

1.1.4 Green roofs on municipal buildings - 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 7.8Km².

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 GHG emissions are estimated at 364,773 tonnes of CO₂. The goal set is to reduce carbon dioxide emissions by 20.2% by 2020, i.e. 73,622 tonnes CO₂.

Municipality of Ilion will fully implement energy savings projects on its building sector to achieve significant reduction of CO₂ emissions. The Municipality is responsible for the operation and maintenance of 45 buildings (sports facilities, technical services, etc) and of 68 school buildings. Municipal buildings annually consume 1,837,992kWh and produce 2,692tCO₂.

Three distinct actions are mentioned in the SEAP document of the Municipality of Ilion, concerning the municipal building sector:

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| Action1 | Energy performance audits under the Greek Regulation of Energy Efficiency of Buildings ("KENAK"). Energy Certificates and Energy Technical Studies are included. |
| Action2 | Implementation of the energy efficiency solutions and services listed in the Energy Technical Studies of KENAK |
| Action3 | Public Awareness Campaign on energy savings projects implemented in municipal buildings |

Concerning the building sector, among various innovative energy efficiency solutions, **Green Roof Construction (GRC)** is intrinsically of greater benefit to the environment and the

biodiversity than more traditional roofing methods, because it can:

1. Decrease electricity consumption at peak demand periods
2. Improve urban microclimate, providing greater thermal performance especially at the hottest temperatures in the summer, along with mental and physical benefits to the people
3. Reduce the distribution of dust and particulate matter throughout the city, as well as the production of smog
4. Moderate the urban heat island effect and the global warming potential
5. Reduce the amount of storm water runoff, resulting in decreased stress on sewer systems at peak flow periods, pollutant reduction and reduction of receiving stream erosion
6. Protect insulation materials beneath the surface layer from substantial overheating and mechanical stress
7. Benefit biodiversity and natural habitats
8. Visually soften the built environment, supporting green management of public spaces
9. Upgrade aesthetically buildings
10. Provide noise and sound insulation
11. Promote environmentally friendly forms of travel and physical activities, such as bicycling and walking

Based on the above mentioned benefits, Municipality of Ilion undertakes a green roof project that will be constructed on the roof top of a municipal nursery school. This action is elaborated by the Municipality of Ilion in the framework of the [GREEN TWINNING](#) project (an [Intelligent Energy Europe](#) programme that aims at strengthening the capacity of public authorities in institutionalising sustainable energy policies into their operations).

Concerning the building of the nursery school, it is built in 1995 with double glazing windows, wall and roof insulation. New roof thermal insulation will be added, prior to the green roof construction. Green roof consists of two separate parts, a ground floor roof and a first floor roof. On the ground floor, a semi-intensive green roof type will be constructed and on the first floor an extensive type one.

Green roof will cover an area of 480.2m², using native plant species from the Mediterranean flora (*Lavandula andustifolia*, *Rosmarinus officinalis*, *Santolina chamecyparissus*, *Hellichrysum italicum*, *Artemissia absinthium*, *Salvia triloba*, *Phlomis fruticosa*, *Capparis spinosa*). Plants selected are hardy, drought, sun tolerant, have non-woody roots and therefore non extensive maintenance effort will be required.

Technical studies concerning the static loads and the drainage capacity of the green roofs are

implemented, thus ensuring the adequacy of the construction and the safety of the users. Construction work and materials meet DIN and EN standards and fully comply with the current construction regulatory framework. Furthermore, they satisfy the German FLL guidelines that are in turn associated with DIN and EN standards and relative legislative requirements. About maintenance work, the contractor provides a detailed handbook and a thorough maintenance timetable for all construction layers of the green roof, the vegetation and the irrigation system.

The GRC project budget is estimated at 159,051€. In our analysis an amount of 35,000€ is excluded from investment cost, spent on the reconstruction of the existing roof insulation of the building (mandatory cost). To calculate the annual energy savings, a state of the art dynamic energy simulation software (TRNSYS) is used. Results show that green roof construction reduces the energy consumption of the building by 921kWh/y, giving an annual profit of 127€. On the other hand, the annual estimated cost of maintenance work is 700€.

It is more than clear that the pilot GRC action under consideration - as an ex-post energy saving investment - will not pay back the capital invested, as annual maintenance expenses are greater than annual energy savings (in case of a new construction or a non insulated building the opposite trend is rather probable).

A cost benefit analysis is then used to take into account the contribution of the GRC action to the socioeconomic welfare of the municipality (direct and indirect benefits throughout the local community, the municipality and the society - not to the building itself). The following methodology is used:

For all expenses and revenues previous estimated, new "shadow" prices are calculated (free of VAT and any other indirect taxes). Specific Conversion Factors (CF) are additionally used for Electricity/Oil (0.96), Skilled labor (1.00), Materials (0.85), Unskilled Labor (0.80) and Investment/Residual value (0.91). New estimates for annual energy savings and annual maintenance cost are now priced at 76€ and 545€ respectively.

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

Reductions of energy and fuel consumption result in carbon dioxide mitigation. Furthermore green roof is expected to have positive air quality benefits. Airborne particulates, nitrogen oxide, ozone, sulfur dioxide, and carbon monoxide levels have been assumed to decrease in the presence of green roofs. Air quality benefits can be summarized in a total monetary amount of 117€ per year.

Three types of storm water benefits are estimated due to the application of green roof, water management savings, reduction of pollution incidents and reduction of receiving streams' erosion, all summarized in a yearly monetary amount of 856€.

Consumption of products relative and/or complementary to the Green Roof sector and the

Gardening sector, local job creation (maintenance work) and aesthetical upgrading of the neighborhood along with mental and health benefits for the building users and the neighborhood residents, can be all assessed up to 5,000€ yearly.

On this basis, total annual social revenues are estimated at 6,049€.

The next step is to estimate the cost benefit analysis of the pilot GRC action using NPV calculations of constant prices, based on a 30 years project analysis term and a constant annual "social" discount rate of 3.00%.

Incorporating all externalities, the project is valued with a considerable total socioeconomic benefit of 28,245€ (NPV). The payback period is now 15 years and the Benefit-Cost ratio equals to 1.31.

A sensitivity analysis is then undertaken to find the project's input variables with the highest impact on its financial performance. Results indicated that the social investment capital and social revenues are 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, a Social Discount Rate of 2%, 3% and 4% is used in each scenario. Social capital is fully refunded except the 4% discount rate's pessimistic scenario. Benefit to Cost Ratio varies between 1.10 and 3.95 (exception value: 0.99).

Design and implementation of all GRC projects, requires interdepartmental cooperation since they affect a wide range of municipal functions (buildings, supplies, urban development, etc). GRC 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 GRC 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 follow the progress during the implementation phases of all GRC actions

(designing, monitoring and reporting) in a timely manner, Municipality of Ilion is using project management tools, based on the tracking Gantt methodology and the GRC organizational structure (eg projects, 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 GRC actions under consideration. In this way, we can use standard cost and time performance indicators along with the CO₂ abatement estimates, to simultaneously measure the environmental performance of all GRC actions.

Strategic plan of the Municipality is the funding of all SEAP GRC actions using any financial tool available. In this framework, the Municipality of Ilion submitted a proposal for the current pilot GRC action entitled "Green Roofs for public buildings in Ilion Municipality" to the national operational programme/ financing instrument entitled "Environment and Sustainable Growth" (EE for public sector) which is co-funded by Cohesion Fund resources. The proposal's budget of 173.879€ is expected to be entirely funded by the national operational programme. Public procurement process will be an open invitation to tender, under the EU and Greek legislation framework.

Project information and results are summarized below in Table 4.

Table 3 Summary of the findings of the assessment study of the action "Green roofs on municipal buildings in Ilion"

Technical/ Environmental Assessment	Title	SEAP action assessment study. Green Roof Construction at a municipal nursery school of Ilion
	Technology employed	Extensive and Semi-intensive type (two parts)
	Technology providers	Various
	Technical specifications	Area: 480.2 m ² Construction and maintenance tasks and materials comply with FLL guidelines, DIN, EN standards and current EU,GR regulatory and legislative framework
	Annual Energy savings	921 kWh
	Annual CO₂ savings	1,168 kgCO ₂
Financial assessment	Financing scheme	Own funds
	Project reference period	30 years
	Project cost	124,051€
	Annual maintenance costs	700€
	Annual project revenues	127€
	Constant Discount rate	3.92%
	Funding Gap Rate	100%

	NPV	-129,368€
	Benefit-Cost Ratio	0.02
	Payback period (years)	-
Socio-economic assessment	Project cost	82,025 €
	Annual maintenance costs	545€
	Annual project revenues	6,049€
	Constant Discount Rate	3.00%
	Funding Gap Rate	-35.47%
	NPV	28,245€
	Benefit-Cost Ratio	1.31
Organisational assessment	Payback period	15 years
	Time schedule	5/2/2014-16/5/2015