Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

INSMART

Integrative Smart City Planning

Mid-Term Implementation Action Plan

Trikala

D-WP 6 – Deliverable D.6.3

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Executive Summary	
The interventions promoted through the MCDA process for the sustainable development of the energy sector of Trikala are further analysed using a pre-feasibility economic viability analysis. Alternative funding schemes are discussed and the most appropriate schemes for each intervention are proposed. The steps of a ten years implementation plant are deployed presenting a time schedule for the actions, the resources required and KPIs for the monitoring of the implementation of the programme.	
Keywords	SEAP, economic viability analysis of interventions, appropriate funding schemes, ten years implementation plan, monitoring KPIs.

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Acronyms and Definitions

CF	Cohesion Fund
DEYAT	Municipal Enterprise for Water and Sewage of Trikala.
ELENA	European Local ENergy Assistance
ERDF	European Regional Development Fund
ESCO	Energy Service Company
ESF	Economic Support Fund
FEC	Final Energy Consumption
JESSICA	Joint European Support for Sustainable Investment in City Areas
LED	Light Emitting Diode
MCDA	Multi-Criteria Decision Analysis
SEAP	Sustainable Energy Action Plan

1. Introduction

In the framework of the INSMART project, the methodology that was applied led to the identification of a set of measures for the sustainable city development in a time horizon until 2030. The key points in this methodology are

- the integrative approach incorporating all the energy consuming and producing sectors in the city which are analysed in an Energy Systems Model,
- the use of specialised models for buildings and transport to provide inputs for the Energy System Model
- the inclusion of all stakeholders in the process of identification of appropriate actions through a multi-criteria approach that takes into account not only quantitative but also qualitative issues.

The final outcome of this process is the development of an action plan for sustainable energy development which is substantially different from the Sustainable Energy Action Plans developed by all the cities involved in the project some years ago. The following table presents the main differences between the two approaches for the city of Trikala.

Table 1.1: Comparison between the previous SEAP approach and the INSMART approach for the sustainable energy development.

	Previous SEAP Approach submitted in 2010	INSMART Approach
Approach	Top-Down with actions identified from the Municipality.	Bottom-up with action identified through a consultation process (workshops with all the local stakeholders).
Sectors	Public/Municipal buildings and street lighting. Transport and residential/commercial buildings were not included.	Includes all the energy consuming sectors within the city Residential, Municipal, Commercial, Transport (industry and agriculture are not included).
Emissions (type)	CO_2 only	CO_2 and local emissions (e.g. particulate emissions).
Measures	Simulation Cost/Benefit for each individual measure.	Optimisation approach using an Energy Systems approach and simulation (what is analysis in certain scenarios).

1.1. Interventions promoted through the MCDA process

The MCDA analysis described in detail in Deliverable "D5.6. Report on the multi-criteria methodology, the process and the results of the decision making – Trikala, Greece" identified a set of acceptable actions by all the stakeholder groups in the city. These actions are presented once again below, since they will be further analysed in the following sections:

Cycling routes: construction of cycling routes with a length of 2.8km in the next 2-3 years and an extra 10km in the next 10 years.

Mobility ring road: construction of the ring road around the city which leads to a reduction of the transport load through the city centre.

Green spaces: implemented in all the city squares and open spaces, in order to reduce the cooling demand of buildings in the city. According to relevant studies it is expected that the cooling energy demand in buildings will be reduced by 5% by 2030 once Green open spaces techniques are applied in the whole of the city.

Buildings All: refurbishment of all the Municipal Buildings following the example of the upgrades of the 16 buildings included in the Baseline scenario. The refurbishments focus on the reduction of thermal and cooling loads and the improvement of lighting installations.

Buildings 80: 80% of the buildings within the geographical limits of the municipality are connected to the natural gas network by 2030. This includes both residential and non-residential buildings.

Street lighting: replacement of existing sodium street light bulbs with high efficiency LED lamps is implemented.

Vehicles replacement: replacement of ten existing municipal small vehicles by electric cars. Furthermore, all the municipal heavy duty vehicles (trucks, refuse collection trucks etc.) will be replaced by Euro 6 vehicles in the next 15 years.

Sewage treatment: The sewage treatment plant is a considerable consumer in the energy system of the city (WP4 data). Based on studies that were already done the energy consumption can be reduced by at least 25% with the use of special bacteria with limited extra cost. This action can be implemented by 2019.

Hybrid/electric cars: Introduce incentives for the promotion of hybrid or electric cars in the city center. This action was identified as acceptable for the Municipality but did not appear in the ranking for the other stakeholder groups.

2. Economic Viability Analysis

2.1. Methodology

Some of the interventions included in the list presented in Section 1.1, are interventions that are not only related to energy. They can be better described as infrastructure projects related to transportation (cycling routes and the new ring road) or related to the overall city planning (green spaces). The energy related benefits of these projects are in a sense "side effects" since their main target is the improvement of transportation and living conditions within the city. For this reason a cost/benefit analysis only on the basis of energy savings cannot be done for these projects, and the only way to assess them is by identifying total costs and energy savings (as was done in the TIMES model analysis) and include them in the overall city planning. For this reason the first three interventions (cycling routes, new ring road and green spaces) are not analysed using the economic viability analysis in the next section. The last intervention in the list which refers to the introduction of incentives for the promotion of hybrid/electric cars is also a measure that cannot be assessed with a standard economic viability approach. The measure refers to the introduction of tolls to conventional cars entering the city centre, which offers a competitive advantage to hybrid/electric cars when citizens make a decision for car replacement, and therefore the standard economic analysis described below cannot be applied.

The remaining interventions are analysed using a pre-feasibility analysis approach. This includes the estimation of investment costs, annual energy savings, and therefore annual cost savings over the whole lifetime of the intervention. Based on the annual cash flows, the discounted payback period of each intervention is calculated using the *Economic Viability Calculation in accordance with VDI 2067* [1]. VDI 2067 uses the annuity method for investment viability analysis, where the initial investment costs are annualised over the entire life time of the equipment. Annual costs are added, which include the operational and maintenance costs and the energy related costs for each intervention that is analysed. Since we study the economic viability of energy efficiency measures the existing situation is compared with the new situation in order to compare the economic savings and calculate the discounted payback time of the investment. This procedure offers a first financial screening of the interventions and is used in following sections for the identification of funding schemes, required resources and implementation steps.

In all the economic calculations a discount rate of 5% was used (the same as in the TIMES model), representing a "social discount" rate from the point of view of the Municipality.

2.2. Economic Viability Analysis

Refurbishment of Municipal buildings.

According to the scenario formulation, the refurbishment of all Municipal buildings can lead to a reduction of 20% in their annual energy consumption for space heating, cooling and lighting. The annual costs in the existing situation and the in the situation after the refurbishment are shown in Table 2.1 (see Appendix I for details). It is assumed that the operation and maintenance costs remain the same and the only difference between the two situations comes from the energy consumption costs. The calculated payback time is rather large, something that is expected for interventions that are related mainly to the improvement of the building shell. Therefore, from a pure economic point of view, these refurbishments might not be very attractive; however they can be funded by grants and they contribute to the improvement of the thermal comfort in the Municipal buildings.

Table 2.1: Annualised costs and economic viability of Municipal Buildings Refurbishment

Euro/year	Existing	Refurbishment
Investment Cost	0	95,955
Consumption Costs	481,729	385,383
Operational Costs	0	0
Total Costs	**481,729**	**481,338**
Payback Time (years)		29.88

The following Figure 2-1 presents the annualised flows (assuming constant cash flows over the whole life time of the investment – see Appendix I for details). The figure (and Table 2.1) presents three categories of costs:

- Annualised investment costs (using the discount rate of 5%);
- Consumption costs which refer to the cost of energy consumed, in this particular case, diesel for space heating and electricity for space cooling and lighting;
- Operational costs, which include any other annual costs related to the operation and maintenance of the equipment. In this case these are taken to be zero in both cases, since we assume that the interventions will not alter the operation and maintenance costs.

The comparison of the three bars and the bar for the total costs between the existing situation and the refurbishment shows annual differences in discounted cash flows between the two situations.

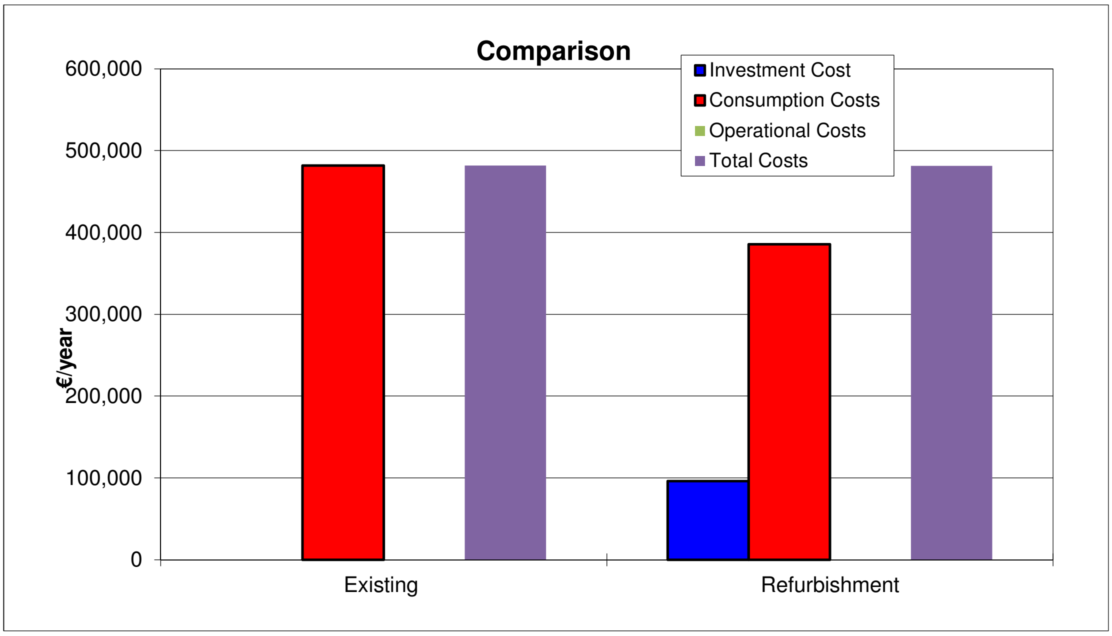

Figure 2-1: Comparison of annualised costs for the refurbishment of Municipal buildings.

Connection of 80% of buildings to the N. Gas Network

Connecting 80% of the building stock of Trikala to the N. Gas network that is currently under expansion and replacing the existing diesel boilers with gas boilers, can contribute significantly to the reduction of the overall consumption for space heating in the city. The initial investment costs include the connection cost to the grid and the cost of replacing the existing boiler. The huge reduction in the consumption costs that can be seen in Table 2.2 is due to the improvement of efficiency (from existing old diesel boilers to new gas boilers) and the lower relative price of natural gas. The discounted payback time of this intervention is very attractive.

Table 2.2: Annualised costs and economic viability of connection to the N. Gas grid

Euro/year	Existing Diesel Boilers	New Gas Boilers
Investment Cost	0	302,459
Consumption Costs	3,718,414	1,871,868
Operational Costs	111,337	111,337
Total Costs	**3,829,751**	**2,285,663**
Payback Time (years)		3.27

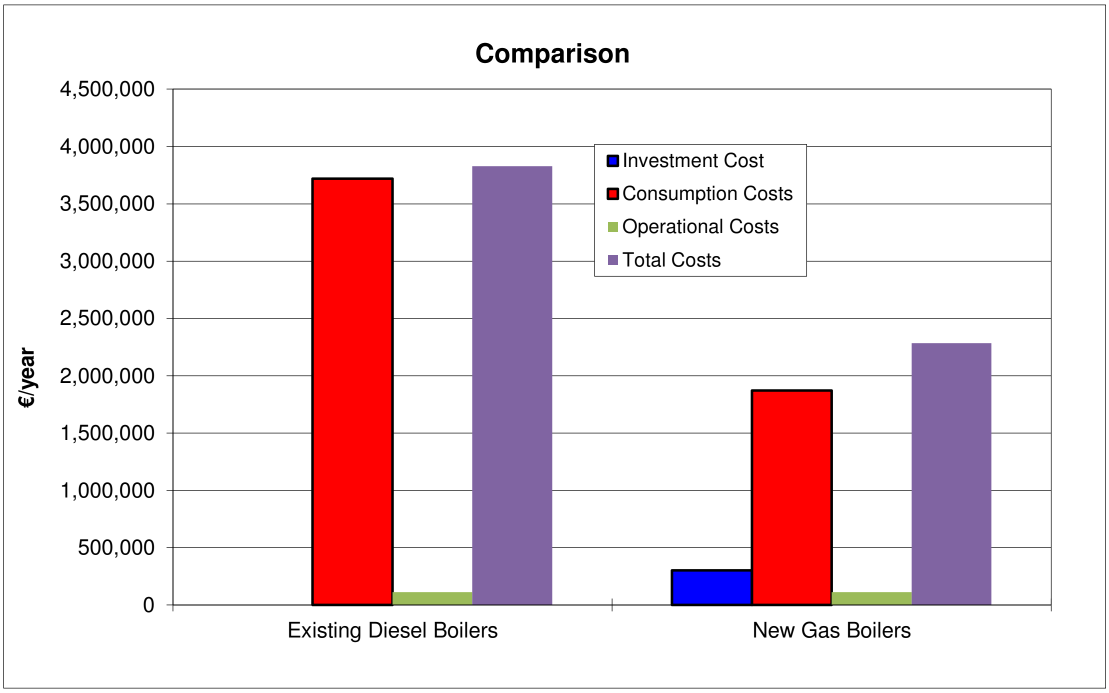

Figure 2-2: Comparison of annualised flows for the connection of buildings to the N. Gas grid.

Comparing the annualised total costs in Figure 2-2 between the existing diesel boilers scenario and the new gas boilers scenario, the economic advantage of the proposed intervention is obvious, with a reduction of the order of 40%.

Replacement of Street Lighting with LEDs

Replacing the existing sodium street lights with LED lights has a discounted payback period of slightly over three years, which makes the investment very attractive. The Municipality is already in the process of implementing this measure in parts of the street lights and will extend it gradually to the whole of the city. The reduction in the electricity consumption costs is dramatic, due to the large increase of lighting efficiency.

Table 2.3: Annualised costs and economic viability of street light replacement

Euro/year	Existing Sodium Lights	LED Lights
Investment Cost	73,111	236,933
Consumption Costs	911,721	364,689
Operational Costs	30,000	30,000
Total Costs	**1,014,832**	**631,622**
Payback Time (years)		3.39

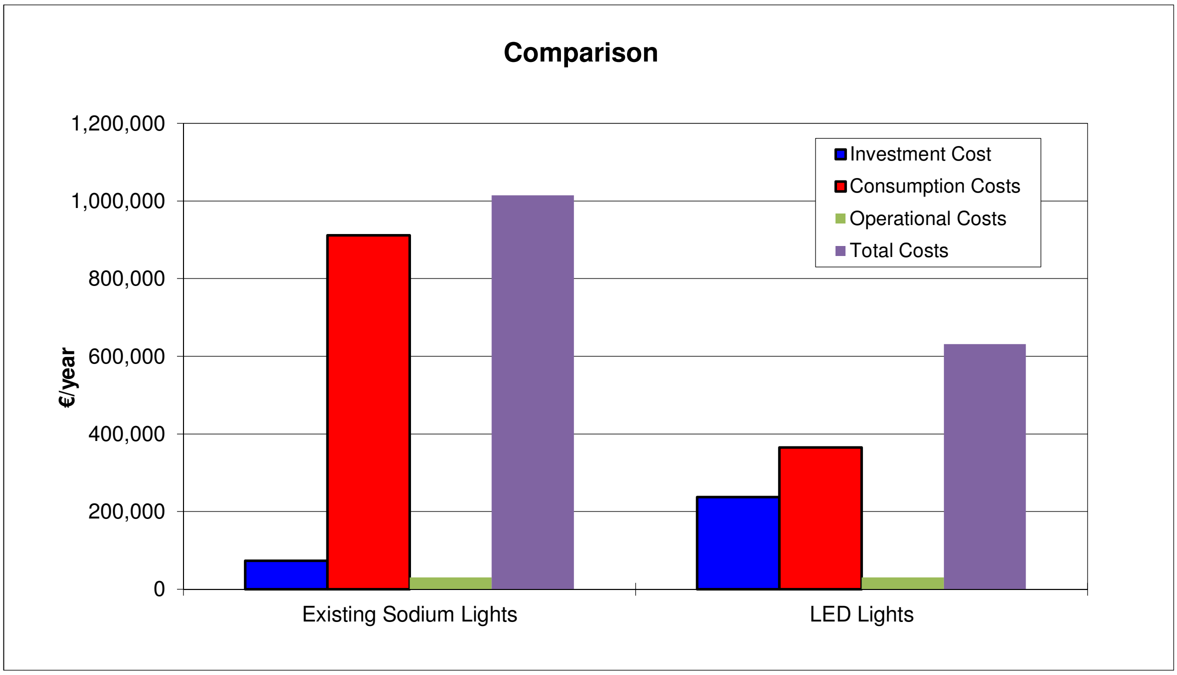

Figure 2-3: Comparison of annualised flows for the street lights replacement.

As can be seen in Figure 2-3, the effect in the reduction of the annual costs is pronounced with a reduction a 60% in the consumption costs, which counteracts the increased annualised cost on investment to LED lights. The total annualised costs are reduced by 37% (taking into account the annualised investment cost).

Replacement of Municipal Vehicles

The Municipality owns some small cars and a number of trucks which will be gradually replaced with electric cars and more efficient trucks over a period of fifteen years. The payback time of the overall intervention is not so attractive, so it might be possible to split the action, replacing first the older trucks that have a high mileage and gradually replace the other vehicles as well.

Table 2.4: Annualised costs and economic viability of Municipal vehicle replacement

Euro/year	Existing Vehicles	New Vehicles
Investment Cost	204,912	253,050
Consumption Costs	456,126	356,840
Operational Costs	115,500	119,000
Total Costs	**776,538**	**728,890**
Payback Time (years)		12.94

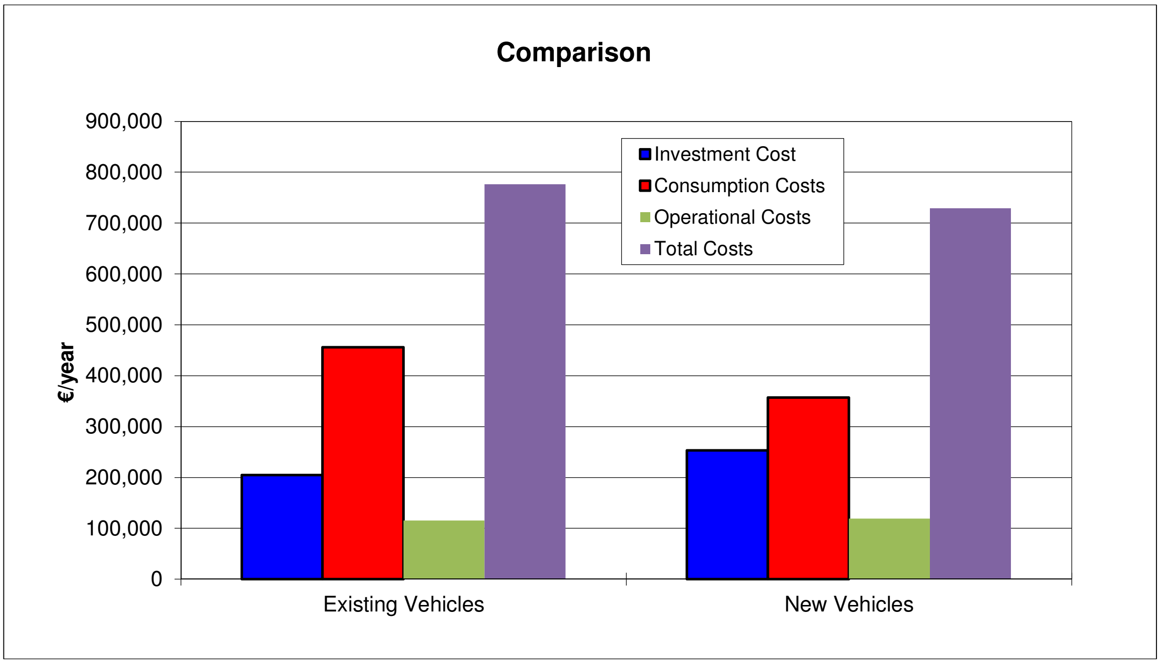

Figure 2-4: Comparison of annualised flows for the Municipal vehicles replacement.

The replacement of all the Municipal vehicles by electric cars and more efficient trucks, leads to a reduction of the annual consumption costs of the order of 22%. (Figure 2-4). However the total annualised costs are only 6% lower with the new vehicles (due to the relatively high cost of acquiring the new vehicles).

Sewage Treatment Plant Interventions

The sewage treatment plant interventions are already planned by DEYAT, the Municipality owned company that is responsible for water supply and sewage treatment. The pre-feasibility analysis shows that the measure is attractive from the economic point of view, with a rather short payback time and a considerable reduction to the annual energy costs of the plant (25% reduction). The reduction of the total annualised costs is at the level of almost 20% (Figure 2-5).

Table 2.5: Annualised costs and economic viability of sewage treatment plant upgrade

Euro/year	Existing	Intervention
Investment Cost	0	10,955
Consumption Costs	210,532	157,899
Operational Costs	0	0
Total Costs	**210,532**	**168,854**
Payback Time (years)		3.80

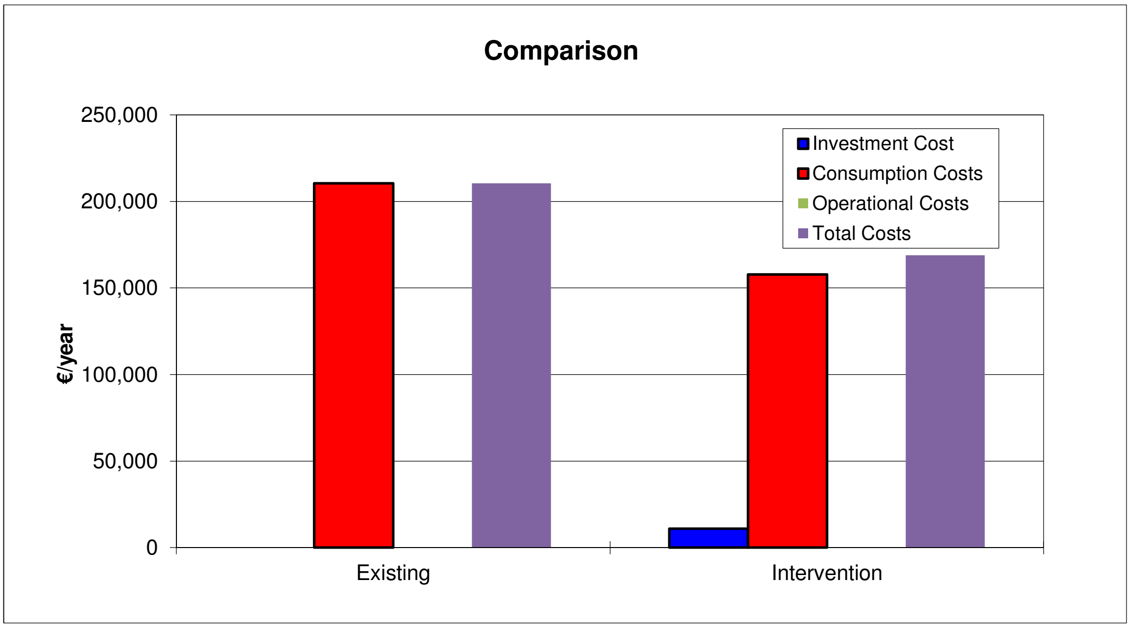

Figure 2-5: Comparison of annualised flows for the sewage treatment plant upgrade

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3. Proposed funding schemes

3.1. Available funding schemes

Funding possibilities for energy related projects in Greek Municipalities can in general be divided into the following three categories:

- National funding programmes co-funded by European Union Funds (ERDF, ESF, CF).
- Funding programmes at the EU level.
- Loans.
- Energy Performance Contracting.

National funding programmes co-funded by European Union Funds (ERDF, ESF, CF).

Historically, most of the funding for energy related projects in Greek Municipalities so far came from the Operational Programme for Competitiveness and Entrepreneurship II, the Operational Programme for Environment and Sustainable Development and the Regional Operational Programmes. The Operational Programme for Competitiveness, Entrepreneurship and Innovation (2014-2020) is the currently active programme that will cover energy savings interventions in a number of programmes:

"Exoikonomo katoikon" programme which covers energy saving interventions in residential buildings. The programme was interrupted for a period but is currently in the stage of starting again with a total amount of 400 million Euros offering up to 70% funding for individual projects of up to 25000Euros. This is the ideal programme for covering the refurbishment of the residential building stock and the connection of residential houses to the natural gas network, with the corresponding replacement of the individual boilers.

Funding programmes at the EU level.

JESSICA: Joint European Support for Sustainable Investment in City Areas

JESSICA was developed by the European Commission in collaboration with the European Investment Bank (EIB), and the Council of Europe Development Bank (CEB). Through the procedures of JESICA, member States are being given the option of using some of the EU Structural Funds, to make repayable investments in projects forming part of an integrated plan for sustainable urban development. These investments, may take the form of equity, loans and/or guarantees, and they are delivered to projects via Urban Development Funds and, if required, Holding Funds. JESSICA is not a new source of funding for Member States, but rather a new way of using existing Structural Fund grant allocations to support urban development projects.

An integrated approach is necessary for projects to be funded by JESSICA. The funds could be targeted specifically at projects such as:

- urban infrastructure, including transport, water/wastewater, energy, etc;
- heritage of cultural sites for tourism or other sustainable uses;
- redevelopment of brownfield sites, including site clearance and decontamination;
- office space for SMEs, IT and/ or R&D sectors;
- university buildings, including medical, biotech and other specialised facilities;
- energy efficiency improvements.

According to the Urban Development Funds (UDF) that have been set up in Greece, Piraeus Bank is the competent UDF for the regions of Central Macedonia and Thessaly. A call for the submission of proposals is open and the basic requirement is to prepare a business plan, providing, at least the following evidence:

• The revenue generating ability of the project so that to repay Urban Development Funds' investment

• The social benefits for local communities arisen through the implementation of the project

• Eligibility of expenditures according to Structural Funds and National rules

• The contribution of the project to the achievement of the objectives set into the respective Priority Axis of the Operational Program that contributed resources to the UDF through the Holding Fund.

• Project implementation is not feasible without JESSICA funding.

In this sense the approach developed in the INSMART project can be used as a starting point for the submission of a proposal for JESICA funding.

ELENA – European Local ENergy Assistance

ELENA is a technical assistance mechanism which supports regional or municipal authorities in speeding up theirs investment plans on energy efficiency and renewable energy. ELENA is run by the European Investment Bank (EIB), and is funded through the European Commission's Horizon 2020 programme. ELENA covers up to 90% of the technical support cost needed to prepare the investment programme for implementation and financing. This could include feasibility and market studies, programme structuring, energy audits and tendering procedure preparation. ELENA helps local authorities to get their projects on the right track and make them bankable, whether it is for retrofitting or integrating renewable energy in public and private buildings, energy-efficient district heating and cooling networks or innovative, sustainable and environmentally-friendly transport systems. As an example, currently ELENA funds with 1.5 million euros a project in the Region of Epirus[1] for the development of efficient and eco-friendly transportation, public lighting and buildings in the region. The Project Development Services (PDS) financed by ELENA will provide support to implement the Investment Programme in the Region of Epirus, and will last from August 2016 to July 2019.

European Energy Efficiency Fund (EEE-F)[2]

Since July 2011, the European Commission created the European Energy Efficiency Fund, in order to finance energy saving and renewable energy projects. The focus will be on projects in urban areas which can lead to energy savings of at least 20%. As an example, projects financed by the EEE-F include retrofit of schools, public lighting upgrades etc. The eligible investments are investments in energy efficiency and renewable energy projects in the range of €5m to €25m. The investment instruments include senior debt, mezzanine instruments, leasing structures and forfeiting loans (in cooperation with industry partners). Also possible are equity (co-)investments for renewable energy over the lifetime of projects or equity participation in special purpose vehicles, both in cooperation directly with municipalities, or with public and private entities acting on behalf of those authorities. Debt investments can have a

[1] http://www.eib.org/attachments/documents/epirus_project_factsheet_en.pdf
[2] http://www.eeef.lu/

maturity of up to 15 years; equity investments can be adapted to the needs of various project phases. The Fund can (co-)invest as part of a consortium and participate through risk sharing with a local bank

Loans.

The current economic situation in Greece, is not particularly positive for the use of loans in order to cover part or whole of the investment cost of energy related projects. However, the Deposit and Loans Fund (DLF) has offered loans up to 100 million euros to municipalities, and 40% of these funds were for energy related projects. Furthermore, the Fund will announce two programs for the acceleration of studies for municipality projects at a level of 14 million euros for the years 2016 and 2017. The aim is to fund studies that can lead to investment in projects of up to 100 million euros, which can be a good opportunity for the projects identified within INSMART for Trikala. Finally, a programme for the increased liquidity in municipalities is currently operational by the DLF, at a level of 50 million euros.

Energy Performance Contracting.

The possibility of the involvement of an ESCO for the implementation of some of the implementation projects that are described in the previous sector is one of the possible options that should be examined in detail. Public lighting investment project are ideal to be funded by ESCO, and the municipality is already in an advanced state of discussions.

Although the legal framework has been put in place over the last years, EPCs applications in Greece and especially in the public sector are non-existent. Currently a project funded by the Ministry of Environment and Energy is aiming to the pilot application of ESCO projects in public buildings, in order to examine in practice the barriers, problems and needs for the application of EPCs in the refurbishment of public buildings.

3.2. Proposed financing approach

In order to find the most appropriate financing option for each of the proposed interventions in Trikala, a number of criteria were used for ranking the alternatives presented in the previous section.

These criteria are:

1. Time availability of a financing source.
   As was described in Section 3.1 different financing schemes have different implementation time frames. For instance the national funding programs are part of the operational programs that last until 2020, therefore they are more suitable for short – term actions. Energy Performance Contracting could be more appropriate for actions with lower payback time, while the EU managed funds would be more appropriate for medium to long term actions.

2. Experience in the Municipality of Trikala in using a financing source.
   The experience of the Municipality employees to deal with the bureaucracy and proposal procedures associated with the different financing schemes can be crucial for the success of a project. The Municipality of Trikala has experience in submitting proposals to national funds and has already implemented projects under these schemes. Furthermore, they are currently running and EPC project related to street lighting which will be extremely useful for acquiring expertise in the implementation of similar projects. European schemes like JESICA and HELENA and EEEF are relatively new for the Municipality of Trikala, therefore it will require some time for the staff to get acquainted with these approaches, make them more appropriate for longer-term actions.

3. Level of financing needed.
   The level of financing needed can affect the type of financing instrument used. For a high investment, like to one needed for the refurbishment of all the residential buildings, the municipality will advise its citizens to get either individual loans with low interest rates (like in the case of Exoikonomisi katikon programme). The level of financing needed for transport intervention will have to come from the state budget.

4. Level of co-funding needed.
   Some of the financing instruments require a level co-funding by the municipality, while others offer the full amount either as grants or as loan. The municipality will have to decide which instrument to choose taking into account the availability of its own funds in order to cover part of the capital requirements.

Taking into account these criteria, the following matrix of financing sources versus interventions was created and is presented in the following pages.

Interventions	National Funding Programmes	Funding programmes EU Level	Energy Performance Contracting	Loans	Own Funding
Cycling routes	National financing schemes can cover part of the cycling routes costs.				Part of the funding for cycling routes can come from Municipality's own funding.
Mobility ring road	National financing schemes for transport cover most of the cost of the ring road.				Part of the funding for the intervention can come from Municipality's own funding.
Green spaces	National financing schemes are available. The Municipality should set up proposals for the funds.				Part of the funding for the Green Spaces can come from Municipality's own funding.
Refurbishment of all Municipal Buildings		The Municipality should coordinate with the other municipalities in the Region and examine the possibility of setting up a proposal under HELENA to help them cover part of the costs of the studies and prepare for an application under JESSICA in order to obtain funds for the refurbishment of Municipal Buildings.	The EPC principle could be tested for refurbishment of Municipal Buildings at a later stage, once implementation issues are cleared. The outcomes of the current project on the implementation of EPCs by CRES can provide know-how to the Municipality.		Part of the cost could be covered from own funding by the Municipality.
Connection of 80% of the buildings to the N. Gas grid.	The connection of buildings to the gas grid could be covered by the "Exoikonomisi katoikon" programme for residential buildings (together with the cost of replacing the burner/boiler when necessary) .			Non-residential buildings could cover the cost through loans and own funding.	Non-residential buildings could cover the cost through loans and own funding.

Street lighting			EPC is already implemented as an approach for upgrading a small part of the street lighting system in Trikala. It is proposed that the same financing approach is followed since the experience gained in the project and implementation will be very useful for the future extension to the whole of the public/street lighting system of the city. The Municipality should formulate a standard Energy Performance Contract based on the experience gained in the project under implementation, and use this in the future projects.		
Municipal Vehicles replacement	The possibility of including part of the replacement in National programmes will be examined.	The possibility of including part of the replacement in EU programmes should be examined.			The replacement costs of vehicles can be covered from the Municipality's own funding.
Sewage treatment					The costs for the upgrade of the sewage treatment plant will be covered from the own funding of DEYAT.
Hybrid/electric cars	The Municipality can include the construction of charging stations in an overall EE programme that can be funded by National Programmes.	The Municipality can include the construction of charging stations in an overall EE programme that can be funded by EU programmes.			The cost of having a hybrid/electric car will have to be covered by the individuals who buy them.

4. Ten years implementation plan steps

The time schedule for the implementation of the interventions identified in the INSMART project is crucial in order to ensure that the different actions are progressing and progress is monitored continuously. Setting an exact timing the each action is not feasible and therefore a distribution was done for the interventions in the following categories:

1) Immediate: actions that can be implemented in the next 1-2 years.
2) Intermediate: actions that can be implemented in the next 3-5 years.
3) Longer term: action that can be implemented in the 6-10 years.

Since the time horizon of planning using the Energy Systems Model was until 2030, the team prioritised the activities in a time horizon of ten years.

The other important topic that should be included in an implementation plan are the required resources (monetary and personnel) for the implementation of each action. An estimation of the required monetary resources was done in Section 2.2, and in the following Table 4.2 these are divided into resources required from the Municipality and resource that should be covered by other sources.

Finally, in order to ensure the effective implementation of an action plan, it is important to define well documented, easily computable Key Performance Indicators. These will be used for monitoring the implementation and taking corrective action if and when needed.

These three elements, namely timing, resources and monitoring are presented in the following three tables for each one on the actions foreseen in the sustainable energy plan for Trikala, for the next ten years.

Table 4.1: Intervention Time Schedule

Interventions:	Immediate	Intermediate	Further ahead
Cycling routes		The first set of cycling routes is planned for the next 2-3 years.	The full length of cycling routes will be deployed over the next ten years.
Mobility ring road		The finalisation of the new ring road is planned in the next five years.	
Green spaces			The development of Green spaces is extended in a longer term than ten years.
Buildings All		The refurbishment of Municipal buildings is planned in the next five years.	
Buildings 80	The connection of		But the target is expected

	buildings to the grid network will start immediately		to be achieved in a time horizon of 10-15 years.
Street lighting	The first projects for street lighting is implemented immediately	The final target will be achieved in a time horizon of five years.	
Vehicles replacement			The replacement of vehicles will be gradually done in the next fifteen years.
Sewage treatment		The implementation of EE measures in the sewage treatment plant is planned for the next 3 years (operation in 2019).	
Hybrid/electric cars			The replacement of cars with hybrid or electric vehicles is a long term goal. The incentives and the required installations of charging points should be planned properly.

Table 4.2: Required Resources

Interventions	Investment Costs covered by the Municipality	Municipality Staff Engagement	Costs external to the Municipality
Cycling routes	A part of the investment could be covered by the Municipality depending on the outcome of the proposals submitted for the National Funds.	The transport department will be actively involved in the planning and implementation of the project.	National financing schemes will cover part of the costs. The share could be up to 100%.
Mobility ring road		The transport department will be actively involved in the planning and implementation of the project.	National budget will cover most of the cost of the ring road.
Green spaces	Part of the investment will come from the Municipalities own funding.	The dept. responsible for parks and roads maintenance will be actively involved in the planning and implementation of the interventions.	Part of the investment will come from national financing schemes. The actual share will depend on the programme and the proposals but it could reach 100% of the investment.
Buildings All		The Dept. responsible for the municipal buildings and for the Schools will run the whole programme.	The investment costs will be covered by the financing sources identified in the previous section.

Buildings 80	The Municipality could cover some administrative costs related to the promotion activities.	The Municipality staff will be responsible for the promotion and dissemination activities. An office supporting the citizens in the process of connecting to the gas network could be setup in collaboration with the local gas utility.	All the costs related to the connection will be covered by the individual owners.
Street lighting		The Dept. responsible for the operation of public lighting, the procurement and contracts dept. will be actively involved.	The investment cost will be covered through the EPC concept.
Vehicles replacement	The Municipality will cover the investment costs from its own budget. This action is already included in the programme of the Municipality.	The staff responsible for the operation of the municipal cars and truck will be involved in the tendering procedure.	The possibility of covering part of the investment costs from National funding should be examined (as part of a wider programme by the Municipality).
Sewage treatment	DEYAT is owned by the Municipality but is a separate company with its own financial resources.	The Sewage treatment plant is owned and operated by DEYAT. DEYAT's staff will participate in the project development and the operation of the installation.	The required investment costs will be covered by DEYAT's budget.
Hybrid/electric cars	The Municipality will not cover investment costs for the private cars. It will cover the administrative costs of promotion activities and possible studies that will be needed.	The Municipality staff will coordinate the dissemination and the introduction of incentives for the promotion of hybrid/electric cars. The Dept. responsible for Transport will coordinate the necessary studies, implement the incentives and examine the possibility of creating a network of charging stations and other amenities within the city centres.	The cost of investing in the electric and hybrid cars will be covered by the private car owners.

Table 4.3: Project Specific Performance Monitoring

Interventions	KPI	Monitoring Frequency	Data Sources
Cycling routes	Length of cycling rou1tes (km).	Annually	Municipality
Mobility ring road	Length of ring road delivered for use (km).	Annually	Municipality
Green spaces	Area of open spaces converted (m^2).	Annually	Municipality
Buildings All	Number of Buildings Refurbished.	Annually	Municipality
	Energy Savings Achieved from the refurbishment (kWh/year).	Annually	Municipality
Buildings 80	Number of buildings connected to the N. gas grid.	Annually	Municipality
	Estimated energy savings from fuel switching (kWh/year).	Annually	Municipality
Street lighting	Number of light fixtures replaced.	Annually	Municipality
	Estimated energy savings from the replacement (kWh/year).	Annually	Municipality
Vehicles replacement	Number of vehicles replaced.	Annually	Municipality
	Estimated energy savings (kWh/year)	Annually	Municipality
Sewage treatment	Measured Energy Savings compared to the baseline consumption (kWh/year).	Annually	DEYAT
Hybrid/electric cars	Number of hybrid/electric cars existing in the municipality.	Annually	Municipality

Apart from this set of project specific KPIs which will be used for the monitoring of the performance of the actions selected in the framework of the scenario analysis, the set of overall indicators identified in D.6.1. “Key Performance Indicators” will also be applied. This will give an overall assessment and monitoring of the sustainable energy improvement in Trikala. These indicators are presented in Table 4.4 together with the updating frequency and the data sources for their calculation.

Table 4.4: Performance Indicators for Monitoring at the City level.

Sector	KPI	Monitoring Frequency	Data Sources
Transport	Variation of FEC (GJ)	2020, 2025,2030	Municipality, National Statistics
	Variation of GHG emissions (tCO2e)	2020, 2025,2030	Municipality, National Statistics
	Investment (M€)	2020, 2025,2030	Municipality
Services	Variation of FEC (GJ)	2020, 2025,2030	Municipality, National Statistics
	Variation of GHG emissions (tCO2e)	2020, 2025,2030	Municipality, National Statistics
Residential Buildings	Variation of FEC (GJ)	2020, 2025,2030	Municipality, National Statistics
	Variation of GHG emissions (tCO2e)	2020, 2025,2030	Municipality, National Statistics
	Investment (M€)	2020, 2025,2030	National Statistics, Estimations
Public Buildings	Variation of FEC (GJ)	Annually	Municipality
	Variation of GHG emissions (tCO2e)	Annually	Municipality
	Investment (M€)	Annually	Municipality
Public Lighting	Variation of FEC (GJ)	Annually	Municipality
	Variation of GHG emissions (tCO2e)	Annually	Municipality
	Investment (M€)	Annually	Municipality
Water services	Variation of FEC (GJ)	Annually	Municipality, DEYAT
	Variation of GHG emissions (tCO2e)	Annually	Municipality, DEYAT
	Investment (M€)	Annually	Municipality, DEYAT
Waste Water services	Variation of FEC (GJ)	Annually	Municipality, DEYAT
	Variation of GHG emissions (tCO2e)	Annually	Municipality, DEYAT
	Investment (M€)	Annually	Municipality, DEYAT

	KPI	Monitoring Frequency	Data Sources
City Level Indicators	Variation of FEC (GJ)	2020, 2025,2030	Municipality, National Statistics
	Variation of GHG emissions (% change from base-yeart)	2020, 2025,2030	Municipality, National Statistics
	Investment (M€)	2020, 2025,2030	Municipality, National Statistics
	Share of endogenous renewables in TFEC (%)	2020, 2025,2030	Municipality, National Statistics
	New PV Installed Capacity in roof tops (MW)	2020, 2025,2030	Municipality, National Statistics
	New Utility scale PV Installed Capacity (MW)	2020, 2025,2030	Municipality, National Statistics
	New Installed Capacity Other RES (MW)	2020, 2025,2030	Municipality, National Statistics

5. Appendix I

Details of the financial calculations for each intervention.

The detailed tables with the pre-feasibility calculations are presented in this Appendix for each one of the interventions analysed.

5.1. Refurbishment of Municipal buildings.

The existing situation for the energy consumption in Municipal buildings was derived from the statistical consumption data provided by the Municipality.

Municipality buildings consumption	Electricity	Diesel
Existing Situation	**TJ**	**TJ**
Consumption for Space heating	0.88	9.28
Consumption for Space cooling	2.95	
Lighting	3.24	
Total	**3.83**	**9.28**

New Situation	Electricity	Diesel
Consumption for Space heating	0.70	7.42
Consumption for Space cooling	2.36	
Lighting	2.59	
Total	**3.06**	**7.42**

Financial Analysis

Choice	**Existing**
Discount Rate	5%

Costs

A. Investment Costs	Initial Costs (Euro)	Years	Annual Costs (Euro)
Investment Cost Diesel Boiler-Municipal	0.00	15.00	0
Investment Cost Diesel Boiler-Residential	0.00	15.00	0
Total	**0**		**0**

B. Annual Consumption Costs	Units TJ	Cost/Unit		
Energy Consumption Costs Diesel	9.28	29.50	Euro/GJ	273,760
Energy Consumption Costs Electricity	3.83	54.30	Euro/GJ	207,969
Total				**481,729**

Γ. Annual O&M Costs	Units	Cost/Unit (Euro)	
Fix O&M	0.00	0.00	0
Total			0

Δ. Total Annual Costs	481,729

Financial Analysis

Choice	New Gas Boilers
Discount Rate	5%

Costs

A. Investment Costs	Initial Costs (Euro)	Years		Annualised Costs (Euro)
Investment Cost	2,878,640	30		95,955
Total	**2,878,640**			**95,955**

B. Annual Consumption Costs	Units TJ	Cost/Unit		
Energy Consumption Costs Diesel	7.42	29.50	Euro/GJ	219,008
Energy Consumption Costs Electricity	3.06	54.30	Euro/GJ	166,375
Total				**385,383**

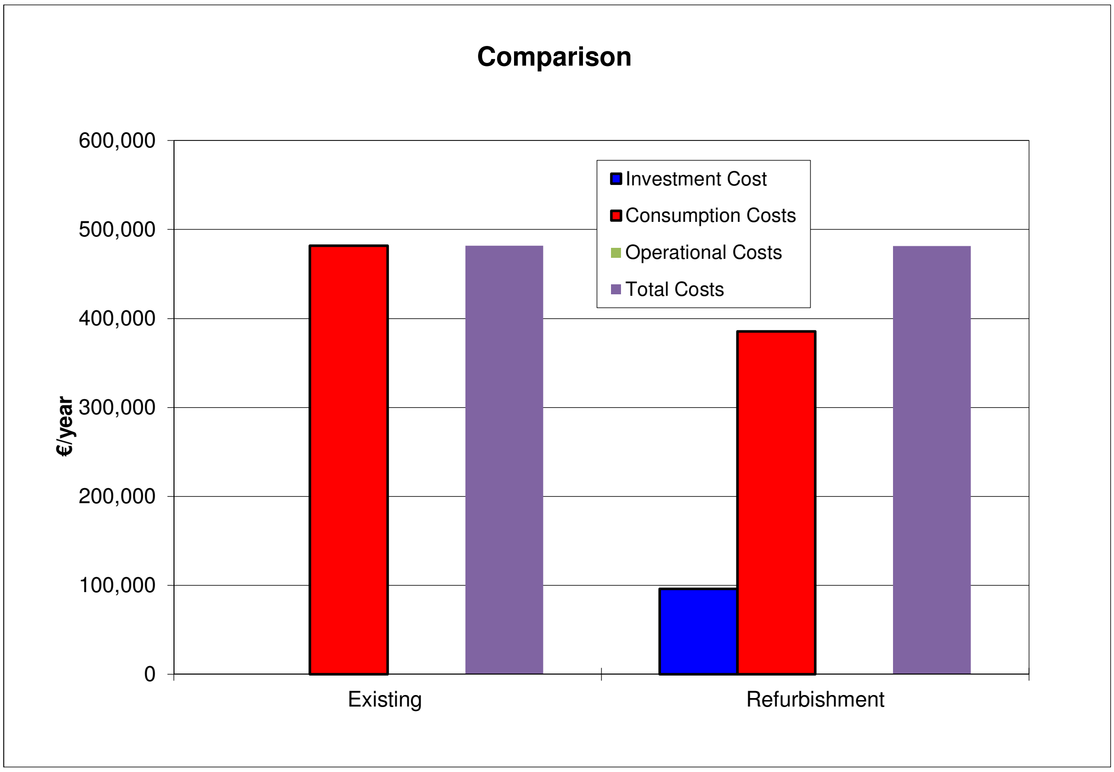
Γ. Annual O&M Costs	Units	Cost/Unit (Euro)		
Fix O&M Gas Boilers-Municipal	0.00	0		0
Total				**0**

Δ. Total Annual Costs	481,338

Payback Time	29.88

Comparison Base Case - Energy Savings

	Existing	New Gas Boilers
Investment Cost	0	95,955
Consumption Costs	481,729	385,383
Operational Costs	0	0
Total Costs	**481,729**	**481,338**
Payback Time (years)		29.88


Comparison
600,000
500,000
400,000
300,000
200,000
100,000
0
€/year
Investment Cost
Consumption Costs
Operational Costs
Total Costs
Existing
Refurbishment

5.2. Connection of 80% of buildings to the N. Gas Network

Energy Consumption for heating					
Share of Connection:	80%				
	Stock (MW)	Efficiency	Availability	Cap2Act (MW to TJ)	Annual Energy Consumption
Existing Diesel Boilers					TJ
Residential	27.656	0.70	0.10	31.54	124.59
Municipal	0.18	0.58	0.15	31.54	1.45
Total	**27.83**				**126.05**

New Gas Boilers					
Residential	27.656	0.85	0.10	31.54	102.61
Municipal	0.18	0.85	0.15	31.54	0.99
Total	**27.83**				**103.60**

Financial Analysis

Choise	**Existing Diesel Boilers**
Discount Rate	5%

Costs

A. Investment Costs	Initial Costs (Euro)	Years		Annual Costs (Euro)
Investment Cost Diesel Boiler-Municipal	0	15		0
Investment Cost Diesel Boiler-Residential	0	15		0
Total	**0**			**0**

B. Annual Consumption Costs	Units	Cost/Unit		
	TJ			
Energy Consumption Costs Diesel-Municipal	1.45	29.5	Euro/GJ	42,884
Energy Consumption Costs Diesel-Residential	124.59	29.5	Euro/GJ	3,675,530
Total				**3,718,414**

Γ. Annual O&M Costs	Units	Cost/Unit (Euro)		
Fix O&M Diesel Boilers-Municipal	0.2	4000		713
Fix O&M Diesel Boilers-Residential	27.7	4000		110624
Total				**111,337**

Δ. Total Annual Costs	**3,829,751**

Financial Analysis

Choise	**New Gas Boilers**
Discount Rate	5%

Costs

A. Investment Costs	**Initial Costs (Euro)**	**Years**		**Annualised Costs (Euro)**
Investment Cost Gas Boiler-Municipal	47412	15		4,568
Investment Cost Connection-Municipal	14052	50		770
Investment Cost Gas Boiler-Residential	3802700	15		253,513
Investment Cost Connection-Residential	2180399	50		43,608
Total	**6,044,563**			**302,459**

B. Annual Consumption Costs	**Units TJ**	**Cost/Unit**		
Energy Consumption Costs N. Gas-Municipal	0.99	14.8	Euro/GJ	14,681
Energy Consumption Costs N. Gas-Residential	102.61	18.1	Euro/GJ	1,857,187
Total				**1,871,868**

Γ. Annual O&M Costs	**Units**	**Cost/Unit (Euro)**		
Fix O&M Gas Boilers-Municipal	0.18	4000		712.96
Fix O&M Gas Boilers-Residential	27.656	4000		110624
Total				**111,337**

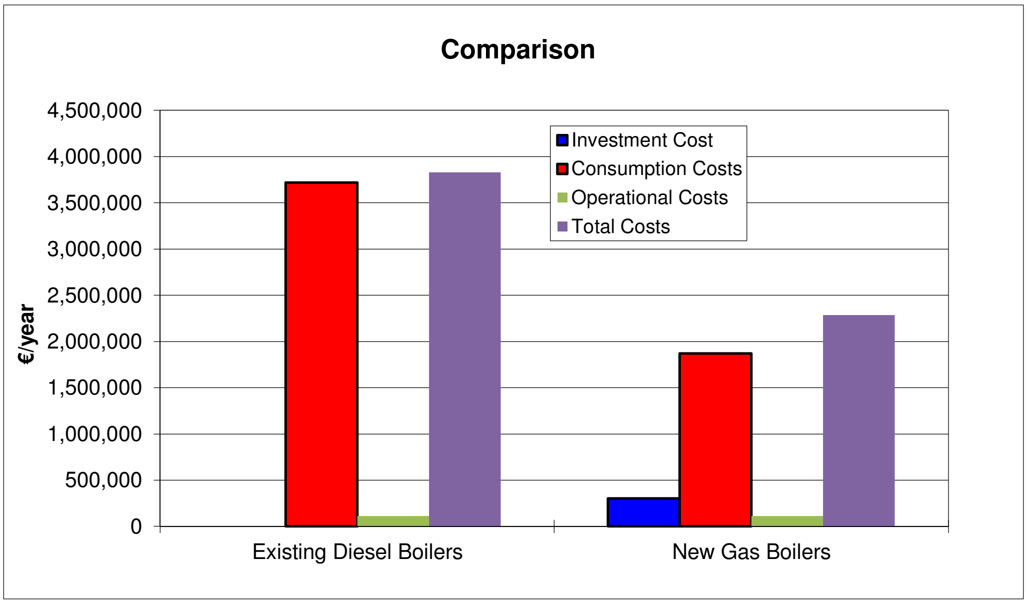
Δ. Total Annual Costs	**2,285,663**

Payback Time	**3.27**

Comparison Base Case - Energy Savings

	Existing Diesel Boilers	**New Gas Boilers**
Investment Cost	0	302,459
Consumption Costs	3,718,414	1,871,868
Operational Costs	111,337	111,337
Total Costs	**3,829,751**	**2,285,663**

Payback Time (years)	3.27


Comparison
€/year
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Investment Cost
Consumption Costs
Operational Costs
Total Costs
Existing Diesel Boilers
New Gas Boilers

5.3. Replacement of Street Lighting with LEDs

Electricity Consumption for lighting

	Number	Capacity/lights	Total Capacity	Operating Hours/year	Annual Energy Consumption
					=[E]*[D]
Existing		(W)	(W)	(hours)	(kWh)
Sodium Lamps	6000	250	1500000	4115.5	6173250
Total	**6000**		**1500000**		**6173250**

New Lights		(W)	(W)	(hours)	(kWh)
LEDs	6000	100	600000	4115.5	2469300
Total	**6000**		**600000**		**2469300**

Financial Analysis

Choise	**Existing Sodium Lights**
Discount Rate	5%

Costs

A. Investment Costs	**Initial Costs (Euro)**	**Years**		**Annual Costs (Euro)**
Investment Cost	360000	12		40,617
Installation Cost	288000	12		32,494
Total	**648,000**			**73,111**
Cost of Materials	**648,000**			

B. Annual Consumption Costs	**Units**	**Cost/Unit**		
Energy Consumption Costs	6173250	0.147	Euro/kWh	906,171
Fixed Capacity Cost	1500.00	3.7	Euro/kVa	5,550
Total				**911,721**

Γ. Annual O&M Costs	**Units**	**Cost/Unit (Euro)**		
Maintenance	6000.00	5		30000
Total				**30,000**

Δ. Total Annual Costs	**1,014,832**

Financial Analysis

Choice	LED Lights
Discount Rate	5%

Costs

A. Investment Costs	**Initial Costs (Euro)**	**Years**		**Annual Costs (Euro)**
Investment Cost	1800000	12		203,086
Installation Cost	300000	12		33,848
Total	**2,100,000**			**236,933**
Cost of Materials	**1,800,000**			

B. Annual Consumption Costs	**Units**	**Cost/Unit**		
Energy Consumption Costs	2469300	0.147	Euro/kWh	362,469
Fixed Capacity Cost	600.00	3.7	Euro/kVa	2,220
Total				**364,689**

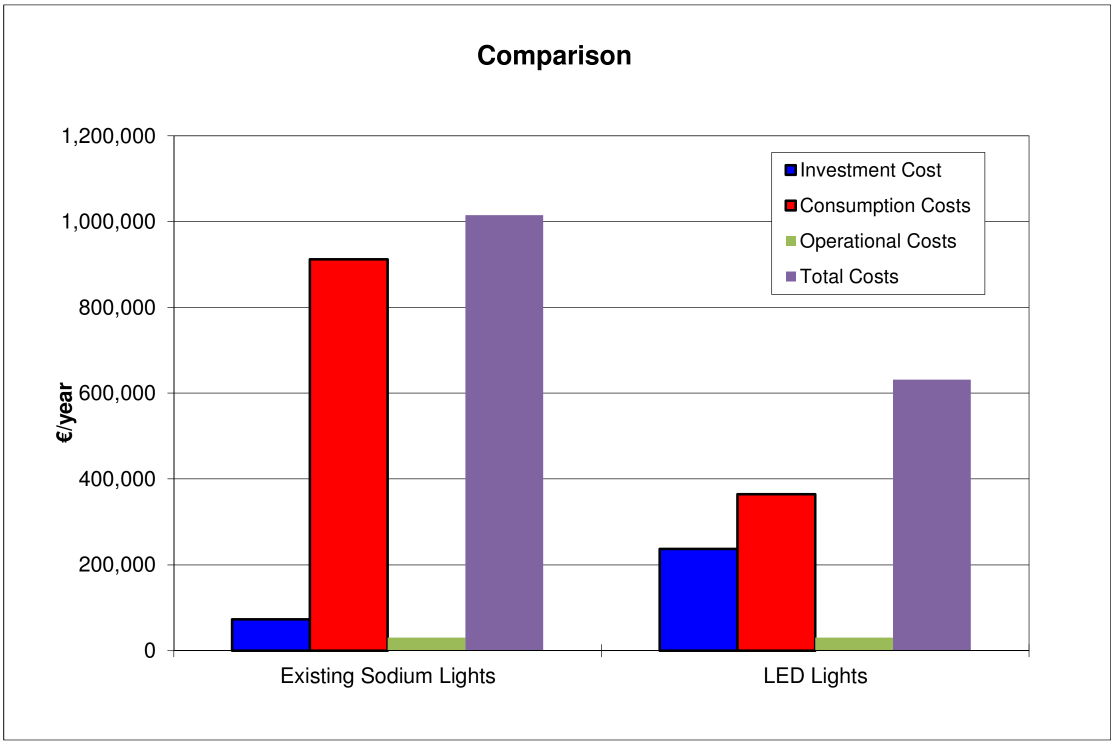
Γ. Annual O&M Costs	**Units**	**Cost/Unit (Euro)**		
Maintenance	6000	5		30000
Total				**30,000**

Δ. Total Annual Costs	**631,622**
Payback Time	**3.39**

Comparison Base Case - Energy Savings

	Existing Sodium Lights	**LED Lights**
Investment Cost	73,111	236,933
Consumption Costs	911,721	364,689
Operational Costs	30,000	30,000
Total Costs	**1,014,832**	**631,622**

Payback Time (years)	3.39


Comparison
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
€/year
Investment Cost
Consumption Costs
Operational Costs
Total Costs
Existing Sodium Lights
LED Lights

5.4. Replacement of Municipal Vehicles

Energy Consumption Municipal Vehicles.

	Number	Vkm/year	TJ/1000Vkm	Annual Energy Consumption
Existing				**TJ**
Gasoline Vehicles	10	70000	0.0028	1.96
Diesel Vehicles	20	70233	0.0086	12.08
Total	**30**			**14.04**

New				
Electric Vehicles	10	70000	0.00067	0.467
Diesel Vehicles	20	70233	0.008	11.2
Total	**30**			**11.7**

Financial Analysis

Choise	**Existing Vehicles**
Discount Rate	5%

Costs

A. Investment Costs	Initial Costs (Euro)	Years		Annual Costs (Euro)
Investment Cost Cars	150000	30		9,758
Investment Cost Trucks	3000000	30		195,154
Total	**3,150,000**			**204,912**

B. Annual Consumption Costs	Units	Cost/Unit		
	TJ			
Energy Consumption Costs Gasoline	1.96	50.9	Euro/GJ	99,764
Energy Consumption Costs Diesel	12.08	29.5	Euro/GJ	356,362
Total				**456,126**

Γ. Annual O&M Costs	Units	Cost/Unit (Euro)	
Fix O&M Gasoline Cars	10	750	7500
Fix O&M Diesel Trucks	20	5400	108000
Total			**115,500**

Δ. Total Annual Costs	**776,538**

Financial Analysis

Choise	New Vechicles
Discount Rate	5%

Costs

A. Investment Costs	**Initial Costs (Euro)**	**Years**		**Annual Costs (Euro)**
Investment Cost Cars	290000	30		18,865
Investment Cost Trucks	3600000	30		234,185
Total	**3,890,000**			**253,050**

B. Annual Consumption Costs	**Units** **TJ**	**Cost/Unit**		
Energy Consumption Costs Electricity	0.47	54.3	Euro/GJ	25,340
Energy Consumption Costs Diesel	11.24	29.5	Euro/GJ	331,500
Total				**356,840**

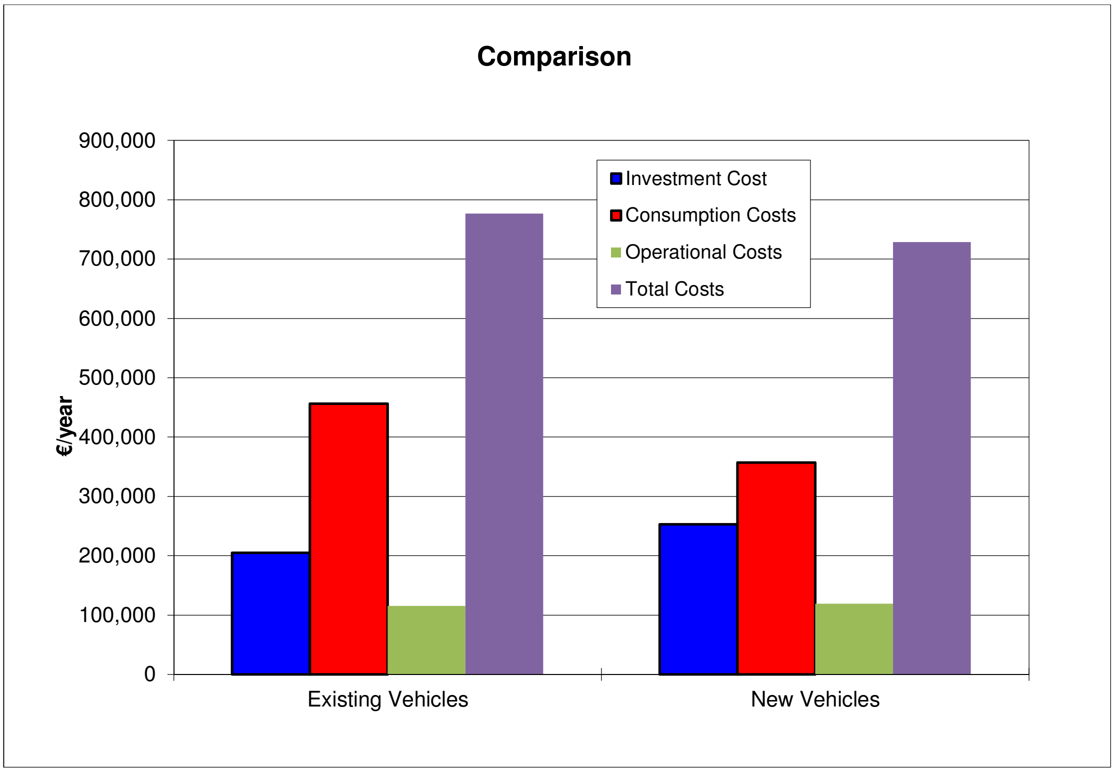
Γ. Annual O&M Costs	**Units**	**Cost/Unit (Euro)**		
Fix O&M Electric Cars	10	1100		11000
Fix O&M Diesel Trucks	20	5400		108000
Total				**119,000**

Δ. Total Annual Costs	**728,890**
Payback Time	**12.94**

Comparison Base Case - Energy Savings

	Existing Vehicles	New Vehicles
Investment Cost	204,912	253,050
Consumption Costs	456,126	356,840
Operational Costs	115,500	119,000
Total Costs	**776,538**	**728,890**

Payback Time (years)	12.94



5.5. Sewage Treatment Plant

Electricity Consumption for Sewage treatment plant

	Annual Energy Consumption
Existing	**TJ**
Existing Setup	3.88
Total	**3.88**

New	**TJ**
New Setup	2.91
Total	**2.91**

Financial Analysis

Choise	**Existing**
Discount Rate	5%

Costs

A. Investment Costs	**Initial Costs (Euro)**	**Years**		**Annual Costs (Euro)**
Investment Cost	0	0		0
Total	**0**			**0**
	0			

B. Annual Consumption Costs	**Units**	**Cost/Unit**		
	TJ			
Energy Consumption Costs	3.88	54.300	Euro/GJ	210,532
Total				**210,532**

Γ. Annual O&M Costs	**Units**	**Cost/Unit (Euro)**		
Maintenance	0.00	0		0
Total				**0**

Δ. Total Annual Costs	**210,532**

Financial Analysis

Choise	Intervention
Discount Rate	5%

Costs

A. Investment Costs	Initial Costs (Euro)	Years		Annual Costs (Euro)
Investment Cost	200000	50		10,955
Total	**200,000**			**10,955**

B. Annual Consumption Costs	Units TJ	Cost/Unit		
Energy Consumption Costs	2.91	54.30	Euro/GJ	157,899
Total				**157,899**

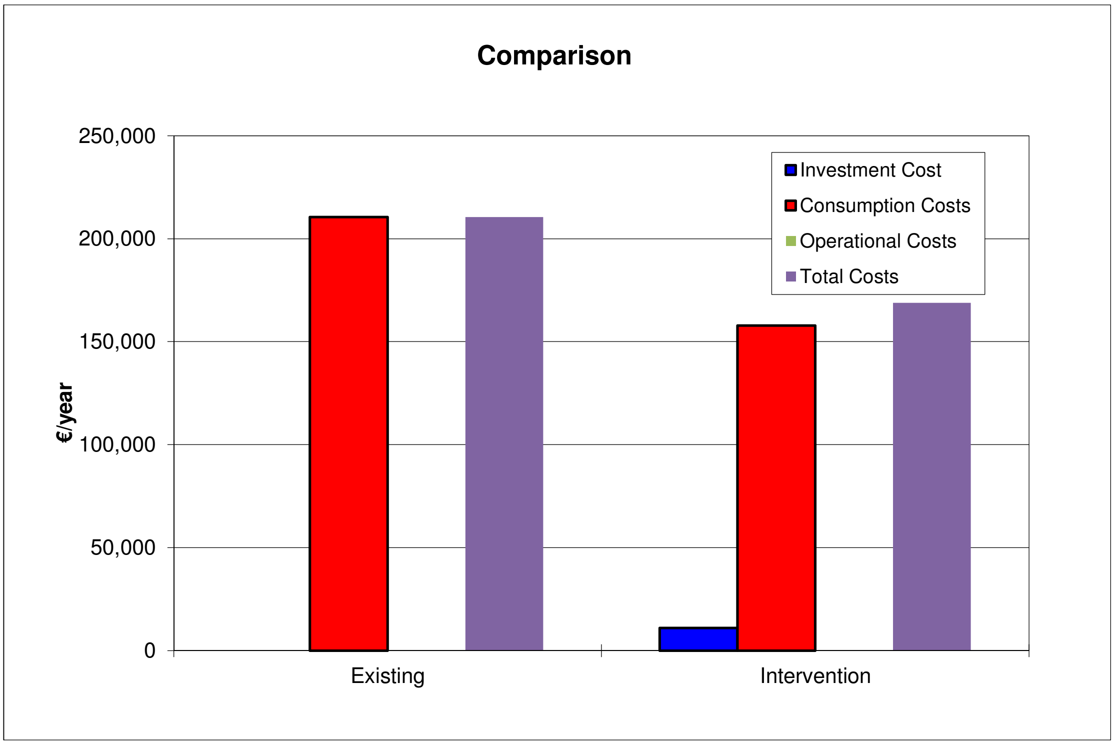
Γ. Annual O&M Costs	Units	Cost/Unit (Euro)		
Maintenance	0	0		0
Total				**0**

Δ. Total Annual Costs	**168,854**
Payback Time	**3.80**

Comparison Base Case - Energy Savings

	Existing	Intervention
Investment Cost	0	10,955
Consumption Costs	210,532	157,899
Operational Costs	0	0
Total Costs	**210,532**	**168,854**

Payback Time (years)	3.80


Comparison
250,000
200,000
150,000
100,000
50,000
0
€/year
Investment Cost
Consumption Costs
Operational Costs
Total Costs
Existing
Intervention

6. References

1. Series of directives VDI 2067 "Cost-effectiveness of building installations", https://www.vdi.de/technik/fachthemen/bauen-und-gebaeudetechnik/fachbereiche/technische-gebaeudeausruestung/richtlinienarbeit/richtlinienreihe-vdi-2067/