1.1.3 Street lighting - Nea Smyrni (GR)

Municipality of Nea Smyrni is one of the seven municipalities of the Southern Sector of Attica Region, located 5,5km south of the center of Athens. Nea Smyrni has a population of 73,090 inhabitants and covers a total area of approximately 3.5Km^2.

The vision of the Municipality of Nea Smyrni is to create an ideal living environment for its residents. To fulfil its vision, Municipality of Nea Smyrni has set itself the following objectives:

- To reduce energy consumption and greenhouse gas emissions in order to act against climate change and global warming potential
- To support renewable energy and efficient management systems for water resources, waste and energy savings
- To enhance the functionality of the municipal fleet and improve its urban infrastructure
- To encourage civil society and create conditions for participation and rallying towards sustainable growth
- To upgrade aesthetically the built environment and support green management of public spaces
- To turn the Municipality into a green and eco - friendly city

Municipality of Nea Smyrni signed the Covenant of Mayors (CoM) adhesion form on April 2010 and submitted its SEAP for approval on December 28, 2012. Within the city of Nea Smyrni, the annual carbon dioxide emissions (CO_2) are estimated at 386,204 tonnes of CO_2.The goal set is to reduce carbon dioxide emissions by 20.3% by 2020, i.e. 76,515 tonnes of CO_2.

Municipality of Nea Smyrni will fully implement street lighting energy savings actions in order to achieve significant reduction of CO_2 emissions. Municipal street lighting consists mainly of HPS, LPS and HPM lamps that annually consumes 2,994MWh of electric energy. Carbon dioxide emissions are estimated at 3,440tCO_2.

Two distinct actions are mentioned in the SEAP document of the Municipality of Nea Smyrni, concerning the street lighting sector:

1. Action1: 100% Replacement of HPM lamps with HPS lamps
2. Action2: 20% Replacement of HPS luminaires with LED luminaires

LED lighting is considered a highly energy efficient technology regarding the potential on energy savings (less power consumption, longer lifetime, remote management and control options) that can cut down the annual operating expenses. In addition, taking into account environmental and socioeconomic perspectives, LED lighting technology also incorporates the following benefits:

1. Eliminates environment disposal of heavy metals pollutants
2. Provides greater thermal photopic and illuminance performance
3. Reduces the number of traffic accidents and acts of vandalism
4. Improves pedestrian and road safety and enhances social-economic development
5. Improves the aesthetics of the surroundings
6. Makes people feel secure and comfortable

Based on the above mentioned benefits, Municipality of Nea Smyrni attractive the overall perspective of LED lighting and therefore will implement an **E**nergy **E**fficient **S**treet **L**ighting (EESL) pilot action; the installation of a new smart (remote monitoring and control) street lighting system of 45 (59w) LED luminaires, capable of advanced functionalities such as adjusting dimming level, on/off timing and diagnosing lamp failure. This pilot EESL action, elaborated by the Municipality of Nea Smyrni in the framework of the GREEN TWINNING project (an Intelligent Energy Europe programme that aims at strengthening the capacity of public authorities in institutionalizing sustainable energy policies into their operations), is a part of a wider urban restoration project, budgeting 1,850,000€.

For comparison purposes in our study, we took under consideration an alternative (base case) scenario; a smart lighting system of 45 HPS luminaires (275w, 250w nominal). Therefore, the cost of the smart lighting system (including the extra investment cost needed for LED luminaires) is now estimated at 166.801€. To estimate energy cost savings, we considered 4,015 hours of annual operation per luminaire, billed at a price of 0.1179 €/kWh (final price). Also, the reduction in the average energy consumption of LED and HPS luminaires is considered to the extent of 40% and 10% respectively, assuming a daily active dimming programme of 5 hours. Concerning maintenance cost savings, LED has a general life expectancy of 50,000h but since dimming lowers overall junction temperatures, we considered an increase of 25,000h.

Therefore, 45 HPS luminaires annually consume 47,427kWh, billed at a rate of 5,592€ per year. Annual maintenance costs, taking into account scheduled lamp replacements and burn-out replacements due to lamp or other component failure, are estimated at 700€. Annual CO_2 emissions are estimated at 33,734Kg.

On this basis, 45 LED light luminaires (59w) annually consume 8,722kWh, billed at a rate of 1,028€ per year (70% less energy cost) and their annual maintenance costs are estimated at 158€ (77% reduction). Annual CO_2 emissions are calculated at 10,021kg.

Hence, relatively to the base case scenario, estimated annual street lighting, the operating cost savings are 5,106€ in total (38,706kWh less energy consumption), while the carbon dioxide abatement is calculated at 44,473Kg CO_2.

To estimate the financial analysis of the pilot EESL action, NPV calculations (of constant

prices), are used based on a 25 years project analysis term, a cost escalation rate of 2% yearly and a nominal discount rate of 6% yearly. NPV analysis showed that the project will not recoup the capital invested. The funding gap is estimated at 49.89% or 80,081€ (NPV).

A cost benefit analysis is then used to take into account the contribution of the pilot EESL action to the social welfare (direct and indirect benefits and impacts throughout the local community, the Municipality and the society). The following methodology is used:

For all previously estimated costs and revenues, new "shadow" prices, free of VAT and any other indirect taxes, are calculated. Specific Conversion Factors (CF) are additionally used for Electricity (0.96), Skilled labor (1.00), Equipment (0.85), HPS Maintenance (0.97) and LED Maintenance (0.88). On this basis, estimated annual street lighting operating savings (energy and maintenance) are now priced at 3,444€.

Then, all externalities such as environmental advantages, safety benefits and socioeconomic welfare enhancements are incorporated into the project (prices are calculated using GDP deflator).

Annual revenues derives from the abatement of air pollutants (CO_2, NOx, SO_2)In total, annual estimated environmental benefits can be summarized in a monetary amount of 5,224€.

Dimmable LED lighting provides significant safety and productivity benefits (natural white color, higher luminous efficacy and better color rendering), resulting in a potential cost decrement of violent incidents and acts of vandalism (2,313€) and road accidents (3,811€). This contribution to the socioeconomic welfare of the Municipality is estimated at 6,124€ per year.

In total, the yearly monetary value of all social benefits of the pilot EESL action is estimated at 14,791€.

The next step is to estimate the cost benefit analysis of the pilot EESL action, using NPV calculations, based on a 25 years project analysis term and a constant "social" discount rate of 3.00% annually. Incorporating all externalities, results show that the action is valued with economic benefits and positive economic performance. Estimated calculated The social NPV of the investment is 108,387€, the social payback period is 9 years, while the social Benefit-Cost ratio equals 1.87.

However, given the downward trend of the production cost in LED industry, future investments and replacement costs are reasonably be expected to be lower than those used in this analysis and thereby shorten the payback period and increase the net present value of the investment.

A sensitivity analysis is then carried out to find the input variables of the EESL action with the highest impact on its financial performance. Results indicated that social investment capital and social revenues are both of major importance (critical variables).

In order to calculate the impact of each critical variable on the project’s performance indices,

a risk analysis is performed. Two asymmetric triangular probability distributions have been selected, one for the social investment capital with a value range of (0.5; 0.8; 1.0) and one for total social revenues with a value range of (0.9; 1.0; 1.5) based on historical data deriving from technical projects. Simulation results, using the Monte Carlo method, show that social investment capital and social revenues risks are low, since there is a 0% probability for negative NPV.

Finally, we undertake a scenario analysis combining the estimated maximum, median and minimum values of the critical variables mentioned above, to build an "optimistic', a "most possible" and a 'pessimistic' scenario. Furthermore, three Social Discount Rates of 2%, 3% and 4% is used in each scenario. Results show that the social capital is fully refunded in all cases. Benefit to Cost Ratio varies between 1.69 and 6.73.

Design and implementation of all EESL actions, require interdepartmental cooperation since they affect a wide range of the municipal functions (buildings, supplies, urban development, etc). EESL actions are supported by the Municipality's Energy Manager and by an organizational structure (Supporting Group) whose synthesis depends on the specific subtasks of the EESL action under consideration. Representation of different municipal Departments in this Group (e.g. Technical Dept., Financial Dept., etc), provides the flexibility and knowledge needed. Supporting Group co-works with all designated supervisors and acceptance committees, in accordance with the Greek and European legal framework and it may collaborate with the energy managers of all contractors involved. Supporting Group also cooperates with the SEAP Working Group, established in the framework of the implementation of the SEAP of the Municipality of Nea Smyrni.

In order to monitor the progress of all EESL actions in a timely manner, Municipality of Nea Smyrni is using project management tools based on the tracking Gantt methodology along with the specific organizational structure of each EESL action (eg subprojects, phases, activities, milestones etc), taking into account time and budget constraints and resources' availability. The "Earned Value Analysis" management methodology is then implemented to track and assess the performance of all EESL actions under consideration. In this way, we use standard cost and time performance indicators along with CO_2 abatement estimates, to simultaneously measure the environmental performance of all EESL actions.

Strategic plan of the Municipality of Nea Smyrni is the funding of all planned EESL actions using any available financial tool. In this framework, the working group submitted the current pilot EESL action under the entitled proposal "Improvement and Restoration of 'Aigaiou' Road" to the national operational programme/ financing instrument "Strengthening Accessibility and Energy Infrastructure - Region of Attica" (EE for public sector) which is co-funded by Cohesion Fund resources. Public procurement process will be an open invitation to tender, of individual discount rates.

Information and results of the EESL action studied are summarized below in Table 3.

Table 2 Summary of the findings of the assessment study of the action "Street lighting in Nea Smyrni"

Technical/ Environmental Assessment	**Title**	*SEAP action assessment study. New case scenario for smart street lighting in Nea Smyrni Municipality.*
	Basic Scenario (kWh, tCO_2, €)	*45 HPS luminaires of 250w nominal power kWh: 47,427 $kgCO_2$:54,494*
	Technology employed	*45 smart LED luminaires*
	Technology providers	*Various*
	Technical specifications	*power 59W, luminous efficacy: ~120 Lumens/watt, color temp: 4,000K, average life:75,000 hours, CRI > 75, IP≥ 65*
	Energy savings	*38,706 kWh*
	CO_2 savings	*44,473 $kgCO_2$*
Financial assessment	**Financing scheme**	*Own funds*
	Project cost	*166,801 €*
	Project reference period	*25 years*
	Annual project revenues	*5,106€*
	Constant Discount rate	*3.92%*
	NPV	*-80,081€*
	Benefit-Cost ratio	*0.50*
	Funding Gap Rate	*49.89%*
Socio-economic assessment	**Project cost**	*129,501 €*
	Annual project revenues	*14,791€*
	Constant Discount rate	*3.00%*
	NPV	*108,387€*
	Benefit-Cost ratio	*1.87*
	Funding Gap Rate	*-86.98%*
	Payback period	*9* **years**
Organisational assessment	**Time schedule**	*1 year*