy saving opportunities.

There are knowledge gaps which need to be addressed prior to determining the level of audit required, primarily obtaining information regarding:

- The half-hourly electricity interval data for each site.
- The building structure and system.
- The needs and requirements of the occupants.

- The most passive ways to reduce power loads such as; reducing lighting, optimising, equipment controls and increasing insulation.
- The cost of potential retrofitting or installation of infrastructure based on payback periods and lifecycle costs.

Action 1 Energy Audits

High consuming sites to be investigated in context of site parameters and building use to determine the need for an energy audit and the level of auditing required.

Energy conservation measures that may have been identified through the audit process should be screened to determine feasibility of implementation. Figure 7 below highlights how each action should be assessed in light of: building capability and use; technical feasibility; cost effectiveness; and the overall energy savings potential. The result will be a final package of measures for each audited site.

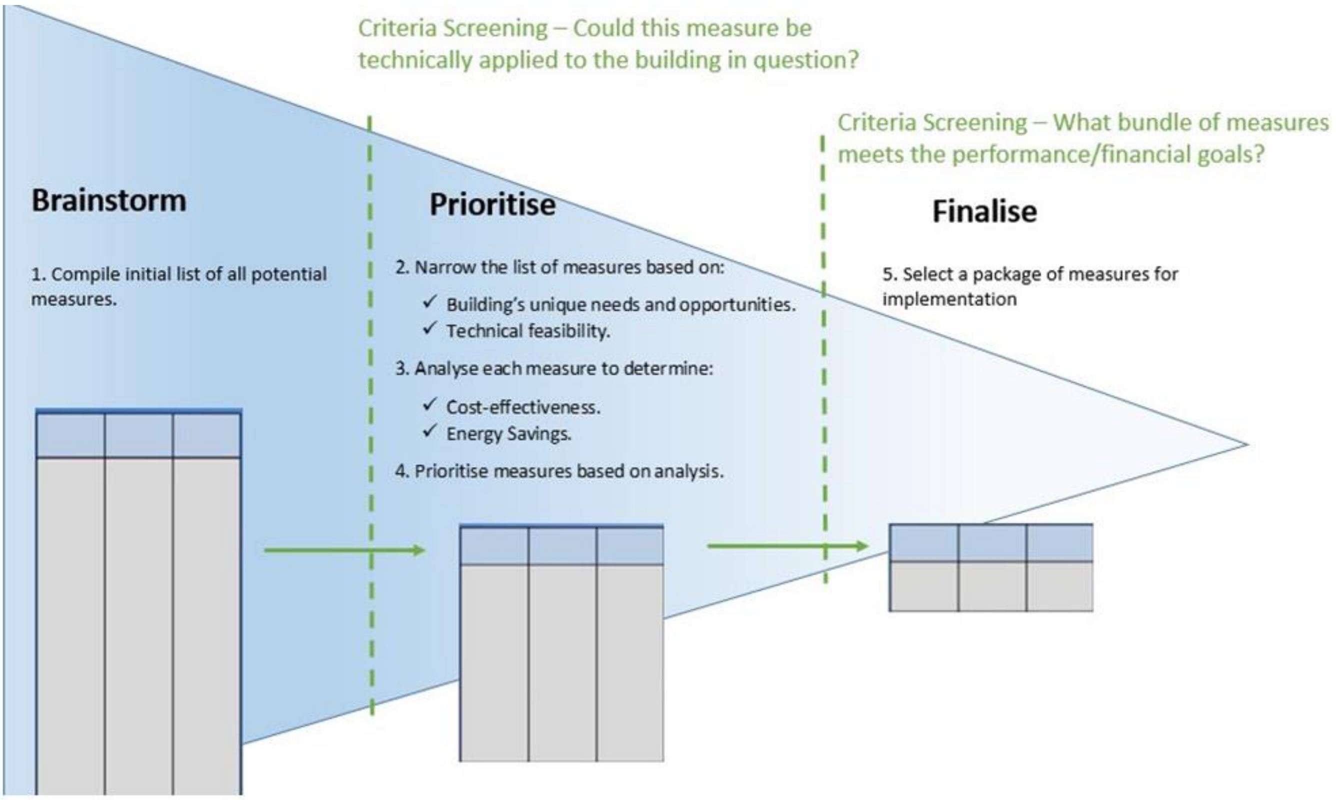


Figure 7 Screening of actions from Energy Audit

Action 2: Work Packages from Energy Audits

Use screening criteria to determine priority actions identified in energy audits.

4.1.2 Lighting

An energy efficiency overview study carried out for the City detailed the potential cost savings the City could achieve should all inefficient lights be retrofitted with LEDs. The savings are depicted in Table 2. A detailed description of lighting efficiency strategies can be found in Appendix B – Lighting Efficiency Strategies. As stated in Appendix B, LEDs are the most efficient lighting technology as they have more effective light dispersion technology which extends their life. It is important, however, to consider individual site constraints when choosing a lighting type for retrofitting. LED lights in buildings are not always effective where roof space areas reach high temperatures. In this case, the life span on the LED power transformer can reduce dramatically, making the whole of life cost higher than low power fluorescent lights.

There are knowledge gaps which need to be addressed before starting a lighting regime:

- The current insulation of roof spaces to guard against extreme temperature fluctuations.
- The required lighting (lux) levels for the site and application.
- The time of use of the lights to be replaced.
- Electricity tariff, luminaire costs and commercial business case for each site.

Indicative Savings Potential Relative to Site		*Lower Estimate*	*Upper Estimate*
Annual Savings	% Electricity savings	10%	25%
	Cost savings	$4,000	$300,000
Capital Cost		$10,000	$1,000,000
Simple Payback Period		1.5 years	4 years
▪ Potentially applicable to all sites			

Table 2 Potential Savings from Retrofitting with LED lights.

Action 3: Initiate low cost and easy to initiate lighting strategies.

E.g. voluntary switch off campaign and de-lamping.

Action 4: Retrofit inefficient lighting

Investigate appropriate lighting types including LED's and Compact

4.1.3 Real time Energy Monitoring Smart Metering

Real time energy monitoring using real-time smart meters such as those in Figure 8 would allow the City to access instant, accurate and detailed information on electricity use and allow for more detailed consideration on how to proactively and practically reduce energy use. The City's involvement in home smart metering for residents would be limited to advocating and supporting their use.

Figure 8 Example of a smart meter dashboard

The proposed electricity savings that could be gained from the installation of smart meters and real time monitoring systems is detailed in the Table 3 below. These estimates are based on previous experience where there have been 5-10% in cost savings. There are knowledge gaps which need to be addressed before installing real time smart meters:

- The electrical boards that require monitoring and their layout.
- The access to network infrastructure at each site; required for real-time energy monitoring systems.

Indicative Savings Potential Relative to Site		Lower Estimate	Upper Estimate
Annual Savings	% Electricity savings	5%	10%
	Cost savings	$2,000	$130,000
Capital Cost		$1,000	$100,000
Simple Payback Period		3 months	3 years
▪ Potentially applicable to: 1. Karratha Airport; 2. Karratha Leisureplex; 3. Karratha Admin Building;			

4. Depot; 5. Frank Butler Community Centre; 6. Roebourne Community Centre; 7. The Youth Shed

Table 3 Potential Savings from installation of Smart Meters

Action 5: Installation of Smart meters

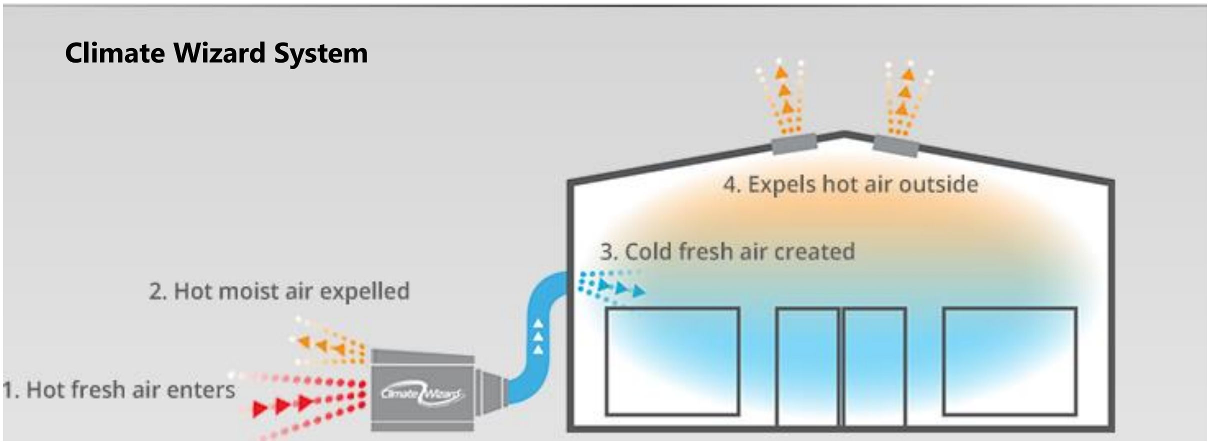
Sites in Table 3 should be prioritized first.

Smart meters are becoming more prolific around Australia and are one of the first steps in reducing on-site energy consumption at a site. It is strongly recommended that real-time monitoring systems be installed.

4.1.4 HVAC (Heating, Ventilation, Air-conditioning) Optimisation and Installation in New Buildings

HVAC systems can account for up to 60% of a buildings electricity use. HVAC optimisation should only be considered after other energy efficiency options have been established as these can impact on the function of the HVAC system (e.g. heating from lights). The efficiency of HVAC systems can be optimised by expanding the systems' allowable ranges for indoor temperature and humidity or 'dead band'. HVAC systems are often designed conservatively using default occupancy values. By adjusting ventilation based on actual occupancy, values can sometimes reduce the amount of outside air by over 30%, saving energy and reducing the size of the system required. Facilities in which proper HVAC maintenance is completed will use at least 15 to 20 percent less energy than those where systems are allowed to deteriorate. Air-Conditioning Energy Savers (ACERS) can be applied to HVAC systems that will switch off compressors when 'thermodynamic saturation' is reached. It is estimated that using ACER's can reduce the energy consumption of a unit by 30%.

The final stage in HVAC optimisation is to replace aged and inefficient systems. This can be costly and needs to be undertaken through review of a building's HVAC requirements and the most energy efficient technology available. For new buildings, such as the development of the new Depot building, the City is considering the installation of 'Climate Wizard" air-conditioning units. These systems operate by removing humid air prior to it entering the air-conditioning unit (see below). This greatly reduces the energy required to provide cold air to a building.



Potential savings range of between $3,000 (Work Depot) and $200,000 (Karratha Airport) should the City undertake the required HVAC optimisation programs depicted in Table 4. Knowledge gaps which need to be addressed before commissioning HVAC Optimisation are detailed in the action box.

Indicative Savings Potential Relative to Site		Lower Estimate	Upper Estimate
Annual Savings	% Electricity savings	5%	10%
	Cost savings	$3,000	$130,000
Capital Cost		$1,500	$100,000
Simple Payback Period		6 months	3 years
▪ Only suitable for sites with significant heating and/or cooling requirements. Potentially applicable to: 1. Karratha Airport; 2. Karratha Leisureplex; 3. Karratha Admin Building; 4. Depot			

Table 4 Potential savings from HVAC optimisation

Action 6: HVAC Optimisation and replacement

Determine for each of the City's HVAC systems:

- The most acceptable 'dead band zone' ranges.
- The ventilation requirements based on building occupancy.
- The maintenance regime required.
- The need for installation of ACERS.
- Possible replacement program (consider 'Climate Wizard' units.

N.B. these steps can possibly be undertaken by professional HVAC repair company.

4.2 Renewable Energy Solutions

The benefits of investing in renewable energies are many, and include:

- Reduced electricity bills.
- Provision of a buffer to the impact of electricity price increases.
- Possible provision of revenue from the sale of surplus energy.
- Can be implemented relatively quickly.
- Provides a long-term, accumulative Greenhouse Gas reduction for the life of an asset.
- Reduces peak energy demand.
- Has been linked to increased awareness of energy use and behaviour change in the wider community.

Details of renewable energy solutions are detailed in Appendix A – Glossary of Energy Efficiency Options.

Currently the Federal Government provide funding for renewable energy projects using Renewable Energy Certificates (RECs). The City of Karratha has the potential to produce RECs through the purchase of solar PV, wind, hydro, solar water heater and heat pump systems. For solar PV projects the number of certificates acquired depends on the size the Solar PV system and the number of panels. Knowledge gaps which need to be addressed before investigating the potential RECs available at each site are:

- Half-hourly interval data for each applicable site (data for some, but not all sites, exists).
- Size of the renewable energy systems to be installed.

Action 7: Investigate potential RECs available at each site

4.2.1 Potential installation of Solar PV Systems to Supplement Power Use at High Consuming Sites

The City recently commissioned an electrical supply analysis study which recommended the potential array sizes for each site. The recommended PV cell number, cost of installation (based on WA prices), cost savings and payback period are listed in Table 5.

Should the City install all proposed PV arrays across the identified buildings, there is the potential for savings of $368,473 in the first year of installation. These installations should progress as soon as possible. If this energy saving measure is adopted by Council an implementation schedule should be built into the City's Long Term Financial Plan. The proposed configuration of PV cells for the City's Administration Building is detailed in Figure 9.

Figure 9 Potential Array of PV Cells for the Administration Building

It is important to note that previous experience in the use of roof mounted PV panels in the Pilbara have resulted in some operating issues. This includes excessive summer temperatures and lack of air circulation resulting in a drop in power generation efficiency. Also, with low rainfall cleaning of PV systems on rooves and a high calcium content of the Pilbara water, cleaning of the cells can be costly and reduce PV power generating efficiency. The other issue is the creation of structural integrity issues with both PV panels and building roof systems. Adding extra penetrations to roof areas to connect PV systems adds potential storm water leak areas. Where land is available, PV systems at ground levels could be a preferred alternative.

Table five details recommendations using simple payback periods, however; more detailed cost/benefit studies are required. The example of the proposed PV array size at the Depot reflects the results of a more detailed feasibility study.

City Site	Proposed PV Array Size	Approx. Cost of Installation	Approximate Annual Cost Savings	Payback Period (approx.)
Karratha Leisureplex	2,200 panels (550 kW_p)	$715,381	$254,000	2.82 years
Karratha Administration Building	320 panels (80 kW_p)	$105,113	$45,600	2.3 years
The City Depot	300 panels (85 kW_p)	$315,000	$35,000	9 years

The Frank Butler Community Centre	160 panels (40 kW$_p$)	$50,942	$14,891	3.4 years
The Roebourne Community Centre	160 panels (40 kW$_p$)	$50,942	$12,197	4.2 years
The Youth Shed (currently has a small array, proposed upgrade)	80 panels (20 kW$_p$)	$28,310	$8,296	3.4 years
The Pam Buchanan Centre	100 panels (25 kW$_p$)	$35,387	$8,671	4.1 years

Table 5 Proposed Solar PV Systems, Installation Costs and Payback Period

Any additional site constraints need to be considered prior to installation of PV cells. For example, the roof of the Leisureplex has been constructed to achieve the highest cyclone rated safety standard. The installation of PV cells must be completed with this in mind and the installers will be required to obtain structural engineering sign-off on the cyclone rating of all equipment.

The figures in Table 5 indicate a less than five-year payback period in order to cover the cost of installation for each of the sites.

Action 8: Solar PV Business Cases

Use cost benefit analysis to determine those high consuming sites that may lend themselves to City purchased and managed PV systems. Determine an associated implementation program.

The Pilbara averages 11 hours of sunlight a day with some of the highest levels of solar irradiation on the planet. In the Pilbara region, solar PV power is being adopted by other local councils. An example is the Shire of East Pilbara, which has installed 120kW at the Newman airport and 78kW over 14 of the Shire's sites.

4.2.2 Other potential renewable Energy Systems

Wind

The City's vast geographical area and excellent wind resources present the opportunity to explore the possibility of a wind farm. Wind farms are generally only cost effective on large utility scale projects which is beyond the scope of works for the City of Karratha. Instead, there is the capacity for the City to take a facilitating role similar to the Power Purchasing Agreement for the solar farm at the City's airport.

Action 9a: Individual Wind Turbines at each site

Action 9b: Funding options for Wind Farms

Investigate wind farm options through economic development, ARENA federal govt. grant program and clean energy finance corporation.

Hydrogen

Producing hydrogen is not within the City's core scope of work however regionally there are plans to produce hydrogen as an exportable commodity. The Pilbara Development Commission in its 2050 Investment Blueprint (Pilbara Development Commission, 2015) seeks to have diversified sources of sustainable energy, including hydrogen.

The Pilbara Development Commission has initiated studies into the feasibility of producing hydrogen through a combination of seawater and the use of solar PV, with the aim of exporting hydrogen to the emerging hydrogen economy in Japan. A pilot project on Yara's Burrup Peninsula site is in the design stage. It is estimated that this pilot project would generate 2500kW of solar power to produce more than 200kg/day of renewable hydrogen through electrolysis of water. Plans are to use this hydrogen energy for ammonia production (Pilbara Newspaper, 2017). At this point in time, hydrogen generation and use is not part of the City's action plan.

Geothermal

For the City of Karratha, where electricity is mainly used for cooling not heating, geothermal is less of an option. Geothermal as a means to generate electricity requires the identification of 'hotspots' close to the surface (which are not abundant in Australia). Finding the right locations to tap into geothermal energy can be an expensive exercise. At this point in time, geothermal cooling is not part of the City's action plan.

Wave / Tidal Power

A study carried out on the renewable energy opportunities in the Pilbara (Evans & Peck, 2011) cited that wave resources in the Pilbara are poor. Effective utilisation of tidal amplitude opposed to current requires a tidal range of greater than 4m which the Pilbara does not maintain (Evans & Peck, 2011). At this point in time, wave and tidal power generation is not part of the City's action plan.

Biomass/Biofuels

Outside of waste to energy, it is out of scope for the City of Karratha to utilise biomass as an energy resource. In the Pilbara region, there have been initiatives into utilising biomass. At the Woodie Woodie mines, crops have been grown using surplus water from the mining process and these crops can be converted into gas energy or biofuel. The 2050 Pilbara Regional Investment Blueprint (Pilbara Development Commission, 2015) marked algae and crop based biofuels as key industries for diversification. The City may readdress Biomass as a plausible means of energy production should there be in excess of 20,000 tonnes of organic waste disposed of in the region per year.

4.3 Energy Efficient Building Design

A key objective from the Pilbara State of Environment Report is to improve efficiency of energy use by using energy efficient fittings (Regional Development Australia Pilbara, 2013). Typically, approximately 40% of a building's energy use is for heating and cooling, therefore there are many opportunities for energy savings through energy efficient building design. A detailed review of energy efficient building design can be found in Appendix C – Energy Efficient Building Design and from this review the following actions are recommended in Table 6:

Table 6 Energy Efficient Building Design Actions

Action Number	Action	Comments
10	Energy Efficient Design for Cooling For all new builds determine the proposed energy efficiency design for cooling: • Free Running • Conditioned • Hybrid	As the City of Karratha is located in a hot humid Summer warm winter climate zone, efficient design is critical compared to other climate zones in Australia.

11	Solar Orientation Design of new builds to consider correct solar orientation of developable area.	In Karratha, where there are no winter heating requirements, the aim is to orientate buildings to exclude direct sunlight and radiant heat from other structures.
12	Insulation Requirements Review the insulation requirements of current City buildings and retrofit accordingly.	Correct insulation can reduce electricity consumption by up to 40% according to the Office of Energy (Western Australia)
13	Shading Requirements Ensure that new builds incorporate the shading requirements of hot humid climates, including: • Correctly positioned landscaping, • Covered outdoor areas, and • Eaves surrounding entire buildings, with eave widths of 50% of building height. • Design eave widths and heights based on summer sun azimuth from 9am to 6pm.	Shading of walls is essential to reduce heating of the building. Unshaded glass can allow 86% of summer heat into a building while shaded glass will only allow 25% (City of Fremantle, 2017).
14	Window Treatments Ensure that all City buildings (new and existing) have appropriate window treatment to reduce SHGC factors. Use sash windows that create flow through ventilation.	Window treatments are important because 79-86% of heat is gained through the windows of a building.
15	Thermal Energy Analysis A Thermal Energy Analysis to be undertaken on all designs of significant City buildings.	Thermal analysis considers the above building design elements and is a comprehensive method of finding energy saving opportunities.

The Building Code of Australia requires that all new dwellings and alternations to dwellings comply with the energy efficiency provision of the building code of Australia relative to the particular climate zone.

4.4 Street lighting

Expenditure on electricity for streetlights is the third highest contributor to the City's electricity costs. In Western Australia, street lighting is the largest source of greenhouse gases (GHG's) from local governments, accounting for 30-60% of their GHG emissions. Of the approximate 2.3 million street lighting lamps in WA, around 67% are found on local roads.

There are a wide range of lighting types available for street lamps. It is important to identify the most widely used lamps within a given area to determine the need for replacement programs based on environmental and cost implications. Figure 10 and Figure 11 depict the composition of lamp types in Australia and Karratha respectively. It is evident that Mercury Vapour is still a widely-used lamp type across the country.

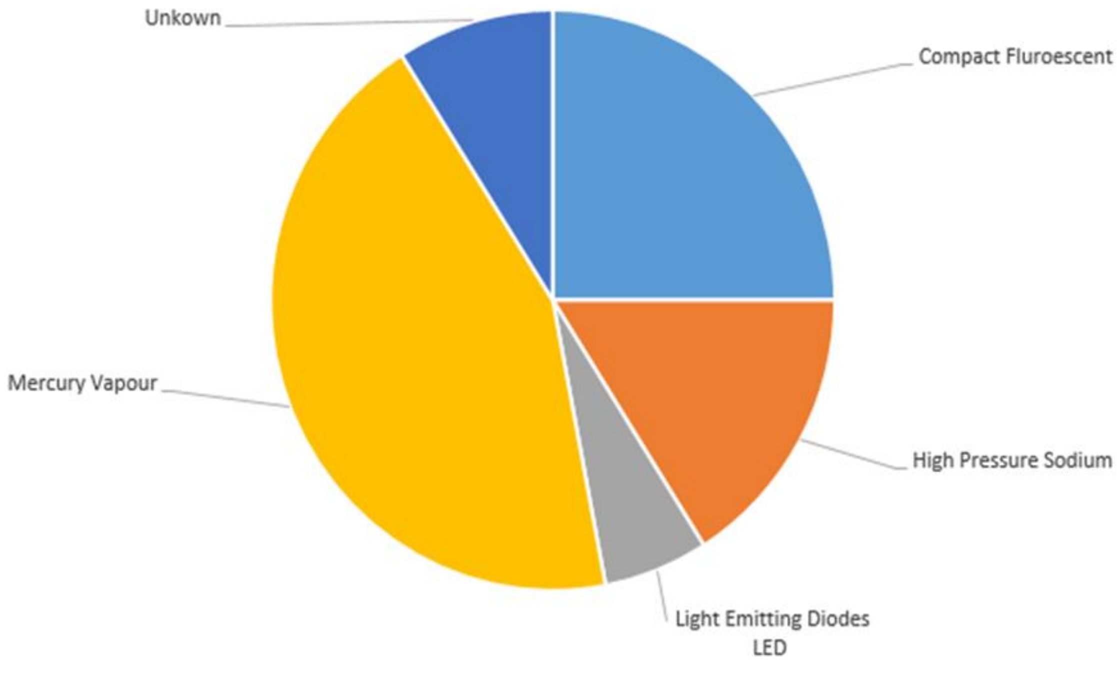


Figure 10 Percentage of Street Lamp Types in Australia in 2011

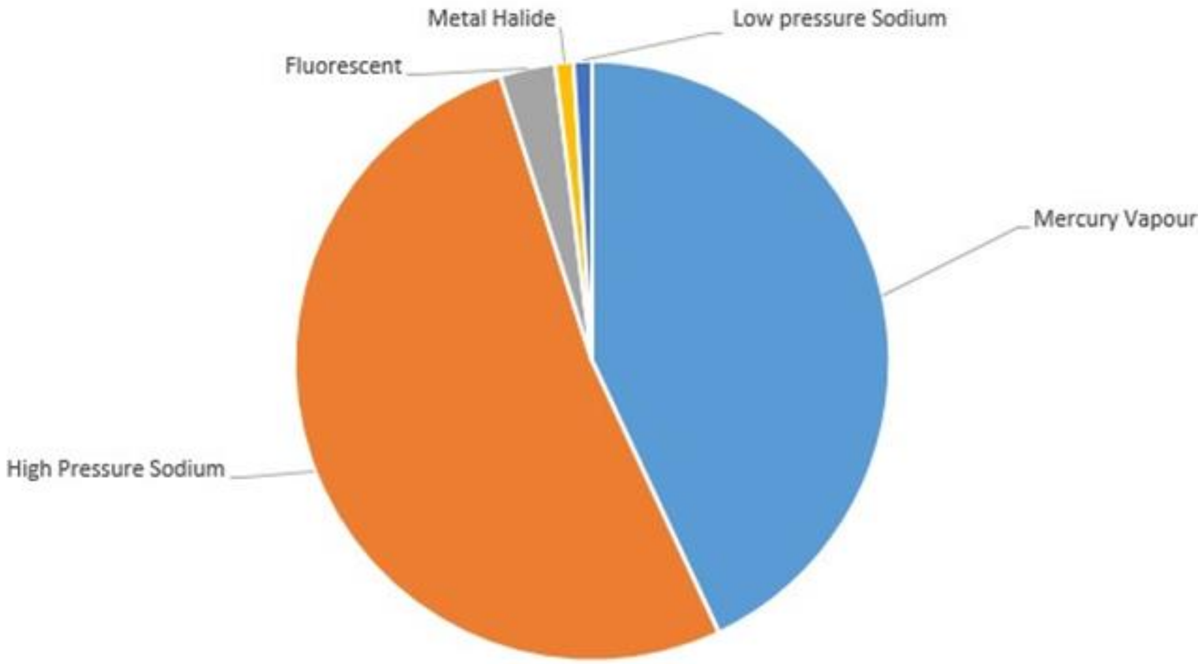


Figure 11 Percentage of Street Lamp Types in Karratha in 2016

One of the predominant street light used by the City of Karratha are mercury vapour lights. They produce five times less lumens per watt compared to LED lights. More details on lights that can replace Mercury Vapour lamps is provided in Appendix D – Mercury Vapour Lamp Replacements. As Horizon Power own the street lights, negotiations need to take place with Horizon Power to have the lights replaced with more efficient lights.

Horizon Power has facilitated a street light retrofit for the Goldfields Voluntary Regional Organisation of Councils (GVROC). Horizon helped to facilitate the replacement of 506 LEDS across four shires. The retrofit of the street lights resulted in an energy reduction of 56% (GVROC, 2015). The replacement of these lights will result in receiving a lower tariff rate for operation of the lights from Horizon Power.

Action 16: Replacement of Street Lights

The City will enter into discussions with Horizon Power as to replacement programs and street lighting designs that promote energy efficiency.

Investigate GVROC lighting programme as a model for negotiations with Horizon power.

4.5 Parks and Gardens

Over $60,000 was spent on electricity attributed to parks and gardens, ovals maintenance, ablutions and ERS irrigation pump stations in the 2015/2016 FY. Energy savings of between 30% and 50% could be realised through equipment or control system changes (Sustainability Victoria, 2009). An initial irrigation assessment is a good first step in understanding potential savings opportunities in an existing irrigation system set-up.

4.5.1 Smart Metering and Automation Controls

For new irrigation systems, technologies such as sensor networks, smart metering, automation controls and variable speed drives on pump motors should be considered. The City of Karratha use a SCADA control centre for the Effluent Reuse pumping station, which allows for the remote allocation and accurate distribution of water to different sites. Reducing unnecessary water use reduces pumping requirements, thereby reducing electricity used to distribute the water.

4.5.2 Variable speed drives on Pump Motors

Traditional pump motors have two speeds: on and off. To achieve maximum efficiency, a higher level of precision is useful. Variable speed drives (VSDs) provide a variety of speeds so that pumps can run at the optimal rate for the amount of water they are moving. The installation of VSDs on pumps is an important energy-saving measure, as lowering the speed of a motor by just 20 percent can produce an energy saving of up to 50 percent.

4.5.3 Correctly Sized and Solar Powered Pumps

Oversized pumps use far more energy than is necessary, while undersized pumps cannot always provide the volume of water needed. An irrigation engineer can help determine the proper pump size and irrigation system layout to ensure energy efficiency. During the investigation of VSD implementation, the city should consider replacing oversized pumps for with smaller pumps suited to the operation at the site. There may be an opportunity to integrate irrigation systems with solar power generators or PV cell arrays. The time-critical nature of irrigation and high power requirements of irrigation systems generally limits the potential of solar; however, hybrid solutions can be cost-effective in some situations.

Action 17: Ensure Energy Efficiency is Programed Through all Parks and Gardens Operations

- Check suitability of VSD Pump motors for irrigation systems based on flow rates and pump application
- Continue irrigation audits of current irrigation systems.
- Engage an irrigation engineer to ensure pump size, pump design and irrigation systems are correct for each irrigation area.

4.6 Corporate Governance

The City of Karratha has systems and procedural arrangements that ensure that all procurement decisions made are transparent and unbiased. Current procurement guidelines focus on the procurement process, value for money, effective use of resources, accountability, and fit for purpose, with limited consideration of environment and sustainability factors in the criteria used to assess suppliers.

There is an opportunity for the incorporation of environment and sustainability considerations into purchasing decisions. All procurement has some level of impact on the environment; many impacts occur before a good or service is purchased. This includes resource extraction, design, manufacturing, transportation and storage. There are also implications on electricity consumption in the use and ultimate disposal of the product (see Figure 12).

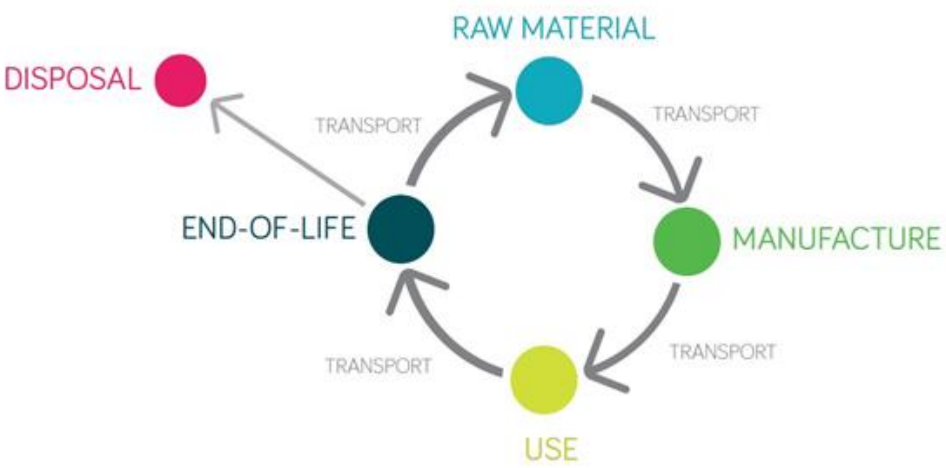


Figure 12 Lifecycle of goods and services

A procurement policy that considers electricity use at all lifecycle stages, would be beneficial for ensuring that energy consumption is fully considered for all City purchasing decisions.

A purchasing policy that has regard for energy efficiency would include the following:

- Government guidelines and energy standards such as the national Equipment Energy Efficiency (E3) Program, which uses the Energy Rating Label for all electrical appliances.
- Product specifications.
- The supplier's commitment to energy efficiency in their operations.

Implementation of such a procurement policy may include a price preference for those goods and services that display reduced energy consumption. For example, the City of Fremantle have a 10% cost weighting for green products.

The City as a large procurer can also influence the supply market of energy efficient goods and services through a well-established procurement policy.

Action 18: Energy Efficiency Procurement Policy
Expand the considerations of energy efficiency purchasing in City policy *3.6 Sustainable Procurement*

Sustainable procurement commitments need to be underpinned by a culture of minimal waste within the organisation.

For those that make substantial procurement decisions the following knowledge gaps should be considered prior to purchase:

- Is the product needed or is there an alternative solution?
- Is the product recycled and recyclable?
- Is the product energy efficient or is there an alternative product that is?
- How far has the product had to travel?
- How much packaging does the product come in? Can it be recycled, reused or returned to the supplier?

Figure 13 details the procurement to waste hierarchy. This indicates that the amount of product entering the 'end of life '(disposal) section can be significantly reduced with good decision making in the initial procurement phase.

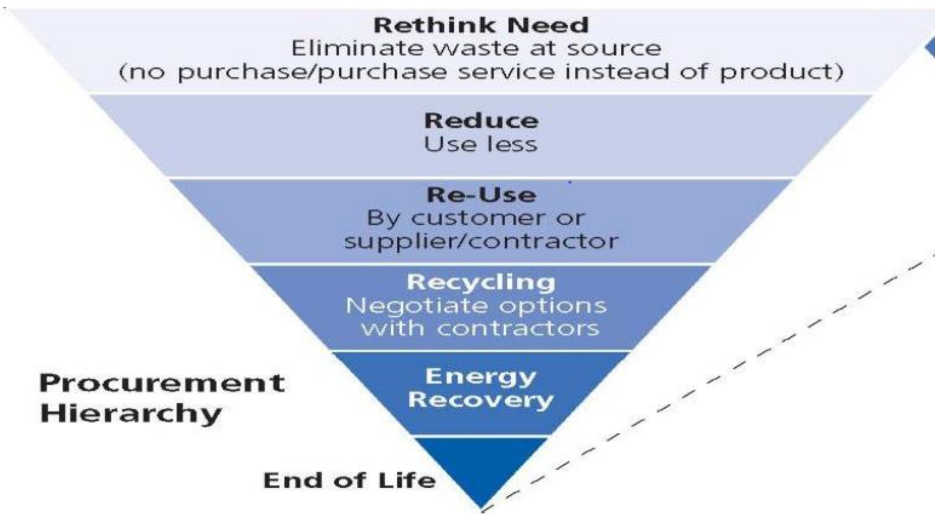


Figure 13 Procurement Hierarchy

It is also important to purchase goods that are energy efficient through their operation

> **Action 19: Promotion of minimal waste culture**
>
> Promotion of a minimal waste culture in the organisation through education and effective decision making.

4.7 Staff Engagement

Staff engagement in energy efficient programs will mean adapting the corporate culture to include energy efficient values. Behaviour change in regards to efficiency measures will require staff to change their habits at work. This can mean regularly turning off lights and equipment, proper use of the recycling system, changed printing and photocopying habits and more.

Staff engagement in energy efficient actions may require the following:

- Securing senior management support.
- Building teams or networks of champions.
- Using effective communication channels.
- Celebrating, growing and sharing achievements.

Earth Hour is a worldwide movement organised by the World Wide Fund for Nature (WWF). The event is held annually encouraging individuals, communities, households and businesses to turn off their non-essential lights for one hour towards the end of March. The City is encouraged to participate in earth hour as a means of indicating its commitment to reduced energy consumption.

Action 20: Participate in Earth Hour

The City is to participate in 'earth hour' by shutting down non-essential lighting for one hour towards the end of March.

City to promote the event and advertise results.

4.7.1 Switch-off Campaigns & Workplace Competitions

A switch-off campaign is a systematic process to find out where energy is being wasted and an effort to adjust people's habits to incorporate 'switch-off' behaviours. Any campaign is likely to have four core elements: measurement, identifying actions, communication, and providing feedback and rewards.

Integrating a competition with the switch-off campaign will engage staff in pursuit of common sustainability goals. It will also provide an opportunity to communicate energy efficient values and create positive social outcomes across the organisation.

Action 21: Switch off Campaigns & Workplace Competitions

Create a program for staff engagement that may include the identification of green champions across the organisation, a switch off campaign and other workplace competitions.

4.8 Monitoring, Evaluation and Re-Assessment

The Energy Efficiency Action Plan will be reviewed annually to ensure the actions are achievable and current. This will include an audit of energy use and an assessment of the targets set in section three of the report. The plan will also be reviewed and updated every five years.

5 Action Table

The action table below is sorted by priority. The priority was calculated based on estimated: effort, budget, annual financial benefit, asset lifetime and government funding. With all recommendations and actions outlined below it is required that all initiatives require a pre-project feasibility study to ensure viability. The knowledge gaps and monitoring criteria outline information and sub-actions to take place for each action.

Action #	Relates to Section	Action Description	Knowledge Gaps / Monitoring Criteria	Responsible Department	Time Frame for Completion	Priority
1	4.1.1	Energy Audits	• The half-hourly electricity interval data for each site. • The building structure and system. • The needs and requirements of the occupants. • The most passive ways to reduce power loads such as; reducing lighting, optimising, equipment controls and increasing insulation. • The cost of potential retrofitting or installation of infrastructure based on payback periods and lifecycle costs.	Strategic Projects and Infrastructure (*Building Maintenance*)	Short Term (1-2 years)	
2	4.1.1	Work Packages from Energy Audits	• Prioritise audits based on ○ Building capability and use. ○ Technical feasibility. ○ Cost Effectiveness. ○ Overall savings potential.	Strategic Projects & Infrastructure (*City Services*)	Short Term (1-2 years)	
8	4.2.1	Solar PV Business Cases and Implementation	• Interval data at each site. • Business case analysis for each site.	Strategic Projects & Infrastructure (*City Services*)	Short Term (1-2 years)	
16	4.4	Replacement of Street Lights	• Investigate GVROC lighting programme as a model for negotiations with Horizon Power. • Enter into discussions with Horizon power to replace street lights.	Corporate (*Financial Services)*	Short Term (1-2 years)	
3	4.1.2	Initiate low cost and easy to implement Lighting Strategy	• The required lighting (lux) levels for the site and application. • The time of use of the lights to be removed. • Electricity tariff, luminaire costs and commercial business case for each site.	Strategic Projects & Infrastructure (*City Services*)	Short Term (1-2 years)	
5	4.1.3	Installation of Smart Meters	• The electrical boards that require monitoring and their layout. • The access to network infrastructure at each site; required for real-time energy monitoring systems.	Strategic Projects & Infrastructure (*City Services*)	Short Term (1-2 years)	
9b	4.2.2	Funding options for Wind Farms	• Investigate wind farm options through economic development, ARENA federal govt. grant program and clean energy finance corporation.	Development (*Economic Development*)	Short Term (1-2 years)	
19	4.6	Promotion of minimal waste culture	• Is the product needed or is there an alternative solution? • Is the product recycled and recyclable? • Is the product energy efficient or is there an alternative product that is? • How far has the product had to travel? • How much packaging does the product come in? Can it be recycled, reused or returned to the supplier?	Corporate (*Governance & Organisational Strategy*)	Short Term (1-2 years)	

21	4.7	Create a program of staff engagement for energy efficiency	• Securing senior management support. • Building teams or networks of champions. • Using effective communication channels. • Celebrating, growing and sharing achievements.	Community (*Community Services*)	Short Term (1-2 years)	
9a	4.2.2	Individual Wind Turbines at each site	• Undertake a feasibility study for the use of individual wind turbines.	Strategic Projects & Infrastructure (*City Services*)	Medium Term (2-5years)	
18	4.6	Energy efficient procurement policy	• Expand section 3.6 (Sustainable Procurement) within the City's Purchasing Policy to include: ○ Government guidelines and energy standards such as the national Equipment Energy Efficiency (E3) Program, which uses the Energy Rating Label for all electrical appliances. ○ Product specifications. ○ The supplier's commitment to energy efficiency in their operations.	Corporate (*Governance & Organisational Strategy*)	Medium Term (2-5 years)	
11	4.3	Solar Orientation	• Design of new builds to consider correct solar orientation of developable area to avoid direct sunlight and radiant heat from other structures.	Strategic Projects & Infrastructure (*Strategic Projects*)	Medium Term (2-5 years)	
6	4.1.4	HVAC Optimisation	• Determine for each of the City's HVAC systems: ○ The most acceptable 'dead band zone' ranges. ○ The ventilation requirements based on building occupancy. ○ The maintenance regime required. ○ The need for installation of ACERS. ○ Possible replacement program.	Strategic Projects & Infrastructure (*City Services*)	Medium Term (2-5 years)	
14	4.3	Window Treatments	• Determine the Solar Heat Gain Coefficient of the glass • Determine if window treatment is required.	Strategic Projects & Infrastructure (*City Services)*	Medium Term (2-5 years)	
20	4.3	Participate in Earth Hour	• Promote and advertise event	Corporate (*Marketing & Communications*)	Medium Term (2-5 years).	
7	4.2	Investigate potential RECs available at each site	• Half-hourly interval data for each applicable site (data for some, but not all sites, exists). • Size of the renewable energy systems to be installed.	Corporate (*Financial Services*)	Medium Term (2-5 years)	
4	4.1.2	Retrofit inefficient lighting	• The required lighting (lux) levels for the site and application. • The time of use of the lights to be replaced. • Electricity tariff, luminaire costs and commercial business case for each site.	Strategic Projects & Infrastructure (*City Services*)	Medium Term (2-5 years)	
10	4.3	Energy Efficient Design for Heating and Cooling	• For all new builds determine the proposed energy efficiency design for heating and cooling: ○ Free Running. ○ Conditioned. ○ Hybrid.	Strategic Projects & Infrastructure (*Strategic Projects*)	Medium Term (2-5years)	
12	4.3	Insulation Requirements	• Review the insulation requirements of current CofK buildings and retrofit accordingly.	Strategic Projects & Infrastructure (*City Services*)	Medium Term (2-5 years).	
15	4.3	Thermal Energy Analysis	• Create business case for thermal energy analysis of the city's sites.	Strategic Projects & Infrastructure (*City Services*)	Long Term (5-10 years)	
13	4.3	Review shading requirements of City buildings.	• Ensure that new builds incorporate the shading requirements of hot humid climates, including: ○ Correctly positioned landscaping, ○ Covered outdoor areas, and	Strategic Projects & Infrastructure (*City Services*)	Long Term (5-10 years)	

			○ Eaves surrounding entire buildings, with eave widths of 50% of building height.			
17	4.5.1	SCADA Automation System	• Keep collecting and analysing data from the SCADA system to determine use patterns and adjust accordingly. • Investigate rolling SCADA out to other pumping stations and expanding use to fit systems with moisture sensors, temperature sensors and timers.	Strategic Projects & Infrastructure (*Parks & Gardens*)	Long (5-10 years)	

Appendix A – Glossary of Energy Efficiency Options

1. Auditing & analysis	
Energy Audit: Level 1*	The energy use profile of a building or facility is reviewed in a report structured to the guidelines in AS3598. A Level 1 audit produces an abbreviated report with a brief list of recommended efficiency actions.
Energy Audit: Level 2*	The energy use profile of a building or facility is reviewed in a report structured to the guidelines in AS3598. A Level 2 audit, which includes a site visit, contains greater detail than Level 1 and delivers a list of recommended efficiency actions and deeper analysis.
Energy Audit: Level 3	The energy use profile of a building or facility is reviewed in a report structured to the guidelines in AS3598. A Level 3 audit, which includes a site visit, is the most rigorous level of audit and delivers a comprehensive, detailed list of recommended efficiency actions and deep analysis.
Energy Management Plan (EMP)	Based on the energy use profile of a building or facility, a list of recommended efficiency actions is developed and presented with an actionable timeline for implementation, providing a roadmap of the EE project(s) most likely to benefit the building or facility.
Business Case*	The costs and benefits of implementing a particular energy efficiency project or technology (e.g. solar PV system, LED lighting upgrade) for a building or facility are assessed and presented as a formal report with short and longer term paybacks.
Feasibility Study*	The technical and financial feasibility of implementing a particular energy efficiency project or technology (e.g. solar PV system, lighting upgrade) for a building or facility is assessed and presented as a formal report.
2. Renewable or alternative electricity generation	
Solar PV (photovoltaic)*	Solar photovoltaic (PV) systems generate electricity from the sun via solar panels mounted on the roof of the building or the ground, reducing the amount of energy that the building needs to draw from the grid especially during peak times (middle of day). Costs of the displaced energy are avoided and CO_2 emissions are reduced.
Wind	Electricity is generated via turbines (horizontal- or vertical-axis) erected at high altitude, reducing costs due to the displaced grid electricity and CO_2 emissions.
Geothermal heating/cooling*	The ground is used as a heat source/sink by virtue of stable temperatures in the earth's surface. A bore pump extracts ground water for space/water heating/cooling applications.
Co-/Tri-generation*	Gas turbines onsite at a building or facility generate electricity and provide heating (co-generation) or generate electricity and provide heating & cooling (tri-generation).
Solar Thermal	Solar heat energy is stored in a salt solution to generate electricity, reducing costs due to the displaced grid electricity and CO_2 emissions.
Waste-to-energy	Waste products are incinerated or gasifier processes to produce natural or synthetic gas that is used to power a gas turbine and generate electricity, reducing costs due to the displaced grid electricity. Waste is eliminated and the solid by-products may also be used.
Biomass / Wave / Tidal	Energy from burning biological products or from wave/tidal motions is used to generate electricity, reducing grid electricity costs and CO_2 emissions.
Hydrogen	Hydrogen gas can be used to power electricity. It doesn't occur naturally, but can be generated by splitting oxygen and hydrogen using an electric current. As such hydrogen is practically a limitless resource. In addition, hydrogen use in fuel cells produce water as a by-product and are therefore greenhouse gas neutral. The splitting of water to extract hydrogen is not yet an efficient process, but may become more so as technology develops. Currently, hydrogen is being extracted from the use of fossil fuels (such as coal), as a clean energy/fossil fuel hybrid process. Hydrogen also has a low density and therefore has to be stored under extreme pressure, thereby creating safety issues.
3. Lighting	

Lighting upgrade*	Existing lights are replaced with energy efficient models such as LEDs or induction lights. Whole light fittings may be replaced during an upgrade, or simply the tubes/bulbs; the latter process is called a retrofit.
Intelligent lighting control & sensors*	The operation times of lights (on, off or dimmed modes) are regulated or reduced based on pre-programmed time schedules, occupancy (motion) sensors or photo sensors.
Solar lighting	Existing lights are replaced with solar-powered lights that include their own batteries to operate during low daylight hours, most commonly used for street lighting and other outdoor applications.
Re-wiring of light controls	The way switches are connected to the lights that they control is reviewed, such as having smaller banks (groupings) of lights connected to a single switch, in consideration of energy efficiency within the parameters of human behaviour and protocols of use.
Energy-saving devices	A class of devices retrofitted to existing lights to improve their efficiency, applicable to certain types of lights or lighting systems. An example is the Light Energy Saver System (LESS) device.
Daylight harvesting	A building is modified to facilitate daylight filtering into its interiors and to optimise light levels without use of luminaires. These works may be minor, moderate or major, and sunlight can be streamed directly into the space or via light "corridors" constructed to direct it via an unconventional path.
De-bulbing or part-load operation	Removing or decommissioning tubes/bulbs in a light fitting reduces the effective rating of the light, reducing both the light levels and energy consumption. Strictly speaking this lowers energy use but does not improve "efficiency" because the performance is correspondingly lowered.
4. Heating, Ventilation, Air-conditioning and Refrigeration (HVACR)	
HVAC optimisation*	The performance of existing HVAC systems is optimised through performance testing, tuning (adjusting the technical parameters) and servicing (e.g. cleaning filters). A service regime may be developed.
Geothermal heating/cooling	See 2.
Co-/Tri-generation	See 2.
Economisers	Devices are installed to economise the operation of existing HVAC systems. For example, enthalpy controls are a way to control humidity in hot, dry climates. Other examples of economisers are CUES and ACES, specific products described under 6.
Doorway controls (e.g. air curtains, strip curtains)	Heat is prevented from escaping cool rooms or air-conditioned areas by means of polymer strip curtains or air curtains, which are jets of air directed downwards that prevent heat flow across a doorway when the door is opened.
Improved insulation (building fabric)	Heat transfer through walls (undesirably causing the building to lose heat in winter and gain heat in summer) is minimised with materials such as thicker insulation or double-glazing of windows. As a result, internal HVAC systems do not need to work as hard (operate more efficiently).
Improved insulation (pipes)	Heat transfer through pipes in HVAC systems is minimised, reducing losses to the air and increasing the efficiency of the HVAC system.
Refrigeration batteries	Technology that stores energy, specifically designed for cool room applications to reduce the required duty of the cooling system
Equipment replacement	Installed and portable HVAC systems are replaced with more efficient models or product classes, or the design and sizing of the HVAC system is reviewed and improved as necessary.
Re-gassing	The gas in an HVAC system is replaced, allowing the system as a whole to operate more efficiently, similar in principle to car re-gassing.
5. Energy management	
Building Management System (BMS)	A centralised platform is used to control and monitor features of the building's HVAC system, lighting system, energy sources and/or other energy-consuming channels. The BMS allows settings to be altered for different areas of the building, including timer schedules, and the general status of equipment to be monitored in real time. Capabilities vary greatly between BMSs. They generally operate over local networks only (not web).

Real-time energy monitoring*	A single- or multi-channel device monitors the electricity use of different circuits or applications (e.g. lights, solar PV system, different regions of the building) and displays data in real time. These devices often come with web-based software platforms. Detailed data is stored on the server and can be analysed for signs of unusual usage patterns, trouble-shooting or general performance monitoring. Auto alerts or reports may be set up.
Sub-metering	Independent devices are installed to monitor the electricity use of different circuits or applications (e.g. lights, solar PV system, different regions of the building). Data is read off the device itself or may communicate with data management systems. Capabilities vary greatly between sub-meters regarding the level of detail recorded; most store data as lump sum values.
Smart metering	Independent devices are installed to monitor the energy consumption and communicate back and forth with the energy retailer, requiring retailer-side technical infrastructure capabilities.
Set point management	The default temperature of a room or a building must balance the comfort of occupants with energy considerations. Managing this temperature "set point" for optimal efficiency reduces the duty of the HVAC system (to work as "least hard" as possible) within an acceptable level of comfort.
Building envelope and room use review	The heat transfer between a building and its surrounding environment (ins and outs) are minimised to improve the efficiency of the HVAC system so it need not work so hard "moving heat" to maintain comfort. Insulation, the placement of landscaping features and different room uses are reviewed.
Equipment replacement	Plug-in loads such as computers, fridges and other appliances are reviewed and replaced with more efficient models (phase out or retrofit).
6. Control and optimisation technology	
Variable Speed Drives (VSD) *	VSD motors intelligently regulate their output based on the application requirements, varying their speed or frequency to optimise energy consumption while adequately meeting needs.
Voltage Optimisation / Regulation (VO/VR)*	VO or VR units regulate or reduce the voltage of the electricity supplied by the grid to a level suitable for the building or facility's appliances. Supply voltages are often higher than necessary, and reducing them can result in energy savings while meeting the operational needs of the site.
Battery Storage	Electricity generated or supplied at particular times which exceed the immediate needs of the site are stored for use later in the day, taking advantage of different time-of-use tariff rates or maximum solar PV energy.
Specialised energy-saving devices	A class of specially-developed devices are retrofitted to the following devices to optimise their efficiency during operation: a) refrigeration thermostats e.g. Chilled Unit Energy Saver (CUES); b) air-conditioning units e.g. Air-conditioning Energy Saver (ACES); c) motors e.g. Intelligent Motor Energy Controls (IMEC); d) lighting systems e.g. Light Energy Saver System (LESS).
7. Electricity retailer agreements & programs	
Tariff Review*	Customers classed in the Contestable Supply category may negotiate their electricity tariff/contract with a range of electricity retailers licenced to operate on the SWIS (South-west Interconnected System), our SW grid.
Power Purchase Agreement (PPA) *	A clean energy system is installed on a building or facility at no cost to the building owners. Electricity generated by the system is sold to the site at a rate lower than the grid or at grid parity with a roof leasing fee received by the owner.
Demand Side Management (DSM)	A voluntary program in which large energy users can form an agreement with their retailer to shift energy use at nominated times in order to control demand on the electricity grid for a financial incentive
Outright Purchase*	The energy efficiency project is purchased via a standard retail transaction. Grants and subsidies may be used.
Power Purchase* Agreement (PPA)	See 7.
Equipment financing	Loans are available for businesses to purchase equipment relating to energy efficiency.

Bank loan	Non-equipment-specific bank loans for businesses are available.
Grants / External funding	A range of grant schemes and incentives for businesses to implement programs or purchase energy efficiency equipment area available.
Renewable Energy Certificates (RECs)*	A government subsidy for purchasing applicable renewable energy systems is in place at the time of writing, based on the capacity of the system (kW) or the amount of energy generated over an agreed period (kWh); RECs are available as STCs (small-scale technology certificates) or LGCs (large-scale generation certificates) and are subject to current policy.
Emissions Reduction Fund (ERF)	Part of the government's direct action climate policy, a competitive reward scheme is in place for offsetting a business's emissions through clean energy / efficiency projects based on a reverse auction format.
Community Energy / Co-operatives	A clean energy system is owned jointly by multiple stakeholders who share in the upkeep of the system and electricity generated.

Appendix B – Lighting Efficiency Strategies

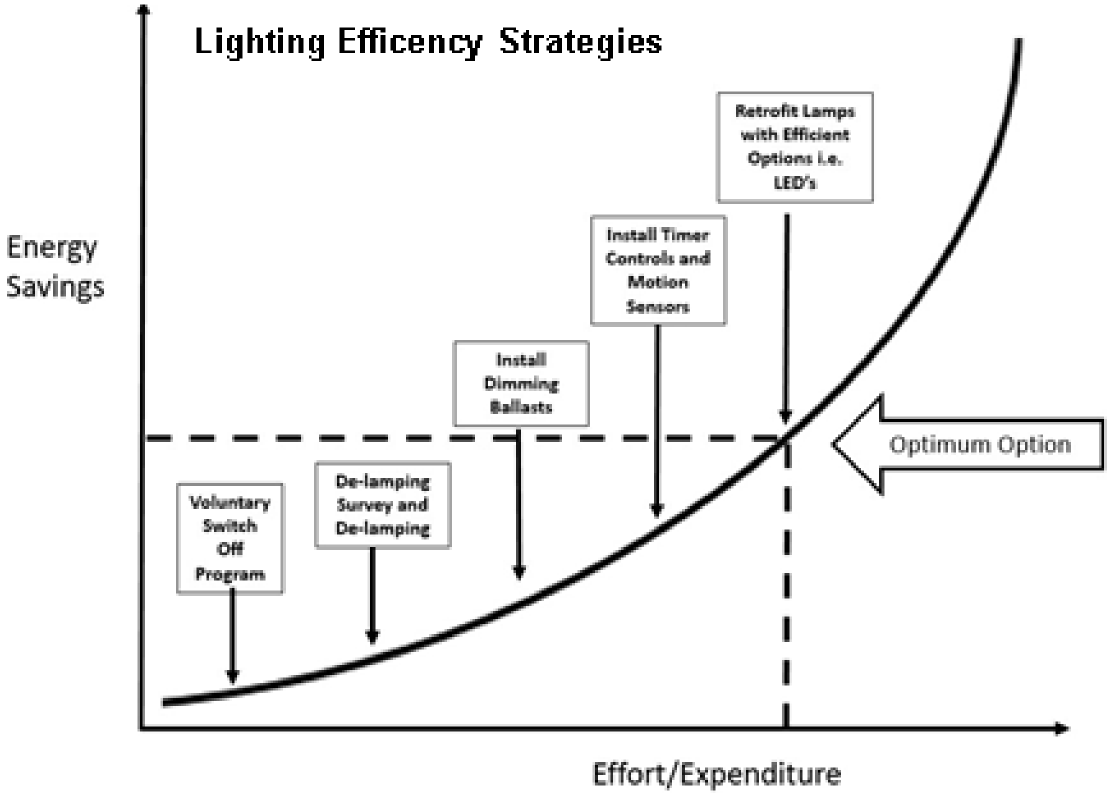


Figure 14 Lighting Efficiency Strategies

There are varying levels of lighting efficiency strategies depending on cost and effort as illustrated in Figure 14. Depending on the sites consumption and lighting requirements the most cost effective means of reducing energy consumption in the lighting sphere can be to retrofit lamps with efficient lighting types such as LED's. A description of each strategy is detailed below.

A voluntary switch off program would involve educating and use of signage to encourage occupants to switch off lights not in use. De-lamping involves removing lamps or fixtures where there is greater than needed illumination. Installing dimming ballasts would give occupants the option to reduce the energy consumption of a light fitting by dimming the light. Installing timer controls and motions sensors would allow the operation times of lights (on, off or dimmed modes) to be regulated or reduced based on pre-programmed time schedules, occupancy (motion) sensors or photo sensors. Retrofitting lamps would involve replacing existing lights with energy efficient models such as LEDs or induction lights. Whole light fittings may be replaced during an upgrade, or simply the tubes/bulbs; the latter process is called a retrofit.

Appendix C – Energy Efficient Building Design

Using energy efficient design for a building can reduce energy use over its entire lifespan. A number of considerations should be investigated when designing and constructing a building. These include:

- Insulation requirements.
- Building orientation.
- Windows and shading.
- Construction materials.

The design requirements for an energy efficient building is dependent on the climatic zone in which the building is located. the City of Karratha is located in zone one of Australia's climatic zones; "Hot Humid Summer, Warm Winter" (Figure 15). This zone is characterised by:

- High humidity with a degree of 'dry season'.
- Moderate to high temperatures year round.
- Low to moderate seasonal temperature variation.

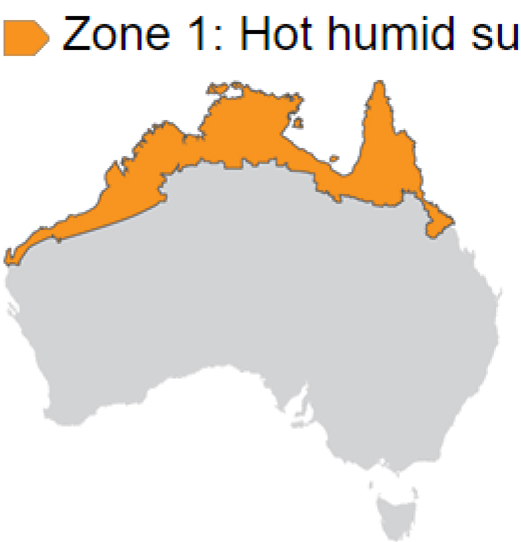


Figure 15 Climatic zone for City of Karratha

The energy efficiency rating of homes in Australia is measured by the Nation Wide House Energy Rating Scheme (NatHERS). Buildings in climate zone one use substantially more energy to achieve thermal comfort than buildings with the same NatHERS star rating in more benign climates. For example, a 6 star rated building in Darwin uses more than double the energy of a 1 star rated building in Brisbane. This locational disadvantage makes energy efficient design all the more critical.

For a new build three distinct design options exist:

1. Free Running: not conditioned (mechanically heated or cooled) but designed to have abundant air movement from fans, whirlybird ventilators, stack ventilation and cross ventilation.
2. Conditioned: Mechanically heated and cooled, the building must be airtight and insulated.
3. Hybrid: include air-conditioned insulated core rooms in the centre of the building for peak discomfort periods, surrounded by free running spaces. It is important to choose the correct design option at the outset as it is difficult to change in the future.

Building Orientation

Orientation is the positioning of a building in relation to seasonal variations in the sun's path as well as prevailing wind patterns. Good orientation, combined with other energy efficiency features, can reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort.

In hot humid climates, such as Karratha, where there are no winter heating requirements the aim is to orientate the building to exclude direct sunlight and radiant heat (from nearby structures) at all times of the year while maximizing access to cooling breezes.

Insulation Requirements

Insulation is any material that reduces the amount of heat transfer to and from buildings through doors, windows, walls, ceilings, floors and gaps. Half of the energy we use to heat or cool our homes can simply leak out without insulation. Insulation can be of two types:

- Bulk insulation which resists the transfer of conducted and convected heat.
- Radiant barriers which consist of a highly reflective material that reflects radiant heat rather than absorbing it.

For free running buildings, where air is not mechanically heated or cooled, it is important that insulation does not stop air movement from fans and cross ventilation. In this situation bulk insulation is to be avoided.

For conditioned buildings (mechanically heated and cooled), it is important that buildings are well insulated and made airtight. Insulation in conditioned buildings includes wall insulation (ensuring internal walls are separated from the external thermal mass) and ceiling insulation (If a ceiling is not insulated, up to 45% of heating and cooling energy can be lost). Figure 16 depicts the average heating gain of a building in summer without insulation.

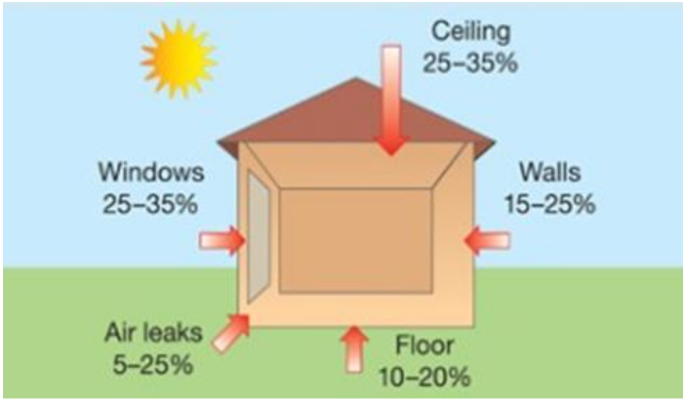


Figure 16 Heating gain of an uninsulated home in summer.

Insulation can also be retrofitted into existing buildings dependent on current design and access into roof and wall cavity's.

Shading

In hot humid climates, it is essential to shade the walls year round and highly advantageous to shade the whole roof. A 'fly roof' can be used to shade the entire building. It protects the core building from radiant heat and allows cooling breezes to flow beneath it.

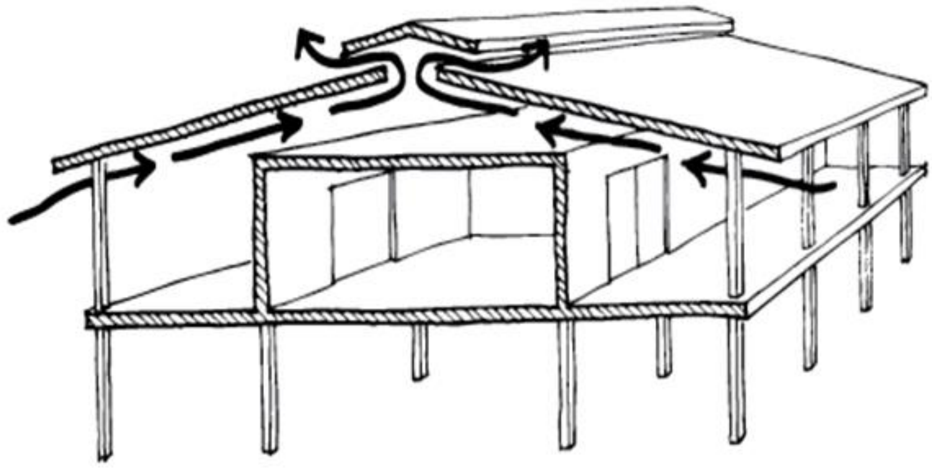


Figure 17 Example of a 'Fly Roof'

Other essential shading requirements for hot humid climates include:

- Use of covered outdoor living areas such as verandas and deep balconies to shade and cool incoming air.
- Choose and position landscaping to provide adequate shade without blocking access to cooling breezes.
- Use plantings instead of paving to reduce ground temperature and the amount of reflected heat.
- Shade all external openings and walls including those facing south.

Eaves

Correctly designed eaves are generally the simplest and least expensive shading method for northern elevations. As a rule of thumb, eaves width should be 45% of the height from the window sill to the bottom of the eaves.

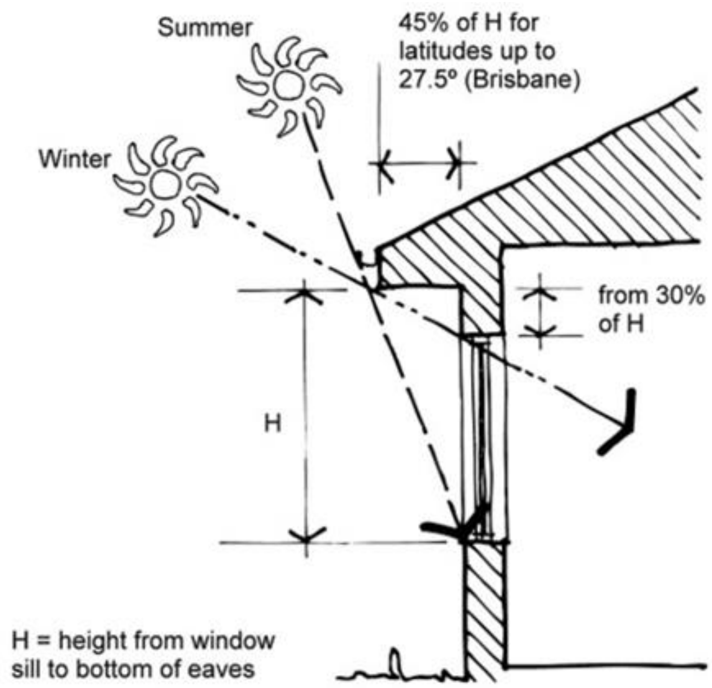


Figure 18 Average Eaves Width

For hot humid, climates with no heating requirements there is opportunity to shade the whole building with eaves, with overhangs of 50% of height from floor level to both north and south where possible. Then to use plantings or adjoining buildings where eaves are not possible.

Windows

Windows can represent a major source of unwanted heat gain in summer. Between 79-86% of a buildings heat can be gained through its windows, severely impacting on the cooling loads.
When designing a building there is the need to determine the Solar Heat Gain Coefficient of the glass (SHGC). SHGC is the percentage of solar energy incident on the glass that is transferred indoors both directly and indirectly through the glass. Appropriate window treatments can significantly reduce the SHGC and thereby reduce the cooling requirements of a building.

Construction Materials

The use of low mass co nstruction materials in a new build is important when considering energy efficiency. In hotter climates low mass does not store daytime heat gains and cools quickly when night-time temperatures drop. Low mass construction also responds more rapidly and efficiently to cooling breezes when available and to active cooling when they are not.

Appendix D – Mercury Vapour Lamp Replacements

Replacement options for Mercury Vapour (MV) Lamps are well established in Australia and worldwide as it is becoming more evident that they are inefficient users of power and have potential environmental impacts due to their mercury content. The inefficiency of MV based luminaires is evident in Figure 19, where MV lamps have an efficacy rating of just 20 lm/W compared to over 100 lm/W for LED lamps.

This graph demonstrates that MV lamps have a much lower efficacy rating than other lamp types. This graph also indicates that for MV lamps the luminaire output is only mid-range at best. Other lamp types have a much greater efficiency and luminaire output. Most notable on the chart are the Light Emitting Diodes (LED's) which have significantly greater light efficacy than other types. Although LEDs have high efficiency their luminaire output can be less than other luminaries. Figure 19 illustrates that Metal Halide (HD) and High Pressure Sodium (HPS) have higher luminaire output but with lower efficiency than LED.

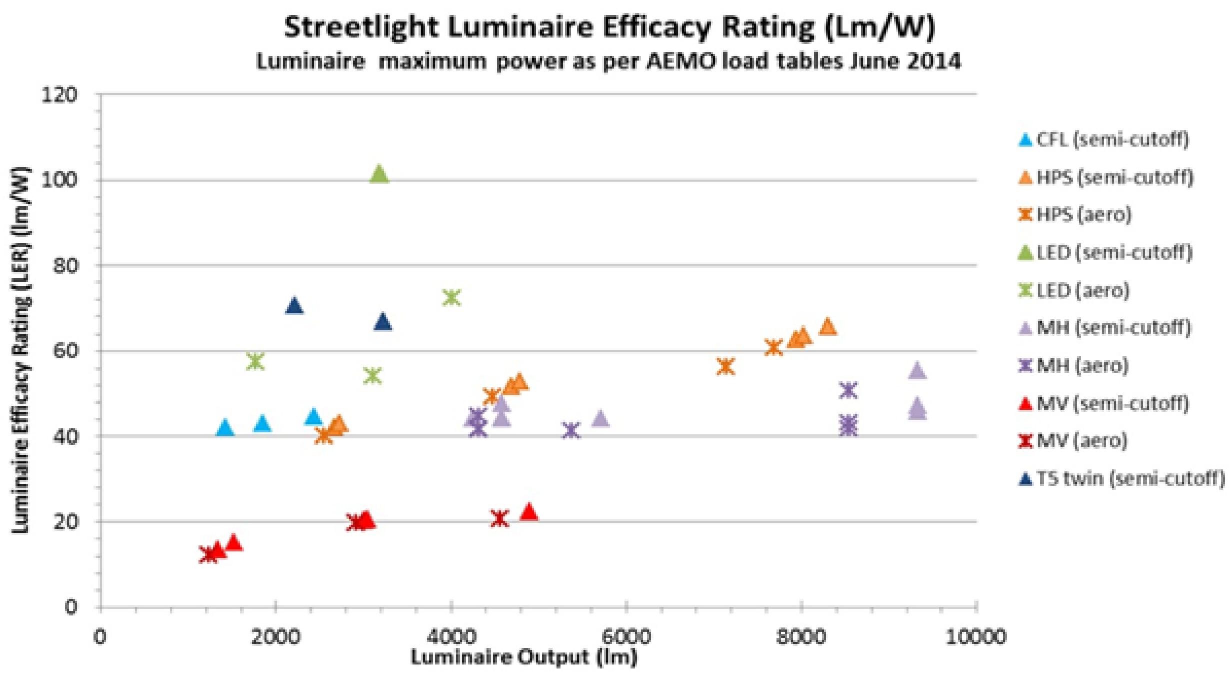


Figure 19 Luminaire Efficacy Rating of Lamp Types

A number of countries have introduced minimum energy performance requirements (MEP's). These MEP's generally are based on watts per metre for streetlights and therefore are contingent on road lighting design. Figure 18 depicts MEP’s of India, Taiwan and the International Energy Agency (IEA consisting of 29 member countries). In order to reach the MEP's for high luminaire output scenario's (such as those needed for street lighting of trafficable areas), the graph below indicates that High Pressure Sodium and Metal Halide lamps are required.

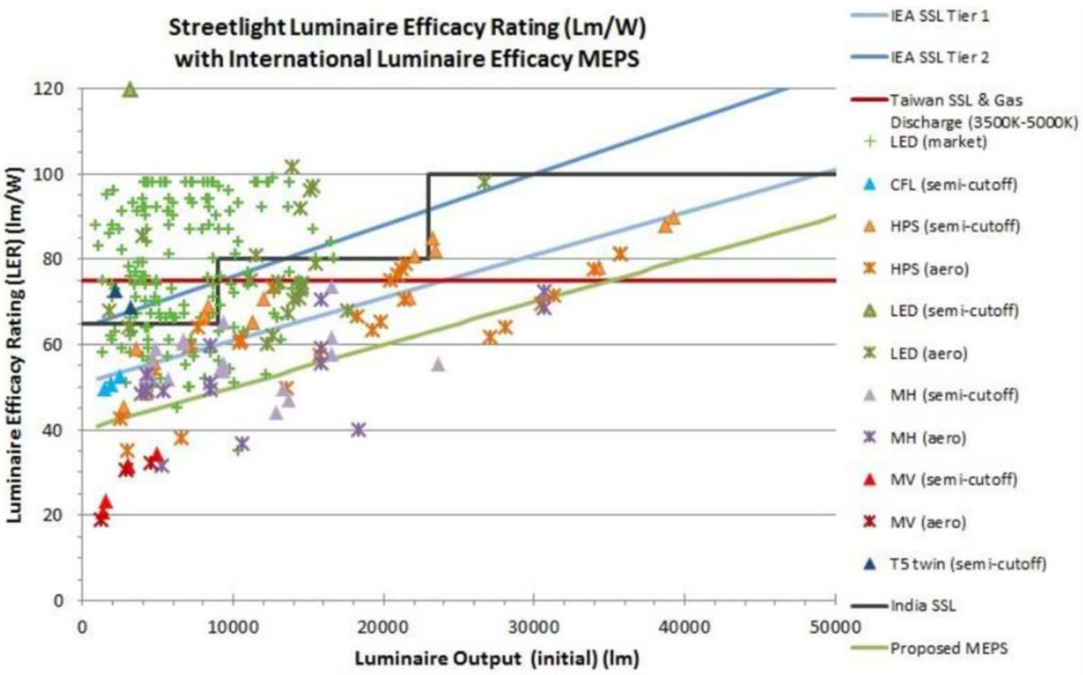


Figure 20 Minimum Energy Requirements

One of the main barriers to potential upgrades of inefficient lamp types is that street lighting in the Karratha municipality is owned and maintained by Horizon Power. However, as the electricity costs fall to the City and the associated GHG's are attributed to City operations, there is a need for negotiations with Horizon Power as to replacement programs and street lighting design. Streetlight design is dependent upon the usage of the street, which in turn impacts on the luminaire output requirement and the required minimum energy performance expected of the chosen lamp type. Horizon Power have indicated that all Mercury Vapour lamps within Karratha will be phased out for more efficient lamp types such as LED's and Compact Fluorescents.

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