Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

INSMART

Integrative Smart City Planning

Mid-Term Implementation Action Plan - Nottingham

D-WP 6 – Deliverable D.6.2

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Executive Summary	
The interventions promoted through the MCDA process for the sustainable development of the energy sectors of Nottingham are further analysed through pre-feasibility economic viability analysis. Funding options are discussed and the most appropriate schemes for each intervention are proposed. The steps of a mid-term implementation plan to 2030 are identified and presented along with the resources required and KPIs for the monitoring of the implementation of the programme.	

Keywords	SEAP, Economic viability analysis, KPI, energy measures, urban modelling

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Acronyms and Definitions

ASHP – Air Source Heat Pump

BEIS – department for Business, Energy and Industrial Strategy

CHP – Combined Heat and Power

DfT – Department for Transport

DHN – District Heating Network

EEEF – European Energy Efficiency Fund

EfW – Energy from Waste

ERDF – European Regional Development Fund

ESIF – European Structural and Investment Funds

ESM – Energy Systems Model

EV – Electric vehicle

FIT – Feed In Tariff

LEP – Local Enterprise Partnership

MCDA – Multi Criteria Decision Analysis

NCC – Nottingham City Council

NET – Nottingham Express Transmit

NGO – Non Governmental Organisation

NPV – Net Present Value

PFI – Private Finance Initiative

PROMETHEE – Preference Ranking Organization METHod for Enrichment of Evaluations

PV – Photovoltaic

RES – Renewable energy sources

SG – Stakeholder Group

T2W – Travel to Work area

TIMES – The Integrated MARKAL-EFOM System

UoN – University of Nottingham

WPL – Workplace Parking Levy

1. Introduction

The INSMART project developed a methodology for urban energy planning. This was applied to the city of Nottingham and led to the identification of a set of measures for sustainable development in a time horizon from the base year (2014) to 2030. The key points in this methodology are

- An integrative approach incorporating disparate energy consuming and producing sectors in the city analysed in an Energy Systems Model (Long & Robinson, 2016a) based on the TIMES-MARKAL approach to energy modelling
- 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 (Long & Robinson, 2016b)

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 Nottingham.

Table 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).

The MCDA process identified the top ranked scenario as Local Leadership – Growth (LL-Growth). LL-Growth represents the maximum level of local engagement modelled during the development of future energy scenarios for the city of Nottingham. Two other scenarios were shortlisted for further review (GG-East and GG-West) and elements arising from these scenarios will be discussed and evaluated in this report. Figure 1 shows a visualisation of the results of the MCDA process. Scenarios are ranked from left (highest scoring) to right (lowest ranked).

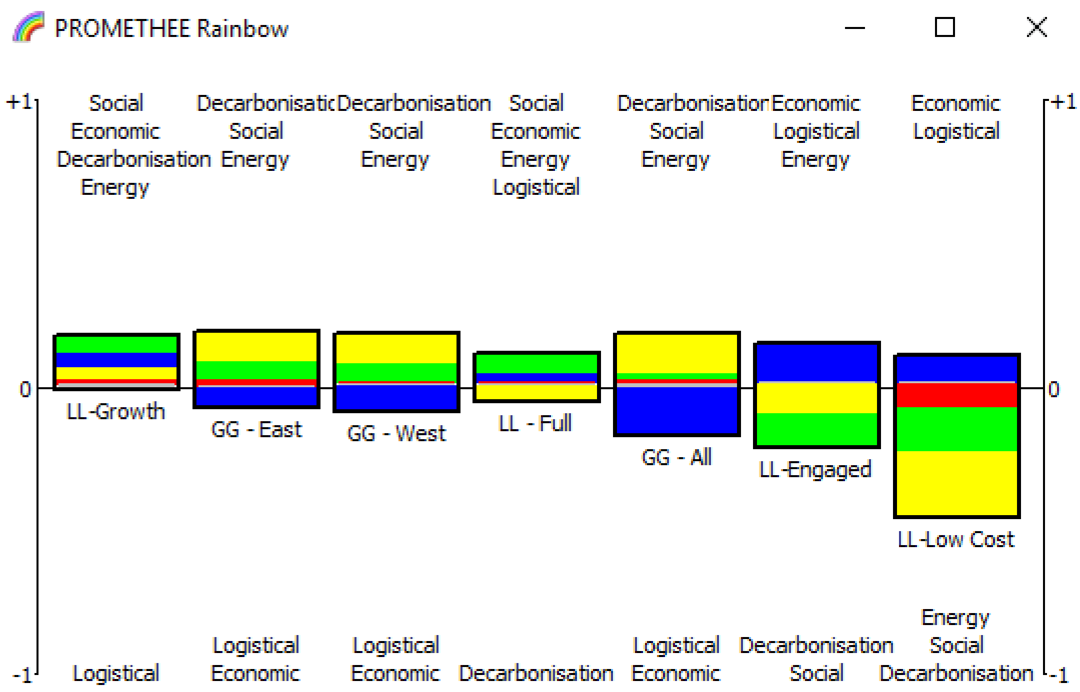

Figure 1: Promethee rainbow chart based on Nottingham MCDA

The LL-Growth scenario reflects many of the aspects of the municipality's current strategy for the city of Nottingham (NCC, 2010). Nottingham City Council (NCC) have clear goals to reduce the city's energy demand and its carbon footprint by 2021. The city is already one of the UK's most sustainable cities (NCC, 2011) and the results of the InSMART programme will help the municipality develop its energy strategy to 2030.

1.1. Interventions promoted through the MCDA process

The LL-Growth scenario includes all interventions/measures included in the other Local Leadership based scenarios with some additional measures to increase the penetration of low carbon energy and further reduce the city's energy use.

The scenario contained a range of measures relating to the transport, residential and energy generation sectors. Table 2 provides details of the measures included as calculated using the TIMES based Nottingham ESM developed for the project.

Table 2: List of measures from the LL-Growth scenario

Measure	Description	Sector
Cycling improvements / Behavioural change	Upgrades to cycling infrastructure in the city under the proposed Nottingham Cycle City Ambition Programme (NCCAP). Also includes strategies to promote the use of non-motorised modes, walking and cycling, as well as encouraging people to utilise opportunities to work from home or car share to work.	Transport
Low carbon vehicles / low carbon zone	Increase in the number of private electric vehicles in the city based on the proposed *Go Ultra Low* programme. Includes plans for new charging infrastructure, use of bus lanes by EVs, subsidies and the introduction of city centre low carbon zone.	Transport
Electric buses	This test looks at the change of the entire city bus fleet from the current diesel engine buses to being fully electric.	Transport
Southern Corridor	Includes a series of traffic infrastructure improvements including introduction of new bus lanes and highway regulations to improve the flow of public transport in the southern area of the city.	Transport
Increased Parking Charges	Measure involves the doubling of average parking charges in city centre area of the city Charges only apply to private car trips. This measure has a limited effect on reducing energy use but provides a source of additional income that can be used to offset some of the other transport related measures.	Transport
Cavity wall insulation	Installing insulation into those residential properties in the city that currently have uninsulated cavity walls.	Residential
Loft insulation	Adding 300mm of insulation to all roof spaces where current insulation is less than 100mm	Residential
Draught-proofing measures	Installation of basic draught proofing measures to applicable properties in the city. Estimate ~25% of properties could benefit.	Residential
Low carbon housing	New residential housing upgraded to a lower carbon standard. ~20% energy reduction compared to existing UK building standards.	Residential
Upgrades to heating system	Replacement and upgrade of existing heating systems to newer and more efficient models.	Residential
External solid wall insulation	Installation of external solid wall insulation to properties without cavity walls.	Residential
District heating expansion	Addition of 3rd line to the city's incinerator allowing expansion of the current district heating network and the addition of new residential connections to the network	Energy generation
Community scale biomass CHP	Introduction of biomass fuelled CHP generation schemes. Provides heat and power for groups of houses or high density apartment buildings. Particularly suitable for new residential developments	Energy generation
Residential rooftop PV	Installation of rooftop PV systems to suitable residential properties in the city.	Energy generation
Solar energy (non-domestic)	Plant scale PV schemes at appropriate sites in the city, such as park and ride locations and local leisure centres. PV canopy to be installed over car parking spaces on each site.	Energy generation

For transport sector measures results for both the city and the entire Nottingham travel to work area (T2W), shown in Figure 2, have been included where applicable. This is because the impact of transport measures typically extends beyond the city boundary. The T2W is the boundary typically used by the city's transport planners when evaluating transport measures.

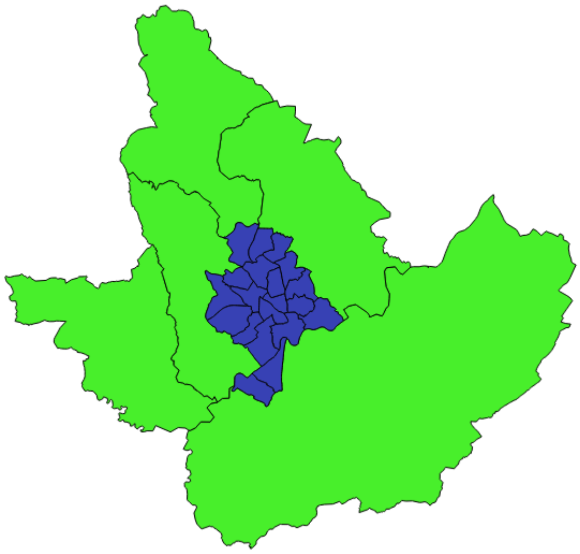

Figure 2: Nottingham city (Blue) and travel to work area (green)

1.2. Additional and alternate interventions considered

In addition to the measures included in LL-Growth, it was decided to consider measures from other scenarios that performed well in the MCDA to examine their economic viability and their potential for inclusion in the action plan. It was also decided, in collaboration with NCC, to investigate heat pump technologies, not considered or non-viable in the TIMES model. Table 3 describes the additional measures.

Table 3: Additional and alternate energy measures

Measure	Description	Source
NET Phase 3 – Extension to HS2	Expansion of the city's tram network. Extension of current line 3 to meet up with proposed national high speed rail network (HS2)	GG-All scenario
NET Phase 3 - Gedling	Expansion of the city's tram network. Creation of new line running east of the city to the village of Gedling	GG-East scenario
Residential heat pumps	TIMES model included options for heat pumps but not economically viable using current cost estimates. This measure investigates options and costs for their inclusion.	Non-viable

2. Economic Viability Analysis

2.1. Methodology

The economic viability and net present value of each proposed measure will be based the investment figures and periods used in the Nottingham ESM. Figures and timescales for investment were provided by stakeholders where available. Where cost estimates were not available, default values were used. These were based on typical costs identified for similar projects.

For measures including major infrastructure items, such as new roads or tramlines, it is neither possible nor practical to include a full costing in this report. The nature and complexity of such projects requires a detailed economic assessment with input from multiple stakeholders and will be subject to large uncertainties.

Costs estimates are assigned over the planned investment period for each measure. The net present value of each measure can then be calculated. A discount rate of 3.5% was used to calculate NPV. This is the value used by UK government when evaluating investments (HM Treasury, 2003) and is often referred to as the social time reference rate. The NPV is then used with the annual cost savings associated with each measure to calculate the payback period. The equation used for calculating net present value and payback period are:

$$NPV\ (i,n) = \sum_{t=0}^{n} \frac{R_t}{(1+i)^t} \qquad Payback\ Period\ pp = \frac{NPV}{AR}$$

Where t = time of the cash flow

i = the discount rate (3.5% in this instance)

R_t = net cash flow at time t

NPV = Net present value for the investment

AR = Annual cost savings

Annual cost savings are based on the energy reduction associated with each measure. The energy savings is multiplied by the associated energy cost applicable for that measure, e.g. for transport related measures the energy reduction is multiplied by the cost of the fuel. It does not include any cost saving of the CO2 reduction associated with the measure.

2.2. Economic Viability Analysis

The economic viability of the measures proposed by the LL-Growth scenario will now be calculated using the method described. A description of the costing data used for each measure will be provided along with any assumptions used. Where there is uncertainty as to the cost values, additional calculations will be given to account for the known uncertainty where applicable.

The Nottingham ESM only has three defined time reporting periods. These are 2014 (base year), 2020 and 2030. It is unlikely that investments for some measures will occur at these three predefined dates. A more detailed estimate of investments over the time horizon can be found in appendix A.

Cycling improvements / Behavioural change

This measure represents a large modal switch (~10%) from motor vehicles to cycling in the city. This switch is based on planned upgrades to cycling infrastructure in the city under the Nottingham Cycle City Ambition Programme (NCCAP). City has received funding for this programme to cover the infrastructure costs. Full details of the programme are available from NCC 1 . In addition to the infrastructure improvements, the measure includes a range of other activities such as education and training programmes, cycle loan schemes (revenue neutral), expanding the city's cycle hire scheme and other traffic measures to improve road safety for cyclists in the city.

Financial cost of the behavioural change aspect of the measure is negligible from the perspective of the need for infrastructure and significant additional local authority funding. However, the potential need to encourage these types of behavioural change through funded education and information programmes might be required to ensure that the degree of change actually takes place over the time horizon. It is assumed that any costs associated with this aspect will be provided by the NCCAP funding. A full breakdown of the costs for this measure can is available from the project website (NCC, 2013).

Table 4 shows the economic viability based on these costs and the projected energy savings due to the reduction in motor vehicle use in the city. The results of this measure only have an impact within the city and the results for the city and T2W are the same as those shown below.

Table 4: Economic viability of cycling improvements/behavioural change intervention

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
3257	6123	0	8238.06	154.6	18,531.42	0.44

[1] The CycleCity website (http://transport2.nottinghamcity.gov.uk/cycle/) describes the project in full including financial case supporting the programme (https://nottinghaminsight.org.uk/insight/d/120181/Download/Enterprise/Major-Projects/Cycle-City-Ambition-Programme/)

Due to the large energy saving this measure is very cost effective. However, it should be noted that the degree of switching from motor vehicles to cycling proposed is highly ambitious. It is possible that a smaller increase in the uptake of cycling uptake occurs. Even in this instance the measure would still be economically viable. To illustrate this, assuming an annual energy saving of only 15GWh, less than ten percent of the modelled saving, would produce the following result:

Energy density of transport fuels: petrol = 9.7 kWh/litre, diesel = 10.7 kWh/litre

Private vehicle fleet fuel mix = 70% Petrol / 30% Diesel (From Nottingham ESM)

Energy use / litre fuel: 10kWh/l = 0.00001 GWh/l

Therefore: 15GWh = 1,500,000 litres fuel

Using a very conservative cost of petrol £1/litre[2] leads to an annual return of £1.5M and a payback period of 5.49 years. Even at only 10% of the target, the measure remains economically viable considering the lifespan of the infrastructure involved.

Low Carbon Vehicles / Low Carbon Zone

This intervention includes a range of measures related to increasing the use of low carbon vehicles (EVs and plug in hybrids) in the city by 2030. This will primarily be achieved through the *Go Ultra Low* programme, from which NCC have recently received funding from the UK government. Go Ultra Low is a national programme aimed at increasing the penetration of EVs in the UK. Nottingham is one of four UK cities chosen to receive funding and support from the programme. The Nottingham programme aims to get around 8000 EVs on the city's roads (including the wider travel to work area rather than just the city boundary) by 2030. Details of the Nottingham Go Ultra Low programme are available online (http://goultralownottingham.org.uk/).

A major element of this measure is the introduction of a low carbon zone in the city centre. This would restrict access to a defined area of the city to higher emissions vehicles from 2018 onwards. This measure is primarily aimed at reducing air pollution issues in the city and helping to improve the health and wellbeing of citizens.

The economic viability of this measure was tested using the outputs of the based Nottingham ESM (see Table 5). The default ESM settings produced an uptake of EVs of around 1000 within the city boundary and over 3000 EVs in the Nottingham Travel to Work area. An alternate measure (referenced as higher in Table 5) with a fixed uptake of EVs closer to the Go Ultra Low goals was modelled in line with the

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[2] Note that this is significantly lower the recent prices for petrol in the UK. Average petrol/diesel prices (as of January 2017) are around £1.20/litre

projections of the Nottingham *Go Ultra Low* programme. This measure models around 8000 electric vehicles on the city's roads by 2030. The alternate measure produces significantly higher annual energy savings (~400% higher) and brings the payback period down to between 3-4 years (for both city and travel to work area). It is expected that the actual uptake in EVs arising from this measure will fall somewhere between the *default* and the *higher* figures shown in the table.

Table 5: Economic viability of the Low Carbon Vehicles / Low Carbon Zone measure

Area of effect	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
Default - City	0	12,595	1,021	10,835	15.0	1,800.6	6.02
Default – T2W	0	17,117	4,658	16,611	43.43	5,211.0	3.19
Higher - City	0	12,595	28,957	26,738	61.05	7,325.8	3.65
Higher – T2W	0	17,117	82,833	61,695	173.97	20,876.9	2.96

The costs shown in the table do not include the additional cost of purchasing an EV to the driver. Costs shown only include the cost of providing the infrastructure to support the additional EVs and the national grants available for purchasers of EVs (up to £4,500/EV). An average grant of £4,000/EV was used in the costing shown in Table 5. This was based on the assumption that, although most EVs will be eligible for the full £4,500 grant, some may qualify for less. It should be noted that it has been assumed that this subsidy will remain available throughout the projected time horizon.

The results shown include the cost of the electrical energy required to charge the EVs. The energy saving shown was calculated by subtracting the energy used by the EVs from the energy that would be used by the same number of Non EV vehicles. This measure is focused on private vehicles. EVs for public transport are discussed as part of the electric buses measure.

Electric Buses

This measure involves the replacement of the city's bus fleet with electric vehicles. Cost figures for the assessment were taken from the Nottingham ESM and the InSMART transport model for Nottingham.

As shown in Table 6, from a purely cost based perspective the measure has low viability with very long payback periods. However, the costs shown in the table include the total cost of replacing the city's bus fleet with electric vehicles. Some of this cost would occur without this measure as older vehicles would need to be replaced naturally. It should also be noted that the introduction of electric buses is primarily aimed at reducing the city's carbon footprint and reducing air pollution.

Table 6: Economic viability of the electric buses intervention

Area of effect	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
City only	0	77,067	146,494	147,178	14.73	1,767	83.29
T2W area	0	77,067	146,494	147,178	19.6	2,352	62.58

Southern Corridor Improvements

Includes a range of highway upgrades and changes intended to improve the flow of public transport in the south of the city. Estimated cost for these changes is £9.68M and is planned to take place around 2020. Table 7 shows the economic viability of this measure. The measure has a more pronounced effect for the Travel to work area as it will improve public transport access for those commuting from outside the city boundary. Due to the relatively low energy reduction associated with this measure the payback periods are relatively high. However, like the previous measure (electric buses), this intervention is not intended to be an energy saving measure but rather to increase the use of public transport and reduce traffic congestion.

Table 7: Economic viability of southern corridor improvement programme

Area of effect	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
City	0	9,680	0	7,874	3.6	431.65	18.24
Travel to Work Area	0	9,680	0	7,874	6.0	725.14	10.86

Increased Parking Charges

Represents a doubling of the average parking charges in the city centre zones. A full description of the measure and its effect on the city's traffic, energy use and CO_2 emissions can be found in the InSMART transport scenarios report for Nottingham (Pollard, 2015). Since the measure concerns an increase in parking charges for existing parking spaces there will be no additional cost required for new parking bays or enforcement. The increase is to be introduced towards the end of projected time horizon as shown in Table 8. The annual return figures shown relate to the energy saving shown caused by a reduction in private vehicle traffic into the city centre caused by the increased charges.

Table 8: Income arising from increased parking charges

Area of effect	Income (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)
	2014	2020	2030			
City	0	0	2,682	1,547	11.78	1,414
Travel to Work Area	0	0	2,682	1,547	24.97	2,996

Income for public car parking spaces goes to the local authority (NCC) and can be used to pay for other transport measures in the city. This measure is therefore an income generator that can be used to offset the costs of other transport related measures and payback period is not applicable. An example of this is shown in Figure 3 for the *electric buses* and *southern corridor* measures. The increased parking charges income almost completely offsets the costs of the southern corridor, reducing the payback period to less than a year for the T2W area and just over three years for the city only. Alternatively it could be used to significantly reduce the payback period for the non-economically viable electric buses measure.

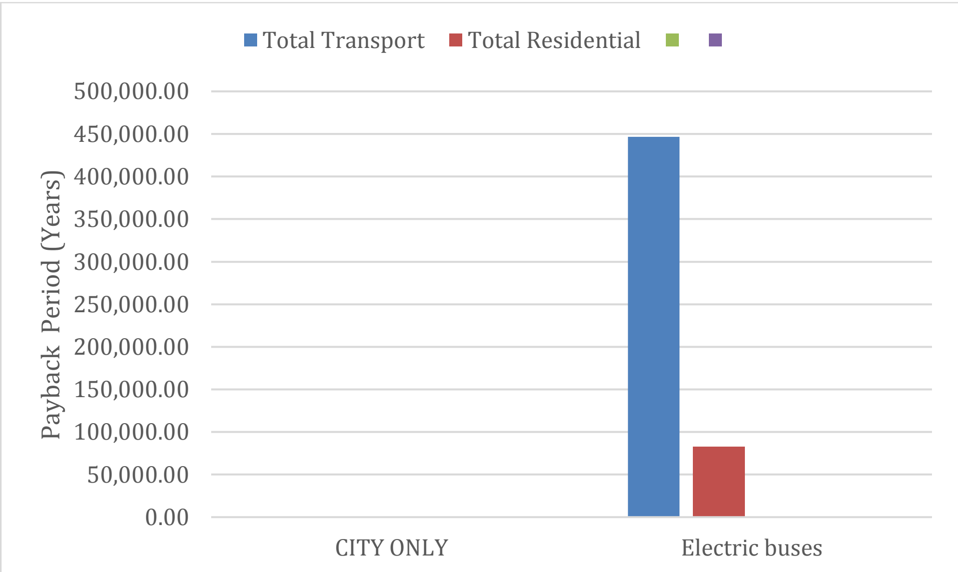

Figure 3: Comparison of payback periods offset by increase in parking charges

Insulate residential cavity walls

According to the results of the InSMART housing surveys carried out in 2015, over 40% of houses with cavity walls are uninsulated. Insulating cavity walls is a simple, low cost measure that can make significant reductions (~10-20%) to a building's energy demand. The Nottingham ESM and MCDA highlighted the insulation of all the uninsulated cavity wall properties as a potential intervention. The economic viability of the measure is shown in Table 9.

Table 9: Economic viability of insulating all cavity wall properties in the city of Nottingham

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	11,334	5,107	12,165	57.9	2,954	4.12

The energy saving shown was calculated by the Nottingham ESM and includes an element of thermal takeback[3] by householders post insulation. The annual return was calculated by multiplying the energy saving by the cost of natural gas (the primary heating fuel used in the city) over the time horizon using projections of energy cost from the UK committee for climate change (as shown in Table 10)

The investment cost shown for this measure is based on the current subsidised cost of cavity wall insulation. Subsidies for home energy improvements like cavity wall insulation are funded by the UK energy providers. The figures shown assume that the subsidy remains in place throughout the projected time horizon. The level of subsidy available can vary according to the type of property and the income of the occupants. An overall average level of subsidy, based on property type, was applied to all properties in the city in the Nottingham ESM.

Table 10: Future energy prices over the time horizon [*Committee for Climate Change, 2014]*

	2013	2020	2030
ELC p/kWh	12.1	10.9	12.3
GAS p/kWh	4.4	4.5	5.1

Loft insulation in residential properties

The InSMART housing survey identified a small number of properties in the city with uninsulated roof spaces. These were limited to a small number of building types and represent around 10% of the housing stock (excluding flats). Adding insulation to these properties is inexpensive and can reduce residential energy demand by around 10-20% (depending on the specific building and its heating schedule). The economic viability of these intervention is shown in Table 11.

As shown, the energy saving associated with this measure is relatively low compared to cavity wall insulation but due to its low cost the payback period is under seven years which is short in relation to the lifespan of residential properties. Like cavity wall insulation, the uninsulated properties are privately owned and therefore any costs

[3] Thermal takeback, often referred to as the rebound effect, a well-documented impact of insulating properties where the occupants take back some of the potential energy saving as an increase in thermal comfort.

and reductions in annual energy bills would go to the occupants/energy bill payer. Like the previous measure, cavity wall insulation, the cost used is subsidised by energy providers and an average level of subsidy was used in the Nottingham ESM.

Table 11: Economic viability of installing 300mm loft insulation to all uninsulated roof spaces

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	430	2,090	1,555	4.5	231	6.73

Residential Draught-Proofing measures

Infiltration can be a significant source of heat loss in buildings. Many older properties in the city have high rates of infiltration due to gaps in the building envelope especially at openings (doors/windows). Basic draught proofing measures[4] can be used to reduce heat loss and save energy in residential properties. InSMART analysis confirmed that around 25% of the city's housing stock would potentially benefit from these types of measure and estimated the energy savings possible. The Nottingham ESM identified this measure as suitable for all applicable properties. The economic viability of the measure is shown in Table 12. The cost of this retrofit measure is assumed to be unsubsidised and would be primarily be funded by the occupant/property owner.

Table 12: Economic viability of installing basic draught proofing measures for suitable properties

Option	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
A	0	1,471	17,554	11,320	24.9	1,269	8.92
B	0	1,765	21,065	13,584	26.1	1,331	10.21

Unlike the previous residential retrofit options (cavity wall and loft insulation), it is not possible to positively identify properties that would be applicable for this measure with total certainty. Therefore it is likely that the measure would need to be carried out a number of inapplicable properties (where zero, or minimal, energy saving might be made) in order to ensure that all applicable properties are retrofitted. Therefore a range of costing options are shown in Table 12. Option A is the cost assuming only the applicable properties are retrofitted. Option B shows the economic analysis based on the retrofitting an additional 20% of properties for only an additional 5% energy

[4] The energy saving trust provide examples of basic measures that can reduce heat loss due to infiltration. http://www.energysavingtrust.org.uk/home-insulation/draught-proofing

saving. The actual cost and economic viability of this measure is uncertain but the two options shown should provide a plausible range of costs and payback periods.

Low Carbon Housing

For this measure it is assumed that all new residential properties in the city will be constructed using low carbon housing principles. This takes the form of a reduction in residential energy demand compared to the current UK building standards. This reduction is assumed to cost, on average, an additional £5000/home. The scale of the energy reduction is uncertain due to differences between types of house and potential energy saving measures that could be included. Therefore a range of potential values has been calculated and is shown in Table 13.

Table 13: Economic viability of introducing low carbon housing for new residential developments in the city

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	27,028	45,047	47,966	27.0-90.41	1,376-4,611	34.85-10.40

The highest level of energy saving and low payback period assumes the full potential of zero carbon housing standards (Zero Carbon Hub, 2014) can be achieved. The minimum energy saving shown assumes only a limited set of low carbon measures can be installed. It is likely that the actual energy savings and payback period will fall somewhere between the two figures shown.

Upgrades to residential heating systems

The majority of properties in the city use gas boilers for space heating. This measure relates to their replacement with newer and more efficient versions. The level of boiler replacement is as per the reference scenario with no increase in boiler replacement over that expected to occur naturally.

The measure produces a significant energy saving in the residential sector as shown in Table 14. The investment cost for this measure will be borne by the property owner with no funding required from the municipality.

Table 14: Economic viability for upgrades to residential heating systems

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	21,924	56,541	50,442	136.41	6,957	7.25

External solid wall insulation

External solid wall insulation is used to insulate the walls of properties without a cavity in the external walls. Typically this includes housing built before 1920 which was constructed using a double layer of brick with no cavity. Non-masonry constructed properties built after this period, such as those built in the 1950s using "no fines" concrete or concrete panels, can also require this type of insulation.

The cost of this type of insulation is much greater than cavity wall insulation although offering a similar level of energy reduction. The implementation of this measure under the LL-Growth scenario is slightly lower than would be expected under the Reference scenario. Economic viability for the limited degree of implementation under LL-Growth is shown in Table 15.

Table 15: Economic viability for the installation of solid wall insulation in suitable properties in Nottingham

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	7,873	13,122	13,972	4.22	215	64.95

District Heating Expansion

Expansion of the city's waste incinerator, and the associated increased capacity for the city's district heating network, has been in planning for a number of years and is mentioned in the city's existing energy strategy (NCC, 2010). This measure assumes that such expansion goes ahead with the addition of a new line at the city's Eastcroft EfW incinerator. This increases the capacity of the city's district heating network enabling the addition of new residential customers to the network.

The city's current District Heating Network (DHN) has around 4,700 residential customers and 150 commercial users (mainly energy intensive sites located around the city centre). The current capacity of the DHN is 30 GWh of electricity generated and 126GWh of heat produced. Under the proposed expansion another 10 GWh of electricity and 79 GWh of thermal energy will be available.

Table 16 shows the results of the economic viability analysis for this measure. The total investment calculated by the Nottingham ESM is £96M and it is assumed that this measure will be implemented around 2020, although it is likely that the addition of customers to the DHN will take place over an extended period. Cost estimates for this type of large energy infrastructure programme are imprecise and often subject to variations due to unforeseen circumstances. The figures shown are illustrative only. It is expected that a full and detailed feasibility study would be undertaken pre-implementation. It is also likely that there would be substantial operating costs in running the expanded DHN which are not included in the calculation due to their uncertainty. The annual return shown in Table 16 has been calculated based on the cost of the grid electricity and mains gas supply that is being replaced by district heating.

The economic viability does not factor in the increase in the percentage of low carbon energy generated by this measure, which is a primary target in the city's current energy strategy.

Table 16: Economic viability relating to the expansion of the city's district heating network

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	96,000	0	78,096	245	15,375	5.08

Community scale biomass CHP schemes

Small scale CHP schemes fuelled by biomass are included in the city's current energy strategy (NCC, 2011). However, there have been no significant installations of this technology to date due to a number of reasons (e.g. cost, environmental concerns, etc.). This measure assumes that these obstacles will be overcome and that a significant capacity will be installed towards the end of the projected time horizon. This measure relates to CHP for residential properties. It would be most suited to new residential developments on the fringes of the city boundary where emissions for the CHP plant would be less likely to be of concern.

Table 17 shows the results for this measure calculated from the Nottingham ESM. The ESM identified three city zones suitable for this measure on the northern edge of the city. However, environmental concerns and logistics would be likely to be major constraints on any final sites for this technology and are not included in the TIMES analysis.

Table 17: Economic viability of installing community scale biomass CHP systems at suitable sites

Investment (£000s)			NPV (£000s)	Energy Generated (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	100,266	11,199	88,025	26.9 ELC / 97.3 THERM[5]	9,497	9.27

Discussions with the city's energy services directorate indicate that the level of energy generation shown in Table 17 may be difficult to achieve from an environmental perspective. Reductions in existing air pollution emissions may need to be in place before additional emissions from CHP schemes would be possible. This could be achieved if other measures in the scenario are met. The energy generation

[5] ELC = Electrical power generated; TH = Heat energy produced

level shown should therefore be considered as the potential maximum that could be achieved.

The annual return shown is the cost of domestic gas and electricity that would be offset by the Biomass CHP but excludes the cost of the biomass fuel. The measure is not an energy reduction but instead a replacement of fossil fuel based energy with a low carbon renewable source of energy. If the cost of biomass was included then the investment costs would not be recouped since the cost of biomass fuel and natural gas are currently comparable.

Rooftop solar energy (PV) schemes

This measure models the installation of solar PV capacity on residential rooftops in the city. The penetration of this measure is not affected by the LL-Growth scenario and is similar to the number of rooftop PV schemes installed under the standard Reference scenario.

The annual return value shown and associated payback period for option A is based on the assumption that all the energy generated by the residential PV is utilised and offsets that amount of grid based electricity. Option B assume that all the energy generated is exported to the electricity grid and that the current rate of feed-in-tariff[6] (FIT) is applied. Option C assumes no FIT and that only 50% of the energy generated is utilised by the property. Assuming that the FIT is no longer applicable in the UK for the schemes proposed in this measure after 2017, then the likely ROI for this measure will lie somewhere between the results shown for Options A and C.

Table 18: Economic viability for installation of PV panels on suitable residential rooftops

Option	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
A	0	1,613	2,386	2,689	14.01	1,732	1.56
B	0	1,613	2,386	2,689	14.01	688	3.91
C	0	1,613	2,386	2,689	7	861	3.12

Solar Energy (non-domestic)

The installation of residential solar energy generation was included as an optional technology in the Nottingham ESM but current levels of financial support for small

[6] Note that the current rate of FIT is not expected to continue beyond 2017 and there is a strong likelihood that residential PV schemes installed after that date will not receive any FIT payments for exporting energy to the national grid.

scale rooftop PV schemes were not sufficient for the TIMES model to identify any significant increase over the standard *Reference* scenario.

Instead of the traditional small residential PV schemes, it was determined to investigate the installation of plant scale PV schemes at suitable sites. A proposal for this type of scheme had been previously put forward but did not go ahead at the time due to budgetary constraints. The scheme involves the creation of a solar canopy of PV panels over car parking sites at a number of potential locations in the city. An example installed at the city's Harvey Haddon Sports Village is shown in Figure 4.

Figure 4: Example of solar canopy - Harvey Haddon sports village, Bilborough, Nottingham

Compared to the other measures described in this action plan, this intervention is relatively low cost and only generates around 0.3 GWh of energy. However, it contributes towards the city's low carbon energy targets and has a reasonably low payback period as shown in Table 19.

Table 19: Economic viability relating to the creation of small plant scale PV sites in the city

Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
2014	2020	2030				
0	0	260	150	0.3	42	3.57

Discussions with city stakeholders indicates that there may be potential to expand upon the capacity modelled in the Nottingham ESM. A number of additional sites for this type of PV scheme are being considered in the city including rooftops of public buildings and undeveloped land owned by the municipality. Based on the example shown, and assuming the suitability of any sites proposed[7], increasing the capacity of

[7] Suitable, in this instance, would refer to sites with access to solar energy throughout the year and where a significant portion of the energy generated could be used locally or stored.

plant scale PV schemes would seem to be an effective way to increase the city's low carbon energy generation and reduce its demand on grid based electricity generated using fossil fuels.

2.3. Economic viability analysis – alternate measures

This section discusses the economic viability of measures not included in the standard LL-Growth scenario as described in section 1.2. The measures included in this section have low economic viability but have the potential for increasing the decarbonisation of transport and residential energy use. Some additional analysis for these measures is included as mitigation for their low economic viability.

NET Extension to HS2 East Midlands hub

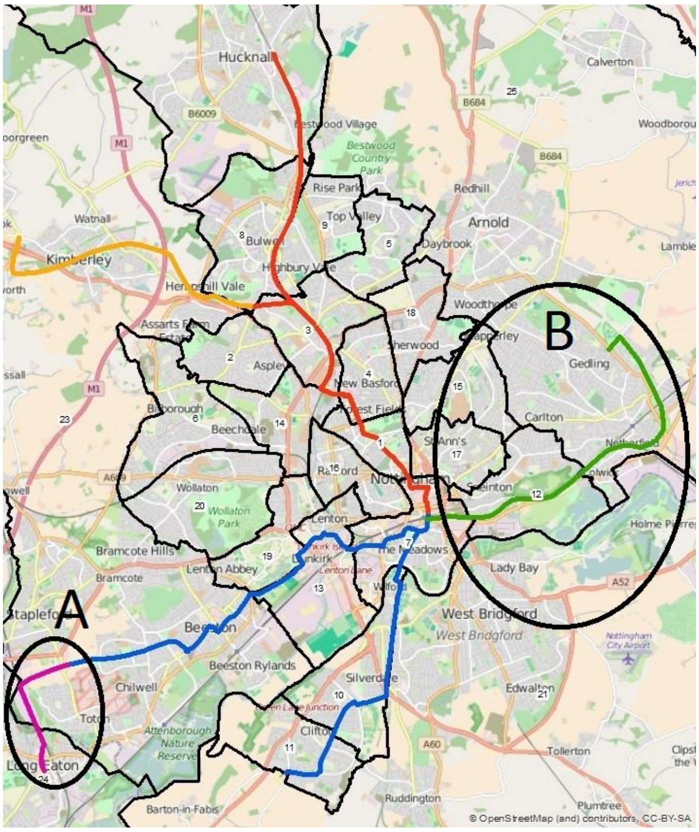

Figure 5: NET currents routes and planned extensions

This alternate measure models an expansion of the city's existing tram network. Specifically, an extension of the current line 3 from the Beeston area to the planned East Midlands hub for the new national high speed rail line (HS2). The extension is shown in Figure 5 and marked as 'A'. An estimated cost for this extension was provided by Systra, the project partner modelling transport. This estimate is subject to large uncertainty due to the complex nature of major transport infrastructure upgrades like the construction of a new tram line. It also does not include the operational costs of the NET extension.

Table 20 shows the economic viability associated with the proposed NET expansion. As shown, the measure has a limited impact of energy use within the city boundary and therefore is not a viable option at that scale. However, for the T2W area the energy saving is more significant with a payback period of less than 10% of the one calculated for the city. This is not surprising as the proposed extension falls outside the city and its impact is mainly on transport originating in the T2W area.

Table 20: Economic viability of NET expansion to HS2

Area of effect	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
City	0	0	105,000	60,554	1.92	230.20	263.05
Travel to Work Area	0	0	105,000	60,554	22.12	2,654.35	22.81

It should also be noted that any expansion of NET would not be done from a purely energy saving perspective. NET expansion, like the electric bus measure described in section 2.2, would be intended to reduce traffic congestion, improve air quality, reduce CO2 emissions and increase local economic development.

NET Expansion – Addition of fourth line to Gedling

The other potential expansion of the city's tram network is a new line linking the existing network with the east of the city and ending in the Gedling area as shown by the green line highlighted by the 'B' in Figure 5. Like the previous NET expansion described, this option does not have high economic viability from a cost perspective. Due to its higher cost estimate it also remain unviable even at the T2W scale, as shown in Table 21. However, like the expansion to HS2 described in the previous section, this option would not be carried out based on a purely economic assessment.

Table 21: Economic viability of NET line 4 (Gedling)

Area of effect	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
City	0	0	250,000	144,176	3.98	477.2	302.11
Travel to Work Area	0	0	250,000	144,176	9.83	1,213,4	118.82

Residential heat pumps

The option to replace existing heating systems with Air Source Heat Pumps (ASHP) was included in the Nottingham ESM. However, this option was not selected by the TIMES model due to the high cost of implementation relative to its ROI. E4SMA calculated the level of subsidy required for this technology to become a viable option for suitable properties at the request of NCC. Flats were chosen as they already typically utilise electricity based space heating. ASHPs can offer significant energy savings over other electric based heating systems but don't produce a significant energy improvement over modern gas boilers. They also operate best in well insulated properties with low levels of heat loss, again more suited to modern flats.

The results of this analysis for each of the scenarios modelled using the Nottingham ESM is shown in Figure 6. The figures shown are based on the assumption that an apartment would only require a small 6kW heat pump.

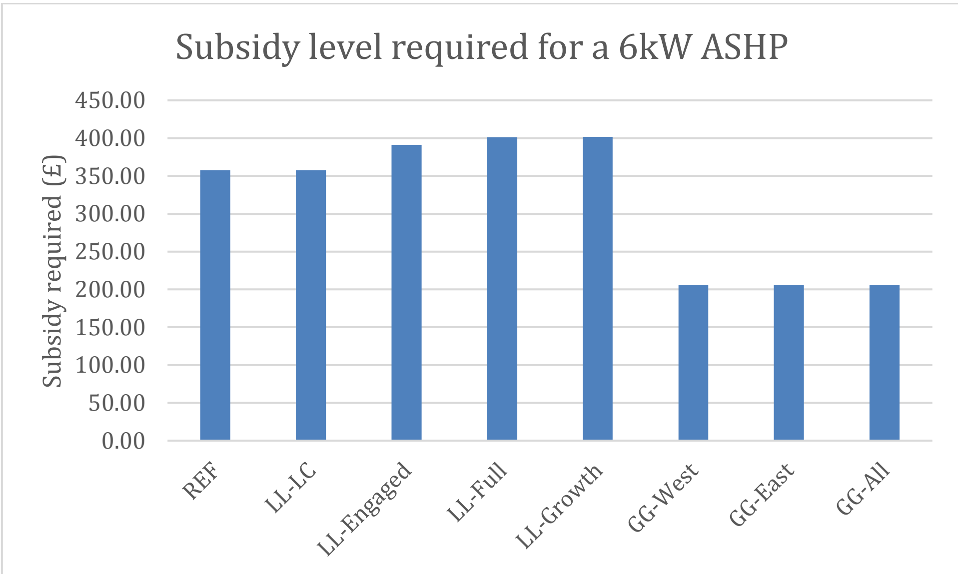

Figure 6: Level of subsidy required for the viable installation of air source heat pumps in residential buildings in Nottingham

The LL-Growth scenario described in this report, requires the highest level of subsidy (£2,409) as this scenario offers a range of more economically attractive options for energy improvements to the residential sector. The GG based scenarios show a much lower level of subsidy due to the introduction of a national carbon tax under those scenarios.

Table 22 provides an illustration of the potential economic viability of the installation of air source heat pumps for a number of options: replacing all existing flats with electric based heating systems, replacing electric heating in existing modern flats (built post 1980) only and installing ASHPs in all new residential properties (using the energy demand calculated for low and zero carbon housing described in section 2.2). The first three options all produce a similar payback period of around 15 years.

The lifespan of an ASHP is estimated to be in the range of 20 years. Any overestimation of energy saving would make the measure non-viable. The space heating requirement of zero carbon buildings is too low to make the technology economically viable.

Table 22: Economic viability for installation of air source heat pumps in suitable properties

Option	Investment (£000s)			NPV (£000s)	Energy Saving (GWh)	Annual return (£000s)	Payback Period (years)
	2014	2020	2030				
All existing flats	0	67,519	67,519	93,866	54.2	6,667	14.08
Modern flats only	0	33,136	33,136	46,065	25.67	3,157	14.59
New residential (low carbon)	0	50,453	50,453	70,139	34.6	4,255	16.48
New residential (zero carbon)	0	50,453	50,453	70,139	6.23	766	91.57

2.4. Economic viability of the overall package of measures

A summary of all the default measures described in section 2.2 is provided in Table 23. Totals for the three sectors are included along with separate values for the city and travel to work area. Where multiple options were presented for measures in section 2.2, the summaries below include the more conservative option.

Table 23: Overall economic viability of the entire package of energy measures proposed

Interventions	Energy saving (GWh)	Total Investment (£000s)	NPV (£000s)	Annual Return (£000s)	Payback Period (years)
Transport (City)	199.54	649,746	404,047	31,978	12.64
Transport(T2W)	248.46	716,664	444,781	54,600	8.15
Residential	254.9	209,520	137,421	13,002	10.6
Energy Generation	393.5	211,725	168,960	26,637	6.34
TOTAL (City)	848.0	1,070,922	710,428	71,617	9.92
TOTAL (T2W)	896.9	1,137,909	751,162	94,198	7.97

As shown, the overall payback periods range from 6-13 years depending on the viability of each sector. The total payback for all measures is between 8-10 years for the T2W area and city respectively.

Figure 7 shows the city's overall energy mix over the projected time horizon for the LL-Growth scenario. The final column, 2030REF, shows the energy mix in 2030 under the Reference scenario without the application of the measures described in this report.

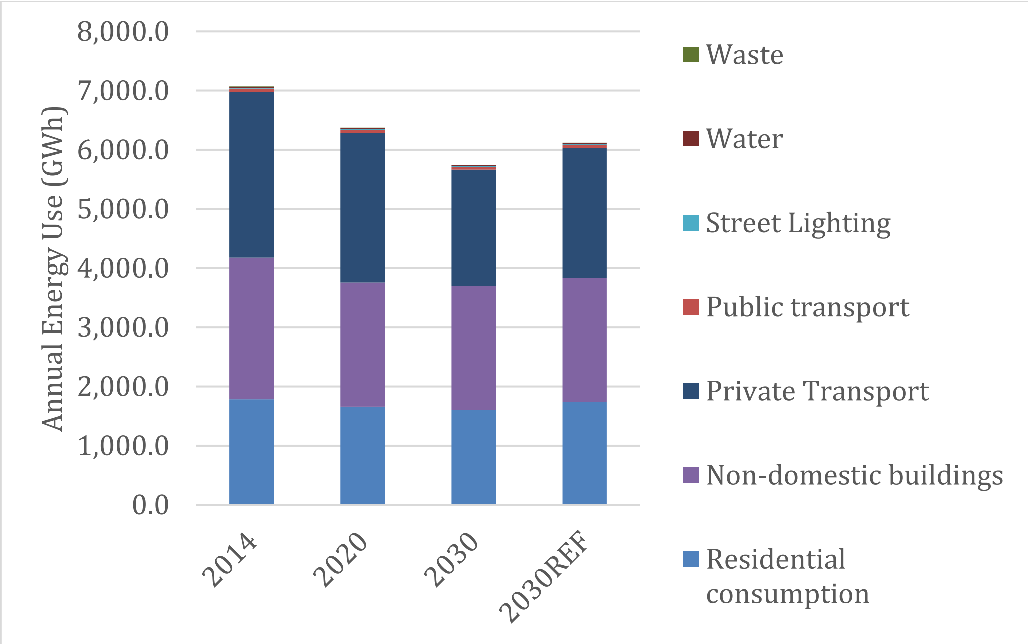

Figure 7: Energy reductions for the scenario over the projected time horizon and comparison with the Reference scenario in 2030

Benefits beyond energy savings should also be considered, when evaluating the impact of the measures considered in this report. Figure 8 shows a chart of CO_2 emissions over the timeline. The difference between the results for LL-Growth and the Reference scenario are more pronounced in this instance. This is due to the increase in low carbon energy used in the city and reduction in polluting vehicles on the city's roads. Figure 9 shows similar results for emissions of other air pollutants modelled.

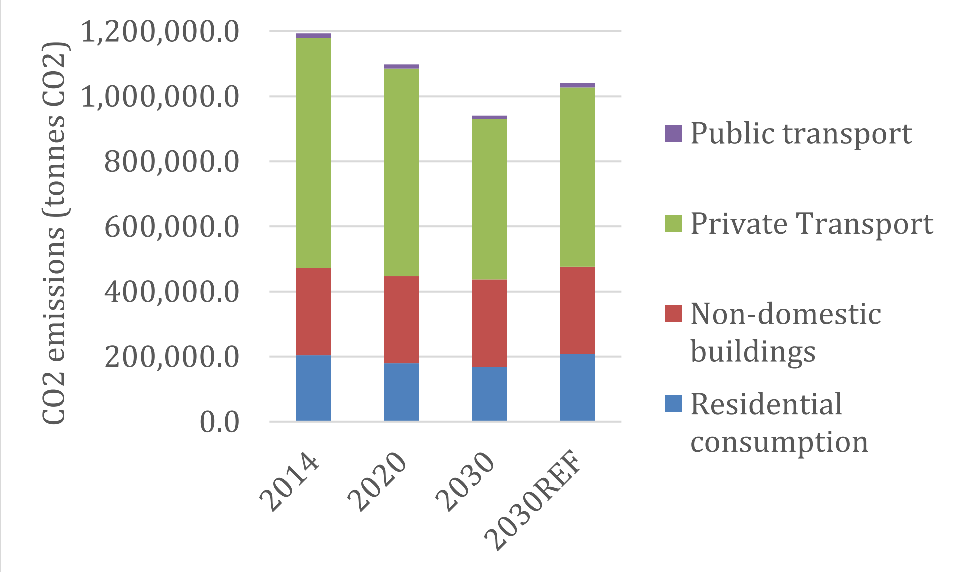

Figure 8: CO2 emissions over the time horizon

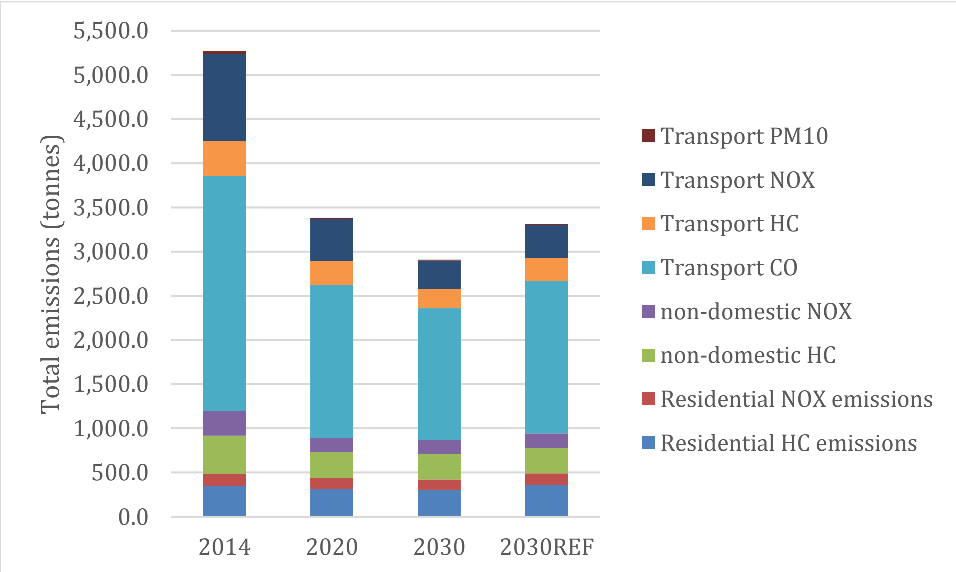

Figure 9: Other air pollution emissions over the time horizon

3. Proposed funding schemes

3.1. Available funding schemes

Funding for energy schemes in the UK can come from a number of potential sources depending on the nature and type of investment required. Four broad areas of funding have been identified:

- EU funding, such as the European Regional Development Fund (ERDF), European Structural and Investment Funds (ESIF) or the European Energy

Efficiency Fund (EEEF). The ERDF in particular has been used to support a range of regeneration projects in the city since 2000.
- Schemes funded by the UK government, usually granted through the relevant government departments, play a significant role in supporting large scale energy/transport infrastructure projects in the city.
- Local funding through the municipality often plays a role in supporting many large scale projects but can also be used to fund smaller scale community based projects.
- Partnerships with the private sector through schemes such as the Private Finance Initiative (PFI).

The potential role of each of these sources of funding will now be briefly discussed.

EU funding

The city of Nottingham has received funding from the ERDF for a number of regeneration projects in the city. Funding has typically being allocated for the construction of new buildings and infrastructure. ERDF funds have also been used to support the setup of schemes aimed at regenerating specific areas of the city.

ESIF funding via the ERDF offers a potential source of funds that could be used for energy related projects and infrastructure. Priority Axis 4 (*Supporting the Shift Towards a Low Carbon Economy in All Sectors*) currently has an open call for the area covered by the D2N2 local enterprise partnership, which includes the city of Nottingham and its travel to work area. This could offer a potential source of funding for some of the measures described.

Funding from the EEEF would seem most suited to many of the energy related measures described in this report. However, the city does not have any experience in applications to the fund and no current plans for submission.

A number of EU funded research programmes are operating in the city of Nottingham and could play an important role in supporting the delivery of some of the measures described. For example, the H2020 funded Remourban[8] project is testing a number of innovative methods for creating a low energy district in the city. Results could provide new options for energy retrofits of residential properties or methods for expanding the use of district heating.

However, with the UK's triggering of article 50 and subsequent departure from the European Union, there is a great deal of uncertainty associated with future EU funding in the UK. This makes the viability of such funding in the mid-term questionable.

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[8] See the project website for further details (http://www.remourban.eu/)

National funding schemes

Funding from national government, usually sourced through the relevant government department, is a primary funding source for large scale infrastructure projects in the UK. A number of the measures described in section 2.2 have already applied for, or received, funds from national programmes (described in section 3.2). National subsidies and incentive schemes provided by the UK government have already been factored into the investment costs shown for many of the measures in chapter 2. These include:

- Residential energy improvements were funded in recent years by the government's Green Deal. However, this programme is no longer funded and a future replacement has not yet been announced. However, subsidies for home insulation are available through other sources such as ECO (see below) and local councils. Funding is often means-tested with the level of financial support dependent on household income levels. An overall average level of subsidy was for home insulation measures was applied to the Nottingham ESM and used to calculate the penetration of these retrofits over the projected time horizon.
- The Energy Company Obligation (ECO) is a government energy efficiency scheme to help reduce carbon emissions. Under the scheme, the major energy suppliers are required to deliver energy efficiency measures like home insulation or boiler replacement to households.
- The UK government offers a grant of up to £4,500 for the purchase of new private electric vehicles. This cost was included in the assessment of low carbon vehicles in section 2.2.
- The Renewable Heat Incentive (RHI) offers homeowners and communities an income for generating low carbon heat through a range of technologies (solar, thermal, heat pumps, biomass CHP, etc.). The income generated is based on the amount of energy generated. The RHI was included in the Nottingham ESM and used to offset the cost of installing these types of technology.

The UK government's Business, Energy and Industrial Strategy (BEIS) department has provides a range of grants and schemes to support the research, development and funding of energy related projects. BEIS's current heat strategy includes funding sources for renewable and low carbon heat networks that could provide funding for expanding the city's DHN or the community scale biomass CHP schemes.

The Department for Transport (DfT) is the government body responsible for supporting transport projects and schemes in the UK. The city of Nottingham has applied for and received funding for a number of transport related projects aimed at reducing carbon emissions and energy use by both private and public transport. DfT financial support will be considered for many of the transport focused measures described in section 2.2.

Both the BEIS and DfT also contribute funding towards UK research projects through the Engineering and Physical Sciences Research Council (EPSRC) and Innovate UK. Nottingham has been involved in a number of UK funded research projects relating to energy and transport. Currently, Innovate UK is funding *Project Scene*[9], is investigating the potential for sustainable community energy networks and the business models to underpin such networks. Results from this work could provide new funding methods and options for some of the measures described in this report (e.g. Solar PV, Community based biomass CHP and low carbon housing).

Regional/Municipal funding

Local funding is a key element of many urban energy related projects. Many national funded awards stipulate that the local authority (or other relevant stakeholders) provide a proportion of the overall budget as a prerequisite of the funding being awarded. Local funding is also a common option for the funding of smaller scale community based projects that may not be eligible for EU or national funding programmes.

Investments that offer a reasonable rate of return can also be funded from NCC's own budgets due to their ability to borrow money at a better rate of interest than would be commercially available to citizens or local companies.

NCC introduced a Workplace Parking Levy in 2012. This is used to support the funding of transport related infrastructure projects in the city. Money raised is currently used to fund NET phase 2 and other projects. As discussed in section 2.2, income for municipal car parking spaces can also be used to offset the cost of transport measures.

Some local authorities in the UK have provided council tax rebates as an incentive for households to improve the energy efficiency of their properties. NCC ran a scheme called *Greener HousiNG* (ended 2016) to help local households improve their energy efficiency. The scheme utilised funding from a range of sources including those already mentioned (ECO, Green Deal, EU funds). A replacement scheme has not been announced yet but would be a way to increase the number of residential retrofits carried out. Funding from local community health budgets could also be used to improve housing though this type of intervention would be focused on increasing indoor thermal comfort rather than reducing energy demand.

In addition to local municipal type funding, regional funds are available through Local Enterprise Partnerships (LEPs). The LEP covering the Nottingham area is the D2N2 partnership. D2N2 provides support through two key sectors, *Low Carbon* and *Transport and Logistics*. These deliver support from the ERDF and the UK Local Growth Fund for their respective areas. For example, D2N2 sourced funding has been acquired for the delivery of the NCCAP programme.

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[9] See the project website for further details (http://www.projectscene.uk/)

Mixed funding

The private sector can also play a significant role in the funding of energy projects. For large infrastructure projects with long payback periods, this is usually done through a Private Finance Initiative (PFI). Nottingham currently has two PFI projects in operation; one relating to the replacement and maintenance of the city's street lighting with modern LED lighting, NET phase 2 (the construction and operation of lines 2 and 3 of the city's tram network) is the other PFI project. PFI projects can be expensive to setup and operate and are only likely to be used where no other funding sources are available.

At the other end of the scale, partnerships with smaller private organisations (often local companies or Non-profit NGOs) are commonly used to implement smaller scale projects like community energy schemes and behavioural change and education programmes. Examples of such arrangements would include

- Sustrans, a UK charity enabling people to reduce their use of private motor vehicles, is supporting Nottingham's NCCAP project aimed at increasing the use of cycling in the city.
- Nottingham Energy Partnership (NEP), a local organization involved in helping alleviate fuel poverty and improve energy efficiency in the local area, has been involved in a number of energy related projects in the city.

Such partnerships are not always a source of funding in themselves but help build consortia that can be eligible for funding sources and provide expert analysis and input that can be used for funding applications.

The ECO funding described under the national funding schemes also falls into this section since, although the ECO funding is managed through national government, the funding itself comes from the private energy companies in the UK.

3.2. Proposed funding approach

Selecting the most appropriate financing option for each of the proposed interventions in Nottingham requires the consideration of a number of options:

1. **Temporal issues** – The funding alternatives described in section 3.1 have different implementation time frames. National subsidies for energy efficiency measures require no lead time but could be terminated (usually with notice) at any time. For instance, the feed in tariff for solar PV in the UK has been declining in recent years and is not expected to continue after 2017. PFI schemes usually require a long lead time to set up and usually run over an extended period (e.g. 25 years). This makes PFI more suited to long term actions with ongoing operational requirements. European funded schemes require a fairly complex application process and often provide funding for the short to medium term.
2. **Municipal Experience** – A major factor in the selection of funding alternatives is the local authority's experience and familiarity with the funding

source. The administrative overhead in setting up a new source of funding can be a significant obstacle. Prior experience in using a funding source may also have a significant impact on whether it will be selected as an alternative in the future.

3. **Overall funding requirement –** The funding sources described in section 3.1 offer different levels of funding. High levels of investment typically require European or national funding sources. Local funding may contribute to such projects but would not be capable of funding them alone. Some interventions require citizen's to fund energy efficiency measures themselves, in this instance local funding may be used to advise citizens of funding options or provide incentives to encourage their uptake. Large infrastructure measures like district heating expansion or transport network upgrades would require state support. Mixed funding under PFI types schemes would be suited to projects with a high budget where repayment could be leveraged over the longer term such as tram network upgrades.
4. **Mix of funding** – Many funding options require a mix of funding from local, national, public and private sources. For example, the NET phase 2 project was undertaken as a PFI project and included funding from the local municipality, national government through the DfT and the NET consortia itself (a private company). The mix of funding required will be a criteria that needs to be assessed in choosing a specific funding alternative.

Based on these factors and current funding sources available to the city of Nottingham, the following table (Table 24) summarises potential funding sources for each of the measures described in the report.

The measure relating to future expansion of the district heating network has been excluded from this section. Plans for this type of large and complex energy generation infrastructure will require a full pre-feasibility analysis and public consultation to be carried out and it is not appropriate to speculate on this process in this report at this time.

Table 24: Matrix of funding sources by measure for the InSMART plan for Nottingham

Intervention	Funding Schemes			
	Citizen funding	Municipal funding	National funding	Other funding sources
Cycling improvements	Citizen's to fund their own cycles through 0% loans or to pay to hire city rental cycles[10]	NCC provide around a third of funds for this measure from a combination of sources (e.g. public health, transport and WPL)	DfT to provide largest proportion (~65%) of funding as outlined in the economic case for the NCCAP project (NCC, 2013)	Third party contributions of around £220,000 as described in NCCAP documentation (NCC, 2013)
Low carbon vehicles / low carbon zone	Vehicle owners expected to fund any additional cost of EVs out of own funds[10].	NCC to provide around £1.5M towards cost of measure as described in *Go Ultra Low* bid document (NCC, 2015)	DfT to provide 75-80% of funding requirements from its *Go Ultra Low* programme. National incentives also contribute up to £4,500/EV	Around £500,000 from Local Growth Fund to contribute towards cost of infrastructure
Electric buses		NCC to contribute portion of funding through transport budget and/or WPL as part of any national funding award	DfT offering funding for low carbon public transport schemes. NCC has experience in applying for such funding.	Nottingham City Transport to contribute towards cost of new bus fleet. NCT also to bear ongoing maintenance and operational cost of fleet.
Southern Corridor		Increased parking charges could offset the cost of this measure as outlined in section 2.2 or pay for local contribution to national funding award.	DfT funding calls aimed at reducing traffic congestion and increasing use of public transport would be a viable option for partial funding of this measure	
Cavity wall insulation	Property owner to pay subsidised cost of insulation and installation			Energy company contribution to ECO fund provides subsidy for home insulation measures

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[10] Note that this funding component was not included in the economic viability analysis

Loft insulation	Property owner to pay subsidised cost of insulation and installation			Energy company contribution to ECO fund provides subsidy for home insulation measures
Draught-proofing measures	Full cost of measure to be paid by property owner. Cost modelled as per professional installation	Subsidies/financial support available to NCH tenants and through public health budgets for vulnerable households.		
Low carbon housing	House buyers to potentially fund low carbon housing through increase in asking price	NCC to support low carbon housing through its part ownership of local low carbon housing developer, Blueprint	Not currently aware of any national funding to enable large scale development. However, research funding available for smaller scale (e.g. Project scene[11], Remourban[12])	Developer to provide initial funding of extra construction cost for low carbon housing. Cost may be passed on to purchaser
Community scale biomass CHP	Community users to contribute towards operational costs through energy bills	NCC may be able to provide partial funding, especially for NCH housing.	BEIS funded UK Heat strategy may be a source of funding (£320M fund announced). BEIS funded RHI subsidy already included in costing model for this measure	
Solar energy (non-domestic)		NCC to fully fund this measure for all suitable properties		

[11] See project website for more details (http://www.projectscene.uk/)

[12] See project website for more details (http://nottingham.remourban.eu/)

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 3-7 years.
3) Longer term: action that can be implemented in the 8-13 years.

This covers the projected time horizon of the Nottingham horizon to 2030. Timing categories for each measure are shown in the following table.

Table 25: Planned timing of intervention measures over the time horizon

	Timing		
Interventions:	Immediate	Intermediate	Further ahead
Cycling improvements	Work under the NCCAP project started. Plans for completion in 2017		
Low carbon vehicles / low carbon zone		The Go Ultra Low programme of work to occur between 2016-2020	Increased uptake of EVs expected to occur from 2020 onwards
Electric buses			Electrification of bus fleet not expected to complete until end of time horizon
Southern Corridor		Improvements planned to be implemented in the early 2020s	
Increased Parking Charges			Charge increases to be introduced gradually Full implementation by late 2020s
Cavity wall insulation	Installation of insulation measures expected to be implemented immediately. Due to high number of properties for insulation, full penetration of measure expected to occur over an extended period		
Loft insulation	Installation of insulation measures expected to be implemented immediately. Full penetration of measure expected to occur over an extended period due to need to engage with private households.		

Draught-proofing measures		Roll out of measure expected to take place once insulation measures in place.	
Low carbon housing	Introduction of low carbon housing expected to occur throughout the time horizon due to the long lead times for construction and constraints of planning permission. Initial low carbon housing for Trent Basin expected to complete by 2018.		
Community scale biomass CHP		Full implementation expected to occur in the latter periods of the time horizon. Initial installations expected in early 2020s	
Solar energy (non-domestic)	Implementation expected to occur on a site by site basis over the short to mid-term of the projected time horizon		

Another important for inclusion in an implementation plan are the resource requirements (monetary and personnel) for the implementation of each action. An estimation of the required monetary resources was provided in chapter 2. In Table 26 these are divided into resources required from the Municipality and resource that should be covered by other sources.

Table 26: Resource requirements by measure

	Resources		
Interventions	Investment Costs covered by the Municipality	Municipality Staff Engagement	Costs external to the municipality
Cycling improvements	NCC to provide funding to support programme	NCC transport dept. involved in design and implementation of programme. NCC to engage with citizens to encourage cycling uptake in the city	DfT to provide 70% of funding.
Low carbon vehicles / low carbon zone	NCC to provide funding of around £1.5M to support programme.	NCC transport dept. involved in design and implementation of programme. NCC to engage with citizens to encourage uptake of EVs in the city	DfT to provide around 80% of funding. Third sector organisations also contribute
Electric buses	NCC to provide local contribution to any national funding awarded	NCC public transport team will be involved in bidding for funding with local bus operators.	DfT to provide % of capital costs through funding schemes for low carbon vehicles
Southern Corridor	NCC to provide local contribution to any national funding awarded	NCC highways team will be actively involved in the design and implementation of scheme	DfT to provide % of capital costs through funding schemes for highway improvement
Cavity wall		NCC energy services team will be	BEIS/Energy

insulation		actively involved in promoting insulation measures to city households	companies to provide subsidies for energy efficiency measures
Loft insulation		NCC energy services team will be actively involved in promoting insulation measures to city households	BEIS/Energy companies to provide subsidies for energy efficiency measures
Draught-proofing measures	Support and subsidies for implementation for vulnerable households	NCC energy services team will be actively involved in promoting energy efficiency measures to city households	
Low carbon housing	NCC to support through Blueprint[13]	NCC energy services to actively support developers in the design and construction of low carbon homes	Cost of low carbon housing to be borne by developer and passed onto purchaser
Community scale biomass CHP	NCC may be required to provide funding to support bids for BEIS funding of such schemes.	NCC involvement in assessing schemes and supporting communities in design and implementation of schemes.	Subsidies for energy generated and % of capital costs to come from BEIS funded schemes.
Solar energy (non-domestic)	All costs covered by NCC	NCC Energy Services will be actively involved in the planning and implementation of the equipment	

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. The KPIs defined for Nottingham are shown in Table 27.

[13] Blueprint are a local developer of low carbon housing who are partially owned by NCC as part of goals to increase the number of low carbon homes in the city

Table 27: KPIs and monitoring for each measure

	Monitoring		
Interventions	KPI	Monitoring Frequency	Data Sources
Cycling improvements	Length of cycle paths	Annually	Municipality financial services
Low carbon vehicles / low carbon zone	Vehicles registered Charging energy used	2020, 2025, 2030 Annually from 2020	DfT NCC Energy services
Electric buses	Number of electric buses in use	2020, 2025, 2030	Nottingham City Transport (NCT)
Southern Corridor	Local traffic congestion Bus punctuality for journeys in corridor	Annually Annually	NCC transport NCT
Cavity wall insulation	Number of properties insulated	Annually	NCC Energy Services / BEIS
Loft insulation	Number of lofts insulated	Annually	NCC Energy Services / BEIS
Draught-proofing measures	Number of properties draught proofed	Annually	NCC Energy Services / NCH
Low carbon housing	Number of low carbon houses built	Annually	NCC Planning control
District heating expansion	Energy generated Number of new customers	Annually 2025,2030	Enviroenergy Enviroenergy
Community scale biomass CHP	Energy generated / Capacity installed	2020,2025,2030	NCC Energy Services / BEIS
Solar energy (non-domestic)	Energy Generated / Capacity installed	Annually	NCC Energy Services

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Appendix A – Alternate calculation of NPV for energy measures

This appendix provides an alternative calculation of the economic viability of the measures as described in chapter 2. In this appendix the costs have been more evenly allocated over a wider distribution of years rather than just the three time points used in the Nottingham ESM. Costing periods in this analysis are defined for every 2 year period from 2016-2030. The allocation of costs to years was done by spreading the cost for the three time periods evenly. 2014 costs were assigned to 2016, 2020 costs were divided across 2018, 2020 and/or 2022, depending on specific measure. Finally the costs associated with 2030 in the original analysis were divided by 4 or 5 and spread from 2024-2030 or 2022-2030. In general this leads to higher NPV values for each measure and a consequent increase in payback period. Tables A1 and A2 shows the results of this for the city and T2W area respectively.

Table A 1: Alternative calculation of economic viability based on higher temporal distribution of spending (city only)

Measure	2016 (£000s)	2018 (£000s)	2020 (£000s)	2022 (£000s)	2024 (£000s)	2026 (£000s)	2028 (£000s)	2030 (£000s)	NPV (£000s)	AR (£000s)	PP (years)
Cycling Improvements	3,257	6,123	0	0	0	0	0	0	8,973	18,531	0.48
Electric Buses	0	20,000	30,000	27,067	36,623	36,623	36,623	36,623	167,470	1,767	94.78
Electric vehicles & low carbon zone	5,706	5,706	5,706	920	920	920	920	920	19,281	1,801	10.71
Higher uptake of EVs	3,149	3,149	3,149	3,149	8,043	8,043	8,043	8,043	33,494	7,326	4.57
Southern Corridor	0	680	3,000	3,000	3,000	0	0	0	7,968	432	18.46
NET Expansion to HS2	0	0	0	0	20,000	25,000	30,000	30,000	71,298	230	309.72
NET Line 4 to Gedling	0	0	0	0	75,000	75,000	50,000	50,000	174,103	491	354.69
R2	0	2,833	2,833	2,833	2,833	1,702	1,702	1,702	12,956	2,954	4.39
R3	0	143	143	143	523	523	523	523	1,811	231	7.84

R4	0	490	490	490	4,388	4,388	4,388	4,388	13,343	1,269	10.52
Low carbon housing	0	9,009	9,009	9,009	11,262	11,262	11,262	11,262	54,537	2,994	18.22
Community CHP	0	0	33,422	33,422	33,422	3,733	3,733	3,733	89,118	9,497	9.38
District Heating	0	32,000	32,000	32,000	0	0	0	0	83,791	15,375	5.45
Plant scale PV	0	0	0	0	0	100	160	0	177	42	4.21
Total Transport	8,963	32,509	38,706	30,987	135,543	137,543	117,543	117,543	449.093	23,252	19.31
Total Residential	0	12,477	12,477	12,477	19,006	17,875	17,875	17,875	82,647	7,447	11.10
Total Energy	0	32,000	65,422	65,422	33,422	3,833	3,893	3,733	173,086	24,914	6.95
TOTAL	8,963	76,985	116,604	108,886	187,972	159,251	139,311	139,151	704,825	55,612	12.67

Table A 2: Alternative calculation of economic viability - transport measures for travel to work area

Measure	2016 (£000s)	2018 (£000s)	2020 (£000s)	2022 (£000s)	2024 (£000s)	2026 (£000s)	2028 (£000s)	2030 (£000s)	NPV (£000s)	AR (£000s)	PP (years)
Electric Buses	0	20,000	30,000	27,067	36,623	36,623	36,623	36,623	167,470	2,352	71.21
Electric vehicles & low carbon zone	5,706	5,706	5,706	920	920	920	920	920	19,281	5,211	3.70
Higher uptake of EVs	4,279	4,279	4,279	4,279	22,722	22,733	22,733	22,733	77,951	20,877	3.73
Southern Corridor	0	680	3,000	3,000	3,000	0	0	0	7,968	725	10.99
NET Expansion to HS2	0	0	0	0	20,000	25,000	30,000	30,000	71,298	2,654	26.86
NET Line 4 to Gedling	0	0	0	0	75,000	75,000	50,000	50,000	174,103	1,213	143.48
Total Transport (T2W)	8,963	32,509	38,706	30,987	135,543	137,543	117,543	117,543	449,093	30,687	14.63

Figure A1 shows a comparison between the payback periods calculated using the original 3 year spending allocations and the more detailed breakdown shown in this appendix. The figure only shows those measures with a payback period of less than 20 years to assist visualization of the differences. For most measures the difference in payback periods is slight. However, for those measures with a significant portion of their budget allocated to the end of the time horizon (e.g. electric vehicles, draught proofing and low carbon housing), the difference can be significant.

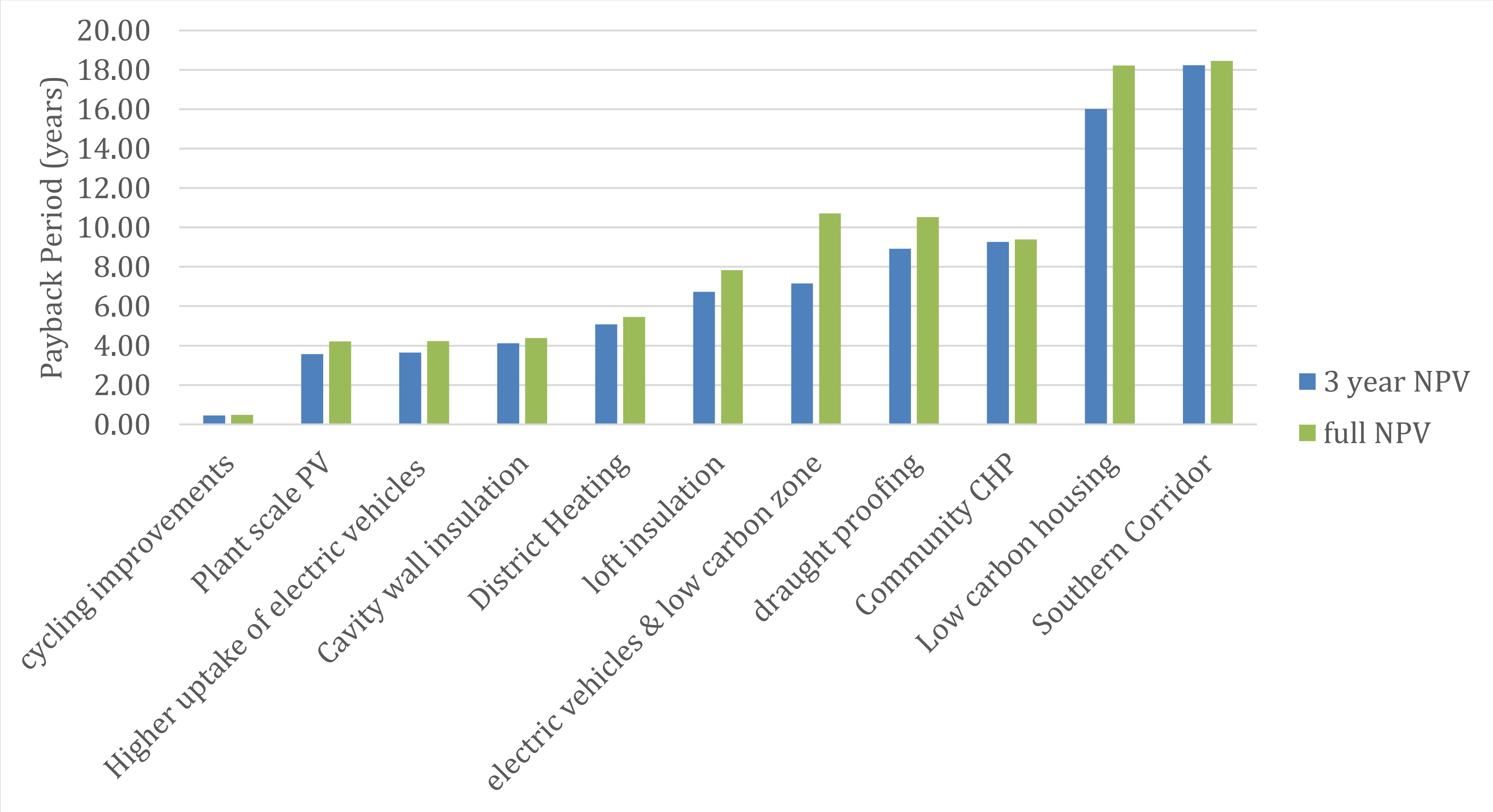

Figure A 1 : Comparison of payback periods for 3 year and revised spending allocation for selected measures

Appendix B – Full economic viability analysis calculations

This appendix provides examples of the full economic analysis carried out for some of the measures as summarized in chapter 2. A full calculation for all measures is not deemed necessary.

Low Carbon Vehicles / Low Carbon Zone

Costs were calculated based on the cost associated with the Go Ultra Low project (shown in Table B1) and the subsidy available for new EVs in the UK. This subsidy is currently up to £4,500/EV and an average subsidy of £4000/EV was used in the calculation. The overall cost of this measure can then be calculated using the number of new EVs registered over the time horizon.

Table B 1: costs associated with the Go Ultra Low project (NCC, 2015)

£m	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	TOTAL
OLEV funding sought	0.360	2.385	2.385	1.450	0.200	0.200	6.980
Local Authority contribution	0.190	0.340	0.340	0.290	0.190	0.190	1.540
Local Growth Fund contribution	0	0.250	0.250	0	0	0	0.500
TOTAL	0.550	2.975	2.975	1.740	1.740	0.390	9.020

The number of EVs was taken from the Nottingham ESM outputs and is shown below in for the standard and higher uptake versions of the measure in the city and travel to work area. The total subsidy required is calculated by multiplying the number of EVs by the average subsidy (£4000/EV), this is then added to the costs shown in table B1 to provide the overall cost of the measure and NPV as shown in Table 5.

Table B 2: Projections for estimated number of EVs

Number of EVs	Standard	Subsidy (£000s)	Higher uptake	Subsidy (£000s)
City	1,150	4,600	8,043	32,172
Travel to work area	3,189	12,756	22,733	90,932

Using figures for the energy efficiency of motor vehicles provided by the project coordinator (CRES), the energy saving associated with the number of EVs can be calculated as shown below:

Fuel Type	Energy Efficiency (TJ/1,000Vkm)	Energy Efficiency (GWh/10,000 miles)
Petrol	0.0028	0.0048
Diesel	0.0086	0.0148
Electric	0.00067	0.0012

Assume average annual mileage of 10,000 miles and fuel split of 70%/30% petrol/diesel from Nottingham ESM:

- ➔ Non EV GWh/10,000 miles = 0.0078
- ➔ EV GWh/10,000 miles = 0.0012

Combining this with the number of EVs allows the calculation of the energy saved and the associated cost saving. The energy saving associated with the introduction of the low carbon zone was taken from the outputs of the Nottingham ESM and added the EV energy cost saving to calculate the return on the measure (shown as the annual return in Table 5). Table B3 shows this calculation. The cost of fossil fuel for transport was assumed to be £1.20/litre and the cost of electricity used to charge the EVs was based on the committee for climate change figures shown in Table 10.

Table B 3: Calculation of energy savings and annual return for low carbon vehicles and low carbon zone

Value	Unit	City only (standard)	T2W area (standard)	City only (higher uptake)	T2W area (higher uptake)
Number EV	count	1,150	3,189	8,043	22,733
Energy Non EV	GWh	9.01	24.99	63.03	178
Energy EV	GWh	1.33	3.69	9.30	26.29
Energy Saving	GWh	7.68	21.30	53.73	151.85
EV Energy Cost	£k	163.58	453.61	1,144	3,234
Energy Saving Cost	£k	922	2,556	6,447	18,222
Energy saving low carbon zone	GWh	7.32	22.12	7.32	22.12
Total Energy saving	GWh	15.00	43.43	61.05	173.97
Low Carbon Zone cost saving	£k	879	2,655	879	2,655
Annual Return	**£k**	**1,801**	**5,211**	**7,326**	**20,877**

Residential retrofits

The economic viability of the four measures relating to energy retrofits of existing residential properties were calculated using the outputs of the Nottingham ESM. This estimated energy savings and costs for each measure as shown in table B4.

Annual returns for the measures were calculated by multiplying energy saving by the cost of domestic natural gas/GWh over the time horizon using the committee for climate change projections (Table 10). This assumes that all heating energy is delivered by natural gas. Properties using other fuel types for space heating are present in the stock but not significant for the typologies that can implement the retrofit measures modelled. Annual returns would be slightly higher if electrically heated properties were costed accurately.

Table B 4: Costs and energy savings associated with residential retrofit measures

Measure	2020		2030	
	Investment (£000s)	Energy saving (GWh)	Investment (£000s)	Energy saving (GWh)
External solid wall insulation	7,873.2	1.6	13,121.9	4.2
Cavity wall insulation	11,333.6	44.0	5,106.9	57.9
Loft insulation	429.9	0.8	2,090.2	4.5
Draught-proofing	1,471.4	2.8	17,553.6	24.9

The annual return is calculated using the 2030 energy saving figure using the following equation:

*Annual return = Energy Saving (GWh) * Cost of natural gas (£000s/GWh)*

Cost of natural gas = 5.1p/kWh = 51 (£000s/GWh)

Annual returns (£000s)

External solid wall insulation = 4.2 * 51 = 214.2

Cavity wall insulation = 57.9 * 51 = 2,953

Loft insulation = 4.5 * 51 = 229.5

Draught-Proofing = 24.9 * 51 = 1,270

NPV Investment (£000s)

External solid wall insulation = $(7872/(1+0.035^{6}))+(13122/(1+0.035^{16})$ = 13,972

Cavity wall insulation = $(11334/(1+0.035^{6}))+(5107/(1+0.035^{16})$ = 12,165

Loft insulation = $(430/(1+0.035^{6}))+(2090/(1+0.035^{16})$ = 1,555

Draught-Proofing = $(1471/(1+0.035^{6}))+(17554/(1+0.035^{16})$ = 11,320

Payback Periods

External solid wall insulation = 13,972 / 214.2 = 64.95 years

Cavity wall insulation = 12,165 / 2,953 = 4.12 years

Loft insulation = 1,555 / 229.5 = 6.73 years

Draught-Proofing = 11,320 / 1,270 = 8.92 years

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

Author(s): G. Giannakidis

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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.

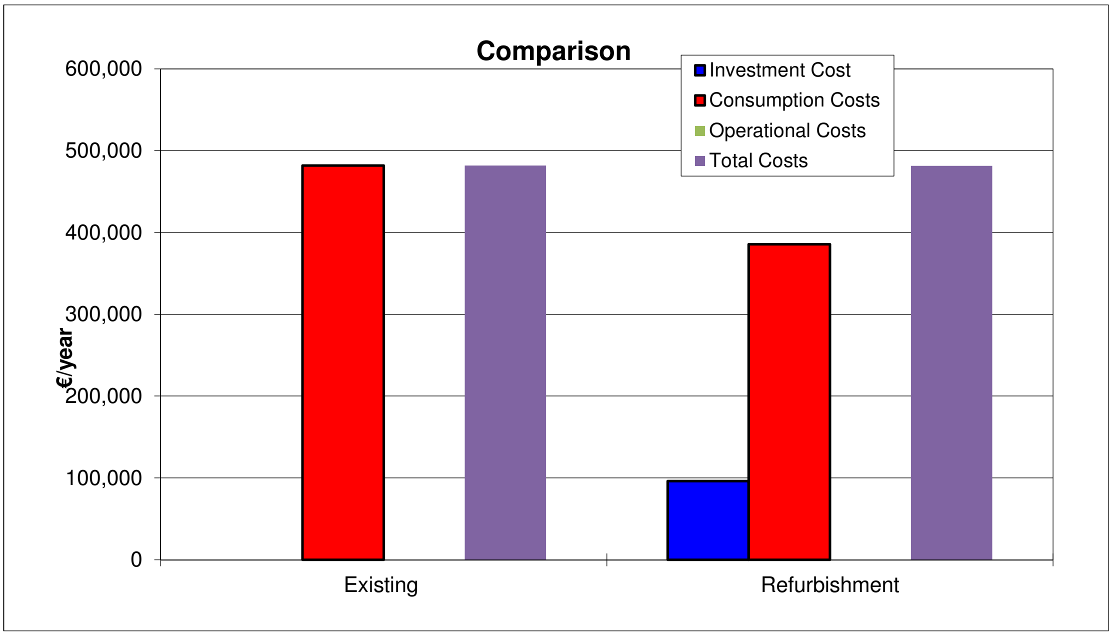

Figure 2-1: Comparison of annualised costs for the refurbishment of Municipal buildings.

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

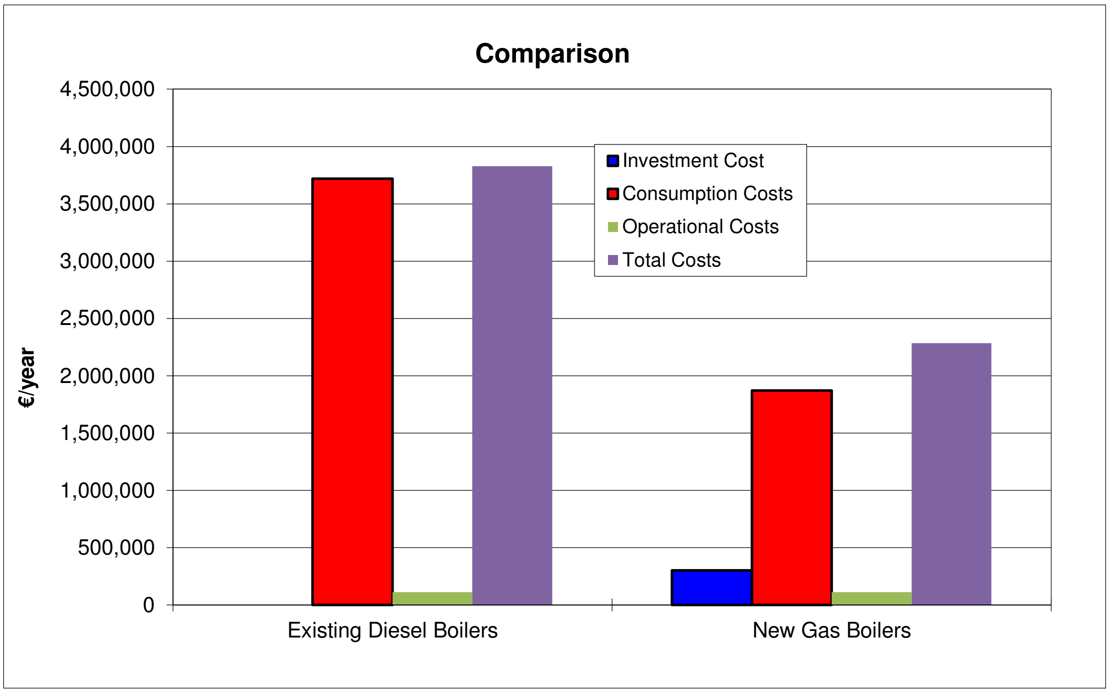

Figure 2-2: Comparison of annualised flows for the connection of buildings to the N. Gas grid.

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

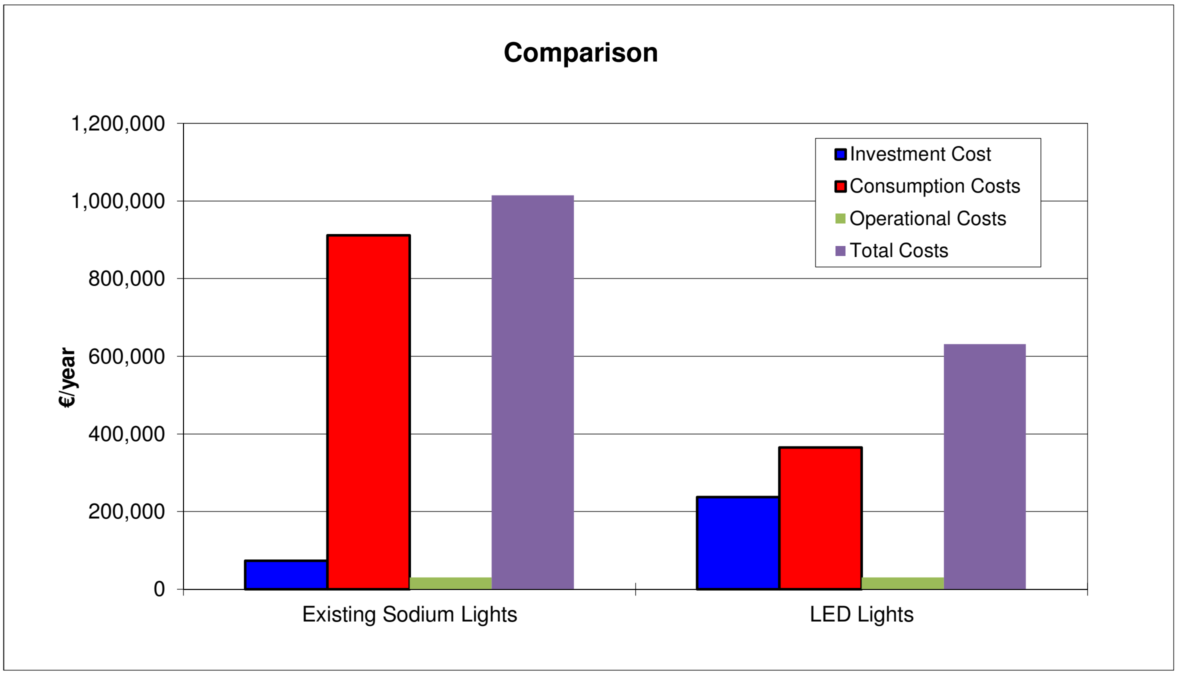

Figure 2-3: Comparison of annualised flows for the street lights replacement.

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

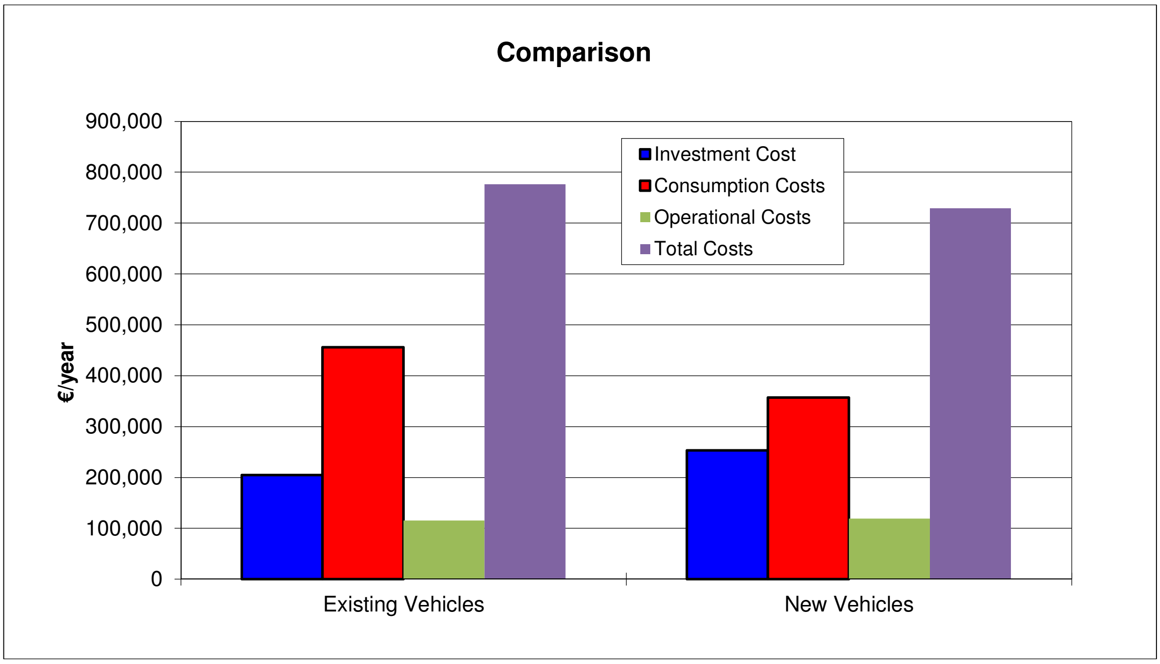

Figure 2-4: Comparison of annualised flows for the Municipal vehicles replacement.

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

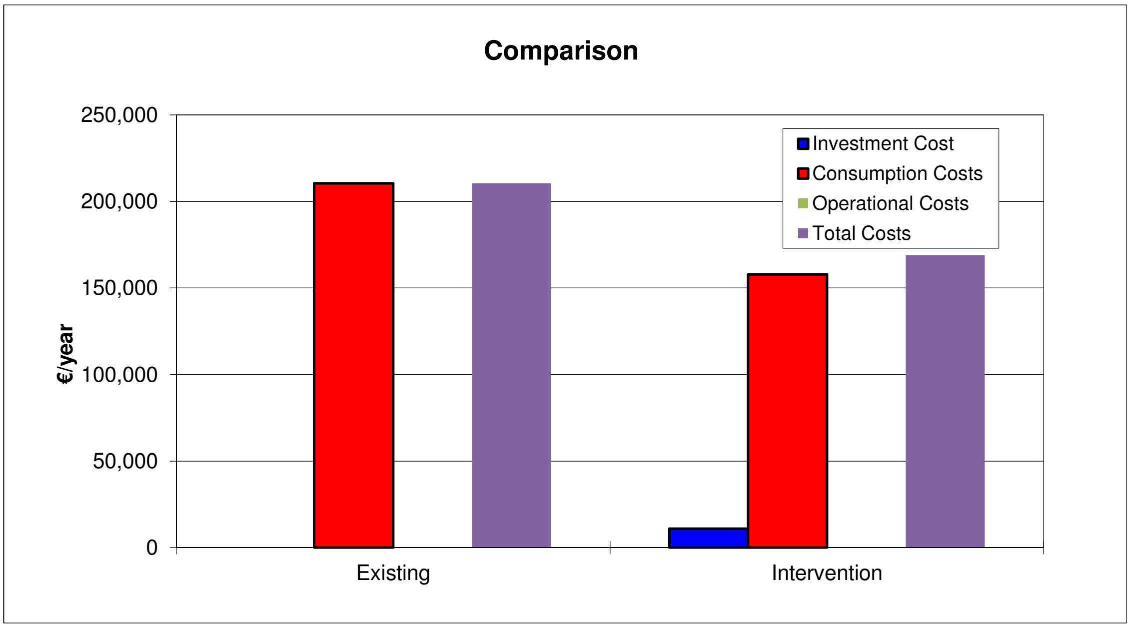

Figure 2-5: Comparison of annualised flows for the sewage treatment plant upgrade

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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**

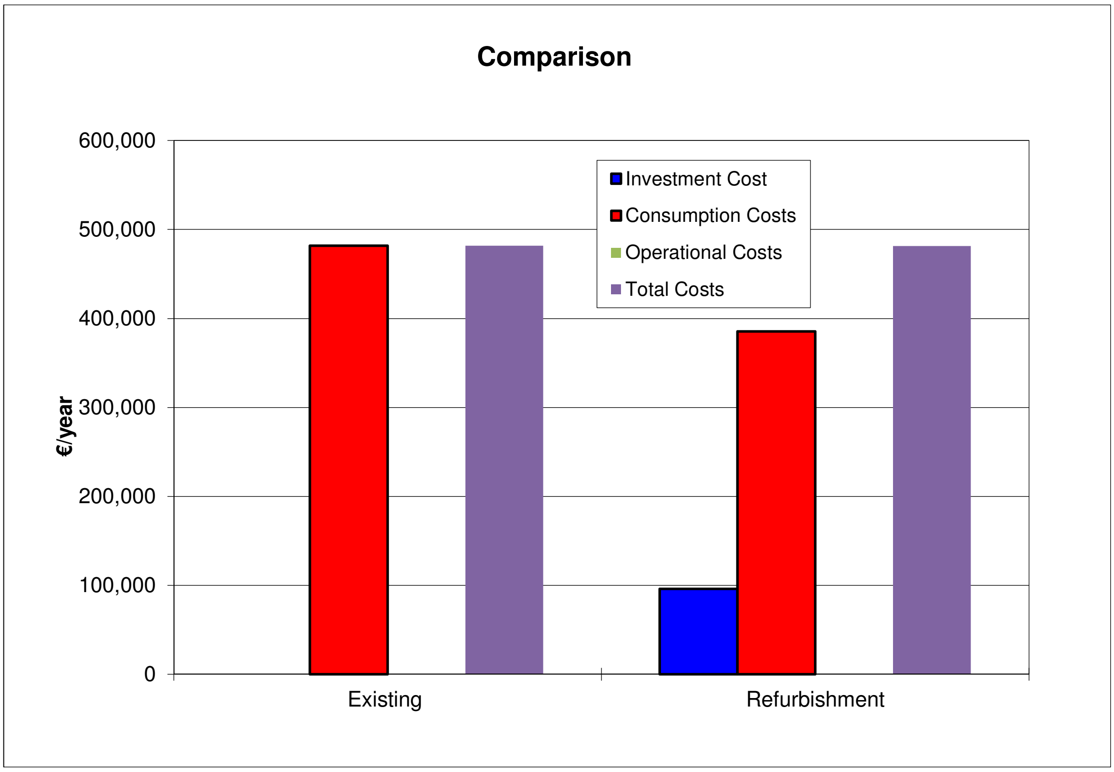
Γ. Annual O&M Costs	Units	Cost/Unit (Euro)		
Fix O&M Gas Boilers-Municipal	0.00	0		0
Total				**0**

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 TJ**	**Cost/Unit**		
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**

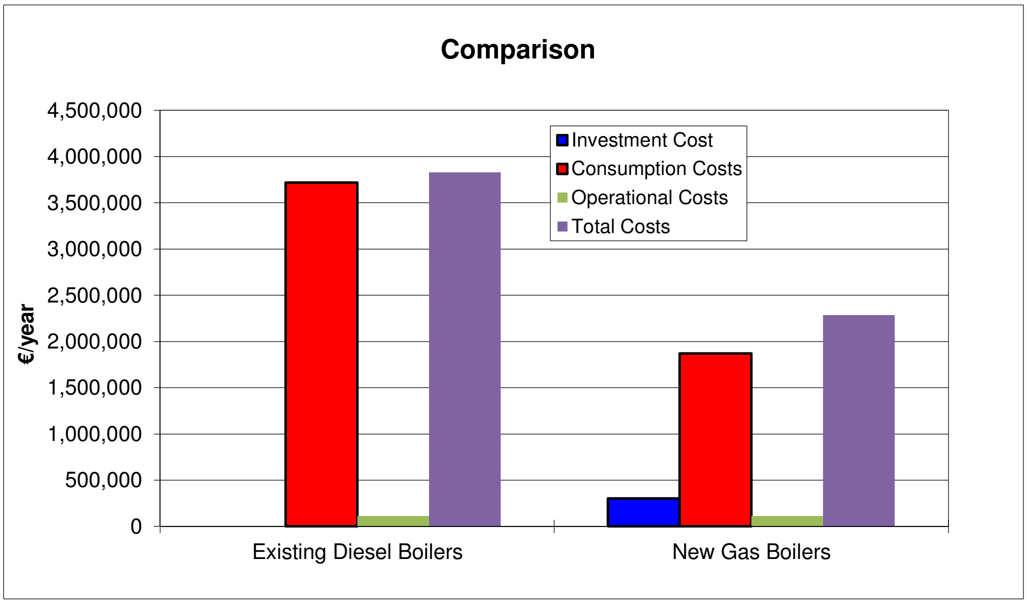
Δ. Total Annual Costs	**2,285,663**

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
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
€/year
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**

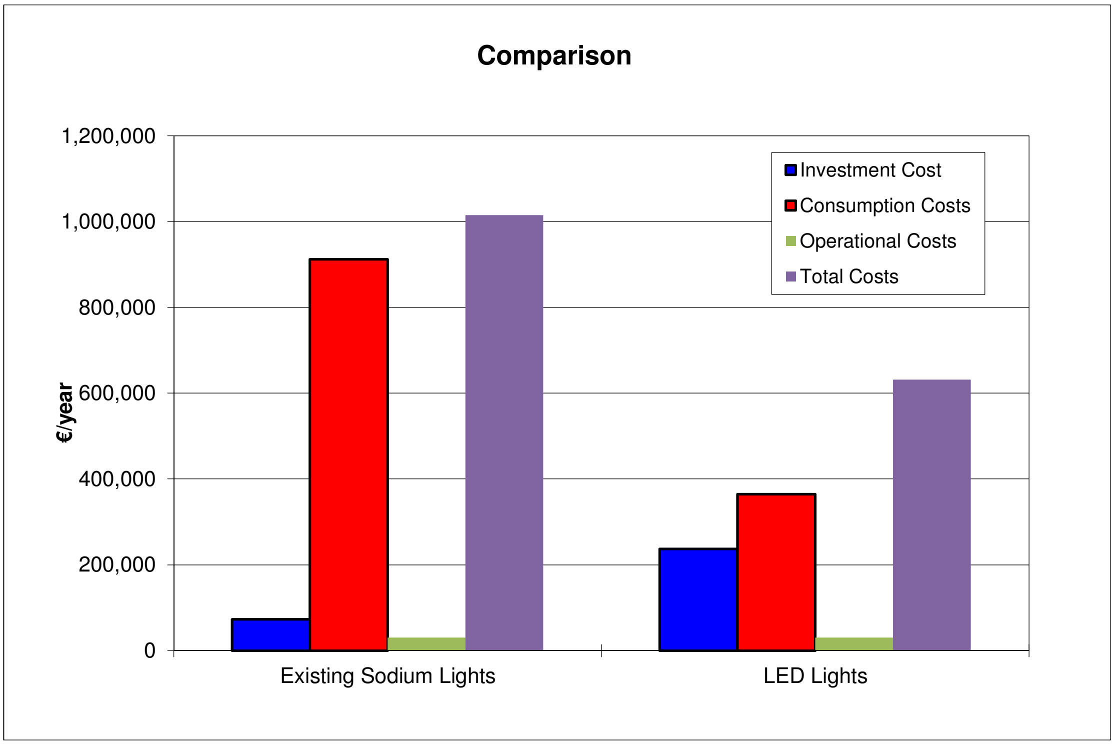
Γ. Annual O&M Costs	Units	Cost/Unit (Euro)		
Maintenance	6000	5		30000
Total				**30,000**

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**	**Cost/Unit**		
	TJ			
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**

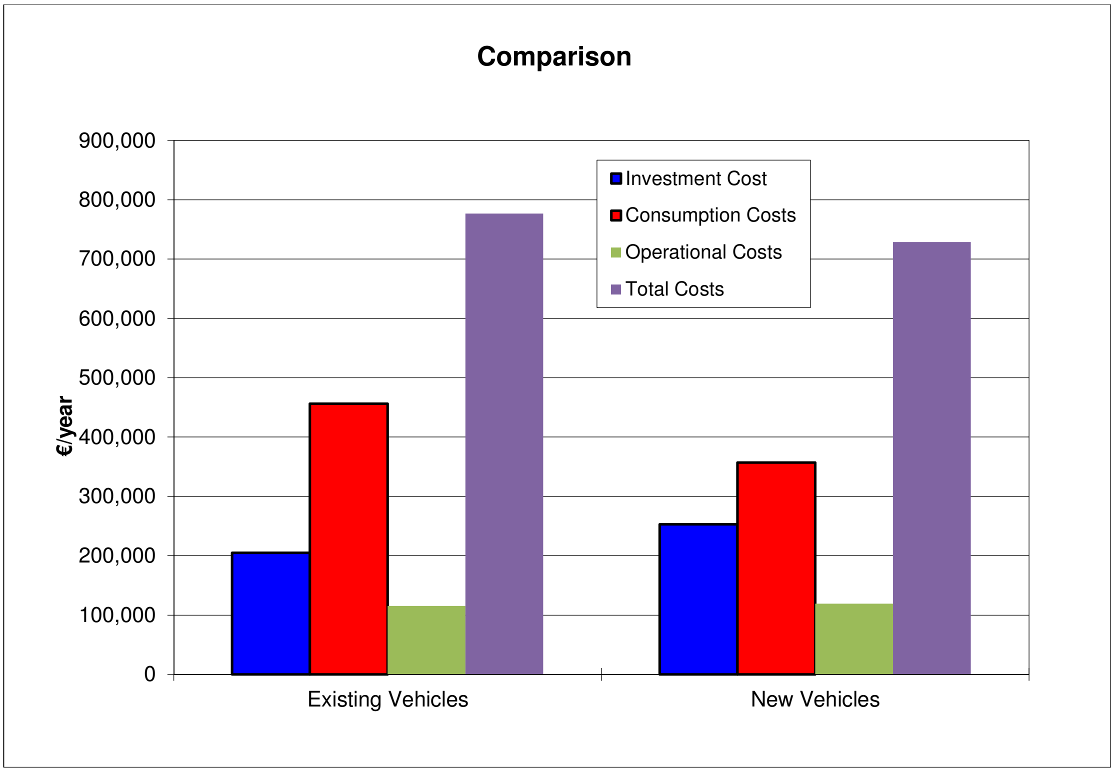
Γ. Annual O&M Costs	**Units**	**Cost/Unit (Euro)**		
Fix O&M Electric Cars	10	1100		11000
Fix O&M Diesel Trucks	20	5400		108000
Total				**119,000**

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	Cost/Unit		
	TJ			
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**

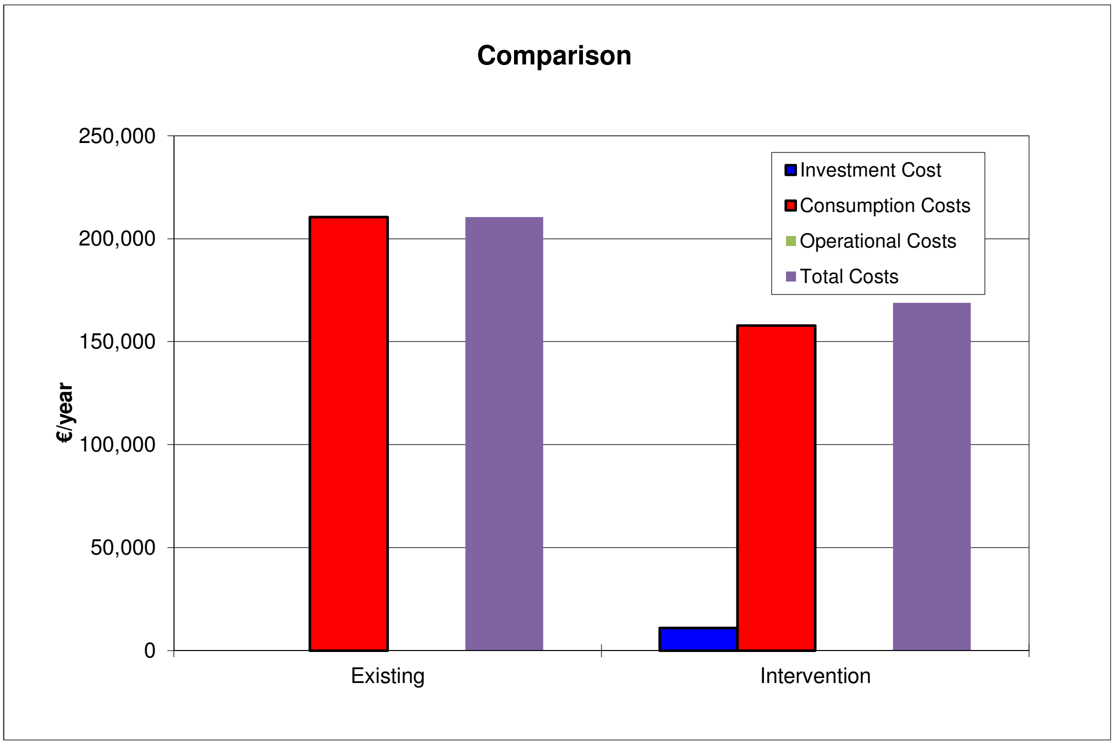
Δ. Total Annual Costs	**168,854**

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/

Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

INSMART

Integrative Smart City Planning

Mid-Term Implementation Action Plan – ÉVORA

D-WP 6 – Deliverable D.6.4

Author(s): António Valentim, Nuno Bilo (Évora Municipality) and Luís Dias, Sofia Simões, Júlia Seixas, João Pedro Gouveia (FCT- NOVA University of Lisbon)

Date: January 2017

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InSMART

Project full title:

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Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTICITIES-2012

Start date of project: 2013-12-01

Duration: 3 years

Deliverable D.6.3

Midterm Implementation Action Plan – ÉVORA

Actual delivery month: M40

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Version	**Submitted by**	**Review Level***	**Date Submitted**	**Reviewed**
V01	CME		Mar. 2017	

Editors		
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Executive Summary
This is the Midterm Implementation Action Plan for the city of Évora. It includes the Interventions promoted through the MCDA process; Economic analysis, Proposed funding schemes and the Ten years implementation steps.

Keywords	Action plan, Economic analysis, Funding schemes, Implementation plan steps

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Acronyms and Definitions

- CIMAC – Comunidade Intermunicipal do Alentejo Central
- CME – Câmara Municipal de Évora (*Municipality of Évora*)
- ESCO - Energy Service Company
- FCT/UNL – Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa
- GESAMB - Gestão Ambiental e de Resíduos, EIM: intermunicipal waste company
- LED - Light-emitting diode lamp
- MCDA – Multi Criteria Decision Analysis
- PEDU - Planos Estratégicos de Desenvolvimento Urbano (Strategic Urban Development Plans)
- PIAE – Parque Industrial Aeronáutico de Évora (*Aeronautical Industrial Park of Évora*)
- PITE – Parque Industrial e Tecnológico de Évora (*Industrial and Technological Park of Évora*)
- POSEUR - Programa Operacional de Sustentabilidade e Eficiência no Uso de Recursos (Operational Program for Sustainability and Efficiency in the Use of Resources)
- TIMES - The Integrated Markal-EFOM System model generator of the Energy Technology System Analysis Programme of the International Energy Agency
- TREVO – public urban transport company

1. Introduction

The measures considered in this plan were developed by the CME and FCT team. The measures result from the work carried out in WP5 with the TIMES-Évora model and the MCDA selection process. The work in WP5 provided generic, aggregated values for the measures, which were screened and analysed by the CME team in more detail in this report, making use of available information to the team.

In the WP5, using the TIMES-Évora model, the following 22 scenarios were tested, each translation a measure or combination of measures to promote sustainable energy in the city:

1. For public lighting: change luminaires with more efficient lamps (two variants of this for 2020 and 2030, i.e. PL1 and PL2[1]);
2. For residential buildings:
    a. Install solar thermal hot water panels in a share of dwellings (two variants of this for 2020 and 2030, i.e. RSD1 and RSD2);
    b. Install solar PV panel in dwellings (two variants for 2020 and 2030, i.e. RSD3 and RSD4);
    c. Retrofit 80% of residential dwellings with double glazing (RSD6);
    d. Retrofit 50% of residential dwellings with small scale insulation solutions (RSD7);
    e. Retrofit 60% of residential dwellings with walls and roofs insulation options (RSD8);
3. For waste, water and waste water treatment:
    a. Increase by 35% the share of recycled MSW after 2020 (R1);
    b. Decrease MSW production per capita in 20% from 2013 values (R2);
    c. Improve energy efficiency in water treatment plants in 50% by 2030 compared to 2009 values (R3);
    d. Improve energy efficiency in waste water treatment plant in 30% compared to 2009 by 2030 (R4);
4. For transport[2]:
    a. Promotion of cycling by extending the existing cycling lanes combined with making city bikes available from 2020 onwards (TRA1);

[1] The code for each scenario refers to the identification codes adopted in the D-WP 5 – Deliverable D5.3 - Report on optimum sustainability pathways –ÉVORA.

[2] It must be noted that the measures TRA2 - Parking rate increase, TRA3 - Traffic restrictions and TRA4 - Speed reduction were reported in the WP3, deliverable D.3.7. Transport Scenarios Results Report Évora as not contributing to energy consumption reduction. In fact, the first two were then expected to increase slightly the energy consumption and the third are expected increase it substantially. However, during the conclusion of WP3 adjustments in previous calculations were necessary, which led to new estimates made by the partner SYSTRA. According to these estimates in fact the three measures lead to lower passenger mobility needs and thus lower energy consumption, which was considered and modelled in WP5.

b. Duplicate parking fees in historic centre from 2020 onwards (TRA2);
c. Interdiction of traffic for all type of vehicles, except residents, public transport and commercial vehicles, to the Évora Acropolis from 2020 onwards (TRA3);
d. Introduce a speed limitation to 30km/h, for all vehicles in the urban area outside the historical centre from 2020 onwards (TRA4);
e. Deploy electric vehicles up to 5% of passenger cars are electric by 2030 (TRAelc);
f. Ensure that all busses use biofuels by 2030 (TRAbus);
g. Construction of 3 parking lots with a total of 500 parking spaces for non-residents in the historic centre from 2020 onwards (TRA7);
h. Implement 300 new disperse parking spaces for residents in the historic centre from 2020 onwards (TRA8);
i. Increase busses availability in order to shift of 15% from private cars mobility to public transportation from 2020 onwards (TRA9).

Through the implementation of the MCDA analysis in WP5, these 22 scenarios/measures were ranked. The most desirable measures were identified, making use of two complementary perspectives: a) all scenarios ranked together and b) ranking of only the scenarios that are under the influence[3] of the municipality, and which are the following:

a. Change luminaires with more efficient lamps (two variants of this for 2020 and 2030, i.e. PL1 and PL2);
b. Increase by 35% the share of recycled MSW after 2020 (R1);
c. Decrease MSW production per capita in 20% from 2013 values (R2);
d. Promotion of cycling by extending the existing cycling lanes combined with making city bikes available from 2020 onwards (TRA1);
e. Duplicate parking fees in historic centre from 2020 onwards (TRA2);
f. Interdiction of traffic for all type of vehicles, except residents, public transport and commercial vehicles, and concerning all purposes to the Évora Acropolis from 2020 onwards (TRA3);
g. Introduce a speed limitation to 30km/h, for all vehicles in the urban area outside the historical centre from 2020 onwards (TRA4);
h. Ensure that all busses use biofuels by 2030 (TRAbus);
i. Construction of 3 parking lots with a total of 500 parking spaces for non-residents in the historic centre from 2020 onwards (TRA7);

[3] The scenarios of paragraphs b), c), h) and k) depend indirectly from the municipality. However, the municipality can contribute to achieving the realization of these targets by: promoting new population habits (waste separation) or by influencing the companies responsible by the implementation of these scenarios, either since the municipality owns part of the company or since the municipality can influence and review clauses in the service concession contracts.

j. Implement 300 new disperse parking spaces for residents in the historic centre from 2020 onwards (TRA8).
k. Increase busses availability in order to shift of 15% from private cars mobility to public transportation from 2020 onwards (TRA9).

Among all the scenarios, the most highly ranked consensual options in the MCDA, among the four different groups of stakeholders, were:

1. TRAelc – Shift of 5% from private cars mobility to public transportation from 2020 onwards;
2. TRAbus – All buses use biofuels in 2030[4];
3. R2 – Decrease MSW production per capita in 20% from 2013 values;
4. TRA4 – Speed limitation to 30km/h, for all vehicles in diverse zones from 2020 onwards;
5. RSD7 – Small scale insulation solutions in 50% of dwellings by 2030;
6. RSD8 – Wall & Roof insulation combined in 60% of dwellings by 2030;
7. RSD6 – Double glazing in 80% of dwellings by 2030;
8. RSD2 – Install solar thermal hot water panels in 40% of dwellings in 2030;
9. TRA2 – Duplicate parking fees in historic centre from 2020 onwards;
10. TRA3 – Interdiction for all type of vehicles and concerning all purposes to the Évora Acropolis from 2020 onwards.

Out of these, it was decided to exclude TRAelc because it is not under the direct influence of the municipality, and RSD2 for the same reason. RSD6, RSD7 and RSD8 were maintained, since there is an ongoing plan to retrofit dwellings that can closely align with these scenarios.

It was also decided to include all other transport related measures since they are under the area of direct influence of the municipality (except TRAbus and TRA9). For the same motive, it was added the public lighting measure (only the more ambitious PL2).

Finally, during the previous stages of the INSMART project, it was not possible to study in detail the energy saving possibilities regarding the municipal buildings and fleet, due to lack of detailed data. However, this is a top priority for the municipality, and thus these two measures are now introduced in the plan.

[4] It was concluded during the TIMES modelling that this scenario will lead to an increase in energy consumption, but also to a reduction in CO_2 emissions. The reason is that more biofuel is needed to operate such buses than for conventional ones.

1.1. Interventions promoted through the MCDA process

In the next table are described all the measures included in the plan, that will be further analysed in the following section. As previously explained, in this list of measures are included: (1) all the measures promoted from the modelling and MCDA that are in the range of action of the Municipality, and (2) other measures directly dependent from the municipality that weren't considered in the modelling and MCDA (municipal buildings and fleet, financial incentives to the residents and waste collection).

Table 1 – Measures included in the Évora plan

Measure	Details
	Municipal buildings
Municipal buildings efficiency	Study in detail the several available options to reduce energy consumption in the CME municipal buildings (walls and windows isolation, warming/cooling systems, equipment, lighting, etc.)
	Municipal fleet
Municipal fleet renovation	Study in detail the several available options to reduce energy consumption in fleet and other vehicles directly managed by the municipality
	Public lighting
LED (previously PL2)	Change the light fixtures in 100% of the equipment to LED in 2030 (in 2014 LED were installed in 0,4% of the equipment)
	Residential buildings
Financial incentives (corresponding to a combination of RSD6, RSD7 and RSD8 only in the historic centre)	Review of the existing municipal programs for the private buildings renovation in the historical centre and provide access to credit schemes for residential owners, aiming to install a combination of double glazed windows, light insulation options and wall and roof insulation in at least 50% of the dwellings by 2030
	Transports
Cycle lanes (previously TRA1)	Increase length of cycle lanes - implementing the Bacelo-PITE lane with 7km length, combined with making free public bicycles available.
Parking rate increase (previously TRA2)	Double the price of parking in the historical centre (after 2020) *[today costs 0.7€/hour to 11€/day]*
Traffic restrictions (previously TRA3)	Prohibition of motorized vehicles in the acropolis of the historical centre, except for residents and shop retainers (after 2020) *[today there's no restriction]*
Speed reduction (previously TRA4)	Speed reduction in the majority of the residential area of the city – outside historical centre – to 30km/h (after 2020)
Parking lot (previously TRA7)	Increase the concentrated parking areas (3 parking lots) in the historical centre, for non-residents (500 new places after 2020) *[in 2014 there were 215 parking places for non-residents]*

Street parking (previously TRA8)	Increase the street parking places in the historical centre for residents (300 new places after 2020) *[in 2014 there were 2019 street parking places, 748 of them to residents]*
Public transport Biofuel (previously TRAbus)	Negotiate with bus company to gradually move towards having buses running exclusively on biofuels, from 2030 onwards *[in 2014 there were no buses running on biofuels]*
Public transport Frequency (previously TRA9)	Negotiate with the bus company to review the conditions of the concession with the municipality, in order to increase the frequency of public transports running between the train station and the Industrial Aeronautic Area. (PIAE).
	Waste
Waste collection (previously R1)	Public communication campaign to increase 35% the urban waste collected separately for recycling (after 2020) *[in 2014, 7% of the urban waste was collected separately to recycling – GESAMB (the waste company) predicts getting 24% until 2020]*
	Assess in more detail the benefits of installing computer management of waste collection operated by the municipal services (waste collection route planner and electronic radio devices in trash containers), aiming to reduce the energy consumption by 30% until 2020)
Waste reduction (previously R2)	Encourage behaviour changes to lower waste production (objective: reduce 20% of the waste produced *per capita* from 2013 to 2020) *[in 2013 it was 502 kg per capita]*

2. Economic Viability Analysis

2.1. Methodology

As previously described, the measures included in this plan, described in the previous section, include some that were tested using the TIMES-Évora model in WP5 and other that were not modelled, but are nonetheless considered important to the municipality.

The measures of this plan include some that are considered financial investments and others that can be seen as social/public investments. The first case refers to the measures that require capital investment and are expected to generate financial benefits to the investor (municipality). These are:

- Municipal buildings efficiency
- Municipal fleet renovation
- LED
- Parking lot
- Street parking
- Waste collection
- Waste reduction

The second case includes the measures that do not require capital investment for the municipality and/or do not generate any financial benefit to the municipality. Nonetheless, these measures in the second group generate added value, such as benefits to the public and/or to the environment, that are very hard to estimate and are not included in this document. This second group of measures may or not require capital investment, as are listed below:

- Financial incentives
- Cycle lanes
- Parking rate increase
- Traffic restrictions
- Speed reduction
- Public transport

The first group of measures justifies the realization of an economic viability analysis prior to the investment. Although, for the moment, the Municipality does not have detailed studies (engineering/architecture) concluded on those measures and there is no rigorous data to support a detailed viability analysis. A simplified study can already be made to provide some insights.

Currently ESCO's proposals are being assessed by the municipality regarding the implementation of some of the above-mentioned measures. In the proposals being made by the ESCO's the achieved energy savings will pay the ESCO service of implementing measure. In these cases, the investment will not be made by the municipality.

The following tables resume the modelling results obtained from the TIMES Évora model used by FCT during the WP5 phase. Investment costs indicated in the tables are rough estimates made by FCT and /or CME. This data is the general economic data for the measured considered in this plan, and is the basis perspective for the analysis done in section 2.2. It should be considered with some caution, because: (i) the values are obtained from a cost-optimisation model that assumes perfect foresight and thus had an inherent drive to implement energy efficiency measures: (ii) they are a relative difference to a Baseline case (i.e a model run where the measure was not fully or at all implemented) for the year of 2030. Note that the costs for the transport related measures and for the waste related measure were not obtained from TIMES-Évora, but form estimates made by the project team (CME and FCT). More explanations on these can be found in the Deliverable 5.3 of WP5.

Table 2 - Performance of the modelled measures for all zones of Évora considered in InSmart. The energy savings and CO2 emission reduction values are a relative difference to a Baseline case in 2030 where the respective measure is not implemented obtained from the TIMES-Évora model in WP5. The financial effort was estimated via different approaches as indicated.

Code	Reduction of energy consumption in 2030 (GJ)	Reduction of CO_2 emission in 2030 (t)	Financial effort for the whole period of the investment (euros 2015)		Estimate source
			Investment	O&M	
PL2	525,08	56.163,31	4.022.638,85	66.695,35	Estimate from TIMES-Évora model
R1	692,29	64.615,98	200.000,00	n.a.	Estimate CME/FCT-NOVA
R2	950,87	89.661,35	300.000,00	n.a.	Estimate CME/FCT-NOVA
TRA1	2.958,89	197.633,11	1.190.000,00	n.a.	Estimate CME
TRA2	3.695,38	261.206,75	0	n.a.	Estimate CME
TRA3	1.617,27	109.703,48	15000	n.a.	Estimate CME
TRA4	18.340,87	1.303.332,86	20000	n.a.	Estimate CME
TRAbus	-37.399,19	2.272.947,66	1.802.422,92	333.240,49	Estimate from TIMES-Évora model
TRA7	901,77	58.467,00	7.000.000,00	n.a.	Estimate CME
TRA8	952,66	62.173,32	13.500,00	n.a.	Estimate CME
TRA9	9.217,64	657.772,23	10.000,00	n.a.	Estimate CME

n.a. – not applicable

Table 3 - Performance of the Financial Incentives measures considered in the Évora implementation Plan for the historic centre of Évora. The energy and CO2 emissions values are a relative difference to a Baseline case in 2030 where the respective measure is not implemented

Code	Reduction of energy consumption in 2030 due to the measure (GJ)	Reduction of CO_2 emission in 2030 (t)	Financial effort for the whole period of the investment (euros 2015)	
			Investment	O&M
RSD6 historical centre - small scale insulation	5.918,43	1.108.710,65	5.633.621,53	n.a.
RSD7 historical centre – wall and roof insulation		1.112.240,23	355.504,83	n.a.
RSD8 historical centre – double glazing		1.112.240,23	11.388.164,06	n.a.

n.a. – not applicable

The savings reflect a combination of the three measures and were modelled with TIMES-Évora. The investment costs were estimated via a survey of insulation options available in the Portuguese market and estimating its application considering the building typologies available in the historic centre, as mapped in WP1 and WP2.

2.2. Economic Viability Analysis

The economical estimated details for each measure are described below. These descriptions include the estimated capital investment, when known, as well as other type of efforts to implement the measure. For each measure, the capital investment needed was estimated in two ways: some were roughly estimated for this plan and others were estimated based on detailed studies concluded by the municipality.

It is also presented the expected savings for each measure accomplishment, expressed in energy savings. These savings were obtained in the WP5 with the model TIMES-Évora.

For the measures that are also seen as financial investments for the municipality, identified in section 2.1, it was not possible to give robust estimates for annual financial revenues resulting from the measures. The main reason for this lack of data is the inexistence of detailed engineering/architecture/urban studies that need to be done to support each measure – some of them running today but are not concluded (detailed information is provided below). Additionally, the municipality does not have decided yet on the way to realize the investments. These can include the negotiation with other institutions or companies, applying for funding schemes and/or getting loans (more information about funding is provided in section 3).

To give a better insight of the consequences of each measure, they were identified other non-financial benefits, that could help to consolidate the economic analysis and the decision when the financial data and analysis could be achieved

2.2.1 Municipal buildings efficiency

This intervention includes two types of investment:

- 1 - In the existing buildings there should be realized energy efficiency improvements. The municipality is presently conducting energy audits that should result in detailed recommendations and respective budget for each building. The municipality considers three ways to implement the recommendations that will be made by the audits: by using its own means (municipal operational services); by contracting external services; and by negotiating with a private investor (ESCO), that will be paid by the savings of energy bills for a certain period (to be negotiated). After that period the savings revert fully to the municipality.

- 2 - Some municipal services should move from a rented building to a municipal one that needs refurbishment work – this investment should be made by the municipality. The main savings are the rental costs. The investment in the current municipal building to be occupied is still under study. Specific solutions to lower the energy consumption of the building are being analysed in the on-going architecture project.

This measure was not modelled during the project, due to lack of data, and detailed descriptions of the different forms of investments are still being prepared and not available at the moment.

Economic data: Measure not modelled in InSmart. Investment and cash-flows are under study by the municipality.

2.2.2 Municipal fleet renovation

The municipal fleet is composed essentially by diesel cars, with an average of more than 10 years. The municipality plans to gradually substitute some old diesel vehicles by more efficient diesel cars or by electric ones. With this action, it is expected to reduce the fuel costs and the maintenance costs.

In 2017, the municipality has a budget of 560 000€ for new vehicles and machines (to buy two waste collection trucks, one van, working machines and cars)

Economic data: Measure not modelled in InSmart due to lack of data. Investment and cash-flows are currently being studied by the municipality.

2.2.3 LED *(previously PL2)*

This intervention is being negotiated to be realized by a private investor (ESCO), that will be paid through the savings of the energy bills for a certain period (to be negotiated). After that period the savings revert to the municipality.

Simultaneously, CIMAC (Intermunicipal Community of Alto Alentejo) promoted a detailed study to change public lighting to LED in the municipalities of the region. This study includes the conversion of existing public lighting to LED and reinforcement of lighting where needed. The study is running and there is still no conclusive data on the investment amounts and the achievable savings. The company responsible by the study has a rough estimate for an investment cost of 8400 000€ in Évora, that should be more detailed as the study continues. For the moment, it does not have estimates for the savings achievable, and thus the ones from TIMES-Évora are used.

Economic data: Measure modelled in InSmart. Detailed study should be available by the end of April 2017.

Table 4 – overview of LED measure

Municipal investment	Rough estimate: 8.400.000€ (funding modality still to decide)
Municipal estimated energy reduction	525.08GJ
Other non-financial benefits	reinforcement of lighting where needed

2.2.4 Financial incentives *(corresponding to a combination of RSD6, RSD7 and RSD8 only in the historic centre)*

The Municipality has a financing aid program for private owners of buildings in the historical centre. This main goal of this program is to contribute for the conservation of the historical centre buildings, classified by UNESCO as World Heritage, and to contribute to the comfort of the inhabitants of these old buildings, which have lower energy efficient standards and/or are deteriorated. The financial aid of the program is focused on windows, façades and roof works. This program was suspended recently.

The municipal executive wants to review this program, which is seen as an opportunity to introduce some energy efficiency improvements on the eligible refurbishment work. This review has not started yet and the InSmart scenarios RSD7, RSD7 and RSD8 should be of great value for that.

The expected financial incentive should be a special credit line for building renovation, to be made available to residential owners. The investment of the municipality will be administrative work and as such is not quantified.

Economic data: Measure modelled in InSmart in TIMES-Évora (group of three scenarios – insulating windows, walls and roofs and light insulation measures). Regulation and financial aspects of the program are to be studied by the municipality.

Table 5 – Overview of Financial incentives measure

Municipal investment	administrative work, not quantified
Private investment (potential)	5 633 600€ for double glazing; 355500€ for small scale insulation solutions; 11388 200€ for walls and roofs insulation options
Private estimated energy reduction	5 918.43GJ
Other non-financial benefits	revitalization of the historic centre

2.2.5 Cycle lanes *(previously TRA1)*

The cycle lane between Bacelo and the Historical Centre is ready to start being built. The architecture project is done and external funding approved. The expected cost is 328 875.15€ for all the works except lighting; lighting should be around 45 000€. Other cycle lanes will be studied.

The main goal of this measure is to establish a pedestrian and cycle connection of a big urban area very close to the centre of the city. Those users must travel in a busy and straight road which has no safety conditions. This measure is seen as an urbanistic investment. Due to the small distance from this area to the city centre, it is expected a shift from cars to pedestrian or cycle travels, as modelled in WP3 and WP5.

Economic data: Measure modelled in InSmart. Architecture project made by the municipality and co-funding approved in the national program PEDU.

Table 6 – Overview of Cycle lanes measure

Municipal investment	173.875.15€
PEDU financing program investment	250 000€
Private estimated energy reduction (shift to pedestrian or bicycle)	2 958.89GJ
Other non-financial benefits	Urbanistic (transport) qualification; safety and quality of the travels; reduction of energy in private daily travels

2.2.6 Parking rate increase *(previously TRA2)*

This measure consists in increasing the parking rate of the existing parking places inside the historical centre. It is essentially an administrative procedure, requiring administrative work and filed work to readjust parking machines, which will be realized by the municipal services.

The social impacts of this measure are yet to be studied, as well as the costs of the implementation. The implementation of this measure is expected to increase revenues to the municipality, but is not seen as an investment. It is considered a change in the transport policy of the city and its impacts on residents and commerce still have to be studied in detail.

Economic data: Measure modelled in InSmart in terms of energy savings (in WP3 and WP5). Social and economic aspects of the measure are to be studied by the municipality.

Table 7 – Overview of Parking rate increase measure

Municipal investment	administrative work, not quantified
Private estimated energy reduction (reduction in car travel)	3 695.38GJ
Other non-financial benefits	Quality of life improved in the historic centre

2.2.7 Traffic restrictions *(previously TRA3)*

Some of the streets of the acropolis area (the centre of the historical centre and where the most important monuments are) are already only pedestrian. With this measure, it is intended to enlarge this restriction to motorized traffic to all the acropolis area.

The expected works are essentially administrative and traffic signs substitution, which should be realized by the municipal services.

The traffic flow, social and commercial impacts of this measure are yet to be studied, as well as the costs of the implementation. The main expectation with the implementation of this measure is to bring social dynamism (residence and commerce) to the urban centre. It is not seen as a financial investment.

Economic data: Measure modelled in InSmart regarding energy savings (in WP3 and WP5). Social and economic aspects of the program are to be studied by the municipality.

Table 8 – Overview of Traffic restrictions measure

Municipal investment	administrative work, not quantified, and traffic signs change, roughly estimated in 15.000€
Private estimated energy reduction (reduction in car travel energy)	1 617.27GJ
Other non-financial benefits	Quality of life improved in the historic centre

2.2.8 Speed reduction *(previously TRA4)*

This scenario represents a speed reduction in great part of the residential area of the city, outside historical centre, from 50 to 30km/h. With this measure, it is intended to promote an energy consumption reduction. Other benefit considered with this measure is the increase of safety and urban quality for pedestrians and cyclists.

This measure was analysed from the point of view of energy consumption, but other expected effects from this measure are still to be studied, such as social acceptance.

The expected works are essentially administrative and traffic signs substitution, which should be realized by the municipal services.

Economic data: Measure modelled in InSmart (in WP3 and WP5). Social and mode detailed impact in traffic flow effects should be further studied by the municipality.

Table 9 – Overview of Speed reduction measure

Municipal investment	administrative work, not quantified, and traffic signs change, roughly estimated in 20 000€
Private estimated energy reduction (reduction in car travel energy consumption)	18 340.87GJ
Other non-financial benefits	Safety and urban quality improved in the city

2.2.9 Parking lot *(previously TRA7)*

This measure consists in constructing 3 parking lots in the historical centre of Évora, offering 500 new places for non-residents. This scenario was tested with the premise that these parking lots should be inside the city centre.

Today, the municipality has identified several spots in the historical centre where such parking lots could be constructed. It is a scenario yet to explore because there are not conclusive studies available, including archaeology, architecture/engineering and financial.

For the moment, it was estimated a possible cost of construction, which is a very rough estimate, considering that there is not even a selection of places to study these constructions in detail yet. At this moment, this measure is seen only as a strategic guideline by the municipality, due to the big uncertainty of the technical aspects regarding the construction, that require further studies.

There is also the intention of the Municipality to revert to public use an existing parking lot currently ceded to the use of the University of Évora, inside the city centre, and to improve another existing park managed by the municipality.

Economic data: Measure modelled in InSmart (in WP3 and WP5). Requires further detailed technical studies, to be made by the municipality, to better assess the measure.

Table 10 – Overview of parking lot measure

Municipal investment	Study, project and construction investment. The construction was roughly estimated in 7 000 000€
Municipal returns (parking fees)	Not studied
Private estimated energy reduction (reduction in car travel)	901.77 GJ
Other non-financial benefits	Hypothetical impact on city centre residents and workers, and on tourism, still to be studied

2.2.10 Street parking *(previously TRA8)*

This measure consists in increasing the parking places in the historical centre streets, offering 300 new places for non-residents. The expected works are traffic sign changes, occasional pavement adjustments to new definitions of street and sidewalk areas, and administrative work, both expected to be done by the municipal services.

The municipality does not have a detailed study for this measure, but it was estimate that, according to the number of street park places and the available spaces, it could be possible to create 300 new places.

This scenario was tested and, within WP5, was roughly estimated a cost of 13 500€ for the works. This includes sign change, but does not include specific pavement works and administrative work.

This measure will generate some revenues for the municipality, since residents have to pay an annual fee to park inside the historic centre, but the revenues were not estimated. This measure can be seen as a financial investment, but is manly faced as a strategic urbanistic measure, that will increase the quality of living of the residents and could attract new residents to the historic centre.

Economic data: Measure modelled in InSmart (in WP3 and WP5). Needs a further detailed urbanistic plan to start the implementation.

Table 11 – Overview of street parking measure

Municipal investment	Study and construction investment to be done by the municipal services. The sign change was roughly estimated in 13 500€
Municipal returns (parking fees)	Not studied
Private estimated energy reduction (reduction in car travel)	952.66 GJ
Other non-financial benefits	Urban quality improved in the city centre

2.2.11 Public transport – Biofuel *(previously TRAbus)*

The urban public transport is operated by the company TREVO, with which the Municipality established a concession contract. Currently, all buses of the company are running on diesel. This scenario represents a gradual change of the diesel fleet to a biofuel fleet. To do so, the municipality should negotiate with TREVO new service conditions, including the change of buses. At the moment, the negotiation has not started and there is no counterpart estimated for the company, to make this investment.

The implementation of this measure will be considered at the next review of the concession agreement.

Economic data: This scenario was modelled in InSmart (WP3 and WP5). The economic details need to be negotiated with TREVO.

Table 12 – Overview of Biofuel buses measure

Municipal investment	Administrative work for negotiation and financial compensation for TREVO to do the investment
TREVO investment	1 802 400€ (rough estimate to buying new biodiesel buses)
TREVO estimated energy reduction	-37 399.19 GJ (biodiesel buses consume more energy)
Other non-financial benefits	Urban quality improved in the city

2.2.12 Public transport – Frequency *(previously TRA9)*

The Industrial Aeronautic Area (PIAE) is a new and fast growing industrial area. Many of the workers live outside Évora and travel daily for the factories to work. They could travel by train and get an urban bus to get to the factories, but the frequency and time schedules of buses are not adjusted to the trains and worktime schedules.

This scenario represents the negotiation with TREVO, the urban public transport operating in Évora with a concession agreement with the Municipality, in order to increase the frequency of public transports running between the train station and the PIAE. This would facilitate the travels of the outside workers by public transports.

Economic data: This scenario was modelled in InSmart (WP3 and WP5). The economic details need to be negotiated with TREVO.

Table 13 – Overview of Frequency of buses measure

Municipal investment	Administrative work for negotiation and financial compensation for TREVO to implement this action
TREVO investment	10 000€
Private estimated energy reduction (reduction in car travel)	9 217.64 GJ
Other non-financial benefits	Urban quality improved in the city

2.2.13 Waste collection *(previously R1)*

This intervention includes two types of investment:

- 1 - Realizing a public communication campaign to increase 35% the urban waste collected separately for recycling.

- 2 - Assess in more detail the benefits of installing computer management of waste collection operated by the municipal services (waste collection route planner and electronic radio devices in trash containers), aiming to reduce the energy consumption by 30%.

The waste management in Évora is done by the municipality and by the company GESAMB. This company collects the separated waste from specific containers and manages the landfill. The municipality collects the unseparated waste and pays for its deposit in the landfill.

The two actions of this measure have environmental positive impacts: separate waste collection increased efficiency and reduction of CO2 emitted by the waste trucks. Furthermore, these actions may have a positive financial impact to the municipality. The first action should increase the urban waste separation for recycling, that will lower the cost for collection and deposit to the municipality. The second action should increase the waste collection efficiency and then reduce its cost.

This effect of improving energy efficiency in waste collection was modelled in WP5, but not the effect of implementing computer management schemes, due to lack of data.

Economic data: Measure modelled in InSmart, assumption of the FCT and CME team. The assessment of a computer management waste system in Évora should be made by the municipality services.

Table 14 – Overview of Waste collection measure

Municipal investment	200 000€ (rough estimate for a public communication plan to increase waste separation for recycling)
Municipal returns	692.29 GJ saved energy
Other non-financial benefits	Lower CO2 emissions in waste collection

2.2.14 Waste reduction *(previously R2)*

This measure consists in a public campaign to encourage the reduction of waste produced by the community, to reduce 20% of the waste produced *per capita* from 2013 to 2020. This is a more ambitious goal than the previous measure 2.2.13, since this one is considered more difficult to attain but with better results, both environmental and financial. It is also considered by the municipality more urgent to implement.

The financial positive impacts are the eventual downsizing of the waste collection systems (municipality and GESAMB) and the reduced costs for recycling and to deposit at the landfill.

The accomplishment of the goal of this measure would represent a decrease of 27.800tons of waste produced.

Economic data: Measure modelled in InSmart in WP5, investment costs are rough assumption from FCT and CME teams.

Table 15 – Overview of waste reduction measure

Municipal investment	300 000€ (rough estimate for a public communication campaign to lower the production of waste)
Municipal returns	950.87 GJ saved energy
Other non-financial benefits	Lower CO2 emissions in waste collection; downsizing the waste treatment by GESAMB

3. Proposed funding schemes

3.1. Available funding schemes

The funding schemes available in Portugal for sustainability, development and climate mitigation existing in Portugal are the following:

1. Portugal 2020 as part of the European Regional Development Funds;
2. National Energy Efficiency Fund;
3. European Union LIFE Programme;
4. JESSICA Holding Fund Portugal;
5. ELENA mechanism;
6. ESCO's and Energy performance contracting.

The **Portugal 2020 programme** is part of the European Regional Development Funds programme. Within Portugal 2020, the financing lines more suited for the measures of the Évora Sustainable Energy Plan are:

- POSEUR - Programa Operacional de Sustentabilidade e Eficiência no Uso de Recursos (*Operational Program for Sustainability and Efficiency in the Use of Resources*);
- PEDU - Planos Estratégicos de Desenvolvimento Urbano (*Strategic Urban Development Plans*);
- Alentejo 2020 (*Regional Development Plan for the Alentejo Region).*

Besides Portugal 2020 funding, there are other national funding possibilities, in particular the **Energy Efficiency Fund (FEE)** implemented through the Decree Law no. 50/2010 with the goal of financing measures considered in the National Energy Efficiency Action Plan (NEAP). This possibility is relevant for retrofitting some households and for improvement in public buildings.

Regarding, European financing possibilities, the following were identified:

- **LIFE EU environment program**; which is a co-financing European programme aiming to "supporting environmental, nature conservation and climate action projects throughout the EU";
- **JESSICA - Joint European Support for Sustainable Investment in City Areas,** was developed by the European Commission in collaboration with the European Investment Bank (EIB), and the Council of Europe Development Bank (CEB). JESSICA is a new way of using existing Structural Fund grant allocations to support urban development projects, and thus should be considered jointly with some of the Portugal 2020 funding. In Portugal, the JESSICA Urban Development Fund is operated with the following financial institutions: Banco BPI, CGD and Turismo de Portugal. JESSICA's operation requires an integrated approach and the funds could be targeted specifically at projects promoting urban rehabilitation, energy efficiency and renewable energy.

- **ELENA – European Local ENergy Assistance**, which is a technical assistance mechanism run by the European Investment Bank (EIB) and supporting regional/municipal authorities to accelerate investment plans on energy efficiency and renewable energy. ELENA is funded through the European Commission's Horizon 2020 programme, and covers up to 90% of the technical support cost needed to prepare the investment programme for implementation and financing, including feasibility and market studies, programme structuring, energy audits and tendering procedure preparation.

Finally, **ESCO's services** and to a less extent, **Energy Performance Contracting**, is becoming more and more common in Portugal. ESCO's are offering to the municipalities to implement some of the energy efficiency measures (in particular regarding public lighting) which is in study in Évora.

3.2. Proposed funding approach

This plan is written when the municipality of Évora was recognized as *municipality in structural financial imbalance*, and as such is under national government financial aid. In this context, the municipality has severe limitations on new investments and on requesting new loans.

The financial solutions used recently by the municipality involve accessing fund schemes that ensure the major part of the investment or finding private investors willing to invest on energy savings in municipal systems (e.g. ESCO's) which finance the implementation of a measure and are paid through the savings obtained for a certain period of time.

The investment solutions identified and/or still under study for the measures of this plan are explained in detail in section 2.2.

4. Ten years' implementation plan steps

To better detail the implementation of this plan, the next tables details about the timing, engaged resourced and monitoring.

4.1. Timing implementation

To classify the timing of each measure, it was considered a ten-year period divided in three steps: immediate 1-2 year, intermediate 3-5 years, further ahead 6-10 years. More immediate timing means that this is also considered with a higher priority for the Municipality.

Table 16- Timing of implementation

	TIMING		
Interventions:	**Immediate (1-2 years)**	**Intermediate (3-5 years)**	**Further ahead (6-10 years)**
Municipal buildings efficiency	X		
Municipal fleet renovation		X	
LED	X		
Financial incentives	X		
Cycle ways	X		
Parking rate increase			X
Traffic restrictions			X
Speed reduction			X
Parking lot		X	
Street parking		X	
Public transport		X	
Waste collection		X	
Waste reduction	X		

4.2. Engaged resources

The engaged resources information is described in the next table. Much of the measures resources are in study or are to study. Details about each measure are provided in section 2.2.

Table 17 – Resources allocated to the plan

	RESOURCES		
Interventions	**Investment Costs covered by the Municipality**	**Municipality Staff Engagement**	**Costs external to the municipality**
Municipal buildings efficiency	Under study	Municipality financial services	Under study
Municipal fleet renovation	Under study	Municipality financial services	Under study
LED	Under study	Municipality financial service	Under study
Financial incentives	Under study	Municipality financial services	Under study
Cycle ways	123.875,15€	Municipality transport service	250.000€ (PEDU)
Parking rate increase	0€	Municipality transport service	0€
Traffic restrictions	To be studied	Municipality transport service	To be studied
Speed reduction	To be studied	Municipality transport service	To be studied
Parking lot	To be studied	Municipality transport service	To be studied
Street parking	To be studied	Municipality transport service	To be studied
Public transport	To be studied	Municipality transport service	To be studied
Waste collection	To be studied	Municipality cleaning service	To be studied
Waste reduction	To be studied	Municipality cleaning service	To be studied

4.3. Monitoring

In the next tables are listed the Key Performance Indicators (KPI) that can be used to monitor the plan's implementation. The sources of information are the several municipal services, including the municipal financial and operational departments. The suggested monitoring frequency is annual.

The indicators selected for monitoring the implementation of the sustainable energy implementation plan in Évora are presented in the following tables.

Table 18 – Évora InSmart KPI

SECTORS	KPI	Unit
Energy		
Transport	Variation of FEC	GJ
	FEC per capita	J/inhab
Residential Buildings	Variation of FEC	GJ
	FEC per capita	J/inhab
Public Buildings	Variation of FEC	GJ
	Energy intensity	J/public employers
Public Lighting	Variation of FEC	GJ
	Share of LED over total lighting	%
Waste services	Variation of FEC in waste systems	GJ
	FEC per capita	J/inhab
INTEGRATED CITY	Variation of TPEC	GJ
	New PV Installed Capacity in roof tops	MW
	New Utility scale PV Installed Capacity	MW
Climate		
Transport	Variation of GHG emissions in transport	tCO2e
Residential Buildings	Variation of GHG emissions in residential buildings	tCO2e
	Average household carbon intensity	kgCO2/household
Public Buildings	Variation of GHG emissions in public buildings	tCO2e
	Average buildings carbon intensity	kgCO2/m2
Public Lighting	Average carbon intensity	
Waste services	Variation of GHG emissions in waste systems	tCO2e
	Average carbon intensity	kgCO2/inhab
INTEGRATED CITY	Variation of GHG emissions	% change from base-year
	Emissions per capita	tCO2e/inhab

SECTORS	KPI	Unit
	Total GHG emissions	tCO2e
Financial		
Transport	Investment in Transport measures	M€
Public Buildings	Investment in public buildings measures	M€
Public Lighting	Investment in public lighting measures	M€
Waste services	Investment in sectoral measures	M€
Other		
Transport	Extension of bike lanes	km
	Public bikes	No.
	EV charging points	No.
	New parking lots	No.
Public Buildings	Zero Energy Buildings	No
Public Lighting	New automated management	No.
Waste services	Variation of waste production	t
	Variation of recycling rate	% from base year

Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

INSMART

Integrative Smart City Planning

Mid-Term Implementation Action Plan – Cesena

D-WP 6 – Deliverable D.6.2

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Executive Summary	
An application of the innovative city planning method, developed within the EU FP7 project INSMART, is applied to the municipality of Cesena (Italy). A multi-model approach is used to explore and rank alternative plans (combinations of actions and measures) towards the sustainable development of the municipality, with a particular focus on the residential and transport sectors.	
Keywords	Mid-term implementation plan, techno-economic viability analysis of interventions, funding schemes and monitoring KPIs.

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Acronyms and Definitions

BaU	Business as Usual
EEC	Energy Efficiency Certificates
ERDF	European Regional Development Fund
ESCO	Energy Service Company
ESM	Energy System Model
KPI	Key Performance Indicator
MCDA	Multi-Criteria Decision Analysis
ROP	Regional Operative Programme
SEAP	Sustainable Energy Action Plan
TJ	Terajoule (= 0.277 GWh)
UIA	Urban Innovative Actions

1. Introduction

An application of the innovative city planning method, developed within the EU FP7 project INSMART, is applied to the municipality of Cesena (Italy). A multi-model approach is used to explore and rank alternative plans (combinations of actions and measures) towards the sustainable development of the municipality, with a particular focus on the residential and transport sectors.

Compared to the existing city Strategic Energy Action Plans of Cesena (mainly based on the downscaling of the national/regional planning approaches), the INSMART method allows to explore multiple future planning hypotheses of the "integrated" energy-urban system (explicitly modelled and simulated) and to engage the local stakeholders in all the steps of the decision problem. Table below summarizes the key differences and highlights the novelty of the approach proposed to the municipality of Cesena. Results and findings presented in this Mid-Term Implementation Action Plan should be looked at based on the following important characteristics.

	Existing SEAP approach (Cesena)	**InSmart approach (Cesena)**
Approach	Top-down. Downscaling of national targets, policies and measures.	Bottom-up. Driven by urban specific needs and integrated with the urban planning.
Sectors (coverage)	Residential, Commercial, Public Administration (very limited analysis of agriculture and industry). Transport is not included.	Residential, Transport, Public Administration.
Emissions (location)	Direct (within the urban area) and indirect (e.g. due to the generation of electricity consumed in the urban area).	Direct (within the urban area). All the emissions "directly" generated by the players of the system (e.g. households) are taken into consideration.
Emissions (type)	Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O)	Carbon dioxide (CO_2), particulate (PM10, PM2.5)
Measures	Simulation. Cost-benefit analysis of individual stand-alone measures.	Optimisation/Simulation (what-if analysis). Integrated system approach.

Table 1. Qualitative comparison between SEAP and InSmart approaches in Cesena

1.1. Interventions promoted through the MCDA process

The modelling analysis developed within the INSMART project, supported by a multi-criteria decision analysis (MCDA)[1], has identified combinations of measures (planning hypotheses) that are ranked “high” according to the preferences of city stakeholders (see Box 1 for details). Among six alternative planning hypotheses[2] the modelling analysis has identified the two planning hypotheses which perform best, to be further analysed in this report: namely the **Alternative “F”** (ranked first), and the **Alternative “A”** (ranked second).

Ranking	Alternative planning hypotheses	Phi	Phi+	Phi-
1	**Alternative F**	**0.2871**	0.4777	0.1906
2	**Alternative A**	**0.1986**	0.381	0.1824
3	Alternative C	0.0455	0.3863	0.3408
4	Alternative B	-0.0338	0.2729	0.3066
5	Alternative E	-0.1552	0.3121	0.4674
6	Alternative D	-0.3421	0.1986	0.5407

Ranking	Alternative planning hypotheses	Results / Decisions
1	**Alternative F**	**Shortlisted**
2	**Alternative A**	**Shortlisted**
3	Alternative C	Below the threshold
4	Alternative B	Likely not of interest
5	Alternative E	Likely not of interest
6	Alternative D	Discarded

Table 2. Generation of “flows of preference” (Phi) and key findings about the alternatives

These alternatives have been composed combining sets of measures in different sectors into “comprehensive” plans. In particular Alternative “A” includes measures on the existing building stock and on transport (speed reduction and modal shift from private car transport to cycling), whereas Alternative “F” simulates more moderate measures on the existing building stock and on renewable energy.

Box 1. Stakeholder engagement in the INSMART project

Due to the complexity of the decision planning process for the city, the wide diversity of impacts of the projects, and the multiple stakeholders involved or impacted by the projects, a participatory multi-criteria approach has been used to identify relevant measures (planning hypotheses) for the city. Local stakeholders have been engaged in all the key stages of the development of the analysis: from the design of the planning options (stakeholders have been asked to imagine and suggest actions and measures to simulate in a time horizon of around 20 years); to the definition of the criteria against which the alternatives are evaluated; and to the selection of their preferences (weights) on these criteria.

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[1] Deliverable D.5.8 - Report on the multicriteria methodology, the process and the results of the decision making – Cesena, R. De Miglio, A.Chiodi, S. Burioli (eds.). Available from: <http://www.insmartenergy.com/wp-content/uploads/2014/12/D5.8-Report-on-the-Multi-criteria-methodology-Cesena.pdf>

[2] Deliverable D.5.4 - Report on optimum sustainability pathways – Cesena, R. De Miglio, A. Chiodi, M. Gargiulo (eds.). Available from: <http://www.insmartenergy.com/wp-content/uploads/2014/12/D5.4-Optimum-Sustainable-Pathways-Cesena.pdf>

The first step for stakeholder engagement was the formal establishment of an interdisciplinary working group composed by technicians of the municipality of Cesena from the Environmental, Mobility, Urban planning, Public and Private buildings and GIS departments; and representatives of “Energie per la città Ltd”. The group has actively participated in the data collection and in the definition of the first list of planning scenarios.

The second step was the enlargement of the stakeholder group to involve others local actors to the decision making process. This stakeholder group included:

- Universities (Architecture and Engineering faculties);
- CEAS (Municipal environmental and sustainability education centre, composed by different associations involved in urban sustainability projects);
- Professional orders (Ordine degli Architetti, Ordine degli Ingegneri);
- Professional associations (CNA Confesercenti, Confartigianato, Confcommercio)
- Consumers associations (Federconsumatori, Adoc Adiconsum)

This group has been involved in the definition of the final list of planning scenarios, the identification of relevant evaluation criteria; and in their preferences based on priorities and perceptions between criteria. The engagement consisted in a number of workshops, organized within the Municipality of Cesena with the collaboration of E4SMA:

- March, 14th 2016 - I workshop

  Presentation of the MCDA method and first draft of the scenarios
- June 2016 - On-line survey for the evaluation of the KPI indicators
- July, 5th 2016 - II workshop

  Presentation of the second draft of the scenarios.
- November, 29th - III workshop

  Presentation of key results from the cost-optimal scenario analysis and the MCDA ranking analysis.

In parallel three meetings with the political parties of the municipality of Cesena were organized:

- January, 28th 2016 - Presentation of the first draft of the scenarios to the Councillor of Urban Planning, Councillor of Sustainable Development and Europe, Councillor of Mobility;
- March, 13th 2016 – Special workshop dedicated to the City Council to present the MCDA method and a first draft of the scenarios;
- May, 10th 2016 - Presentation of the scenarios Council Committee Environment and Energy

2. Economic Viability Analysis

2.1. Methodology

This implementation plan focuses on the two best-performing alternative planning hypotheses (i.e. “F” and “A”), rather than to the best one only, as it aims to provide detailed information to the stakeholders and clarify pros and cons of such complex decision problem. For each key action of the planning hypotheses particular emphasis is given to *costs* – the economic effort – and *location* of the investments, as relevant for the implementation of a realistic and applicable mid-term implementation plan. The breakdown of each key indicator is provided on a zonal basis, as shown in Figure 1.

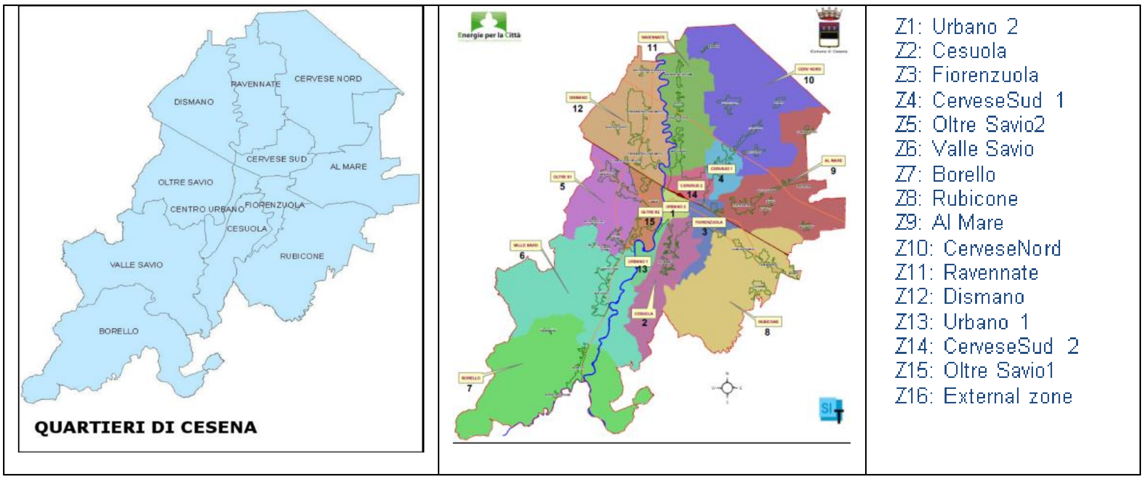

Figure 1. Administrative disaggregation by zone of the city (left), and disaggregation by zone of the model (right)

2.2. Economic Viability Analysis

This section provides a detailed techno-economic viability analysis on the key components (specific actions) which underpin the two shortlisted strategies for the Municipality of Cesena. The key element of novelty of such approach to the energy planning is that different actions (e.g. “retrofit-oriented”, “renewables-oriented” and “transport-oriented”) can be designed as separate actions and analysed in detail, but are *de facto* interdependent in an integrated system, like an urban-energy system. For example, these are subject to the same budget constraints (e.g. the available budget at family level for investing in more efficient technologies), and technical constraints (e.g. the available roof area which can be allocated either to solar photovoltaic or to solar water heaters). Integrated analysis can both provide detailed overview of implications of specific planning hypotheses, and, at the same time, useful insights about integrated city level dynamics.

The key components (specific actions) which underpin the two shortlisted planning hypotheses (alternatives) are the following:

1. Alternative A:

- Strong urban regeneration of the existing building stock;
- Simple measures on transport;

2. Alternative F:
   - Moderate urban regeneration of the existing building stock;
   - Expansion of renewable energy (decentralized production);

For both the alternatives, strong information campaigns are also part of the strategy.
The following sections provide a description of specific assumptions of these alternative strategies and the key findings. A reference case considering all the current key policy developments is also used as basis against which to compare the alternative city planning hypotheses.

Alternative A

This Alternative A ranked "second" in the multi-criteria stage of the work, thus representing the second "most-balanced" option among the available alternative sustainable-oriented plans. This alternative was meant to simulate the impacts of a deep urban "regeneration" of the existing building stock, in combination with few simple measures on transport system which favour a shift from private transport to *soft* transport modes (e.g. bikes).

Action A1: Urban regeneration

The first action was meant to simulate the impact of the refurbishment of a large share of the most energy-greedy (existing) building stock of the city. This alternative simulates the impacts of refurbishing 40% of the current building stock with an energy rating equal or lower than class-E (above 130 kWh/m^2 year). Of this 40%, 10% will be brought to class-A (< 40 kWh/m^2 year), while the remaining 30% to class-C (below 90 kWh/m^2 year). Such a "simple and city-wide" statement and target has been translated into a specific constraint of the city energy system model (City-ESM) of Cesena. Model has returned a set of quantitative information by zone, by building type and by time-slice which are here used to evaluate the specific benefits of the action with respect to the key objectives of the city.
Figure 2 shows the projected energy savings (in terms of useful energy) in 2020 and 2030 in the residential building stock due to the implementation of the action. Around 51 TJ (in 2020) and 144 TJ (in 2030) are expected to be saved at city level. The distribution at zonal level of savings reflects the actual location of the existing class-E (or lower) building stock in the city, and the cost-effective potential of the refurbishment options. A large share of the retrofit interventions will be located in the central part of the city: namely Zone 1 (Urbano 2), 3 (Fiorenzuola) and 15 (Oltre Savio 1).

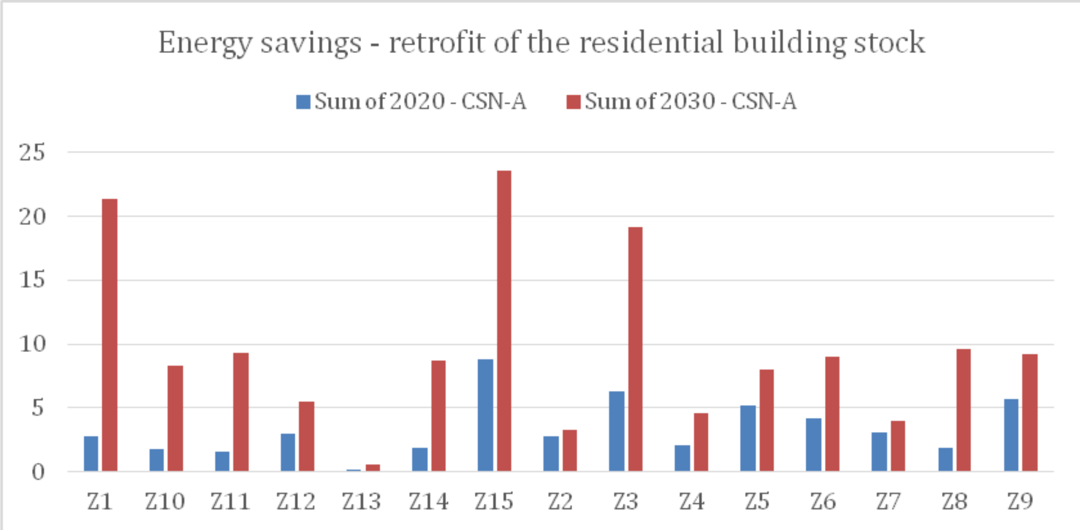

Figure 2. Energy savings (useful energy, TJ) in the residential building stock by zone in 2020 – 2030

Additional insights, about the most rationale way to implement the action, can be obtained by Figure 3. The results indicate that interventions on semidetached and terraced buildings – in particular for dwellings built before 1980 – should be prioritized among the other building typologies. Of these, the cost-optimal analysis suggests for semidetached dwellings the insulation of about 7000 roofs (measure "R2"), and the replacement of windows with high efficiency ones in about 6000 dwellings (measure "R3")[3]; while for terraced dwellings the insulation of about 4500 external walls. Other typologies, like flats – which are the most common building typologies in Cesena – or detached houses (high costs of retrofit), contribute to the target with a smaller proportion of retrofit investments.

This type of results is an example of unique insights that can be gained from an integrated analysis, which in this case identifies – under a certain policy or planning strategy – the least-cost combination of retrofit options, building typology and location.

Appendix 1 reports an overview of the saving potentials, by type of retrofit and building typologies, as calculated in WP2, used in the model.

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[3] Due the additive nature of the savings generated by the three retrofit options (assumptions based on the work of WP2), it is like to say that 6000 out of 7000 are expected to be refurbished with both R2 and R3.

R1 - Walls: Installation of external insulation on the walls for typologies without insulation or insufficient insulation, according to the thermal properties defined by the Italian Regulation for the specific climate zone.

R2 - Roof: Installation of external insulation on the roof for typologies without insulation or insufficient insulation, according to the thermal properties defined by the Italian Regulation for the specific climate zone.

R3 - Windows: Replacement of existing windows, according to the thermal properties defined by the Italian Regulation for the specific climate zone.

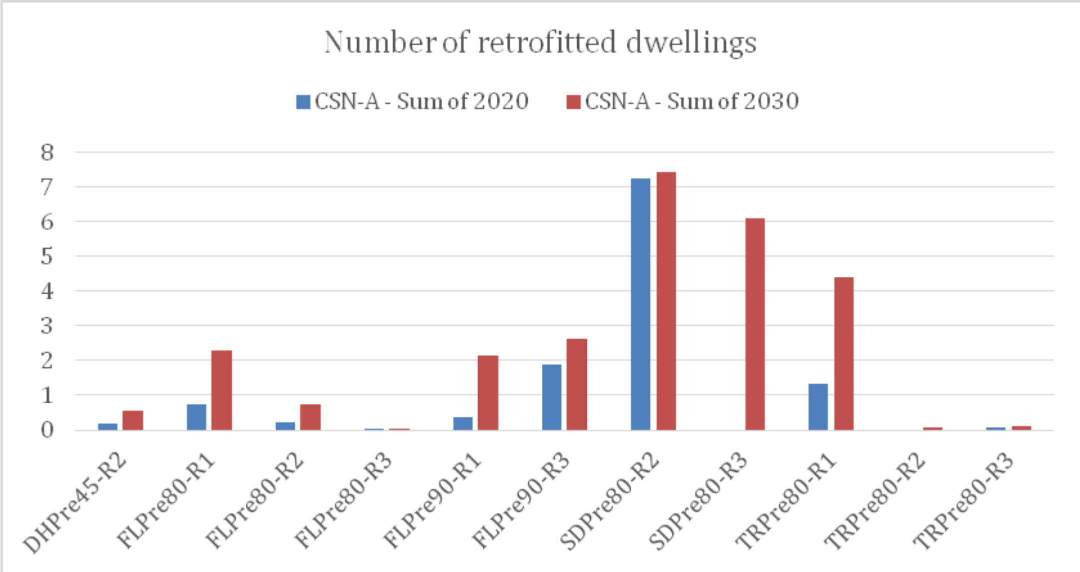

Figure 3. Number of retrofitted dwellings (thousands of dwellings) by type in 2020 – 2030.

In the city of Cesena, residential consumption is currently dominated by natural gas, which is also foreseen to be the key energy commodity used in the sector by 2030, as shown in the chart below.

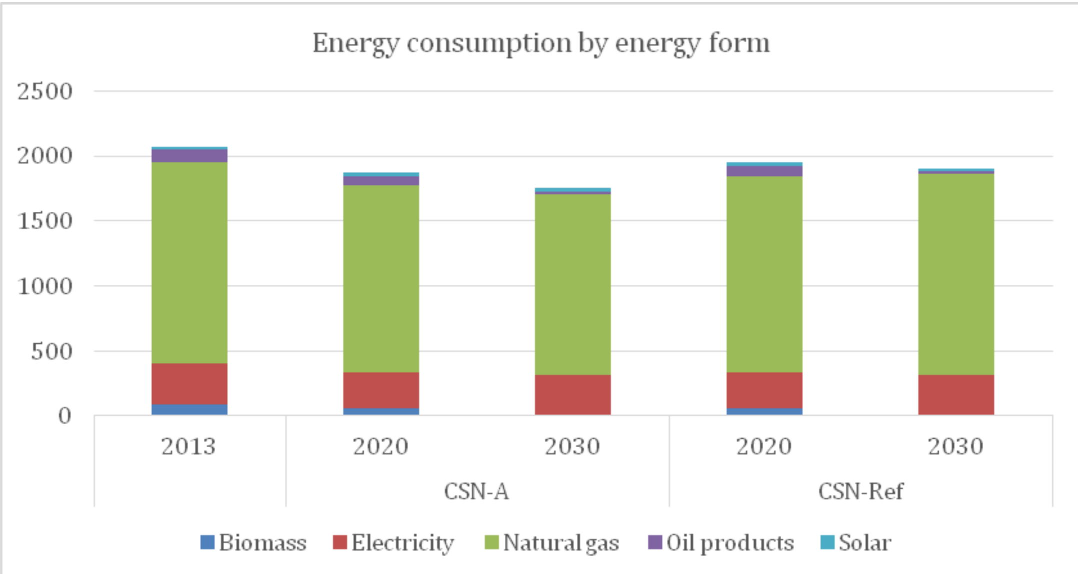

Figure 4. Energy consumption in the residential sector (TJ)[4] – Comparison between Alternative A and Reference

An interesting impact of this action is the reduction of the gas consumption in the high heating demand periods. Figure 5 shows (in relative terms), the yearly gas consumption profile across 24 time slots[5] in three cases: in the base year of the analysis (2013), in 2030 under the reference development of the system, and in 2030 after the implementation of the action. The benefit of an action which boosts the

[4] Solar includes the energy for water heating only. Generation of PV technologies is part of the item "electricity".

[5] See Appendix 2 for details about the inter-annual periods.

building stock retrofit, can be measured in 2030 as a 10% of reduction of gas consumption in the peak season (S1 = January), and in about 8%-10% in the intermediate seasons (S2, S6).

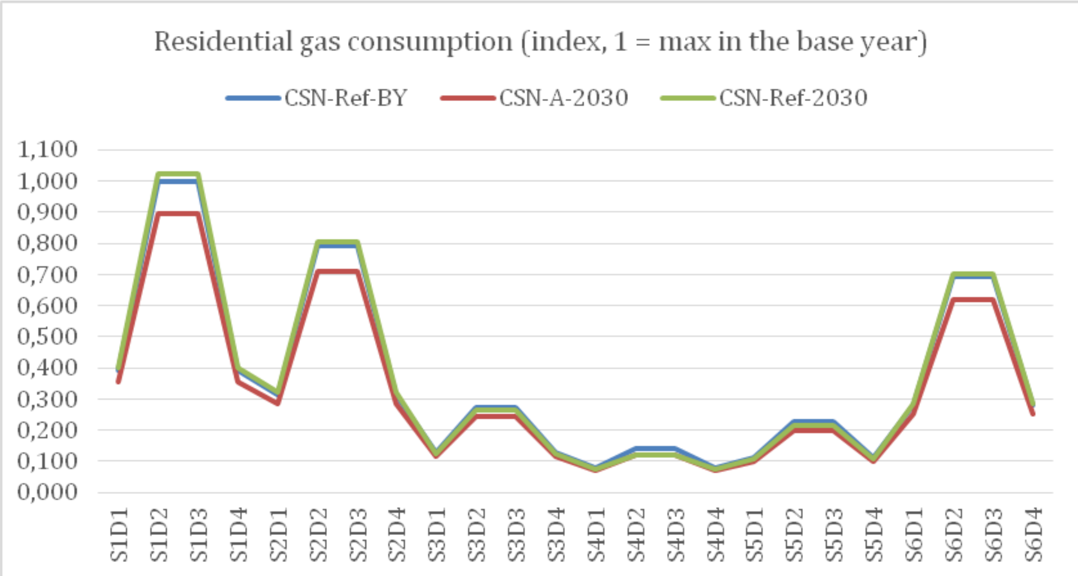

Figure 5. Gas consumption profile in the residential sector (index)

The "overnight" cost of the action, estimated on the basis of the model response, is about 108.7 Euro millions (equivalent to approximately 1120 Euro/inhabitant to retrofit a fraction of the existing building stock with the above mentioned standards, at the costs-per-retrofit reported in Appendix 3). For a more detailed analysis, this total cost can be further broken down by retrofit measure (40.6% for R1, 13.2% for R2, 46.2% for R3), by building typology (1.3% for detached, 50.6% for semi-detached, 23.4% for flat, 24.8% for terrace), and by zone (13.6% in Z1, 14.4% in Z3, 18.8 in Z15, etc.[6]).

Assuming an average domestic gas price of 27 Euro/GJ, the overall "payback period" of the action is not lower than about 25 years.

Action A2: Transport measures

The second important action of the integrated planning hypothesis "A", focuses on the transport sector. In particular this action foresees two main interventions:

1) The completion of cycle paths (for a total of 16 km) along the main road network and within the so-called "areas 30", to favour the use of the bicycles in daily home-school and home-work trips.
2) The realization of "environmental" bike paths along the river Savio for cycling tourism (for a total of 87 km) and to connect the low population density areas (in particular between zones 11, 10, 4 and 9).

[6] A complete set of results has been shared with the experts of Cesena

The results of the analysis performed with a transport-specific model [7], reported in the table below, shows the impact of the actions on the transport demand per each transport mode in terms of “number of total movements” per day (daily vehicle demands) and the equivalent vehicle-kilometres (including the average distances per movement) at the end of the horizon (2030). Table 3 reports a reduction of private demands of around 11500 movements per day, while the vehicle demands of public and freights are equivalent to the reference case and not affected by the action. The indicator of *private vehicles dependency* (movements of cars and moto over the total) is then reduced of around 4% with respect to the reference case.

	Alternative A – 2030			**Reference – 2030**		
Description	Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms	Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms
All Cars	233578	2147353	723659289	243458	2234571	753050787
Buses	2069	22129	7457939	2069	22129	7457939
Freight	9775	104417	35189858	9775	104417	35189858
Moto	39971	368447	124167703	41559	382498	128903388
Total	285393	2642346	890474789	296861	2743615	924601972

Table 3. Impact of the action on the transport demand

The action cost (overnight investment) is expected to be of about 450000 Euro per km of cycle lane, for a total investment of 7.2 Euro million. The private contribution is supposed to be negligible, as the cost is almost entirely supposed to be covered by the Municipality.

The total energy consumption of the transport sector, as calculated by the integrated model[8], is reported in Figure 6. Chart shows a decrease of energy consumption in the reference case mainly driven by two elements: demands in 2030 (movements) are expected to be lower than in the base year[9], and technology substitution. The penetration of more efficient and hybrid-engine vehicles due to national regulation/standards and to the cost-effectiveness of more efficient vehicles is expected to be an important factor of the coming 15 years, no matter which local-specific sustainable-oriented actions is applied.

Based on these results, chart also shows the relatively small, but still important, effect of the transport-specific action (included in the integrated alternative “A”) on the consumption of the sector in 2030. When compared to the reference profile, energy

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[7] Deliverable 3.8 (2015), Transport Scenarios Results Report Cesena, Available from: <http://www.insmartenergy.com/wp-content/uploads/2015/10/D.3.8.v2-Transport-Scenarios-Cesena.pdf>

[8] As reported in the specific project deliverable, values must be interpreted as follows: the consumption for private, public, freights movements the origin of which is in the geographical area of analysis.

[9] Movements by transport mode are projected making use of the transport specific model.

use drops of additional 140 TJ. At an average price of gasoline of 45 Euro/GJ, the overall "saving" (due to the modal shift "from car to bicycle") is expected to be about 6.3 Euro millions (approximately 65 Euro per person) in the final year.

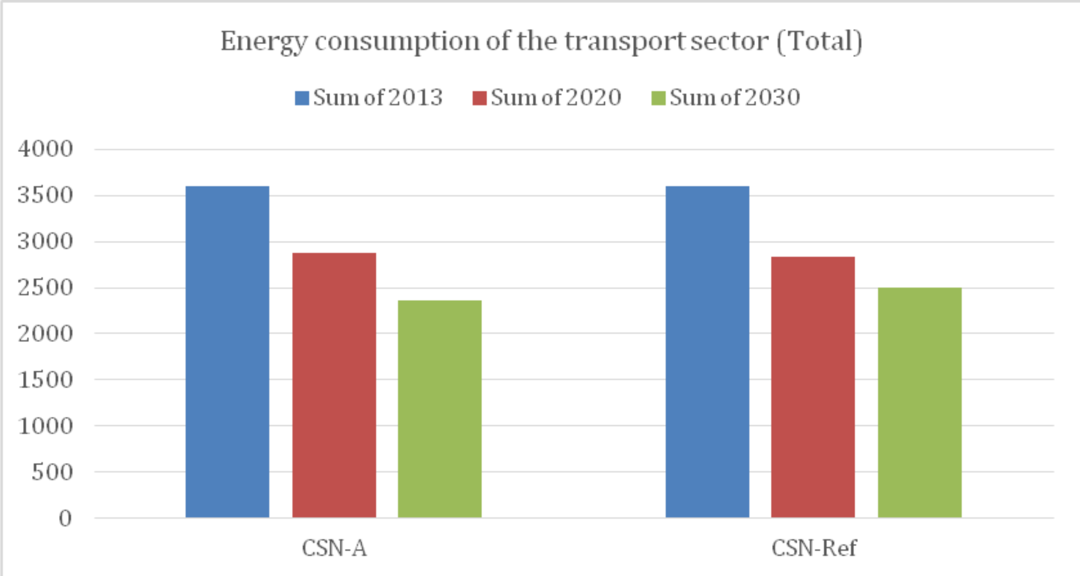

Figure 6. Energy consumption in the transport sector (TJ)

A more conservative projection of consumption for the transport sector, is provided by the transport-specific model (making use of different methodologies and assumption) which calculates a reduction of consumption, from the base year to 2030, of about 15% in the reference case.
But even according to this analysis, the impact of the realisation of cycle routes is relatively small with respect to the total consumption of fuels in 2030.

Alternative F

This planning hypothesis ranked "first" in the multi-criteria stage of the work, thus representing the "*most-balanced*" option among the available alternative sustainable-oriented plans. The Alternative F was meant to simulate the impact of an increase of 30% (relative to 2013) in the use of renewables[10] in the local energy system (residential + tertiary + supply, transport is excluded) by 2030, in combination with the refurbishment of a medium-to-small share of the most energy-greedy buildings. As for the Alternative A, such a "simple and city-wide" combination of measures has been translated into constraints for the energy-system-model of Cesena, in order to control the two specific targets. The quantitative information "by zone", "by building type" and "by timeslice" returned by the integrated model are used below to evaluate the specific benefits of the actions with respect to the key objectives of the city.

[10] Mainly solar and biomass/biogas. Potential of wind at urban level was not considered.

Action F1: Urban regeneration

This action was meant to simulate the impact of bringing 25% of buildings currently with an energy rating equal or lower than class-E (over 130 kWh/m^2 year), to class-B (below 60 kWh/m^2 year).

Figure 7 shows the expected energy savings (in terms of useful energy) in 2020 and 2030 in the residential building stock, due to the implementation of this retrofit plan. Around 39 TJ (in 2020) and 100 TJ (in 2030) are expected to be saved at city level, well below the values reported for the urban regeneration action of Alternative A.

The distribution at zonal level of such savings largely reflects the actual location of the existing class-E building stock in the city, and the cost-effective potential of the refurbishment options. However, given the limited family budget available for investments, this distribution is in part also affected by the simultaneous target on renewables (Action F2), which leads to a different location of intervention. The largest share of retrofits would be still needed in the central part of the city – Oltre Savio 1 (Z15) and Fiorenzuola (Z3) – but energy savings are now more evenly distributed across the zones, as shown in Figure 7.

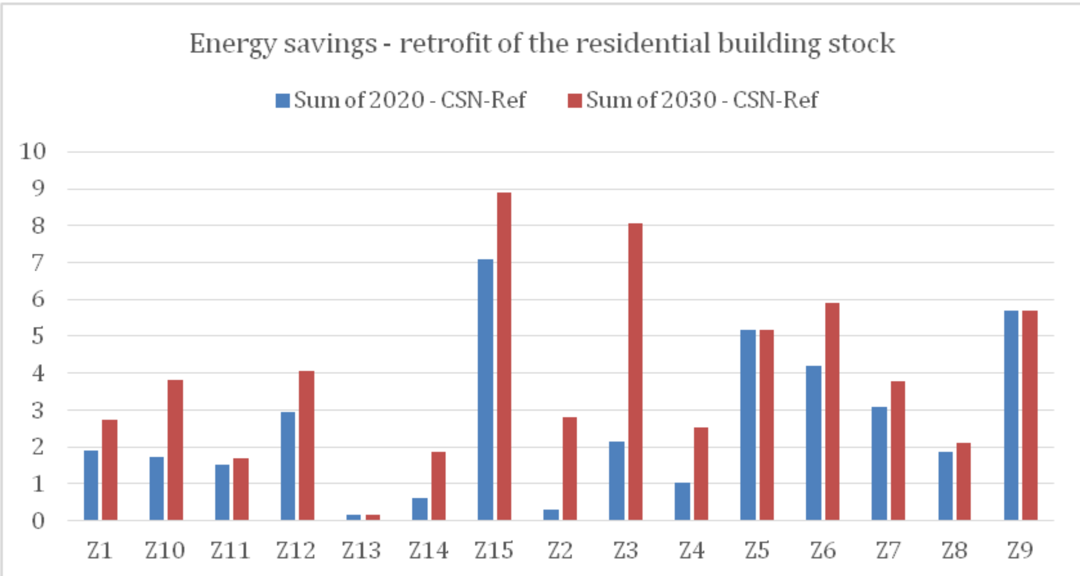

Figure 7. Energy savings (useful energy, TJ) in the residential building stock by zone in 2020 – 2030

Figure 8 provides a detailed overview of the type of dwellings subject to retrofit and the type of measures, as allocated by the model. The main building typology which should be focused on are, as for the Alternative A, semidetached dwellings. To fully implement the action in the cost-effective way, up to 7000 semidetached dwellings – built before 1980 – are required to be retrofitted with the measure “R2” (roof insulation) and up to 3000 with the measure “R3” (windows replacement)[11].

[11] Due the additive nature of the savings generated by the three retrofit options (assumptions based on the work of WP2), it is like to say that 6000 out of 7000 are expected to be refurbished with both R2 and R3.

The numbers of retrofitted dwellings is lower than in the alternative A, however in general this planning hypothesis performs well against many criteria.
Based on model results, we can conclude that the most cost-effective way to reach the target designed by this action is to orient most of the efforts to the semidetached, retrofitting windows and roofs, and terrace, for which the installation of external insulation of walls (for the equivalent of around 2000 dwellings) is fruitful.

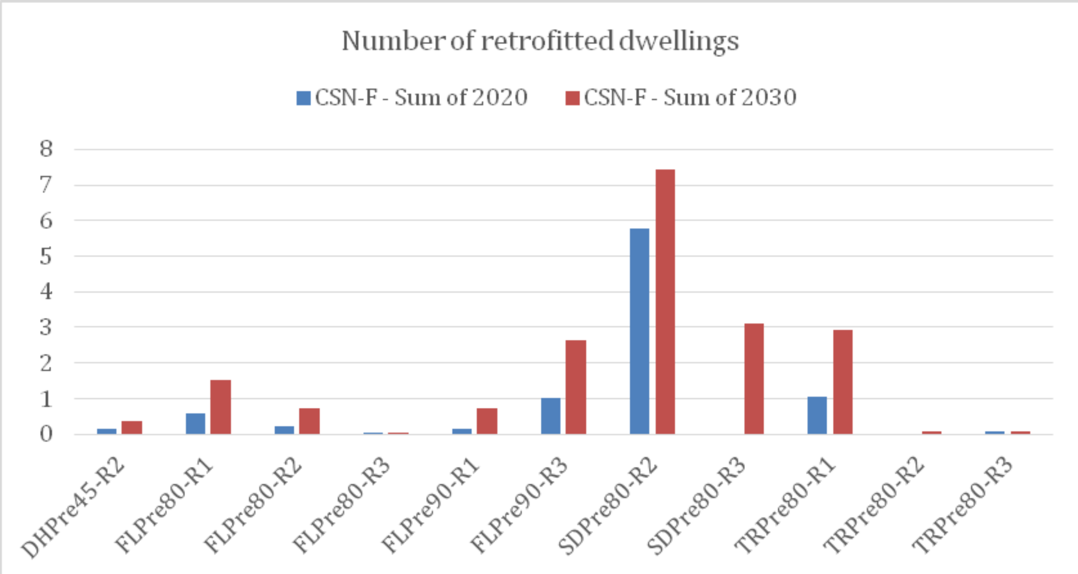

Figure 8. Number of retrofitted dwellings (000dwellings) by type in 2020 – 2030.

Residential consumption is dominated by natural gas which is also projected to be the key energy commodity used in the sector by 2030, as reported in the chart below (Figure 9). However, driven by the renewable target, solar energy takes a non-negligible share in the mix.

R1 - Walls: Installation of external insulation on the walls for typologies without insulation or insufficient insulation, according to the thermal properties defined by the Italian Regulation for the specific climate zone.
R2 - Roof: Installation of external insulation on the roof for typologies without insulation or insufficient insulation, according to the thermal properties defined by the Italian Regulation for the specific climate zone.

R3 - Windows: Replacement of existing windows, according to the thermal properties defined by the Italian Regulation for the specific climate zone.

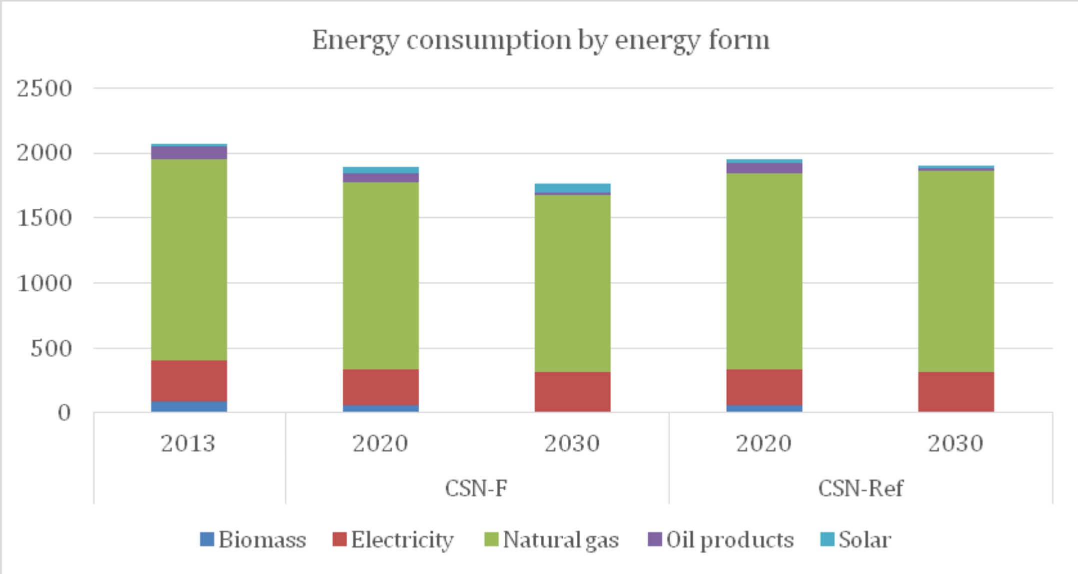

Figure 9. Energy consumption in the residential sector (TJ)[12] – Comparison between Alternative F and Reference

The "overnight" cost of this urban regeneration action, based on the response of the model in terms of type and number of retrofit and building involved, is about 69.654 Euro millions (approximately corresponding to 715 Euro/inhabitant to retrofit a fraction of the existing building stock with the above mentioned standards, at the costs reported in Appendix 3).

For a more detailed analysis, this total cost can be further broken down by retrofit measure (38% for R1, 20% for R2, 42% for R3), by building typology (1.4% for detached, 49.1% for semi-detached, 23.9% for flat, 25.6% for terrace), and by zone (12.4% in Z1, 12.1% in Z3, 9.2% in Z15, 10% in Z10, etc.).

Assuming an average domestic gas price of 27 Euro/GJ, the overall "payback period" of the action is not lower than 23 years, slightly lower than the Alternative "A", but with also less savings.

Action F2: Increase of renewables

But the "key" action of such planning hypothesis is on renewable energy. It has been specifically designed with the aim of increasing the overall use of renewable energy for the production of decentralised heat and electricity (transport is excluded from the action) in the city-system of (at least) 30% by 2030.

The contribution of the household sector to this integrated planning hypothesis is shown in the following figures and charts. Around 5.3 MW of solar PV roof technologies (amorphous silicon) are suggested to be installed in the buildings by 2030, together with around 10 MW of solar water heaters in addition to the existing installed capacity. The total overnight cost for the household sector (compatible with the budget constraint) of the action is 34.115 Euro millions (approximately

[12] Solar includes the energy for water heating only. Generation of PV technologies is part of the item "electricity".

corresponding to 350 Euro/inhabitant), of which 40% for investments in PV-roof technologies and the remaining for solar water heaters, according to the optimal configuration of the system.
Total cost can be also broken down by dwelling type: namely 21% of the investments would be assigned to the detached, 47% to the flat, 13% to the semidetached and the remaining to the terraced. By comparing these figures with the distribution of investments for building retrofits, it results evident that for some building typologies (semidetached) the most cost-effective allocation of the available (household) budget is for the reduction of the heating needs, while for other dwellings (flat) there seems to exist a larger cost-effective room for the boosting the use of solar technologies.
Such a finding can be obtained only when an integrated system-oriented analysis is undertaken, and different policies and measures are tested "simultaneously"[13].

Figure 10 shows the production of renewable electricity (from solar PV technologies) in the residential sector by timeslice in the base year (2013), and in 2030 under both the Reference and the Alternative F scenarios. Around 69 TJ of electricity are projected to be generated in 2030 when the action is implemented, 12 TJ more than in the base year. At an average electricity price of 65 Euro/GJ in the medium term, the overall "payback period" of the action is expected to be around 15 years.

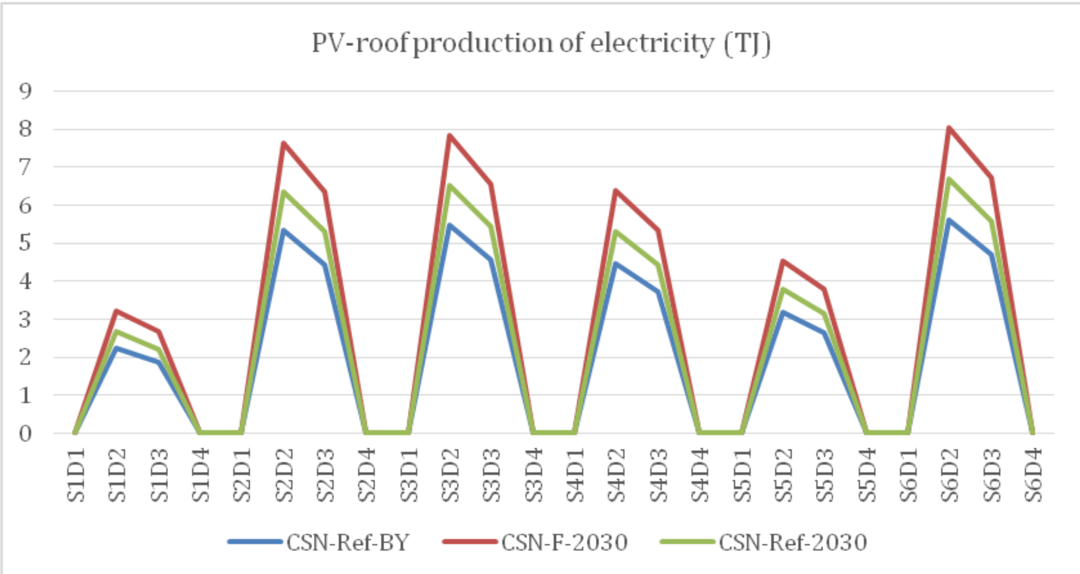

Figure 10. PV-roof production of electricity by time slice and scenario.

The combined effect of building retrofits, penetration of renewables (both explicitly included in alternative "F"), and energy efficiency improvements of the electric appliances (based on cost-effectiveness in all the scenarios) in the households sector, can be also analysed by time slot as shown in the following chart (Figure 11).

[13] Each alternative planning hypothesis is designed by combining different actions in a "single" plan. Synergies and redundancies can be found by analysing the results of the integrated simulation.

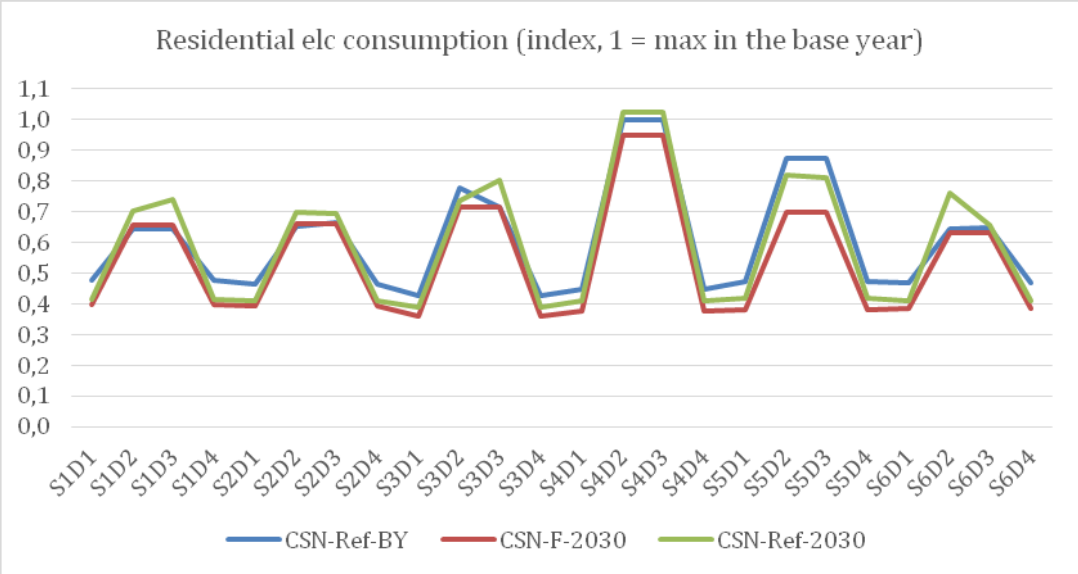

Figure 11. Electricity consumption in the residential sector (index)

Results show a reduction of electricity demand of around 5% in the peak slices (S4D2, S4D3) with respect to the base year, and a consumption curve (red line) which is generally placed "below" the reference load shape (green line).

The above-mentioned results must be interpreted on the basis of the storyline of alternative F and of the integrated response of the city-model. Reduction of electricity demand due to energy efficiency, in particular in the summer time[14] (S4), coupled with budget constraints of the households, discourages extra investments in PV technologies (which mainly operate in the summer time). That is why 60% of the investments in solar technologies are allocated to the water heaters.

Moreover, biomass technologies in the residential sector are replaced by other heating options in the medium-term, improving the indicator of PM emission but reducing at the same time the share of "renewables" in the energy mix of the city. This makes the target on renewables even more challenging as only solar technologies (no utility scale plants are allowed) and biogas can play a role.

Hence, the only way to meet the target set by the action – i.e. a 30% increase of renewables at city-wide level – is to call for investments in the "local" supply sector, for example with new biogas micro-cogeneration plants able to produce about 15 TJ of additional "CO_2-free" electricity within the borders of the city, and consuming an equivalent of 45 TJ of biogas.

It's also worth noting the response of this comprehensive planning hypothesis (Alternative "F") with respect to the gas consumption across the slices of the year. The simultaneous application of a "soft" retrofit strategy and the boost of renewable energy (solar) depicts a slightly different consumption curve (Figure 12).

[14] No significant increase in cooling demand was assumed.

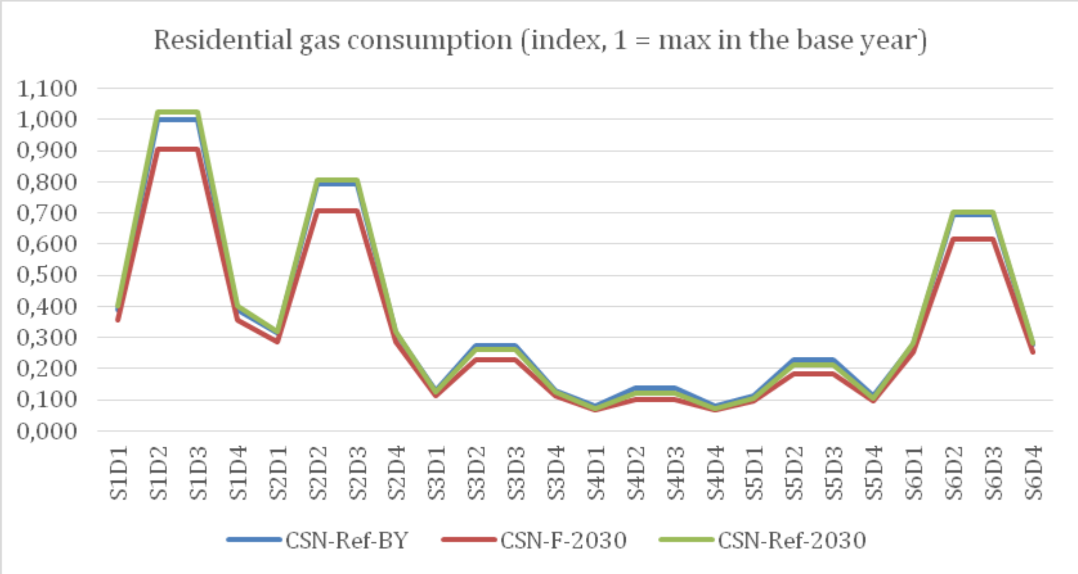

Figure 12. Gas consumption profile in the residential sector (index)

The benefits during the heating seasons are still evident (although lower than for the Alternative A), but a reduction of gas consumption also occurs in the intermediate year-slots. This is mainly due to an extra penetration of solar water heaters in the residential technology mix, as the larger part of the family's budget can be allocated to the renewables and efficient boilers rather than to heavy building retrofits.

Overall, in 2030 the expected consumption of gas in the sector is around 25 TJ lower than in the case "A". This result points out that the combination of actions designed in the alternative "F" is more effective on average among different criteria, even if under the indicator "gas consumption in the residential sector" it performs (slightly) worse.

Assuming the INSMART approach to the strategic planning, the penetration of solar PV technologies does not impact (reduce) the "direct" CO_2 emissions of the city-system, as all the centralised generation of electricity is placed out of the borders of analysis (the municipality of Cesena). On the other hand, the penetration of solar water heaters does impact on the direct emissions, as some gas-fired boilers are replaced by solar technologies.

A consistent definition of the space of analysis is of extreme importance when policies and measures are designed and monitored. This latter comment, which is of particular importance for plan "F" (the "best" planning hypothesis, according to this analysis) when the indicator on CO_2 emissions is analysed, introduces a final comparison between the out-of-the model goals and the response of the present modelling exercise.

Information campaigns (and other legislative and regulatory measures)

Without adequate information on the benefits of some choices, inhabitants have no possibility of understanding the dynamics, the objectives and the possible opportunities of a "rational" (energy-related) behaviour.

Strong "information campaigns" are assumed as being part in both the "most effective" plans for the municipality of Cesena. Information campaigns are twofold important: they are expected to act in such a way that the explicit actions designed for the integrated strategies (retrofit of the building, penetration of renewables) can be actually met by due time, and they have to "impact" on the rationale of the private investment decisions which are not explicitly mentioned in the policy and planning actions (e.g. replacement of the heating systems, reduction of overheating, substitution of the electrical appliances in the residential sector, or efficiency improvement in the tertiary sector, etc.)[15]. In other words, info campaigns are needed to enable decision-makers to contribute in the realisation of the designed measures, and to allow them to take smart investments decisions for everything is "not directly/explicitly" included in the planning hypotheses. The benefits on the energy-environmental system can be measured in terms of rate of energy efficiency improvements and, consequently, in terms of corresponding consumption and emission level.

Information campaigns play in an environment which is already "regulated" by supranational, national and local measures, so that the benefits for the city of such an action is "incremental" to the effects of the existing regulations (taken into consideration by default in the analysis):

- the Directive 2009/125 / EC was introduced with the aim of reducing energy consumption under the Kyoto Protocol. It made mandatory the production and commercialization of condensing boilers (high efficiency) only, starting from September 2015. Information campaigns can explain / make clear / suggest the benefits of the new options (compared to the existing) to the consumers, thus boosting the substitution of old technologies with the new (condensing) ones, *even before the end of the technical lifetime* when, and if, the replacement is "cost-effective" for the city-system.
- the Directive 2010/30/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products[16]. The directive itself aims to improve the efficiency of products related to energy consumption through an *informed choice* of the consumer. But, again, a full recognition of the (economic) benefits of replacing inefficient appliances with efficient appliances can be supported by the action of the campaigns. Awareness campaigns may turn the resistance of change, cope the lack of information of consumers, and help them in making rational decisions (which may result in the allocation of more money for the "investment" in order to save money during the operation of the device).

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[15] Simulations run with a (constrained) optimisation approach meaning that investment decisions are based on rational behaviour of the agents and on a cost-effective allocation of resources/costs/budget.

[16] The new labelling code provides additional three classes of greater energy efficiency (A +, A ++ and A +++), which are in addition to traditional classes A, B, C and D, and must be applied by manufacturers to refrigerators, freezers, washers, dryers, dishwashers, TVs and to air conditioners.

Costs for information campaigns vary depending on the mean and the level of the awareness message. An open web-page with a free energy savings calculator may cost from 10 to 15 Euro per household (per each "home appliance" decision), a doorstep campaign up to 40-60 Euro per household (per each "home-appliance" decision), while a more targeted, strong and permanent info-point may result even more expensive for the municipality. A cost of 75 Euro per household (per each "home-appliance" decision) has been assumed to simulate the effort needed to enable decision-makers to contribute in the realisation of the designed actions (e.g. retrofit of the building stock), and to support them to behave in a smarter way with respect to the energy-related decisions (investments and utilization of energy technologies). The total investment cost of such an action would be about 16 Euro millions (approximately corresponding to 165 Euro/inhabitant) distributed across the time periods.
Schools and associations can also promote initiatives and contribute to make people more aware of the implication of the energy consumption on the environment. Although their impacts is hardly "quantifiable", the direct involvement of such actors in education and information is expected to lower the burden (cost) for the Municipality.

Short-medium term sustainable goals

This section briefly compares some key results from the analysis of the best performing option (Alternative "F"), with the objectives of the existing Sustainable Energy Action Plan (SEAP).
The three key objectives of the SEAP were:

- A reduction of 20% of the emissions (based on values in 1995).
- A reduction of emissions per capita to 2.9 tons of CO_2.
- A reduction of 133000 tons of CO_2 with respect to the BaU scenario.

As mentioned in section 1, a direct comparison between these policy targets and the INSMART results is not straightforward, due to the several differences in the approach and in the sectoral coverage of the analysis.
Although these differences, this section provides a first-order "*rough*" comparison. The total CO_2 emissions calculated by the integrated model for the base year (2013) has been moved backward (to 1995) by applying a correction factor of 1.22 to lower the emissions to the reference point in the time. Emissions covered by the present analysis are assumed to be scaled down with the same factor used to calculate the emission in 1995 and 2007 in the existing/available Action Plan.
Table 4 summarises the key data used to calculate and benchmark the indicators.

Scenario / Period	**1995**	**2013**	**2020**	**2030**
Population	88000	97000	97000	97000
Reference (kt CO_2)	297000	359450	301828	273869

Alternative "F" (kt CO_2)	297000	359450	312379	246819

Table 4 Short-medium term sustainable goals - "key" data

The key findings are:

- In 2030, emissions covered by the INSMART analysis reduce to about 17% relative to 1995 levels. However, when the results of the model are adjusted – with an out-of-the-model calculation of the indirect emissions[17] – to include indirect emissions from centralised electricity generation, the emissions achieve a 23.5% reduction. This proves that the inclusion or exclusion of the indirect emission is a very important assumption in the design of sustainable implementation plans at local level.
- Emission per capita covered by the present analysis reduces to 3.2 in 2020 and to 2.5 in 2030 (t/capita).
- A BaU scenario, assuming a direct correlation between CO_2 emissions and population, would project a value of 359450 kt CO_2 in 2030. A reduction of around 113000 tons of CO_2 with respect to the BaU is then obtained.

Other designs for a comprehensive energy plan

The inclusion of additional "explicit measures" in the planning hypothesis, as well as the selection of a different combination of the actions already identified, may lead to a different development of the system and of the corresponding energy-environmental performances.

Based on the proposed approach to the "integrated" analysis of the local system, it is not possible to estimate "ex-ante" the "exact" impact of such new designs, because of the important "feedback and interdependencies" that some actions may have. In other words, *the response of the "integrated simulation" is different from the algebraic sum of the stand-alone actions which are part of the planning hypothesis*.

In spite of that, it is still possible to capture some more qualitative trends resulting from the implementation of differently designed alternatives. For example, the planning hypothesis "F" (the best ranked) can be further extended by including the realisation of "new cycle routes".

Enhanced strategy (F+)			
Extra intervention	Emissions	Energy Efficiency / penetration of renewables	Costs covered by the Municipality
New cycle routes	↓	↑	↑

[17] Assuming the carbon intensity indicators (from the PRIMES model – reference scenario) for electricity and steam production equal to 0.345 t of CO2/MWh (in 2013), and to 0.24 t of CO2/MWh (in 2030).

The expected response of a so-defined new integrated strategy (compared to the standard option “F”) would result in a further reduction of the emissions (due to the reduction of the private demand), a simultaneous increase of energy efficiency and/or penetration of renewable energy in the household sector, a different distribution of the refurbishment at zonal level, but a higher cost covered by the Municipality.
The enhancement of strategy “F” with an extra measure (on transport) is likely to lower the emissions covered by the present analysis of around 20%[18] (based on values in 1995), so that the objective of the existing Action Plan can be met even without any assumption about the indirect emissions.

3. Proposed funding schemes

3.1. Available and proposed funding schemes

National and regional instruments (e.g. incentive schemes) are currently available to support investments in efficient and renewable technologies. Some of the most interesting options which may enable the proposed actions (as designed in the mid-term plan described in the above sections) are reported below.

<u>Retrofits and renewables in the households sector</u>
An important part of the investment is expected to be paid by the families. Tax reliefs are the most common instruments to enhance energy savings in the residential sector.

- Tax relief for energy-efficiency measures: for costs incurred from 6 June 2013 to 31 December 2016 it was possible to take advantage of a tax relief (from the national systems) of 65%, for the interventions to improve energy efficiency, respectively for individuals (Irpef) and companies (Ires). This tax relief is recognized for the costs incurred, for example, for the reduction of energy requirements for heating, thermal upgrading and retrofit of the building (insulation, windows frames, etc.), the installation of solar thermal collectors, etc.
- Tax relief for interventions of building renovation: the costs sustained for building renovations determine an advantage in terms tax relief (on individual income tax deduction) of 36%; for expenditure that have been incurred from 26 June 2012 to 31 December 2016, the income tax relief is equal to 50%. This fiscal instrument is applicable to energy efficiency measures, as well.
- Energy Efficiency Certificates (hereinafter E.E.C.): these are the so called “White Certificates” (market-oriented instrument), put in place by the ministerial decree of 20 July 2004 and subsequent amendments. Energy Markets Manager (hereinafter EMM) certify the achievements in terms of energy savings among end-users through energy efficiency interventions and

[18] Compared to the 17% of the default Alternative F.

upgrading projects. According to the legislative decree 20/2007, also high-efficiency cogeneration units can access the E.E.C. mechanism.

This scheme can be used to fund the extra investments needed to meet the renewable target (+30%) which cannot be covered by the household sector.

- Thermal Account (so called 'Conto Termico'): foreseen by M.D. 28 December 2012, amended by M.D. 16 February 2016, it promotes actions to increase energy efficiency and generate thermal energy from renewable sources. Incentives may be accessed by public administrations, private individuals, and companies. Incentives will be available and reserved to the public administrations for interventions improving efficiency of buildings' envelope (insulation of walls and roofs, replacement of doors and windows, etc.), the replacement of existing boilers with condensing boilers, interior lighting, building automation technologies. Incentives are available both for public administrations and private individuals, with regards to small interventions for the production of thermal energy from renewable sources (heat pumps, solar thermal plants, etc.).

Assuming that these incentive mechanisms are reconfirmed by local governments, they are considered to continue to positively influencing private decisions about upgrading interventions on buildings and to represent a useful funding source for citizens.

The Emilia-Romagna Regional Operational Programme is the programming document that defines the strategy and operations of use of EU resources allocated to the Region by the European Regional Development Fund within the framework of cohesion policy, for economic growth and the attractiveness of the territory. The 2014-2020 program focuses on six priority actions - axes. Axis 4 of ROP-ERDF (2014-2020), in particular, promotes the reduction of energy consumption in buildings and public facilities and the introduction of systems for the production of renewable energy. Other objectives of Axis 4 are explained in the following paragraphs, as they are more specific for renewables and transport.

Renewables

- Ministerial decrees of 6 July 2012 and 23 June 2016: they provide incentive schemes for plants using renewable sources other than photovoltaic solar energy, with power equal to or greater than 1 kW, having become operational from 1 January 2013. Terms and payments are defined in the Decrees. With the entry into force of the Ministerial Decree of 23 June 2016, defining new incentive arrangements, some plants (as defined in the Decree) can continue to apply for incentives under the previous Decree of 6 July 2012.

  This scheme can be used to fund the extra investments needed to meet the renewable target (+30%) which cannot be covered by the household sector.
- The development of projects addressing renewable energy sources could also be financed through the involvement of Energy Services Companies (ESCOs).

These companies can provide all the technical, commercial and financial services to carry out energy efficiency interventions, by bearing investment costs and the risk of lost savings, in front of the signature of a contract where profits are established.

European Funds are also available in the sector of renewables, in the form of structural funds managed by national and regional institutions, as well as direct funds, managed directly by the European Commission. The following are the ones that Cesena Municipality used the most in order to finance or co-finance its interventions:

- ERDF

The ERDF-Emilia Romagna ROP (2014-2020 program), as stated above, foresee in the Axis 4, along with sustainable mobility and transports, the objective of encouraging efficiency and energy saving and the development of renewable sources by both public entities and businesses with a view to sustainable development in the region both in terms of environmental protection and energy cost savings.

The results to be pursued are: reducing the energy consumption of production processes of industrial enterprises and public buildings by 20% and raise the production of energy from renewable sources in enterprises and 20% for self-consumption by 25%.

Axis 4 objectives for renewables are: promoting the reduction of energy consumption of enterprises and the production of energy from renewable sources for own consumption also through the creation of ecologically equipped productive areas.

Cesena Municipality is working on ERDF Axis 4 in order to support some key interventions on its area (requalification of public buildings and renewable energy production installations). These interventions require a quote of Municipal co-funding, alongside the Regional funding.

- Horizon 2020

The EU's Research and Innovation Programme Horizon 2020 provides €5.931 billion in funding towards energy projects between 2014 and 2020. These projects aid in the creation and improvement of clean energy technologies such as smart energy networks, tidal power, and energy storage. Cesena Municipality is submitting some project ideas under this funding stream.

In the previous programming period, energy projects were funded by the 7th Framework Programme for Research and Technological Development (FP7), then included into Horizon2020, which ran from 2007 to 2013. In the past, Cesena Municipality took part to a pilot action for the retrofit of a school building inside the successful project School of the Future, funded under the FP7.

Intelligent Energy Europe (IEE) Programme was another previous funding scheme that came to an end in 2013 and then included into Horizon 2020, where Cesena Municipality acted as partner in PassREg project (Passive House Regions with Renewable Energies), aimed at the empowerment of local and regional authorities and involvement of local politician for the introduction of Passive House in construction practices.

- Territorial cooperation

Other EU funding schemes supporting innovation and energy efficiency can be found in the territorial cooperation programmes. European Territorial Cooperation is central to the construction of a common European space, and a cornerstone of European integration. It has clear European added value: helping to ensure that borders are not barriers, bringing Europeans closer together, helping to solve common problems, facilitating the sharing of ideas and assets, and encouraging strategic work towards common goals.

Under one of these programmes (e.g. Interreg Central Europe) Cesena Municipality is running a project coordinated by Wismar University (Germany) for energy savings in planning public lighting, called Dynamic Light.

- UIA

Urban Innovative Actions (UIA) is an Initiative of the European Commission that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. Based on article 8 of ERDF, the Initiative has a total ERDF budget of EUR 372 million for 2014-2020.

Among other topics, UIA supports projects dealing with "circular economy", energy transition (in particular energy efficiency and local renewable energy systems) and sustainable urban mobility.

<u>Transport</u>

- With the aim to finance the extension of the cycle path network, the municipality of Cesena is trying to access to Regional, National and European funding schemes. In particular city has already applied at the call for tender "Collegato ambientale" from the national Ministry of Environment (Ministero dell'Ambiente e della tutela del territorio e del mare). The tender includes the financing mechanism for implementing actions which promote green economy mechanisms and rational use of natural resources. The scheme co-finances the 60% of the awarded projects, up to a maximum of 1 million of Euro. No direct participation of the private sector is considered (expected) for this action.

European Fuds are available for sustainable mobility and intelligent transport systems:

- ERDF

Axis 4 of ROP-ERDF (2014-2020) plans to allocate 27 million Euros for urban areas in the following themes:

  - Action 1: implementation of the existing Regional Travel Planner - Integrated timetable information service of public transport in Emilia-Romagna with the aim of creating a dynamic Travel Planner covering all the possibilities for modal mobility;

- Action 2: development in urban areas of a system of tickets purchase on board of the local public transport (LPT) in contactless mode through the use of the credit card;
- Action 3: upgrading of the regional public transport stops on iron, in interchanges with the network by road, through the installation of monitors and video surveillance systems;
- Action 4: implementation of measures to encourage modal interchange at stops and vehicles of LPT;
- Upgrading the buses and trolley fleet with environmentally friendly vehicles;
- Bike paths, 30 km/h zones, traffic lowering, redevelopment of the LPT stops.

- CEF

The Connecting Europe Facility (CEF) supports trans-European networks and infrastructures in the sectors of transport, telecommunications and energy.

The CEF benefits people across all Member States, as it makes travel easier and more sustainable, it enhances Europe's energy security while enabling wider use of renewables, and it facilitates cross-border interaction between public administrations, businesses and citizens.

In addition to grants, the CEF offers financial support to projects through innovative financial instruments such as guarantees and project bonds. These instruments create significant leverage in their use of EU budget and act as a catalyst to attract further funding from the private sector and other public sector actors. Since January 2014, INEA is the gateway to funding under the CEF, it implements most of the CEF programme budget, in total €27.4 billion out of €30.4 billion (€22.4 billion for Transport, €4.7 billion for Energy, and €0.3 billion for Telecom).

- UIA

As stated in the previous paragraph, the UIA tool supports projects addressing sustainable mobility in urban areas.

Alongside the incentives, legislation on energy has been evolving as well, introducing new requirements or changing some provisions. Main changes regarding buildings and energy production are, for example:

- Legislative decree 102/2014: it establishes the duty for large companies to perform an energy audit by 5 December 2015 and every four years. Then, starting from July 2016 those auditing can be performed only by Energy service companies that are certified according to UNI CEI 11352 or by energy auditor, certified according to UNI CEI 11339. It also imposes the duty, by 31/12/2016, to install in apartment dwellings and in multi-purpose buildings with central heating, direct heat accounting and temperature control systems for single housing unit, or, if not technically or economically feasible, on each radiator of housing units.
- European Directive 2009/125/EC: aimed at reducing energy consumptions in the framework of the Kyoto Protocol, it provides, among other measures, that from September 26, 2015 only condensing boilers can be produced and supplied.
- Emilia-Romagna Region Council Resolution no. 967/2015: it approves the "regional technical coordination Act for the definition of minimum requirements of buildings energy performance ". The Act establishes minimum energy performance requirements to be met for the design and construction in the regional area of new buildings and for equipment installed on them, new systems which are going to be installed in existing buildings, interventions on existing buildings and plants. It then defines that, with effect from 1 January 2017, new public buildings should be "nearly to zero energy buildings", and with effect from 1 January 2019 this will be applied to all the other buildings. The regional timeline is earlier than expected by national legislation.
- Emilia Romagna Region Council Resolution no. 1715/2016: (in force since 11 March 2016) containing amendments to the Regional Council Resolution no. 967/2015. The resolution makes some changes to the previous legislation regarding minimum energy requirements on buildings performance.

4. Ten years implementation plan steps

The key characteristics of the actions included in the mid-term implementation energy plan for Cesena, fully described in the project deliverable 5.4 as part of an integrated sustainable strategy, are summarised in the following tables. Additional details on timing, resources and monitoring are also reported to make the plan as much detailed and applicable as possible.

ACTION.1.B – URBAN REGENERATION

General description:

Refurbishment of a medium-to-small share of the most energy-greedy existing building stock of the city with the following standards: 25% from class E to class B

To fully implement the actions in the cost-effective way, up to 7000 semidetached dwellings (built before 1980) are required to be retrofitted with external insulation on the roof and up to 3000 (built before 1980) replacing existing windows.

The municipality covers only the costs regarding urban regeneration projects on public buildings

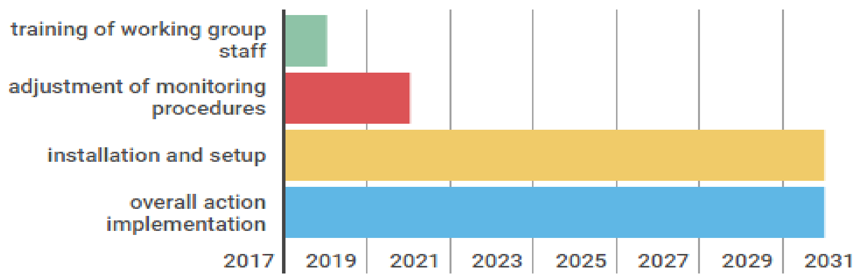
Energy savings in 2020:
39 TJ (useful energy)

Energy savings in 2030:
110 TJ (useful energy)

Overnight cost:
715 €/inhabitant

Reduced emission sources	
☐	Electricity (indirect)
☑	Methane
☑	Fuel oil
☑	Gasoline/DieselOil/Lpg

Incentive mechanisms	
☑	Retrofit tax relief
☑	Energy renovation tax relief
☑	Thermal Account
☑	Energy Efficiency Certificates



Responsible organisation/department:
Urban Planning and Private

Monitoring:
KPI: Variation of GHG emissions in residential buildings; Average household carbon intensity; Investment in Residential buildings measures; Zero Energy

Housing Department	Buildings **Monitoring frequency**: yearly **Data sources**: Urban Planning and Private Housing Department, Territorial Information System, Emilia Romagna Region. **Time schedule**: intermediate / further ahead

ACTION.5.A – INCREASE OF RENEWABLES (IN 2030)

General description:

Refurbishment of a medium-to-small share of the most energy-greedy existing building stock of the city with the following standards: 25% from class E to class B.

Around 5.3 MW of solar PV roof technologies (amorphous silicon) are suggested to be installed in the buildings by 2030, together with around 10 MW of solar water heaters in addition to the existing installed capacity.

Investments in supply sector (e.g. biogas micro-cogeneration) are also needed to fully meet the designed target. This cost will be covered by investments of the services sector and, in part, by Municipality projects

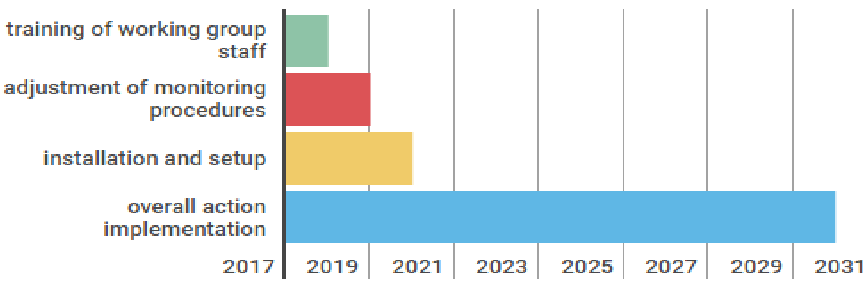
Generation in 2030 (household sector):
69 TJ

Overnight cost (household sector):
350 €/inhabitant

Extra investments are needed to supply CO_2-free energy into the system

Reduced emission sources	
☑	Electricity (indirect)
☑	Methane
☐	Fuel oil
☐	Gasoline/DieselOil/Lpg

Incentive mechanisms	
☑	Retrofit tax relief
☐	Energy renovation tax relief.
☐	Thermal Account
☑	Energy Efficiency Certificates



Responsible organisation/department: Energie per la Città Spa	**Monitoring:** **KPI**: Variation of FEC; FEC per capita; Share of green electricity in FEC; New PV Installed Capacity in roof tops; New Installed Capacity Other RES; New businesses related with energy services; New jobs created; **Monitoring frequency**: yearly

Data sources: TIS; Energy Service Manager; Environment Department; Energie per la Città Spa.
Time schedule: intermediate

ACTION.4.C – INFORMATION CAMPAIGN

General description:

Awareness raising campaign addressed to the citizenship, in order to promote information about further efforts on energy to be implemented, the viable incentive mechanisms and the development of new energy technologies. (Opening of an "Energy info point" where citizens can have information, educational labs on energy culture in schools and implementation of good energy-saving habits in public buildings).

Dissemination of the principles and duties at the base of the campaign "Clean Heat", relating to thermal plants in the Emilia-Romagna Region and that includes the analysis, at rates established according to the type of generator, of combustion products and of generator efficiency.

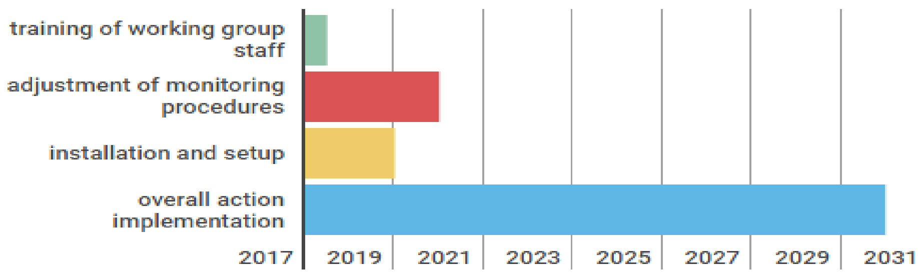
Cost is totally covered by the Municipality.

Investments in 2030:
To enable the rational behaviour of consumers and meet the goals (of scenario F)

Energy savings in 2030:
To enable the rational behaviour of consumers and meet the goals (of scenario F)

Overnight cost:
165 Euro/inhabitant

Reduced emission sources		Incentive mechanisms
☑	**Electricity (indirect)**	☐ Retrofit tax relief
☑	**Methane**	☐ Energy renovation tax relief
☑	**Fuel oil**	☐ Thermal Account
☑	**Gasoline/DieselOil/Lpg**	☐ Energy Efficiency Certificates



Responsible organisation/department:
Energie per la Città Spa

Monitoring:
KPI: Number of admission to the front office, satisfaction, distribution of questionnaires to monitor different aspects of energy (if needed).

Monitoring frequency: quarterly and yearly
Data sources: Energie per la Città Spa
Time schedule: immediate

ACTION.3.B – CYCLE PATHS

General description:

Completion of cycle paths (tot of 16 km) along the main road network and within the so-called "areas 30", to implement the use of the bicycle in the home-school and home-work trips.

Realization of "environmental" bicycle paths along the Savio river for cycling tourism and within the low population density areas (in particular zones 11-10-4-9).

Municipality is expected to cover 100% of the cost which will be possibly co-financed by the Ministry of Environment.

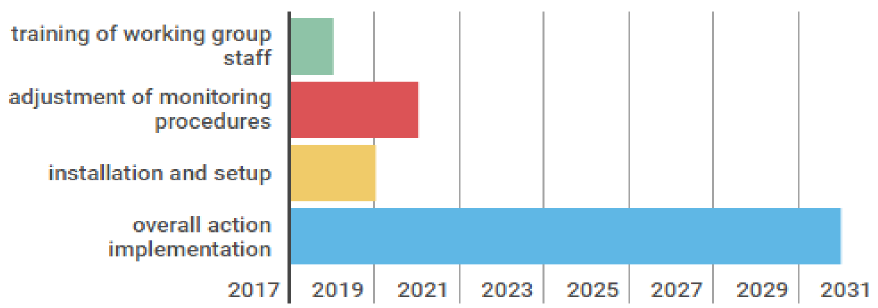
Private dependency in 2003:
-4%

Energy savings in 2030:
140 TJ

Overnight cost:
75 €/inhabitant

Reduced emission sources	
☐	Electricity (indirect)
☐	Methane
☐	Fuel oil
☑	Gasoline/DieselOil/Lpg

Incentive mechanisms	
☐	Retrofit tax relief
☐	Energy renovation tax relief.
☐	Thermal account
☐	Energy Efficiency Certificates



Responsible organisation/department:
Mobility and Transports Department

Monitoring:
KPI: Variation of FEC; Share of mobility in public transportation; Share of electricity in FEC; FEC per capita; Variation of GHG emissions in transport; Average vehicles carbon intensity; Investment in Transport measures; Extension of bike lanes; Public bikes; EV charging points
Monitoring frequency: yearly

Data sources: Mobility and Transport Department
Time schedule: intermediate

Conclusions / Acknowledgement

This document demonstrates the applicability (and strength) of the INSMART methodology for an integrated and participatory sustainable energy planning at city level, and in particular in accompanying the City of Cesena on a path towards a smart future to 2030.
Turning a regular city into an INSMART city is not simple. There are a lot of challenges and issues to be tackled: detecting reliable data sources, identifying the funding sources; defining the strategic plan; knowing the right benefits to the citizen and so on. Government entities are complex 'companies' – that is, a lot of people with different rules and responsibilities and with their own focus and problems. In order not to fall into the same old patterns of redundant initiatives and stand-alone or disconnected solutions, it is very important to have someone in the government responsible for the "whole" initiative who can use the City Vision as the City Roadmap.
The core of the INSMART multi-criteria approach is first of all, the municipality and the interdisciplinary working municipal group, who have interacted with other stakeholders, and experienced a new way of planning in an integrated manner to set smart energy solutions and policies.
The results contained in this Plan are just the starting point of a complex planning process that is expected to last long and evolve over time: the results of the analysis presented above depend on several factors such as the type of policies and measures included, the (quantitative) input parameters, the modelling details, and the level of participation of the stakeholders. Other assumptions and specifications may lead to different responses of the models.

The real challenge now is to try to create a dialogue on INSMART method with other sustainable planning tools at local level, strengthening data collection modes and the interaction between sectors of the territorial government.
In the case of the municipality of Cesena, the starting point will be sharing the INSMART method with the others five municipalities, which are part of the Union of Municipalities of Savio Valley since January 2015, as a concrete example of how to approach the concept of energy smart cities in the near future.
Furthermore, on 16 June 2016, the municipality of Cesena has signed the "Mayors Adapt" the new initiative promoted by the Covenant of Mayors to support local authorities in defining adaptation strategies to climate change at local level to 2030, in particular through improved energy efficiency and increased use of renewable energy sources. By signing the Mayors Adapt the Municipality of Cesena is committed to draw up within two years, the new Sustainable Energy and Climate Action Plan (SECAP), to design a set of policies and interventions that will integrate energy

policies and adaptation to increase the resilience of the territory. Within this framework, the INSMART method, is a unique opportunity to continue an integrated and participatory sustainable energy planning process at local level.

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Appendices

Appendix 1 – Reduction of heating needs by retrofit measure (R) and building typology (T)

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17
	Reduction of heating needs (%)																
R1	10%	17%	15%	1%	0%	9%	16%	1%	0%	24%	15%	0%	1%	29%	14%	0%	0%
R2	28%	3%	2%	2%	0%	8%	1%	1%	1%	2%	2%	1%	1%	4%	1%	1%	0%
R3	25%	26%	13%	15%	0%	18%	9%	12%	4%	12%	10%	14%	4%	12%	12%	16%	4%

Key: T1: Detached (Pre1945), T2: Detached (1946-1980), T3: Detached (1981-1990), T4: Detached (1991-2005), T5: Detached (2005-2011), T6: Semidetached (1946-1980), T7: Semidetached (1981-1990), T8: Semidetached (1991-2005), T9: Semidetached (2006-2011), T10: Terraced (1946-1980), T11: Terraced (1981-1990), T12: Terraced (1991-2005), T13: Terraced (2006-2011), T14: Apartment (1946-1980), T15: Apartment (1981-1990), T16: Apartment (1991-2005), T17: Apartment (2006-2011)

Appendix 2 – Time granularity of the energy system model of the city of Cesena

Time of day	**D1**	**D2**	**D3**	**D4**	**Year**	
Season	N. hours	N. hours	N. hours	N. hours	N. days	Start - End
S1	7	6	5	6	31	1 Jan - 31 Jan
S2	7	6	5	6	74	1 Feb - 15 Apr
S3	7	6	5	6	76	16 Apr–30Jun
S4	7	6	5	6	62	1 Jul - 31 Aug
S5	7	6	5	6	44	1 Sept - 14 Oct
S6	7	6	5	6	78	15 Oct - 31 Dec

Appendix 3 – Investment costs per dwelling (assumptions) by building typology and retrofit measure

Dwelling type / Retrofit type	Cost	Unit
Flats-R1	4000	Euro/dwellings
Flats-R2	600	Euro/dwellings
Flats-R3	2800	Euro/dwellings
Detached-R1	9000	Euro/dwellings
Detached-R2	2500	Euro/dwellings
Detached-R3	10500	Euro/dwellings
SemiDetached-R1	6000	Euro/dwellings

SemiDetached-R2	1700	Euro/dwellings
SemiDetached-R3	7000	Euro/dwellings
Terrace-R1	6000	Euro/dwellings
Terrace-R2	900	Euro/dwellings
Terrace-R3	4100	Euro/dwellings

Appendix 4 – Transport specific actions

Transport Action 1 (T1) – Two new tram routes

This scenario foresees a decrease in traffic of 15% in 2030 compared to the reference scenario in the areas adjacent to the Via Emilia street (zones 12, 14, 9, 5, 15, 1, 3) and Cervese street (Cesena's main streets), through the following actions:

1) the construction of 2 tram routes:

-> Along the Via Emilia street (zones 5, 15, 1, 3)

-> Along the Cervese street (zones 4, 14, 1, 15)

Each tramway provides 150 seats per trip with a frequency of 4-5 minutes and should move at least 10,000 people / day.

2) the creation of 3 new park and ride with a capacity of about 300-400 (free parking spaces).

The 3 new park will be built at the terminus of the new tram routes (in particular the zones 5, 3, 4).

	T1 – 2030				**Reference - 2030**		
Description	Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms		Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms
All Cars	241421	2147100	723571842		243458	2234571	753050787
Buses	2069	22129	7457939		2069	22129	7457939
Freight	9903	104583	35247530		9775	104417	35189858
Moto	41438	369756	124606085		41559	382498	128903388
Total	294831	2643568	890883396		296861	2743615	924601972

Transport Action 2 (T2) – New cycle routes

This measure, as part of the Alternative “A”, is described in the corresponding section.

Transport Action 3 (T3) – Car share and electric vehicles

This measure foresees the construction of 15 new stations electric car-sharing for a tot. of 500 electric vehicles. The new stations will be built within each INSMART zone. Below is the number of vehicles per INSMART zone: Zona1 (50), Zona 2 (50), Zona 3 (50), Zona 4 (30), Zona 5 (40), Zona 6 (10), Zona 7 (10), Zona 8 (30), Zona

9 (30), Zona 10 (30), Zona 11 (30), Zona 12 (30), Zona 13 (20), Zona 14 (50), Zona 15 (40).

The car-sharing system will be structured in such a way that users can choose not to use the car ownership. In addition, the electric vehicles will have access to the limited traffic zone and free parking.

	T3 - 2030				**Reference - 2030**		
Description	Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms		Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms
All Cars	243959	2238066	754228068		243458	2234571	753050787
Buses	2069	22129	7457939		2069	22129	7457939
Freight	9775	104417	35189858		9775	104417	35189858
Moto	40971	378401	127518345		41559	382498	128903388
Total	296774	2743013	924394210		296861	2743615	924601972

Transport Action 4 (T4) – Transport changes in the Northern sectors

This measure provides the reorganization of the road system in centuriation Cesena (zone 11-10-4-9), in particular through the reduction of speed to 30km / h from the current 50km / h of the following streets:
Via s.orsola, Via culverts, Via redichiaro, Via Marian, Via melona, Via parataglio, Via Montaletto, Via masiera, Via circle of s.martino, Via backhand, Via Targhini, Via border s.giorgio
Within the individual areas it is expected to create special one-way and the ban in driving except for residents and cycles.

	T4 – 2030				**Reference - 2030**		
Description	Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms		Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms
All Cars	221409	2228846	751120697		243458	2234571	753050787
Buses	2069	22129	7457939		2069	22129	7457939
Freight	9517	104596	35250639		9775	104417	35189858
Moto	37847	381984	128732707		41559	382498	128903388
Total	270842	2737555	922561982		296861	2743615	924601972

Transport ALL Actions (TS1+TS2+TS3+TS4) – All changes

This integrated measure aim to simulate all the above mentioned actions, together in the same scenario.

	TS1+TS2+TS3+TS4 - 2030				**Reference - 2030**		
Description	Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms		Daily Vehicle Demand	Daily Vehicle Kms	Annual Vehicle Kms
All Cars	205800	2059191	693947622		243458	2234571	753050787
Buses	2069	22129	7457939		2069	22129	7457939
Freight	10208	104778	35310309		9775	104417	35189858
Moto	34849	351702	118525062		41559	382498	128903388
Total	252926	2537800	855240932		296861	2743615	924601972