ICLEI Local Governments for Sustainability

IRENA International Renewable Energy Agency

CITY IN FOCUS

SYDNEY, AUSTRALIA - NAGPUR, INDIA

Lighting up the streets

SUMMARY

Well-functioning public lighting improves a city's quality of life, but contributes also significantly to its energy consumption and greenhouse gas (GHG) emissions. The use of renewable energy (RE) and energy efficiency (EE) measures in public street lighting, present opportunities to reduce energy demand, to harvest financial savings from reduced electricity use and to reduce related GHG emissions. Many options exist for local governments to explore, such as: 1) energy conservation and efficiency (*i.e.*, reducing operation hours, the number of lights and power); 2) stand-alone photovoltaic (PV) powered lighting; 3) grid-interactive PV-powered lighting; or 4) procurement of RE for lighting. Local governments often incorporate more than one of these options, depending on the local priorities and circumstances, as well as policy contexts. The cases of Sydney, Australia, and Nagpur, India, are examples of local governments choosing suitable options for public lighting. In Sydney, existing light bulbs have been replaced with more energy efficient ones. Light-emitting diode (LED) lighting is expected to save around USD 830,000 a year in electricity bills and maintenance costs, and reduce electricity consumption in local street lights by 51% and CO_2 emissions by 2,185 tonnes a year. In Nagpur, PV-powered street lighting systems have been installed and significant energy and emissions savings are also being recorded.

Figure 1: Sydney central business district and Darling Harbour

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INTRODUCTION

REDUCING EMISSIONS THROUGH INNOVATIVE STREET LIGHTING SOLUTIONS

Well-functioning public lighting improves a city's quality of life. It contributes to an increased sense of safety, prevents crime and allows for longer use of public spaces for recreational and economic activities. Street and public lighting are among the core services a local government provides, or can influence.

Public lighting also significantly contributes to a city's energy consumption. The use of RE and EE measures in public street lighting provide opportunities to reduce energy demand, harvest financial savings from reduced electricity use and reduce related GHG emissions. RE solutions can be an easy option for providing lighting in areas that do not have an electricity infrastructure. This can be especially relevant in rapidly urbanising areas or in under-developed areas of a city.

Local governments can implement a variety of actions to improve public lighting for streets, pathways, roadways, parking lots, gardens and lawns across a city. While some of the applications can be used within an integrated programme, others can only be used independently (*e.g.* stand-alone vs. grid-integrated PV; changes to installations can be difficult to revert). Principal opportunities a local government can explore include:

- Promote energy conservation and efficiency: Energy can be reduced by revising operation hours, the number of street lights, and power. This does not require any additional expenditure. A further step would be to replace existing lighting with more energy efficient lighting systems (*e.g.* LED lights).

- Stand-alone PV powered lighting: Stand-alone solar street lights are self-contained systems that do not consume energy from the electricity grid. An advantage of this technology is the relative simple installation. Next to saving conventional energy, this technology can also reduce maintenance and running costs compared to grid-interactive street lights (see below). Solar lights are also considered reliable. Furthermore, they operate at low voltages and hence a safe option for workers.

- Grid-interactive PV powered lighting: Grid-interactive lights contribute to the electricity grid by day and draw from it by night. In contrast to stand-alone lights, this system ensures that all energy produced is utilised, and avoids possible lighting failure due to energy shortages. Lighting can feature as part of a smart grid, which uses information and communication technology to gather and act on the information (*e.g.* the light only switches on when natural day light falls below a certain threshold level). Grid-interactive PV powered lighting systems may however not be suitable in many situations. Nevertheless, the benefit of being connected to an electricity grid, is that it can draw upon RE generated elsewhere (*e.g.* solar power plant, wind farm, etc.).

- Procurement of renewable energy for lighting: By purchasing the equivalent amount of electricity and feeding it into the general electricity grid, street lighting can be fed from remote RE sources. This could have the additional benefit of supporting local or regional renewable electricity production, as well as being part of a wider shift of local government operations to RE.

Local governments often incorporate more than one of the above, depending on local priorities and circumstances. The main differences depend upon the pre-existing regulatory framework, infrastructure, initial installation costs, and available investment. Local government actions may, however, be restricted where streets and their lighting are in the responsibility of state or national agencies.

CITIES IN FOCUS: SYDNEY AND NAGPUR

The cases of Sydney, Australia, and Nagpur, India, are examples of local governments choosing their most suitable options. In both cities, the local government took action to reduce GHG emissions and energy costs, as well as address energy security issues, by changing their approach to public lighting. Different local and regional conditions including the varying policy contexts, lead to diverse solutions. In Sydney, existing light bulbs have been replaced with more energy efficient ones. In Nagpur, PV-powered street lighting systems have been installed.

CITY IN FOCUS: Sydney, Australia Population 4.6 million (2012)

SYDNEY

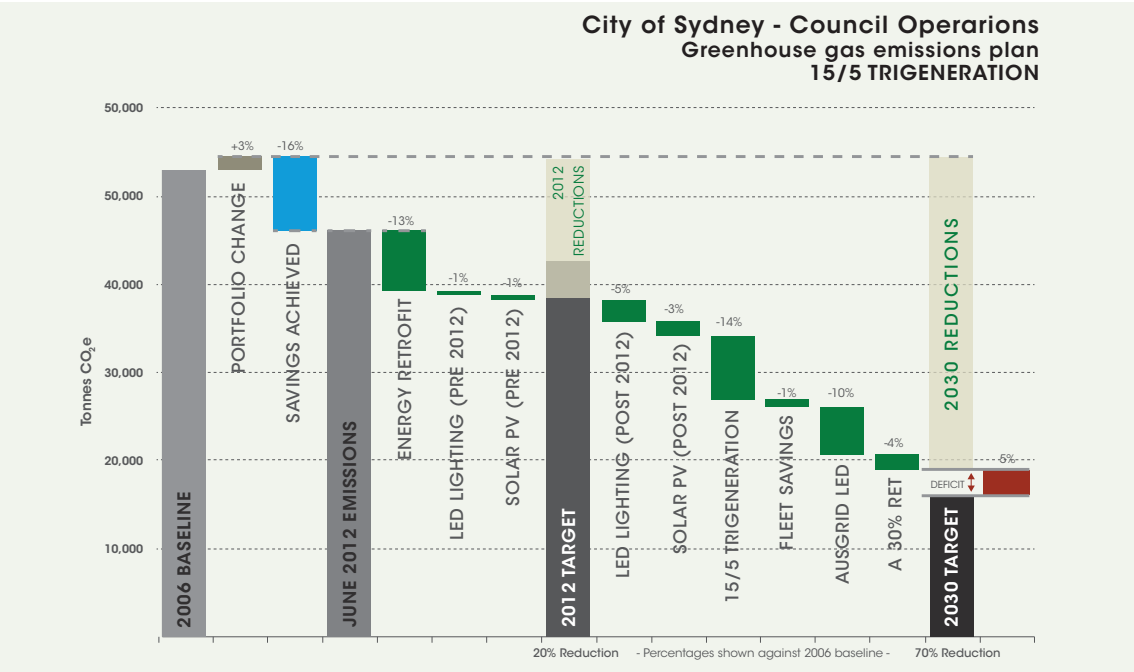
CONTEXT

ENERGY EFFICIENCY IN STREET LIGHTING

With the adoption of the plan Sustainable Sydney 2030, following one of the largest consultation processes ever undertaken by the city, Sydney city council formulated and endorsed a set of energy related targets and goals. The plan provides the following city-wide targets:

» To reduce 70% of GHG emissions by 2030 based on 2006 levels.

Figure 2: Waterfall diagram indicating the City of Sydney's targets for GHG emissions reduction against baselines.



Source: City of Sydney (2012)

- To remove reliance on coal-based electricity by 2030.
- 70% of the local government's electricity needs should come from tri-generation (combined production of cooling, heat and power) and 30% from renewable electricity.
- The local government's operations have already been carbon neutral since 2006/2007 (see box on carbon neutrality). However, targets have been set to further reduce the local government's emissions (20% reduction of GHG emissions by 2012 compared to 2006 levels).

To achieve the above targets, improvements in the provision of street lighting are key. The city government has one of the largest portfolios of street lighting in New South Wales with 22,000 lights. Of these, 13,500 are maintained by Ausgrid (formally known as EnergyAustralia) and 8,500 by the city government. Sydney's public lighting consumes a total of 13,100 megawatt hours a year (MWh/yr) and produces 14,017 tonnes of GHG emissions.

DESCRIPTION OF ACTIVITIES

REPLACING EXISTING LIGHT BULBS WITH ENERGY EFFICIENT LIGHTING SYSTEMS

As part of efforts to achieve the targets described in the Sustainable Sydney 2030 plan, the local government is replacing 6,450 conventional lights with LED lights. The process of selection was based on a cost and benefit analysis of different options. LED lights are highly efficient and require less energy than traditional forms of lighting. They are also estimated to last longer than

Carbon Neutrality

Carbon neutrality can be defined as a state where no net GHG emissions are produced by an entity or activity during a particular time period. The concept of carbon neutrality can be applied to an entire organisation, a particular event that the organisation is responsible for, goods that the organisation produces, or services it delivers. Steps to reach carbon neutrality can include measuring GHG emissions, reducing those emissions as much as is cost effective and off-setting residual emissions by purchasing carbon credits.

Figure 3: Lamps, Sydney Harbour

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traditional forms of lighting, which lengthens the replacement cycle, thereby lowering maintenance costs and reducing the amount of waste generated.

PV-POWERED STREET LIGHTS

The option of PV-powered street lights was not selected due to a number of identified drawbacks. The cost of the installation of solar streetlights, when the grid and the street light network already exist, was estimated to be higher than other options. The selection of the PV panels was problematic, with so many available options. There was also concern that companies would not exist for the duration of the warranty. The full-life cycle of the batteries for stand-alone solar installations, their production, maintenance and disposal, were difficult to assess from an environmental perspective. As such, for Sydney, the costs outweighed the benefits for stand-alone or grid connected solar street lighting.

TRIAL AND EVALUATION OF LED TECHNOLOGY

A number of concerns emerged about the risks associated with LED, including the risk of failing to deliver the expected outcomes (*i.e.* expected savings and the quality of lighting according to Australian standards) or unplanned costs. To address these concerns, the local government undertook a lengthy trial using multiple LED lighting types and providers in various locations throughout the city. The trial was successful in proving that LED could meet the city's requirements and expectations. It also helped to select the most suitable devices. The feedback from the public was positive with more than 90% of people finding the new lighting appealing.

ENABLING CONDITIONS TOWARDS IMPLEMENTATION

A number of conditions contributed to the success of the LED project. Firstly, the City of Sydney was supported by international partners. An international trial of LED lighting with London, New York and Hong Kong, and Sydney as participants was organised by the Climate Group, an international environmental organisation. An outcome of the trial was a detailed report on the benefits of LED lighting in cities, produced by the Climate Group.

The international trial of LED lighting and other activities were useful in obtaining technical assistance, including the provision of a customised technical protocol to measure the performance of the LED lights, third party verification of data and a loan for the LED measurement equipment. The Australia/New Zealand Standard (AS/NZS) for good practices in roads and public space lighting also supported the inclusion of LED lights in public places (*Australia/ New Zealand Standard: Lighting for roads and public spaces, Part 6: Luminaires" - AS/NZS 1158.6:2010*). These standards are used for quality assurance and support aligning regulations with these standards.

RESULTS

The *Sustainable Sydney 2030 plan* and the related replacement of street lighting devices are on-going. Sydney is on track to reduce its 2006 level emissions by 20% by end of 2012. The GHG emissions from the local government come from a range of sources, but the major source was electricity from buildings and street lighting. Between 2005 and 2011, the local government has reduced carbon dioxide (CO_2) emissions from 44,973 tonnes of CO_2 equivalent (tCO_2e) to 38,664 tCO_2e.

According to Sydney's State of the Environment Report 2011/2012, LED lighting will save around USD 830,000 a year in electricity bills and maintenance costs, and reduce electricity consumption

in local government-owned street lights by 51% and CO_2 emissions by 2,185 tonnes a year. Far greater savings can be achieved if the other network operator within the municipal boundary would also upgrade its street lighting with LED technologies.

COST AND FINANCING

While the terms of the tender contract are confidential, financially the project is forecast to break even in over 10 to 12 years. The local government's *2012-2015 Corporate Plan* and *Long Term Plan* has adequate funds assigned to run the project.

NAGPUR

CONTEXT

RENEWABLE ENERGY FOR STREET LIGHTING IN NAGPUR, INDIA

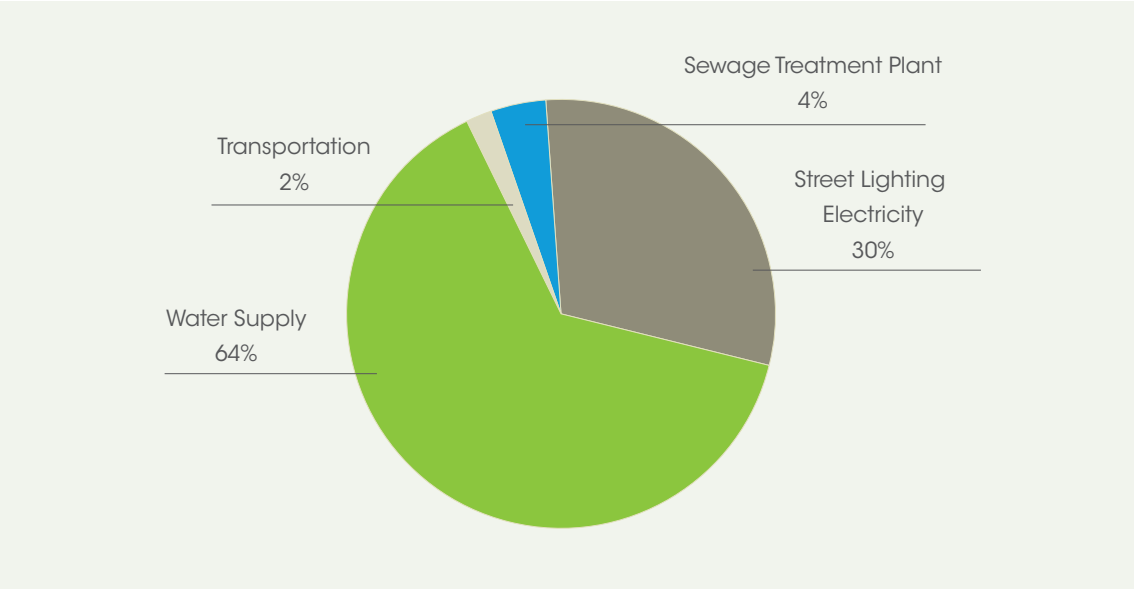
CITY IN FOCUS: Nagpur, Maharashtra, India Population 2.4 million (2011)

In India, local governments face great challenges in providing adequate utility services to their populations. Unstable energy supply and the increasing energy demands of a rapidly growing population can often lead to a weak electricity grid. As a result, most cities and towns are facing severe electricity shortages. Municipal corporations can ameliorate these strains through targeted interventions to reduce energy consumption from municipal operations in street lighting and water supply.

The local government (the Nagpur Municipal Corporation - NMC) consumes energy in operations such as water treatment and supply, sewage treatment and pumping, street lighting, transportation and hot mix asphalt plants (diesel operated), as well as in its own buildings.

Nagpur is renowned as the first model Solar City in India. In 2007, the local government set RE and EE targets for 2012: a 3% reduction in conventional energy consumption across the city and a 20% reduction in conventional energy consumption in municipal operations and facilities (with 2005 as

Figure 4: Nagpur GHG emissions from municipal operations



Source: ICLEI 2009, Energy and Carbon Emissions Profiles of 53 South Asian Cities,

the baseline year). The focus of the activities is on the promotion of RE applications with the goal of meeting 10% of the city's primary energy consumption with RE sources.

DESCRIPTION OF ACTIVITIES

LOCAL RENEWABLES PROGRAMME IN NAGPUR RAISES AWARENESS

The NMC took part in ICLEI's *Local Renewables Programme* starting in 2006, in order to reduce its own energy consumption and to switch to RE. The project was created to mobilise a wide variety of key partners to become the first platform linking local governments and institutions to pursue the generation of RE and EE at the local level. The concept of RE was very new in Nagpur and the benefits had to be explained to the NMC staff. Also, the NMC did not have the financial resources to engage in a large scale project and RE was not considered a priority.

Solar Cities Program

The Indian MNRE approved the Solar Cities programme under the 11th Five Year Plan devised in 2008. One of the objectives was to support Urban Local Bodies to prepare a road map toward RE cities or solar cities. The objectives of the programme include:

- Enabling/empowering urban local governments to address energy challenges at the city-level.
- Providing a framework and support to prepare a master plan, including the assessment of the current energy situation, future energy demand and action plans.
- Building capacity in the urban local bodies and creating awareness within the society.
- Involving various stakeholders in the planning process.
- Overseeing the implementation of sustainable energy options through public-private partnerships.

Source: Renewable Energy and Energy Efficiency Status in India, Report compiled by ICLEI May 2007.

Solar street lighting systems in India

A solar street lighting system (SSL) is an outdoor lighting unit used to illuminate a street or an open area and consists of a compact fluorescent lamp (CFL) fixed inside a luminaire, which is mounted on a pole. The PV module is placed on top of the pole and a battery is placed in a box at the base. The module is mounted facing the south to receive optimal solar radiation throughout the day without being exposed to a shadow. A typical SSL uses a PV module of 74-Wp capacity, a 12 V flooded lead-acid battery, 75 Ampere-hour, and a CFL of 11-W. This system is designed to operate from dusk to dawn. The CFL automatically lights up when the surroundings become dark.

Source: Renewable Energy and Energy Efficiency Status in India, Report compiled by ICLEI May 2007.

Table 1: Performance of solar public lighting and energy efficiency measures in Nagpur between 2006-2007

Measures	Investment (USD)	Energy Savings (ekWh / Year)	Savings in Emissions (tCO_2e / Year)	Financial Savings (USD)
20 Solar Lights installed in NMC premises	1790	1051	0.85	90
20 Solar Lights installed in the premises of the high court	1790	1051	0.85	90
60 solar lights installed in gardens, parks etc.	5375	3154	2.55	250
42 solar blinkers installed (37 Wp)	11290	2331	1.89	180
Conversion of 12000 of 70 watt HPSV* to 50 watt HPSV lights	860150	240	0.19	18
Total	**880400**	**7827**	**6.34**	**630**

(*) HPSV - High Pressure Sodium Vapour lamp

Source: Lighting Department NMC 2012, Mr. Sanjay Jaiswal, Executive Engineer

The Local Renewables Programme included:

- Establishing a renewable resource centre to raise awareness.
- Identifying relevant stakeholder groups.
- Providing training programmes and awareness-raising events to different stakeholder groups.

To ensure the successful implementation of the project, the NMC appointed a staff member to work and train for the project. The project also sought suggestions and approval from the elected local representatives, holding meetings with local stakeholders. In 2006, the location, design and estimates for the Resource Centre were identified. It was opened to the public in November 2006 to provide information and a point of exchange for RE and EE.

The improved awareness led to support from local politicians and other actors for a new approach to urban energy, which resulted in local policies on RE and EE. The greater awareness amongst politicians, staff and companies on these issues was instrumental to a relatively fast decision-making process. Nagpur was amongst the first Indian cities (in parallel with the same process in the city of Bhubaneswar) to adopt comprehensive sustainable energy policies.

Based on the successes of Nagpur, the city was selected by the Ministry of New and Renewable Energy (MNRE) as one of India's Solar Cities. The status *Model Solar City* made Nagpur eligible for additional national funds. Nagpur also benefited from India's *Jawaharlal Nehru National Solar Mission*, which was initiated in 2010 and targets the installation of 20 million solar lighting systems in homes and streets across the country. In some places, street lights are installed on the outside of houses, while residents keep the batteries of the street lights indoors to prevent theft.

SOLAR LIGHTING IN THE STREETS, IT CAN BE DONE!

Consuming more than 22 gigawatt hour of electricity, street lighting represented the second highest source of electricity consumption for local government operations in 2005-2006 (37% of the total). The initiated RE policies and programmes provided an opportunity to reduce electricity

consumption, while increasing the availability of street lighting. Between 2006 and 2007, NMC installed PV powered streetlights across the city following a lifecycle cost-benefit analysis.

Solar lights and EE light bulbs were tested and compared against each other in different parts of the city. Although the implementation costs were found to be higher for solar lights than for EE lighting systems, as a whole, the benefits of solar lights outweighed those for EE lights. The factors that encouraged NMC to select solar lighting included:

- Compared to other Indian cities, Nagpur is relatively affluent in solar radiation, with more than 300 sunny days a year.
- NMC received additional funds from MNRE (INR 95 million, almost USD 1.8 million) for promoting RE in the city.

RESULTS

Since being part of the *Local Renewables Programme* in 2006, the local government has implemented a variety of actions, including an analysis of the city's energy performance, and initiated the *City Lighting Improvement Project (CLIP)* to improve the illumination levels in the city. The city already features approximately 72,000 street lights. The new system has energy-saving devices, automatic switch-on/switch-off arrangements, closed luminaries/lighting device (to protect against humid or dusty environments), etc. The measures and results (expressed in energy and carbon savings) are presented in table 1.

LESSONS LEARNT FOR REPLICATION:

Different solutions tailored to local resources and conditions Local governments' choices in their public lighting installations are based on the pre-existing regulatory framework, available

Figure 5: Solar Street Light in Nagpur

Copyfight: Nagpur Municipal Corporation

technology and infrastructure, and the initial installation costs and available funds. Each city needs to determine the most suitable technological and economic solution for street lighting within its policy, resource and energy context.

In certain cities, this process could lead to EE lighting combined with RE. The benefits of this strategy can be in terms of cost and a quicker payback for local governments with existing infrastructure and RE electricity supply. In cities where a pre-existing grid is absent or energy supply is not secure, the assessment may conclude, for example, that installing new stand-alone RE sourced public lighting systems, which may or may not be connected to a grid, is cost-effective.

Awareness raising. Street and public lighting contribute substantially to local governments' consumption of electricity. The first step to reduce energy demand and the corresponding GHG emissions is the identification of potential actions that improve the public lighting sectors. Street lighting can also be part of a more integrated approach towards RE and EE across the city. Raising awareness amongst policy makers, the public and other stakeholders is subsequently pivotal. Once the opportunities have been identified, public consultations and awareness campaigns can play an important part in the understanding and approval of new technologies. Experiences and technologies used can be shared amongst communities and cities to accelerate the learning curve.

Cost and life cycle assessments. In cases where local governments have different departments and responsibilities for constructing and maintaining public lighting, calculating the complete costs and payback of installations can be complex. Any initiatives should include other relevant departments to identify benefits and prevent additional costs. Complete life-cycle assessments should also consider other factors, such as the means for disposal of any used lights and batteries including those from the maintenance process.

Figure 6: Lighting Arrangement with 50 Watt Sodium Vapour Lamps

Copyfight: Nagpur Municipal Corporation

National and state targets and policies. Local decisions also depend on national policies and incentives to assist in RE and EE street lighting installation (*e.g.* subsidies or grants). Targets and policies at the federal and state level need to accommodate unique conditions for local implementation. A broad national RE framework should encourage and assist cities by: assessing their present energy consumption status; setting clear targets for and preparing action plans for RE and EE; and providing appropriate financing mechanisms. In this way, national governments can benefit from local action, and accelerate themselves towards reaching nation-wide targets.

Cost saving and GHG reductions in street lighting, Aguascalientes, Mexico (population 0.7 million)

Aguascalientes has committed to reducing GHG emissions. The local government's broad strategy includes, an intervention into the city's street lighting infrastructure to improve efficiency and switch to clean energy. The investments into EE street lighting has allowed for the saving of 55 million kWh between 1996 and 2005. This represents 16% of the local government's total consumption over the same period and a financial saving of approximately MEX 80 million (USD 8 million). The municipality also entered into a purchasing agreement with Comexhidro, a private company operating a 14 MW hydroelectric plant. The agreement allows the municipality to cover 45% of the total street lighting energy needs through RE. As the energy is sold at a cheaper rate than through the national grid, the agreement has allowed for savings of USD 0.6 million between 2005 and 2007. These initiatives have helped to reduce the city's expenditures and carbon emissions.

Source: Commission for Environmental Cooperation, (accessed Nov 2012), Best energy management practices in 13 North American Municipalities, www.cec.org/municipalenergy

Public-private partnerships to promote RE street-lighting, Nairobi, Kenya (population 3.2 million)

Different initiatives have been undertaken in Nairobi to provide the city with solar-powered street lighting. The initiatives are aimed at boosting environmental sustainability, while reducing costs and making residents feel safer. In 2010, Nairobi municipality began installing solar-powered streetlights as part of a climate-change response strategy launched by the Kenyan government in the same year. The project, funded through a USD 10 million investment by the government, aims to light up 12 streets and a major highway. In 2012, under the United Nations Environment Programme's *enlighten initiative*, Philips and the Kenyan Urban Roads Authority jointly conducted a pilot solar-powered LED street lighting scheme on a single avenue of the city. Large energy savings could be made if these solar powered lights were installed on a wide scale across the country.

Source: UNEP (2012), Philips Unveils Solar LED Street Lights in Nairobi as Part of UNEP Enlighten Project, (accessed Nov 2012), www.unep.org/

AlertNet (2011), Solar street lamps help Nairobi see the light, (accessed Nov 2012) www.trust.org/

Leading the installations of energy efficient LED lamps in Germany, Freiburg (population 0.2 million)

The City of Freiburg in Germany is leading the installations of LED lamps in public areas in Germany. In 2010 the city won the Federal Research Ministry competition *Communities in a new light*. A grant of EUR 2 million was given to the German LED model city, which required Freiburg to share its experiences. Using the grant, the local government equipped symbolic public places with LED lights, such as the world famous cathedral and market, the town hall, public gardens and other parts of the inner city. Lamps which had used 250 Watt now run with only 46 watt. The lamps work with self-generated solar power and are not connected to the public grid. These installations result in significant savings in energy consumption and, thus, reduce the operation costs.

Source: City of Freiburg, www.greencity.freiburg.de

Further readings:

See additional relevant case studies at www.iclei.org/casestudies, for example:
110 - Water sector audit enables efficient use of water and energy resources in Nagpur - Nagpur, India I
141 - The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) India

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