1.1.2 Street lighting and GIS study - Ilion (GR)

Municipality of Ilion is one of the seven municipalities of the Western Sector of Attica Region, located 8km northwest of the center of Athens. Ilion has a population of 84,793 inhabitants and covers a total area of approximately 7.8Km^2.

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

- To demonstrate commitment to the environmental protection, the efficient use of energy resources and the reduction of CO2 emissions
- To encourage the participation of civil society and create conditions for participation and rallying towards sustainable growth
- To access National and European funds and effectively adapt the new legislation framework towards environmental energy savings
- To gain economic and environmental benefits and improve its infrastructure, through energy savings, use of renewable energy and cooperation with other municipalities or institutions participating in the Covenant of Mayors

Municipality of Ilion signed the Covenant of Mayors (CoM) adhesion form on February 11, 2010 and submitted its SEAP for approval on June 7, 2012. Within the city of Ilion, the annual carbon dioxide emissions (CO_2) are estimated at 364,773tCO_2. The goal set is to reduce carbon dioxide emissions by 20.2% by 2020, i.e. 73,622 tCO_2.

Municipality of Ilion will fully implement energy savings actions on its street lighting sector to achieve significant abatement of CO_2 emissions. Municipal street lighting consists of 8,000 (125w) HPM luminaires and 1,700 (250w) HPS luminaires that annually consumes 6,293,513kWh of electric energy. Carbon dioxide emissions are estimated at 7,231tCO_2.

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

1. Action 1: Adoption of energy efficient technologies
2. Action 2: Development of energy studies

In the context of the first SEAP Action, 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 socioeconomic development
5. Improves the aesthetics of the surroundings
6. Makes people feel secure and comfortable

Based on the above mentioned benefits, Municipality of Ilion finds attractive the overall perspective of LED lighting and therefore will implement an **E**nergy **E**fficient **S**treet **L**ighting (EESL) pilot action; replacement of 260 existing (125w) HPM street luminaires with 260 (60w) LED luminaires. This retrofit action is elaborated by Ilion Municipality 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.

To estimate energy cost savings of the LED retrofit action, we consider 4,015 hours of annual operation per luminaire, billed at a price of 0.1179 €/kWh (final price). Therefore, 260 HPM luminaires (138w, nominal 125w) are billed at a rate of 16,923€ 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 4,183 €. Annual CO_2 emissions are calculated at 164,923Kg.

On this basis, 260 LED light luminaires (60w) are billed at a rate of 7,385€ per year (56% less energy cost) and their annual maintenance costs are estimated at 3,586€ (14% reduction). Annual CO_2 emissions are calculated at 71,966Kg.

Relative to the BAU (business as usual) scenario, the annual energy savings of the retrofit scenario under consideration are estimated at 10,134€ (80,902kWh), while the annual carbon dioxide abatement is calculated at 92,957KgCO_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. The analysis of the retrofit scenario showed that it will not recoup the capital invested. The funding gap is estimated at 9,618€ or 5.7% of the capital invested (NPV). 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 investment capital and energy savings 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 investment capital with a value range of (0.5; 0.8; 1.0) and one for energy savings 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 the investment capital is a low risk variable, since there is only 0.6% probability that the NPV will be negative. On the contrary, energy savings risk is relatively high, since there is a 34.6% probability that the NPV will be negative.

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 discount rates of 2.91%, 3.91% and 4.91% is used in each scenario. Results show that the capital invested is always fully refunded except the three cases of the pessimistic scenario. Benefit to Cost Ratio varies between 0.79 and 3.02.

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), a cost benefit analysis 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), Materials (0.85), HPM Maintenance (0.98) and LED Maintenance (0.88). On this basis, estimated annual street lighting operating savings are now priced at 7,917€.

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

Annual revenues of 10,909€ derives from the abatement of air pollutants (CO_2, NOx, SO_2), while disposal expenses of the hazardous HPM lamps are annually estimated at 25€. In total, annual estimated environmental benefits can be summarized in a monetary amount of 10,934€.

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 (762). This contribution to the socioeconomic welfare of the Municipality is estimated at 3,075€ per year.

In total, the yearly monetary value of all social benefits of the pilot EESL action is estimated at 20,728€.

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. The social NPV of the investment is 242,930€, the social payback period is 6 years, the social Benefit-Cost ratio equals 3.06, while the social Internal Rate of Return is 7.47%.

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 Energy Manager of the Municipality of Ilion 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 Ilion.

In order to monitor the progress of all EESL actions in a timely manner, Municipality of Ilion 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 Ilion is the funding of all EESL actions using any available financial tool. In this framework, the Municipality of Ilion submitted a proposal for the current pilot EESL action entitled "Using LED technology for street lighting of the Municipality of Ilion" to the national operational programme/ financing instrument "Urban Revitalization 2012-2015" which is funded by the public entity “Green Fund”. The budget of the proposal (175,890€) is 100% funded by the national operational programme and the public procurement process is an open invitation to tender, under the EU and Greek legislation framework.

Information and results of the pilot EELS action studied are summarized below in Table 2.

Table 1 Summary of the findings of the assessment study of the action “Street lighting and GIS study in Ilion”

Technical/ Environmental Assessment	**Title**	*SEAP action assessment study.* *Retrofit scenario for street lighting in Ilion Municipality.*
	Basic Scenario (kWh, tCO_2, €)	*260 street lights.* *125w HPM luminaires* *kWh: 143.536* *$kgCO_2$:164.923*
	Technology employed	*60w LED luminaires*
	Technology providers	*Various*
	Technical specifications	*power ≤ 60W,* *power factor: 0.9,* *luminous efficacy: >120 Lumens/watt,* *color temp: 3700-4200K, average life:≥ 50.000*

		hours, CRI >65, IP≥IP 65
	Energy savings	*80,902kWh*
	CO_2 savings	*92,957kgCO_2*
Financial assessment	**Financing scheme**	*Own funds*
	Project cost	*175,890*
	Project reference period	*25 years*
	Annual project revenues	*10,134€*
	Constant Discount rate	*3.91%*
	NPV	*-9,618 €*
	Benefit-Cost ratio	*0.94*
	Funding Gap Rate	*5.68%*
Socio-economic assessment	**Project cost**	*121,550 €*
	Annual project revenues	*20,728€*
	Constant Discount rate	*3.00%*
	IRR	*7.47%*
	NPV	*242,930€*
	Benefit-Cost ratio	*3.06*
	Funding Gap Rate	*-205.86%*
	Payback period	*6 years*
Organisational assessment	**Time schedule**	*15/4/2014-5/9/2014*