Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

Analysis of the city energy system –Nottingham

D-WP 4 – Deliverable D4.1

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Executive Summary	
This report refers to WP4 (Tasks 4.1. to 4.4.), including the analysis of the current status of urban spaces, water/sewage systems, waste chain and decentralised energy supply at the cities level.	
Keywords	Local Authority, Nottingham City Council, Waste Chain, Parks & Gardens, District Heating

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Acronyms and Definitions

CHP –Combined heat and power

GIS – Geographic information system

O&M – Operation and maintenance

PROMETHEE - Preference Ranking Organization Method for Enrichment of Evaluations

PV - Photovoltaic

RES – Renewable energy sources

TIMES – The Integrated MARKAL-EFOM System

1. Introduction

1.1. Overview of InSMART

The InSMART concept brings together cities, scientific and industrial organizations in order to establish and implement a comprehensive methodology for enhancing sustainable planning addressing the current and future city energy needs through an integrative and multidisciplinary planning approach.

InSMART project intends to identify the optimum mix of short, medium and long term measures for a sustainable energy future, addressing the efficiency of energy flows across various city sectors, namely buildings, transport and mobility. Urban spaces, water/sewage system, waste chain and decentralized energy supply.

Each city's energy system will be analysed, covering all relevant sectors and a comprehensive GIS platform including energy database will be developed. Apart from being a valuable planning tool, the GIS database will inform and be linked to the TIMES planning model. This model will be used to analyse the cost-optimal mix of measures required to meet sustainable energy targets taking into account exogenous parameters (*e.g.*, environmental targets, city expansion). These measures will be further assessed with respect to non-technical criteria using a multi-criteria decision making method (PROMETHEE) that will address economic, environmental as well as social issues.

A detailed economic analysis of the mid-term measures identified through this two stage optimisation procedure will be undertaken, identifying all relevant investment indicators. Finally, a detailed, realistic and applicable mid-term implementation plan will be developed to describe the necessary steps, required resources and monitoring procedures for each city.

1.2. Objectives of this Report

This report refers to WP4 (Tasks 4.1. to 4.4.), including the analysis of the current status of urban spaces, water/sewage systems, waste chain and decentralised energy supply at the cities level.

This report describes the relevant city sectors excluding Residential Buildings and Transports, already characterized and assessed in WP2 and WP3.

In a graph theory-like vision, surveys undertaken under the WP2 and WP3provide the description of "nodes" (demand centers), namely the quantification of the stocks of processes and technologies (e.g. buildings, space heating devices, vehicles) and characterization of energy services required in the selected geographical polygons of the urban area.
The goal of WP4 is to extend the analysis of the demand centers including relevant non-energy services, and to look at the "edges" (the physical networks linking

different demand centers and allowing the movements of energy, people and goods) and at the devices used to properly operate the urban infrastructures.

1.3. Outline of the Report

The report is organized in 7 chapters covering each specific theme that data was provided for.

Chapter 2 – City Districts Description

This chapter contains specific information and description about each individual ward within the Nottingham City Boundary

Chapter 3 – Urban Spaces

This chapter contains specific information on the over 30,000 public lighting system, and the associated energy use of green and open spaces within the Nottingham City Boundary

Chapter 4 – Water & Sewage Systems

This chapter is intended to contain information regarding the water and sewage distribution systems within Nottingham City Boundary. Due to the privatisation of water supply in the UK, no information was presented from the local water supply company

Chapter 5 – Waste Chain

This chapter contains specific information regarding the waste disposal streams within Nottingham City boundary, and the disposal centres outside of Nottingham City

Chapter 6 – Energy Supply System

This chapter contains information regarding the centralised and decentralised energy networks within Nottingham City boundary

Chapter 7 – Tertiary Sector

This chapter contains information regarding the energy consumption of local authority buildings controlled by Nottingham City Council

2. City Districts General Description

This section presents a brief description of the city of Nottingham regarding the spatial sectors (or districts) that were previously selected for the buildings and transport surveys and assessment. These districts will be used within report as one of the spatial layers for the description of the other energy consuming sectors (described in the next sections) and later on in the integrative modelling in WP5.

Nottingham has 20 wards which are the political administration districts for the City of Nottingham. Data for this report has been produced for ward level analysis. Ward level can be drilled down further to lower super output areas, but the data required for this report is not available.

In table 2.1 data included is the population as per 2011 UK census, the number of buildings are the buildings which data has been provided for as part of this report; the area is the square kilometres.

Table 2.1: Nottingham City Wards

Wards	Population	Number of buildings	Area
Aspley	17,700	8	2.82
Arboretum	14,188	8	1.75
Basford	16,394	9	3.78
Berridge	18,986	9	2.46
Bestwood	16,990	17	2.94
Bilborough	16,957	18	5.19
Bridge	15,311	38	4.53
Bulwell	16,052	24	5.36
Bulwell Forest	13,547	8	3.31
Clifton North	13,574	9	4.60
Clifton South	13,728	11	4.35
Dales	16,563	16	5.15
Dunkirk & Lenton	11,466	10	5.21
Leen Valley	10,966	13	3.04
Mapperley	15,585	11	3.61

Radford & Park	22,484	21	2.41
Sherwood	15,425	10	3.19
St Anns	19,600	21	2.54
Wollaton East & Lenton Abbey	10,407	0	2.88
Wollaton West	14,828	9	5.54

Significant buildings in that ward as which we do not have the energy data for are

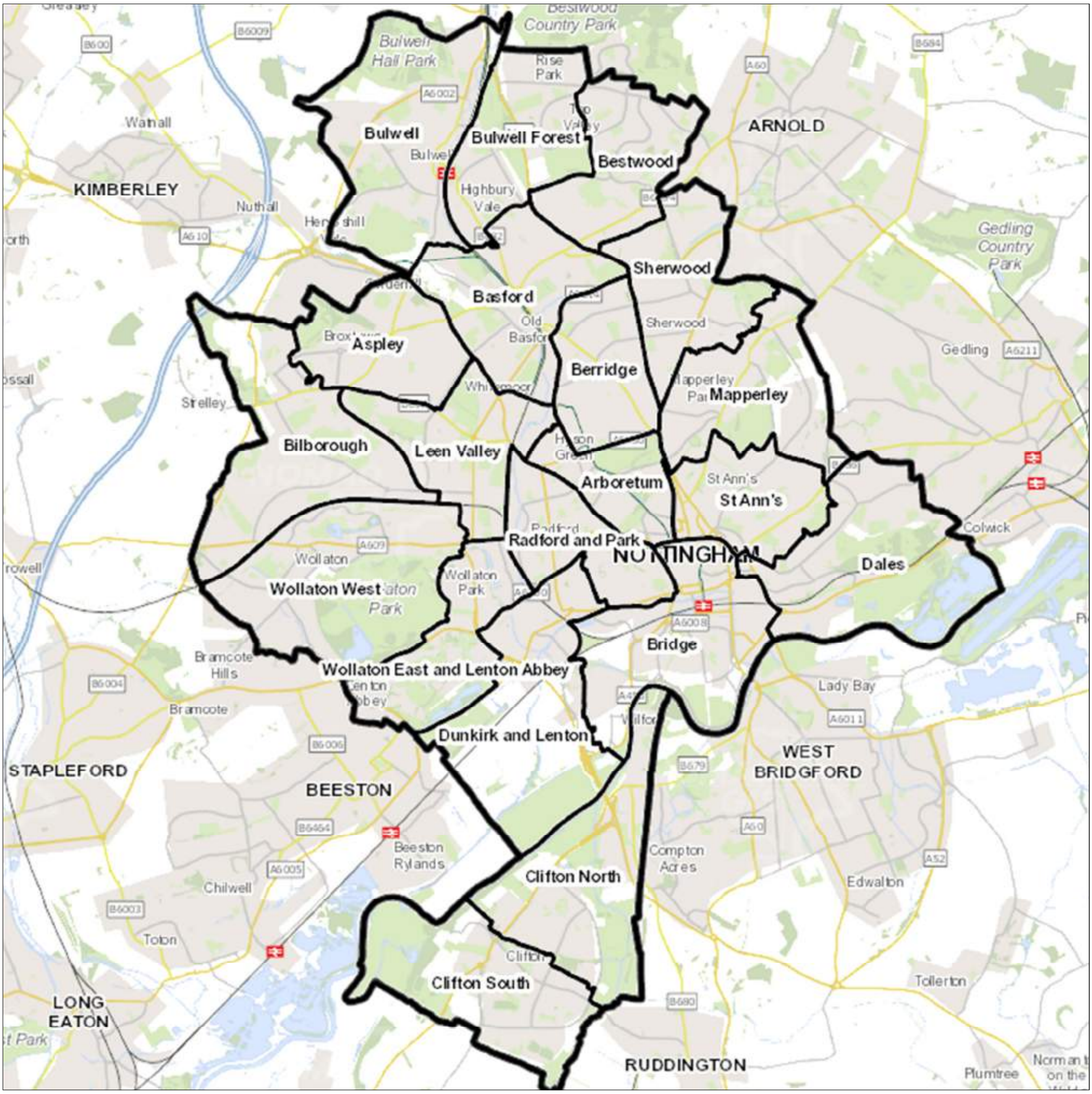
Bridge: City Centre, also includes Broad Marsh Shopping Centre, Nottingham Railway Station, Waste Incinerator, District Heating Plant, and Notts County FC Sports Stadium

Dunkirk & Lenton: Queens Medical Centre

Sherwood: Nottingham City Hospital

St Anns: Victoria Shopping Centre

Figure 2.1: Map of the city of Nottingham outlining the wards within the City.



3. Urban Spaces

3.1 Public Lighting

Characterization

Nottingham City has over 30,000 street lighting points. In 2010 Nottingham entered into a private finance initiative (PFI) to improve and upgrade and replace every street light / column in the city.

In this sub section a generic characterization of the public lighting system in the city and per district is provided, including data on:

Table 3.1 Street Lighting Columns by Ward

Ward	Number of Street Lighting Columns
Arboretum	1,399
Aspley	1,299
Basford	1,768
Berridge	1,474
Bestwood	1,971
Bilborough	1,901
Bridge	2,911
Bulwell	2,669
Bulwell Forest	1,686
Clifton North	1,269
Clifton South	1,369
Dales	1,752
Dunkirk & Lenton	1,005
Leen Valley	1,138
Mapperley	1,652
Radford & Park	1,482
Sherwood	1,593
St Anns	2,660
Wollaton East & Lenton Abbey	518
Wollaton West	1,298

Table 3.1.2 Number of masts / luminaries & lamp characterization

Number of masts	33,082		
Number of luminaries	33,304		
Lamp Characterization			
Lamp Type	Number	Age from	Age to
CDMT	63	6 months	2.9 years
CDM-T Elite	16	6 months	2.1 years
Cosmo Extreme	2		2 years
Cosmo White	23,988	1 month	3.9 years
LED	58		1.4 years
MBFU	2		1.4 years
PL	2		6 months
PL-L	134		3.1 years
SON	436		3.5 years
SON - E	45		3.7 years
SON - I	4		1.2 years
SON - T	8110		4.1 years
SOX	22		3.5 years

Table 3.1.3 Operation control system

Gear Type	Number	Max Watts Used
Compact High Frequency Electronic 4 pin	3	36
Electronic DALI Xt Full power	988	267
Electronic -DV DALI Xt TMWe full power	9	225
Electronic DV-Xt Full Power	5,757	159
Electronic Extreme DALI full power	9,928	153
Electronic Gine 2.2 ECO156 740 N/White-ECO166 657 C/White	5	139
Electronic Gine GRN136	8	147

W/White 3LKm 830		
Electronic HF-R TD full power	133	38
Electronic HID-DV DALI Xt R1.6 full power	13,967	50
Electronic HID-PV full power	58	157
Electronic HID-PV White full power	8	51
Electronic HID-PV Xtreme full power	17	67
Electronic LMIDD HID	2	109
Electronic M/Luma M1A C/White 7-N/White 6.6-Luma 1 C/White 7.4-N/White 6.6-Luma 2A N/White 6.8KLm	6	46
Electronic PL-L S/G single lamp circuit	1	33
Low Loss	289	190
Standard	1902	449

Figure 3.1 GIS Map of Street Lighting Points

Nottingham City Council has an on-going PFI contract to replace its street lighting stock. During the first five years of the contract (running from September 2010 to August 2015 and referred to as the Core Investment Period), there will be significant changes to the lighting in the city. During this Core Investment Period, most of the ageing outdated street lighting columns in Nottingham will be replaced. There will still be one third of the columns in the city that will not need replacing as they are already of an acceptable standard which will be subject to a lantern conversion. Some technical changes will be made to improve the quality of light in residential areas, for example, outdated yellow lights will be replaced by better quality white lights. The white light source will be installed in all residential areas which will improve colour recognition; the contract is expected to save an additional 2 million kWh over the present consumption data of 14.1 kWh. The contract has already seen reductions of over 4 million kWh since the financial year 2007-08

3.2 Gardens/green areas and public fountains

Characterization

There are 136 parks and gardens in Nottingham City. Not all parks have an energy usage. Our parks do not have sub meters installed, so specific usage for different activities at each park are not available for this study. The consumption figures given are for all activities on site. Whilst there are a number of parks and gardens which have fountains installed, these are not currently in use, and there are no plans to start using them in the mid to long term future.

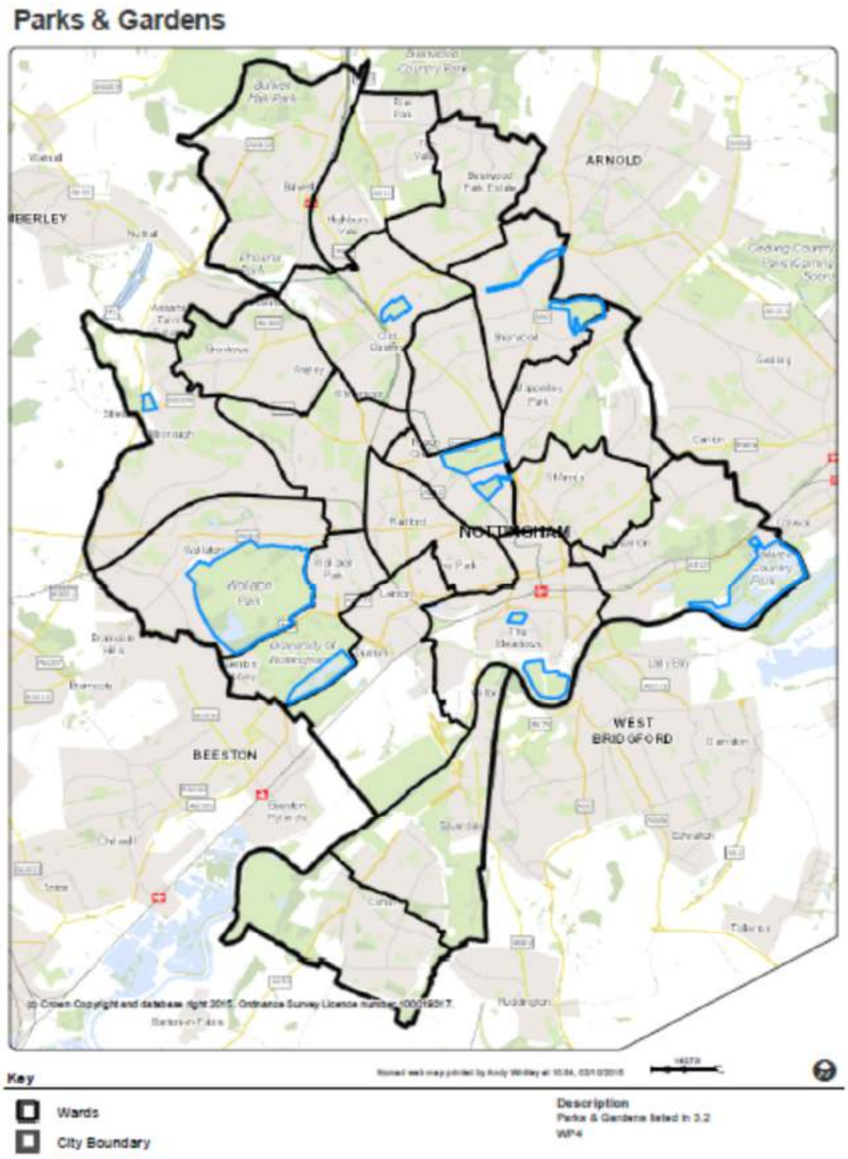
Table 3.2.1 Gardens & Green Areas

Ward	Park / Garden	Square Meters	Irrigation Methods	Facilities
Arboretum	Arboretum	1,552	By hand	Aviary Bandstand Public Toilets Fountain (not in use)
Arboretum	Forest Recreation Ground	2,487	By hand	Café Fountain (not in use)
Basford	Vernon Road Park	1,364	By hand	Pavilion
Bilborough	Strelley Road Park	811	By hand	Pavilion
Bridge	Meadows Bowling Green		By hand	Pavilion
Bridge	Victoria Embankment	2292	By hand	Pavilion Café Memorial Gardens & Park Paddling Pool Fountain (not in use)

Dales	Colwick Country Park	4,594	Not required	
Sherwood	Valley Road Tennis Courts	1,393	By hand	Pavilion
Sherwood	Valley Road Park	1,743	Not required	Pavilion Wet Meadows
Sherwood	Woodthorpe Park	2,822	By hand	Café Electricity use at this site also includes IT servers which are located here, but not sub-metered
Wollaton East & Lenton Abbey	Highfields	2,607	By hand	Café Boating lake
Wollaton West	Wollaton Park	6,548	By hand	Hall Café Shop Lake

The current energy efficiency / energy consumption policies in place for parks is the corporate target of Nottingham City Council to reduce carbon emissions by 31% by 2016, and then 45% by 2020 from a 2007 baseline. Recently a Building Management System upgrade has been carried out at Wollaton Hall, at present however there are no plans to upgrade any parks, as these are not major users of energy within Nottingham City Councils assets.

Figure 3.2.1 GIS Map of Parks and Gardens in Nottingham



Future Plans

There only plans in place is for a major refurbishment of Victoria Embankment, which would include refurbishments to the pavilions, café, and bandstands, these are early plans, and no other data is currently available

4. Water and Sewage Systems

4.1 Water Treatment and Distribution Systems

Due to the way that water is supplied in the UK,, each region has a commercial organisation which supplies and treats water. For the City of Nottingham, our regional supplier is Severn Trent Water Ltd. Unfortunately despite negotiation, Severn Trent Water Ltd have been unwilling to provide the data required to complete this section, and therefore no data is available.

The UK uses on average 150 litres of water per day. However energy associated with water pumping in the UK is not as significant as a Southern European climate, due to the relatively high climate in the UK, and the reduced need for pumping.

5. Waste Chain

Characterization

The majority of the City of Nottingham's waste chain is disposed of via incineration for the city's district heating network. There are four main sites that our waste is disposed to

Table 5.1 Waste Receiving Site

Ward	Site	Year of Construction	Waste Treated	Other Las waste treated	Tonnage & % of total waste
Bridge	Incinerator	1972	Household & Commercial Waste	Yes	83,157 (54%)
Outside City	Recycling Centre	1998	Household & Commercial Waste	No, Nottingham City Council only	41,064 (28%)
Outside City	Green Waste Processing	2007	Green Organic waste	Yes	13,489 (9%)
Outside City	Landfill	1997	Household & Commercial Waste (when Incinerator is unavailable)	Yes	15,021 (9%)

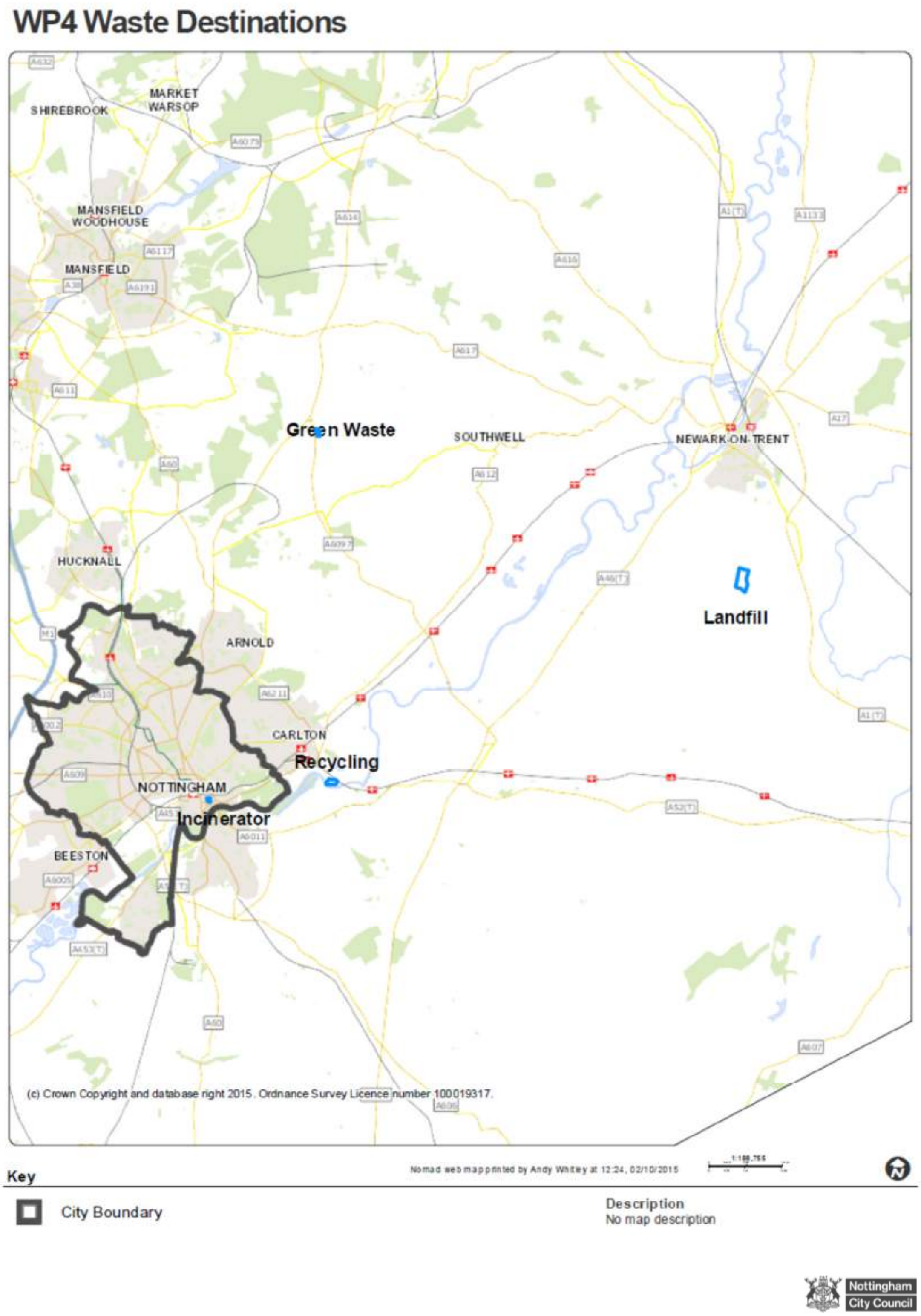
Table 5.2 Waste Fleet

Vehicle Type	Number of vehicles	Gross Vehicle Weight (tonnage)	Capacity (tonnage)
2.8 tonne	1	2.8	
3.3 tonne	1	3.2	
3.5 tonne	2	3.5	
7.5 tonne	3	7.5	
18	6	18	

26 tonne	28	26	11
18 tonne skip loader	2	18	5
32 tonne	14	32	11

The total number of miles covered by our waste fleet for 2014/15 was 685,000 miles

Figure 5.1 GIS Map Waste Destinations



Future Plans

City of Nottingham's Municipal Waste Management Strategy 2010-2030 (MWMS) seeks to develop a waste less society for the City of Nottingham. Here are five key actions.

- To produce the lowest amount of household waste per person of any Core City in England
- To increase the amount of reuse and recycling from just over a third of our waste at present to the majority of household waste (55%+)
- To transform the management of trade waste and other (non household) wastes by providing new services and infrastructure to reduce, recycle and recover energy
- To save an additional 3-6000 tonnes of carbon dioxide per year by recovering resources and energy from waste, saving about 16-19,000 tonnes of carbon
- To recover around 47kWh of energy from waste using the Energy from Waste Plant, and other recovery technologies

There are a number of key performance indicators for Nottingham

- Number of tonnes of household waste per person = 0.36tonnes per person
- Number of tonnes of recycled waste per person = 0.17 tonnes per person
- To reduce number of litres of fuel used for household waste collection = 37,000 litres per month

6 Energy Supply System

Characterization

The City of Nottingham has 3 primary energy networks, being the national grid for electricity and natural gas, and a decentralised district heating network of 68 km covering the Bridge and St Ann's wards.

The city also has an accelerated programme of PV installs, and the local authority has invested in installs on social housing

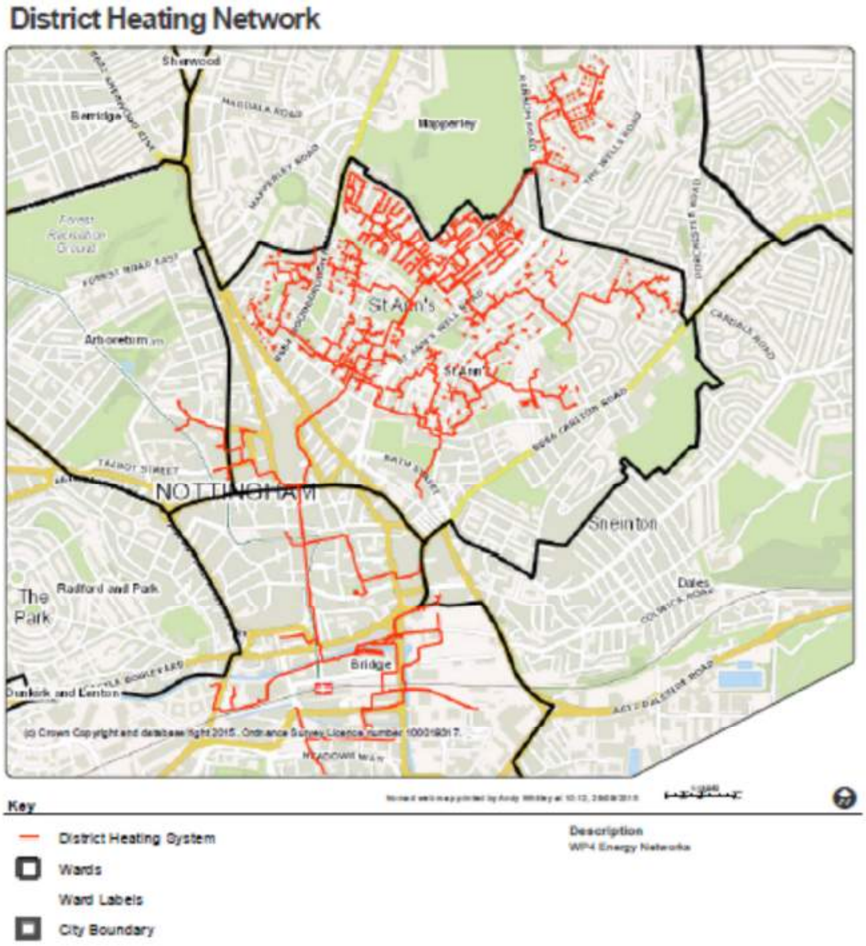
Table 6.1 City of Nottingham Energy Supply Networks

Supply Type	Number of Domestic Properties	Consumption	Installed Capacity
Electricity (National Grid)	130,618	487 gWh	n/a
Natural Gas (National Grid)	114,795	1,488 gWh	n/a
District Heating (Est 1972) (connected to waste Incinerator)	4,700	4 gWh	60 gWh

Table 6.2 City of Nottingham Renewable Energy Supply

Technology	Number Installed	Installed Capacity	
PV	4157	12.071 gWh	
Solar Water	18	0.034 gWh	
Heat Pump	-	0.77 gWh	
CHP	6	580 gWh	

Figure 6.1 City of Nottingham District Heating Network



A list of the relevant GIS maps should be presented. Pictures portraying the location of the different facilities by technology should be included here. The location of energy storage facilities and natural gas, electricity and district heating spatial coverage should also be shown.

Future Plans

As part of the City of Nottingham's commitment to the Covenant of Mayors we produced a study in 2011 of the maximum potentials by 2021 for renewable generation capacity across a number of renewable technologies. This study produced the following results:

Table 6.3 Maximum Potentials by 2021

Technology	Maximum Potential
CHP Biomass (wood fuel)	3.146 MWe
Waste heat from power station	15.32 MWth
Wind	8.55 MWe
PV	200.7 MWe
Solar Thermal	37.4 MWth
Ground Source Heat Pumps Domestic	150 installs

The UK government policy has recently shifted with regards to incentives for renewable energy technologies, and therefore plans for continued investment and installs in Nottingham are currently under review

7 Tertiary Sector

7.1 Buildings managed by the Municipality

Characterization

The City Of Nottingham has over 300 property assets which are connected to the national grid for Electricity and the national grid for Natural Gas or District Heating

Table 7.1 – City of Nottingham Owned Building Types

Property Type	Number of Buildings
Schools	87
Museums / Concert Halls / Libraries	22
Leisure Centres	9
Offices	29
Other Buildings	128

Table 7.2 Energy Consumption of Local Authority Buildings (2013)

Energy Type	Consumption (kWh)	Number of Buildings
Electricity	30,900,000	428
Natural Gas*	49,900,000	154
District Heating*	14,000,000	16

*Natural Gas and District Heating has NOT been weather corrected

Figure 7.1 – Arboretum Ward

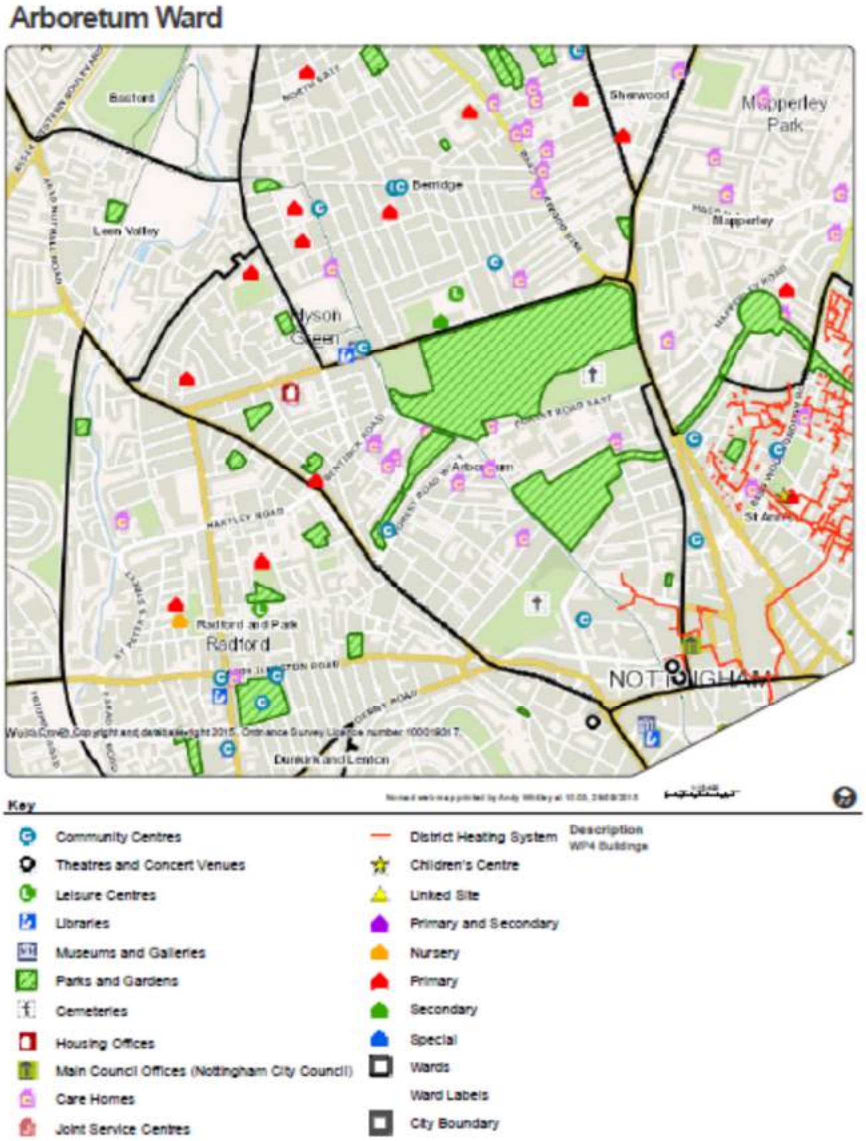


Figure 7.2 Aspley Ward

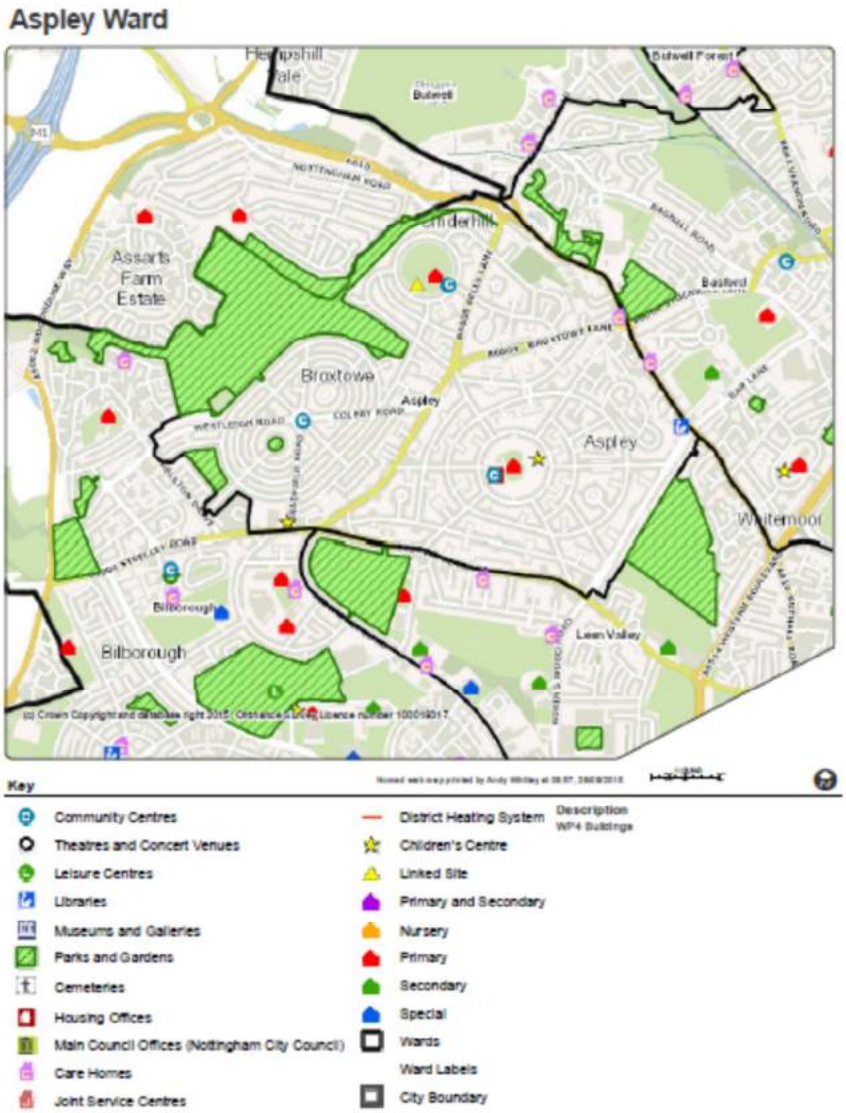


Figure 7.3 Basford Ward

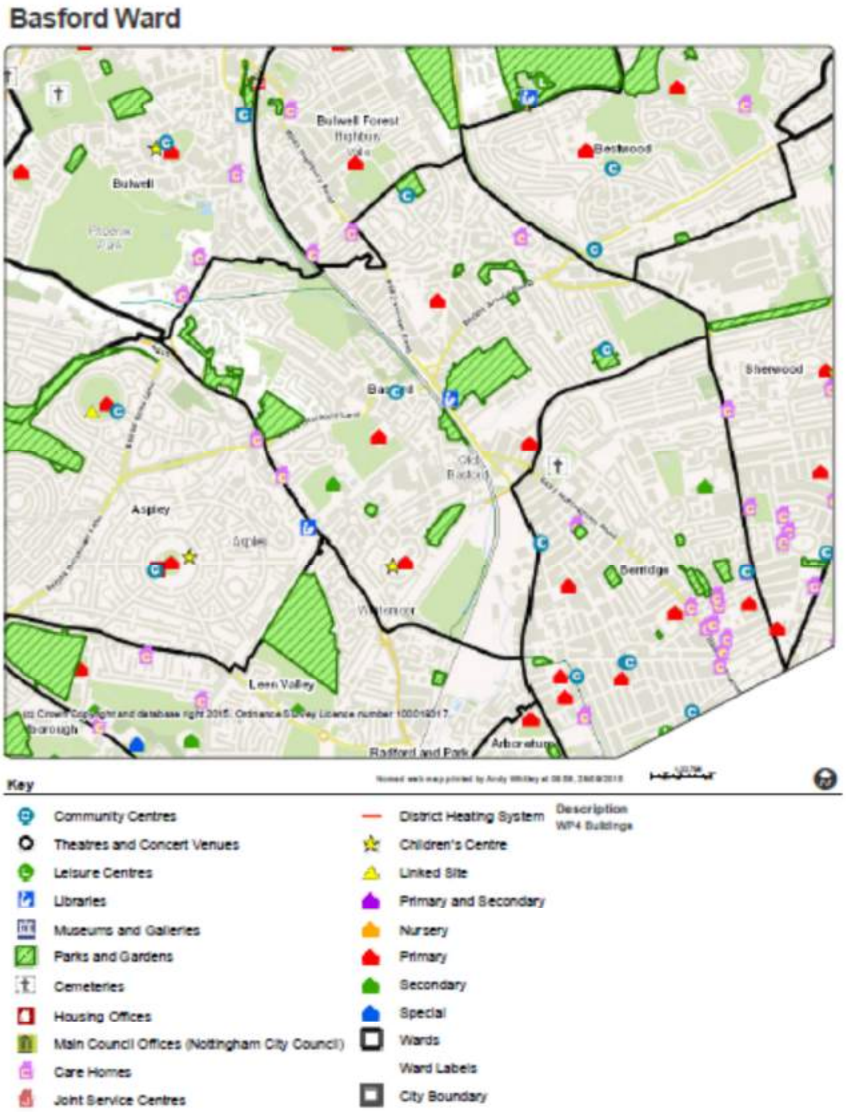


Figure 7.4 Berridge Ward

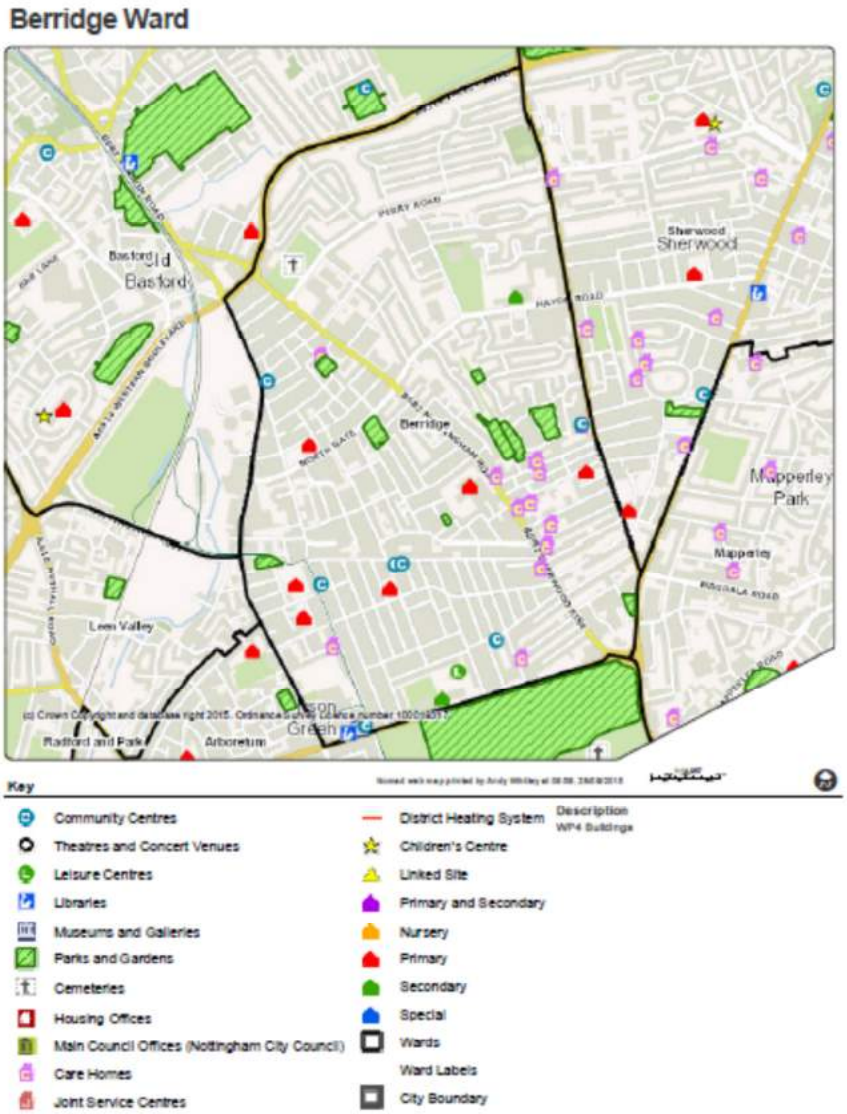


Figure 7.5 Bestwood Ward

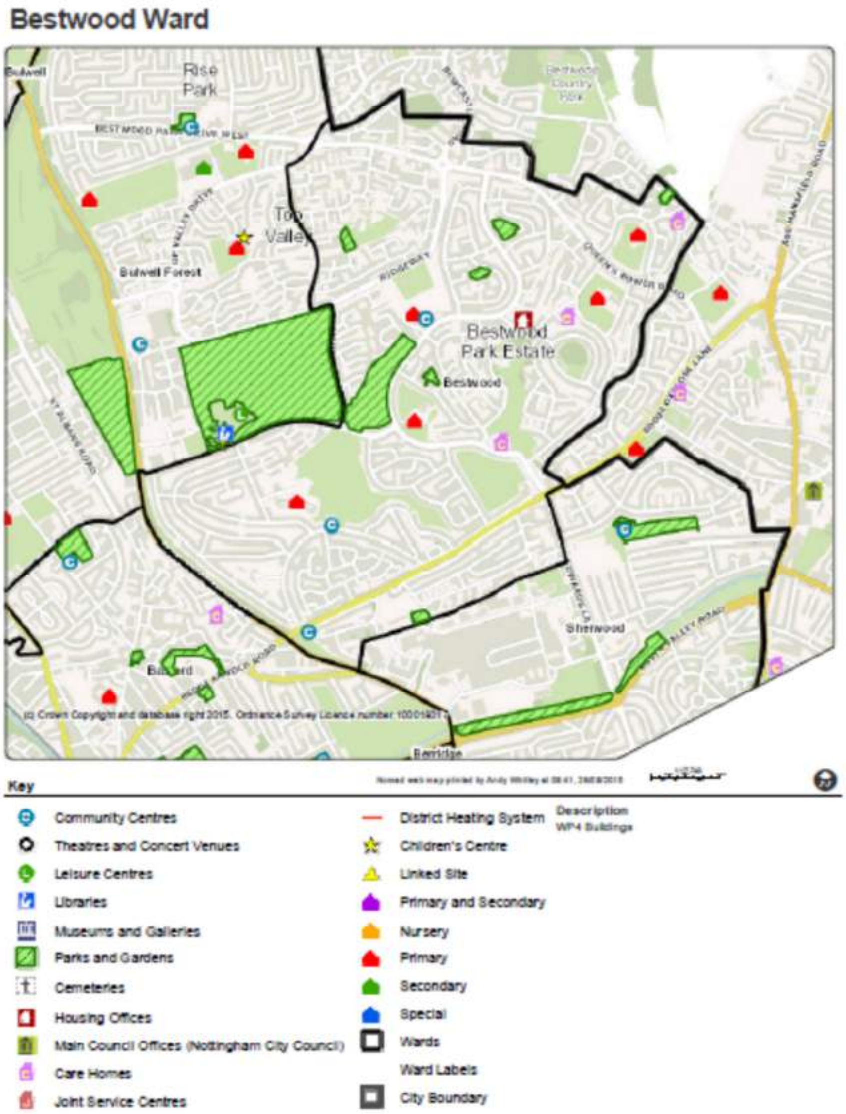


Figure 7.6 Bilborough Ward

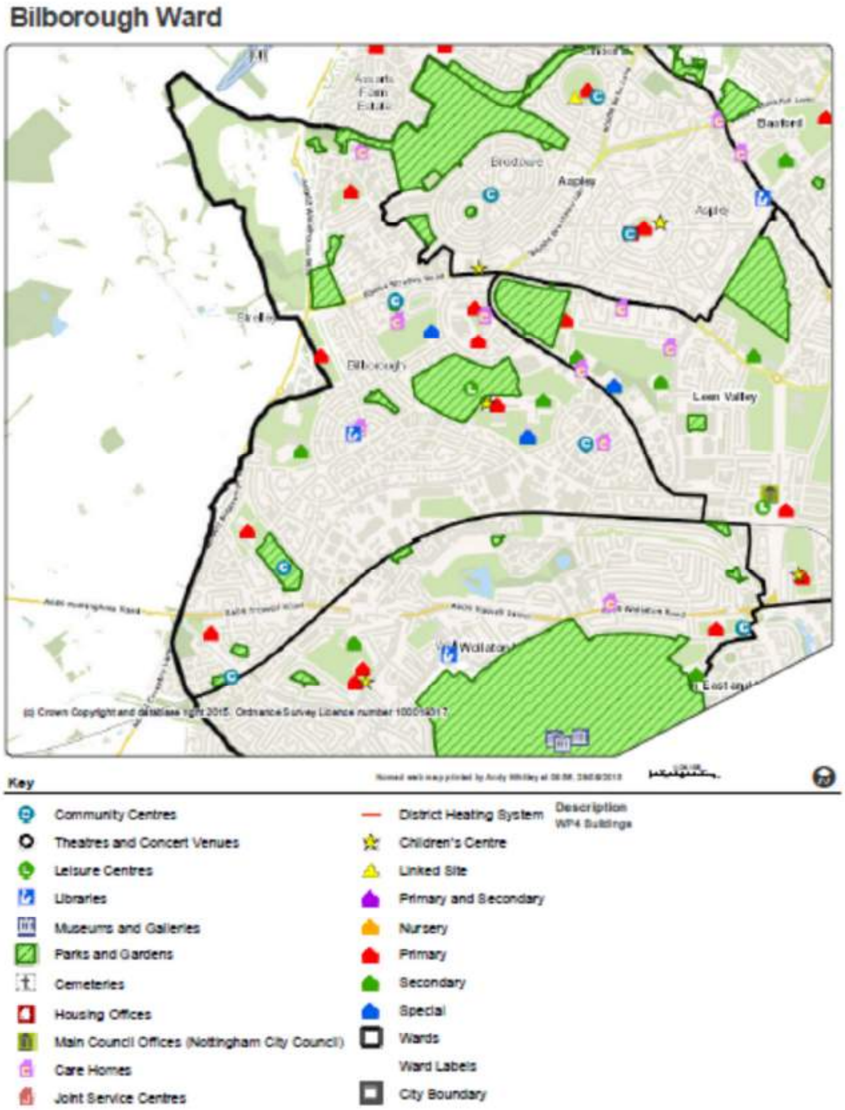


Figure 7.7 Bridge Ward

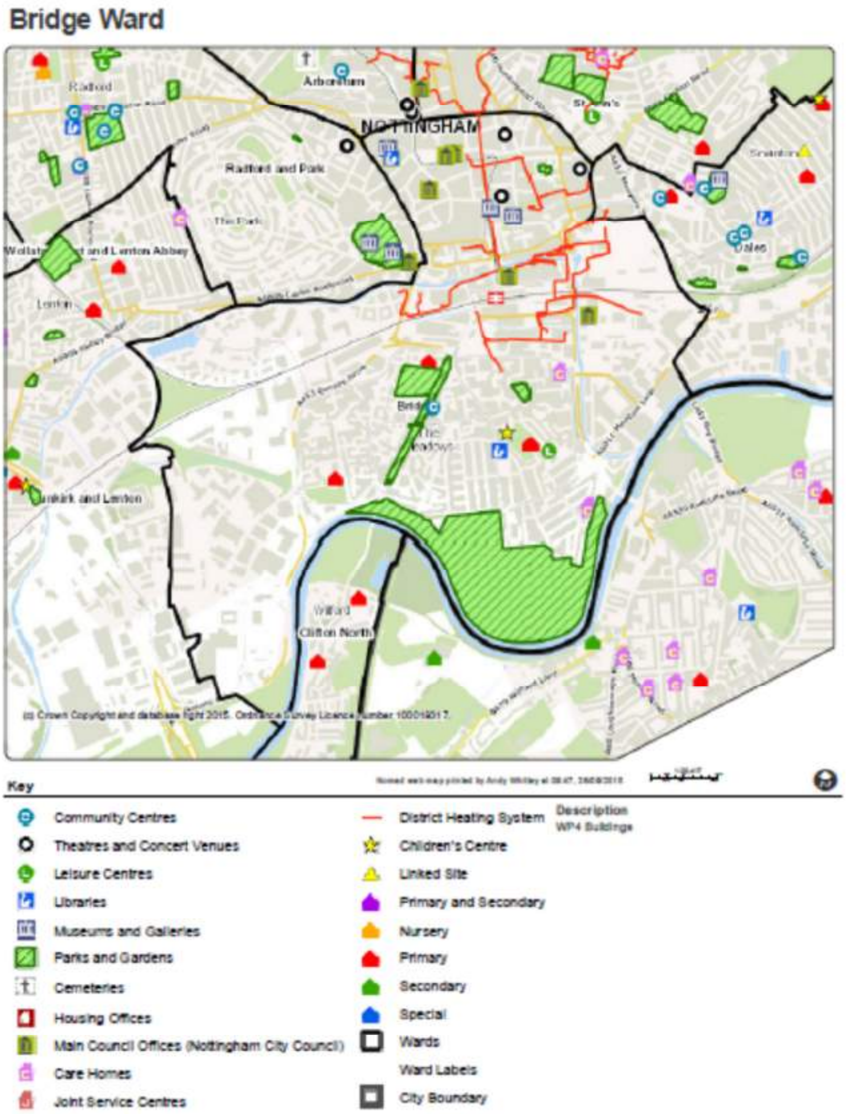


Figure 7.8 Bulwell Forest Ward

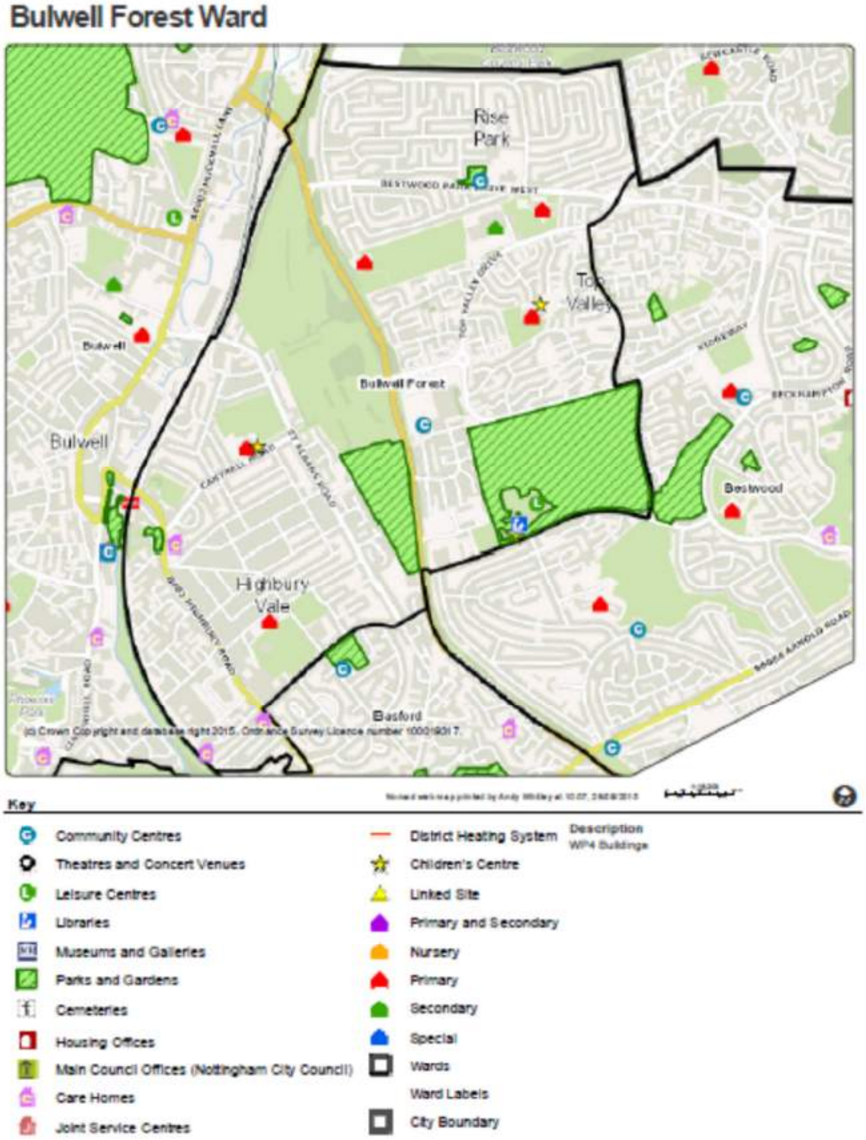


Figure 7.9 Bulwell Ward

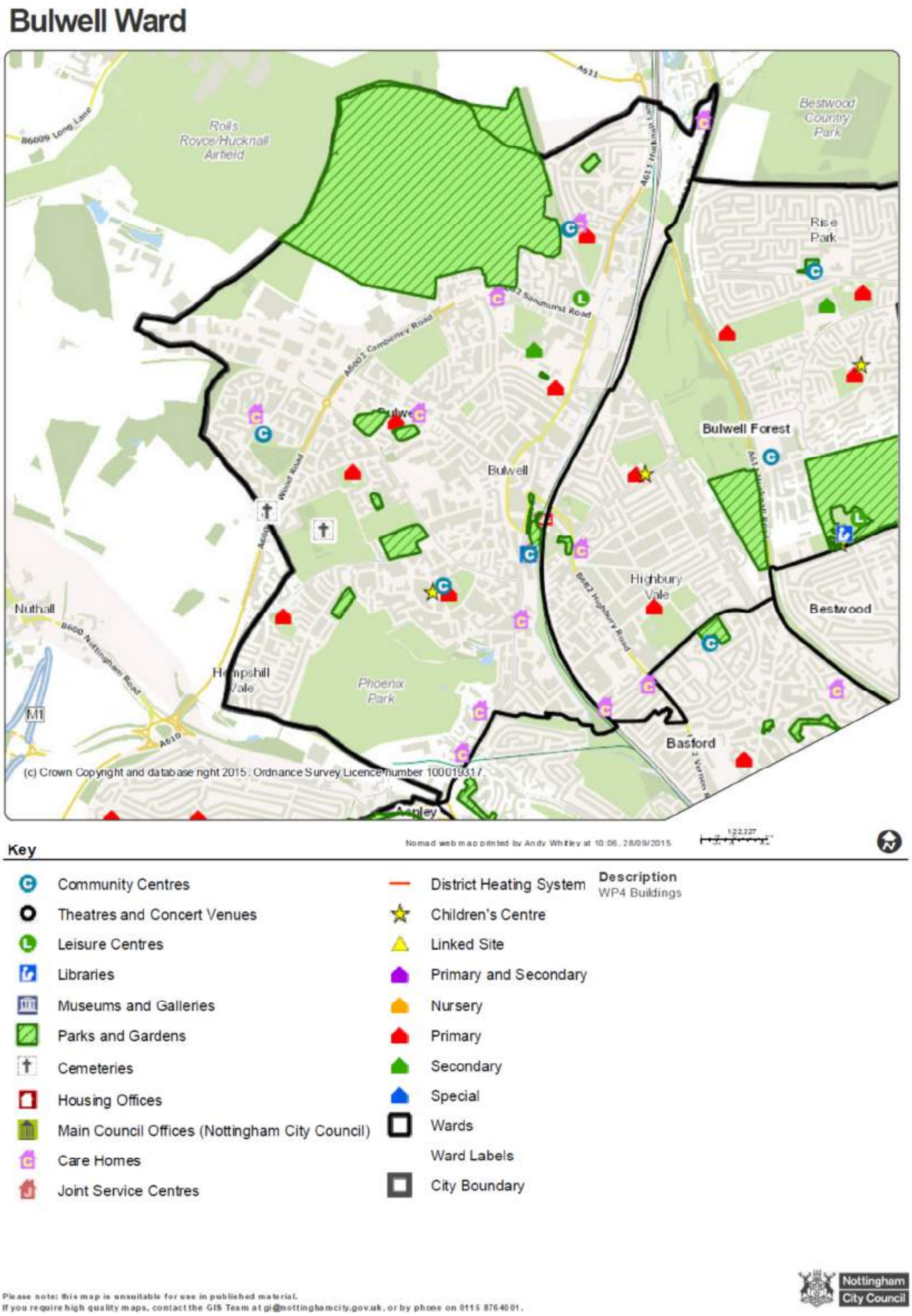


Figure 7.10 Clifton North Ward

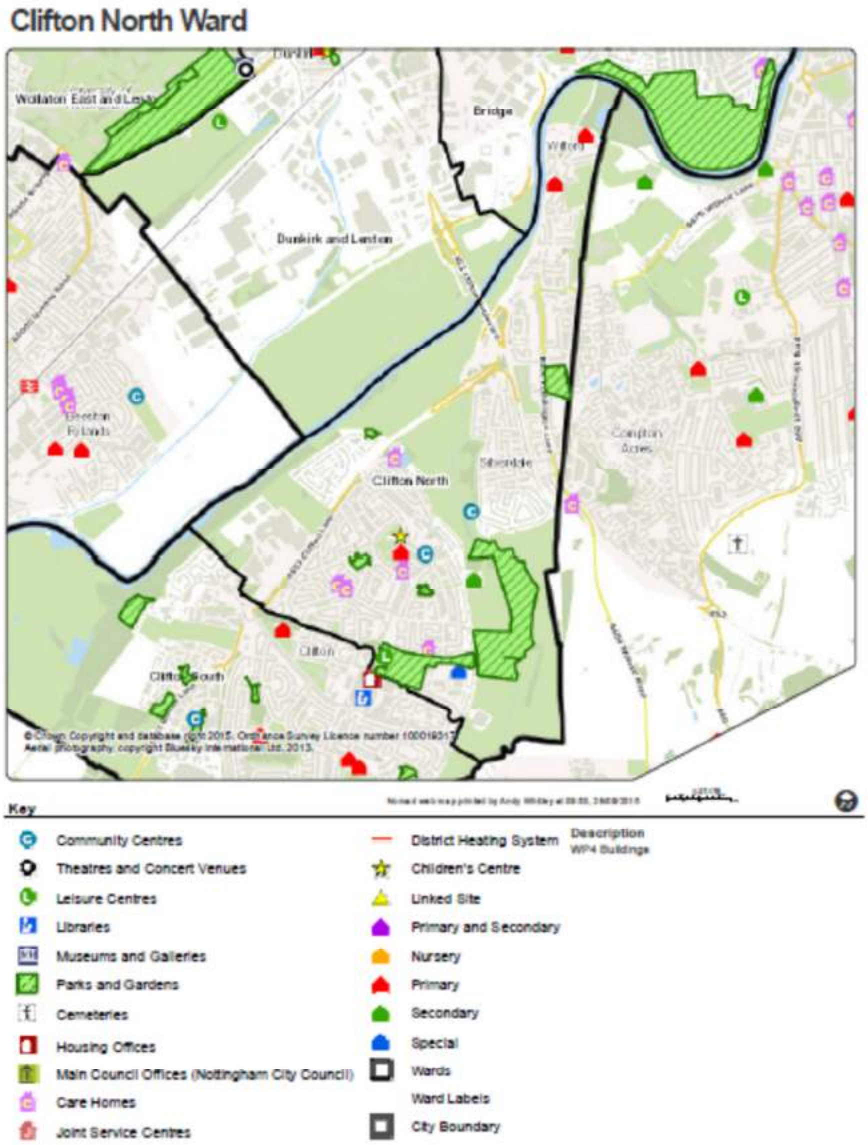


Figure 7.11 Clifton South Ward

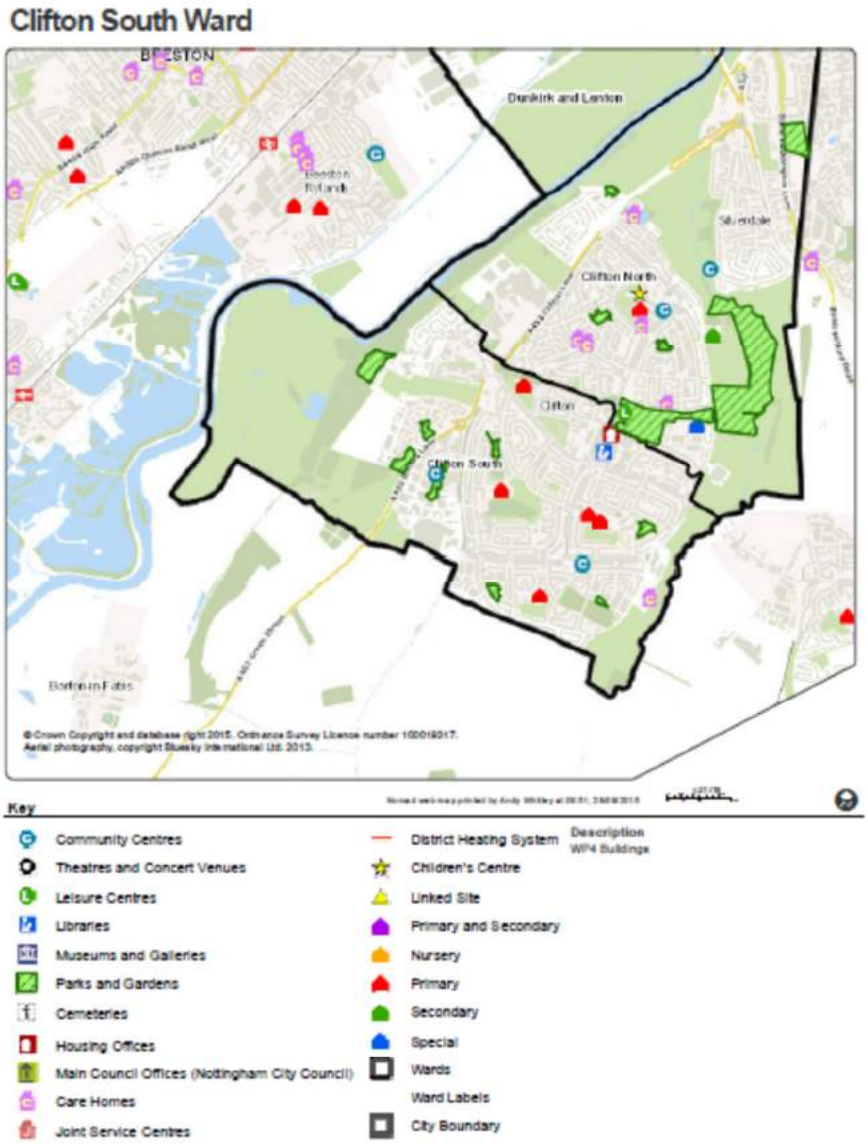


Figure 7.12 Dales

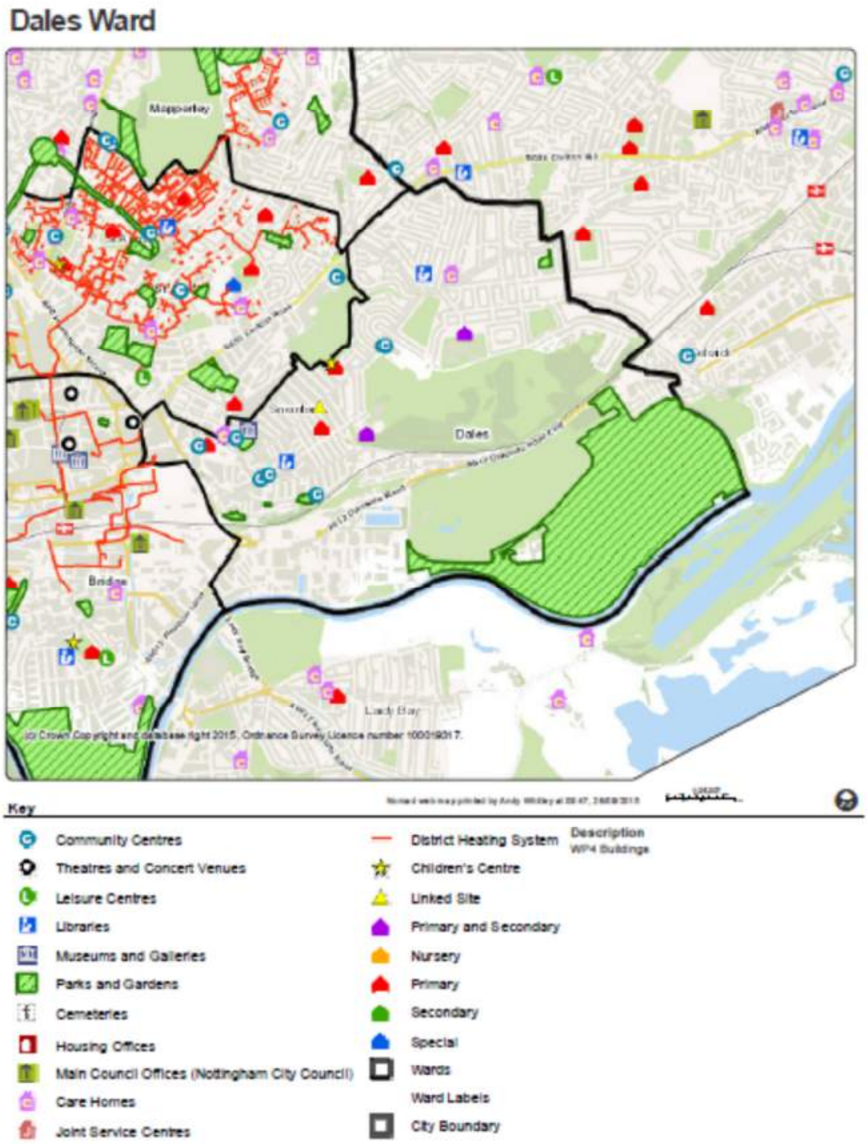
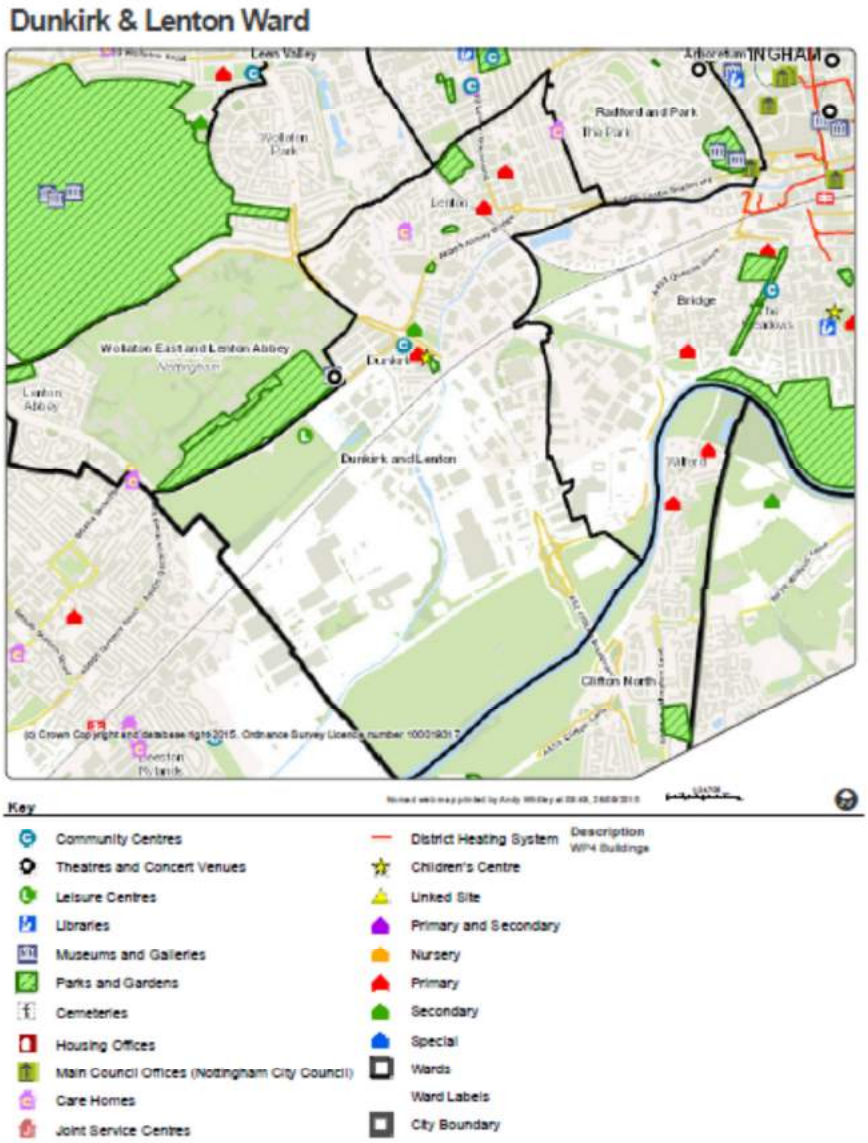
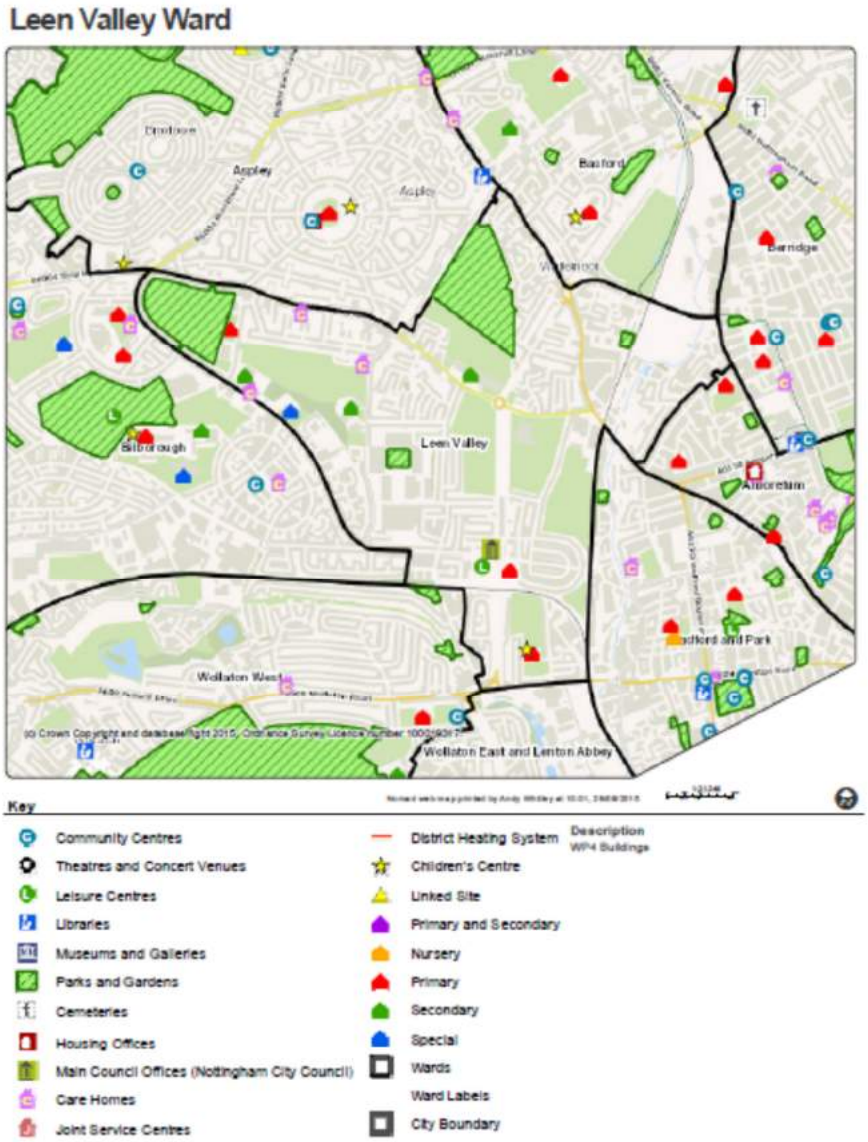


Figure 7.13 Dunkirk & Lenton Ward

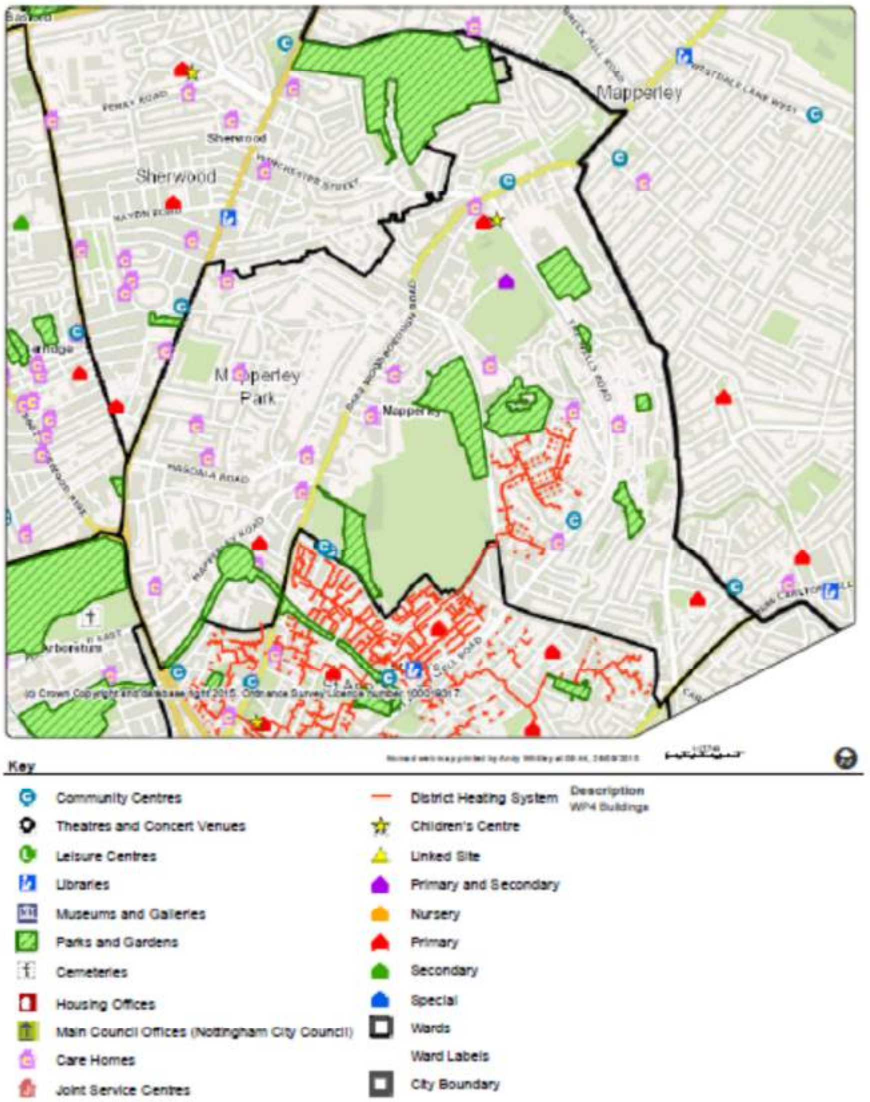


7.14 Leen Valley Ward

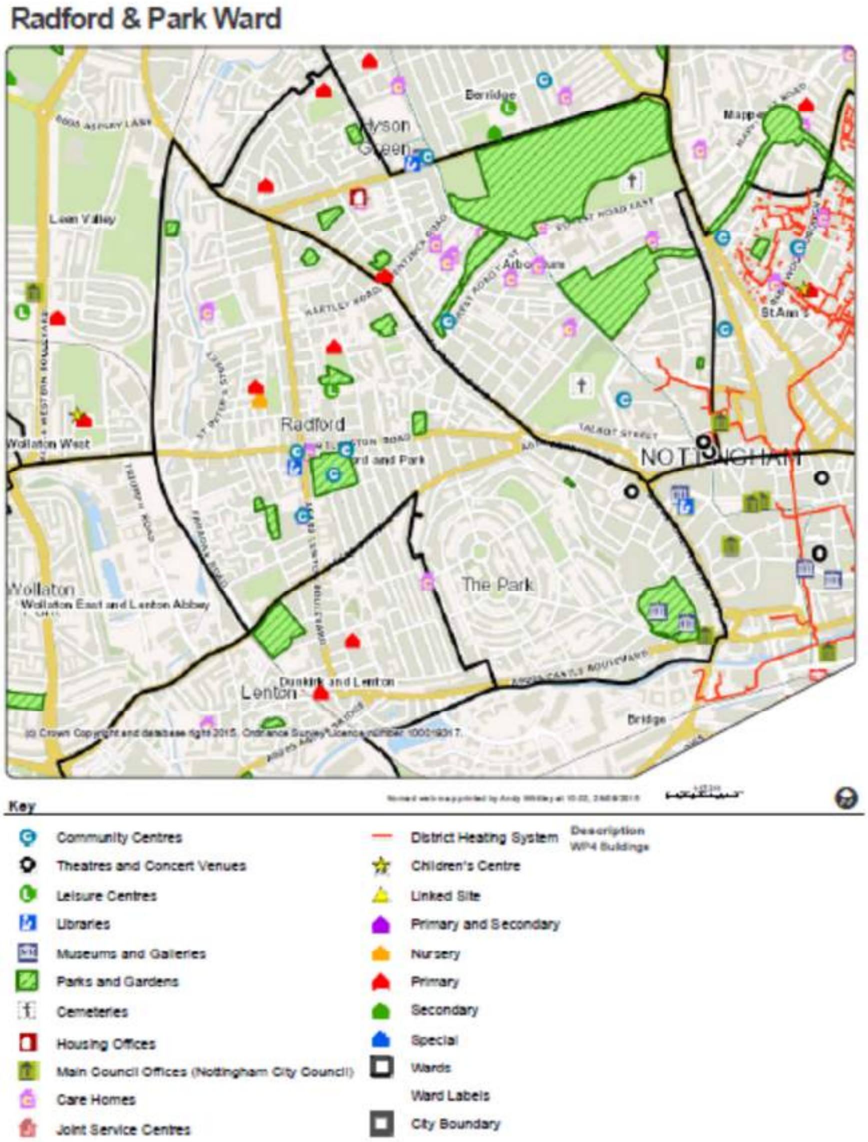


7.15 Mapperley Ward

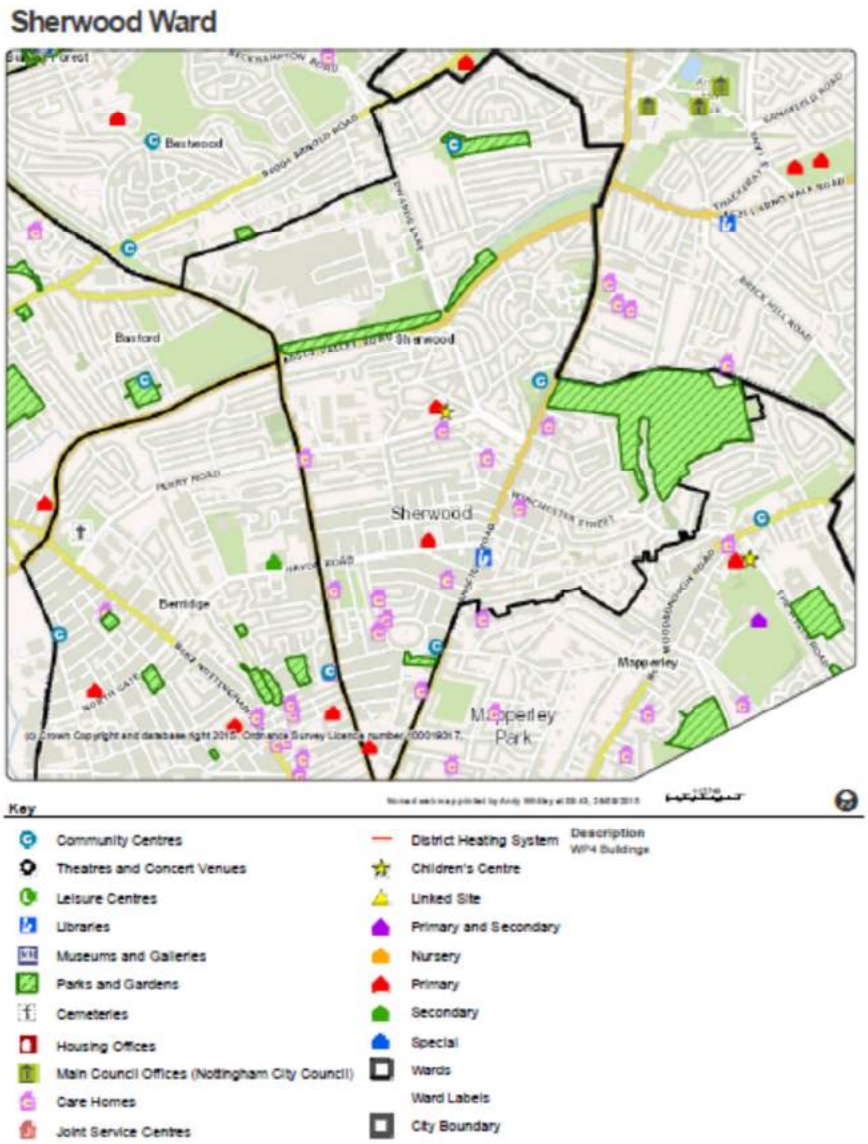
Mapperley Ward



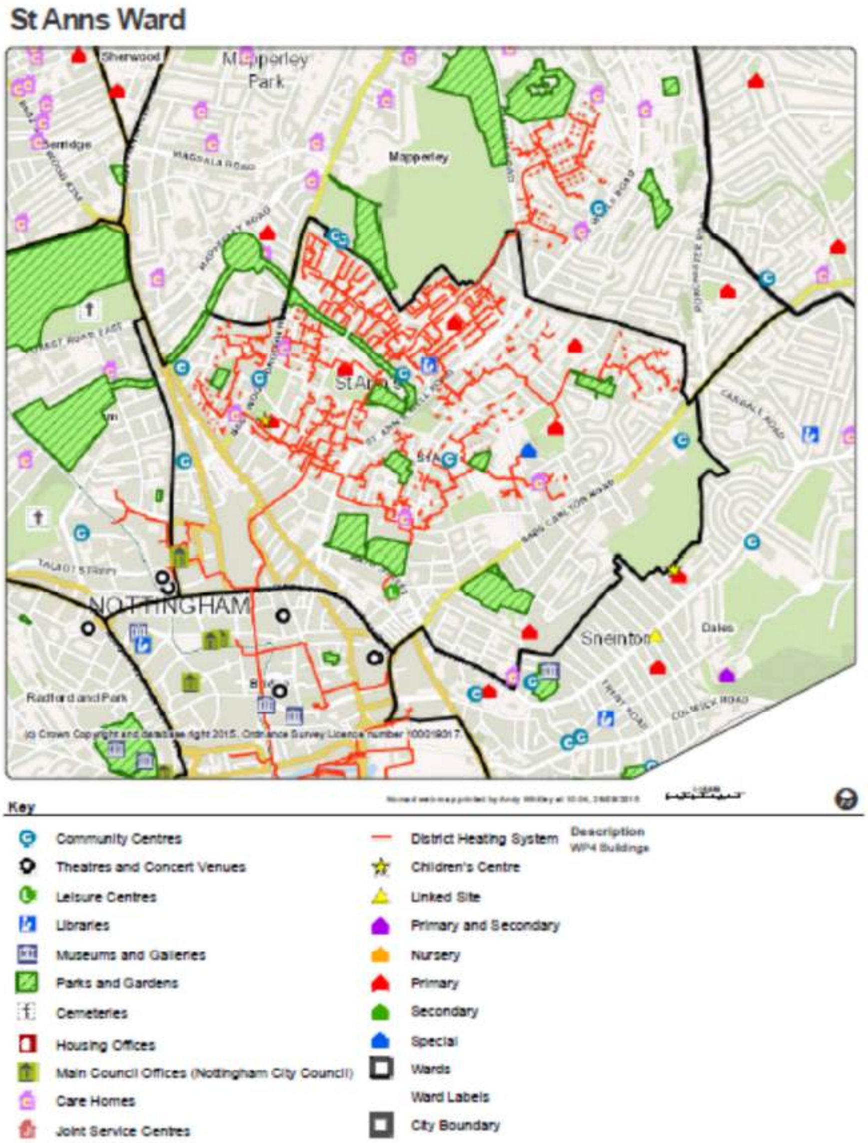
7.16 Radford & Park Ward



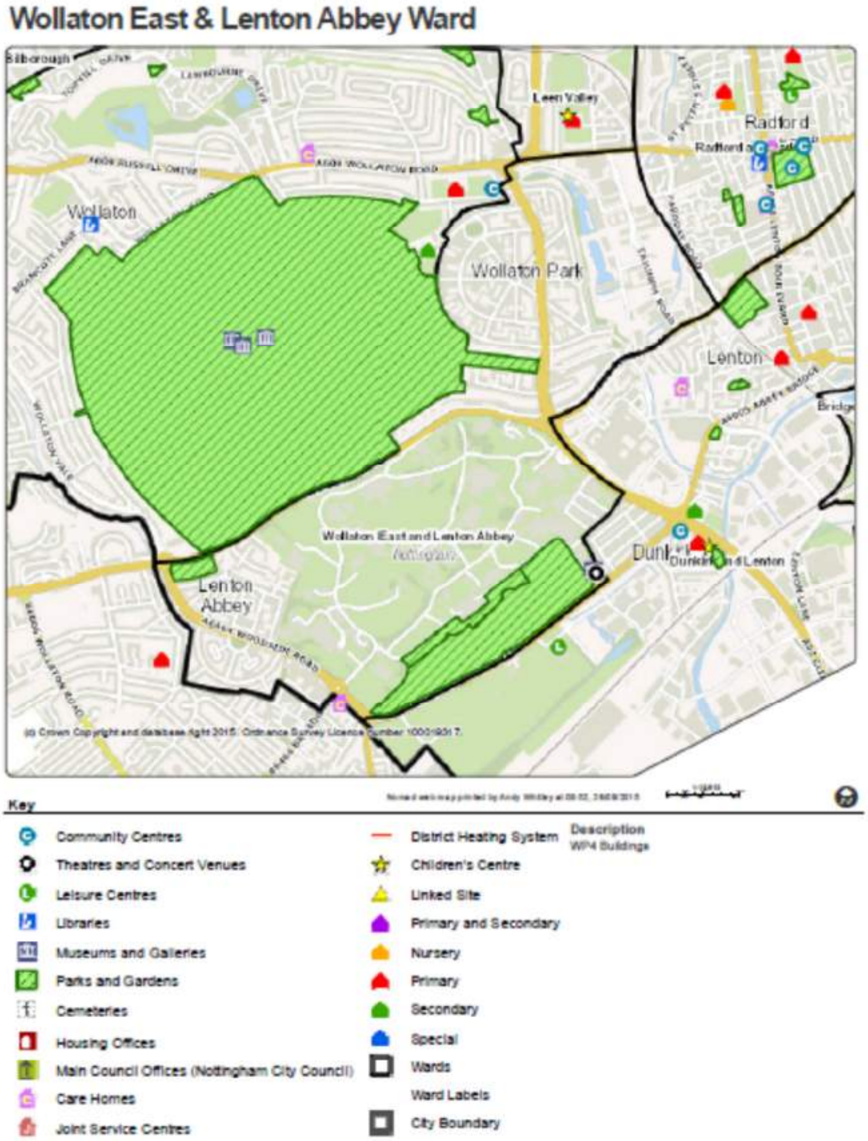
7.17 Sherwood Ward



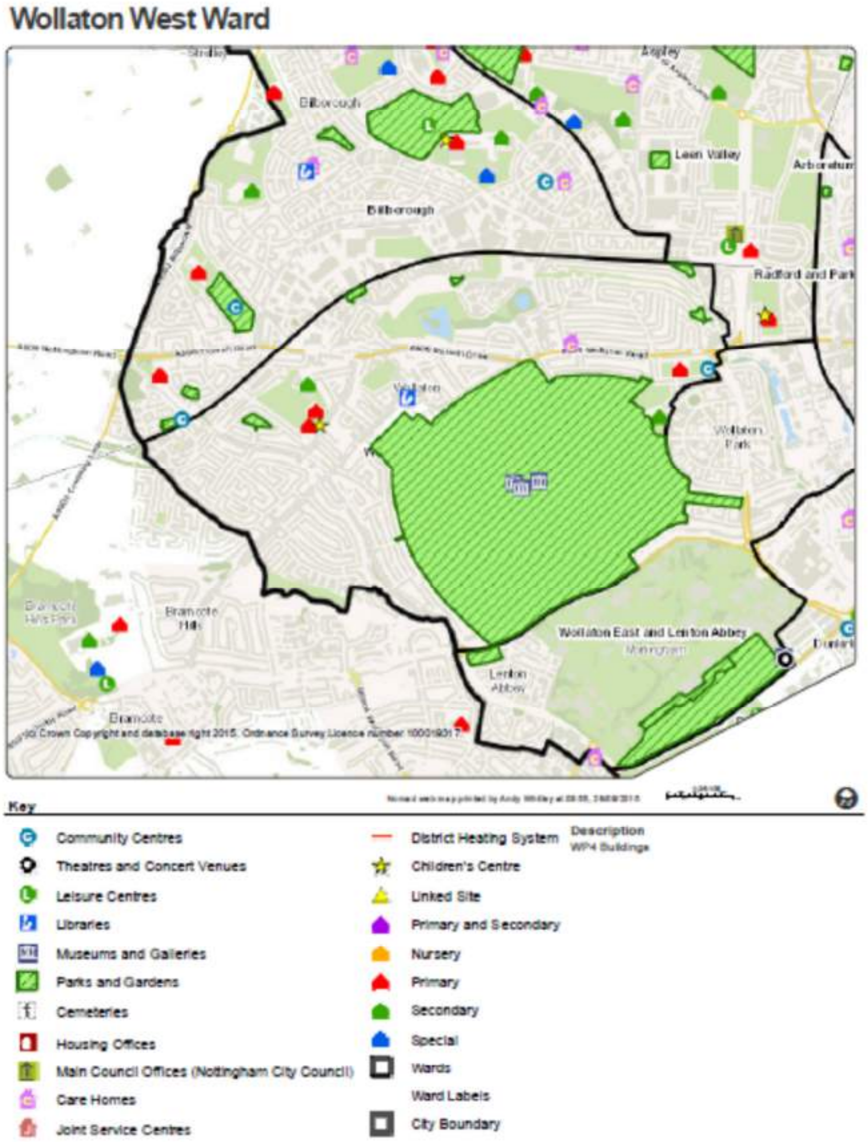
7.18 St Ann’s Ward



7.19 Wollaton East & Lenton Abbey Ward



7.20 Wollaton West Ward



Future Plans

The City of Nottingham has two targets to reduce its carbon emissions associated with its building assets. A target of 31% reduction by 2016, and a further target of 45% by 2020 from a 2007 baseline is expected. Nottingham will achieve these targets via a mix of energy efficiency retrofit programme, investments in renewable technologies, and behaviour change. Also the way that Nottingham manages those building assets will assist in further reductions in Nottingham City Councils energy demand

7.2 Other Tertiary Buildings

No information for this section is presented

8 References

2011 UK Census

2013 – 14 Carbon Management Plan

Nottingham City Council Waste Strategy 2010-2030

Nottingham City Council Energy Strategy 2010-2020

Nottingham Energy Partnership Vantage Point Analysis and Evidence Report

WaterWise – Water the facts 2012

9 Appendix: Data Tables

Task 4.1 Analysis of the urban spaces (TL: UoN) For each main street and public space (e.g. squares) the electricity consumption for lighting will be determined either through specific metering data or through analysis of aggregate data. The results will be inserted into the GIS platform. Consequently analysis of energy efficiency scenarios for the lighting of streets and public spaces will be conducted in order to identify promising technical solutions (efficient lamps, control systems, etc.) that will be inserted to the TIMES optimisation model.

3.1 Public Lighting

Table 1. Analysis and description of the public lighting network

		Length of Line	Number of masts	Number of Luminaires per Mast	Number of Lamps per Luminaire	Power by type of Lamp							Age by type of Lamp							Type of Luminaire			Type of Ballast				Control System				Switching on/off hour						Electricity consumption
City district	Street					Mercury Vapour	HPS - High-pressure sodium	LPS - Low-pressure sodium	Metal Halide	Halogen	Fluorescent	Other (Describe)	Mercury Vapour	HPS - High-pressure sodium	LPS - Low-pressure sodium	Metal Halide	Halogen	Fluorescent	Other (Describe)	with Reflector (Define Type)	with Cap (Define Type)	Other (Define Type)	Magnetic	Electronic	Electronic with Control Options	Other (describe)	Manual Switch	Timer	Electronic Management System	Other (describe)	Summer On	Summer Off	Winter On	Winter Off	Intermediate On	Intermediate Off	
	unit	*m*	*n.°*	*n.°*	*n.°*	*W*							*Years*																		*hour*						*kWh (daily, monthly, yearly)*
A	Christmas lighting																																				11006
A	(…)																																				
B	Street y																																				
B	(…)																																				
C	Street z																																				
C	(…)																																				
D	Street u																																				
D	(…)																																				

Table 2. Future plans and projects regarding public lighting

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
City district	Street	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*e.g. number or share of technology substitution*
A	Street x						
A	(…)						
B	Street y						
B	(…)						
C	Street z						
C	(…)						
D	Street u						
D	(…)						

3.2 Gardens/green areas and public fountains

Table 3. Analysis and description of the Gardens/green areas

			Irrigation method	Activity	Operation and maintenance Cost	Control System				Switching on/off hour						Electricity consumption
City district	Specific location					Manual Switch	Timer	Electronic Management System	Other (describe)	Summer On	Summer Off	Winter On	Winter Off	Intermediate On	Intermediate Off	
		unit		*Hours/day or Days/year*	*€/year*					*hour*						*kWh (yearly)*
Basford	Vernon Road Park		Information not available													43,822
Bilborough	Strelley Park		Information not available													7,053
Bridge	Bowling Green Pavilion (Meadows)		Information not available													17,676
Bridge	Victoria Embankment Pav & Rec Grd		Information not available													13,696
Colwick Country Park	Dales		Information not available													38,192
Sherwood	Tennis Courts Pavilion & Model Railway		Information not available													9,995
Sherwood	Valley Road Park		Information not available													6,710
Sherwood	Woodthorpe Park		Information not available													68,874
Wollaton West	Wollaton Park/Hall		Information not available													143,790

Table 4. Analysis and description of the public fountains (including water pumping and lights)

			Activity	Operation and maintenance Cost	Control System				Switching on/off hour						Electricity consumption
					Manual Switch	Timer	Electronic Management System	Other (describe)	Summer On	Summer Off	Winter On	Winter Off	Intermediate On	Intermediate Off	
City district	Specific location	*unit*	*Hours/day or Days/year*	*€/year*					*hour*						*kWh (daily, monthly, yearly)*
		Information not available													

Table 5. Future plans and projects regarding Gardens/green areas

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
City district	Street	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*e.g. number or share of technology substitution*
		Information not available					

Table 6. Future plans and projects regarding public fountains (including water pumping and lights)

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
City district	Street	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*e.g. number or share of technology introduction and/or substitution*
	Information not available						

<u>Task 4.2. Analysis of the water/sewage system (TL: FCT)</u> The water/sewage system will be analysed merely in terms of the pumping stations energy needs. Data from the cities and the utility companies regarding the technical characteristics of the pumps, operational characteristics will be collected and possibilities for energy efficiency measures regarding the rehabilitation of the equipment both in terms of current as well as future needs (expansion) will be identified.

4.1 Water Treatment and Distribution Systems

Table 7. Analysis and description of the water treatment and distribution systems

City District location	Facility Name	Type of technology	Date of implementation	Lifetime	Installed capacity	Energy consumption (daily/monthly/yearly)	Hours of operation (daily/monthly/yearly)	Water pumped or treated	Operation and maintenance Cost	**Share of city district served population by the facility** (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Water consumption: Residential	Water consumption: Tertiary	Water consumption: Other sectors	Water consumption: Total
	unit		*Year*	*Years*	*kW*	*kWh*	*n.º hours or %of day*	*m3, or m3/h*	*€/water pumped*		m^3 of delivered water per person or % of water pumped treated	m^3 of delivered water per m2 or % of water pumped treated	m^3 of delivered water per person or % of water pumped treated	m^3 of delivered water per person or % of water pumped treated
A	*Water treatment plant x*													
A	*Water Suction Pumps y*													
A	*Water Supply Pumps u*													
A	*(…)*													
B	*Water treatment plant x*													
B	*Water Suction Pumps y*													
B	*Water Supply Pumps u*													
B	*(…)*													
(…)	*Water treatment plant x*													
(…)	*Water Suction Pumps y*													
(…)	*Water Supply Pumps u*													
(…)	*(…)*													
Out of the scope area	*Water treatment plant x*													
Out of the scope area	*Water Suction Pumps y*													
Out of the scope area	*Water Supply Pumps u*													
Out of the scope area	*(…)*													

Table 8. Future plans and projects regarding Water supply system

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
City district	**Street**	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of table 7.)*
A	*Water treatment plant x*						
A	*Water Suction Pumps y*						
A	*Water Supply Pumps u*						
A	*(…)*						
B	*Water treatment plant x*						
B	*Water Suction Pumps y*						
B	*Water Supply Pumps u*						
B	*(…)*						
(…)	*Water treatment plant x*						
(…)	*Water Suction Pumps y*						
(…)	*Water Supply Pumps u*						
(…)	*(…)*						

4.2 Sewage Systems

Table 9. Analysis and description of the wastewater treatment and distribution systems

City District location	Facility Name	Type of technology	Date of implementation	Lifetime	Installed capacity	Energy consumption by fuel (daily/monthly/yearly)	Energy production by fuel and technology (daily/monthly/yearly)	Hours of operation (daily/monthly/yearly)	Wastewater pumped and treated	Operation and maintenance Cost	**Share of city district served population by the facility** (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Sewage treated: Residential	Sewage treated: Tertiary	Sewage treated: Other sectors	Sewage treated: Total
	unit		*Year*	*Years*	*kW*	*kWh*	*kWh*	*n.º hours or %of day*	*m3, or m3/h*	*€/water pumped*		*m3 of treated wastewater per person and* number of people served by the system	*m3 of treated wastewater per m2*	*m3 of treated wastewater per person and* number of people served by the system	*m3 of treated wastewater per person and* number of people served by the system
A	*Wastewater treatment plant x*														
A	*Wastewater Pump y*														
A	*(…)*														
B	*Wastewater treatment plant x*														
B	*Wastewater Pump y*														
B	*(…)*														
(…)	*Wastewater treatment plant x*														
(…)	*Wastewater Pump y*														
(…)	*(…)*														
Out of the scope area	*Wastewater treatment plant x*														
Out of the scope area	*Wastewater Pump y*														
Out of the scope area	*(…)*														

Table 10. Future plans and projects regarding sewage system

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
City district	**Street**	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of table 9.)*
A	*Wastewater treatment plant x*						
A	*Wastewater Pump y*						
A	*(…)*						
B	*Wastewater treatment plant x*						
B	*Wastewater Pump y*						
B	*(…)*						
(…)	*Wastewater treatment plant x*						
(…)	*Wastewater Pump y*						
(…)	*(…)*						

Task 4.3. Analysis of the waste collection and treatment processes regarding their energy use impact (TL: CRES) Waste chain will also be analyzed merely on the basis of current waste disposal patterns, possibilities for on site waste reduction, recycling and energy utilization of remaining waste quantities. The data from the aforementioned analysis will be introduced to the city GIS database in order to form various GIS layers related to resource and energy use.

5. Water Treatment and Distribution Systems

Table 11. Analysis and description of the waste chain - Solid waste production

Solid Waste production		Waste characterization by type	Quantity by type
	unit	*% of each type*	*(ton/year*
Municipal Solid Waste (MSW)			
	household		98178
	commercial and services		
Industrial Wastes			
Hospital waste			
Other (e.g. livestock industries)			

Table 12. Analysis and description of the waste chain - Waste collection

Waste collection		Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Vehicles fleet (stocks)	Age	Distances covered	Waste collected	Waste collecting capacity	Energy consumption (by type of fuel)
Collection type	*unit*		*n.°*	*years*	*km/y*	*tons of collected waste per person (per city spatial district)*	*ton of waste/vehicle*	*liters or toe*
General collection								
Dedicated collection	**Total**							

Table 13. Analysis and description of the waste chain - Sorting centers

Sorting centers		Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Activity	Input and output waste characterization	Lifetime	Operation and maintenance Cost regarding energy production	Energy consumption (by type of fuel)
City district location	*unit*		*ton waste/year*	*ton/type of waste*	*Years*	*€ total cost or annualized*	*liters or toe*
Out of City	Wastecycle			Recycling			
	Simpro			Composting			

Table 14. Analysis and description of the waste chain - Waste destination

Waste destination	City district location	*unit*	Activity	Input waste characterization	lifetime/total capacity of storage	Fuel consumption (by type of fuel)	Energy production (by type of fuel) (daily, monthly, yearly)	Operation and maintenance Cost regarding energy production.	Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)
			ton waste/year	*ton/type of waste*	*Years*	*liters or toe*	*m3; kWh; toe*	*€ total cost or annualized*	
Managed Landfills	*e.g. City sector A or out of the scope area*								
Open dump sites									
Incineration									
Composting									
Recycling									

Table 15. Future plans and projects regarding waste chain

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
Waste chain phase	**Spatial coverage (scope area or more)**	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of tables 11 to 14.)*
Solid Waste production							
Waste collection							
Sorting centers							
Waste destination							

<u>Task 4.4 Analysis of the energy supply system (TL: E4SMA)</u> Data on the existing energy supply systems (DH/CHP, solar thermal, PVs etc.) at a city level will be recorded and their technical status will be evaluated in order to identify further technical measures for energy efficiency improvement (e.g. in case of thermal plants) or potential for further deployment (e.g. in the case of RES).
Furthermore the potential of RES utilisation (e.g. PVs, solar thermal, geothermal heat pumps etc.) will be analysed on a city specific case with the use of relevant simulation tools and databases (e.g. PV-GIS)

6. Energy supply system

Table 16. Analysis and description of the energy supply system

City District location	Type of technology		Date of implementation	Lifetime	Installed capacity	Electricity production (daily/monthly/yearly)	Other forms of energy production (refer the type) (daily/monthly/yearly)	Energy consumption (refer by type) (daily/monthly/yearly)	Hours of operation (daily/monthly/yearly)	Efficiency	Technologies associated with the other systems (waste, water, sewage, etc.)	Fixed and variable operating costs
		unit	*Year*	*Years*	*kW*	*kWh*	*Joule or kWh*	*Joule or kWh*	*n.º hours or %of day*	*%*	*%*	*€/kW and €/kWh*
Bridge	District heating (DH)		*1972*		*102532*	*60148172*		*14318000*	*24hrs*	*86*		
City Wide	Combined heat and power (CHP)					580.69GWh						
City Wide	Solar Thermal					0.034GWh						
City Wide	Solar pv					12.065GWh						
(…)	(..)											

Table 17. Analysis and description of the energy supply system - District heating network aditional specifications

District heating network		length of the network	Users connected to the DH system	Energy consumption of the auxiliaries	Capacity consumption of the auxiliaries	Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)
City District location	*unit*	*km*	*n.º*	*kWh*	*kW*	
St Anns		68	4700	4169525	570	24%
B						
(…)						

Table 18. Analysis and description of the energy supply system - Natural gas network aditional specifications

Natural Gas network		Lenght of the network	Users connected to the NG distribution	Energy consumption of the auxiliaries	Capacity consumption of the auxiliaries	Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Natural Gas storage
City District location	*unit*		*n.º*	*kWh*	*kW*		*m3 storaged*
Arboretum		n/a	5707	67883948		5%	n/a
Aspley		n/a	6551	73298110		5%	n/a
Basford		n/a	7038	85355271		6%	n/a
Berridge		n/a	6303	86853032		6%	n/a
Bestwood		n/a	7453	79658550		5%	n/a
Bilborough		n/a	8042	102601826		7%	n/a
Bridge		n/a	5318	64065671		4%	n/a
Bulwell		n/a	7185	77616713		5%	n/a
Bulwell Forest		n/a	5834	79166995		5%	n/a
Clifton North		n/a	6050	80920439		5%	n/a
Clifton South		n/a	5316	68671907		5%	n/a
Dales		n/a	7014	91660465		6%	n/a
Dunkirk & Lenton		n/a	3012	40643046		3%	n/a
Leen Valley		n/a	3500	51176733		3%	n/a
Mapperley		n/a	5932	88308772		6%	n/a
Radford & Park		n/a	6616	83963100		6%	n/a
Sherwood		n/a	6290	98064361		7%	n/a
St Anns		n/a	3846	33925009		2%	n/a
Wollaton East		n/a	2056	31950269		2%	n/a
Wollaton West		n/a	5732	102682427		7%	n/a
				1488466644			

Table 19. Future plans and projects regarding energy supply system

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
Technology	**Spatial coverage (city district or more)**	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of tables 16 to 19)*
District heating (DH)							
Combined heat and power (CHP)							
Solar Thermal							
Solar pv							
Wind							
(…)							

7. Buildings under Municipal Management

Note: Information could be filled for the total of each Buidling type or in a One by one basis if information is available. Please replicate lines when needed for energy consumption by different building types and city district location

Table 20_ Analysis and description of the Buildings under Municipal management

City District location	Building type	Total surface area (m2).	Number of Buildings/Facilities for each type	Number of users per annum (e.g. students, employees)	Activity/operation: daily opening-closing time (e.g 9a.m to 6p.m.)	Activity/operation: months of the year	Energy production by type (e.g. PV, CHP) (KWh/y)	Energy form	Energy consumption	Space Heating	Space Cooling	Water Heating	Water Heating e	Cooking	Lighting	Other applicances g	Other applicances e
A	Schools and kindergardens									58%	2%	15%	2%	8%	20%	19%	76%
Radford & Park	Alternative Learning, Unity Complex	1323			8:00 to 18:00	9		Elec	60981		1220		1220		12196		46346
					8:00 to 18:00	9		Natural Gas	212517	123260		31878		17001		40378	
Aspley	Ambleside Primary School	2588		588	8:00 to 18:00	9		Elec	188495		3770		3770		37699		143256
					8:00 to 18:00	9		Natural Gas	481210	279102		72182		38497		91430	
Dales	Arches Adventure Centre - Meadow Lane Boat Yard	n/a			8:00 to 18:00	9		Elec	25842		517		517		5168		19640
Bestwood	Beckhampton Centre (PRU)	148			8:00 to 18:00	9		Elec	11744		235		235		2349		8925
Arboretum	Bentinck Primary & Nursery	1812		230	8:00 to 18:00	9		Elec	60334		1207		1207		12067		45854
					8:00 to 18:00	9		Natural Gas	376947	218629		56542		30156		71620	
Arboretum	Berridge Primary School	1029		545	8:00 to 18:00	9		Elec	104502		2090		2090		20900		79422
Arboretum	Berridge Primary School (Bobbers Mill Site)	2708			8:00 to 18:00	9		Elec	36673		733		733		7335		27871
Bestwood	Bestwood Pk Yth Proj (William Olds)	840			8:00 to 18:00	9		Elec	29878		598		598		5976		22707
Bestwood	Bestwood/Southglade Access Centre	0			8:00 to 18:00	9	PV = 26130	Elec	93570		1871		1871		18714		71113
Bilborough	Brocklewood Junior School	2056		538	8:00 to 18:00	9		Elec	103391		2068		2068		20678		78577
					8:00 to 18:00	9		Natural Gas	517856	300356		77678		41428		98393	
Bulwell Forest	Bulwell Forest Children's Centre	0			8:00 to 18:00	9		Elec	63181		1264		1264		12636		48018
Sherwood	Burford Primary & Nursery	1984		197	8:00 to 18:00	9		Elec	76082		1522		1522		15216		57822
					8:00 to 18:00	9		Natural Gas	273690	158740		41054		21895		52001	
Bulwell Forest	Cantrell Primary & Nursery	2179		490	8:00 to 18:00	9		Elec	82783		1656		1656		16557		62915
					8:00 to 18:00	9		Natural Gas	505041	292924		75756		40403		95958	
Sherwood	Carrington Primary School	1171		207	8:00 to 18:00	9		Elec	50896		1018		1018		10179		38681
Bridge	City Mobile Project	0			8:00 to 18:00	9		Elec	158		3		3		32		120
Berridge	Claremont Primary & Nursery	2364		338	8:00 to 18:00	9		Elec	111765		2235		2235		22353		84941
					8:00 to 18:00	9		Natural Gas	494257	286669		74139		39541		93909	
Bulwell	Crabtree Farm Primary School	2305		404	8:00 to 18:00	9		Elec	11561		231		231		2312		8786
Clifton North	Dovecote Primary	3367		391	8:00 to 18:00	9		Elec	108575		2172		2172		21715		82517
					8:00 to 18:00	9		Natural Gas	612328	355150		91849		48986		116342	
Dunkirk & Lenton	Dunkirk and Lenton Childrens Centre	0			8:00 to 18:00	9		Elec	11382		228		228		2276		8650
Dunkirk & Lenton	Dunkirk Primary & Nursery	1209		276	8:00 to 18:00	9		Elec	51349		1027		1027		10270		39025
					8:00 to 18:00	9		Natural Gas	269836	156505		40475		21587		51269	
Dunkirk & Lenton	Dunkirk Primary School (Abbey Campus)	1725			8:00 to 18:00	9		Elec	51349		1027		1027		10270		39025
					8:00 to 18:00	9		Natural Gas	33901	19663		5085		2712		6441	
Clifton South	E Learning Centre	0			8:00 to 18:00	9		Elec	87096		1742		1742		17419		66193
Dales	Edale Rise Primary and Nursery	1265		208	8:00 to 18:00	9		Elec	100997		2020		2020		20199		76758
Basford	Ellis Guilford School and Sports College	12723			8:00 to 18:00	9		Elec	989234		19785		19785		197847		751818
					8:00 to 18:00	9		Natural Gas	1000578	580335		150087		80046		190110	
Clifton South	Fairham Community College	6098			8:00 to 18:00	9		Elec	26266		525		525		5253		19962
Clifton South	Farnborough School Technology College	7641			8:00 to 18:00	9		Elec	478864		9577		9577		95773		363937
					8:00 to 18:00	9		Natural Gas	765241	443840		114786		61219		145396	
Wollaton West	Fernwood Infant School	1838		360	8:00 to 18:00	9		Elec	66070		1321		1321		13214		50213
					8:00 to 18:00	9		Natural Gas	78998	45819		11850		6320		15010	
Wollaton West	Fernwood Junior School	2451		480	8:00 to 18:00	9		Elec	70944		1419		1419		14189		53917
					8:00 to 18:00	9		Natural Gas	308353	178845		46253		24668		58587	
Bilborough	Firbeck Primary & Nursery	1671		215	8:00 to 18:00	9		Elec	68292		1366		1366		13658		51902
					8:00 to 18:00	9		Natural Gas	95222	55229		14283		7618		18092	
Berridge	Forest Fields Primary School	1816		510	8:00 to 18:00	9		Elec	169938		3399		3399		33988		129153
					8:00 to 18:00	9		Natural Gas	275265	159654		41290		22021		52300	
Bestwood	Glade Hill Primary School	2103		207	8:00 to 18:00	9		Elec	90857		1817		1817		18171		69051
					8:00 to 18:00	9		Natural Gas	343782	199394		51567		27503		65319	
Bilborough	Glenbrook Primary School	2809		205	8:00 to 18:00	9		Elec	65510		1310		1310		13102		49788
					8:00 to 18:00	9		Natural Gas	1333831	773622		200075		106706		253428	
Bridge	Greenfields Community School	1437		208	8:00 to 18:00	9		Natural Gas	362396	210190		54359		28992		68855	
Bilborough	Hadden Park High School	9695			8:00 to 18:00	9		Elec	487179		9744		9744		97436		370256
					8:00 to 18:00	9		Natural Gas	1314588	762461		197188		105167		249772	
Sherwood	Haydn Primary School	1732		411	8:00 to 18:00	9		Elec	16041		321		321		3208		12191
					8:00 to 18:00	9		Natural Gas	17774	10309		2666		1422		3377	
Basford	Heathfield Primary School	1310		348	8:00 to 18:00	9		Elec	56483		1130		1130		11297		42927
Bulwell	Hempshill Hall Primary School	1494		396	8:00 to 18:00	9		Elec	131232		2625		2625		26246		99736
					8:00 to 18:00	9		Natural Gas	163213	94664		24482		13057		31010	
Bestwood	Henry Whipple Primary School	3693		207	8:00 to 18:00	9		Elec	137634		2753		2753		27527		104602
					8:00 to 18:00	9		Natural Gas	740727	429622		111109		59258		140738	
Mapperley	Hogarth Primary & Nursery	1418		192	8:00 to 18:00	9		Elec	42643		853		853		8529		32409
					8:00 to 18:00	9		Natural Gas	9633	5587		1445		771		1830	
	Learning Works for Young People	2002			8:00 to 18:00	9		Elec	3198		64		64		640		2430
Bilborough	Melbury Primary & Nursery	1626		238	8:00 to 18:00	9		Elec	26990		540		540		5398		20512
					8:00 to 18:00	9		Natural Gas	375638	217870		56346		30051		71371	
Radford & Park	Mellers Primary and Nursery School	1340		214	8:00 to 18:00	9		Elec	115894		2318		2318		23179		88079
Wollaton West	Middleton Primary & Nursery	2047		397	8:00 to 18:00	9		Elec	92145		1843		1843		18429		70030
					8:00 to 18:00	9		Natural Gas	208810	121110		31322		16705		39674	
Radford & Park	Nottingham Nursery & Training Centre	0			8:00 to 18:00	9		Elec	74204		1484		1484		14841		56395
Bilborough	Portland Primary and Nursery	3654		373	8:00 to 18:00	9		Natural Gas	518085	300489		77713		41447		98436	
Radford & Park	Radford Unity Complex	2066			8:00 to 18:00	9		Elec	63657		1273		1273		12731		48379
					8:00 to 18:00	9		Natural Gas	867929	503399		130189		69434		164907	
Bulwell Forest	Rise Park Primary	2074		416	8:00 to 18:00	9		Elec	121741		2435		2435		24348		92523
					8:00 to 18:00	9		Natural Gas	287112	166525		43067		22969		54551	
Bridge	Riverside Primary School and Early Years Unit	1338		234	8:00 to 18:00	9		Elec	84224		1684		1684		16845		64010
Leen Valley	Robert Shaw Primary School	2306		420	8:00 to 18:00	9		Elec	102406		2048		2048		20481		77829
					8:00 to 18:00	9		Natural Gas	29888	17335		4483		2391		5679	
Bestwood	Robin Hood Primary School	2187		398	8:00 to 18:00	9		Elec	140754		2815		2815		28151		106973
					8:00 to 18:00	9		Natural Gas	323320	187526		48498		25866		61431	
St Anns	Rosehill School	2749			8:00 to 18:00	9		Elec	230771		4615		4615		46154		175386
					8:00 to 18:00	9		Natural Gas	11992	6955		1799		959		2278	
					8:00 to 18:00	9		District Heating	463000	268540		69450		37040		87970	
Aspley	Rosslyn Park Primary and Nursery School	2345		598	8:00 to 18:00	9		Elec	126492		2530		2530		25298		96134
					8:00 to 18:00	9		Natural Gas	375961	218057		56394		30077		71433	
Bulwell	Rufford Primary School	1094		256	8:00 to 18:00	9		Elec	94803		1896		1896		18961		72050
Berridge	Scotholme Primary & Nursery	1848		415	8:00 to 18:00	9		Elec	119032		2381		2381		23806		90464
					8:00 to 18:00	9		Natural Gas	290040	168745		43641		23275		55279	
Bilborough	Seagrave Primary and Nursery	2124			8:00 to 18:00	9		Elec	105692		2114		2114		21138		80326
					8:00 to 18:00	9		Natural Gas	438738	254468		65811		35099		83360	
Sherwood	Seely Primary School (old Infant)	1535		466	8:00 to 18:00	9		Elec	74237		1485		1485		14847		56420
Sherwood	Seely Primary School (old Junior)	1802			8:00 to 18:00	9		Elec	88285		1766		1766		17657		67097
					8:00 to 18:00	9		Natural Gas	218843	126697		32766		17475		41504	
Bulwell	Snape Wood Primary and Nursery School	1362		173	8:00 to 18:00	9		Elec	66464		1329		1329		13293		50513
					8:00 to 18:00	9		Natural Gas	323762	187782		48564		25901		61515	
Dales	Sneinton Centre for the Child	0			8:00 to 18:00	9		Elec	91063		1821		1821		18213		69208
Dales	Sneinton Sure Start	0			8:00 to 18:00	9		Elec	34806		696		696		6961		26453
Clifton North	South Wilford Endowed CE Primary	1803		295	8:00 to 18:00	9		Elec	95188		1904		1904		19038		72343
Bestwood	Southglade Primary School	2303		382	8:00 to 18:00	9		Elec	90334		1807		1807		18067		68654
					8:00 to 18:00	9		Natural Gas	462230	268093		69335		36978		87824	
Leen Valley	Southwold Primary School & Early Years' Centre	1102		195	8:00 to 18:00	9		Elec	77347		1547		1547		15469		58784
					8:00 to 18:00	9		Natural Gas	124127	71994		18619		9930		23584	
Bulwell	Springfield Primary School	2089		174	8:00 to 18:00	9		Elec	57695		1154		1154		11539		43848
					8:00 to 18:00	9		Natural Gas	573040	332363		85956		45843		108878	
Mapperley	Springwood ATC	3423			8:00 to 18:00	9		Elec	50430		1009		1009		10086		38327
					8:00 to 18:00	9		Natural Gas	750783	435454		112617		60063		142649	
Bestwood	St Margaret Clitherow Catholic	1169		200	8:00 to 18:00	9		Elec	60531		1211		1211		12106		46004
Clifton North	St Patricks RC Primary School	1460		191	8:00 to 18:00	9		Elec	75745		1515		1515		15149		57566
Leen Valley	St Teresa RC Primary School	1968		430	8:00 to 18:00	9		Elec	79530		1591		1591		15906		60443
					8:00 to 18:00	9		Natural Gas	176589	102422		26488		14127		33552	
Bulwell	Sure Start (Bulwell)	0			8:00 to 18:00	9		Natural Gas	76786	44536		11518		6143		14589	
	Sure Start (Clifton)	0			8:00 to 18:00	9		Elec	46190		924		924		9238		35104
Bulwell	Sure Start (Crabtree Farm Playgroup)	530			8:00 to 18:00	9		Elec	51978		1040		1040		10396		39503
					8:00 to 18:00	9		Natural Gas	27564	15987		4135		2205		5237	
Bridge	Sure Start (Meadows)	1439			8:00 to 18:00	9		Elec	24328		487		487		4866		18489
St Anns	Sycamore Primary School	2213		212	8:00 to 18:00	9		Elec	125828		2517		2517		25166		95629
					8:00 to 18:00	9		Natural Gas	27475	15936		4121		2198		5220	
Clifton North	The Nottingham Emmanuel C of E School	11000			8:00 to 18:00	9		Elec	810072		16201		16201		162014		615655
					8:00 to 18:00	9		Natural Gas	929571	539151		139436		74366		176618	
Bulwell Forest	The Ridge Adventure Playground	232			8:00 to 18:00	9		Elec	33192		664		664		6638		25226
Mapperley	Thorneywood Education Base (St Anns Hospital Sch)	585			8:00 to 18:00	9		Elec	22877		458		458		4575		17387
					8:00 to 18:00	9		Natural Gas	140384	81423		21058		11231		26673	
Leen Valley	Trinity RC Comprehensive	4561			8:00 to 18:00	9		Elec	307021		6140		6140		61404		233336
					8:00 to 18:00	9		Natural Gas	694994	403097		104249		55600		132049	
Leen Valley	Trinity RC Comprehensive Upper	9117			8:00 to 18:00	9		Elec	251190		5024		5024		50238		190904
					8:00 to 18:00	9		Natural Gas	715611	415054		107342		57249		135966	
Mapperley	Walter Halls Children's Centre	0			8:00 to 18:00	9		Elec	23467		469		469		4693		17835
Mapperley	Walter Halls Primary School	2293			8:00 to 18:00	9		Elec	56283		1126		1126		11257		42775
Bridge	Welbeck Primary & Nursery	1187			8:00 to 18:00	9		Elec	53485		1070		1070		10697		40649
					8:00 to 18:00	9		Natural Gas	378631	219606		56795		30290		71940	
Bilborough	Westbury School (new)	2143			8:00 to 18:00	9		Elec	112444		2249		2249		22489		85457
					8:00 to 18:00	9		Natural Gas	271516	157479		40727		21721		51588	
Bulwell Forest	Westglade Primary School	1511			8:00 to 18:00	9		Elec	76628		1533		1533		15326		58237
					8:00 to 18:00	9		Natural Gas	106023	61493		15903		8482		20144	
Clifton North	Whitegate Primary and Nursery School	2495			8:00 to 18:00	9		Elec	86288		1726		1726		17258		65579
					8:00 to 18:00	9		Natural Gas	339701	197027		50955		27176		64543	
Basford	Whitemoor Primary and Nursery School	2724			8:00 to 18:00	9		Elec	143870		2877		2877		28774		109341
					8:00 to 18:00	9		Natural Gas	553000	320740		82950		44240		105070	
Dales	William Booth Primary and Nursery School	1084			8:00 to 18:00	9		Elec	72688		1454		1454		14538		55243
Wollaton West	Wollaton Children's Centre	0			8:00 to 18:00	9		Natural Gas	387009	224465		58051		30961		73532	
Leen Valley	Woodlands School	2858			8:00 to 18:00	9		Elec	115145		2303		2303		23029		87510
								Natural Gas	554004	321322		83101		44320		105261	
A	Museums and cultural spaces (e.g. theater)							%		100%	20%				60%		20%
Radford & Park	Albert Hall				n/a	12		Elec	75997		15199				45598		15199
						12		Natural Gas	277165	277165							
Aspley	Aspley Library				9:30 to 17:30	12		Elec	25033		5007				15020		5007
						12		Natural Gas	114663	114663							
Dales	Bakersfield Library				14:00 to 17:00	12		Elec	12714		2543				7628		2543
Basford	Basford Library				10:00 to 17:30	12		Elec	15615		3123				9369		3123
Bilborough	Bilborough Library				9:30 to 18:00	12		Elec	451		90				271		90
					9:30 to 18:00	12		Natural Gas	6306	6306							
Radford & Park	Brewhouse Yard Museum				12:00 to 16:00	12		Elec	65482		13096				39289		13096
					12:00 to 16:00	12		Natural Gas	213165	213165							
Radford & Park	Castle Museum				10:00 to 16:30	12		Elec	327928		65586				196757		65586
					10:00 to 17:00	12		Natural Gas	383196	383196							
Bridge	Central Library				8:15 to 17:00	12		Elec	814454		162891				488672		162891
Clifton South	Clifton Library				9:30 to 18:00	12		Elec	33125		6625				19875		6625
Dales	Greens Mill Museum				10:00 to 16:00	12		Natural Gas	26220	26220							
Berridge	Hyson Green Library				9:30 to 18:00	12		Elec	14772		2954				8863		2954
Wollaton West	Industrial Museum & Beam Display				11:00 to 16:30	12		Elec	179125		35825				107475		35825
								Natural Gas	534161	534161							
Bridge	Meadows Library				10:00 to 13:00	12		Elec	27513		5503				16508		5503
Out of City	Newstead Abbey				12:00 to 16:00	3		Elec	154928		30986				92957		30986
								Natural Gas	111482	111482							
Radford & Park	Playhouse				n/a	12		Elec	709125		141825				425475		141825
								Natural Gas	891686	891686							
Radford & Park	Radford/Lenton Library				9:30 to 18:00	12		Elec	25468		5094				15281		5094
Arboretum	Royal Centre (Theatre & Cncrt Hall)				n/a	12		Elec	1303283		260657				781970		260657
Sherwood	Sherwood Library				9:30 to 17:30	12		Elec	24799		4960				14879		4960
Dales	Sneinton Library				9:30 to 17:00	12		Elec	35158		7032				21095		7032
Bulwell Forest	Southglade Park Library				9:30 to 17:30	12		Elec	16890		3378				10134		3378
St Anns	St Ann's Library				8:30 to 18:30	12		Elec	19942		3988				11965		3988
Wollaton West	Wollaton Library				9:30 to 19:00	12		Natural Gas	62655	62655							
A	Swiming pool and gyms																
										74%		26%					
											50%				50%		
										60%		17%				23%	
											50%				50%		
Leen Valley	Beechdale Leisure Centre (wet)				7:00 to 21:30	12		Elec	592632		296316				296316		
								Natural Gas	1323349	794009		224969				304370	
Clifton North	Clifton Leisure Centre (wet)				7:00 to 22:00	12		Elec	696350		348175				348175		
								Natural Gas	1221293	732776		207620				280897	
Berridge	Djanogly Community Leisure Centre (wet)				7:00 to 22:00	12		Elec	454804		227402				227402		
								Natural Gas	5598256	3358954		951704				1287599	
Bilborough	Harvey Hadden Sports Centre (dry)				7:00 to 22:00	12		Elec	92565	68498.1		24066.9					
								Natural Gas	334914		167457				167457		
Radford & Park	John Carroll Leisure Centre (wet)				7:00 to 22:00	12		Elec	389337		194668.5				194668.5		
								Natural Gas	1610706	966424		273820				370462	
Bulwell	Ken Martin Swimming Centre (wet)				8:00 to 22:00	12		Elec	115038		57519				57519		
								Natural Gas	1529730	917838		260054				351838	
Mapperley	Mapperley Sports Village (wet)							Natural Gas	11656		5828				5828		
Bulwell Forest	Southglade Sports Centre (wet)				7:00 to 22:00	12		Elec	584846		292423				292423		
								Natural Gas	1908767	1145260		324490				439016	
Dunkirk & Lenton	Tennis Centre (dry)				7:00 to 22:00	12		Elec	454881	336611.94		118269.06					
								Natural Gas	482427		241213.5				241213.5		
St Anns	Victoria Leisure Centre (dry)				6:30 to 21:00	12		Elec	848359		424179.5				424179.5		
										80%		20%					
A	Office small (<500m2)										26%				41%		23%
	Adaptions and Renewal Agency	0			9:00 to 17:00	12		Elec	940		244.4				385.4		216.2
	Arts Department	0			9:00 to 17:00	12		Elec	542		140.92				222.22		124.66
	Bilborough Housing Office	255			9:00 to 17:00	12		Elec	21349		5550.74				8753.09		4910.27
								Natural Gas	6306	5044.8		1261.2					
Bulwell	Bulwell Advice Centre	115			9:00 to 17:00	12		Elec	676		175.76				277.16		155.48
	Century House	0			9:00 to 17:00	12		Elec	16176		4205.76				6632.16		3720.48
								Natural Gas	88800	71040		17760					
	Communities Courtyard	0			9:00 to 17:00	12		Elec	28643		7447.18				11743.63		6587.89
								Natural Gas	115576	92460.8		23115.2					
	Homelessness Family Unit	0			9:00 to 17:00	12		Elec	91997		23919.22				37718.77		21159.31
	Housing Choice	0			9:00 to 17:00	12		Elec	61827		16075.02				25349.07		14220.21
	Housing Liaison Team (Ash View Court)	0			9:00 to 17:00	12		Elec	149480		38864.8				61286.8		34380.4
								Natural Gas	12711	10168.8		2542.2					
Bridge	Karlsruhe House	0			9:00 to 17:00	12		Elec	14664		3812.64				6012.24		3372.72
	Manor Farm	213			9:00 to 17:00	12		Elec	2923		759.98				1198.43		672.29
	Multi Agency Team	0			9:00 to 17:00	12		Elec	19454		5058.04				7976.14		4474.42
	Sheltered Scheme	0			9:00 to 17:00	12		Elec	2132		554.32				874.12		490.36
								Natural Gas	16563	13250.4		3312.6					
	Social Services Offices - Unit 24, Clk Twr Hse	268			9:00 to 17:00	12		Elec	58249		15144.74				23882.09		13397.27
	Supervisor's Office-Loughborough Rd	0			9:00 to 17:00	12		Elec	24136		6275.36				9895.76		5551.28

	The Woodlands	0		9:00 to 17:00	12		Elec	389129		101173.54		159542.89	89499.67
							Natural Gas	77491					
	TRACS Neighbourhood Centre	216		9:00 to 17:00	12		Elec	1611		418.86		660.51	370.53
	Woodview Business Centre	0		9:00 to 17:00	12		Elec	3870		1006.2		1586.7	890.1
A	Office Large (>500m2)												
Bridge	Castlegate House	1519		9:00 to 17:00	12		Elec	114850		29861		47088.5	26415.5
Radford & Park	Castlegate Offices (No 51)	2345		9:00 to 17:00	12		Elec	10577		2750.02		4336.57	2432.71
Arboretum	Clarendon Chambers	1716		9:00 to 17:00	12		Elec	55770		14500.2		22865.7	12827.1
Radford & Park	College Street Centre for Performing Arts	1722		9:00 to 17:00			Elec	46530		12097.8		19077.3	10701.9
							Natural Gas	394260	315408		78852		
Bridge	Exchange Buildings	7766		9:00 to 17:00	12		Elec	195772		50900.72		80266.52	45027.56
							Natural Gas	465	372		93		
Radford & Park	Gate House	1913		9:00 to 17:00	12		Elec	88836		23097.36		36422.76	20432.28
							Natural Gas	158532	126825.6		31706.4		
Radford & Park	Hounds Gate	2884		9:00 to 17:00	12		Elec	368448		95796.48		151063.68	84743.04
Radford & Park	Lenton Business Centre	4363		9:00 to 17:00	12		Elec	227459		59139.34		93258.19	52315.57
							Natural Gas	511911	409528.8		102382.2		
Bridge	Loxley House	20508		0:00 to 24:00	12	CHP	Elec	4962658		1290291.08		2034689.78	1141411.34
St Anns	Milton Chambers Offices	2538		9:00 to 17:00	12		Elec	9353		2431.78		3834.73	2151.19
Sherwood	Woodthorpe Grange Offices	852		9:00 to 17:00	12		Elec	216380		56258.8		88715.8	49767.4
							Natural Gas	676644	541315.2		135328.8		
A	Other Buildings under Municipal management												
Wollaton West	Aspinall Court Common Room			n/a	12		Elec	7028					
				n/a	12		Natural Gas	37596					
Aspley	Aspley Community & Training Centre			n/a	12		Elec	5245					
				n/a	12		Natural Gas	109431					
Dales	Bakersfield Comm Centre (B.A.N.C.A)			n/a	12		Elec	19741					
				n/a	12		Natural Gas	193437					
St Anns	Bath Street Mess Room & Toilets			n/a	12		Elec	4284					
Bilborough	Beechdale Community Centre			n/a	12		Elec	20184					
				n/a	12		Natural Gas	88853					
Leen Valley	Beechdale Court			n/a	12		Elec	99407					
St Anns	Bellevue Court Common Room			n/a	12		Elec	8625					
Aspley	Bells Lane Community Centre			n/a	12		Elec	6279					
				n/a	12		Natural Gas	72071					
Out of City	Benedict Court Common Room			n/a	12		Elec	4209					
				n/a	12		Natural Gas	24381					
Bilborough	Birchover Park Community Centre			n/a	12		Elec	42167					
				n/a	12		Natural Gas	54210					
St Anns	Blue Bell Hill Community Centre			n/a	12		Elec	15424					
				n/a	12		Natural Gas	30042					
Bilborough	Bramley Green E.P.H.			n/a	12		Elec	5429					
				n/a	12		Natural Gas	55249					
Bridge	Briar Court Community Centre			n/a	12		Elec	5365					
				n/a	12		Natural Gas	51596					
Bridge	Broadmarsh Bus Station			n/a	12		Elec	122971					
Bridge	Broadmarsh Multi-Storey Car Park			n/a	12		Elec	311142					
Bridge	Brookfield Court Community Centre			n/a	12		Elec	7302					
				n/a	12		Natural Gas	52730					
Bulwell	Bulwell Bus Station Toilets			n/a	12		Elec	13653					
Bulwell	Bulwell Market Store			n/a	12		Elec	15163					
Bestwood	Cadlan Court			n/a	12		Elec	6777					
Bridge	Canal Street - Car Park			n/a	12		Elec	17289					
St Anns	Car Park - Brook St			n/a	12		Elec	715					
St Anns	Carlton Road Public WC/Pavilion			n/a	12		Elec	6709					
Bestwood	Carnforth Court Common Room			n/a	12		Elec	5398					
				n/a	12		Natural Gas	62822					
Bulwell	Chatham Court E.P.H			n/a	12		Elec	14003					
Bestwood	Cherry Trees			n/a	12		Elec	244965					
				n/a	12	Ground Source Heat Pur	Natural Gas	103748					
Dunkirk & Lenton	Childrens Home - Chippendale Street			n/a	12		Elec	3249					
Dunkirk & Lenton	Childrens Home - Mettham Street			n/a	12		Elec	7211					
Out of City	Childrens Home - Percival Street			n/a	12		Elec	5721					
				n/a	12		Natural Gas	30484					
Dunkirk & Lenton	Childrens Home - Sherwin Road			n/a	12		Elec	5659					
				n/a	12		Natural Gas	21942					
Bridge	City Information Centre			n/a	12		Elec	62515					
Clifton North	Clifton Community Centre			n/a	12		Elec	45809					
Basford	Clover Green Common Room			n/a	12		Elec	15132					
				n/a	12		Natural Gas	52128					
Dales	Colwick Woods Court			n/a	12		Elec	14638					
Bulwell Forest	Community Home (12a Ranskill Gardens)			n/a	12		Elec	57					
Bestwood	Community Home (9 Beckhampton)			n/a	12		Elec	27943					
				n/a	12		Natural Gas	80797					
Sherwood	Community Home (Beechwood)			n/a	12		Natural Gas	9453					
Radford & Park	Community Home (Hamilton Court)			n/a	12		Elec	41205					
				n/a	12		Natural Gas	132505					
Bestwood	Cornfields Complex for Older People			n/a	12		Elec	6860					
				n/a	12		Natural Gas	115780					
Bulwell	Crabtree Farm Community Centre			n/a	12		Elec	11561					
				n/a	12		Natural Gas	52111					
Bridge	Crocus Fields			n/a	12		Elec	78327					
Bestwood	Crossfield Court Common Room			n/a	12		Elec	35498					
Bridge	Cubicle- Wilford Grove			n/a	12		Elec	711					
Bridge	Cubicle, opp war memorial			n/a	12		Elec	93					
St Anns	Curzon Court			n/a	12		Elec	11054					
St Anns	Curzon Street Car Park			n/a	12		Elec	39171					
St Anns	Dane Court No.1a			n/a	12		Elec	9992					
				n/a	12		Natural Gas	27					
Bulwell	Duchess Gardens Community Centre (565 Wac)			n/a	12		Elec	8344					
				n/a	12		Natural Gas	63327					
Bulwell	Duke Street Unisex Disabled WC			n/a	12		Elec	222					
Sherwood	Edwards Lane Community Centre			n/a	12		Elec	15864					
Clifton South	Fairham Day Centre/Summerwood Day Service			n/a	12		Elec	23					
				n/a	12		Natural Gas	29008					
Basford	Fenton Court Common Room			n/a	12		Elec	52440					
				n/a	12		Natural Gas	93635					
Dunkirk & Lenton	Finch Close Pumping Station			n/a	12		Elec	3					
Berridge	Forest Fields Community Centre			n/a	12		Elec	21510					
				n/a	12		Natural Gas	60044					
Arboretum	Forest Road East (messroom)			n/a	12		Elec	13170					
Bilborough	Foxton Gardens			n/a	12		Elec	179958					
				n/a	12		Natural Gas	631633					
St Anns	Furze Gardens Common Room			n/a	12		Elec	4128					
Clifton South	Gabor Court Common Room			n/a	12		Elec	27633					
				n/a	12		Natural Gas	228961					
Radford & Park	Garden Street Family Centre			n/a	12		Elec	49401					
				n/a	12		Natural Gas	74373					
Radford & Park	Garfield Court Common Room			n/a	12		Elec	40950					
				n/a	12		Natural Gas	153087					
Aspley	Gas Monitoring Station			n/a	12		Elec	6558					
St Anns	Gedling Street Toilets			n/a	12		Elec	131					
Clifton South	Green Lane Youth and Community			n/a	12		Elec	28963					
				n/a	12		Natural Gas	11002					
Bridge	Greyhound Street Public Toilets			n/a	12		Elec	22030					
				n/a	12		Natural Gas	39030					
Clifton South	Haworth Court E.P.H.			n/a	12		Elec	11402					
				n/a	12		Natural Gas	26842					
Bulwell	Hazlehurst Gardens Community Block			n/a	12		Elec	8554					
				n/a	12		Natural Gas	37185					
Bulwell	High Wood Cemetery			n/a	12		Elec	22779					
Basford	Highbury Vale Community Centre			n/a	12		Elec	14289					
Berridge	Hyson Green CC (The Green Youth & Comm Ctre)			n/a	12		Elec	20428					
Berridge	Hyson Green Market Site			n/a	12		Elec	2712					
Basford	Kibworth Close Community Centre			n/a	12		Elec	6546					
				n/a	12		Natural Gas	48359					
Not known	Kirkwhite Court Common Room			n/a	12		Elec	8020					
				n/a	12		Natural Gas	38477					
Bridge	Lace Market Multi-Storey Car Park			n/a	12		Elec	44894					
Clifton South	Lakehead House No 1			n/a	12		Elec	32222					
				n/a	12		Natural Gas	43779					
Arboretum	Larkdale Contact Centre			n/a	12		Elec	18823					
Bulwell	Lathkill Close Community Centre			n/a	12		Elec	46912					
Clifton North	Laura Chambers Lodge			n/a	12		Elec	179743					
				n/a	12		Natural Gas	683579					
Leen Valley	Leen Valley Community Centre			n/a	12		Elec	6490					
Bridge	Long Meadow Day Centre			n/a	12		Elec	57457					
Bridge	Lothmore Court			n/a	12		Elec	14048					
Dales	Manvers Court			n/a	12		Elec	74197					
Bulwell	Mariner Court No.11 E.P.H.			n/a	12		Elec	6496					
				n/a	12		Natural Gas	34719					
Bestwood	Masson Court Common Room			n/a	12		Elec	5776					
				n/a	12		Natural Gas	51174					
Bridge	Mayfield Court Community Centre			n/a	12		Elec	6655					
				n/a	12		Natural Gas	41755					
Bridge	Meadows Youth & Community Centre			n/a	12		Elec	20123					
Radford & Park	Meden Gardens Community Centre			n/a	12		Elec	5721					
				n/a	12		Natural Gas	39557					
Leen Valley	Naburn Court Laundry Room			n/a	12		Elec	7160					
				n/a	12		Natural Gas	19615					
Bulwell	Naomi Court Laundry			n/a	12		Elec	42559					
				n/a	12		Natural Gas	140195					
Berridge	New Basford Community Ctr (Silver Birches Day Ctr)			n/a	12		Elec	15563					
				n/a	12		Natural Gas	78933					
Bulwell	Northern Cemetery			n/a	12		Elec	12474					
				n/a	12		Natural Gas	34276					
St Anns	Oakdene Residential Unit			n/a	12		Elec	137150					
				n/a	12		Natural Gas	6370					
	Ogden Court Community Centre			n/a	12		Elec	23906					
Leen Valley	Orchard Court			n/a	12		Elec	19672					
				n/a	12		Natural Gas	60861					
Dunkirk & Lenton	Park & Ride Queens Drive			n/a	12		Elec	34665					
Dales	Park and Ride - Colwick Racecourse			n/a	12		Elec	117					
	Peartree Orchard			n/a	12		Elec	6947					
				n/a	12		Natural Gas	16487					
Dunkirk & Lenton	Penn Avenue Community Centre			n/a	12		Elec	4371					
Bridge	Queens Walk Community Centre			n/a	12		Elec	98331					
Basford	Rona Court			n/a	12		Elec	4031					
				n/a	12		Natural Gas	25489					
Arboretum	Selhurst Court			n/a	12		Elec	7974					
				n/a	12		Natural Gas	27586					
Bilborough	Sheila Russell Community Centre			n/a	12		Elec	15668					
				n/a	12		Natural Gas	64782					
Sherwood	Sherwood Community Centre			n/a	12		Natural Gas	140521					
Clifton South	Simone Gardens Common Room			n/a	12		Elec	18362					
				n/a	12		Natural Gas	34100					
Aspley	Six Ways Centre			n/a	12		Elec	12017					
				n/a	12		Natural Gas	53613					
Bulwell	Sketchley Court C.C.			n/a	12		Elec	7430					
				n/a	12		Natural Gas	38798					
Bulwell	Snapewood Community Centre			n/a	12		Elec	13823					
				n/a	12		Natural Gas	41782					
Dales	Sneinton Youth Club			n/a	12		Elec	12728					
Out of the City	Southern Cemetery and Crematorium			n/a	12		Elec	117362					
				n/a	12		Natural Gas	1891605					
Bilborough	St Agnes Close Community Room			n/a	12		Elec	18763					
St Anns	St Ann's Valley Centre			n/a	12		Elec	600828					
Bilborough	Stanwick Close E.P.H.			n/a	12		Elec	15710					
				n/a	12		Natural Gas	43133					
Aspley	Stepney Court			n/a	12		Elec	30964					
Bridge	Strome Court Common Room			n/a	12		Elec	10001					
				n/a	12		Natural Gas	46709					
Mapperley	Sunridge Court Community Centre			n/a	12		Elec	3935					
Leen Valley	Superintendent's House - Beechdale LC			n/a	12		Elec	7291					
Clfton North	Superintendents House- Clifton LC			n/a	12		Elec	2236					
Leen Valley	The Martin Jackaman Centre			n/a	12		Elec	123820					
				n/a	12		Natural Gas	514117					
Mapperley	The Oaks			n/a	12		Elec	94346					
				n/a	12		Natural Gas	8234					
Bilborough	The Willows			n/a	12		Elec	389129					
				n/a	12		Natural Gas	404604					
Clifton South	Todd Court Common Room			n/a	12		Elec	22225					
				n/a	12		Natural Gas	199000					
Bestwood	Townsend Court Common Room			n/a	12		Elec	33260					
St Anns	Trinity Square Multi-Storey C Park			n/a	12		Elec	492352					
Bestwood	Valley Farm Court			n/a	12		Elec	10832					
				n/a	12		Natural Gas	79004					
St Anns	Victoria Centre Surveillance Team			n/a	12		Elec	22088					
St Anns	Victoria Market			n/a	12		Elec	1293547					
Bridge	Willowbrook Court E.P.H.			n/a	12		Elec	11757					
				n/a	12		Natural Gas	61889					
Wollaton West	Wollaton Park Community Centre			n/a	12		Elec	12432					
				n/a	12		Natural Gas	59006					
Wollaton West	Wollaton Vale Community Centre			n/a	12		Elec	9617					
				n/a	12		Natural Gas	93054					
Dales	Woodview Court			n/a	12		Elec	6548					

InSMART – Integrative Smart City Planning

Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

Analysis of the city energy system – TRIKALA

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Executive Summary	
This report presents the energy footprint of the different sectors in a city of Trikala apart from the residential buildings and transport which were examined in detail in WP2 and WP3 respectively. More specifically the report refers to the energy consumption for public lighting, water and sewage system operation, municipal buildings and tertiary sector buildings. Furthermore the current situation regarding energy supply is presented and the potential of the local renewable energy sources is analysed.	
Keywords	Energy consumption, lighting, waste, water and sewage, tertiary sector consumption, renewable energy potential, energy supply.

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Acronyms and Definitions

CHP – Combined heat and power

GIS – Geographic information system

O&M – Operation and maintenance

PROMETHEE - Preference Ranking Organization METHod for Enrichment of Evaluations

PV - Photovoltaic

RES – Renewable energy sources

TIMES – The Integrated MARKAL-EFOM System

1. Introduction

1.1. Overview of InSMART

The InSMART concept brings together cities, scientific and industrial organizations in order to establish and implement a comprehensive methodology for enhancing sustainable planning addressing the current and future city energy needs through an integrative and multidisciplinary planning approach.

InSMART project intends to identify the optimum mix of short, medium and long term measures for a sustainable energy future, addressing the efficiency of energy flows across various city sectors, namely buildings, transport and mobility. Urban spaces, water/sewage system, waste chain and decentralized energy supply.

Each city's energy system will be analysed, covering all relevant sectors and a comprehensive GIS platform including energy database will be developed. Apart from being a valuable planning tool, the GIS database will inform and be linked to the TIMES planning model. This model will be used to analyse the cost-optimal mix of measures required to meet sustainable energy targets taking into account exogenous parameters (*e.g.*, environmental targets, city expansion). These measures will be further assessed with respect to non-technical criteria using a multi-criteria decision making method (PROMETHEE) that will address economic, environmental as well as social issues.

A detailed economic analysis of the mid-term measures identified through this two stage optimisation procedure will be undertaken, identifying all relevant investment indicators. Finally, a detailed, realistic and applicable mid-term implementation plan will be developed to describe the necessary steps, required resources and monitoring procedures for each city.

1.2. Objectives of this Report

This report refers to WP4 (Tasks 4.1. to 4.4.), including the analysis of the current status of urban spaces, water/sewage systems, waste chain and decentralised energy supply at the cities level.

This report describes the relevant city sectors excluding Residential Buildings and Transports, already characterized and assessed in WP2 and WP3.

In a graph theory-like vision, surveys undertaken under the WP2 and WP3 provide the description of "nodes" (demand centers), namely the quantification of the stocks of processes and technologies (e.g. buildings, space heating devices, vehicles) and characterization of energy services required in the selected geographical polygons of the urban area.

The goal of WP4 is to extend the analysis of the demand centers including relevant non-energy services, and to look at the "edges" (the physical networks linking different demand centers and allowing the movements of energy, people and goods) and at the devices used to properly operate the urban infrastructures.

1.3. Outline of the Report

The report is organized in 7 chapters. Chapter 2 presents an overview of the city sectors that were used in the analysis of the residential energy demand and the transport analysis in the city of Trikala. Chapter 3 presents the energy footprint of urban spaces, including public lighting, gardens and open areas and public fountains. Chapter 4 presents the water and sewage systems and their respective energy consumption and Chapter 5 presents an analysis of the waste chain in the city. The energy supply system and the potential of renewable energy sources is analysed in Chapter 6. A detailed analysis of the energy consumption of residential buildings was performed in WP2. In order to complete the analysis of the building sector Chapter 7 presents the energy behaviour of the non-residential buildings. This includes the buildings that are managed by the Municipality and all the other tertiary sector buildings.

2. City Districts General Description

This section presents a brief description of the city of Trikala regarding the spatial sectors (or districts) that were previously selected for the buildings and transport surveys and assessment. These districts will be used within report as one of the spatial layers for the description of the other energy consuming sectors (described in the next sections) and later on in the integrative modelling in WP5.

The city of Trikala is distinguished in 17 Urban Units and 20 City Districts divided into numerous building blocks. The Urban Units represent the urban development of the city in time including historic neighbourhoods such as "Varousi" or the new city centre or the commercial centre, while the City Districts are linked with the transport mobility of the city's population from specific mobility centers to others. The Building Blocks are composed from the geographical data of Census 2001 of the Hellenic Statistic Authority (EL.STAT) and altogether form the study area of interest in the INSMART project. Each building block has a specific Occupancy Type. The related statistical data from EL.STAT for the Building Blocks is available as well.

There are 2 Occupancy type layers available from Trikala Municipality. The first type consists of occupancy zones (polygons) that may intersect a building block, so that one or more occupancy types exist within the same building block. The second type consists of building blocks, which are not identical to EL.STAT's. Each building block has a specific occupancy type that indicates the type in the entire block (Figure 1). These 2 layers were used to assign an occupancy type to each geographical unit of EL.STAT. Figure 1 shows an example of the Occupancy Types for the city of Trikala. Figure 2 shows the overlaps of the 17 Urban Units with the 20 City Districts.

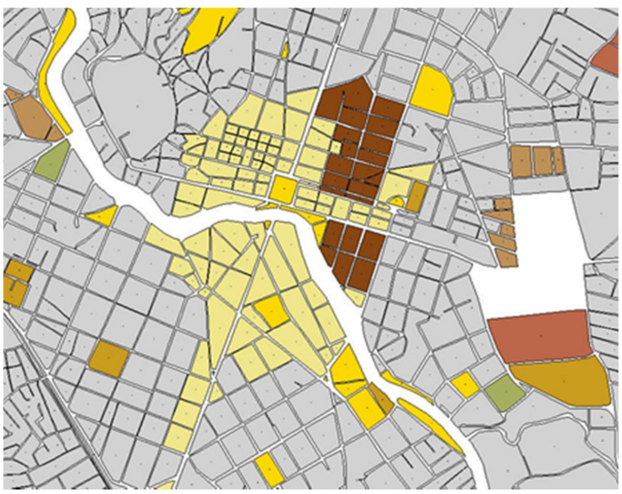

Figure 1: Example of occupancy type that indicates the zone in the entire building block

Figure 2: Map of the city of Trikala showing, the Urban Units, VS the City Districts.

The graphic below presents the methodology used in order the City Districts to be divided into Building Blocks and typologies. Each typology in each Building Block has specific total area (m2).

Although the outlines of buildings are also available from EL.STAT, they could not be used as the basic geographical entity for the purpose of our modeling, due to the fact that the available statistical data is not available for each individual building as explained below (Identification of building typologies). Due to the fact that the data of EL.STAT was not adequate for the InSmart building modeling (data is not available on a building basis), additional data from other sources such as Urban Units has been used.

The Trikala City's 20 Districts are depicted in the Figure 3, whereas apart from the geographical borders the respective population is presented. The most populated city district sectors are Nr 4. 8. 12 and 19 where there are more than 5000 inhabitants. In Table 1 the City Districts Names and the respective population of each District is Presented.

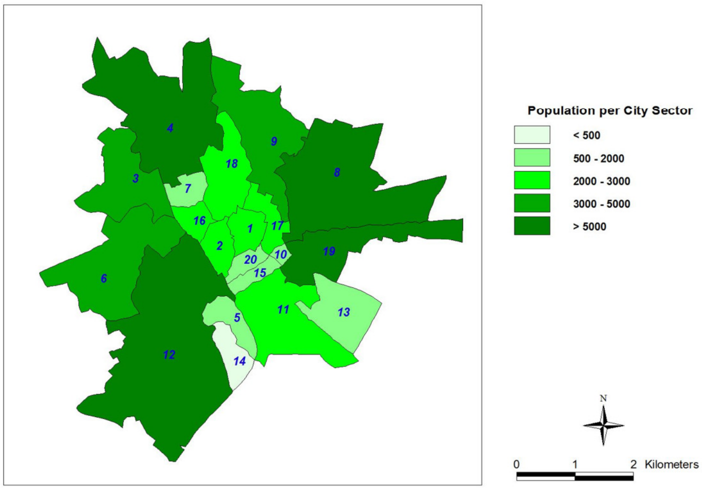

Figure 3: City Districts Population Map

Table 1 City Districts Name and respective population

SECTOR	SECTOR NAME	POPULATION
1	City Centre	2537
2	Alexandra	2473
3	Pirgos	3491
4	Koutsouflianis	7323
5	Papamanou	527
6	Pirgetos	4031
7	Nekrotafio Trikalon	1995
8	Mavili	6917
9	Paleologou	3434
10	Spartis	506
11	General Hospital	2974
12	Train Station	9422
13	Patmou	644
14	Flamouliou	364
15	Archimidi	1417
16	Dim Ntai	2042
17	Sokratous	2599
18	P Mela	2860
19	Ethniko Stadio	5222
20	Siggrou	1378

Moreover, in Table 2 for each City District the Buildings population (total sqm) is presented per different Building Typology. From the disperse of the typologies it can be seen that the T7 and T7i typologies which are the single house, double house after 80s buildings along are located everywhere throughout the city where the multifloor buildings T5 , T5 , T5i and T6, are located mostly to the business and commercial centre of Trikala. These data are confirmed by the EL.STAT statistics as well as the the City' view. GIS maps showing the Buildings population (total sqm) in the City

Districts for specific Building Typologies such as T4 and T7 are presented on Figure 4 and Figure 5 respectively.

Table 2: City Districts Name and respective Buildings population (total sqm) per typology

		RESIDENTIAL AREA PER BUILDING TYPOLOGY (SQM)							
SECTOR	SECTOR NAME	T1	T2	T4	T5	T5i	T6	T7	T7i
1	City Centre	390	0	74214	901	34235	576	3118	0
2	Alexandra	1441	0	12677	87849	15707	29663	77937	8558
3	Pirgos	80	0	0	0	0	0	17451	23047
4	Koutsouflianis	240	0	0	0	0	1129	61844	19547
5	Papamanou	0	0	0	0	0	0	5287	2896
6	Pirgetos	275	0	0	0	0	0	22426	11859
7	Nekrotafio Trikalon	125	0	0	0	0	0	33417	8508
8	Mavili	170	0	0	0	0	0	49105	15044
9	Paleologou	263	0	0	19499	0	15426	60082	34873
10	Spartis	0	0	0	978	0	2449	11142	2582
11	General Hospital	160	0	0	0	0	0	48071	16301
12	Train Station	638	0	0	0	0	805	112627	54027
13	Patmou	0	0	0	0	0	0	6665	1316
14	Flamouliou	100	0	0	0	0	0	3474	1097
15	Archimidi	270	0	0	8250	0	2985	25572	7254
16	Dim Ntai	465	0	0	11390	0	2463	35578	12441
17	Sokratous	1780	0	19359	71574	27903	13277	66059	9085
18	P Mela	7154	23126	4138	5297	1449	1425	32540	2077
19	Ethniko Stadio	85	0	0	0	0	0	29177	11177
20	Siggrou	502	0	0	10387	0	2525	23639	6407

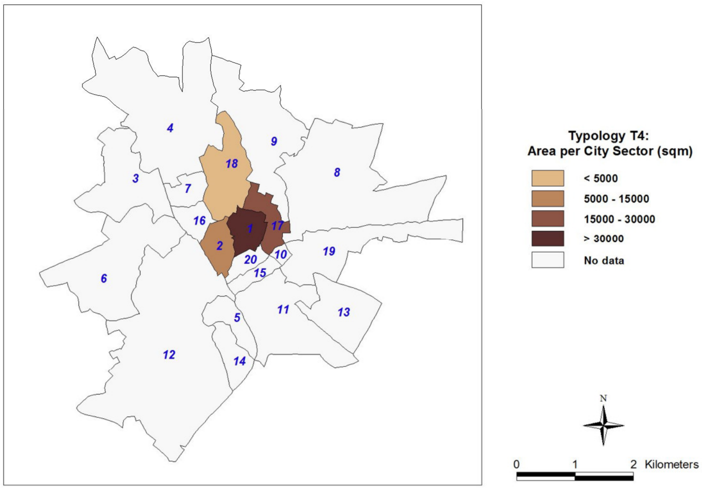

Figure 4: T4 typology population (sqm)

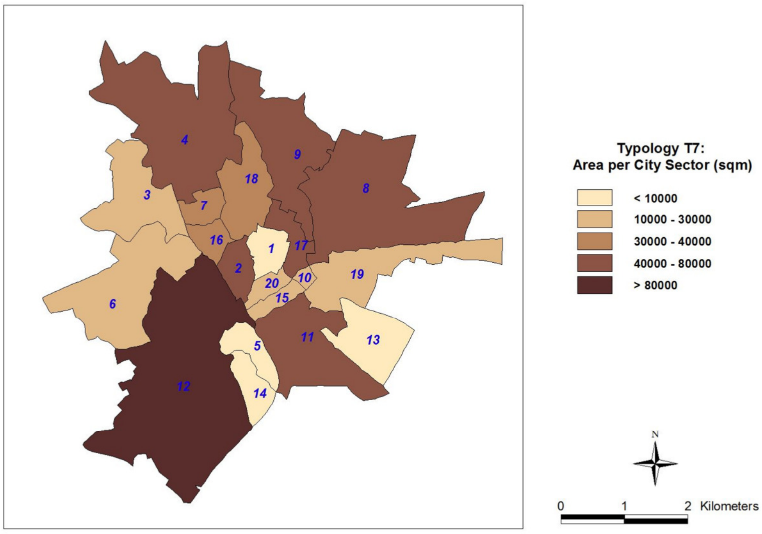

Figure 5: T7 typology population (sqm)

3. Urban Spaces

Chapter 3 analyses the energy uses in urban spaces, including public lighting. The electricity consumption for public lighting in done through the analysis of aggregated data. These include electricity bills and the total number of installed light bulbs, per type and the corresponding operating hours. The future plans for replacement of the existing lighting systems will be used in the TIMES energy system model in order to analyse the energy efficiency scenarios.

3.1 Public Lighting

Characterization

City of Trikala main urban kernel is included inside a global ring road of 21Km (Figure 6), which interconnects all the city entrances with the main national roads (to Larissa, Karditsa, Ioannina and Arta (Pyli)). With regard to its energy network facility, the Municipality of Trikala is responsible for a part of it (the remainder belongs to the National Energy provider (DEI)), which length is approximately 44,5 Km, which comes across the main city districts and roads. A total number of 3.007 lamps have been encountered in this network, mainly of 250W power.

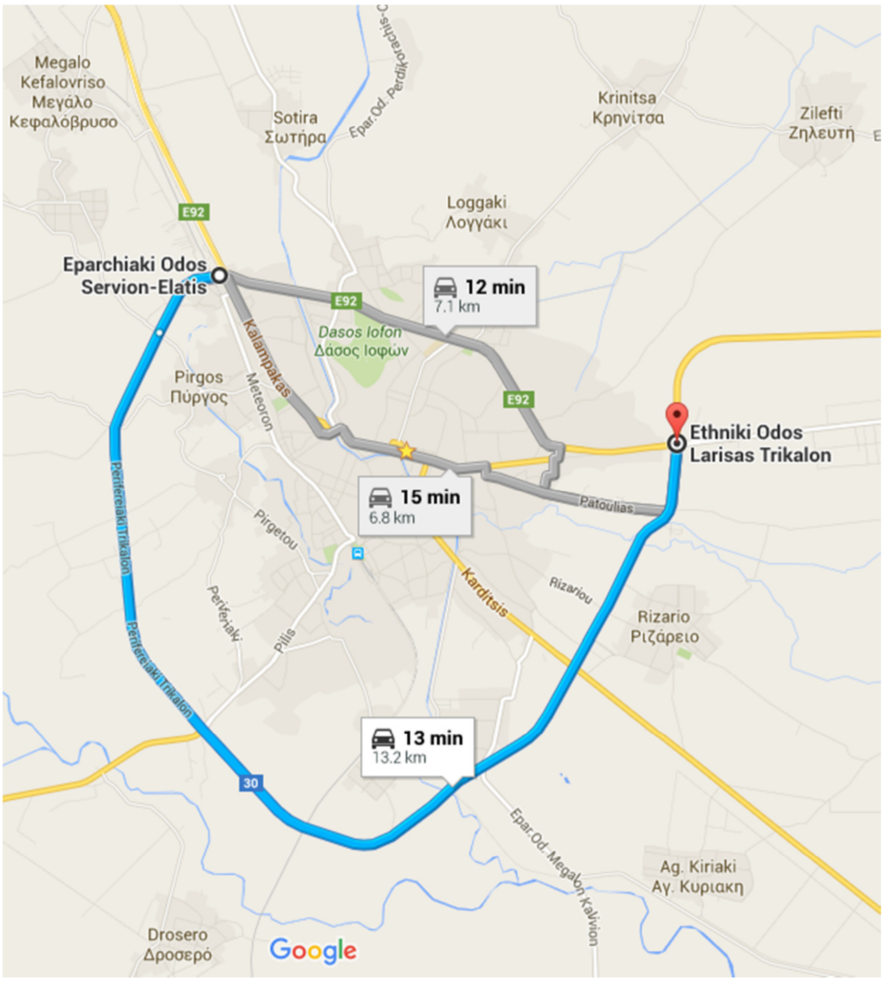

Figure 6: Trikala city urban space

The above description of the public lighting system in the city of Trikala can be summarized to the following:

- Length of network (km): 44,470m
- Masts and luminaires characterization
    - Number of masts: 937
    - Number and type of luminaires (total and by masts): 3,007
- Lamps characterization
    - Number and type (Mercury, Sodium, LED, etc.):
        - Sodium Lamps: 2,888 250W
        - Sodium Lamps: 122 400 W
    - Age (years): 5-15
- Operation control system characterization: N/A
- Normatives on exterior lighting for safety and security: N/A
- Current energy efficiency/energy reduction policies in place: N/A

The above public lighting network is being deployed mainly in 33 streets and the 2 halves of the ring road, while it passes over 4 bridges and connects 3 nodes and 3 squares. A detailed table for the public lighting system that is run by the Municipality is included in the Appendix in sheet "3. Urban Spaces".

GIS Maps

The GIS map with the public lighting system is available on the live GIS application on the project website at http://beta.cres.gr/insmart/trikala.

Future Plans

The Municipality of Trikala has developed a study of replacing the entire sodium lamp-based public lighting network with LED lamps. According to the study, the network upgrade will be assigned to a contractor, who will be responsible for its operation for a 5-year contract and will be funded by the energy savings that will be secured for the Municipality. This upgrade will be included in the TIMES model for the city of Trikala.

3.2 Gardens/green areas and public fountains

Characterization

A total of 6 fountains is installed in the primary city squares, which cause an electricity consumption of an approximate €2,570 per annum which corresponds to about 21.6MWh per year.

Detailed description of this topic on electricity consumption and O&M costs are included in Tables 3 and 4 of the Appendix in sheet "3. Urban Spaces".

GIS Maps

The GIS map with the public areas is available on the live GIS application on the project website at http://beta.cres.gr/insmart/trikala.

Future Plans

The city of Trikala has planned to develop other 2 fountains by 2019, of a total budget of €22,260, pumped with recycled water, which is part of a broader recycling water network project. Moreover, 7 green area/garden projects are planned to be developed within the next 3 years (by 2019), of an approximate total budget of €685,000.

Detailed description of the information needed for this topic is described in Tables 5 e 6 of the Appendix in sheet “3. Urban Spaces”.

4. Water and Sewage Systems

4.1 Water Treatment and Distribution Systems

Characterization

The city of Trikala hosts a population of approximately 80,000 residents, which its Water and Sewage Collection and Distribution municipal company (DEYAT) has the duty of the installation, operation and maintenance of the corresponding water supply network. This network covers the entire urban kernel of the city and all corresponding facility is installed within its boundaries.

A set of 12 water pumps supports the operation of the central drill station and all provide an amount of 2,2 m^3/h on a daily basis. Water treatment is performed in the central station, before water distribution. This productivity rate results to an average annual consumption of 240 m^3 per resident.

Detailed description of each facility is provided on Sheet 4. Water and Sewage Systems, Table 7 of the Appendix.

GIS Maps

The GIS map with the position of the pumping stations is available on the live GIS application on the project website at http://beta.cres.gr/insmart/trikala.

Future Plans

DEYAT has recently installed a data centre that enables remote water consumption monitoring and measurement, which covers a proportion of 20% of the entire water supply network. Its plans concern the expansion of this network to all its consumers within the following 3 years (2019).

Moreover, it plans to renovate parts of the water supply network, which were installed 40 years ago and result to water loss and water quality impacts. An approximate amount of 2Km pipes are planned to be replaced inside the city by 2020.

4.2 Sewage Systems

Characterization

The city has installed a central sewage collection and treatment centre with the ability to treat an amount of 300m^3 of wastewater per hour. This centre covers the entire city with its entire population and collects sewage with the support of 7 pump stations located inside the city, which can supply an amount of 636m^3 of wastewater per hour. This productivity rate result to an approximate amount of 69.4m^3 of waste water collected and 32,85m^3 treated for each inhabitant on an annual basis.

Table 9 of the Appendixcontains detailed information with regard to this section in sheet “4. Water and sewage”.

GIS Maps

The GIS map with the position of the pumping stations for the sewage system is available on the live GIS application on the project website at http://beta.cres.gr/insmart/trikala.

Future Plans

DEYAT has planned the implementation of a project that extends its sewage network beyond the city boundaries by 2019, in its attempt to serve city's eastern and western suburbs. This project concerns the installation of a second treatment centre and an accompanied sewage collection network of an approximate 5 Km length. Treated water is planned to serve municipal garden watering and the operation of 2 fountains that will be installed in nearby regions. The budget of this project is expected to exceed €22 million.

Table 10 of the Appendix in sheet "4. Water and sewage" contains the detailed information for the development plans of the sewage treatment system in Trikala.

5. Waste Chain

Characterization

The city of Trikala uses its own fleet of 16 vehicles to perform garbage collection from green buckets located across the city and 3 vehicles for recycling purposes from blue buckets too. Vehicles' age varies from 10 to 18 years, they can carry 4,3 tons of waste and they run a distance of 1,920 Km on an annual basis.

This system covers the needs of the entire city and its inhabitants and a total amount of 27,557 tons of garbage has been calculated to be collected on an annual basis. This results to a collected amount of 0.34 tons of garbage per resident on an annual basis.

The basic proportion of the collected solid waste (86.5%) is being delivered to landfills, while the remainder (0.047 tons per resident on an annual basis) is being recycled as follows:

- Plastics: 1.56% (429,88 tons)
- Glass: 0.20% (55,11 tons)
- Paper: 11.56% (3185,58 tons)

Non-recyclable material and organic waste is being delivered to Spaces of Uncontrollable Litter Disposal (S.U.D.L.) and waste sanitary land filling and its extensions. On the other hand, municipal vehicles deliver the recyclable waste to the Recycling Sorting Plant (R.S.P.), which is installed outside the city and controlled by a regional organization named Environmental Development Agency of Western Thessaly S.A. (PADYTH S.A.), where all Municipalities of Western Thessaly participate.

Details of the waste treatment chain are described in Tables 11 to 14_of sheet "5. Waste Chain" of the Appendix.

GIS Maps

The GIS map shows the position of the landfill site in Trikala.

Future Plans

No particular future plans have been composed by the Municipality with regard to solid waste chain management improvement or upgrade.

6 Energy Supply System

An overview of the existing decentralised energy generation systems in Trikala is presented in this chapter, together with the existing infrastructure for the supply of electricity and natural gas. An estimation of the potential of RES at the level of the Municipality is also performed which will be used as an input to the modelling analysis of the city energy system.

Natural Gas

A high pressure natural gas pipeline connecting Trikala to the main gas pipeline in Greece started operation in 2010 (Figure 7) and since then the local utility is expanding the distribution system within the city. The peak capacity of the pipeline connection that covers the area of the city is 20000 Nm^3/h and the maximum daily capacity is 5356 MWh/day. According to the data provided by the Hellenic Gas Transmission System Operator[1] the maximum demand in 2014 reached only 15% of the maximum capacity of the pipeline, which shows that there is still a high potential for the introduction of N. Gas in the city. A total of 6859 connections to the network exist and the distribution network with a total length of 83kms could cover currently up to 46% of the population in the city. The total consumption of natural gas in 2014 was 47.2GWh.

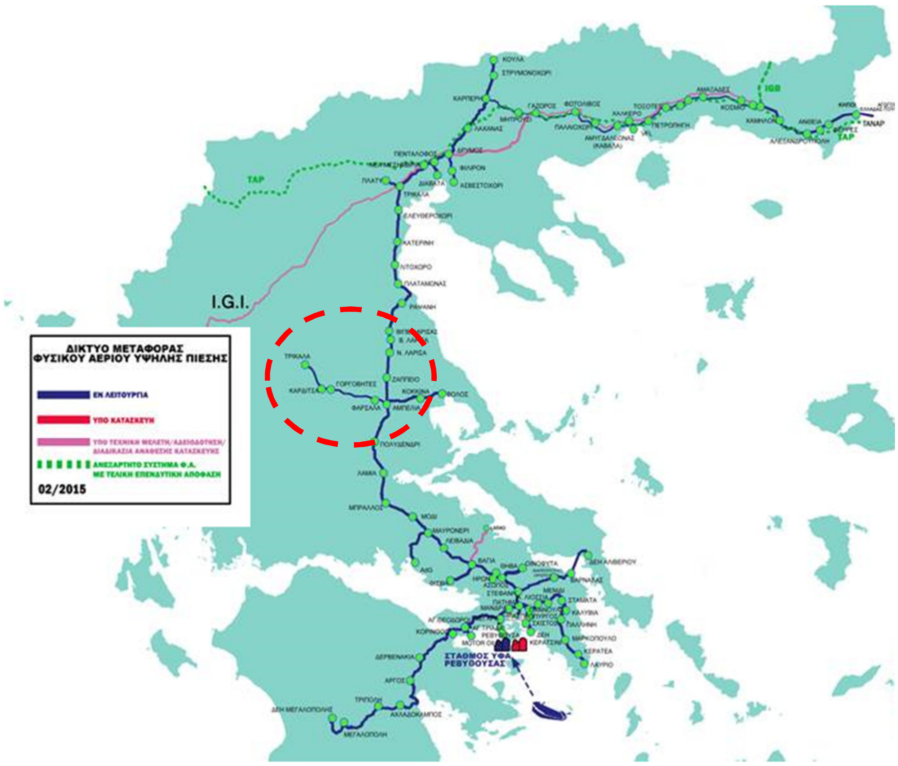

Figure 7: Natural Gas pipeline network in Greece.

[1] http://www.desfa.gr/

Data regarding the energy supply in Trikala was collected with the contribution of the urban planning municipal service and the natural gas provider. According to existing data, an approximate number of 11,500 space heating systems using heating oil have been installed in the city since 1970. Diesel Oil was the primary heating source for city buildings but this changed mainly after the financial crisis in 2010 and the combined effect of the availability of Natural Gas in the city. Since 2010 an approximate number of 6,850 natural gas heating system have been installed in the city, enabling 135 users to be connected to an approximate 4.2 Km mean-pressure and almost 7,000 users to be connected to an approximate 83,5Km low-pressure network. These units replaced or work in parallel with the oil heating systems, while they serve both households' heating and cooking needs. With regard to its performance, the natural gas network supplies: the 40% of the residential district (urban kernel) with an approximate 180Km length pipe-network and 110 MWh power supply; 25% of the commercial city district with an approximate 45 Km length pipe-network and 41MWh power supply; 14% of the industrial and agricultural city districts with an approximate 25 Km length pipe-network and 38MWh power supply; and the 3% of public buildings with an approximate 5 Km length pipe-network and 8MWh power supply.

Electricity

The city of Trikala is connected to the 400kV lines that run from the North to the South of Greece with a double 150kV circuit (Figure 8). This offers the possibility of installing and connecting local power stations (mainly renewable energy technologies) without problems and without the need of expensive line expansions.

There aren't any power plants installed in the vicinity of the city while a total of 4.5MWs of rooftop PVs are in operation. The average generation of rooftop PVs in the region is estimated to be 1250kWh/kW, based on recorded data presented in the National Registry of RES installations[2].

There is no detailed information on a city level regarding the installed hot water solar systems and the city does not have a district heating network. An estimation of the number of existing solar water heaters can be performed using the average statistics of the country.

[2] http://www.resoffice.gr/file/reg/searchprod_pvr.jsp

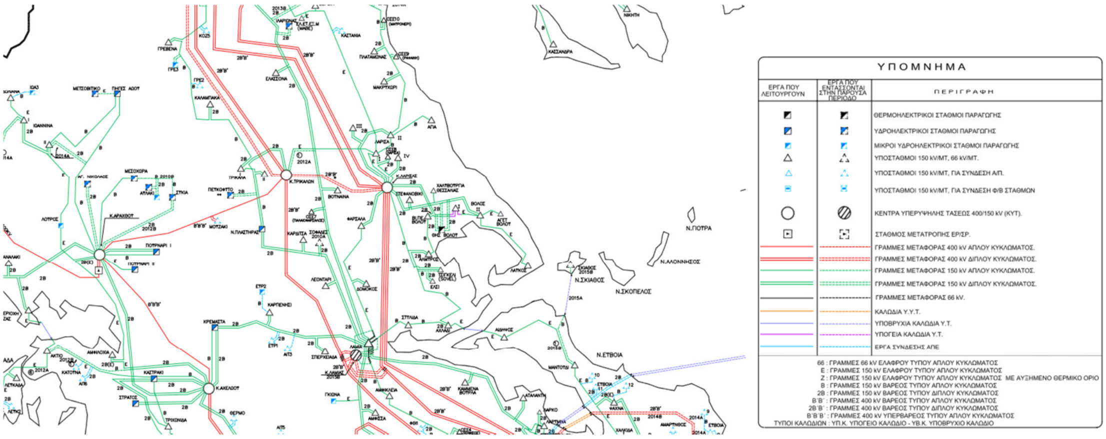

Figure 8: Electricity transmission network in Greece.

Renewable Energy

Renewable energy units' installation remains far behind, since corresponding government policy has been transformed quite a lot during its initial appearance in 2009 and impacted private investments. Most of the renewable energy systems concern solar power parks, which have been installed in open lands nearby urban borders and provide energy that is being sold to the energy provider (DEI). An approximate amount of 280 units of 30-year life-time have been installed between 2010 and 2013 in the urban space, they support heating and electricity consuming, while most of them produce 13,500 KWh annually. Solar panels are located on both private and public buildings and operate approximately 4,320 hours per annum, while they cover an approximate proportion of 80% of household needs.

Assessment of RES resource potential

The following sections present an analysis of the renewable energy resource potential in the city of Trikala. The resources examined are:

1) Solar PVs both at the level of roof top installations on residential buildings and installations in large commercial buildings and other areas within the city limits.
2) Solar water heaters for roof top installations on residential buildings.
3) Geothermal potential (low enthalpy geothermal in particular).
4) Wind resources in the city.
5) Biogas resource potential from the sewage treatment system and the landfill.
6) Biomass resource potential in areas surrounding the city.

Roof top solar installations (PV and Solar Water heaters).

In order to estimate the technical potential for PV and Solar water heater installations on the buildings, the first step is to identify the area that is available on the roof of the buildings. The following procedure was used in the city of Trikala in order to perform this estimation:

1) In the city of Trikala, for each one of the city sectors, the GIS system holds information on the total area (m^2) per typology of residential buildings. Each building typology has an average number of floors associated with it. Therefore, the ratio of the total area over the average number of floors provides an estimation of the total roof surface for each typology per city sector. This is presented in Table 3 together with the type of roof that is associated with each typology.

Table 3: Estimated roof area of residential buildings per typology and city region (m2)

	Typology									
City Region:	T1	T2	T3	T4	T5	T5i	T6	T7	T7i	Estimated roof area (m2)
1	195		133	18554	150	6847	82	3118		**29,078**
2	721			3169	14642	3141	4238	77937	4279	**108,126**
3	40							17451	11524	**29,015**
4	120						161	61844	9774	**71,899**
5								5287	1448	**6,735**
6	138							22426	5930	**28,493**
7	63							33417	4254	**37,734**
8	85							49105	7522	**56,712**
9	132				3250		2204	60082	17437	**83,104**
10					163		350	11142	1291	**12,946**
11	80							48071	8151	**56,302**
12	319						115	112627	27014	**140,075**
13								6665	658	**7,323**
14	50							3474	549	**4,073**
15	135				1375		426	25572	3627	**31,135**
16	233				1898		352	35578	6221	**44,281**
17	890			4840	11929	5581	1897	66059	4543	**95,738**
18	3577	11563		1035	883	290	204	32540	1039	**51,129**
19	43							29177	5589	**34,808**
20	251				1731		361	23639	3204	**29,185**
Roof Type:	Sloped	Sloped	Sloped	Flat	Flat	Flat	Flat	Sloped	Flat	

2) Typology T1 refers to buildings constructed before 1900, in the old city, and the existing restrictions in the building codes do not allow the installation of PV systems on its roof. For this reason the available area for this typology is considered to be zero. According to Karteris et al[3] in Greek cities *"The density of the urban built environment, the differences in the attached buildings' heights, the mandatory parapets, which are frequently opaque, the existence of obstacles like stairwells, shafts, etc. reduce the exploitable surfaces quite significantly, frequently to less than 50% of the roof's*

[3] "Urban solar energy potential in Greece: A statistical calculation model of suitable built roof areas for photovoltaics", Karteris et al, Energy and Buildings 62:459-468, July 2013.

surface."[3]. Therefore, a conservative approach of considering 40% of the gross roof area as area available for the installation of solar systems was used for Trikala. This leads to the area estimates presented in Table 4.

Table 4: Estimated roof area per typology and city region (m2)

	Typology									
City Region:	T1	T2	T3	T4	T5	T5i	T6	T7	T7i	Estimated roof area of residential buildings (m^2)
1			53	7421	60	2739	33	1247		**11,553**
2				1268	5857	1257	1695	31175	1712	**42,962**
3								6980	4609	**11,590**
4							65	24738	3909	**28,712**
5								2115	579	**2,694**
6								8970	2372	**11,342**
7								13367	1702	**15,068**
8								19642	3009	**22,651**
9					1300		881	24033	6975	**33,189**
10					65		140	4457	516	**5,178**
11								19228	3260	**22,489**
12							46	45051	10805	**55,902**
13								2666	263	**2,929**
14								1390	219	**1,609**
15					550		171	10229	1451	**12,400**
16					759		141	14231	2488	**17,619**
17				1936	4772	2232	759	26424	1817	**37,939**
18		4625		414	353	116	81	13016	415	**19,021**
19								11671	2235	**13,906**
20					692		144	9456	1281	**11,574**
Roof Type:	Sloped	Sloped	Sloped	Flat	Flat	Flat	Flat	Sloped	Flat	

The average slope of the roofs in typologies T2 and T3 is 30^{o} according to the normal building practices in Greece.

3) The estimation of the roof top areas of non-residential buildings was performed in the next step. The GIS map offers the possibility to calculate the total roof area of all the buildings in each city region. Subtracting the gross area of the residential buildings shown in Table 4, the remaining area corresponds to the roofs of the non-residential buildings. The same rule of thumb used in the residential buildings considering that 40% of the gross area is available for solar installations is also applied in the non-residential buildings giving the distribution presented in Table 5 per city sector.

Table 5: Available roof surface on non-residential buildings.

City Sector	Available roof top surface (m^2)
1	48490
2	16766
3	27568
4	66462
5	4840
6	31629
7	17173
8	44486
9	39715
10	2173
11	29886
12	88758
13	8634
14	5963
15	10535
16	14867
17	25506
18	26195
19	33527
20	9083

As was analysed in detail in "D2.2 Simulation Report for Building Typologies in Trikala", the majority of new residential buildings in Trikala are constructed in a "continuous" system, without leaving free spaces between buildings and creating high levels of shading of the vertical surfaces. For this reason the potential of building integrated PVs on the facades of residential buildings is considered to be negligible. Some tertiary sector buildings could be considered as appropriate for façade integrated PVs but their number is so small that is not expected to make an impact on the overall energy system of the city.

An analysis of the available free spaces in the city, led to the conclusion that there are no other available area which could be used for the installation of PVs other than the roof top areas described above.

Geothermal Energy

Greece has areas with high geothermal potential[4] associated with volcanic activity and tertiary basins. However, as can be seen in Figure 9, the areas of geothermal potential

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[4] "Update and Characteristics of Low-Enthalpy Geothermal Applications in Greece" N. Andritsos, P. Dalabakis, G. Karydakis, N. Kolios and M. Fytikas, Proceedings European Geothermal Congress 2007 Unterhaching, Germany, 30 May-1 June 2007

are not located around the city of Trikala. Furthermore, there are no indications of geothermal activity in the area (hot springs etc.) and for this reason geothermal technologies will not be considered in the analysis of the energy system modelling in TIMES. The only use which will be included in the modelling is the installation of geothermal heat pumps for heating and cooling of buildings.

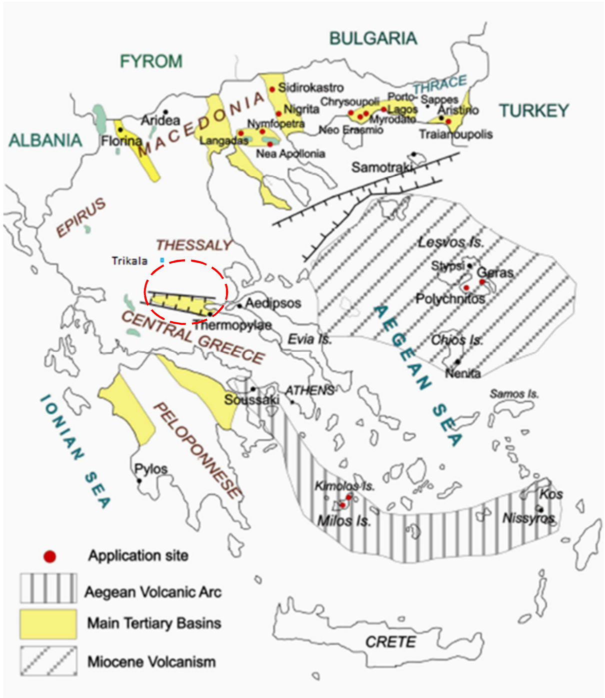

Figure 9: Geothermal potential in Greece

Wind potential

A detailed wind atlas of Greece was developed in 2001 by CRES, using measured data from a number of locations around the country and flow simulation software in order to calculate average annual wind speeds. Figure 10 presents the wind speed map around the city of Trikala. The area is flat, without significant level of wind speed. The average annual wind speed calculated in the wind atlas is below 4 m/s in the city and all the surrounding areas, which is rather low. High-rise buildings that could create more favourable wind conditions do not exist in the city of Trikala. In the city centre the tallest buildings are seven storeys high (around 25m), while in the areas around the city centre the majority of the buildings are 2-3 storeys high.

According to literature data, small horizontal axis wind turbines with a nominal capacity of 2.5kW can operate at a nominal wind speed of 9m/s and have a start wind speed of 3m/s[5]. Manufacturers' data for Vertical Axis Wind Turbines also show that the range of the nominal wind speeds is from 9 to 14 m/s (even for 300W machines[6]).

[5] URBAN Wind Turbines, Guidelines for small wind turbines in the built environment, Wind Energy Integration in the built environment project, 2007 www.urbanwind.org

[6] http://www.windturbinestar.com/300w-vertical-wind-turbine.html

This analysis show that the installation of small urban wind turbines in the city of Trikala is not considered being a viable option. Therefore, urban wind turbines will not be included in the analysis that will be performed in the framework of the project.

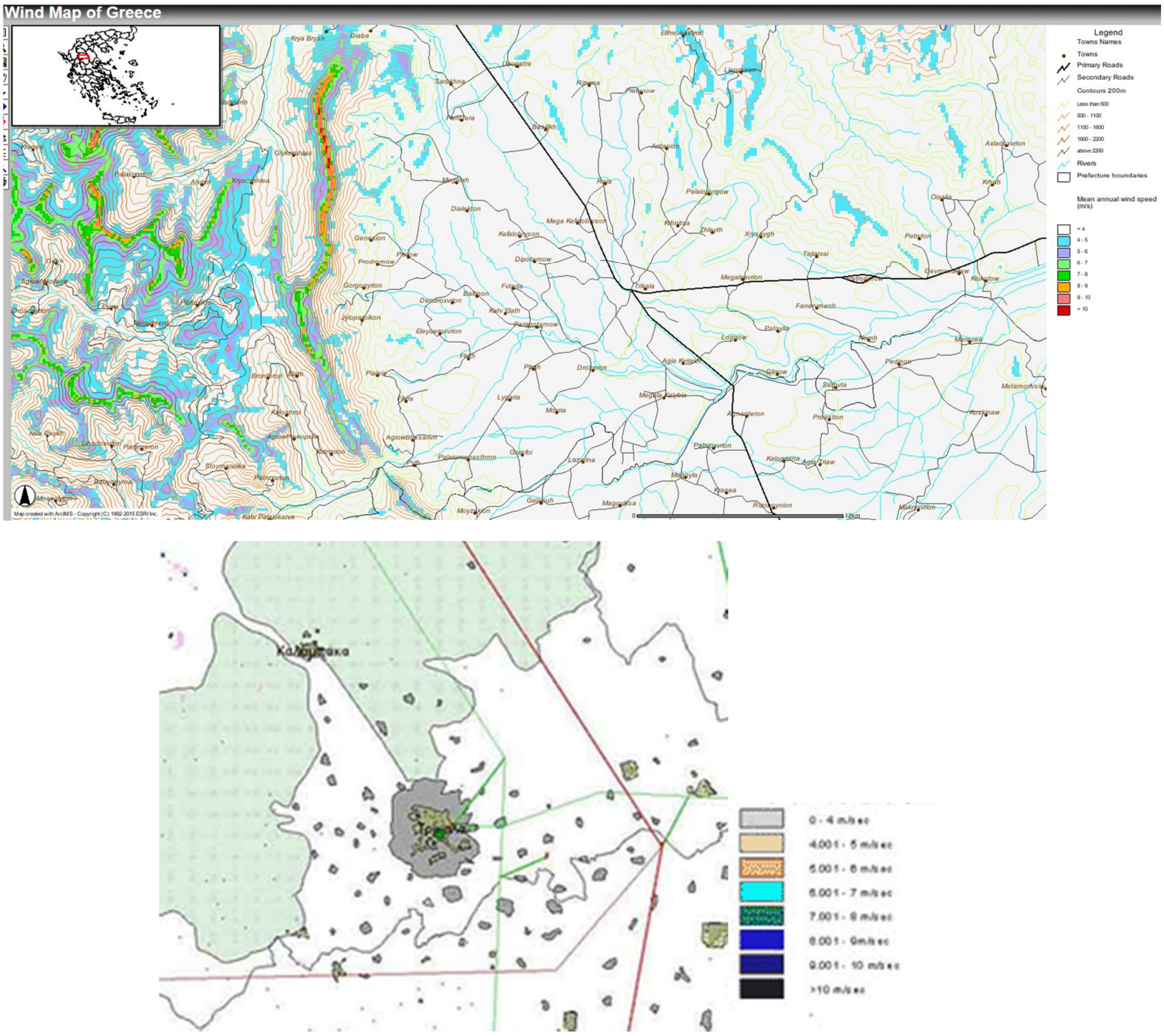

Figure 10: Estimated annual average wind speeds in and around Trikala (Source: Wind Atlas of Greece, http://www.cres.gr/kape/datainfo/maps.htm).

Biomass

The Prefecture of Trikala, according to the latest data from the Greek Statistical office, has 57711hectares of land used for agricultural purposes. The local agricultural production includes cotton, tobacco, fruits and vegetables, wheat and corn. Furthermore, almost 1/3 of the total area of the prefecture is covered by forests with mainly fir, oak and beech.

The geographical boundaries for the analysis regarding energy consumption in buildings and transport, and in the analysis of available solar technologies' potential, were defined to be the same as the boundaries of the city of Trikala. However, in order to assess the potential of biomass available for energy uses, the boundaries of the analysis were extended to those of the Municipality, which extend to include farm land that can be the source of biomass.

The available potential of solid biomass in the Municipality of Trikala was assessed by CRES and is available in the form of online maps[7]. This assessment was used as the main source of information for the biomass potential presented in the following tables.

The theoretically available potential for biomass is divided in the following categories:

- **Residues from wood processing factories:** The estimated theoretically available potential is 1567GJ of biomass per year.
- **Arable crops:** Figure 11 presents the available potential from residues of arable crops (wheat, corn, cotton, tobacco etc.). The total theoretical available potential within the boundaries of the Municipality is estimated to be 63769 GJ per year.

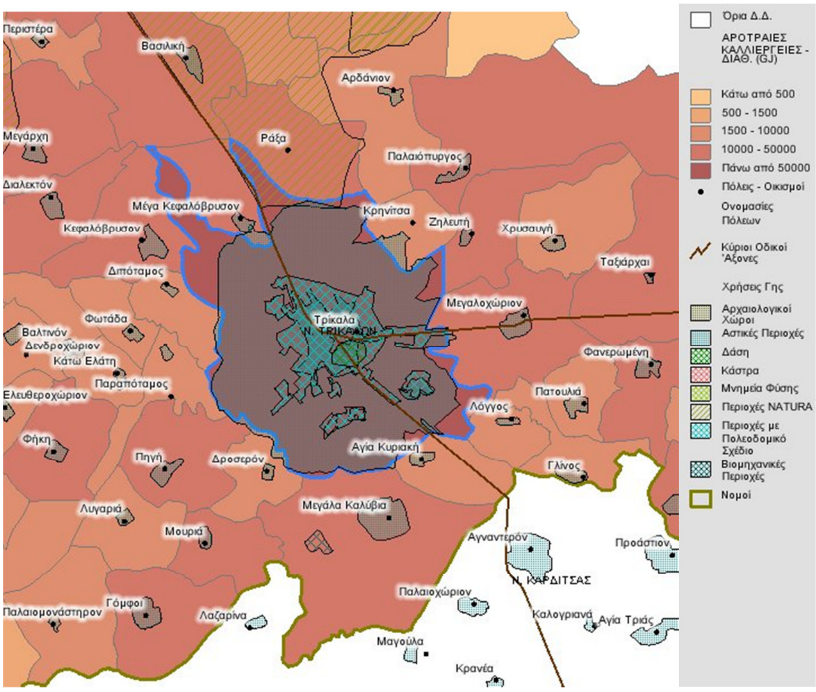

Figure 11: Arable crops residues available potential.

- **Vegetables produced in greenhouses:** There are a number of greenhouses within the boundaries of the Municipality and the available energy potential is estimated at 2736GJ per year.
- **Tree Crops** (fruit and olive trees) in the Municipality can produce prunings that reach 2069GJ per year.

Summarizing these data, the available potential of biomass in the form of agricultural residues is given in the following table:

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[7] http://www.res-thermal.info/servlet/SDEBiomassServlet

	Available Potential (GJ)
Residues from wood processing factories	1567
Arable crops	63769
Vegetables produced in greenhouses	2763
Tree Crops	2069
Total	**70168**

Forest residues are not available within the limits of the Municipality but a rather high potential is available in the prefecture of Trikala and in neighboring municipalities (Figure 12). However, these are not included in the analysis since they can be considered as energy sources outside the limits of the city, that can be supplied at a certain cost level.

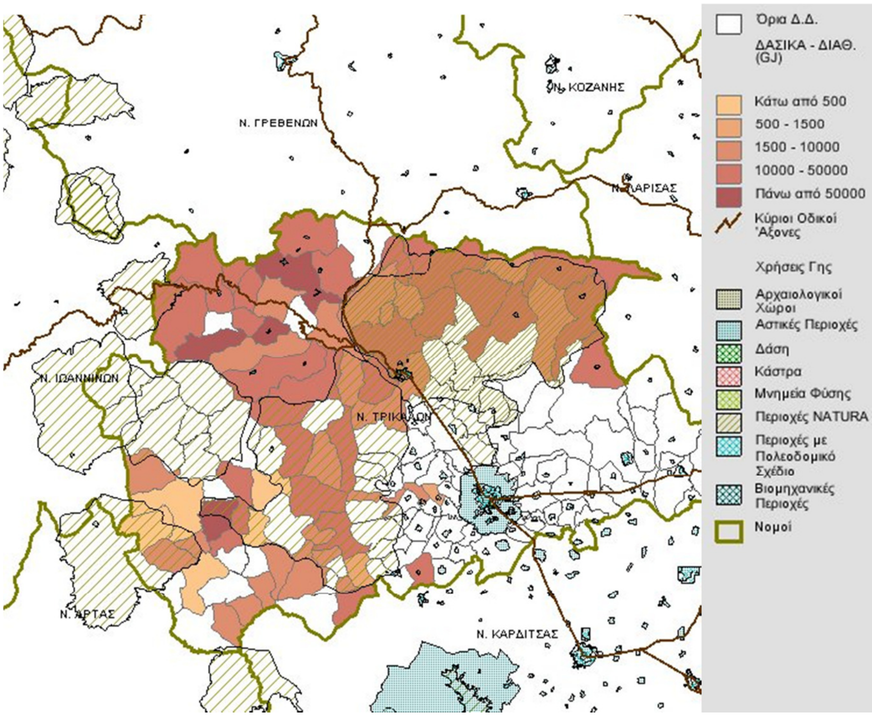

Figure 12: Forest residues available potential.

Biogas

The possible sources of biogas in Trikala are:

1) Municipal Sewage treatment plant
2) Landfill, which was used as a repository from the whole Region of Thesallia, so it cannot be considered as a municipal resource.
3) Local factories for milk products that could have biogas production facilities, which they use to cover their own needs. There are six such factories in the prefecture of Trikala and two of them are close to the city of Trikala. One factory already plans to install a biogas plant of 3MW.

4) Local cattle and pig farms that can be used as a source of organic waste. According to an analysis performed in the framework of the project Big - East[8], the theoretically available organic wastes and the estimated power output from a biogas plant that could use all this capacity is shown in the following table. However, this potential cannot be considered as available on the level of the city of Trikala.

Table 6: Theoretical potential of organic waste for biogas production in the Prefecture of Trikala.

Resources	Units	Capacity	Organic waste (tn/year)	Installed capacity (MW)
Cattle	653	25946 cattle	644758	12.36
Pig farms	110	9474 sows	152790	2.51
Abattoirs	2	1066 tn/year (cat.2) 845 tn/year (Cat 3)	1911	0.25
Total			799459	15.12

Source: "Assessment studies for specific biogas sites in the target region of Greece" Big-East, Biogas for Eastern Europe EIE project, February 2009[8].

Future Plans

The support regime of RES in Greece is going through a period of updating and reforming. The feed in tariffs for PV systems over the last year led to a higher than the expected increase of the installed capacity. The feed in tariffs were gradually decreased over the last two years, and currently the market has reached a halt since the target for installed capacity of PVs was achieved and the new installations do not receive feed in tariffs at the moment. The new market model is currently under development and is expected to be in force after 2017. Following these developments, the rooftop installations of PVs are expected to proceed based only on the relative economic merit of the technology.

Trikala does not have a district heating system and currently there are no plans or studies to develop one. In general, the idea of district heating systems in Greece is limited to cities in the Northern part of the country, were the heating loads are rather high.

Currently the development of the natural gas network receives the main focus and is continuously expanded. There are no storage facilities of Natural Gas in the distribution system.

[8] http://www.big-east.eu/downloads/IR-reports/ANNEX%202-52_WP6_D6.3_Site-Assessment-Greece.pdf

Regarding the development plans for new RES plants in the area around the Municipality of Trikala, as can be seen in Figure 13 currently there is one PV station of an installed capacity of 5.2MW that has reached the stage of environmental conditions licensing and two biogas power stations (of 3MW each) that are still at the first stage of the licensing procedure. The development of these plants depends of the decisions of the private investors to proceed or not.

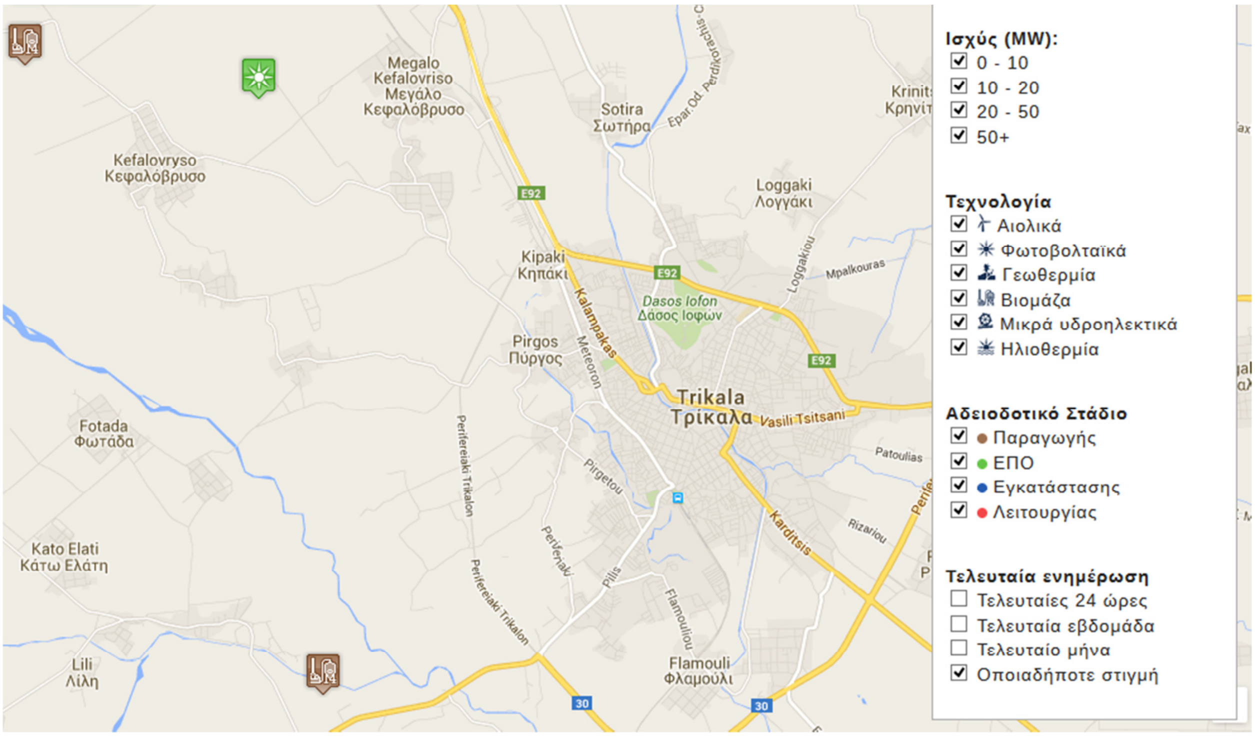

Figure 13: Future RES plants foreseen in the area around Trikala (source: http://www.energyregister.gr/xartis).

7 Tertiary Sector

7.1 Buildings managed by the Municipality

Characterization

Municipality of Trikala supervises 15 Kindergartens of approximately 23,000 m^2 surface with 91 employees that serve about 500 children; 46 schools of all educational levels (elementary, primary, secondary and for children creative studies) of approximately 70,000 m^2 surface that host with 1000 employees and teachers that serve about 5000 students; 13 buildings of an approximate 3,250 m^2 surface for elderly care with 27 employees that serve about 1,200 old citizens; and a public hospital of approximately 34,000 m^2 surface with 100 employees and doctors that can host 240 patients;

Trikala has a significant cultural background, since it's an ancient city with extensive music history. With more than 13 cultural organizations, the Municipality serves more than 500,000 visitors annually and occupies 57 employees. These organizations are hosted in 10 different buildings of more than 4,500 m^2 space.

Similarly, Trikala is an athletic city, with significant athletic background and teams of various kinds of sports, while a sports university is located there. The Municipality serves more than 15,000 funs and 750 athletes with 4 sport centers (stadiums, pools and gyms) located in 4 buildings with approximately 7,000 m^2 of space.

On the contrary, Municipal organizations are located in only 3 buildings, 2 of which contain small offices at an approximately 2,300 m2 space, while the third building hosts big offices and it is a cultural auditorium of a 750 m^2 space.

Details with regard to all these buildings and spaces are presented in Tables 20 to 25 of the Appendix "Sheet 7_Buildings managed by the municipality"

Future Plans

Tsitsanis museum is under development with funding from both national and European sources and it is going to be hosted at the renovated past jails' building in Trikala. On the other hand, the Municipality aims to aggregate the existing museums in fewer buildings in order to minimize operational costs.

7.2 Other Tertiary Buildings

Characterization

According to data provided by the Commercial Chamber of Trikala, an approximate number of 800 retail companies operate in Trikala, occupy about 5,500 employees and hosted in buildings of 100,000 m^2. These companies operate working days and hours on an annual basis and energy consumption was calculated with models published by the National Technical University of Athens (NTUA)[1] -which estimate electricity consumption to 160KWh/m^2 for heating for instance-. Energy consumption varies according to the type of retail business but a mean value was utilized for our calculations.

Similarly, an approximate number of 1,800 private companies operate in an approximate 300,000 m^2 space and occupy about 8,000 employees. Energy consumption was calculated with the use of the same models.

The local Education sector concerns 3 universities (Sports University, University of Applied Sciences and Military School); 10 private schools for all education levels and an approximate number of 30 schools for after school support and vocational training. According to the Administration of Secondary Education of Trikala, an approximate space of 115,000 m^2 is used by this sector, which hosts about 6,000 students and occupies 1,250 employees (faculty and administrative staff).

Moreover, 6 hotels are located in the city of Trikala, which –according to the Commercial Chamber- are able to host 372 visitors on a daily basis and 55,442 day stayings on an annual basis. These hotels occupy an approximate space of 3,588 m^2 and 605 employees. Energy consumption was calculated according to models provided by Spiliotis (2013)[9].

Additionally, the health sector concerns 6 private and a public hospital, which are mainly focused on elder, psych and incurable diseases and occupy an approximate space of 70,000 m^2. These organizations can host 490 patients and employ medical staff of 220 employees.

Finally, according to the Commercial Chamber, the entertainment sector contains 348 companies –mainly bars and restaurants-, which are hosted in a space of approximately 47,000 m^2 and occupy about 2,600 employees. Energy consumption was calculated with mean values coming from NTUA models[1].

Future Plans

No particular plans have been developed by the Municipality with regard to these sectors.

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[9] Spiliotis, E. (2013). Energy Consumption Prediction Models for Buildings (in Greek). Graduate Dissertation, National Technical University of Athens, Assimakopoulos V., Raptis A. and Legaki N. (Supervisors).

8 References

[1] Natural Gas System Operator http://www.desfa.gr/

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[4] N. Andritsos, P. Dalabakis, G. Karydakis, N. Kolios and M. Fytikas, Update and Characteristics of Low-Enthalpy Geothermal Applications in Greece, Proceedings European Geothermal Congress 2007 Unterhaching, Germany, 30 May-1 June 2007

[5] URBAN Wind Turbines, Guidelines for small wind turbines in the built environment, Wind Energy Integration in the built environment project, 2007 www.urbanwind.org

[6] Wind Atlas of Greece, http://www.cres.gr/kape/datainfo/maps.htm)

[7] Biomass potential database http://www.res-thermal.info/servlet/SDEBiomassServlet

[8] "Assessment studies for specific biogas sites in the target region of Greece" Big-East, Biogas for Eastern Europe EIE project, February 2009

[9] Spiliotis, E. (2013). Energy Consumption Prediction Models for Buildings (in Greek). Graduate Dissertation, National Technical University of Athens, Assimakopoulos V., Raptis A. and Legaki N. (Supervisors). Retrieved, June 15, 2015 from http://artemis-new.cslab.ece.ntua.gr:8080/jspui/bitstream/123456789/6729/1/DT2013-0158.pdf

[10] Commercial Chamber of Trikala (2008). Business Sector of Trikala. Retrieved, July 18, 2015 from http://www.trikala-chamber.gr/trikala/articles/article.jsp?context=103&articleid=2877

[11] Municipality of Trikala (2015). Business Plan 2014-2019 (In Greek). Retrieved, July 18, 2015 from http://www.trikalacity.gr/page/epixeirisiako-programma-dtrikkaion-2014-2019

9 Appendix

Tables with detailed data

Task 4.1 Analysis of the urban spaces (TL: UoN) For each main street and public space (e.g. squares) the electricity consumption for lighting will be determined either through specific metering data or through analysis of aggregate data. The results will be inserted into the GIS platform. Consequently analysis of energy efficiency scenarios for the lighting of streets and public spaces will be conducted in order to identify promising technical solutions (efficient lamps, control systems, etc.) that will be inserted to the TIMES optimisation model.

3.1 Public Lighting

Table 1. Analysis and description of the public lighting network

City district	Street	Length of Line	Number of masts	Number of Luminaires per Mast	Number of Lamps per Luminaire	Power by type of Lamp: Mercury Vapour	HPS - High-pressure sodium	LPS - Low-pressure sodium	Metal Halide	Halogen	Fluorescent	Other (Describe)
	unit	m	n.°	n.°	n.°	W						
A	V.Tsitsani(Larisis)	500	10	128	128			250 W Na				
A	Kondili	1200	24	56	56			250 W Na				
A	Sarafi	700	14	45	45			250 W Na				
A	Kalampakas	1700	34	112	112			400 W Na				
A	Kalampakas	1700	34	112	112			250 W Na				
A	Karditsas	3400	68	83	83			250 W Na				
A	Siggrou	500	10	19	19			250 W Na				
A	Asklipiou	600	12	37	37			250 W Na				
A	Node Ag.Konstantinou	0	4	25	25			250 W Na				
A	Node Vouvis	0	4	16	16			250 W Na				
A	Node Meteoron-Eleutherias	0	4	14	14			250 W Na				
A	Bridge Trikaioglou	30	2	4	4			250 W Na				
A	Bridge Venizelou	25	2	4	4			250 W Na				
A	Bridge Garivaldi	40	2	4	4			250 W Na				
A	Bridge Korai	25	2	4	4			250 W Na				
A	Othonos	450	9	42	42			250 W Na				
A	Kanouta	300	6	9	9			250 W Na				
A	Kalamata	220	5	20	20			250 W Na				
A	Amalias	750	15	22	22			250 W Na				
A	Satovriandou	900	18	48	48							125 W Hg
A	Frourio	0	20	20	20							250 W Hg
A	Zavlanion	120	3	16	16			250 W Na				
A	Meteoron	3100	62	85	85			250 W Na				
A	Makedonias	1100	22	49	49			250 W Na				
A	Arrianou	450	9	20	20			250 W Na				
A	Venizelou	500	10	9	9			250 W Na				
A	Miaouli	175	4	7	7			250 W Na				
A	Square Antoniou	0	0	29	29							250 W Hg
A	Square Vouvis	0	0	30	30							250 W Hg
A	Square Agrotissas	0	0	20	20							250 W Hg
A	Garivaldi	260	5	9	9			250 W Na				
A	Korai	350	7	9	9			250 W Na				
A	Pedestrian Asklipiou	300	6	20	20							150 W Hg
A	P.E.O. Trikalon	7800	156	330	330			250 W Na				
A	P.E.O. Trikalon	13200	264	950	950			250 W Na				
A	V.Tsitsani(Larisis)	4500	90	600	600			250 W Na				
				3007								

City district	Street	Age by type of Lamp: Mercury Vapour	HPS - High-pressure sodium	LPS - Low-pressure sodium	Metal Halide	Halogen	Fluorescent	Other (Describe)	Type of Luminaire: with Reflector (Define Type)	with Cap (Define Type)	Other (Define Type)	Type of Ballast: Magnetic	Electronic	Electronic with Control Options	Other (describe)	Control System: Manual Switch	Timer	Electronic Management System	Other (describe)	Switching on/off hour: Summer On	Summer Off	Winter On	Winter Off	Intermediate On	Intermediate Off	Electricity consumption
	unit	Years																		hour						kWh (daily, monthly, yearly)
A	V.Tsitsani(Larisis)									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Kondili									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Sarafi									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Kalampakas									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Kalampakas									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Karditsas									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Siggrou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Asklipiou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Node Ag.Konstantinou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Node Vouvis									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Node Meteoron-Eleutherias									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Bridge Trikaioglou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Bridge Venizelou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Bridge Garivaldi									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Bridge Korai									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Othonos									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Kanouta									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Kalamata									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Amalias									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Satovriandou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Frourio									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Zavlanion									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Meteoron									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Makedonias									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Arrianou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Venizelou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Miaouli									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Square Antoniou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Square Vouvis									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Square Agrotissas									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Garivaldi									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Korai									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	Pedestrian Asklipiou									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	P.E.O. Trikalon									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	P.E.O. Trikalon									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			
A	V.Tsitsani(Larisis)									√								√		9:00 p.m.	6:00 a.m.	5:00 p.m.	7:30 a.m.			

Table 4. Analysis and description of the public fountains (including water pumping and lights)

City district	Specific location		Activity	Operation and maintenance Cost	Control System: Manual Switch	Timer	Electronic Management System	Other (describe)	Switching on/off hour: Summer On	Summer Off	Winter On	Winter Off	Intermediate On	Intermediate Off	Electricity consumption
		unit	Hours/day or Days/year	€/year					hour						kWh (daily, monthly, yearly)
A	Fountains pumping and lighting Central Square	1	8/day	685	X				19:00	03:00	17:00	02:00			N/A
A	Fountains pumping and lighting Riga Ferraiou Square	1	4/day	470	X				20:00	24:00:00	19:00	23:00			N/A
A	Fountains pumping and lighting Central Bridge	1	4/day	450	X				20:00	24:00:00	19:00	23:00			N/A
A	Fountains pumping and lighting Venizelou & Karditsis rd	1	4/day	360	X				20:00	24:00:00	19:00	23:00			N/A
A	Fountains pumping and lighting Kroma Ekelou & Katsimidou rd	1	90days/year	270	X				20:00	24:00:00	19:00	23:00			N/A
A	Fountains pumping and lighting Chatzipetrou Square	1	120days/year	335	X				20:00	24:00:00	19:00	23:00			N/A
B	Fountains pumping and lighting y														
B	(…)														
C	Fountains pumping and lighting z														
C	(…)														
D	Fountains pumping and lighting u														
D	(…)														
				2570											

Table 5. Future plans and projects regarding Gardens/green areas

Spatial coverage: City district	Street	Name	Description	Duration	Investement cost	Operation cost	Technical elements
		Short description	*Main objectives and framework*	*Starting year and full implementation year*	*€total cost or annualized*	*€total cost or annualized*	*e.g. number or share of technology substitution*
A	Garden/green area 1 Riverside	Increase green urban surface	New green surface and forresty	2016 - 2019	245000	12000	GIS data creation
A	Garden/green area 2 Kolokotroni st (new square)	Increase green urban surface	New green surface and forresty	2016 - 2019	275000	14500	GIS data creation
A	Garden/green area 3 West city entrance	Increase green urban surface	New green surface and forresty	2016 - 2019	45000	1200	GIS data creation
A	Garden/green area 4 East city entrance	Increase green urban surface	New green surface and forresty	2016 - 2019	45000	1200	GIS data creation
A	Garden/green area 4 Tsitsanis Museum square	Increase green urban surface	New green surface and forresty	2016 - 2019	85000	3500	GIS data creation
B	Garden/green area y						
B	(…)				695000		
C	Garden/green area z						
C	(…)						
D	Garden/green area u						
D	(…)						

Table 6. Future plans and projects regarding public fountains (including water pumping and lights)

Spatial coverage: City district	Street	Name	Description	Duration	Investement cost	Operation cost	Technical elements
		Short description	*Main objectives and framework*	*Starting year and full implementation year*	*€total cost or annualized*	*€total cost or annualized*	*e.g. number or share of technology introduction and/or substitution*
A	Fountains pumping and lighting Matsopoulos park (with recycling water)	Fountain with recycling wastewater, after a collect and treatment site and network installation	A novel wastewater treatment site and network is planned to be installed in the western suburbs and interconnect them with the treatment site. Recycled water will be returned to 2 fountains located at 2 parks	2017-2019	(total project budget) €22.260.000	10000	water recycling
A	Fountains pumping and lighting Railway station park (with recycling water)	-//-	-//-	-//-	0	0	water recycling
B	Fountains pumping and lighting y						
B	(…)						
C	Fountains pumping and lighting z						
C	(…)						
D	Fountains pumping and lighting u						
D	(…)						

Task 4.2. Analysis of the water/sewage system (TL: FCT) The water/sewage system will be analysed merely in terms of the pumping stations energy needs. Data from the cities and the utility companies regarding the technical characteristics of the pumps, operational characteristics will be collected and possibilities for energy efficiency measures regarding the rehabilitation of the equipment both in terms of current as well as future needs (expansion) will be identified.

4.1 Water Treatment and Distribution Systems

Table 7. Analysis and description of the water treatment and distribution systems

City District location	Facility Name	Type of technology	Date of implementation	Lifetime	Installed capacity	Energy consumption (daily/monthly/yearly)	Hours of operation (daily/monthly/yearly)	Water pumped or treated	Operation and maintenance Cost	**Share of city district served population by the facility** (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Water consumption: Residential	Water consumption: Tertiary	Water consumption: Other sectors	Water consumption: Total
		unit	*Year*	*Years*	*kW*	*kWh*	*%of day*	*m3/h*	*€/water pumped*		m^3 of delivered water per person or % of water pumped treated	m^3 of delivered water per m2 or % of water pumped treated	m^3 of delivered water per person or % of water pumped treated	m^3 of delivered water per person or % of water pumped treated
A	*KENTRIKOS LAKMNONOS*	*Drill station*			*20 KW*		*100*	*100*						
A	*No3-AMPELOKIPOI*	*Pump*			*37KW*		*100*	*215*						
A	*No4-MAVROKORDTOY*	*Pump*			*30 KW*		*100*	*300*						
A	*No6-PYRGOY SOUTH*	*Pump*			*30 KW*		*100*	*230*						
A	*No7-PYRGETOY*	*Pump*			*30 KW*		*100*	*170*						
A	*No8-PYRGOY NORTH*	*Pump*			*75 KW*		*100*	*220*						
A	*No9-AG.APOSTOLON*	*Pump*			*51 KW*		*100*	*156*						
A	*No10-OPISTHEN AGREX*	*Pump*			*37 KW*		*100*	*175*						
A	*No11-GARDIKAKI*	*Pump*			*75 KW*		*100*	*220*						
A	*No12-AG.GEORGIOY-RIZARIO*	*Pump*			*37 KW*		*100*	*150*						
A	*No13-SOTIRAS*	*Pump*			*40 KW*		*100*	*155*						
A	*No14-MPALKOYRA*	*Pump*			*11 KW*		*100*	*75*						
A	*No15-AG.APOSTOLON-ATHIGANI*	*Pump*			*7,5 KW*		*100*	*20.9*						

4.2 Sewage Systems

Table 9. Analysis and description of the wastewater treatment and distribution systems

City District location	Facility Name	Type of technology	Date of implementation	Lifetime	Installed capacity	Energy consumption by fuel (daily/monthly/yearly)	Energy production by fuel and technology (daily/monthly/yearly)	Hours of operation (daily/monthly/yearly)	Wastewater pumped and treated	Operation and maintenance Cost	**Share of city district served population by the facility** (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Sewage treated: Residential	Sewage treated: Tertiary	Sewage treated: Other sectors	Sewage treated: Total
		unit	*Year*	*Years*	*kW*	*kWh*	*kWh*	*n.º hours or %of day*	*m3/h*	*€/water pumped*		*m3 of treated wastewater per person and* number of people served by the system	*m3 of treated wastewater per m2*	*m3 of treated wastewater per person and* number of people served by the system	*m3 of treated wastewater per person and* number of people served by the system
A	*A1-AKATHARTON-KALIPSOS-AG.KON/NOS*	*wastewater treatment plant*	*1990*	*50*	*3x22,00*			*100*	*300*		*100*	*2628000*			*32.85*
A	*A2-KATSIMIDOY*	*pump station*	*1993*	*50*	*2x7,50*			*100*	*100*		*100*	*876000*			
A	*A3-MAVILI-PHARMAKI*	*pump station*	*1993*	*50*	*3x22,00*			*100*	*300*		*100*	*2628000*			
A	*A5-ERGATIKOY-PYRGOY*	*pump station*	*2007*	*50*	*2x3,50*			*100*	*48*		*100*	*420480*			
A	*A4-AGIA MONI*	*pump station*	*2000*	*50*	*2x7,50*			*100*	*100*		*100*	*876000*			
A	*A6-ENANTI KLOTSOTIRA*	*pump station*	*1998*	*50*	*2x1,30*			*100*	*30*		*100*	*262800*			
A	*A7-ALONIA MPARAS*	*pump station*	*1998*	*50*	*2x3,00*			*100*	*40*		*100*	*350400*			
A	*AP1-RIZARIO*	*pump station*	*2014*	*50*	*1x1,30*			*100*	*18*		*100*	*157680*			

Table 10. Future plans and projects regarding sewage system

Spatial coverage: City district	Spatial coverage: Street	Name	Description	Duration	Investement cost	Operation cost	Technical elements
		Short description	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of table 9.)*
A	*Wastewater treatment plant for eastern and western suburbs*	*Wastewater collection and treatment site construction*	*A novel wastewater treatment site and network is planned to be installed in the western suburbs and interconnect them with the treatment site. Recycled water will be returned to 2 fountains located at 2 parks*	*2017-2019*	*(total project budget) €22.260.000*	*10,000.00 €*	water recycling

A	*Wastewater Pump y*
A	*(…)*
B	*Wastewater treatment plant x*
B	*Wastewater Pump y*
B	*(…)*
(…)	*Wastewater treatment plant x*
(…)	*Wastewater Pump y*
(…)	*(…)*

<u>Task 4.3. Analysis of the waste collection and treatment processes regarding their energy use impact (TL: CRES)</u> Waste chain will also be analyzed merely on the basis of current waste disposal patterns, possibilities for on site waste reduction, recycling and energy utilization of remaining waste quantities. The data from the aforementioned analysis will be introduced to the city GIS database in order to form various GIS layers related to resource and energy use.

5. Waste chain

Table 11. Analysis and description of the waste chain - Solid waste production

Solid Waste production *unit*	Waste characterization by type *% of each type*	Quantity by type *(ton/year*
Municipal Solid Waste (MSW)		
household	Solid waste in general (70% of total waste)	19249.16
commercial and services	Solid waste in general (30% of total waste)	8249.64
Industrial Wastes		0
Hospital waste		58.2
Other (e.g. livestock industries)		0

Table 12. Analysis and description of the waste chain - Waste collection

Waste collection Collection type	*unit*	Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Vehicles fleet (stocks) *n.º*	Age *years*	Distances covered *km/y*	Waste collected *tons of collected waste per person (per city spatial district)*	Waste collecting capacity *ton of waste/vehicle*	Energy consumption (by type of fuel) *liters or toe*
General collection	GREEN BUCKET	86.5%	16	18	1920	0.298	4.33	203,616.00
Dedicated collection	BLUE BUCKET	13.5%	3	10	1920	0.047	0.675	38,178.00
	Plastics	1.56%	3	10	1920	0.00537	0.078	38,178.00
	Glass	0.20%	3	10	1920	0.00069	0.01	38,178.00
	Paper	11.56%	3	10	1920	0.03982	0.578	38,178.00
	TOTAL WEIGHT	27,557				0.34	137785	

Table 13. Analysis and description of the waste chain - Sorting centers

Sorting centers City district location	*unit*	Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)	Activity *ton waste/year*	Input and output waste characterization *ton/type of waste*	Lifetime *Years*	Operation and maintenance Cost regarding energy production. *€total cost or annualized*	Energy consumption (by type of fuel) *liters or toe*
A		100%	22,737	non- recyclable materials and organic waste			
A		100%	1100	recyclable materials for land filling			
A		100%	3,720	recyclable materials			

Table 14. Analysis and description of the waste chain - Waste destination

Waste destination	City district location	*unit*	Activity *ton waste/year*	Input waste characterization *ton/type of waste*	lifetime/total capacity of storage *Years*	Fuel consumption (by type of fuel) *liters or toe*	Energy production (by type of fuel) (daily, monthly, yearly) *m3; kWh; toe*	Operation and maintenance Cost regarding energy production. *€total cost or annualized*	Share of city district served population by the facility (e.g. 40% within sector A and 40% in sector C and 20% to population out of the scope area)
Managed Landfills	*City sector A*		1,100		30				100
Recycling	*City sector A*		3,720						100

Table 15. Future plans and projects regarding waste chain

Spatial coverage Waste chain phase	Spatial coverage (scope area or more)	Name *Short description*	Description *Main objectives and framework*	Duration *Starting year and full implementation year*	Investement cost *€total cost or annualized*	Operation cost *€total cost or annualized*	Technical elements *Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of tables 11 to 14.)*
Solid Waste production							
Waste collection							
Sorting centers							
Waste destination							

<u>Task 4.4 Analysis of the energy supply system (TL: E4SMA)</u> Data on the existing energy supply systems (DH/CHP, solar thermal, PVs etc.) at a city level will be recorded and their technical status will be evaluated in order to identify further technical measures for energy efficiency improvement (e.g. in case of thermal plants) or potential for further deployment (e.g. in the case of RES).
Furthermore the potential of RES utilisation (e.g. PVs, solar thermal, geothermal heat pumps etc.) will be analysed on a city specific case with the use of relevant simulation tools and databases (e.g. PV-GIS)

6. Energy supply system

Table 16. Analysis and description of the energy supply system

City District location	Type of technology		Date of implementation	Lifetime	Installed capacity	Electricity production (daily/monthly/yearly)	Other forms of energy production (refer the type) (daily/monthly/yearly)	Energy consumption (refer by type) (daily/monthly/yearly)	Hours of operation (yearly)	Efficiency	Technologies associated with the other systems (waste, water, sewage, etc.)	Fixed and variable operating costs
		unit	*Year*	*Years*	*kW*	*kWh*	*Joule or kWh*	*Joule or kWh*	*n.º hours or %of day*	*%*	*%*	*€/kW and €/kWh*
A	heating oil	11479	1970-2013	70	N/A	N/A	(used for heating purposes only)					
A	natural gas	6859	2014	100	N/A	N/A	(used for heating and cooking purposes only)					
A	Solar pv	30	2011	30	100	13500/year			4320	80		
A	Solar pv	250	2010	30	10	11500/year			4320	80		
A	Solar pv	2	2013	30	95.04	13500/year			4320	80		

Table 17. Analysis and description of the energy supply system - District heating network aditional specifications

District heating network		length of the network	Users connected to the DH system	Energy consumption of the auxiliaries	Capacity consumption of the auxiliaries	**Share of city district served population by the facility** (e.g. 40% within sector A and 40% in sector C and 20% to population out
City District location	*unit*	*km*	*n.º*	*kWh*	*kW*	

Table 18. Analysis and description of the energy supply system - Natural gas network aditional specifications

Natural Gas network		Lenght of the network	Users connected to the NG distribution	Energy consumption of the auxiliaries	Capacity consumption of the auxiliaries	**Share of city district served population by the facility** (e.g. 40% within sector A and 40% in sector C and 20% to population out	Natural Gas storage
City District location	*unit*		*n.º*	*kWh*	*kW*		*m3 storaged*
A	1 (mean pressure)	4.2Km	135	947,650.21	947,650.21	46.3	N/A
A	2 (low pressure)	83,5Km	6724	46,252,350	46,252,350	46.3	N/A

Table 19. Future plans and projects regarding energy supply system

Spatial coverage		Name	Description	Duration	Investement cost	Operation cost	Technical elements
Technology	**Spatial coverage (city district or more)**	*Short description*	*Main objectives and framework*	*Starting year and full implementation year*	*€ total cost or annualized*	*€ total cost or annualized*	*Type of technology introduction/substitution; efficency and expected activity (it can be used the indicators of tables 16 to 19)*
District heating (DH)							
Combined heat and power (CHP)							
Solar Thermal							
Solar pv	C	solar park installation in 128.000 sqm land (still under planning)	5MW energy production	2019	N/A	N/A	
Wind							
Biomass	C	Biomass collector and treatment unit (under planning)	To cover industrial and agricultural use	2020	N/A	N/A	

7. Buildings under Municipal Management

Note: Information could be filled for the total of each Buidling type or in a One by one basis if information is available. Please replicate lines when needed for energy consumption by different building types and city district location

Table 20_ Analysis and description of the Buildings under Municipal management

City District location	Building type	Indicators: Total surface area (m2).	Number of Buildings/Facilities for each type	Number of users per annum (e.g. students, employees)	Activity/operation: daily opening-closing time (e.g 9a.m to 6p.m.)	Activity/operation: months of the year	Energy production by type (PV) (kWh/y)	Energy indicators – Energy consumption: Energy form	Energy service (Please best guest share by type of service used): Space Heating	Space Cooling	Water Heating	Cooking	Lighting	Other applicances
A	Kindergardens	23,016.36	15 Buildings	91 person employees and 500 children	9:00 p.m.-4:00 a.m.	11 months								
A	Schools	69,049.69	46 Buildings	5000 students + 1000 employees	8:00 p.m.-1:35 a.m.	9 months	27000							
A	Elderly Care Centers (KAPH)	3,250.00	13 Buildings	1244 citizens + 27 employees	8:00 p.m.-1:35 a.m.	12 months								
A	Trikala public hospital	34,152.00	37 Buildings inside	240 patients + 100 employees	all day	12 months		Electricity consumption per year (kWh/y)	1,855,277.16					
	TOTAL	129,468.05						Natural gas (toe/y)	386,600.64					
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (KWh/y)	17,465,239.95					
								Biomass (toe/y)						
A	*Museums and cultural spaces*	4,530.00	10 Buildings	500000 visitors/year + 57 employees										
	Folklore Museum (6 Garivaldi rd, 450m2)							Electricity consumption per year (kWh/y)	64,914.90					
	Music artists' musem - Dorothea School (38 Sarafi rd, 750 m2)							Natural gas (toe/y)						
	Sports Museum (13 Kapodistriou rd, 250m2)							LPG (toe/y)						
	Dimitris and Lego Katsikogiannis Museum (National road Trikala-Pili, 480m2)							Gasoline (toe/y)						
	Municipal Gallery - Dorothea School Building ((38 Sarafi rd, 750 m2)							Fuel oil (toe/y)						
	Markellos Gallery (6 Garivaldi rd, 450m2)							Diesel Oil (KWh/y)	564,211.50					
	Municipal Library (8 Garivaldi rd, 820m2)							Biomass (toe/y)						
	Municipal Music School (32 Vironos rd, 260 m2)													
	Municipal Band - Dorothea School (38 Sarafi rd, 750 m2)													
	Municipal Choir - Cultural Center (8 Garivaldi rd, 800 m2)													
	Municipal Dance Group (18 Theodosopoulou rd, 220 m2)													
	Municipal Puppet center (48 Vas. Tsitsani rd, 200 m2)													
	Municipal Theater -Matsopoulos center (22 Pilis rd, 500 m2)													
A	*Swiming pool and gyms*	7,000.00	4 Buildings	15000 funs + 750 athletes + 50 employees										
	Municipal Stadium's Gym (32 Katsimidou rd, 500 m2)							Electricity consumption per year (kWh/y)	100,310.00					
	Municipal Gym A (44 Katsimidou rd, 3000 m2)							Natural gas (toe/y)						
	Municipal Gym B (Trikala ring-road, 2000 m2)							LPG (toe/y)						
	Municipal Pool (Trikala ring-road, 1500 m2)							Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (KWh/y)	871,850.00					
								Biomass (toe/y)						
A	Office small (<500m2)	2,275.00	3 buildings	450 employees										
	Townhall (18 Askipilou rd, 1775 m2)							Electricity consumption per year (kWh/y)	32,600.75					
	Municipal Offices (13 Dionisiou rd, 500 m2)							Natural gas (toe/y)						
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (KWh/y)	283,351.25					
								Biomass (toe/y)						
A	Office Large (>500m2)	750.00	1 building	500 visitors										
	(cultural auditorium)							Electricity consumption per year (kWh/y)	10,747.50					
								Natural gas (toe/y)						
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (KWh/y)	93,412.50					
								Biomass (toe/y)						
A	Other Buildings under Municipal management													
(...)	(...)													

8. Services Buildings

Note: Information could be filled for the total of each Buidling type or in a One by one basis if information is available. Please replicate lines when needed for energy consumption by different building types and city district location

Table 21_ Analysis and description of the Services Buildings

City District location	**Building type**	**Indicators**													
		Total surface area (m2).	*Number of Buildings/Facilities for each type*	*Number of users per annum (e.g. students, employees)*	*Activity/operation*		*Energy production by type (e.g. PV, CHP) (kWh/y)*	*Energy consumption*	*Energy indicators*						
									Energy service (Please best guest share by type of service used)						
					daily opening-closing time (e.g 9a.m to 6p.m.)	*months of the year*		*Energy form*	*Space Heating*	*Space Cooling*	*Water Heating*	*Cooking*	*Lighting*	*Other applicances*
A	Retail (1)	108,405	*803 retail companies*	*5466 employees*	*8:00 p.m.-2:00 a.m.*	*12*								
					5:00 a.m. to 9:00 a.m									
								Electricity consumption per year (kWh/y)	*17,290,597.50*	*726,205.10*	*1,210,341.83*	*622,461.51*	*12,867,673.50*	*7,317,337.50*
								Natural gas (kWh/y)	*2,508,137.50*					
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (toe/y)						
								Biomass (toe/y)						
A	Employment (2)	295,380	*1840 private businesses*	*8280 employees*	*8:00 p.m.-2:00 a.m.*	*12*								
					5:00 a.m. to 9:00 a.m			*Electricity consumption per year (kWh/y)*	*47,113,110.00*	*1,978,750.62*	*3,297,917.70*	*1,696,071.96*	*35,061,606.00*	*19,938,150.00*
								Natural gas (kWh/y)	*3,983,512.50*					
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (toe/y)						
								Biomass (toe/y)						
A	Education (3)	115,000	*3 Universities, 10 private schools, 30 centers for after school and vocational training*	*5750 students, 1250 employees*	*8:00 p.m.-20:00 a.m.*	*10*								
								Electricity consumption per year (kWh/y)	*1,647,950.00*					
								Natural gas (kWh/y)	*1,301,800.00*					
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (kWh/y)	*15,513,500.00*					
								Biomass (toe/y)						
A	Leisure (4)	3,588	*6 hotels able to host 372 visitors*	*55442 visitor day stayings, 605 employees*	*all day*	*12 months*	7500							
								Electricity consumption per year (kWh/y)	*51,416.04*		*34,962.91*	*5,141.60*	*22,623.06*	
								Natural gas (kWh/y)	*40,616.16*		*27,618.99*			
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (kWh/y)	*484,021.20*					
								Biomass (toe/y)						
A	Health (5)	68,700	*7 buildings (1 public)*	*490 patients + 224 employees*	*all day*	*12 months*								
								Electricity consumption per year (kWh/y)	*984,471.00*					
								Natural gas (kWh/y)	*777,684.00*					
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (kWh/y)	*9,267,630.00*					
								Biomass (toe/y)						
A	Other - Bar and Restaurants	46,980	*348 companies*	*2610 employees*	*all day*	*12 months*								
								Electricity consumption per year (kWh/y)	*673,223.40*	*188,502.55*		*235,628.19*	*87,519.04*	*40,393.40*
								Natural gas (kWh/y)						
								LPG (toe/y)						
								Gasoline (toe/y)						
								Fuel oil (toe/y)						
								Diesel Oil (kWh/y)						
								Biomass (toe/y)						
(...)	(...)													

Subdivisions:
(1) Retail includes: Large Food stores supermarkets, large Non-food stores, and local shops (those within the residential areas);
(2) Employment includes: Office, Industrial and warehouse;
(3) Education includes: Primary, secondary and college/University;
(4) Leisure includes: Combined restraunts, hotels, cinemas, leisure centers;
(5) Health includes: Hospitals and health centers;

Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

INSMART

Integrative Smart City Planning

Analysis of the city energy system – Évora

D-WP 4 – Deliverable D4.3

Author(s): Luís Dias, João Pedro Gouveia, Júlia Seixas, Nuno Bilo, António Valentim

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Start date of project: 2013-12-01

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Report on the analysis of the city energy system – Évora

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)	

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Executive Summary	
This report refers to WP4 (Tasks 4.1. to 4.4.). It includes the analysis of the current status of urban spaces, water/sewage systems, waste chain and decentralised energy supply at the cities level. Two annex files complement this report: one excel file with detailed data for each of the analysed energy consuming city system, and the GIS files.	
Keywords	Évora, city energy system and networks, urban spaces, water/sewage systems, waste chain, energy supply system

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Acronyms and Definitions

CDW – Construction and demolition waste

CHP – Combined heat and power

CPV – Concentrated Photovoltaic

FiT - Feed-in Tariffs

GIS – Geographic information system

kWh - kilowatt hour

LED – Light-emitting diode

MSW – Municipal solid Waste

O&M – Operation and maintenance

PDME – Plano Director Municipal de Évora (Évora Master Plan)

PROMETHEE - Preference Ranking Organization METHod for Enrichment of Evaluations

PV – Photovoltaic

RES – Renewable energy sources

RES-E - Renewable energy sources for Electricity production

SIRU – System of Municipal solid Waste of the District of Évora

SLP – Street lighting point

TIMES – The Integrated MARKAL-EFOM System

1. Introduction

1.1. Overview of InSMART

The InSMART concept brings together cities, scientific and industrial organizations in order to establish and implement a comprehensive methodology for enhancing sustainable planning addressing the current and future city energy needs through an integrative and multidisciplinary planning approach.

InSMART project intends to identify the optimum mix of short, medium and long term measures for a sustainable energy future, addressing the efficiency of energy flows across various city districts, namely buildings, transport and mobility. Urban spaces, water/sewage system, waste chain and decentralized energy supply.

Each city's energy system will be analysed, covering all relevant sectors and a comprehensive GIS platform including energy database will be developed. Apart from being a valuable planning tool, the GIS database will inform and be linked to the TIMES planning model. This model will be used to analyse the cost-optimal mix of measures required to meet sustainable energy targets taking into account exogenous parameters (*e.g.*, environmental targets, city expansion). These measures will be further assessed with respect to non-technical criteria using a multi-criteria decision making method (PROMETHEE) that will address economic, environmental as well as social issues.

A detailed economic analysis of the mid-term measures identified through this two stage optimisation procedure will be undertaken, identifying all relevant investment indicators. Finally, a detailed, realistic and applicable mid-term implementation plan will be developed to describe the necessary steps, required resources and monitoring procedures for each city.

1.2. Objectives of this Report

This report refers to WP4 (Tasks 4.1. to 4.4.), including the analysis of the current status of urban spaces, water/sewage systems, waste chain and decentralised energy supply at the cities level and also identify applicable technical solutions. Another objectives is to inform the GIS energy database for each city (namely Nottingham, Trikala, Évora and Cesena).

This report describes the relevant characteristics and energy consuming city sectors excluding Residential Buildings and Transports, already characterized and assessed in WP2 and WP3. The report focuses on the city of Évora.

In a graph theory-like vision, surveys undertaken under the WP2 and WP3 provide the description of "nodes" (demand centres), namely the quantification of the stocks of processes and technologies (e.g. buildings, space heating devices, vehicles) and characterization of energy services required in the selected geographical polygons of the urban area.

The goal of WP4 is to extend the analysis of the demand centres including relevant non-energy services, and to look at the “edges” (the physical networks linking different demand centres and allowing the movements of energy, people and goods) and at the devices used to properly operate the urban infrastructures.

1.3. Outline of the Report

The report is organized in seven chapters. Chapter one presents a brief description of the project and the objectives of this report. Chapter 2 depicts the city districts used for spatial analyse and a general overview of the city energy consumption. The remaining chapters focus on each of the energy consuming sectors under scope on this WP. The urban spaces are divided into public lighting and other urban spaces energy uses such as in gardens and fountains. The water/sewage system, the waste chain, the decentralised energy supply, and the energy consumption of the tertiary sectors subdivided in municipality managed buildings and other tertiary buildings are characterized on those chapters from chapters 3 to 7.

2. City Districts General Description

Évora municipality, comprises one of the largest municipalities in Portugal, with 1 307.08km² (5% of the region) and 56 596 inhabitants in 2011. The city of Évora is the capital of the District of Évora and of Alentejo region (NUTS II) integrated in a vast plain that extends south of Portugal (Alentejo). The Alentejo countryside is open wide with extensive cereal fields, pasture and remarkable forest patches of cork and holm oak, often with cereals and pastures under cover. Olive groves, vineyards, irrigated crops such as rice, round out the diversity and unity of this region. The Évora municipality is composed mainly of rural area as 9 of its 12 parishes are rural and the remaining urban (1 in the historical centre). According to INE (2011), 80% of its inhabitants live in urban areas and 20% in rural areas.

This section presents a brief description of the city of Évora regarding the spatial sectors (or districts) that were previously selected for the buildings and transport surveys and assessment. These districts will be used within report as the spatial layer for the description of the other energy consuming sectors (described in the next sections) and later on in the integrative modelling in WP5. Also an overview of Évora municipality energy consumption is presented.

The level of spatial detail of the city's sectors differs between what was defined for the transport sector and buildings. For buildings there were set four sectors (Figure 1) and in transport 21 (Figure 2). Though under the scope of this report, data availability and consistency of information it was decided that all city energy consuming systems, with the exception of the transport sector, would be characterized taking into account the breakdown defined for buildings – 4 districts.

As indicated in the WP1 Internal report (January 2014) the four Évora municipality districts are: 1) Rural which includes all rural parishes; and 2) Malagueira e Horta das Figueiras; 3) S. Mamede, Sé e S. Pedro e St. Antão, 4) Bacelo e Sra da Saúde which are the three urban parishes. The number of buildings, households and resident population for each city sector is presented in Table 1.

Table 1 - Main characteristics of Évora city districts

City district	Number of Buildings	Number of Households	Resident population
Rural	5 303	5 977	11 246
Bacelo e Sra da Saúde	5 072	7 630	18 233
Malagueira e Horta das Figueiras	5 007	8 007	22 379
S. Mamede, Sé e S. Pedro e St. Antão	2 590	3 541	4 738
Total	**17 972**	**25 155**	**56 596**

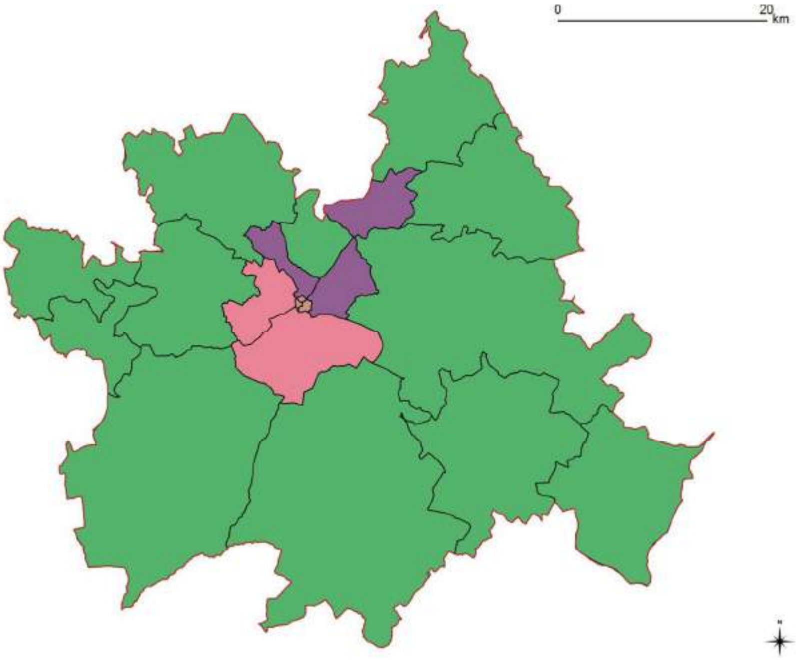

Figure 1 - Évora city districts regarding the Building sector

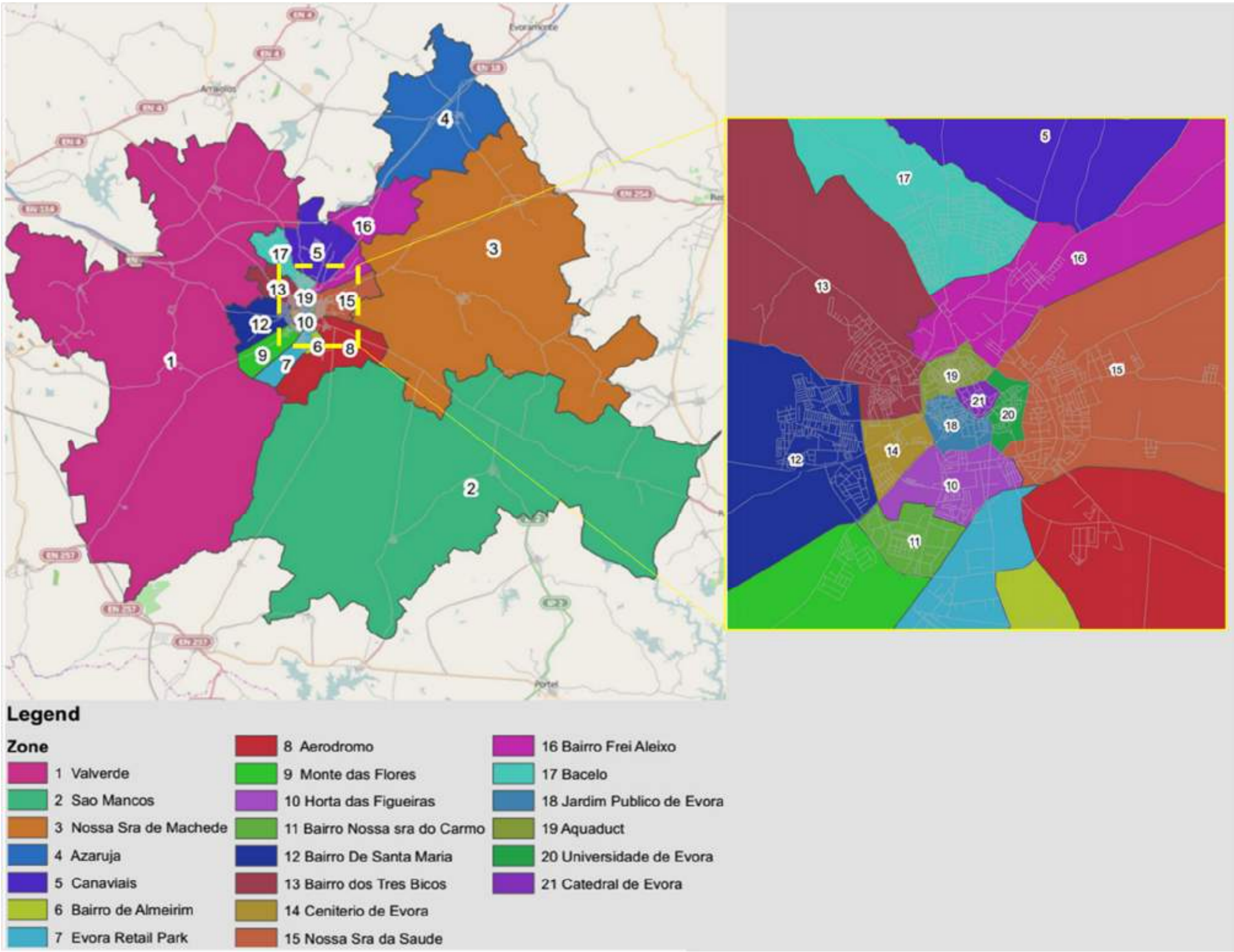

Figure 2 - Évora city districts in the transport sector

2.1. Évora municipality final energy consumption

The final energy consumption of Évora municipality flows in 2013 is presented in Figure 3. The total consumption was nearly 2.6 PJ (DGEG, 2015), being 60% of this consumption oil products (gasoline, diesel and LPG) consumed for mobility (where was included the machinery in agriculture).

Despite the predominance of refined petroleum products, the electricity has a representation of 36% being consumed in the residential (32%) and tertiary (33%) sectors and also in the industry (26%) (Figure 4). Natural gas is consumed in those same sectors (Figure 5) yet with lower prevalence, 0.1 PJ corresponding to 5% of total final energy consumption in Évora. The biomass and solar thermal use on residential sector was estimated through national statistics on biomass and solar thermal equipment ownership and the consumption per household

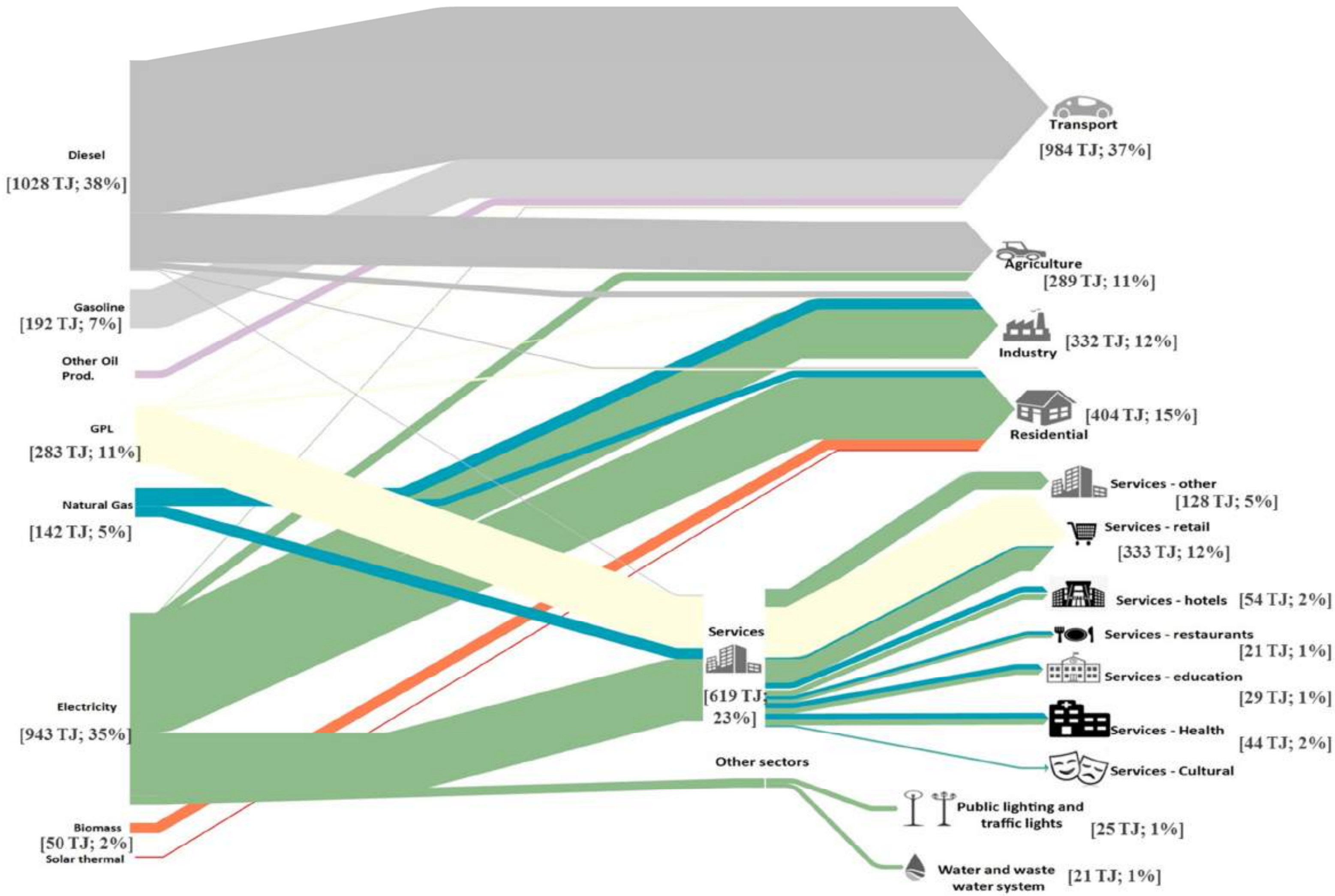

Figure 3 - Sankey diagram of final energy consumption for Évora 2013 (Data source: DGEG, 2015)

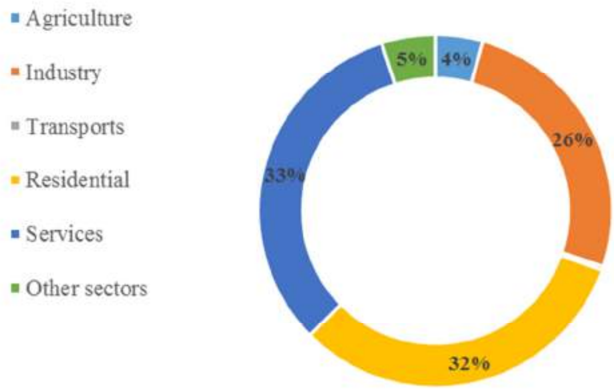

Figure 4 - Évora electricity consumption by sector in 2013 (DGEG, 2015a)

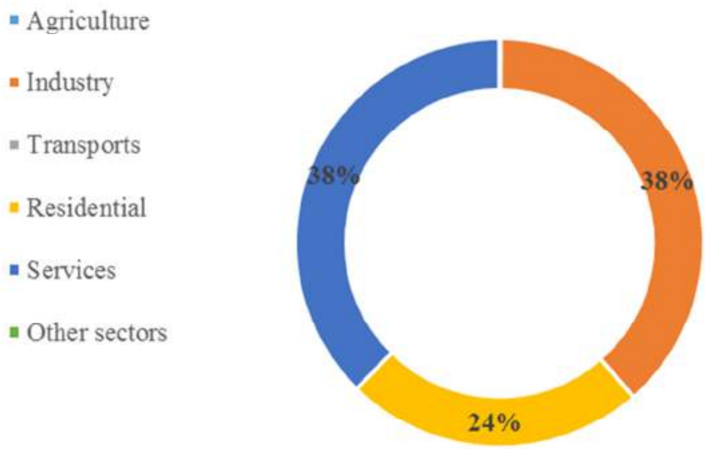

Figure 5 - Évora natural gas consumption in 2013 (DGEG, 2015b)

The consumption oil products manly occur in the transport sector (64%), of which 76% corresponds to diesel and 20% to gasoline. LPG consumption, although not significant expression in the transport sector (1%), still represents 18% (255 PJ) of the total oil products consumed. The LPG is mostly consumed in the services sector (90%).

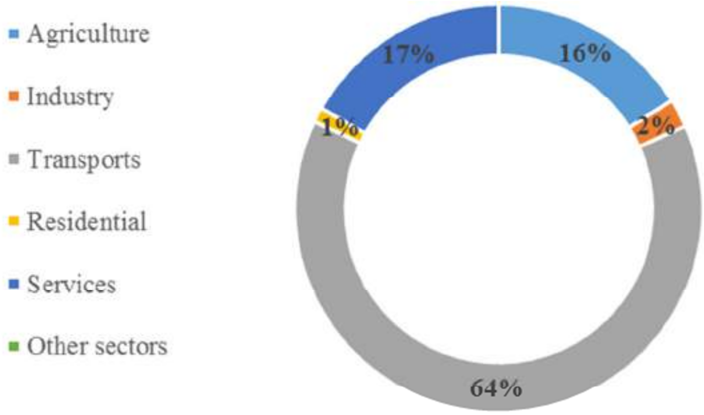

Figure 6 - Évora oil products consumption in 2013 (DGEG, 2015c)

3. Urban Spaces

In this chapter we provide a characterization of the public urban spaces with relative importance consumption of energy within Évora city. The analysis will focus the electricity consumption for street lighting and other public places like gardens and fountains within the municipality and a possible downscale to city sector level.

3.1 Public Lighting

3.1.1. Characterization

The municipality of Évora is responsible for the public lighting, including the lighting levels and schedules, the type and number of luminaires and lamps used.

Street lighting is therefore one of the most essential services provided by municipal authorities, and its cost and operation management is a continuous challenge. The introduction of new technologies, like more efficient lamps or smart controls can deliver improvements in energy usage and consequence lower costs. The assurance of a quality service is a paramount condition, and therefore the measures that reduce energy consumption should not include turning off lamps, but only its substitution through technological improvement or better use. The street light design process involves the selection of the proper lighting equipment and the establishment of the geometry of the system in order to provide the most effective lighting conditions to satisfy the needs. The systems definition also needs to take in account design conditions such as light source size and average luminance depending on the area of deployment (e.g. residential zone or freeways). Nevertheless, there is the assumption that this design conditions are independent of the type of technology to deploy, and do not act as a limitation to any type of measure such as new lamp types and control systems.

In recent years, Évora has already applied a list of measures to reduce its electricity consumption associated with public lighting, through the replacement of current inefficient lighting sources with LED (Figure 7) and the introduction of more efficient control systems (Figure 8). The municipality lighting managers have also switched off certain luminaires, which cannot be seen as an energy efficiency improvement but rather a lighting services reduction aiming to reduce the electricity bill.

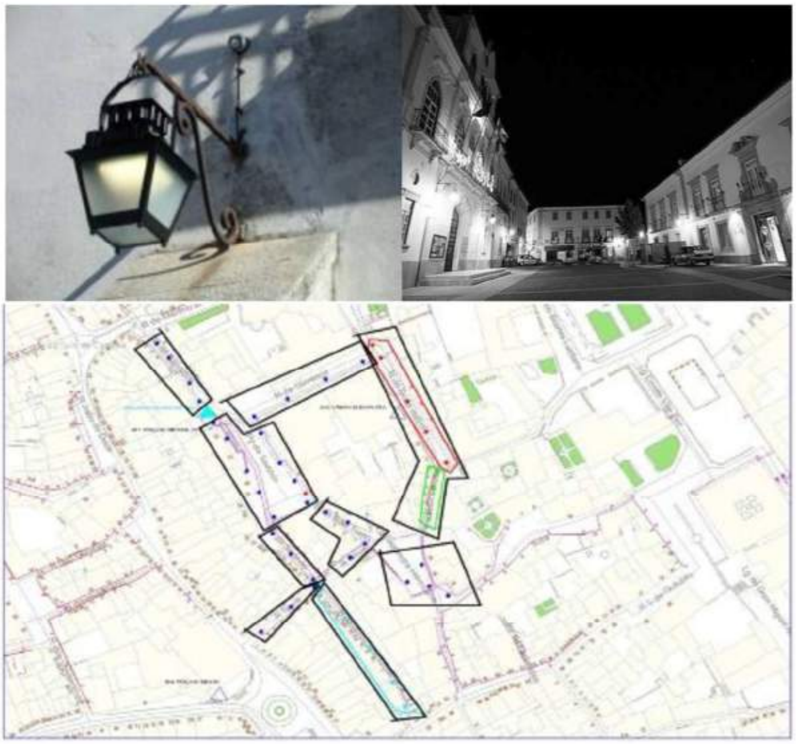

Figure 7 - LED luminaire and location of the recent replacements

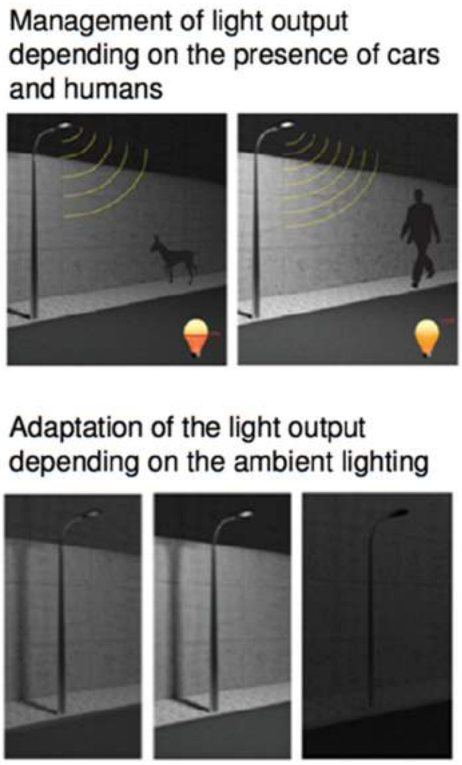

Figure 8 - Examples of new lighting management system in place

The public lighting system in Évora is showed in Figure 9. The luminaires are concentrated in residential areas manly in the Évora city centre.

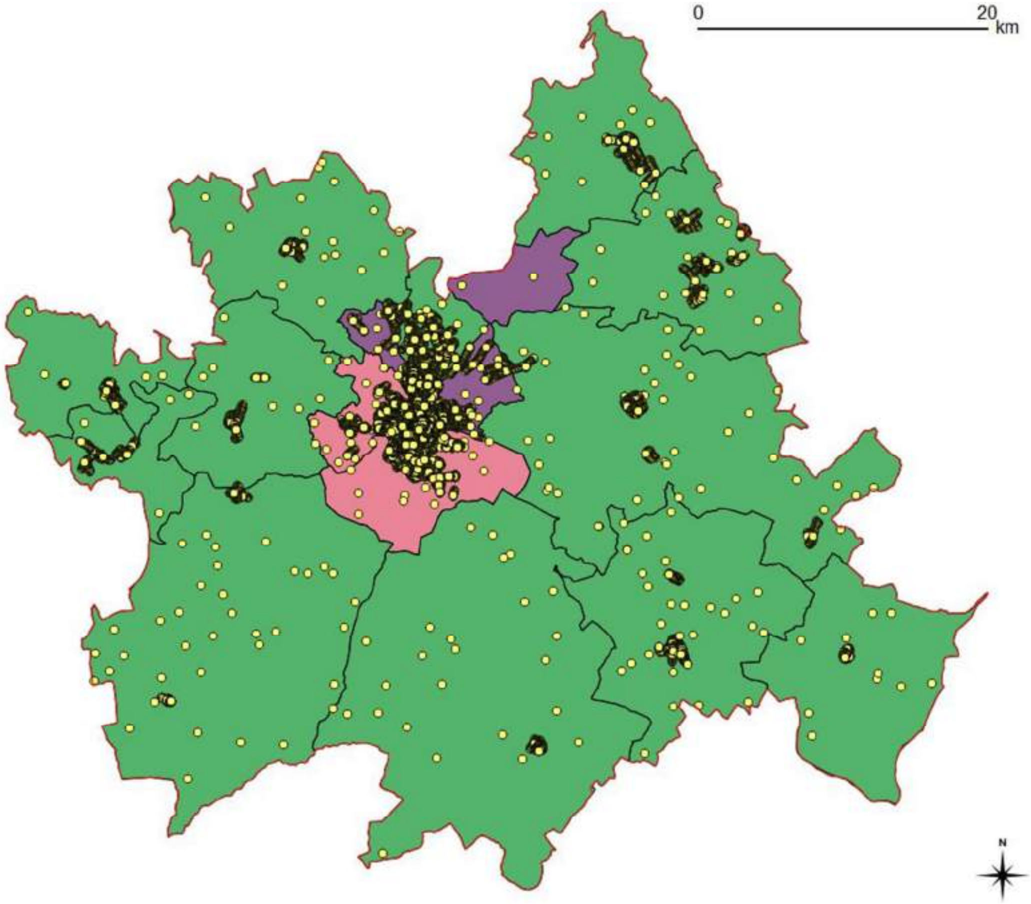

Figure 9 - Street lighting points (SLP) in Évora municipality

The system has a total of 15 065 light points with five different types of street light control systems. The control systems in use are: the teleparameterized, the remote control, the flow regulators, the stable systems by photocells and astronomical timeclock. The most applied control system in Évora (Table 2) is the astronomical time clock (55%), with the correspondent higher number of connected luminaire points (57%). Also the photocell control type has a high predominance within the municipality (35%). The teleparameterized and remote control types are still insignificant and are only found in the city districts of Bacelo and Sra da Saúde and S. Mamede, Sé and S. Pedro and St. Antão, and are related to the recent implementation of high efficiency LED systems.

Table 2 - Types of public light operation control systems and street lighting points (SLP) in Évora municipality (Data source: EDP, 2015a)

Control system	**Number**	**Share**
Photocell	120	35%
Number of SLP	4885	*32%*
Astronomical timeclock	188	55%
Number of SLP	8553	*57%*
Teleparameterized	1	0%
Number of SLP	0	*0%*

Control system	Number	Share
Remote control	2	0%
Number of SLP	54	*0%*
Flow regulator	31	9%
Number of SLP	1573	*10%*
Total	**5649**	
Total SLP	**15065**	**100%**

The type of luminaire and the respective share within the municipality are presented in Table 3. The types of masts with the highest share (Table 4) are the concrete and metallic posts with an average of only one luminaire.

Table 3 - Luminaire types in Évora municipality (Data source: EDP, 2015a)

Luminaire type	Number	Share
Without luminaire	6	0%
Urban closed	5727	40%
Urban open	365	3%
Rural open	3870	27%
Rural closed	2479	18%
Garden type	92	1%
Decorative	1603	11%
Special	19	0%
Stylized	3	0%
Total	**14164**	100%

Table 4 - Luminaire mast types in Évora municipality (Data source: EDP, 2015a)

Mast support type	Number	Share
Concrete column	856	6%
Stylized post	3	0%
Fiber post	0	0%
Wood post	0	0%
Metallic post	5571	40%
Façade	2479	18%
Pole	2	0%
Concrete post	5150	37%
Suspension	24	0%
Total	**14085**	**100%**

The predominant type of lamp in Évora municipality is the Sodium- vapour (low and high pressure) (76%), followed by mercury vapour (13%) and metal iodates (10%) (Table 5). In more recent years there has been a continuous replacement of the oldest lamps with more efficient technology like LEDs and fluorescent ones, but its share is still not significant. Nevertheless, this current status situation shows a high potential for technological efficiency improvements and better lighting management in the municipality of Évora.

Table 5 - Number of lamps and power in Évora municipality (Data source: EDP, 2015a)

Lamp type	Number	Share (%)	Power (kW)	Share (%)
High and low pressure Sodium	10756	76%	1146.2	79%
Mercury	1889	13%	142.7	10%
Metal Iodates	1437	10%	150.2	10%
LED	50	0%	4.8	0%
Fluorescent	21	0%	2.1	0%
Total	**14153**	**100%**	**1445.9**	100%

The public lighting system in each city sector of Évora is showed in Figure 10. The highest density of luminaires is Évora city centre (defined as S. Mamede, Sé and S. Pedro and St. Antão). The majority of the luminaires are located in residential area, as it is portrayed in the figure for rural area, and also alongside the main roads although with more spacing between each one.

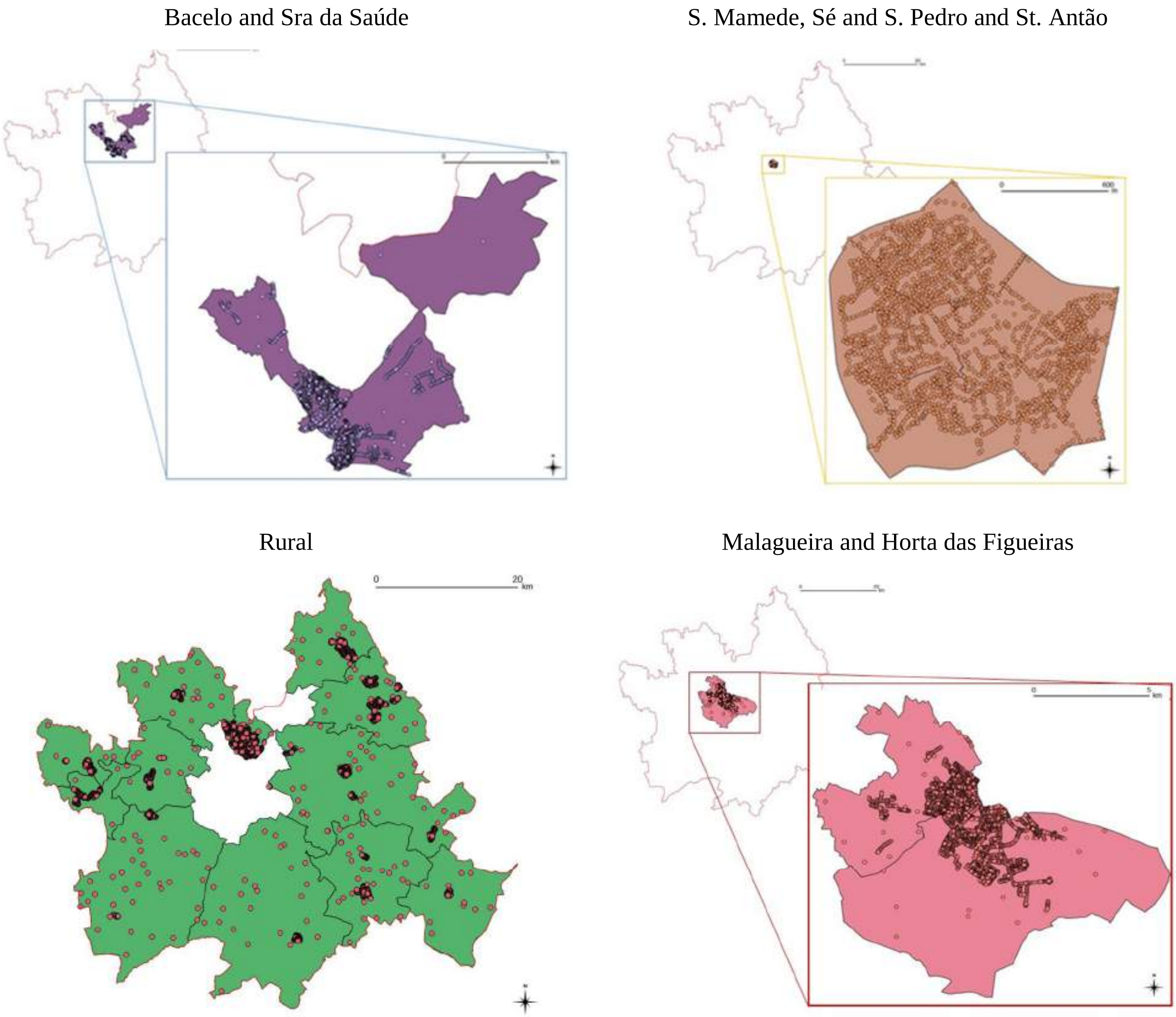

Figure 10 - Street lighting points (SLP) in Évora municipality city districts

Table 6 breaks down the type and number of lamps in place for the four city districts. The more efficient lamp types in place – LED, are only on the two main urban sectors in Évora City centre (S. Mamede, Sé and S. Pedro and St. Antão and Bacelo and Sra da Saúde).

The characterization of types of light control systems cannot be pointed by city district since the control systems are not limited to each district but rather to a network of luminaires that in some cases cross more than one city district.

Table 6 - Number of lamps and power in Évora city district (Data source: EDP, 2015a)

Lamp type	Malagueira and Horta das Figueiras		S. Mamede, Sé and S. Pedro and St. Antão		Bacelo and Sra da Saúde		Rural			Total	
	Number	Power (kW)	Number	Power (kW)	Number	Power (kW)	Number	Power (kW)		Number	Power (kW)
High and low pressure Sodium	4654	564	190	21	2895	305	3017	256		10756	1146
Mercury	562	44	5	0	357	26	965	72		1889	143
Metal Iodates	101	10	1329	140	7	0	0	0		1437	150
LED	0	0	42	4	8	1	0	0		50	5
Fluorescent	0	0	15	2	6	1	0	0		21	2
Total	**5317**	**618**	**1581**	**167**	**3273**	**333**	**3982**	**328**		**14153**	**1446**

The electricity consumption for public lighting (including traffic lights) was 25 TJ in 2013 (DGEG, 2015), corresponding to 5% of total electricity consumption in Évora. The electricity consumption for public lighting varies through the year as a function of the daylight hours across seasons (Figure 11).

There is also a difference between urban and rural profiles of electricity consumption for public lighting, due to different types of light operating control systems in each zone, as the urban sectors have more efficient technologies, which have higher synchronization of lamps activity to natural lighting conditions. EDP Distribuição provided the data on daily electricity consumption per district and sector.

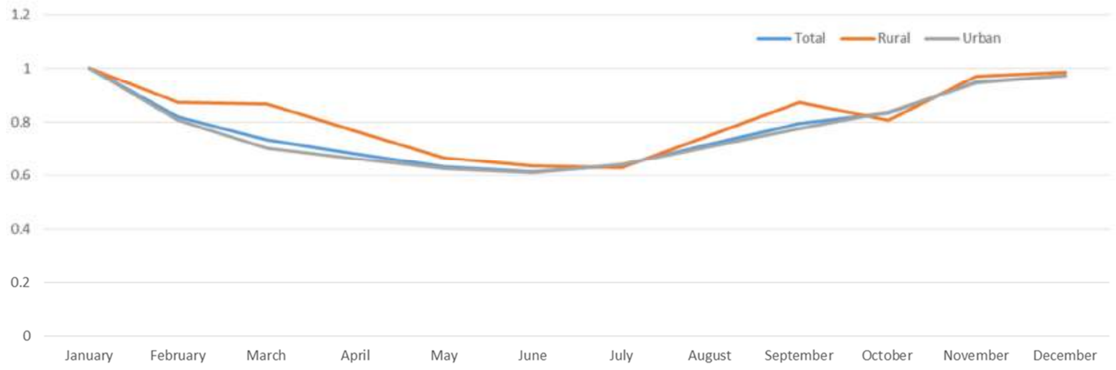

Figure 11 - Public lighting electricity consumption annual profile for 2013 (Data source: EDP, 2015b) (1=energy consumption in January)

Along the month, the daily electricity consumption for public lighting[1] has low variance (Figure 12), since the variation in the number of hours of daily natural light has no significant impact on the operation of public lighting.

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[1] *Peak, Off-peak and shoulder* – refers to the time periods with different electricity prices.

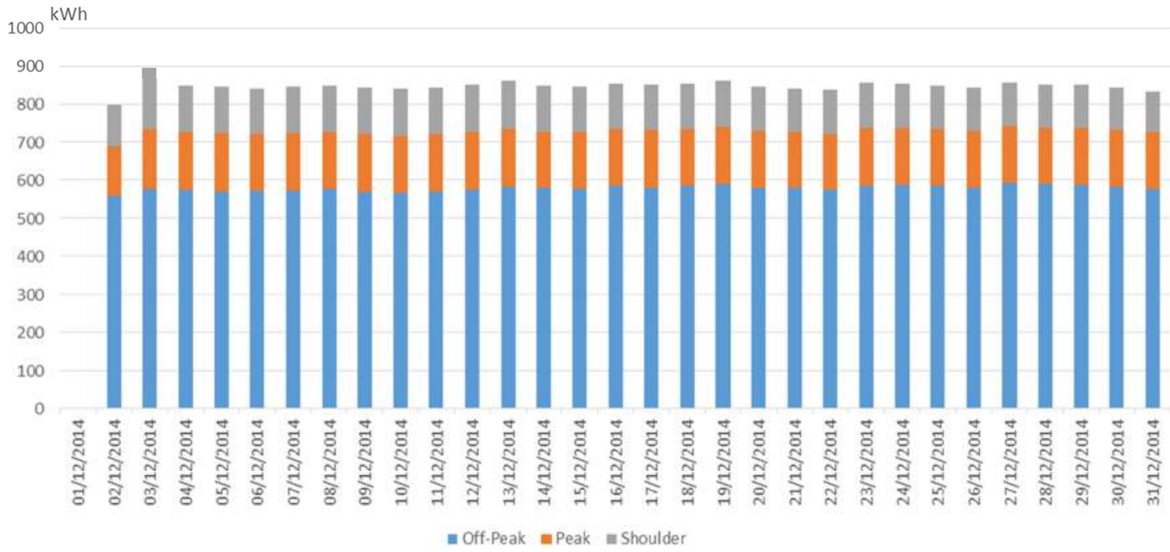

Figure 12 - Public lighting electricity consumption month profile – January 2013 Data source: EDP, 2015b)

An in-depth description of the public lighting network, including specific data of the mentioned characteristics, is presented in the annex excel work file "WP4_Detailed Description.xlsx"; sheet 3_Urban Spaces.

3.1.2. GIS Maps

The GIS maps provided for Public Lighting include shape file name: *Public lighting.shp.* It shows the location of all the lamps of the municipality, although there is no detailed characterization of the attributes lamp by lamp.

3.1.3. Future Plans

Currently, there is a process in place to hire technical audits to prepare for a wide renewal of the public lighting in Évora, aiming very high-energy savings.

3.2. Gardens/green areas and public fountains

3.2.1. Characterization

There are currently 12 fountains in Évora municipality. The green areas and public fountains are located in the main urban zones of the municipality (Figure 13). The green areas, where is included the Zona Verde da Malagueira, Zona Verde da Vila Lusitano and the Parque das Coronheiras, cover an area of approximately 160ha. The electricity consumption associated with these elements (Table 7) represent a small share of the total municipality annual electricity consumption (0.028%), nevertheless these elements are important to be taken into account since they are directly managed by the municipality and would be easier to intervene.

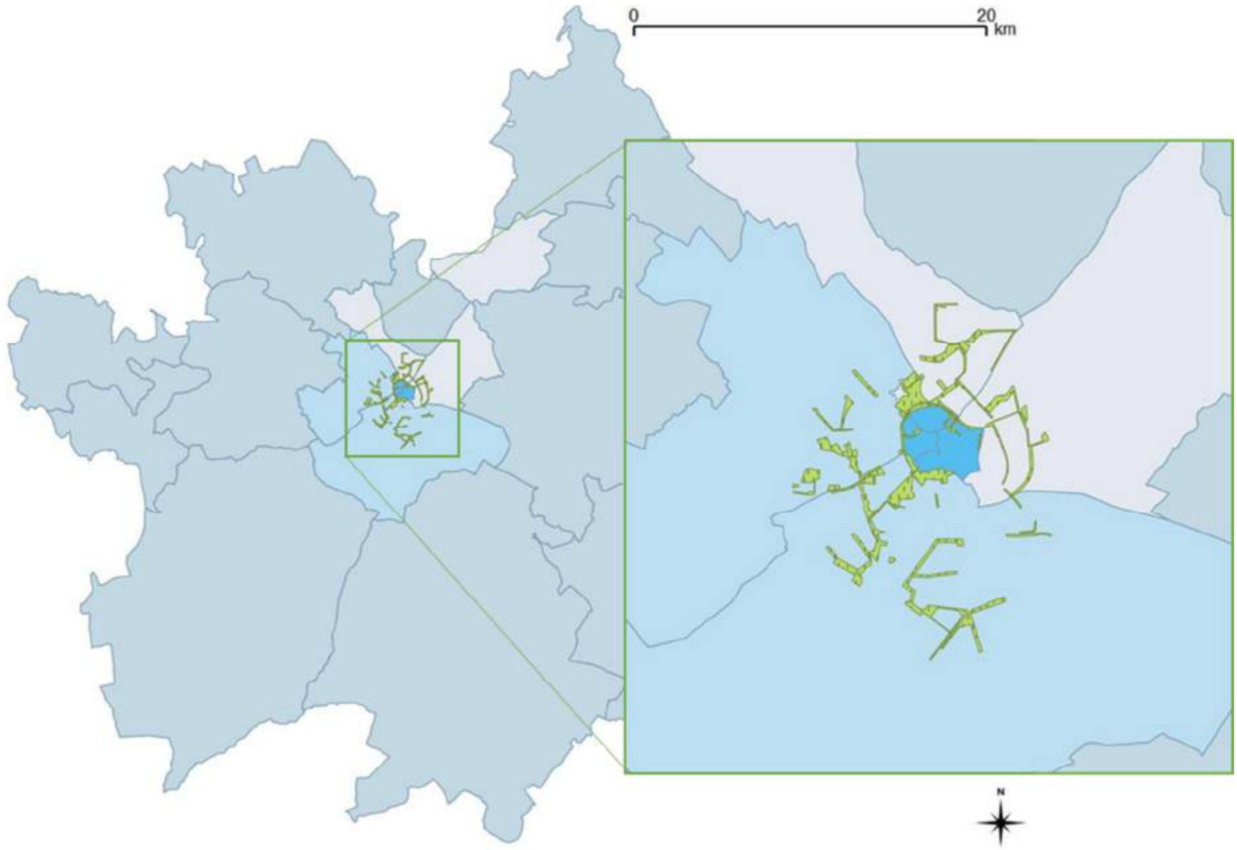

Figure 13 - Gardens/green areas location in Évora municipality

Table 7 - Electricity consumption of gardens and fountains in 2013 in Évora municipality (kWh)

Type/electricity consumption	Peak (kWh)	Off-peak (kWh)	Total
Gardens	79 304	52 811	13 2115
Lighting	2 759	3 459	6 217
Irrigation	68 044	13 252	81 296
Other	8 501	36 100	44 601
Fountains	**30 175**	**42 220**	**72 394**

3.2.2. GIS Maps

The GIS map for these elements is: *Areas verdes.shp* that includes the total area of green areas.

3.2.3. Future Plans

There are no plans for new fountains and gardens, or significant alterations on the present ones that can affect its energy consumption.

4. Water and Sewage Systems

Two different institutions manage the water supply and wastewater systems depending on the levels of infrastructure concept. There are the “high” and “low” infrastructure concepts, where the low is managed by the municipality and the high by Águas de Portugal (former Águas do Centro Alentejo, S.A.). The High concept is related with the transport of water and sewage and the low with distribution of water to the dwellings and the collection of wastewater.

4.1 Water Treatment and Distribution Systems

4.1.1. Characterization

The water distribution network at low level has 325 km and serves 24882 households, corresponding around 50059 inhabitants in 2013 (90% of total resident population) (ERSAR, 2015a). This system 15 reservoirs and 5 groundwater extraction points, and is directly managed by the municipality. Águas do Centro Alentejo, S.A. manages the volume of water transported in the high system as well as the water treatment facility. This system covers more than Évora municipality, also including the surrounding area. The energy consumption of the water lifting stations is 0.5 kWh/(m^3.100m), that refers to a medium service quality (ERSAR, 2015a).

The characterization of this system is still underdevelopment, as the detailed information has been requested to the responsible and official entities and still awaiting response. Nevertheless, a more general description is provided utilizing national statistics, and close as possible to the desired spatial scale.

The current multi municipal water and sewage system was created as part of the first Strategic Plan for Water Supply and Sewerage Services (PEAASAR) for the timeframe 2000-2006.

Figure 14 - Évora municipality water system facilities map

The whole water supply network of Évora in 2013, including the treatment system, consumed around 21 TJ of electricity (DGEG, 2015), corresponding to an average energy consumption indicator of 0.37 GJ/inhab.

Data from smart meters provided by EDP allowed building the monthly electricity consumption profiles (Figure 15) of daily-metered data. Nevertheless, the data available is only for the aggregation of water and wastewater systems. Figure 15 show that these facilities consume more electricity in weekends than on the weekdays.

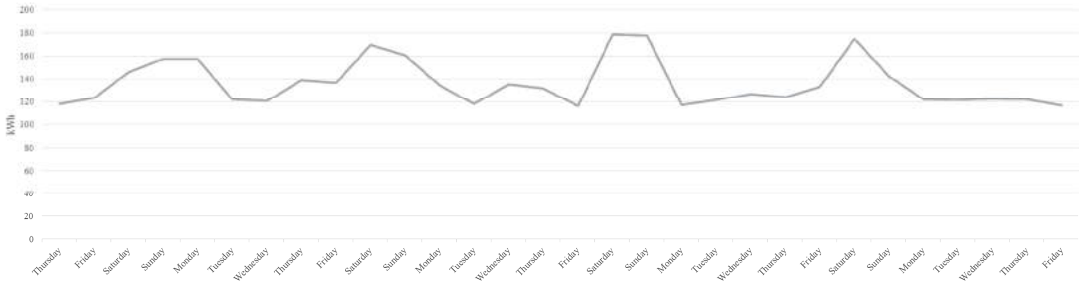

Figure 15 – Daily electricity production on Water and wastewater treatment system for January 2013 (data source: EDP, 2015b)

4.1.2. GIS Maps

The location of the different water system are mapped in the following GIS Shapefiles:

1) *ETA_Pcloragem_TIPO__POSTO DE CLORAGEM*
2) *EstElevAgua*
3) *ETA_Pcloragem_TIPO__ETA*

4.1.3. Future plans

Currently, there are no future plans for water management, although there have been recent developments in the revision of the PEAASAR for 2020 regarding improvements of efficiency and services quality targets.

4.2 Sewage Systems

4.2.1 Characterization

The water sewage system covers all the urban and rural areas of the municipality. In 2001 rural areas had 26% of the resident population with collection of wastewater made through septic tanks. In 2009, around 82% of Évora population was served by the wastewater treatment plant (INE, 2009).

Table 8 - Évora population connected to sewage system by type and city district 2001 (Data source: INE, 2001)

City district	Connected to the public sewage system	Particular sewage system (septic tanks)	Other	With no sewage system
Rural	7968	2818	461	306
S. Mamede; Sé e S. Pedro and Santo Antão	5445	15	8	3
Bacelo and Senhora da Saúde	15740	1560	96	113
Malagueira and Horta das Figueiras	19597	1021	162	328
Total	48750	5414	727	750

Drainage network of other urban centres and rural parishes, whose resident population is under 1000 inhabitants are less complex and have proportionally shorter extensions.

In total there are 13 wastewater treatment plants and 4 septic tanks. The treatment processes vary according to the characteristics of water as well as with the volumes, local conditions and needs in different urban areas. In Évora the following processes are used: activated sludge, stabilization lagoons and septic tanks (CME, 2014).

Figure 16 presents the location of the wastewater pumping stations and treatment plants. There is only one wastewater lift station within the municipality, in São Manços - rural zone.

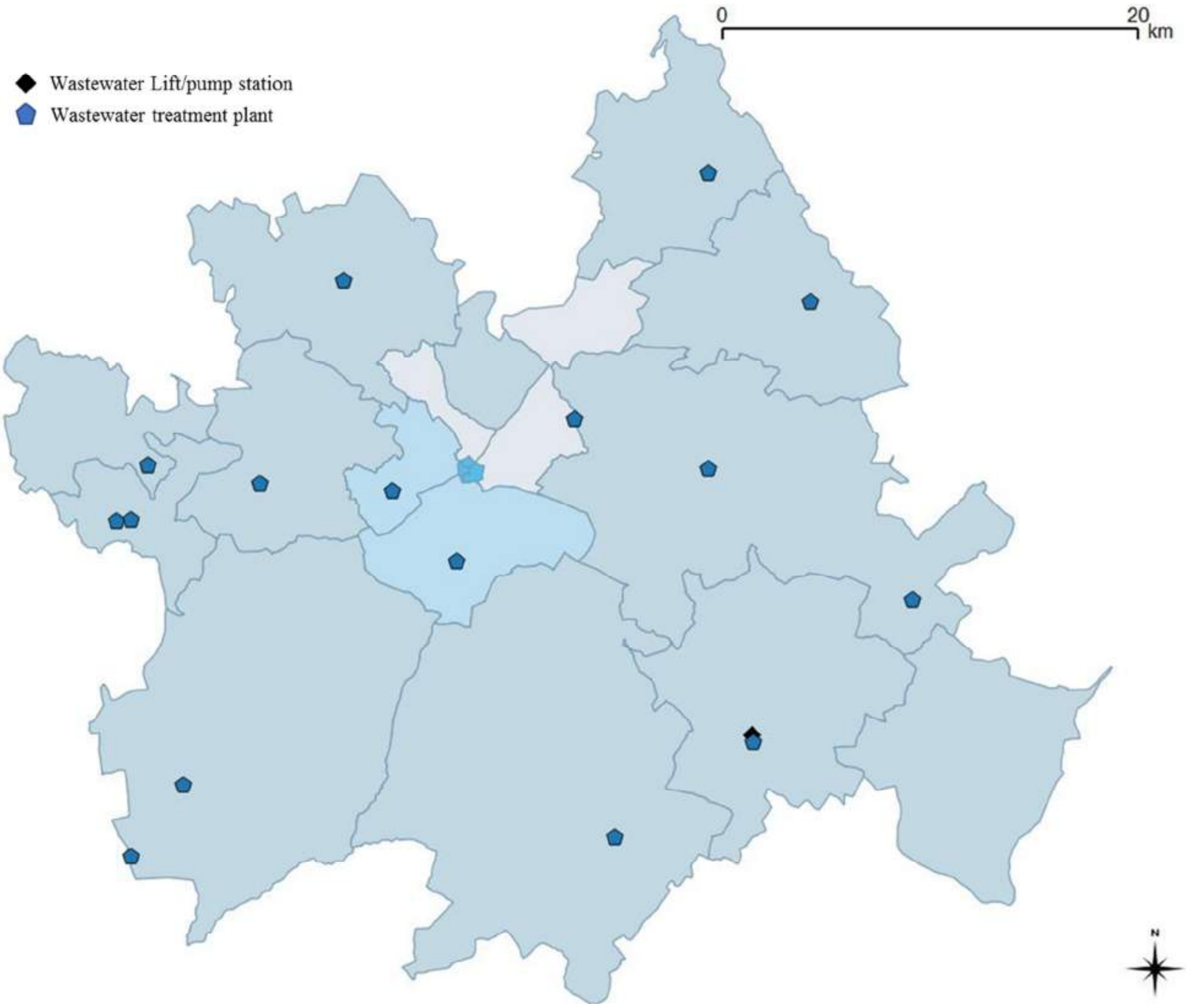

Figure 16 - Wastewater system facilities map

4.2.2 GIS Maps

4.2.3 Future Plans

Indication of expected future plans and projects for new or increase of current facilities of wastewater treatment, including perspectives for potential energy production at these sites. This should include the spatial location in city districts under study in InSMART and the description of the measures namely in terms of technology characterization and year of full implementation (might be useful stakeholders meetings). Fill in Table 10 for detailed facilities description.

5. Waste Chain

5.1 Characterization

The Intermunicipality System of Municipal solid Waste (MSW) of the District of Évora (SIRU) (Figure 17) is an integrated system of solid waste that is reflected by the set of packaging operations and transport of waste and the solutions of treatment, recovery and/or final destination, which responds to general and sectoral objectives of the interests of a region and the priorities of national and EU policy on the matter.

GESAMB – Gestão Ambiental e de Resíduos is the company responsible for the management and operation of SIRU in the District of Évora, which includes the municipalities of Alandroal; Arraiolos; Borba, Estremoz, Évora, Montemor-o-Novo; Mora; Mourão, Redondo, Reguengos Monsaraz, Vila Viçosa and Vendas Novas. Although the system aboard more municipalities than Évora, the main facilities are located within Évora municipality boundaries, and receive solid waste from the surrounding municipalities. The municipality of Évora has one landfill, one waste sorting centre, one eco-centre and 218 recycling curbside collectors spread throughout the municipality. The main facilities (landfill (Figure 18), sorting centre, etc.) located in Évora receive all the waste collected in the district.

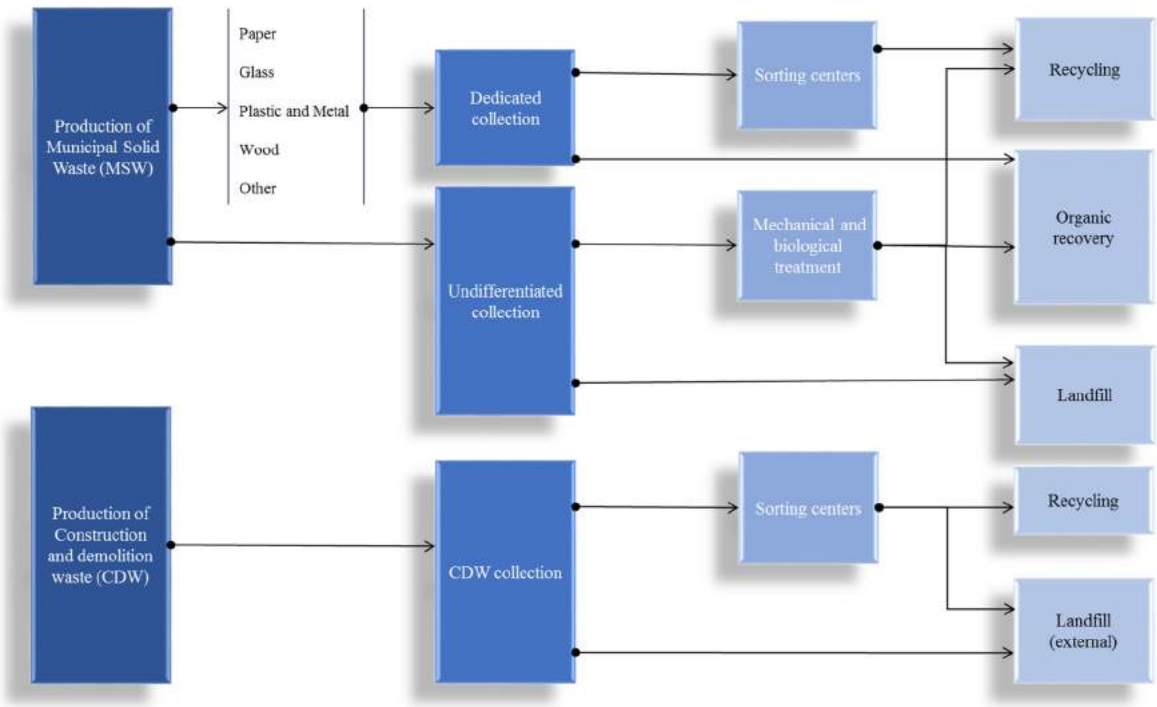

Figure 17 – Inter-municipality System of Municipal Waste of the District of Évora (SIRU) flowchart

Figure 18 - Évora landfill

In 2014, each inhabitant in Évora municipality produced, in average, approximately 484kg of collected urban waste, corresponding to a total of 27636 ton. Table 9 presents the input waste characterization, for the entire waste system and for just Évora municipality. Évora contribute with 35% to all the MSW collected in the system, being the undifferentiated waste the main type of waste collected. The dedicated collection has small share, with only 3% of the total waste collected.

Table 9 - Waste collected in Évora district and municipality (Source: GESAMB, 2015)

Input waste characterization	**Whole system at district level** (t)	**Évora municipality**		
		Quantity (t)	**Share (of whole system)**	**Waste per inhabitant (kg/capita)**
Undifferentiated collection	69 693	26 822	38%	473.9
Selected collection waste	9 059	814	9%	14.4
Paper	2 248	193	9%	3.4
Plastic and Metal	1 122	4	0%	0.1
Glass	1 697	21	1%	0.4
Wood	2 534	405	16%	7.2
Other	1 458	191	13%	3.4
Total	**78 752**	**27636**	**35%**	**502.7**

The Rural city district has the lowest quantity of selected waste collection per inhabitant

Table 10.

Table 10 – Selected collection waste by city district in 2014 (Source: GESAMB, 2015)

City district	Type of material	Quantity (kg)	Quantity (kg/capita)
Rural	Plastic and metal	46.7	4.2
	Paper	84.8	7.5
	Glass	86.3	7.7
	Total	217.8	**19.4**
Bacelo and Senhora da Saúde	Plastic and metal	122.7	6.7
	Paper	193.4	10.6
	Glass	130.9	7.2
	Total	447.1	**24.5**
S. Mamede; Sé e S. Pedro and Santo Antão	Plastic and metal	31.3	6.6
	Paper	62.5	13.2
	Glass	38.1	8.0
	Total	131.9	**27.8**
Malagueira and Horta das Figueiras	Plastic and metal	155.6	7.0
	Paper	248.5	11.1
	Glass	180.1	8.0
	Total	584.3	**26.1**

The monthly quantity of selected MSW is presented in Figure 19.

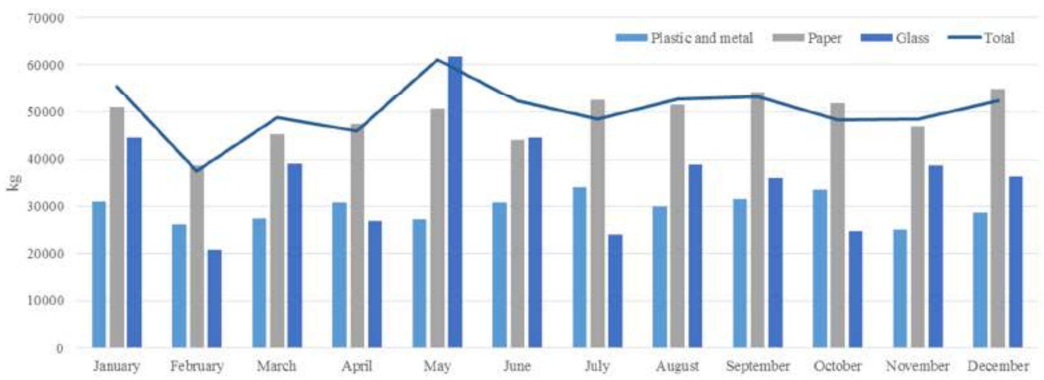

Figure 19 - Month quantity of selected MSW in 2014 in Évora municipality (Adapted from GESAMB, 2015)

The collection of waste is made by two vehicles that cover the Évora municipality grid. One vehicle is for dedicated collection and the other to the undifferentiated collection. The two vehicles cover 21 303 km/year and consume 3 792 litters of diesel.

The Évora waste treatment facilities include the following components: ecocentre/recycling, and sorting centre, landfill and mechanical and biologic treatment unit, all of them located in the same zone, referred in Figure 20 as *landfill*. The Évora ecocentre emerges as a complementary system to recover materials and send them for recycling, functioning as a reinforcement of selective collection of recycling curbside collectors, constituting as an additional way to enhance the recovery of recyclable materials contained in waste. In addition it also receive materials, which, by their nature, cannot be covered by the normal collection circuits.

The landfill is composed by 6 storage cells with an overall capacity of 1 967 948 m^3, although only four are currently being explored.

The sorting centre started its operation in 2004, and is dimensioned to receive the waste selective collected from recycling curbside collectors distributed in the 12 municipalities of Évora district. Since 2014 a new infrastructure for receiving construction and demolition waste was implemented in Évora. Also since 2014 a unit for mechanical and biologic treatment was implemented in order to meet the objectives set at national level to divert biodegradable municipal from waste landfill.

Figure 20 - Location of Évora waste treatment facilities

GESAMB provided individually information on energy consumption for each facility - mechanical and biological treatment and pressing and sorting for recycling materials (Table 11) on 2014. The energy consumption associated with the landfill was not provided.

Table 11 – Electricity consumption by solid waste treatment in 2014 (source: GESAMB, 2015)

Facility	Electricity consumption	
	(kWh)	(kWh/capita)
Mechanical and biological treatment (MBT)	283 417	5.0
Ecocenter and Sorting centre (including sorting line and presses)	24 246	0.4
Total	**307 663**	**5.4**

The energy consumption of the MBT is associated with the treatment of MSW from undifferentiated collection and the energy consumption from the sorting lines and presses for the selected collection waste (i.e. paper, glass and metal).

According to DGEG, 2015, the MSW chain in Évora municipality, referred as *Waste gathering, treatment and elimination* sector consumed 173 GJ of electricity in 2013. This value is much higher than the one provided by GESAMB for 2014 (308 MWh), but it is related with the operational start of the MBT in that year. No energy valorisation of wastes is currently in place in the municipality and according to GESAMB, the production of biogas is currently financially unfeasible. Also the production of electricity by burning waste is not feasible given the insufficient amount of waste produced to feed a power plant (CME, 2012). Additional information is provided in excel work file "WP4_Detailed Description.xlsx"; sheet 5. Waste Chain.

5.2 GIS Maps

The GIS map for the waste treatment facilities is named: *waste landfill*, with the location of the facilities but no energy consumption for each facility.

5.3 Future Plans

The future plans for the waste system in Évora municipality are defined on the Action Plan of GESAMB 2015-2020 (Plano de Ação da GESAMB para 2015-2020). This action plan intends to set the contribution to the national objectives under the Strategic Plan for Urban Solid Waste Management (PERSU). This plan was reviewed and appeared a new industry benchmark for Urban Waste, the PERSU II to time horizon from 2007-2016, sets priorities, goals to be achieved, and the actions for implementing multi-municipality, inter-municipality and municipal plans and it is guiding rules. PERSU II contributes to the achievement of national and Community targets for municipal waste management. The established targets for the period 2007–2016, applied only to mainland Portugal. The main goals of the new strategic plan are as follows:

- a review of PERSU I goals;
- to divert biodegradable MSW from landfill to composting and incineration coupled with MBT;
- a commitment to reduce greenhouse gas emissions;
- the development of recovery technologies, investing in units to produce CDR

The strategic guidelines of PERSU II are in line with the Waste Intervention Plan Municipal Solid and Similar (PIRSUE), approved in 2006 to address the delay in meeting the European recycling and recovery targets. PERSU II came also review the National Strategy for Reducing Biodegradable Municipal Waste destined for landfills, published in 2003 to comply with landfill diversion obligations laid down in Directive "Landfills"[2].

Although the European Commission adopted in 2014 a legislative proposal and annex to review recycling and other waste-related targets in the EU Waste Framework Directive 2008/98/EC, the Landfill Directive 1999//31/EC and the Packaging and Packaging Waste Directive 94/62/EC, it is not totally clear of the impact on national targets, and therefore it's not yet quantified.

The expected future plans and projects for new or increase of current facilities are defined in the Action Plan of GESAMB 2015-2020, where is the indication on futures perspectives of waste collection by waste type (Figure 21), and also the correspondent final destination (Figure 22). The information presented in plan is for the entire Évora district, and therefore an allocation to municipality scale was made using indicators from historic information.

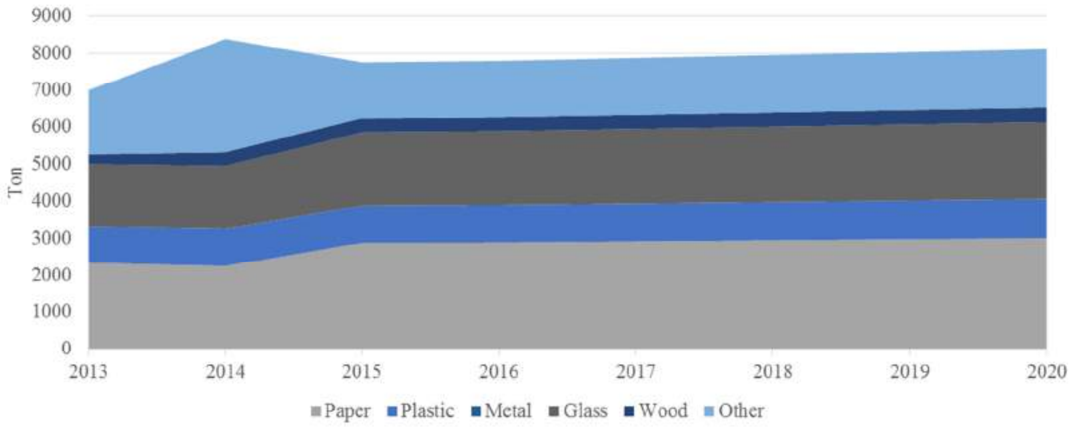

Figure 21 - Projections on selected waste collection for Évora district (GESAMB, 2015c)

[2] Landfill Directive 1999//31/EC

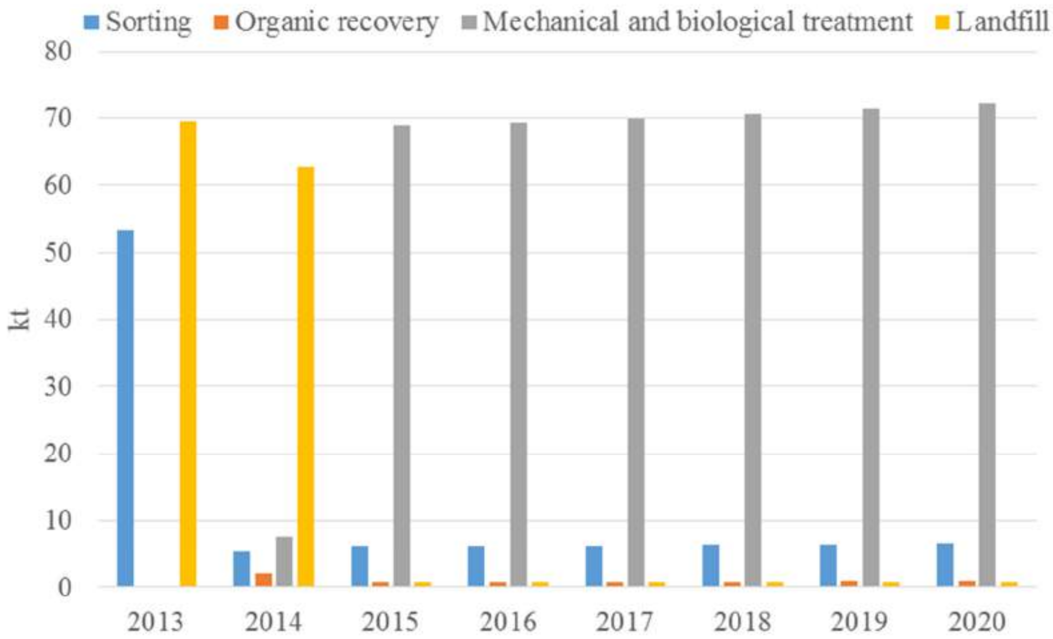

Figure 22 - Projections on waste final disposal for Évora district (GESAMB, 2015c)

6. Energy Supply System

6.1. Characterization

This chapter presents the analysis and depiction of the decentralized energy supply technologies as well as the potential for renewable energy sources (RES). The description of the different energy supply technologies will focus on PV technology due to its promising role in the city energy system.

6.1.1. Solar Photovoltaic

Solar PV decentralized scale

There are 239 small solar PV installations in Évora municipality, corresponding to a total of 1224 MW being 81% of those located in the urban area (Table 12). The technology is predominating in the residential sector with 63% of total PV capacity. The services sector, although with a smaller share (30%), has larger installations: 9.7 kW in average when comparing with the 4.7 kW on the residential sector. This difference is inexistent in the rural area due to the smaller density of services buildings.

The total electricity produced in 2014 was 1285 GJ (357 MWh), which corresponds to less than 1% of the total electricity consumed in the municipality in that year. For the residential sector the amount of electricity corresponds is 0.4% and results for the annual electricity consumption of 124 households.

Table 12 - Solar PV technology in Évora municipality in 2014 (data source: EDP, 2015c)

City Sector	Sector	Installed capacity (kW)		Electricity production (kWh)	
		Total	**Average**	**Total**	**Average**
Urban	Industry	7.4	3.7	11 164	5 582
	Residential	626.1	4.7	909 288	6 889
	Services	318.2	9.4	510 687	15 475
	Agriculture	41.1	3.7	57 801	5 255
Total		**993**		**1 488 940**	
Rural	Industry	0.0	0.0	0	0
	Residential	150.2	3.6	235 495	5 744
	Services	46.1	3.5	66 299	5 100
	Agriculture	34.7	6.9	55 491	11 098
Total		**231**		**357 285**	

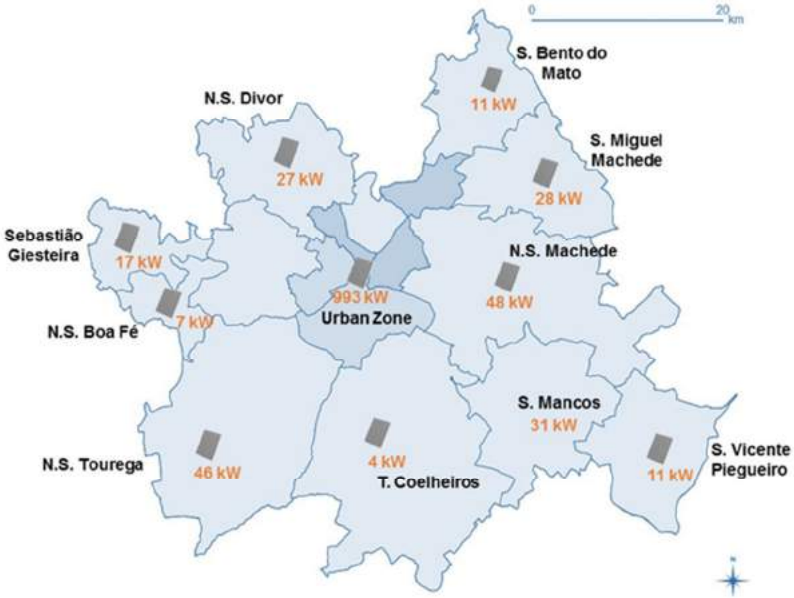

Figure 23 – Solar PV power capacity in Évora municipality in 2014 (data source: EDP, 2015c)

The solar PV small-scale decentralized facilities are regulated in Portugal through specific Decree-Laws regarding the micro generation[3] (systems up to 5.75 kW or 11.04 kW for condominiums) and mini generation[4] (systems up to 250 kW). The mini generation solar PV facilities account for 34% of the total decentralized PV systems in 2014. According to the Ministry of Economy, the solar PV units increased from 48 kW in 2008 to 1224 kW in 2014 (Figure 24) (MEE, 2014).

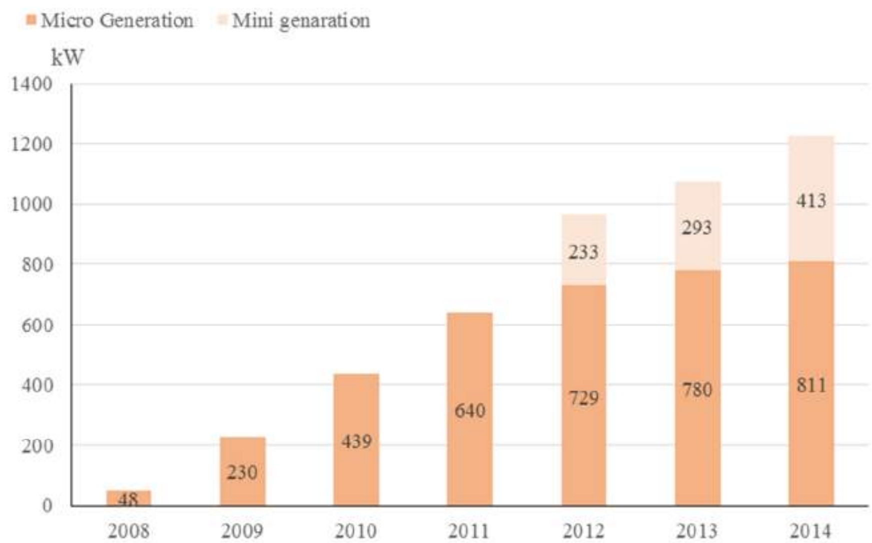

Figure 24 - Micro and mini Solar PV installed capacity in Évora (data source: MEE, 2014)

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[3] Micro generation – Decree-Law n. º 363/2007, November 2nd, updated by the Decree-Law n. º 118-A/2010, October de 25th, and by the Decree-Law n. º 25/2013, February 19th

[4] Mini generation– the Decree-Law n. º 34/2011, March 8th, and updated by the Decree-Law n. º 25/2013, of February 19th

In order to simplify the prevailing legal norms (stated above) regarding grid injection (Mini and Micro production), a new national legislation on distributed energy generation seeks to guarantee, that the size of future installations is adapted to the local consumption needs, thus avoiding the oversizing of installations.

The new legislation on distributed energy generation foresees two type of production units: Production Units for Self-consumption (UPAC) and Small Production Units (UPP) Centralized PV. Although it's importance, the level of impact in the promotion of decentralized PV panels is not currently perceptive.

Solar PV utility scale

In terms of utility scale PV Évora has two solar facilities totalling 2.4 MW of installed capacity. The *Cycloid* and *Glintt* facilities have different PV technologies. The *Glintt* facility, which started its operation in 2014, has 1.3MW of Concentrated PV technology, and the *Cycloid* with 1.1 MW of typical PV cell technology. The facilities are located, respectively, in Malagueira e Horta das Figueiras and Rural city districts (Figure 25).

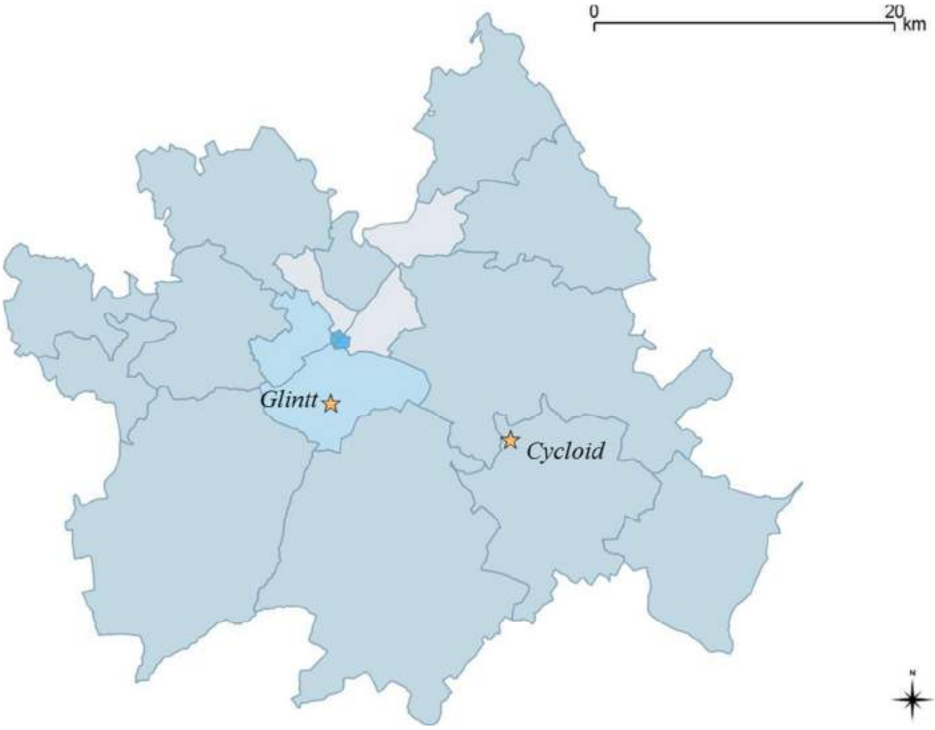

Figure 25 - Location of the two solar PV power plants

There is very detailed information on the electricity production for both utilities. The 15 min temporal scale of measurements provide a key opportunity for characterization of different production profiles, as follows: a) annual and seasonal electricity production profiles (Figure 26 and Figure 27), b) Average hourly electricity production (Figure 28) and c) Average capacity factor (Figure 29). Due to confidentiality restrictions, only the production profiles are allowed to be published, although the detailed data is available for the modelling work of WP5.

Figure 26 - Annual electricity production profile

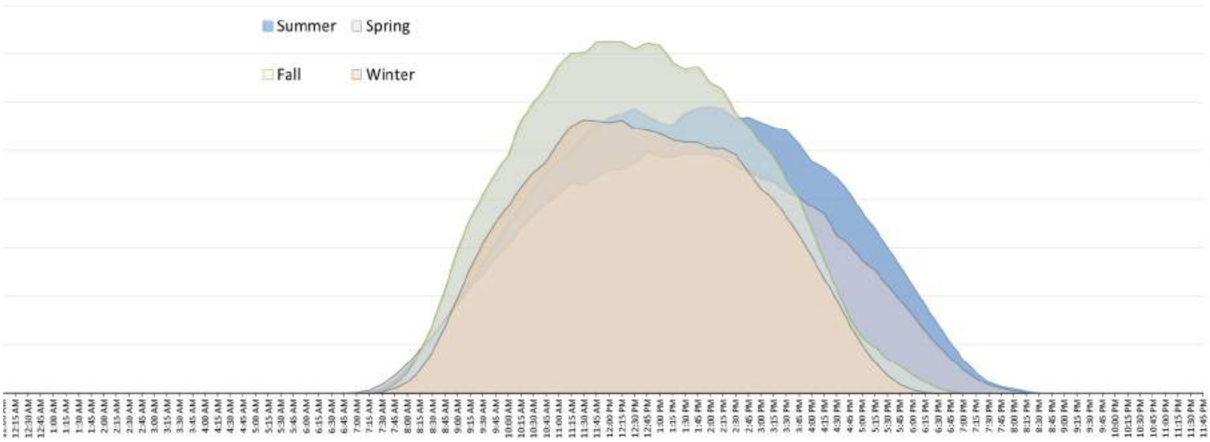

Figure 27 - Average electricity profile of production by season

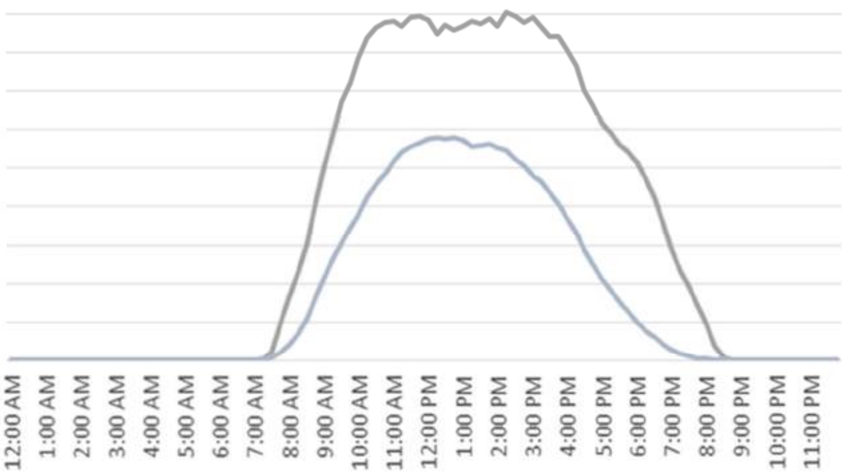

Figure 28 - Average hourly profile of electricity production

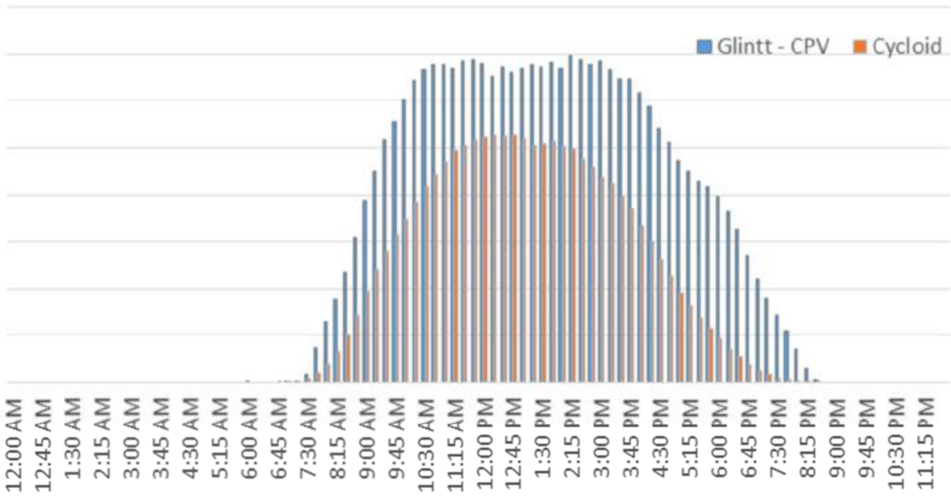

Figure 29 - Average capacity factor

6.1.2. Solar Thermal

There is no detailed information on the solar thermal equipment's in Évora. Therefore, similar to the quantification of the solar energy consumption for water heating it was made an estimation on the number of equipment using the basic characteristics of a standard solar thermal system (occupies $2m^2$, with a storage capacity of 150l per day, providing an average energy supply of 1.32 MWh/m^2.year). The results show that there are 21 solar thermal systems in Évora.

6.1.3. Wind

Currently there are no small or utility scale wind energy technologies in Évora.

6.1.4. Biogas

There is only one cogeneration power plant in Évora municipality, associated with the main wastewater treatment plant that consumes the biogas gathered in the treatment process. The plant was installed in 2005 and runs in parallel to the grid, having an electrical power of 170 kWe and a thermal power of 260kWt (Turbomar Energia, 2014).

6.1.5. Biomass

There are no biomass power plants located in Évora municipality. The consumption of biomass in the municipality refers to residential space heating through fireplaces.

6.1.6. Geothermal

Évora municipality has no significant geothermal resource to make viable any centralized facility.

6.2. Technical potential assessment

This section provides the methodology and results of assessment of the technical potential for the various RES-E within Évora municipality.

6.2.1. Solar Photovoltaic

6.2.1.1. Utility scale

Solar PV at utility scale refers to plants with an installed capacity higher than 1MW. Usually, these type of plants are located outside the city boundaries, but it could happen to be feasible to consider it in some available area in the city.

The methodology for the assessment of technical potential of PV at utility scale, in terms of installed capacity in the municipality/city area encompasses two main steps (Figure 30):

1. Assessment of the available area for PV plant size installations and
2. Suitable and useful areas for the PV optimal deployment.

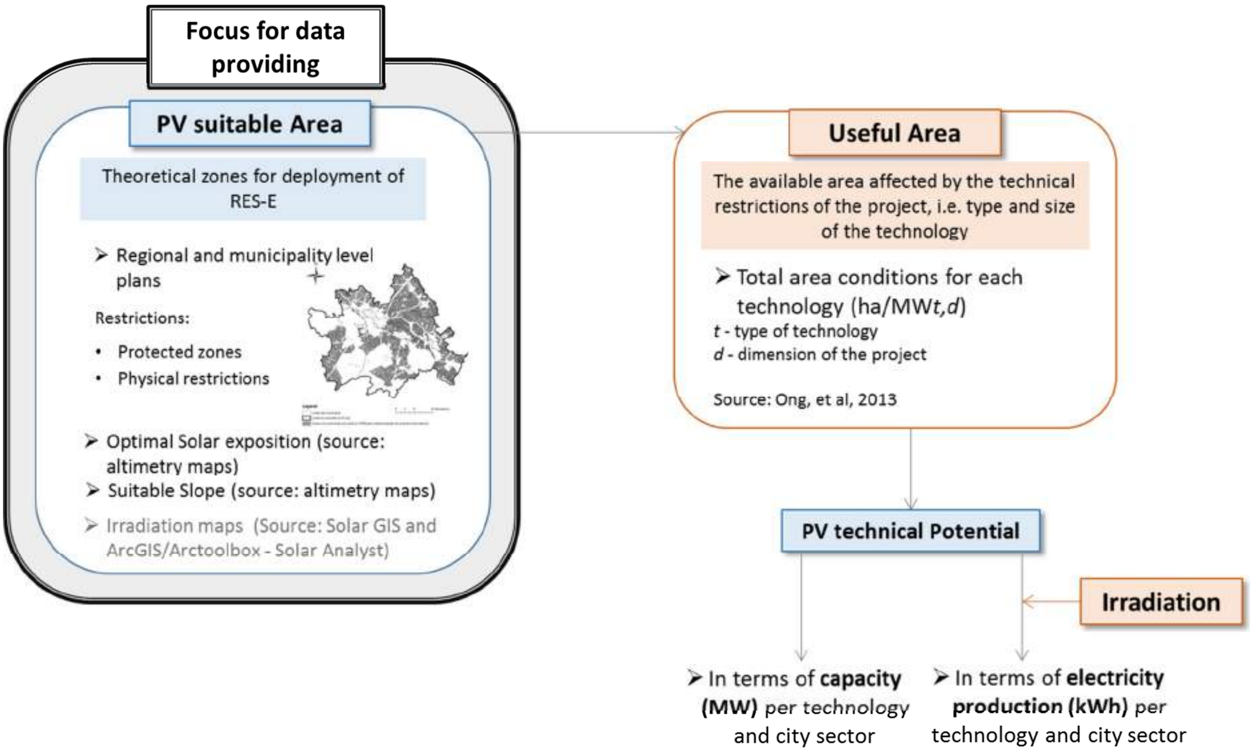

Figure 30 - Methodology for the assessment of the technical potential of PV plant size (>1MW) (Data gathering inside bold fence)

We consider as available area the group of rural spaces that due to their characteristics in terms of land use allow the installation of RES electricity production projects from solar PV. To accomplish this purpose, two major restrictions were considered: legal and infrastructures restrictions. The legal restrictions correspond manly to the land-use constrains defined in the Municipality Master Plans (MMP), and the infrastructural to the categories of land-use with no possibility to implement large-scale PV projects: urban areas, road and rail networks, water lines, dam reservoirs and flood zones. For all these categories we incorporated a buffer zone in order to take into account their specific protection characteristics that can limit the implementation of the PV project.

Since the objective was to evaluate PV technical potential in rural areas, our first step was to exclude urban agglomeration areas. Through the regulation of the MLP of Évora, dated December 2007 and the amendment to the Regulation, dated October 2012, it were identified administrative easements and public utility land use, which are considered due to its importance to natural level, the implementation of an energy utilization project from renewable sources, in this case solar PV.

The rural land use was classified according to the existing uses and the protection of the natural resources that imply a conditioning of new infrastructures.

The rural land-uses classes with protection character were automatically considered as non-PV deployment area. These zones refer to: agriculture and ecological reserves, protected natural areas (e.g. Natura2000 network), protection of water lines and water reservoirs, protection of electrical lines and national road network, regional roads and unclassified roads.

The detailed analysis of the specific legislation proven that only on areas Rural and forest spaces and Environmental protection spaces are permitted, subject to standards defined for each sub-category space, the installation of energy utilization projects from renewable sources. Note that in this analysis it was considered, that in the absence of specific reference in the legislation to the permit to RES-E projects, the sub-classes were viewed as not eligible. Furthermore, if in the legislation there was a reference to the legal impossibility to install high and medium voltage stations, or electricity transport network those areas were classified as not eligible. A deeper analysis of the activities and infrastructures permitted on the sub-classes of land-uses Rural and forest spaces and Environmental protection spaces was made, resulting in the inclusion of only three possible land use classes for PV deployment.

The PV suitable area was defined by including the slopes and solar exposure of the terrains as these are two very important parameters to take into account in the selection of the best areas for the installation of solar energy utilization projects. Before working on these two variables it was necessary to draw up the exposure and slope maps in vector format.

For optimal slope definition it was decided to exclude areas with a slope exceeding 3%. These values are considered as a restriction on the implementation of such projects based on (Lopez et al. 2012).

The solar exposure selection was divided into two levels: a) the optimum exposure, ranging from SouthEast (135^0) and SouthWest (225^0) and b) the least appropriate exposure (remaining).

After the overlay of all the previous mentioned restrictions and optimal parameters definition, the assessment of the technical potential of utility-scale PV in Évora rural areas requires the definition of the type of PV technology to be considered, as different technologies require different amount of space for deployment also related to the power capacity to be implemented. Thus, it was considered two different technologies: 1) PV system with tracking device with one axis and crystalline silicon solar cells (c-Si) (PV-track); 2) Concentrated PV (CPV) system with two axis and multi-junction high efficiency solar cells; and four project dimensions, representing the most common existent projects sizes: 1MW, 10 MW, 20MW and 30MW.

The first PV system (c-Si PV-track) was chosen has they constituted approximately 90% of global module production capacity in 2014 (Metz et al. 2015) and are the most mature of all PV technologies (MIT 2015) low current average market price and its high efficiency (NREL, 2015) around 25%, when compared with other types of cheaper systems (NREL, 2015 The second system (CPV) was chosen due to its high efficiency, around 40% (NREL, 2015) and the fact that allows for greater compatibility of land use once the panel is at a higher distance from the ground and with just one centrepiece. This type of system is also under large investments, even in the territory of Évora. According to (Carvalho et al. 2011) the low concentration and medium concentration (MCPV), and the single-axis tracking systems are the most profitable technologies 150kW mini-generation system in 7 countries, including Portugal.

The land area needed for each type of PV technology and system size was based on (Ong et al. 2013) each of these systems requires area to be occupied with the solar panels and between them (direct area), but and also contemplate the area free for operation and maintenance (total area).

Under the objective of these work it was only selected the areas with strict rural land use restrictions that imply that only areas with low land value are suitable for PV installation. The available area for the deployment of PV is presented in Table 13 and in Figure 31.

Table 13 - Available area for the strict land use scenario

Scenario	Strict		
Exposure	**Optimal**	**Weak**	**Total**
Available area (ha)	5 244	1 707	6951
% of Évora municipality	4	1,3	5,3

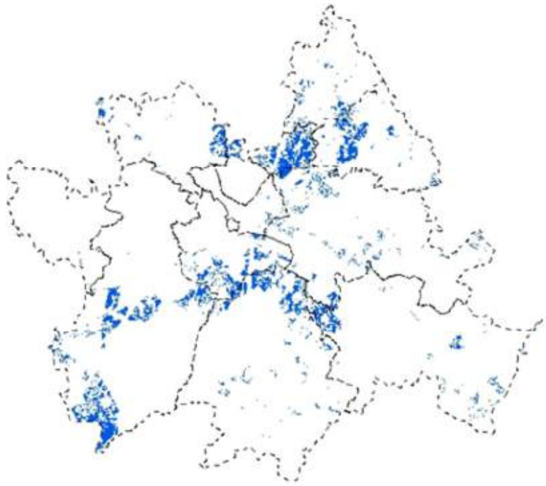

Figure 31 - Available area for the strict land use scenario

The useful area, corresponding to the available area affected by the needed area for each type of PV system, is presented in Table 14.

Table 14 - Useful area for the scenarios under analysis

Scenario	**Strict**							
Technology scenario	**PV *tracking* 1 axis horizontal NS (c-Si)**							
Installed capacity	**1MW**		**10MW**		**20MW**		**30MW**	
Exposure	Optimal	Weak	Optimal	Weak	Optimal	Weak	Optimal	Weak
Useful Area (ha)	3 905	1 155	675	312	258	69	104	0
Total (ha)	**5 060**		**987**		**327**		**104**	
Technology scenario	**CPV *tracking* 2 axis (Multi-Junction)**							
Installed capacity	**1MW**		**10MW**		**20MW**		**30MW**	
Exposure	Optimal	Weak	Optimal	Weak	Optimal	Weak	Optimal	Weak
Useful Area (ha)	3 852	1 127	556	276	258	69	104	0
Total (ha)	**4978**		**832**		**327**		**104**	

The utility scale PV potential in Évora rural areas (

Table 15) can reach up to 1.5 GW. The more appropriate PV project sizes are the one with 1 MW and 10 MW, since they show a higher efficiency on terms of area occupancy and can be located more close to the urban areas (Figure 32).

Table 15 - PV technology potential of installed capacity and energy production for the different scenarios

Technology/Exposure		**1 MW**		**10 MW**		**20 MW**		**30 MW**	
		PV	**CPV**	**PV**	**CPV**	**PV**	**CPV**	**PV**	**CPV**
Production (GWh)	Optimal	1 819	1 957	315	282	142	165	58	68
	Weak	538	573	145	141	37	44	0	0
	Total	**2 357**	**2 530**	**460**	**423**	**179**	**209**	**58**	**68**
Installed capacity (MW)	Optimal	1 116	1 041	193	150	76	78	31	32
	Weak	330	305	89	75	20	21	0	0
	Total	**1 446**	**1 346**	**282**	**225**	**96**	**99**	**31**	**32**

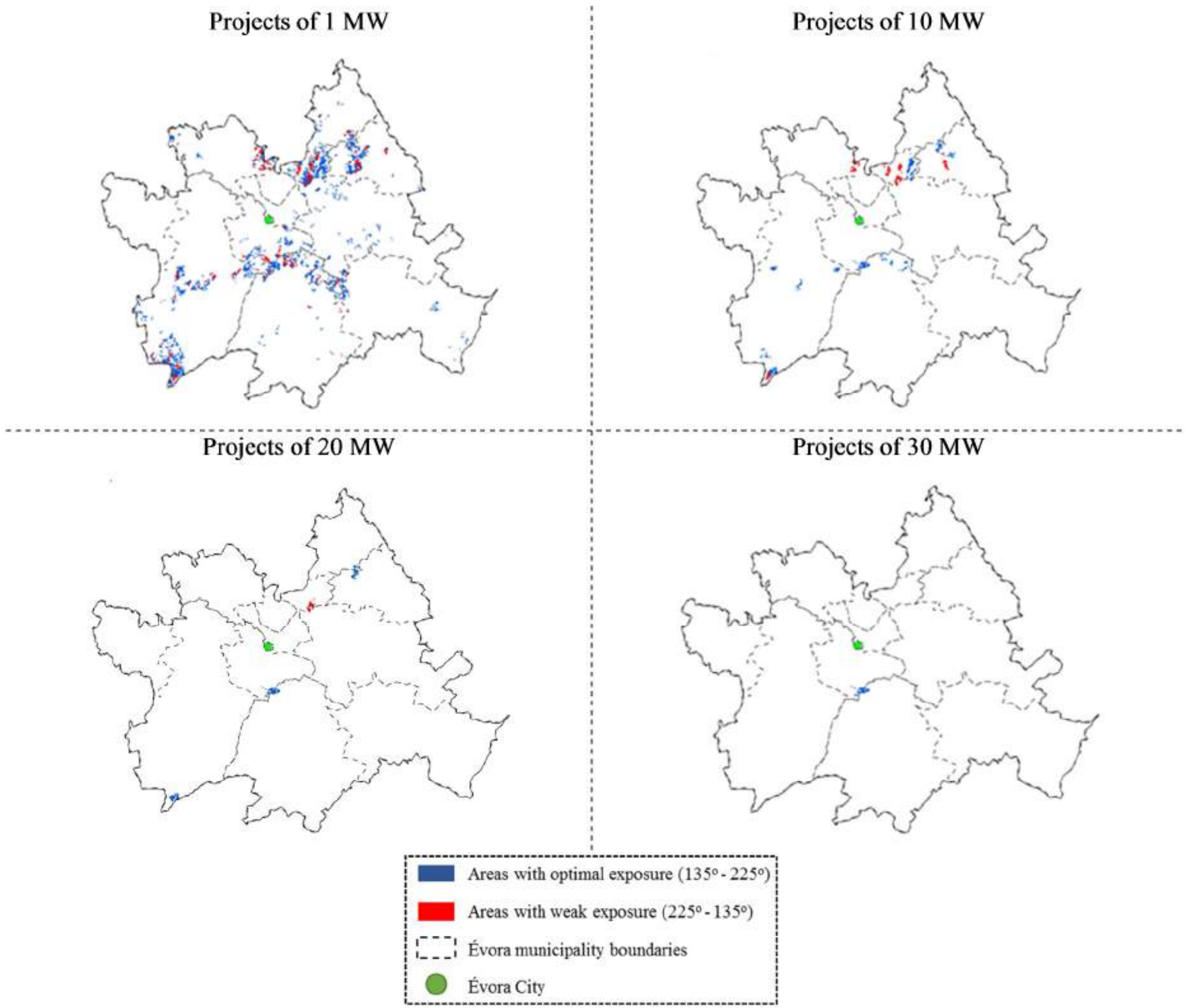

Figure 32 - Location of the utilities with different sizes

6.2.1.2. Building integrated PV

The BIPV includes the application of PV on building roof and also in the façade. The potential of building integrated photovoltaic (BIPV) is dependent of the building stock characteristics with respect to the suitability of the building stock skin and roof. Some buildings' surfaces have technical limitations and others have limited capabilities to generate photovoltaic power due to inadequate orientation, roof inclination or shading effects.

PV in Rooftop of Residential buildings

Figure 33 presents the workflow of the methodology to estimate the PV technical potential in rooftops of residential buildings. Most of the data used was based on the WP1 building survey results, namely the average household area and roof slope and orientation.

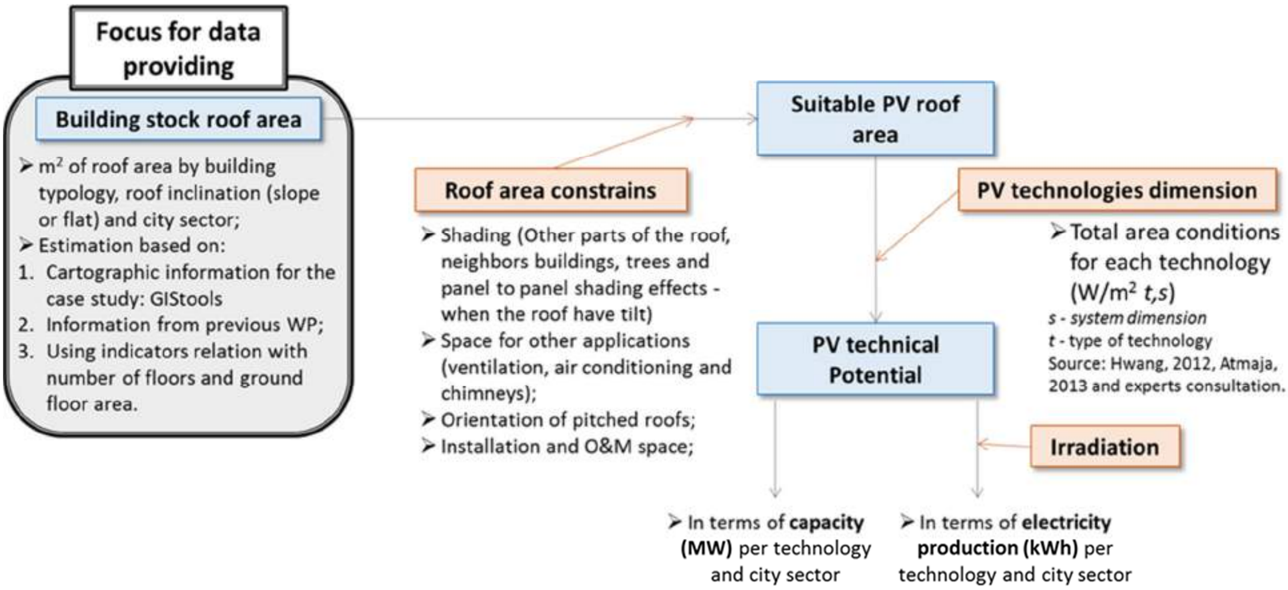

Figure 33 - Methodology for the assessment of the technical potential of PV in rooftops

To accommodate the level of uncertainty of this approach, it was considered conservative estimation considering only the buildings roofs with optimal conditions in terms of orientation (facing south) and slope (between 25º and 35º). Nevertheless, we acknowledge that roof orientation is not a strong restriction on PV installation, as it can be overcome, by using additional structures (Figure 34) with consequences on higher installation costs. After the estimation of available building roof area it was applied reduction factors based on (Byrne et al. 2015), to accommodate the different type of constrains in the roof (i.e. Shading and necessary space for operational and maintenance of the system). With this it was possible to estimate the suitable area that is the actual area for PV installation. For the potential estimation, four PV technologies were considered (c-Si - monocrystalline silicon, mc-Si - multicrystalline silicon, HIT-Si - HIT (Heterojunction with Intrinsic Thin Layer) and 3-a-Si - amorphous silicon (non-transparency type)) with different installation areas, based on (Hwang et al. 2012).

Figure 34 - Different examples structures for PV systems for no optimal roof orientation and inclination.

The results show that it can be installed up to 40 MW of PV in the Évora municipality building's rooftops (Table 16). The city sector *Bacelo e Sr. da Saúde* and *Rural* have the highest potential with around 15 MW for each one. The building typology TP8 presents the higher potential for PV installation, with a total capacity of 19 MW of monocrystalline silicon (c-Si). More specific information on BIPV by building typology is provided in the annex excel file.

Table 16s - BIPV rooftop technical potential assessment results for Évora by city district

City district	Number of Buildings	Number of Households	Average area of household (m^2)	Total area (m^2)	Suitable area (m^2)	PV technology (kW)			
						c-Si	*mc-Si*	*HIT-Si*	*3-a-Si*
Bacelo e Sr. da Saúde – "B"	5 072	7 630	124	874 142	85 360	15 092	11 839	13 035	5 369
Malagueira e Horta das Figueiras – "M"	5 007	8 007	123	889 056	25 429	4 496	3 527	3 883	1 599
S. Mamede, Sé e S. Pedro e St Antão - "CH"	2 590	3 541	106	343 628	23 696	418 9	3 287	3 618	1 490
Rural – "R"	5 303	5 977	123	735 745	92 711	16 391	12 859	14 157	5 832
Évora	**17 972**	**25 155**	**117**	**2 842 572**	**227 197**	**40 168**	**31 512**	**34 693**	**14 291**

PV in buildings façade

A simple approach to estimate the PV technical potential in the buildings' façade is applied, due to a relatively high uncertainty on the current appropriated PV technology and methods to incorporate the PV panels in the façade. To obtain suitable PV wall area, a rule of thumb was used associating the façade area with the floor area. The methodology described in Novak et al. (2002) was used, mainly the "ratio of solar architecturally suitable area / ground floor area utilization factor", corresponding to 0.15%, meaning that for each 1m^2 of ground floor area only 0.15m2 can use for PV application. Also, only one façade of the building (the one facing south) is suitable for PV integration. To accommodate this it was assumed only 1/4 of the façade area is available. It was assumed that only the detached houses, corresponding to building typologies 1, 2 and 3, and located in the rural districts have suitable conditions to apply PV on the façade. The urban area was excluded due to the shadow effect of high density of buildings. Table 17 presents the results for BIPV façade potential and a more detail data by building typology can be find in the annex excel file.

Table 17 - BIPV façade technical potential assessment results for Évora by city district

City sector	Number of Buildings	Number of Households	Total area (m^2)	Façade area (m^2)	PV technology (MW)			
					c-Si	*mc-Si*	*HIT-Si*	*3-a-Si*
Bacelo e Sr. da Saúde	5072	7630	944211	35413	-	-	-	-
Malagueira e Horta das Figueiras	5007	8007	983125	40492	-	-	-	-
S. Mamede, Sé e S. Pedro e St Antão	2590	3541	375547	14158	-	-	-	-
Rural	5303	5977	735745	27590	578	454	500	206
Évora	17972	25155	2935105	112845	578	454	500	206

6.2.2. Solar thermal

The assessment of the solar thermal - Domestic Solar Water Heating (DSWH) – technical potential is important due to a high level of consumption of energy for water heating in the residential sector. Also, there is a competitive relationship between DSWH and BIPV systems in terms of roof available area in households (Wei et al. 2014). Although hybrid technologies coupling solar thermal and PV begin to appear in the market, we only consider each of them individually. The methodology to obtain the technical potential of DSWH (Figure 35) uses part of the data gathered in the assessment of the PV roof type.

The suitable roof area data for solar thermal can be extracted from the assessment made for BIPV, as it corresponds to the same area, as both are subject to the same restrictions, like shading and other roof uses. Additionally, we also used the data on average number of persons per building or the average number of dwellings per building and correspondent average persons per dwelling. This information was used to check whether the roof area in each building is sufficient to install the solar thermal systems matching the occupants heating water needs.

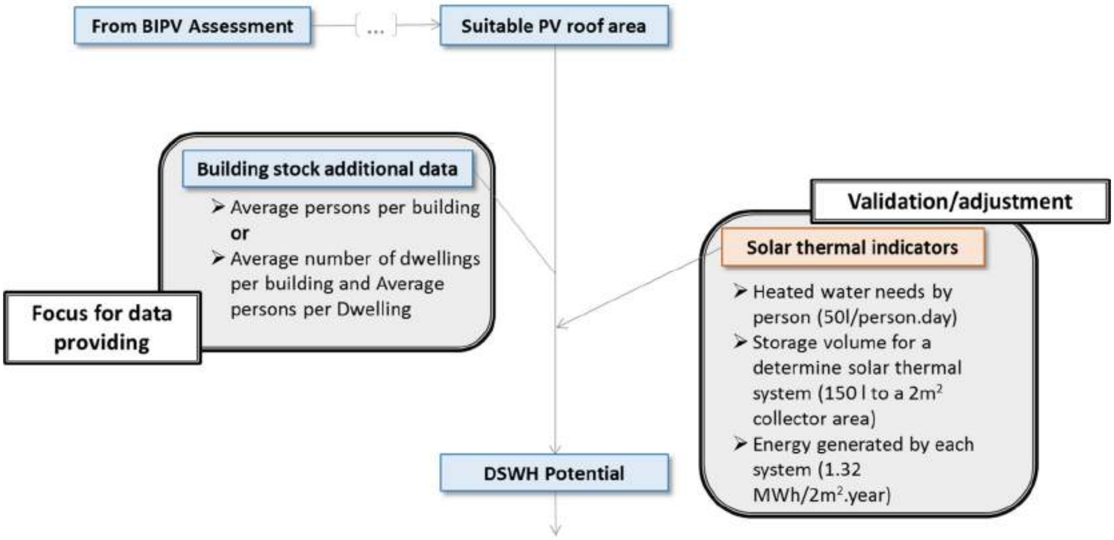

Figure 35 - Overview of the methodology for estimation of domestic solar water heating potential assessment

The technical potential for DSWH included the estimating of the energy generated by solar collectors for water heating. Therefore, there it was consider representative indicators regarding hot water demand by household and solar thermal systems characteristics. For the case of Évora, we assume the national characteristics that hot water consumption by conventional occupant corresponds to 50 liters per person.day, and the standard solar thermal system occupies 2m^2 with a storage capacity of 150l per day, providing an average energy supply of 1.32 MWh/m^2.year. These indicators and the knowledge of the number of occupants per building in each city sector, allow the estimation of the annual energy consumption for domestic hot water.

The results show that for the buildings that have optimal rooftops, in terms of orientation and slope, the available area to array thermal solar panels technology has enough capacity to guarantee the daily needs of hot water (

Table 18). In *Malagueira e Horta das Figueiras* city district there are five building typologies that do not have the available area to comply with the solar panels area needs and cover the daily hotwater needs,

Table 18 - DSWH technical potential assessment results for Évora

City sector	Number of Buildings	Number of Households	Suitable area (m^2)	Average number of household members	Total daily hot water needs (L)	Number of equipment	Area needed (m2)	Is the area available enough?
Bacelo e Sr. da Saúde	5 072	7 630	85 360	2	928 042	1 8561	37 122	YES
Malagueira e Horta das Figueiras	5 007	8 007	25 429	3	1 219 005	24 380	48 760	NO
S. Mamede, Sé e S. Pedro e St Antão	2 590	3 541	23 696	2	292 130	5 843	11 685	YES
Rural	5 303	5 977	92 711	3	817 455	16 349	32 698	YES
Évora	17 972	25 155	227 197	2	3 256 631	65 133	130 265	-

6.2.3. Wind

The wind energy can be an important resource for producing electricity within a city, but the site and resource characteristics are decisive for a viable technical and economic installation. Therefore, the deployment of wind turbines is directly dependent on two main factors: wind resource and land/area availability. For Évora municipality the analysis of wind potential include two different wind system sizes (Figure 36): a) Small scale (less than 100kW) with rotor diameter: 3.5m and Hub height: 11m; and b) utility-scale (>2MW) - Rotor diameter: 82m Hub height: 78m.

Figure 36 – Examples of small (left) and utility (right) scale wind turbines

6.2.3.1. Small scale

The definition for what constitutes a small wind turbine, it is generally defined as a turbine with a capacity of 100 kW or less. Although small wind turbines are a proven technology, further advances in small wind turbine technology and manufacturing are required in order to improve performance and reduce costs (IRENA; 2012).

The implementation of a wind turbine in the residential sector is limited. Heagle et al. (2011) point barriers the viability of residential small wind installations concerning regarding an adequate capacity factor, cost effectiveness, wind variability, economics, audio-aesthetics, health, and safety. The demand for space for the turbine is large, since the foundations need at least $9m^3$ in volume (Greening & Azapagic 2013), that in an urban context is manly available in large backyards. The possibility of installation in the roofs is also viable if the roof can offer the necessary stability and space. The slope roofs are not suitable for the technology, only flat ones. In this way the small wind installation is limited to the buildings with flat roofs and more than 4 floors, assuring suitable foundation. Even if the urban area is available it is also difficult to have proper wind speed, as the cut-in speed for the technology is 3.5m/s (Greening & Azapagic 2013) and there is sheltering and turbulence due obstacles in the city that make the wind nor stable or frequent to proper functioning of the wind turbine.

6.2.3.2. Utility scale

Évora municipality has 1707 ha of available land as mentioned for the PV utility scale potential assessment (Table 13). Some national studies already pointed out the low potential of wind in Évora region. (Salgado 2014) referred a sustainable potential of wind for Évora District, for Number of Equivalent Full Load Hours (NEFLH) above 2700 hours, of 32.75MW. However, this value cannot be directly applied to the case study (Évora municipality) as the value corresponds to spatial resolution NUTS III containing more 13 municipalities (which combined are the Évora District), and as it can be seen by the Figure 33 the results are not related to Évora municipality.

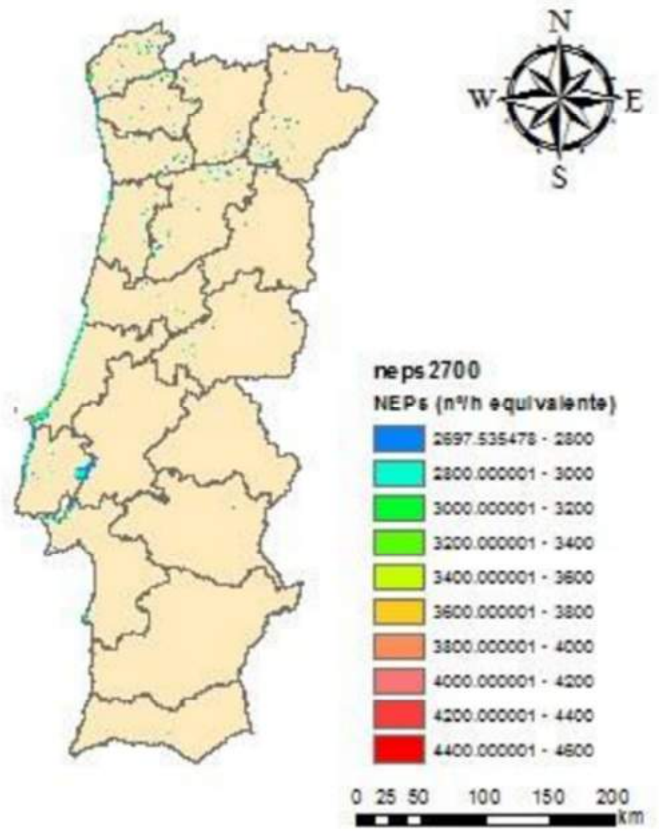

Figure 37 - Location of the areas with Number of Equivalent Full Load Hours above 2700 hours (Salgado 2014)

Also this study was made for all the country, and did not analyse in detail the restrictions on national parks land use restrictions that can influence this potential.

Wind resource

As well as land availability, other key element that affects the wind farms technical potential is the wind resource with its two main characteristics: wind speed and the correspondent frequency. Based on (Santos et al. 2015) it was assumed, for a 2 MW rated power wind turbine power curve (in kW) of the E-82 E2, ENERCON, a cut-in wind velocity of 3 m s^{-1} and a cut-out velocity (28 m s^{-1}), but in order to viable implementation it was assumed 6.25 ms^{-1} the ideal predominant wind speed. For Évora the values for wind speed and direction found at (CME 2014) and presented in Figure 38 demonstrate that the resource is not sufficient for wind turbines deployment, since the wind speed not surpass the 4.5 ms^{-1}. Also in IRENA – Global Atlas[5], the different database pointed values for average wind speed in Évora below 4.5ms^{-1}: 3.67 ms^{-1} (*Europe 10 m 10km CENER 2010-12*); 2.26 ms^{-1} for (*K-Weibull Europe 10km*) and 4.2 ms^{-1} for (*A-Weibull Europe 10km*). The *Solar and Wind Energy*

[5] More information found at: http://irena.masdar.ac.ae/

Resource Assessment provided by NREL[6] and based on *NASA Surface meteorology and Solar Energy (SSE) Release 6.0 Data Set (Jan 2008)* pointed annual average speed of 5.17ms^{-1}.

Figure 38 – Monthly average wind speed and predominant direction for Évora. Based on: (CME 2014)

Although there is no detailed specific study on small or large wind technology potential in Évora municipality, it was decided, and based on the indications on wind resource availability, that there is no potential for wind farms in Évora municipality.

6.2.4. Biogas

Biogas production is typical associated with waste treatment facilities – wastewater or organic waste composting. There is already a biogas co-generation facility in Évora, associated with the sewage treatment. There is also the possibility of biogas production from manure, although the type livestock production in Évora is manly on extensive regime, and therefore providing low capacity for utilization for biogas production.

6.2.5. Biomass

Although, there is no specific studies on the biomass potential for Évora municipality, there are some studies that include the region or nearby zones that can provide important insights on the available biomass.

(Viana et al. 2010) mapped the spatial distribution of biomass by the NUT III regions in Portugal, and referred that in the southern regions (Alentejo and Algarve) the biomass amount is significantly lower. This due to that in north and central Portugal, pinus and eucalyptus species are the dominant ones and have higher density than the cork oak and holly oak, that are the most abundant species in the south of the country. The study also referred an important point that there is a limit on the implementation of biomass power plants, including cogeneration. Alentejo region do not produce enough forest biomass and will need other fuel source to supply their biomass needs. Although, (Lourinho & Brito 2014) assessed the potential of biomass residues from agroforestry sources in a region of Portugal (Alto Alentejo), within the scope of

[6] More information found at: http://en.openei.org/apps/SWERA/

energy valorisation of the biomass by means of combustion technologies. The model uses a GIS-based method to estimate the technical potential of biomass based on current cartographic and statistical data. The analysed components related to the biomass potential are: effective biomass area (in ha), biomass availability (in dry t/year) and energy potential (in GJ/year). The potential of agricultural and forest residues in Alto Alentejo is estimated to be 4 000 dry t/year and 40 000 dry t/year, respectively. This is more than sufficient to supply the Évora municipality demand for biomass in the residential sector, the estimated value of 3977 t in 2012 (equivalent to 50 107 GJ).

The estimated consumption of biomass in Évora municipality in 2012 was 50 107 GJ. The estimation was made using the fraction of dwellings that consume biomass, and the typical amount of biomass consumed per dwelling, based on INE, 2012.

From the results of the mentioned studies, it can by conclude that there’s no enough biomass for a power plant in the region. Nevertheless, the biomass available from surroundings municipalities assure that are enough to supply the current needs of the Évora residential sector.

6.2.6. Geothermal

Évora municipality has no significant geothermal resources. This type of resource is located in the north and centre of the country (Figure 39). Assuming a conservative approach, the Enhanced Geothermal Systems (EGS) was also excluded. This type of technology injects high pressure water to expand existing rock fissures, however no toxic chemicals are used, there can be conflicts with others uses of water. In fact, water is a high scarce resource in this region of the country, and therefore a priority to agricultural and human consumption was assumed. Moreover, there is no estimation of geothermal resources of low enthalpy to eventually support geothermal heat pumps.

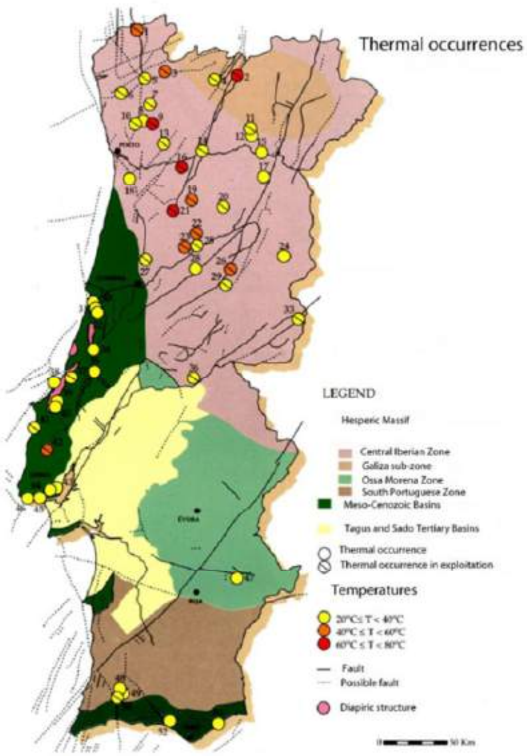

Figure 39 - Geological sketch of Portugal Mainland, with thermal occurrences. Extracted from: (Carvalho et al. 2015)

6.3. GIS Maps

The GIS maps for the current PV systems are in the dropbox folder under shape file names:

Solar PV

- **Small installations**
- *PVmin_Urban_SMamede_SePedro*
- *Rural*
- *PVmin_Urban_Malagueira Horta Figueiras*

Legend for the shape attributes

PVmic_kWh – corresponds to the electricity production (kWh) during 2014

PVmic_EFF – Corresponds to the capacity factor (%) for all the micro and mini installations

PVmic_kW – Corresponds to the installed capacity (kW) in 2014

- **Utility scale**
- *PVCentral_Evora_final*

Legend for the shape attributes

Startyear – corresponds to the operation starting year of the facility

ElecprodkW - corresponds to the electricity production (kWh) during 2014

Cap_kW - Corresponds to the installed capacity (kW)

6.4. Future Plans

There are no public specific futures plans for any of the RES projects, although we acknowledge that private investments may be envisaged as possible.

7 Tertiary Sector

7.1 Buildings managed by the Municipality

7.1.1 Characterization

There are a high number of buildings under Évora municipality management. The analysis of the current energy consumption provide the identification for potential improvements. The main energy source, and the one with more available information is the electricity consumption. The public buildings managed by Évora municipality can be divided in 7 categories. Table 19 presents the electricity consumption of the buildings and equipments managed by Évora municipality. The available data only respects January to September of 2013, but it was extrapolated to the remaining 3 months. The electricity consumption was accessible for 4-day time slices, grouped into *peak* and *off-peak* periods. The highest share of annual electricity consumption is from public lighting and in buildings with public services.

Table 19 – Electricity consumption of the buildings and equipment's managed by Évora municipality in 2013 (CME, 2015)

Sector	Peak (kWh)	Off-peak (kWh)	Total annual (MWh)
Municipal buildings	657 235	1 051 159	1 708
Education	304 401	215 609	520
Dwellings for social housing	4 044	0	4
Churches and monuments (lighting)	31 072	82 568	114
Parking lots	3	0	3
Sport facilities (swimming pools, sports halls)	N.A.	N.A.	N.A.
Leisure (Teatro Garcia de Resende)	N.A.	N.A.	N.A.

7.1.1. Education

Évora municipality manage a large number of educational services facilities, divided in primary and secondary schools. There are 25 primary schools that are grouped in four clusters (Figure 40).

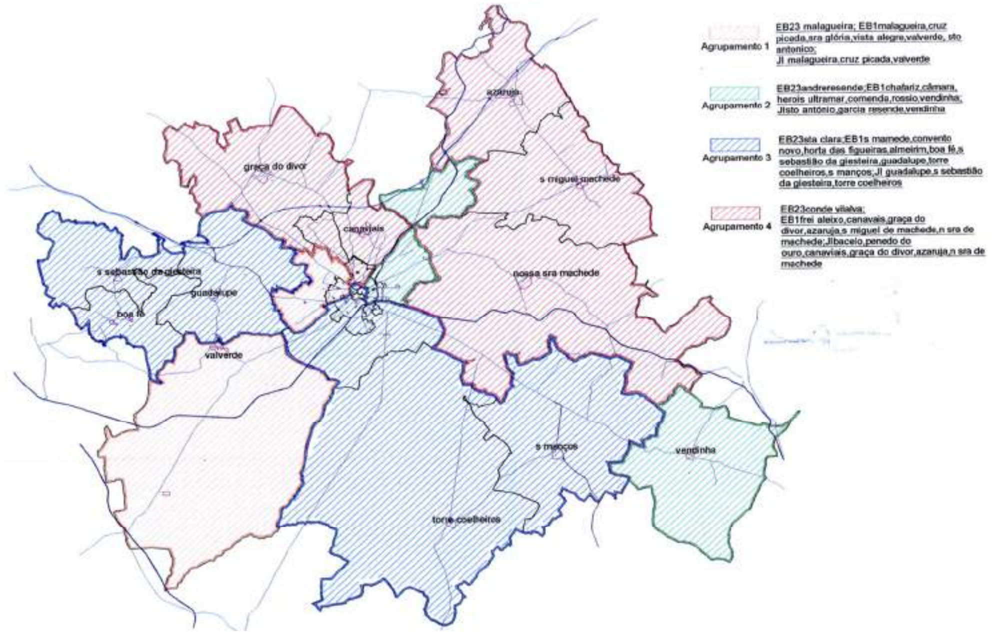

Figure 40 - Schools clusters of Évora municipality (CME 2006)

There is no complete information on complete and detail energy consumption for each primary and secondary schools. The primary schools and kindergartens have around 6250 students and consumed in the year 2011 1040 GJ of electricity. The primary and secondary schools are located widespread in the municipality as presented in Figure 41.

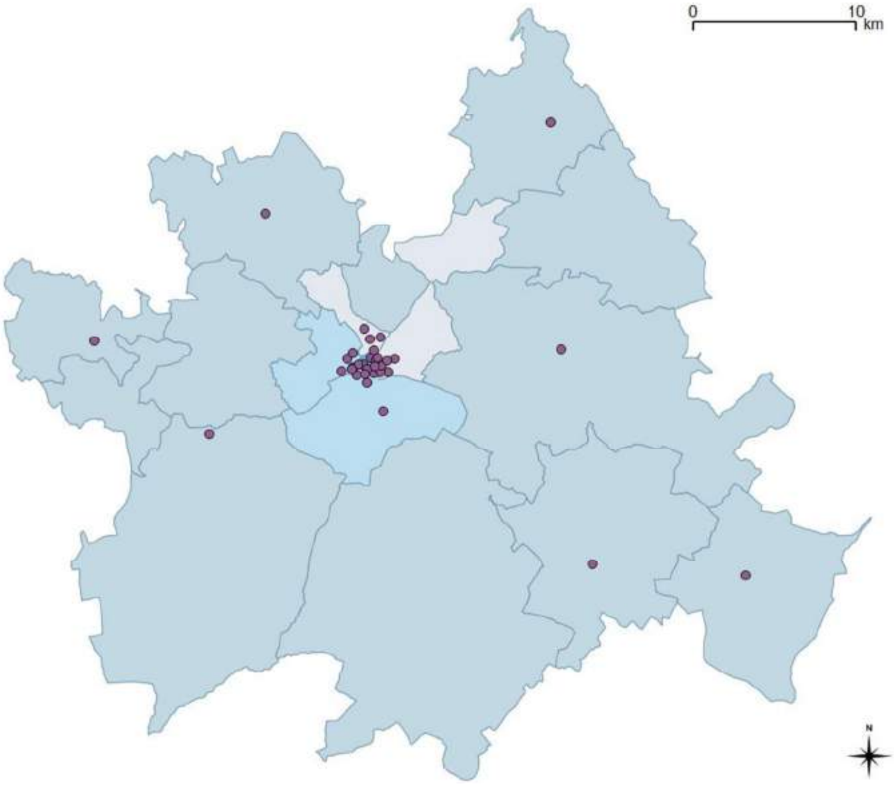

Figure 41 - Location of Évora primary and secondary schools

7.1.1 Future Plans

7.2 Other Tertiary Buildings

7.2.1 Characterization

This chapter address the analysis of the tertiary (private or public) buildings that are not directly managed by Évora municipality, that have a significant impact on energy consumption.

The sectors under analysis, and in conformity with the sectors defined in transport model, are:

- Retail includes: Large Food stores supermarkets, large Non-food stores, and local shops (those within the residential areas);
- Office buildings
- Education includes: Primary, secondary and college/University;
- Leisure includes: Restaurants, hotels, cinemas, leisure centres;
- Health includes: Hospitals and health centres

There is no information in detail on the main characteristics for all the mentioned sectors in Évora. Nevertheless, a general characterization in terms of energy consumption (Table 20) and key indicators was made.

Table 20 - Energy consumption by fuel type and service sub-sector in 2013 (DGEG, 2015a, DGEG, 2015b and DGEG, 2015c)

Fuel	Offices (TJ)	Retail (TJ)	Leisure (TJ)	Education (TJ)	Health (TJ)
Electricity	116	87	50	26	29
Natural Gas	8	1	26	4	16
LPG	5	242	8	0	0
Gasoline	0	0	0	0	0
Diesel	0	4	0	0	0
Total	128	333	83	29	44

According to Table 20, electricity and LPG are the main fuels consumed in service sector, respectively 41% and 50%. Electricity consumption is widespread across all sub-sectors, with the prevalence of employment (38%) and Retail (16%). LPG is consumed almost entirely in Retail (95%).

The majority of the services are located in the urban city districts (Figure 42).

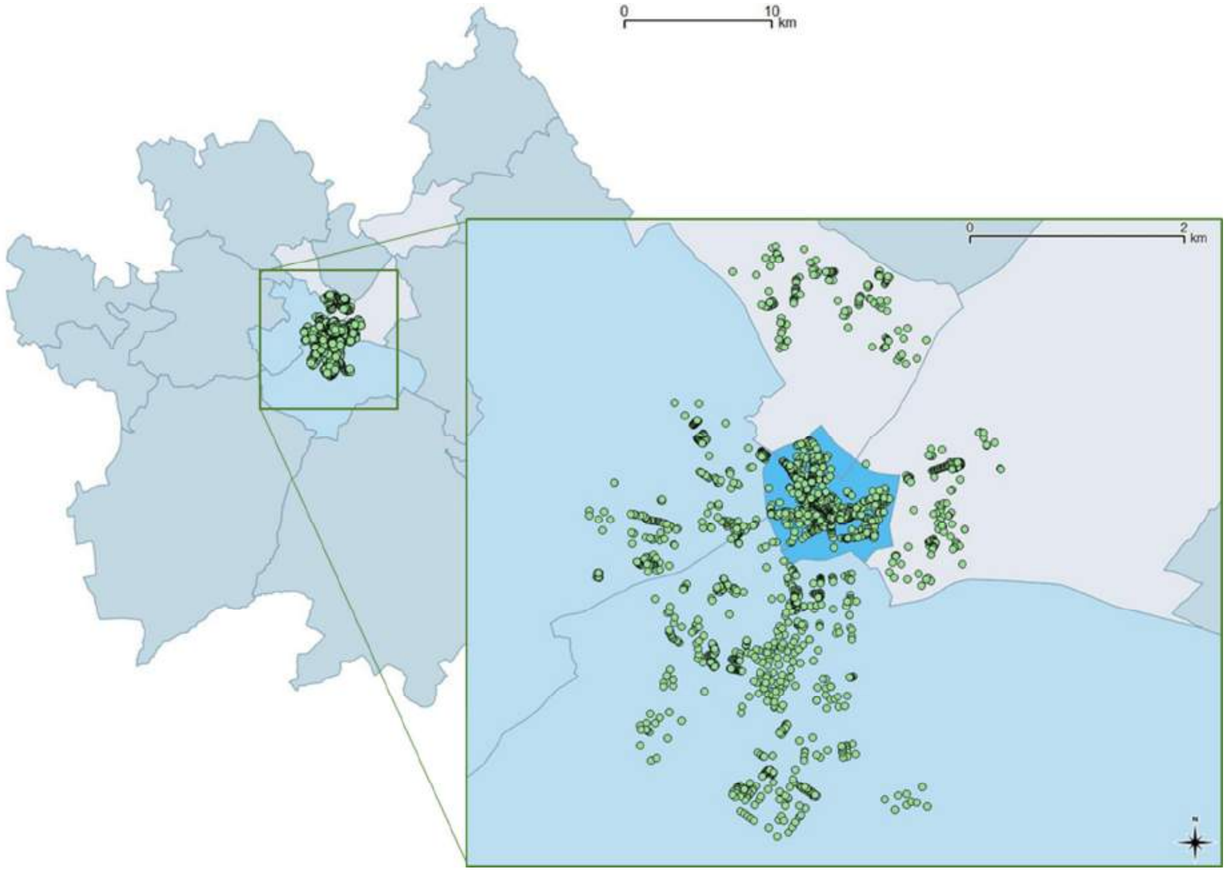

Figure 42 - Location of small services buildings in Évora municipality

From the smart meters data provided by EDP Distribuição it was possible to develop different profiles on the daily electricity consumption in services sector. Figure 43 shows the daily electricity consumption of the retail sector based on information from 1032 smart meters. It shows a reduction on the electricity consumption on the weekends when comparing with the weekdays, this is due to as most of the Évora local shops close on Saturdays and Sundays.

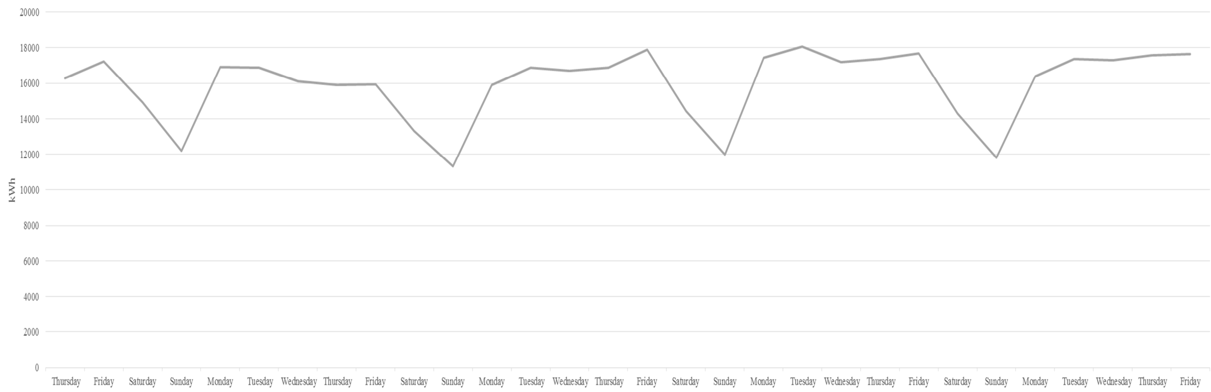

Figure 43 – Daily electricity consumption on retail sector in January 2013 (Data source: EDP, 2015b)

7.2.1.1 Education

The Évora University provided specific data on the energy consumption. The university has high importance on social and economy components of the municipality. The university is divided in various facilities, but the majority located in city historic centre (Figure 44). The university has a total surface area of 61 513 m^2 with annual electricity consumption of 243 GJ mainly for space heating (36%) and other appliances (40%).

Figure 44 - Location of the Évora University facilities

7.2.1.2 Health services

Although there is no detailed information on the energy consumption by health facilities, the aggregated information provided for health services, including hospitals and health centres, by DGEG (2015) refer to consumption in 2013 of 28 532 GJ of electricity and 15817 GJ of natural gas.

There are two hospitals in Évora located in the centre of the municipality (Figure 44).

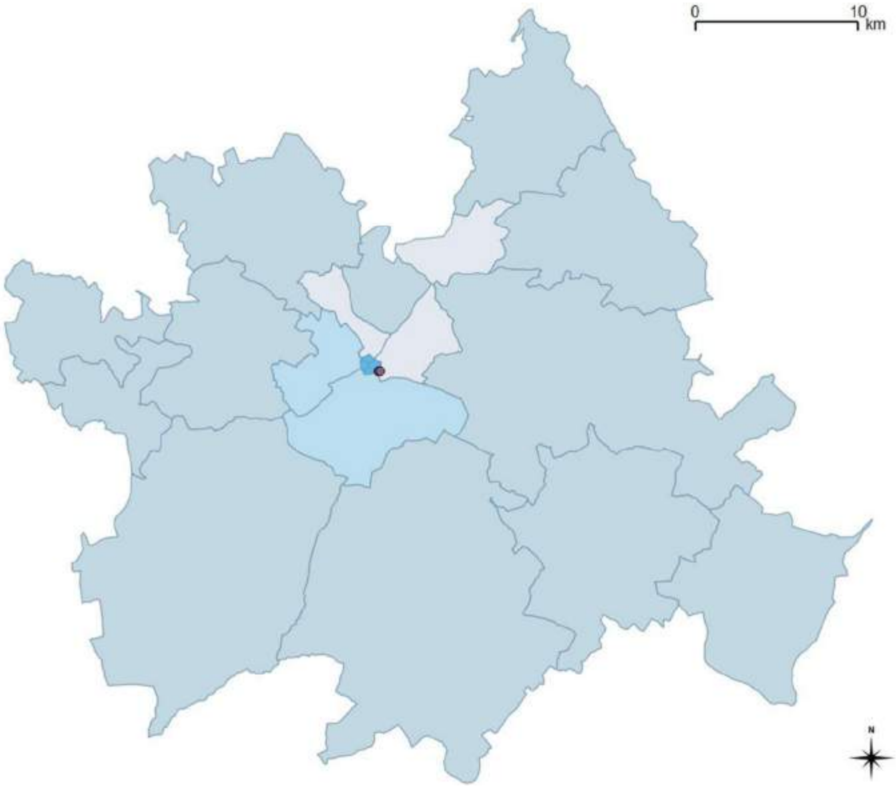

Figure 45 - Locations of the two Évora hospitals

7.2.1 GIS Maps

A list of the relevant GIS maps should be presented. Pictures showing the location of the different individual facilities by type should be included here.

Related GIS compatible maps should be uploaded in the Dropbox folder.

- Hospitals

  Shape file name: *Hospitals*

- Schools and university

  Shape file name: *Schools*

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Coordination and support action (Coordinating Action)

FP7-ENERGY-SMARTCITIES-2012

INSMART

Integrative Smart City Planning

Analysis of the city energy system – MUNICIPALITY OF CESENA

D-WP 4 – Deliverable D4.4

<u>Author(s)</u>:

<u>Date:</u> October 2015

Grant agreement no.:

314164 (ENER/FP7/314164)

Project acronym:

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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.4.4

Analysis of the city energy system – MUNICIPALITY OF CESENA

Project co-funded by the European Commission within the Seventh Framework Programme				
Dissemination Level				
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PP	Restricted to other programme participants (including the Commission Services)			PP
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)			
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Executive Summary:	
Analysis of the energy systems and network of the relevant city sectors of the Municipality of Cesena: urban spaces, water/sewage systems, waste chain and decentralised energy supply.	
Keywords	data analysis, energy systems, urban spaces, water/sewage systems, waste chain, decentralised energy supply

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Acronyms and Definitions

CHP – Combined heat and power

GIS – Geographic information system

O&M – Operation and maintenance

MSW – Municipal Solid Waste

PROMETHEE – Preference Ranking Organization METHod for Enrichment of Evaluations

PV – Photovoltaic

RES – Renewable energy sources

TIMES – The Integrated MARKAL-EFOM System

1. Introduction

1.1. Overview of InSMART

The InSMART concept brings together cities, scientific and industrial organizations in order to establish and implement a comprehensive methodology for enhancing sustainable planning addressing the current and future city energy needs through an integrative and multidisciplinary planning approach.

InSMART project intends to identify the optimum mix of short, medium and long term measures for a sustainable energy future, addressing the efficiency of energy flows across various city sectors, namely buildings, transport and mobility. Urban spaces, water/sewage system, waste chain and decentralized energy supply.

Each city’s energy system will be analysed, covering all relevant sectors and a comprehensive GIS platform including energy database will be developed. Apart from being a valuable planning tool, the GIS database will inform and be linked to the TIMES planning model. This model will be used to analyse the cost-optimal mix of measures required to meet sustainable energy targets taking into account exogenous parameters (*e.g.*, environmental targets, city expansion). These measures will be further assessed with respect to non-technical criteria using a multi-criteria decision making method (PROMETHEE) that will address economic, environmental as well as social issues.

A detailed economic analysis of the mid-term measures identified through this two stage optimisation procedure will be undertaken, identifying all relevant investment indicators. Finally, a detailed, realistic and applicable mid-term implementation plan will be developed to describe the necessary steps, required resources and monitoring procedures for each city.

1.2. Objectives of this Report

This report refers to WP4 (Tasks 4.1. to 4.4.), including the analysis of the current energy-related status of urban spaces, water/sewage systems, waste chain and decentralised supply, at the city level.

Thus, report describes the other relevant sectors of the local energy system, excluding the residential building and the transport uses, which have been already characterized and assessed in WP2 and WP3.

In a graph theory-like vision, surveys undertaken under the WP2 and WP3 provide the description of “nodes” (demand centers), namely the quantification of the stocks of processes and technologies (e.g. buildings, space heating devices, vehicles) and characterization of energy services required in the selected geographical polygons of the urban area.

The goal of WP4 is to extend the analysis to other demand centers as the relevant non-energy services, to look at the "edges" (the physical networks linking different demand centers and allowing the movements of energy, people and goods) and at the devices used to properly operate the urban infrastructures, as well as to explore the potentials of decentralized options of energy supply (and/or storage).

1.3. Outline of the Report

The report is organized in six main chapters and describes all the key additional components that must be taken into account for a sustainable energy planning at municipal level.

For each component, the present report provides:

- the characterization of the major processes and technologies and the corresponding energy consumption/potential (where available);
- a list of GIS maps that have been provided in support of the analysis;
- the quantitative description of future projects of development, the planned investment of the municipality and of private companies.

It emphasizes that report contains basic and descriptive information. Detailed data are reported in spreadsheet format (Excel files are attached to the report) and are organised in a common template across all the municipalities.

2. City Districts General Description

As already described in the Internal report "Survey of city energy data (housing) (WP1. T1.2) - Typologies, methodology and results Cesena", the most granular geographical representation of the Municipality of Cesena was set starting from the current definition of 12 city districts (quartieri) and through a further disaggregation into 15 city zones, as shown in **Error! Reference source not found.**.

The disaggregation has interested *Centro Urbano*, *Cervese Sud* and *Oltre Savio* districts, all densely populated areas. This was done in order (i) to reduce the heterogeneity of building and land use patterns in single areas; (ii) to better capture commuting paths between zones as the same definition has been used to develop the InSMART transport model of Cesena (WP 3).

These 15 city zones are also converted into one of the spatial layers for the description of the other energy uses (described in the next sections) at morel local level, and will be used later on in the integrative modelling analysis of WP5.

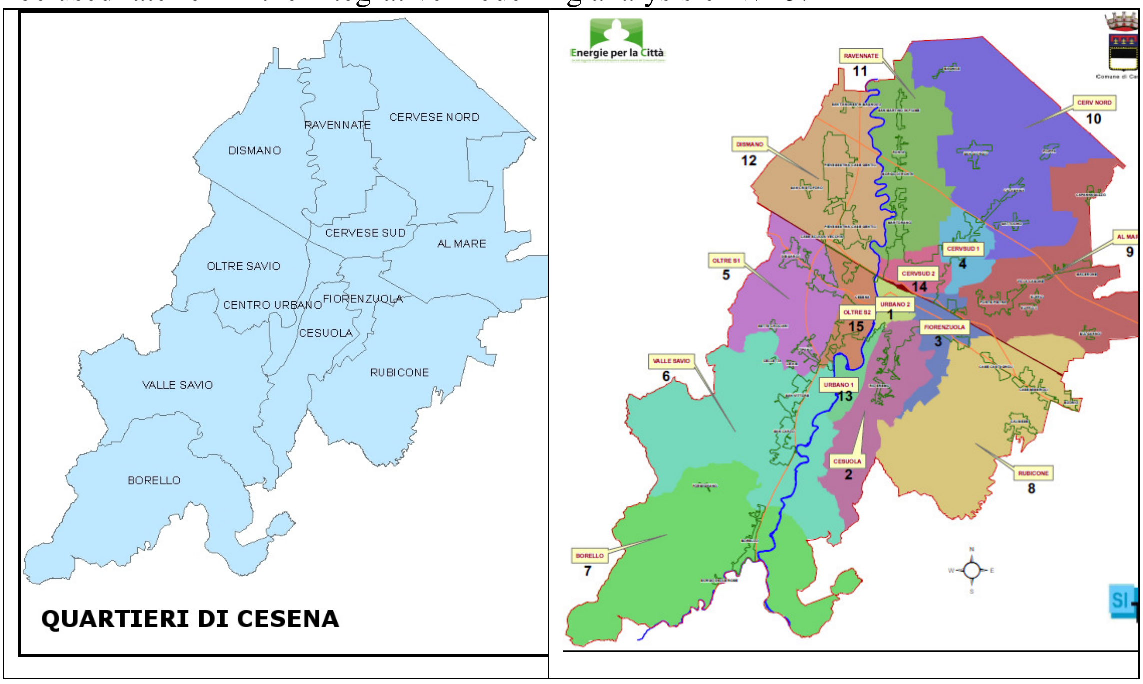

Figure 1 - Cesena districts (left) and 15 InSMART city zones (right).

The table below describes the InSMART city zones with the corresponding area (in m^2) and number of residents (updated to 2014).

Insmart city zones	Total resident (2014)	Total Area (m2)
AL MARE	6825	15.5785
BORELLO	2766	48.598
CERV NORD	6501	173.765
CERVSUD 1	4255	8.665
CERVSUD 2	9170	178.574
CESUOLA	5089	106.414

DISMANO	4637	76.028
FIORENZUOLA	10745	142.248
OLTRE S1	4650	95.899
OLTRE S2	14406	17.2703
RAVENNATE	5347	92.214
RUBICONE	5082	13.9471
URBANO 1	310	9.227
URBANO 2	11421	143.655
VALLE SAVIO	5671	107.466

Table 5 – Resident population and area of the InSMART city zones of Cesena (source: Census of Population 2011)

3. Urban Space

3.1 Public Lighting

Characterization

The municipality of Cesena has entrusted to Hera Luce Inc. the management of part of the public lighting and traffic lights with an agreement signed in 2000 and a duration of 27 years. Hera Luce Inc. is a company specialized in management of public and artistic lighting installations (construction and maintenance).

The municipality is responsible for controlling and monitoring the quality of service in terms of energy savings and efficiency and to prevent the non-compliance with current regulations. The municipality also has the function of directing the investment policy of Hera Luce Inc. (approval of Investment Plan) and of setting new goals and standards of quality, innovation, and service organization.

Within the municipal area there is a total of 20,373 light points. The total energy consumption of the public lighting in the year 2012 was 2.081.709, 92 KWh. The municipality of Cesena manages directly 5,351 light points. Most of the light points are HPS - High Pressure Sodium lamps.

Furthermore, all public lighting systems of the municipality of Cesena, must comply with the regulations of the Emilia Romagna Region - Law no. 19-2003 "Rules on reducing light pollution and energy saving". Currently all plants have features comply with the regional law.

The quality of light is another key feature to keep in mind when designing new public lighting systems. In particular, the standard of the municipality of Cesena is the "photochromic" light, which allows to distinguish at a distance the color and the shape of objects either static or in movement.

GIS Maps

GIS maps provided for public lighting (updated in 2012) keep track of:

- ✓ Localization of light points
- ✓ Localization of lighting lines
- ✓ Localization of supply areas
- ✓ Localization of electric cabins

Future Plans

The key aspect that guides the municipality in designing new projects on public lighting is to optimize the network and the installation of lighting points, using low energy light bulbs and LEDs.

To increase energy efficiency, in the last three years, the municipality has established that all new installations are made using LED lights. Recent investments are aimed to gradually replace obsolete lighting with LEDs. The goal is to decrease by 30-40% the energy consumption and increase the effectiveness of lighting in public spaces.

The municipality is also studying the possibility of inserting systems equipped with intelligent sensors (or domotics devices) that turn to the passage of people to use in the most popular places taking into account the hours and the type of attendance. Again the driver is the energy consumption reduction with the simultaneous keeping of the effectiveness of lighting in public places. This type of system would help to reduce energy consumption in neighborhoods that have different needs and different urban characteristics.

In particular, two scheduled projects will be realized in the downtown (*Centro Urbano* zone); the key characteristics are described below.

PROJECT 1

The project aims to redevelop the public lighting of roads and parking in the *Centro Urbano* district along 2000 meters, like as follows:

- a new electrical panel will be installed;
- a number of 90 new lighting points will be installed;
- a total number of 80 light points will be removed.

The total power currently used is about 11000 Watt. Only 5844 Watt will be required after the renovation in a Low Mode, with a corresponding saving of 5156 Watt. With a High Mode renovation, it is expected an increase of consumption of 754 Watt. Lighting devices will be supplied with low voltage current (380-400 / 220-230 V).

Renovation in a “Low Mode”

Location	N. of lights	Type of lamp in Low Mode	Total power W
Via Madonna delle Rose	23	60 LED - 66 W	1.518
Via Montanari	12	100 LED - 108 W	1.296
Via Turchi	30	40 LED - 46 W	1.380
Via Vittorio Veneto e via Fiume	8	60 LED - 66 W	528
Via Montegrappa	10	60 LED - 66 W	660

Via Podgora	4	60 LED - 66 W	264
Via Curtatone	3	60 LED - 66 W	198
TOT	**90**	**/**	**5.844**

Renovation in a "High Mode"

Location	N. of lights	Type of lamp in High Mode	Total power W
Via Madonna delle Rose	23	60 LED - 132 W	3.036
Via Montanari	12	100 LED - 224 W	2.688
Via Turchi	30	40 LED - 91 W	2.730
Via Vittorio Veneto	8	60 LED - 132 W	1.056
Via Montegrappa	10	60 LED - 132 W	1.320
Via Podgora	4	60 LED - 132 W	528
Via Curtatone	3	60 LED - 132 W	396
TOT	**90**	**/**	**11.754**

The following light points are planned to be removed/replaced.

Location	N. of lights	Type of lamp	Total power W
Via Madonna delle Rose	18	Mercury Vapour 160 W	2.880
Via Montanari	14	Mercury Vapour 160 W	2.240
Via Turchi	30	100 W SAP	3.000
Via Vittorio Veneto	7	Mercury Vapour 160 W	1.120
Via Montegrappa	5	Mercury Vapour 160 W	800
Via Podgora	3	Mercury Vapour 160 W	480
Via Curtatone	3	Mercury Vapour 160 W	480
TOT	**80**	**/**	**11.000**

PROJECT 2

The total power currently used is about 3040 Watt. Only 2300 Watt will be required after the renovation of the lamps stock, with a corresponding saving of 740 Watt. Changes to the current electricity supply are expected not to be required. The details of the project are as follows:

- a total number of 23 new lighting points will be installed;
- a total number of 19 light points will be removed;
- 540 meters of lighting network (between streets and squares) will be renovated.

The following light points are planned to be installed.

Location	N. of lights	Type of lamp	Total power W
Via Milani	7	60 LED - 100 W	700
Via Isei	5	60 LED - 100 W	500
Piazzetta Isei	4	60 LED - 100 W	400
Via Martiri d'Ungheria	4	60 LED - 100 W	400
Via Tiberti	3	60 LED - 100 W	300
Via Chiaramonti	16	60 LED - 100 W	1.600
Corso Comandini	14	60 LED - 100 W	1.400

TOT	53	/	5.300

The following light points are planned to be removed/replaced.

Location	N. of lights	Type of lamp	Total power W
Via Milani	6	Mercury Vapour 160 W	960
Via Isei	4	Mercury Vapour 160 W	640
Piazzetta Isei	3	Mercury Vapour 160 W	480
Via Martiri d'Ungheria	3	Mercury Vapour 160 W	480
Via Tiberti	3	Mercury Vapour 160 W	480
Via Chiaramonti	17	HPS - High-pressure sodium 150 + losses auxiliary 180 W	3.060
Corso Comandini	13	Mercury Vapour 160 W	2.080
TOT	**49**	**/**	**7.700**

3.2 Gardens/green areas and public fountains

Characterization of Gardens/green areas

The municipal office of Urban Decor and Green Areas is responsible for the management, maintenance and design of the green areas of the city of Cesena.

The total number of green areas, according to the numbering system adopted and available in the municipal mapping, is today of 565 areas.

The green areas of Cesena, with the exception of natural areas, are divided into five main categories: "Public Green", "Uncultivated", "Green areas in school", "Cemeteries", "Sports areas". Table below shows the area of green areas by typology (m^2 and numbers).

	TYPOLOGIES	AREA (m^2)	N.° AREAS
1	Public green	1671616	406
	Green forestation	*9275*	
	Green road	*97782*	
	Equipped green	*1482867*	
	Equipped green - Horticultural areas	*20294*	
	Green Historical	*48624*	
	Green furniture sponsored	*12772*	
2	Uncultivated	1321696	23
3	Green areas in school	155223	40
4	Cimiteries	24706	53
5	Sports areas	343163	43
	TOTAL	**3516405**	**565**

Table 6 - Green areas and gardens of the city of Cesena at December 31, 2013. Source: Municipality of Cesena.

The irrigation systems of the green areas in Cesena are supplied with 9 volt batteries. The only irrigation plant that has a power consumption associated is located in Park

Ippodromo (Oltresavio district). Data on electricity consumption of the irrigation system of the “Parco Ippodromo” (year 2004-2014) and O&M costs are available on Tables 3 and 4 of the attached excel file.

Characterization of public fountains

The municipal office of Urban Decor and Green Areas is also responsible for the public fountains (management, maintenance, and design).

Currently, only one ornamental fountain is in operation in the city center: the *Fontana Masini* (located in *Piazza del Popolo - Centro Urbano* district). There is also another ornamental fountain located in roundabout *Torre del Moro* (*Oltresavio* district) which, however, it is currently turned off.

In 2012, the Municipality of Cesena signed an agreement with the main local managers of water supply (*Hera Spa, Romagna Acque, and Adriatica Acque*) for the realization of “Water Houses” (*Casine dell’Acqua*), to encourage the use of public water and reduce the environmental impacts arising from the production and disposal of plastic bottles. “Water Houses” are public fountains which distribute public water coming from the aqueduct, appropriately filtered, controlled, chilled and carbonated.

The establishment of such distributors is rapidly spreading across the Italian municipalities as this water has several advantages:

- is Ecological: citizens can fill self-service their own bottles thus avoiding to dispose plastic bottles of mineral water; in this way it is possible to reduce plastic waste at source contributing to the reduction of carbon dioxide due to the production, transport and disposal of PET;;
- is Cheap: citizens can get significant savings compared to buying bottled mineral water;
- is Socially Valuable: it allows to raise awareness about waste reduction.

Currently, there are three “Water Houses” in Cesena:

- Water House 1 - *Centro Urbano* district - *IV Novembre* street
- Water House 2 - *Centro Urbano* district - *Moretti* street
- Water House 3 - *Cervese Nord* district - *Montaletto* street

The Water Houses in Cesena have the following characteristics:

- mechanical filtration system with filter 50micron polypropylene;
- hourly production: 200 liters per hour for natural and sparkling & chilled water;
- working hours: 24 hours;
- power consumption: 10 kWh / day - 300 kWh / month - 3600 kWh / year.

GIS Maps

GIS maps provided for green areas and fountains keep track of:

✓ localization and area (m^2) of green areas by type;

- ✓ localization of gardens/green areas with public water irrigation and public fountains.

Future Plans

Between 2016 and 2017 the Municipality of Cesena will realize the redevelopment of one of the main square located in the city center Freedom Square (*Piazza delle Libertà*). The project includes the renovation and improvements of urban furniture, the restoration of the pavement and lighting system, the construction of a new ornamental fountain (at ground level) with jets of water from below. The total cost of the project is 65000 Euro. Currently, no other projects or future plans for the construction of new public fountains or the extension of green areas are in the agenda.

4. Water and Sewage Systems

4.1 Water Treatment and Distribution Systems

Characterization

The municipality of Cesena uses water from the dam "Idracoli" located in the Municipality of Santa Sofia (out of the scope of the analysis). The aqueduct network and the location of the dam are shown in the figure below.

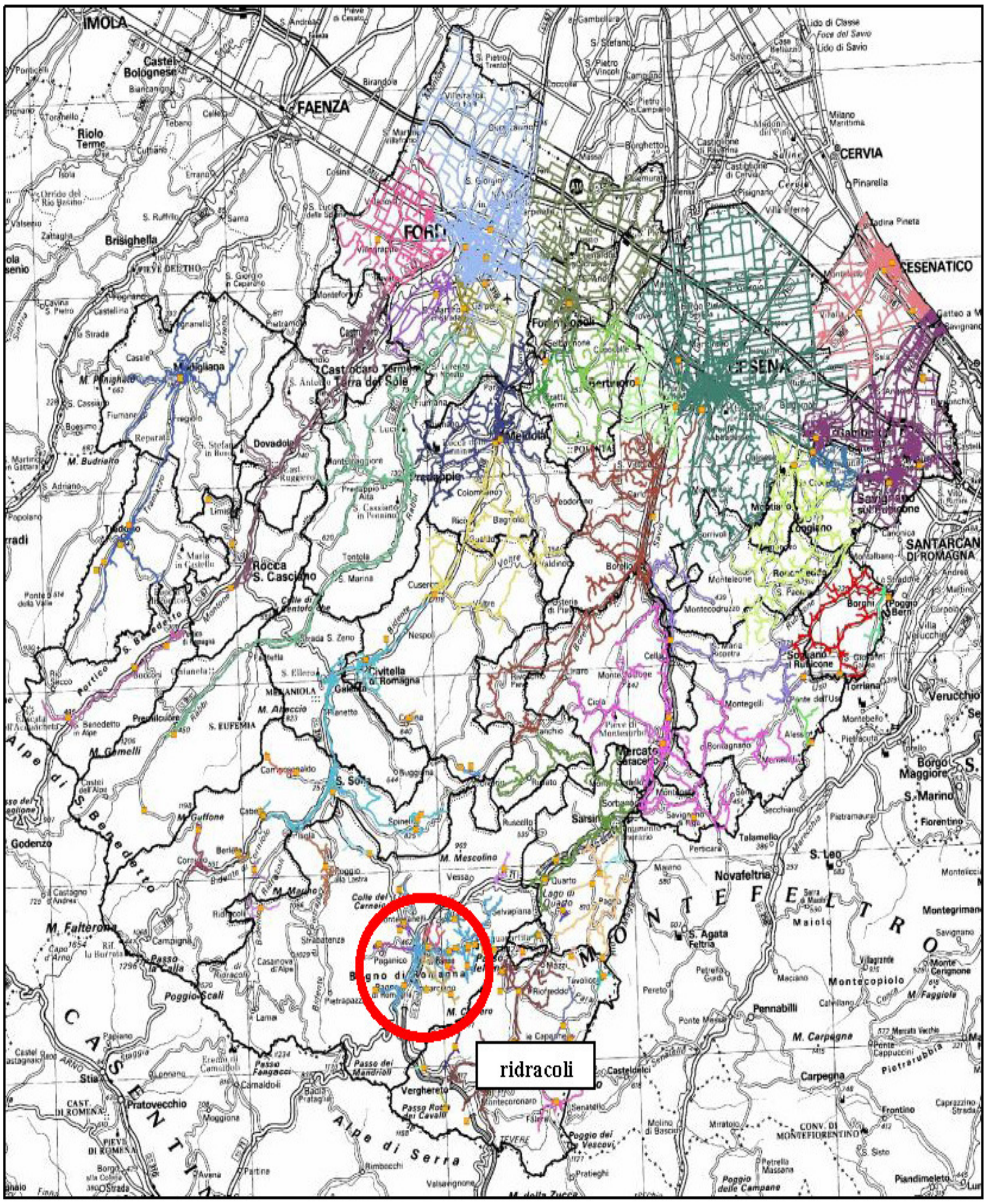

Figure 2 - The aqueduct networks (colored lines) in the Province Forlì-Cesena. Circled in red: dam called "Idracoli" (located in the Municipality of Santa Sofia) that serves the Municipality of Cesena

The integrated water system of the city of Cesena is currently entrusted to two companies operating in coordination with each other:

- Romagna Acque Inc. is the company that manages the water supply throughout the province of Forlì-Cesena and has competence with regard to the entire local water chain (water collection, treatment, supply of water resources);

- HERA Inc. is the company in charge of the final distribution of water to the end user within the municipal area. They directly control part of the water distribution systems, in particular lifting equipments and wells.

The water supply to the city of Cesena is performed by operating two different plants:

1 – Water treatment plant Capaccio

- The plant is located in the Municipality of *Santa Sofia* (out of the scope of the analysis)
- Origin of the resource - from the dam *Ridracoli* (surface water)
- Capacity of the system (volume of concession) - 63000 m^3/year
- Type of treatment technology: chemical plant physical the system allows the removal of pollutants present in the water through oxidation processes to remove organic substances, turbidity, any iron and manganese present. The following processes are used in particular for municipal water treatment: pre-oxidation, primary sedimentation, filtration, gravity beds of quartzite, and finally disinfection.
- Date of construction of the plant - years 1984-1988
- Lifetime of the plant - 40 years average (estimate)
- Installed capacity (kW) - 500
- Energy consumption (annual - kWh) - 1080000
- Operating hours (Annual) - 365 days - 24 h
- Total volume treated (m^3/year) - 57351000 cubic meters (2014)
- Net volume supplied to the Municipality of Cesena (m^3/year) - 6485000 (estimate)
- Operating and maintenance costs (Euro/treated volume) - 0,15 Euro/m^3 (estimate).

2 – Plant Campo Pozzi

- the plant is located in the municipality of Cesena (within the area of analysis)
- Number wells total - 9
- Origin of the resource - underground water
- Capacity of the system (volume of concession) - 3.2 million cubic meters/year
- Type of treatment technology: disinfection with chlorine dioxide
- Date of construction - 70s and 80s
- Lifetime of the plant - 40 years average (estimate)
- Installed capacity (kW) - 1000
- Energy consumption (annual - kWh) - 1750000
- Operating hours (Annual) – 15.000 (average)
- Volume pumped or treated - 2.81 million cubic meters (2014)

- Net volume supplied to the City of Cesena (m^3/year) - 1.964 million cubic meters (2014)
- Operating and maintenance costs (Euro / treated water) - 0,28 Euro/mc (estimate).

The water from the plant *Campo Pozzi*, treated with a simple process of disinfection, is only used at certain periods of the year (summer) to supply the city during the dry and peak-of-touristic season.

A detailed description of each facility (type of technology and brief description, year of implementation, current energy efficiency/energy reduction policies in place) is included on Sheet 4. Water and Sewage Systems, Table 7 of the attached excel file.

Within the municipal area, there are also 5 points of delivery where the company *Romagna Acque* hands the water resources to the network operator (*Hera*):
1. Cabin derivation of *San Carlo* – to the South/West of the city - the supply is only from the dam *Ridracoli*;
2. Cabin derivation of *San Carlo Savio* – to the South/West of the city - the supply is only from the dam *Ridracoli*;
3. Tank *Cappuccini* – to the old town and the majority of the city;
4. Cabin Offset *Calisese* – to the North/East of the city - the supply is only from the dam *Ridracoli*;
5. Cabin derivation of *San Carlo* – to the North/East of the City - the supply is only from the dam *Ridracoli*.

Regarding water consumption, data of 2013 for the municipal area are reported below:

<u>Water fed into the grid in 2013</u>

- Total m^3 of drinking water delivered to the grid in 2013 - 8947526 m^3
- Total m^3 of drinking water supplied in 2013 (ie. water measured at the meters of the individual end-users and also water consumed in public places as schools and hospitals, for the fountains and for watering the public green areas) - 7063055 m^3

<u>Water consumption in 2013</u>

Total m^3 of drinking water billed in the calendar year (January 1 to December 31) in 2013, divided into the following uses:

- Domestic use (utilities related to housing) - 4773099 m^3
- Non-domestic use (utilities concerning offices and public establishments) - 1758962 m^3
- Total civil use (a + b) - 6532061 m^3
- Use of agricultural and livestock - 72888 m^3
- Other use (includes large utilities and internal use) - 458116 m^3

GIS Maps

GIS map provided for water treatment and distribution systems keep track of:

- ✓ Location of main water treatment facilities (water production and treatment)

Future Plans

The only project that involves the construction of new facilities in support of the current integrated water system is out of the area of analysis. In the Province of *Ravenna* it is planned the construction of a new water treatment plant called *Standiana*. This new plant will withdraw surface water from the river Po and ensure the water supply to the Province of Ravenna mainly. The increase in volumes processed by this new plant is expected to free large volumes of water in the dam *Ridracoli*. This additional water will be distributed in the remaining territories of Romagna region, including the municipality of Cesena. The project will be realize in 2016/2017 with an investment (Euro/year) of 4.8 million/year. The capacity of the system (volume of concession) is 31536000 (m^3/year). The water treatment will be performed through ultrafiltration membranes for the elimination of the elements in suspension, either physical or microbiological.

4.1 Sewage Systems

Characterization

Hera SpA in addition to the service of water distribution and supply to users, also operates the sewage system within the municipal area.
In particular, *Hera SpA* manages 5 depurators and 4 Imhoff tanks in Cesena.

The table below presents the main technical characteristics of these plants.

Tipology plant	Name	Tecnology	Installed capacity KW	Energy consumption 2014 kWh	Quantity of treated sewage 2014 (m^3)
Depurator	DEP CESENA	activated sludge	781	2907937	7177473
Depurator	DEP PIEVESESTINA	activated sludge	95	298265	466464
Depurator	DEP CALABRINA	activated sludge	6	23390	4854
Depurator	FITO CALABRINA	imhoff + phytodepuration	20	11090	4980
Depurator	FITO BAGNILE	imhoff + phytodepuration	10	1785	3481
Imhoff tank	CAPANNAGUZZO	Imhoff tank	-	-	3168
Imhoff tank	BULGARNÒ	Imhoff tank	-	-	6335
Imhoff tank	FORMIGNANO	Imhoff tank	-	-	2091
Imhoff tank	MONTECAVALLO	Imhoff tank	-	-	1267

Table 7 - Technical characteristics of the main plants of the sewage system (Hera).

GIS Maps

Note. the shape file with the localization of sewage plants are not available.

Future Plans

All of the following projects are being planned by *Hera SpA* and concern specific interventions to improve the sewerage system in the area of Cesena and surroundings:

- Collection of the discharge treatment with the elimination of the Imhoff tank in *San Cristoforo*
  Year of full implementation: after 2019
  Total cost (euro): 294000

- Expansion of the lifting system and substitution of the pipeline with a larger diameter in *San Giorgio*
  Year of full implementation: after 2017
  Total cost (euro): 490000

- Elimination of direct discharges to the creek *Cesuola* (in *Cesuola* district)
  Year of full implementation: after 2019
  Total cost (euro): 900000

- Optimization of the sewage system of Cesena - Elimination of water parasitic in blackwater sanitary sewer in the municipal area.
  Year of full implementation: after 2018
  Total cost (euro): 220000

5. Waste Chain

Characterization

The municipal waste management of Cesena, is currently entrusted to *HERA Inc.* which is subject to obligations related the quality and quantity of the services offered in line with regional and national directives.
The Municipality of Cesena contributes to the proper management of the municipal wastes with the following specific activities:

- verifies the correct execution of the collection and sweeping services;
- monitors and punishes incorrect behaviour of the users;
- promotes communication campaigns;
- may require *HERA Inc*. to change the waste collection procedures with specific projects.

WASTE TREATMENT FACILITIES
The main waste treatment facilities for the disposal or process of the wastes produced by the municipality are described below. Only a fraction of the municipal solid wastes are treated within the municipal area.

<u>Landfill</u>
Within the municipal area of Cesena there are two landfills managed by *Hera Inc.* that are now closed and not in operation:

- "*Rio Eremo*" landfill, decommissioned from 19 years;
- "*Busca*" landfill for non-hazardous waste activated in April 1999.

<u>Waste to energy plant</u>
No waste to energy plant is installed within the municipal area. All the not differentiated municipal solid wastes are disposed by the waste to energy plant located in the municipality of *Forlì*.

- Activity (*ton/year*): 120000 - 33000 of which from Cesena
- Lifetime: more than 20 years
- Energy production: potential 46.5 MW
- Capacity (*ton/day*): 284
- Operating (*hours/year*): 7500

<u>Composting plant</u>
A composting plant for the treatment of organic waste operates since 2011 within the municipal area. It is managed by *Romagna Compost Srl*, a company established by *HERA Inc.* with the involvement of other private companies of the agri-food district.

- Activity (*ton/year*): 40000 (ton/year) - 10500 of which from Cesena
- Lifetime: more than 20 years
- Installed electric power: 1.0 MW

- Expected electricity consumption: 8000000 kWh/year

Recycling plants

There are two small recycling plants privately operated and therefore can be considered small industry activities:

- storage and recovery of metals;
- selection of paper and plastic. The waste collected is therefore sent to other recycling facilities in the region/national territory (out of the scope area), where are further treated and recycled.

WASTE CHARACTERIZATION

The main types of municipal solid waste (MSW) considered in the framework of this analysis are:

- the total amount of unsorted waste (ton);
- the amount of separate waste collection to recovery (ton);
- the amount of separate waste collection to disposal (ton);
- the total amount of separate collection (ton).

Wastes are produced by 95525 residents (37541 households) and 6328 non-domestic users. The key findings of the data collection are reported below for the year 2013:

- Total MSW collected (ton): 68935
- Total MSW produced per capita kg/inhabitant resident (ton): 709.71
- % of Separate Waste Collection: 52.75%

Based on a detailed analysis of the waste chain, specific indicators like the amount (ton) and % of the waste collected "by type" (from the year 2008 to 2013) have been tracked. Furthermore, spatial information describing the "route" of the wastes (from the collection to the disposal point) have been collected.

Data are available in the tables 11 and 13 of sheet 5. Waste Chain of the excel file.

GIS Maps

GIS maps provided for the waste chain keep track of:

- ✓ Map of the street for which the waste collection is managed by the municipal (annual frequencies for single street – 2015);
- ✓ Location of dumpsters within the municipal area (2005).

Future Plans

The Municipality of Cesena has set the following main objectives that guide the development of policies and interventions in the field of waste management:

- limit the amount and hazardous waste (reduce);
- increase the life time of the products and reduce the disposable (reuse);
- increase the quantity and quality of waste collection (recycle / waste sorting).

The main project that the municipality of Cesena is going to develop in the upcoming few years, is the expansion of the municipal waste "separate" collection system (a *"door to door system"*) to the entire city, which is currently available in four districts of the city only. Here below some details:

- service manager: *HERA spa*;

- time of implementation: 2015-2017;
- type of system: doorstep collection of organic waste and unsorted waste for all the families and the economic activities that fall in the neighborhoods of the city of Cesena;
- future objective: 65% of urban waste differentiated;
- investement cost: 950000 € in 3 years.

5 Energy Supply System

Characterization

The most relevant energy production facilities of the municipal area of Cesena area briefly described below.
Data about (small-scale) "supply centres" are available in the Tables 16-18 of the sheet 6. Energy supply system, of the attached excel file.

District heating system

The district heating service in Cesena is operated by *HERA Inc*. and is composed by two main poles described below:

Polo Ippodromo

- Date of implementation (year): 2009
- Installed capacity (kW): 18500
- Energy production:
  - 12.970 MWht thermal energy provided to users (year 2012)
  - 1.820 MWhe net electricity introduced into the national grid

Polo Bufalini

It is an "evolved" trigeneration plant, provides thermal energy as:

- hot water at 90°C …………..…. heating and hot water;
- chilled water ………………..…… cooling;
- steam (pressure = 10 bar) ….... sterilization, humidification and cooking

The electrical energy produced is used for the operation of the system, while the surplus is dispatched on the distribution network.

the plant scheme is composed of:

- 2 hot water boilers. Power 5,3 MW each;
- 2 fast vaporization boilers. Power 2,1 MW each;
- 2 CHP unit. Total power 1,9 MWe and 2,3 MWt;
- Absorption chiller. Power 1,5 MWf;
- A cooling tower. Thermal capacity of about 3,7 MW.

- Date of implementation (year): 2012
- Installed capacity (kW): 14,200
- Electricity production (kWh): 13,292,000 (thermal energy year 2012)
- Energy production:
  15.132 MWht thermal energy produced (of which 1,840 of cooling energy)
  6.880 MWhe electric energy

For both poles the district heating network length is 16.443 km, divided between districts:

District	meter
CENTRO URBANO	6.737,63
CERVESE SUD	858,91
FIORENZUOLA	5.881,96
OLTRE SAVIO	2.954,59
TOTAL	**16.433,09**

Table 8 - Lenght of the network (meter).

Additional data about the district heating system and the corresponding gas consumption per type of service (year 2011), are available in the sheet 6. Energy supply system, of the attached excel file.

Micro-hydropower station

In the municipal area there is a micro hydroelectric plant "*Brenzaglia*" managed by *ENEL ltd*.

- Date of implementation (year): 1923
- Installed capacity (kW): 300
- Electricity production (kWh): 447 (year 2011)

Biogas Cogeneration Busca garbage dump

The garbage dump located in Tessello, via Rio della Busca 1325, (within the scope area) exhausted from 31/12/2012, is equipped with a combustion system of biogas whose maximum capacity is 1200 Nmc/h.
From 2006 started working the power plant generation with use of landfill biogas consisting of two engines, one of the potential maximum of 625 kW and the other of 511 kW.
From about mid-November 2013 come into operation the third engine of the maximum capacity of 990 kW.
All three engines, of total potential of 2,1 MW, are owned by the company Energie Romagna.
During the summer 2014 there has been a gradual shutdown of the engines 1 and 2, whose exercise is finished, no longer be taken, in the month of July 2014.

HERA Inc. redirected the flow of residual production of biogas from the landfill connected to the two motors, to the third one, ensuring the processing of the extracted gas, in compliance with regulatory and authorization requirements.

The electricity put into the network grid by engines 1 and 2 in the year 2014 is 2.986.860 kWh. The electricity put into the network grid by engine 3 in the year 2014 is 3.266.534 kWh.

Biogas Cogeneration Busca sewage disposal

It is a plant for the treatment of organic waste from differentiated waste collection.

- Installed capacity (MW): 1
- Electricity production (kWh): 7.182523 (year 2013)

Wind Plant (*Parco PESEA*)

- Installed capacity (kW): 40

- Electricity production (kWh): 55000

Photovoltaic plants on public buildings

Thanks to the project "The school of the sun" managed by *Energie per la città*, in the years 2011, 2012, 2013, a total of 19 photovoltaic installations have been realized on school buildings, for a total capacity of about 633 kW and an annual production of about 700000 kWh of electricity, the equivalent consumption of about 280 families. This allows avoiding the emission of about 275 tonnes of CO_2.

Photovoltaic plants on private property

All data relating to photovoltaic plants on private property are managed and monitored at national level by the *GSE (Manager of Energy Services*). The municipal GIS department of Cesena has only incomplete data of the PV plants authorized at local level since year 2010.

Since no longer exist state subsidy and from year 2013 all PV installations can be realized without any authorization, we don't have updated data on photovoltaic plants in the municipal area.

ASSESSMENT OF THE RES RESOURCE POTENTIAL

For modelling purposes (WP5), there is the need to assess the renewable energy sources (RES) technical potential at the city sector level. For most resources, the technical potential need be seen in a dynamic context, thus the estimation of RES potentials has been assessed taking into account the evolution of key variables such as technical boundary conditions, the efficiency of conversion technologies, as well as overall technical limitations, namely the available land area (e.g. the future building rate of new houses that could support PV-rooftop). Potentials have been estimated in terms of maximum capacity (as for the case of solar PV) or maximum energy production level (as for the case of thermal solar), in accordance to the common methodology described in the report of WP4 "Assessment of RES potential at city level". A complete set of indicators is reported in the attached excel file.

GIS Maps

GIS maps provided for the energy supply system keep track of:

- ✓ District heating network (2013) (*HERA*)
- ✓ Gas Network (2013) (*HERA*)
- ✓ Gas delivery points (2013) (*SNAM*)
- ✓ Photovoltaic systems installed in public and private properties (from 2008 to 2012)
- ✓ Electric grid (*ENEL*)
- ✓ Power lines (high voltages) (*ENEL*)
- ✓ Power lines (medium voltages) (*ENEL*)

Future Plans

Energie per la Città Spa, through "Schools of the sun" project, has just completed the construction of 5 photovoltaic plants with a total capacity of 58,25 kW, 5 additional photovoltaic plants (with a total power of about 27 kW) are in the planning phase. Plants are made on school buildings roof.

Through the company *Romagna Acque Inc.* is under construction a micro hydropower plant at the tank Cesena Cappucini (within the scope area).

Target data expected for the hydrological year average are:

- Hydraulic power: min. 21,2 kW - max. 128,7 kW
- Power delivered to the grid: min. 13,4 kW - max. 95,8 kW
- Average power delivered to the grid: 79,1 kW equivalent to an average annual production of about 693.000 kWh.

Works are in advanced stage of completion.

Tertiary Sector

5.1 Buildings managed by the Municipality

Characterization

In January 2011 the municipality of Cesena established an in-house company (100% municipally owned) *Energie per la Città Ltd* that deals with the energy-related issues of the building stock managed by the Municipality, with specific reference to energy management, facility management, energy services, and promotion of renewable energy sources.
Energie per la Città Ltd provided detailed data (updated to 2012) on energy consumption by type of municipal building. Note that exist other public buildings managed by third organizations (eg. theatre, the public pool), but no data on energy consumption are available for those buildings.

Data provided

- localization by street of different type of buildings
- volume of the buildings (m3)
- natural gas consumption per year (m3/year)
- district heating consumption (MWh/year)
- electricity consumption per year (kWh/year) for type of buildings
- electricity production by PV (kWh/year)

Type of Municipal building

- office
- sports centers/gyms
- art gallery museums
- cultural centers
- district
- heritage
- school
- university
- cemetery
- social centers

All detailed data are available in the sheet 7. Buildings under Municipal Management of the excel file.

GIS Maps

GIS maps provided keep track of:

✓ localization of cemeteries
✓ localization of places of interest (e.g museum)
✓ localization of sports facilities
✓ localization of schools

Future Plans

Extension work of school "S.Vittore"
During the summer of 2015, at the Nursery School "S.Vittore" was built an extension. The dispersants structures have been isolated to reach the suggested values for passive buildings.
The heating system of this new area is done with radiant floor and it was installed a heat pump (integrated with condensing boiler serving existing school).

In addition, the existing nursery school was redeveloped through vertical external wall insulation (U <0,23 W / m2K), roof insulation (U <0,20 W / m2K) and replacement of existing windows with higher energy performance windows (Uw <1,5 W / m2K). The existing school's boiler has been replaced with a condensing boiler.

It has installed a photovoltaic system with a power of 10 kWp on the building roof.

In September 2015, the Energy Performance Certificate (APE) has classified the whole building into class B, according to existing classification in Emilia Romagna Region, with aTotal Energy Performance Index of 10,62 kWh/ m3/year

New gymnasium "S.Giorgio"
During the summer of 2015, has been designed the new gymnasium "S.Giorgio" (total area 677,30 sq m) and an adjacent building (approximately 260 sq m) were will be located changing rooms, showers and utility rooms.
Building structures will be insulated with 20 cm of expanded polyurethane and will reach high energy performance. For heating there will be a heat pump system and a ventilation system with heat recovery.

New headquarters of the Municipal Police of Cesena
It is being planned the requalification of Ex-district court offices (adjacent to "Ex-GIL" Gymnasium), which will become the new headquarters of the Municipal Police of Cesena.
This requalification, in addition to affecting a redistribution of interior spaces, will include:

- external walls insulation;
- roof insulation to reach a transmittance at U <0.20 W / m2K;
- replacing existing windows with windows with total transmittance Uw <1.5 W / m2K;
- installation of a PV plant on the roof to cover part of electricity needs;
- installation of a solar thermal system to cover part of of domestic hot water needs;
- installation of an air conditioning system with heat pump.

5.2 Other Tertiary Buildings

Characterization

The energy consumption of the (private) tertiary buildings are not controlled by the municipality (confidential data). The only additional available figure is the annual total consumption of electricity of the entire municipality (year 2010):

- MV 78084149 kWh
- LV 106245088 kWh

GIS Maps

Data non available.

Future Plans

Currently there are no plans and projects.