Deliverable 2.5

Impact assessment database

Deliverable Number	D2.5
Deliverable Name	Impact assessment database
Deliverable Version	V1.0
Work Package (WP)	WP2 Status assessment, baseline and stakeholder mapping
Due date	28th February 2019
Date of Submission	12th March 2019
Main Author	UNIZAG FSB
Contributors	All Partners

This report has been submitted to the EC for approval and as such it is still to be considered as draft

This project is funded by the European Commission
under Horizon 2020 Grant Agreement No. 784994

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Introduction

The municipalities play an important role in achieving international, national, regional and local goals to reduce greenhouse gas emissions through improving energy efficiency and increasing the use of renewable energy. Developing Sustainable Energy (and Climate) Action Plans (SE(C)AP) is an effective and important first step in this process. This report provides a detailed and comprehensive database of the potential impacts which certain measures, usually suggested in SE(C)APs, could achieve.

Project background

The PentaHelix project is focusing on developing and testing a new approach for integrating multi-governance planning for sustainable energy, both horizontal and vertical, together with close interaction with key stakeholders in energy efficiency and sustainable energy solutions. Here, integrated development focuses on five different stakeholder groups, who constitute the PentaHelix pillars:

- Public authorities (local, regional, national and international);
- Industry (and businesses such as SMEs, farmers, trade etc);
- Academia (research and educational institutes);
- NGOs (associations, interest organisations, etc);
- Citizens (house owners, car owners, commuters etc).

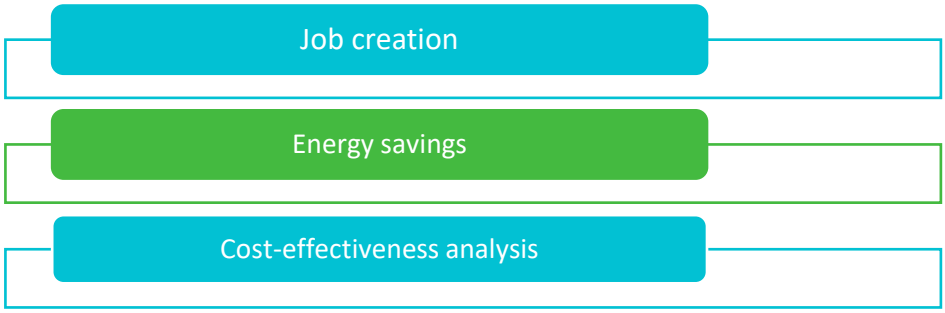
Representatives of the PentaHelix pillars constitute the task force groups, that serve as a driver for a wider scope of the of Sustainable Energy and Climate Action Plans (SECAPs), as well as bringing in valuable insights and identification of potential measures, system solutions and a better understanding of drivers and barriers for a more sustainable society as a whole, in each specific region. The approach will be developed and tested in Norway, Croatia, Latvia, Belgium and Spain, what will enable its validation across a wide set of different economic, climate, social and political conditions. In each of those countries, municipalities which will act as the pilot municipalities, are chosen.

Furthermore, the project aims at developing the peer-to-peer online platform for SECAP development that can be used for multiple public authorities in joint planning and implementation. This will enable the integration of different administrative levels and geographical planning areas as well as enhance the cost efficiency in the entire planning and implementation process based on economy of scale and closer cooperation and exchange.

To further enhance the impact of the project a broad replication and dissemination strategy and actions will be rolled out in many countries in the EU. To ensure that the PentaHelix project will reach out to all parts of the civil society, the consortium includes two network partners- Climate Action Network Europe (CAN Europe) and the EBN innovation network.

Scope of the report

This database gives an insight into the large scope of possible outcomes from specific actions related to energy efficiency and renewable energy production. Presented data are based on existing cases, past experience and relevant research and obtained for project partner counties. This database contains three major parts, as depicted in the figure below.



Due to a difference between the prices, labour costs, climatology and similar factors between the partner countries and even between regions within the same country, numerical values have a significant range for some impacts. However, the results collected in this database can provide a general set of guidelines and allow municipalities to prioritize the implemented measures according to their estimated impacts. This database will be updated with the results and data obtained from the implementation of the PentaHelix project and submitted together with the Final project report.

Impacts on job creation

The number of direct jobs generated as a result of the installation of renewable energy generation facility or investment in energy efficiency can be calculated according to installed capacity or achieved energy savings and employment factors.

Job creation from renewable energy generation

The numbers of jobs created as a result of renewable energy production can be calculated based on employment factors and installed peak renewable energy generation capacity. Employment factors assume different values regarding the phases of the life cycle. In a case for the renewable energy installation, following phases of the life cycle and respective employment factors can be differed [1]:

- **Manufacturing employment factor -** the number of jobs necessary to manufacture one unit of new renewable energy generation capacity [job /newly installed MW]
- **Construction and installation employment factor** - the number of jobs necessary to construct and install one unit of new renewable energy generation capacity [job/ newly installed MW]
- **Operation and maintenance employment factor** -- the number of jobs necessary for renewable energy facility to run, applied to the total installed renewable energy generation (peak) capacity [job/MW]

Calculation of job creation from renewable energy generation is depicted in Figure 1.

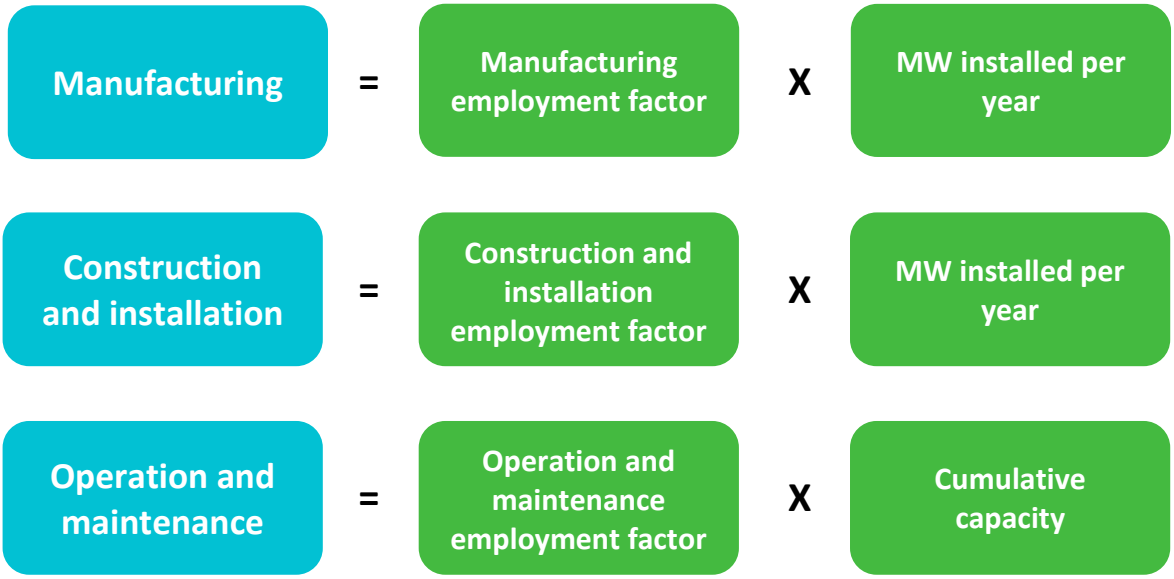


Figure 1 Calculation of energy supply jobs

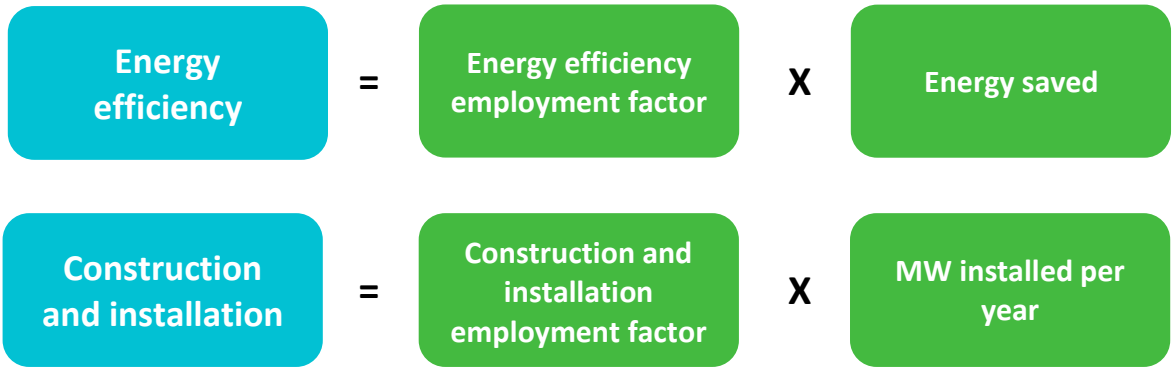
Manufacturing, construction and installation refer to new and additional capacity, as well to replaced ones (such as repowering for wind turbines). As such, those factors represent relatively temporary impacts for employment in comparison to the entire plant lifetime. Manufacturing, constructing and installing the equipment for a renewable energy project require from several months or up to a few years of work [1]. Operation and maintenance employment factors rely on the cumulative installed capacity of renewable energy generation plant over the lifetime of the plant [1]. Employment factors estimated for different renewable energy generation technologies are presented in Table 1.

Table 1 Employment factors for different renewable energy generation technologies [2]

Fuel	Construction times [year]	Construction & installation [Job years/MW]	Manufacturing [Job years/MW]	Operation & maintenance [Jobs/MW]
Biomass	2	14	2.9	1.5
Hydro – large	2	3.5	7.4	0.2
Hydro – small	2	15.8	10.9	4.9
Wind onshor	2	3.2	4.7	0.3
Wind offshore	4	8	15.6	0.2
Solar Photovoltaics	1	13	6.7	0.7
Geothermal	2	6.8	3.9	0.4
Solar thermal	2	8	4	0.6
Geothermal – heat	6.9 jobs/ MW (construction and manufacturing)			
Solar – heat	8.4 jobs/ MW (construction and manufacturing)			
Combined heat and power	CHP technologies use the factor for the technology (i.e. biomass, geothermal etc.) increased by a factor of 1.5 for O&M only.			

Job creation from investment in energy efficiency

The most common way to assess the number of jobs gained due to the implementation of energy efficiency is via annual investment or achieved energy savings. Similar to calculation of job creation from renewable energy generation, job creation from improving energy efficiency can be calculated by using the following equations:



Employment factors per energy savings for different sectors are listed in Table 2.

Table 2 Energy efficiency employment factors per energy savings for different sectors [3]

Sector	Employment factor [Job/ GWh saved]
Residential	0.49
Commercial	0.62
Industrial	0.27
Appliances and electronics	1.02
Transport	0.06
Utilities	0.03
Weighted average	0.19

Energy savings per specific measures

Energy saving measures can significantly contribute to energy efficiency improvements, leading to decarbonization and additional sustainability benefits. Iimpacts on energy savings, which certain measures can achieve in residential and non-residential sectors, are presented in Table 3 and Table 4.

Table 3 Assessment of energy savings for measures in non-residential buildings [4]

Measure		Source	
		[4]	[5]
Renewable energy	Installation of solar collectors for sanitary hot water production	25-80% EES.	-
Lighting	Installation of energy efficient lighting	60% EES	6% EES
Building envelope	Thermal insulation of external walls for buildings without or inadequate insulation	28-44% TES. 4-5% EES	2% EES
	Installation of double glazing	10-28% TES	7% EES
	Installation of external shading	10-20% EES	-
	Thermal insulation of roofs for buildings without or inadequate roof installation	4-8% TES 2% EES	2% EES
Space heating and cooling	Installation of Building Management System	20% TES 30% EES.	-
	Installation of ceiling fans	60% EES	-
	Maintenance of central heating installations	11% TES	-
	Installation of temperature balance controls for central space heating	5% TES	5% TES
	Installation of space thermostats and use	5% TES	-
	Decrease set-point temperature for Winter and increase for Summer	-	3-4% TES

*EES Electrical energy savings

*TES-Thermal energy savings

Table 4 Assessment of energy savings for measures in residential buildings [4]

Measure		Source	
		[6]	[7]
Renewable energy	Installation of solar collectors for sanitary hot water production	50-80% TES	60-74% TES
Lighting	Installation of energy efficient lamps	60% EES	63-85% EES
Building envelope	Thermal insulation of external walls for buildings without or inadequate insulation	33-60% TES	21-42% TES
	Weather proofing (sealing) of openings/ Reduced infiltration rate due to envelope and window cracks	16-21% TES	7-18% TES
	Installation of double glazing	14-20% TES	7-27% TES
	Installation of external shading/shading of houses with threes/ Installation of awning	10-20% TES	0-10% TES
	Thermal insulation of roofs for buildings without or inadequate roof insulation	2-14% EES	1-7% TES
	Insulation of the floor	-	4-28% TES
	Insulation of heat distribution pipes	-	2.4-5.2% TES
	Painting the external wall with light colours	-	2-4% TES
Space heating & cooling	Replacement of old and inefficient local air-conditioning units	72% EES	-
	Installation of ceiling fans	60% EES	57-68%
	Maintenance of central heating installations	10-12% TES	-
	Installation of temperature balance controls for central space heating	3-6% EES	-
	Installation of space thermostats	3-6% EES	-
	Installation of thermostatic valves	-	10-30% TES

*EES Electrical energy savings

*TES-Thermal energy savings

Cost-effectiveness analysis

In order to conduct cost-effectiveness analysis, data on achieved and possible impacts which certain measures can have, have been gathered for each partner country. Since geographical location can have a significant impact, data have been obtained for different geographical regions for each considered country.

This analysis has covered the following sectors:

- Municipal buildings, equipment/ facilities
- Residential buildings, equipment/facilities
- Tertiary buildings, equipment/facilities
- Transport
- Public lighting
- Local heat/cold production
- Local electricity production

Within the analysis, specific implementation cost for following parameters has been assessed:

- Annual CO_2 reduction [t_{CO2}]
- Annual final energy reduction [MWha]
- Annual primary energy reduction [MWha]
- Annual renewable energy production [MWha]

The results of the analysis are presented in Table 5. Values presented in the first row of cells present the range, while the value in the second row presents the average value. Annexes A,B,C,D and E present the input data used for the cost-effectiveness analysis for each partner country.

Table 5 Cost-effectiveness analysis

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Municipal buildings, equipment/ facilities	Installation of photovoltaic systems	Croatia	2170-5509 3580		1150-1820 1500		[8], [9]
		Spain	17400-22200 19040		5750-7350 6300	2450-3100 2660	[10]
		Belgium	780-9150 4950				[8], [11]
	Installation of solar thermal collectors	Latvia	1070-1550 1300		280-295 285		[8], [12]
		Croatia	2150-2650 2450				[8]
	Thermal insulation of municipal building envelopes and roofs	Croatia	1560-3400 2300	1420			[8], [13]
		Latvia			1050-1680 1365		[14]
	Integrated refurbishment of municipal buildings	Croatia	2200-23840 11930	582-11940 3970			
		Spain	6270-10100 8180	3340-6780 5060		1280-6270 3770	[8]
		Belgium	5090-9700 7260				[8]
	Replacement of fossil fuel powered heaters with renewable fuel	Croatia	565-3030 1800	290-1790	325-2780 1230		[15], [9], [8]
		Spain	11200		3350	2840	[8]

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Municipal buildings, equipment/ facilities	Replacement of inefficient lighting with energy efficient lighting	Croatia	850-5090 2970	300-1800 1040			[15], [16]
		Spain	2225-19500 10850	735-6450 3560		280-2470 1380	[8]
		Belgium	810				[8]
	Management and regulation of energy in municipal building	Spain	2310	780		720	[8]
	Replacement of energy-ineffective windows on municipal buildings	Croatia	4750-11650 8270	1120-3000 2400			[8], [17]
		Spain	2020				[8]
Residential buildings, equipment/facilities	Thermal insulation of residential building envelopes and roofs	Latvia		1580-1890 1730			[18]
		Croatia	1570-3470 2380	320-620 485			[8], [19]
		Spain	2100				[8]
		Belgium	1040				[8]
	Integrated refurbishment of residential buildings	Croatia	1575-4670 3250	320-1160 720			[20], [8], [21], [22]
		Spain	2050	700		580	[8]
		Belgium	1700				[8]

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Residential buildings, equipment/facilities	Installation of solar thermal collectors in residential buildings	Spain	3170-4520 3850		1080-1530 1300	910-1300	[8]
	Installation of photovoltaic systems	Belgium	630-4130 2380			1180	[8]
	Installation of biomass boilers in residential buildings	Spain	1600				[8]
	Replacement of the inefficient lighting with the energy efficient lighting in residential buildings	Croatia	880	290			[15]
	Energy efficiency education for the citizens	Spain	420				[8]
		Belgium	30-60 50	10			[8], [23]
	Purchase of the energy-efficient electrical appliances for the residential buildings	Croatia	4560	1065			[19]
		Spain	1330-10200 5760	3770		3110	[8]
		Belgium	10840				[24]

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Tertiary buildings, equipment/facilities	Installation of solar thermal collectors	Croatia	1320-6820 4070		305-2180 120		[16]
		Spain	2200-2600 2380		810-950 880	680-810 740	[10]
		Belgium	4590				[24]
	Installation of photovoltaic systems	Spain	4350		1160	490	[8]
	Integrated refurbishment of tertiary buildings	Croatia	4450-5150 4900	1010-1650 1350			[16], [19], [25]
		Belgium	5160	1050			[26]
	Thermal insulation of the tertiary building envelopes and roofs	Belgium	4370				[24]
	Replacement of inefficient lighting with energy efficient lighting	Croatia	1350-1540 1450	450-510 480			[27], [17]
		Spain	3020	1000		380	[8]
		Belgium	5870				[24]
	Replacement of energy-ineffective windows on tertiary buildings	Belgium	2910				[24]

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Transport	Purchase of electric bicycles	Croatia	1820	500			[19]
	Purchase of electric vehicles	Latvia	7100-17500 12300				[12]
		Croatia	13600-15870 14920	3120-3640 3380			[13]
		Spain	28750				[8]
		Belgium	10580-26470 17000				[8]
	Purchase of electric motorcycles	Spain	4230	1110		1030	[8]
	Measures for encouraging use of the public transport	Spain	1670-3240 2710	400-960 710		370-890 650	[8]
	Replacement of vehicles powered by conventional fuels with more sustainable ones	Spain	22020	6630		6130	[8]
		Norway	988				[28]
	Introduction of a bike-sharing model	Spain	290	90		80	[8]
	Construction cycling path	Belgium	750-1120 940				[8]

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Public lighting	Management and regulation of the public lighting system	Spain	1430	475		180	[8]
	Replacement of public lighting installations with LED	Croatia	1300-3450 2350	300-1140 740			[8], [27], [29] [13][30] [25]
		Latvia	7640				[8]
		Spain	8500-1540 12670	2820-5100 4200		1080-1950 1610	[8]
		Belgium	3600				[8]
Local heat production	Installation of biomass CHP	Latvia	720- 1935 1420		100-140		[8]
	Installation of wood biomass boiler	Latvia	240-490		65-100		[8]
		Spain	1030		235	210	[8]
	Refurbishment of the district heating distribution grid	Croatia	3470	2410			[13]
	Connection of residential buildings to district heating	Spain	5730-13440 9400	1530-4550 3040		3110	[8]

Measure		Country	Specific cost per annual CO_2 reduction [€/tCO_2a]	Specific cost per annual final energy savings [€/tCO_2a]	Specific cost per annual renewable energy production [€/tCO_2a]	Specific cost per annual primary energy savings [€/tCO_2a]	Source
Local electricity generation	Electricity Generation from the wind power	Spain	1480-1662 1570				[8]
		Belgium	3690-5540 4200		1150		[31], [32], [33], [24]
	Electricity Generation from the Solar power	Spain	740-1670 1200				[8]

ANNEX A- Input data gathered for cost-effectiveness analysis for Croatia

Measure		Additional description	Implementa-tion cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]"	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Municipal buildings, equipment/ facilities	Installation of photovoltaic systems		19095	6.22		16.55		Koprivnica	[8]
			54050	9.81		29.73		Šibenik	[29]
			293959	135.7				Rijeka	[8]
	Installation of solar thermal collectors	Installation of solar thermal collectors for DHW preparation	5503355	2077		9344		Zagreb	[8]
			356231	165.35		609.63		Zadar	[8]
	Thermal insulation of municipal building envelopes and roofs		190000	56	134			Rijeka	[13]
			38016000	24346				Zagreb	[8]
			315790	163.36				Bjelovar	[8]
	Replacement of energy-ineffective windows on municipal buildings		77895	16.43				Jastrebarsko	[8]
			394737	71.47	350			Bjelovar	[8]
			8050	0.72				Drniš	[17]
			11409	0.98				Skradin	[17]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]"	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Municipal buildings, equipment/ facilities	Integrated refurbishment of municipal buildings		460000	210.35	790			Karlovac	[15]
		Integrated energy refurbishment of a kindergarten (building envelope, heating system)	900675	82.85	409.04			Varaždin	[20]
			2890000	182.1	639.114			Šibenik	[29]
		Integrated energy refurbishment of elementary schools (building envelope, HVAC system)	621500	45.86	136.567			Rijeka	[13]
			1100000	46.15	178.025			Rijeka	[13]
			380000	16.31	31.844			Rijeka	[13]
			3080000	407	1005			Zadar	[30]
			162200	40	204			Zadar	[30]
			1748843	197.81				Karlovac	[8]
			752560	81.76	305.55			Karlovac County	[16]
	Replacement of fossil fuel powered heaters with more renewable energy sources	Replacement of fuel oil boilers with biomass fired boilers	67550	30.46				Karlovac	[15]
			281133	498.4				Kastav	[8]
			19455	10.83				Karlovac	[8]

Measure		Additional description	Implementa-tion cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]"	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Municipal buildings, equipment/ facilities	Integrated refurbishment of municipal buildings	Utilization of renewables for public pool heating	585130	193				Šibenik	[29]
	Replacement of inefficient lighting with energy efficient lighting		8100	9.55	27.778			Karlovac	[15]
			29850	5.86	16.66			Karlovac County	[16]
Residential buildings, equipment/facilities	Integrated refurbishment of residential buildings		91428	58	285			Varaždin	[20]
			311200	94	482			Varaždin	[20]
			80300	26	131			Varaždin	[20]
			2490000	531	2142			Varaždin	[20]
			567500	160	485266			Pula	[21]
			780071	173	748			Zadar	[30]
			197368	75				Koprivnica	[8]
			2684570	1005,7	4978			Međimurje County	[22]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]"	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Residential buildings, equipment/facilities	Thermal insulation of residential building envelopes and roofs		90900	58	285			Varaždin	[8]
			800000	40	1929			Varaždin	[8]
			91428	58	285			Labin	[19]
			311200	94	482			Krapina-Zagorje County	[19]
	Purchase of energy-efficient electrical appliances for	Co-financing of purchase of electrical appliances with A+++ energy label	1072390	235	1006.2			Aggregated for Croatia	[19]
	Installation of solar thermal collectors		60550	8.88		27.78		Karlovac County	[16]
			277685	210.71		910		Zadar	[8]
Tertiary buildings equipment/facilities	Integrated refurbishment of tertiary buildings		12400000	2412	7553			Zagreb	[25]
			10813500	2146.96	8041			Karlovac County	[16]
			325000	73	321			Ivanec	[19]
	Replacement of inefficient lighting		5400	3.98	12.06			Split	[27]
			4479	2.9	8.8			Knin	[17]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]"	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Transport	Purchase of electric vehicles		94600	5.96	25.968			Rijeka	[13]
			60800	4.47	19.476			Rijeka	[13]
			137500	9				Jastrebarsko	[8]
	Purchase of electric bicycles		9650	5.3	19.2			Lepoglava	[19]
Public lighting	Replacing outdated lighting fixtures with energy-efficient and more environmentally-friendly lighting fixtures	470000	212.5	644				Split	[27]
		4460000	1290	3909.08				Split	[27]
		250000	191	881				Zadar	[30]
		162160	100.96	269.52				Šibenik	[29]
		355521	108.75	360				Križevci	[8]
		3175000	2292	6944				Zagreb	[34]
		355522	108.75	360.28				Križevci	[8]
Local heat/cold production	Refurbishment of the district heating distribution grid	6080000	1750	2522				Rijeka	[13]

ANNEX B- Input data gathered for cost-effectiveness analysis for Spain

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Municipal buildings, equipment/ facilities	Installation of photovoltaic systems		19845	1.09		3.30	7.81	Soria	[10]
			19729	1.03		3.10	7.34	Soria	[10]
			20187	1.16		3.50	8.29	Valladolid	[10]
			19844	1.09		3.30	7.81	Valladolid	[10]
			19845	0.89		2.70	6.39	Palencia	[10]
	Installation of solar thermal collectors		112830	43.49		118.30	139.83	Soria	[10]
			250000	106.48		286.50	342.37	Valladolid	[10]
			257674	117.63		316.50	378.22	Valladolid	[10]
	Management and regulation of the public municipal buildings		300000	130,00	383.47		414.92	La Coruña	[8]
	Integrated refurbishment of municipal buildings		272724	43.50	40.20		43.50	La Coruña	[8]
			49461	4.90	14.80		38.63	Basauri (Bilbao)	[8]
	Replacement of fossil fuel powered heaters with more renewable energy sources		100000	8.93		29.77	35.19	Gasoleo C / Propano	[8]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
	Replacement of inefficient lighting with energy efficient lighting		19500	1.00	3.02		7.88	Tarragona	[8]
			1669	0.75	2.27		5.92	Marchan (Granada)	[8]
Residential buildings, equipment/facilities	Installation of solar thermal collectors		71418	22.50		66.37	78.45	Arroyo de Ojanco (Jaén)	[8]
			45371	10.039		29.62	35.01	Espeluy (Jaén)	[8]
	Thermal insulation of residential building envelopes and roofs		773762	369.215				Úbeda (Jaén)	[8]
	Purchase of energy-efficient electrical appliances for residential buildings		33803	25.31				Alozaina (Málaga)	[8]
			21600	2.12	6.40		6.93	Alozaina (Málaga)	[8]
	Replacement of energy-ineffective windows on residential buildings		15133	7.49				La Puerta de Segura (Jaén)	[8]
	Energy efficiency education for the citizens		1000	2.36				Marchal (Granada)	[8]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
	Biomass boilers installation in residential buildings		278024	174				San Lúcar La Mayor (Sevilla)	[8]
Tertiary buildings equipment/faciliti	Thermal insulation of the residential building envelopes and roofs		454601	222	654.85		774.04	Torreperogil (Jaén)	[8]
	Replacement of inefficient lighting with energy efficient lighting		45072	14.9	45		117.49	Algar (Cádiz)	[8]
	Installation of photovoltaic systems		195489	45		168.42	398.82	Jódar (Jaén)	[8]
Transport	Purchase of electric vehicles		60000000	2087.	7006.14		7580.6	Malaga	[8]
	Purchase of electric motorcycles		5250	1.24	4.7		5.1	Alella (Barcelona)	[8]
	Replacement of urban buses with conventional fuels for more efficient ones (natural gas, hybrids)		24000	1.09	3.62		3.9	Mollet del vallés (Barcelona)	[8]
	Introduction of a bike-sharing model		752860	2600	8728.00	9443.7		Murcia	[8]
	Measures for encouraging use of the public transport		176000	54.28	182.71		197.7	Almaden de la Plata (Sevilla)	[8]
			33600	20.13	84.70		91.6	Montecorto (Málaga)	[8]
			33600	10.42	43.87		47.5	Marbella (Málaga)	[8]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Public lighting	Replacing outdated lighting fixtures with energy-efficient lighting fixtures		68730	4.86	14.7		38.31	Alquería de Azar (Alicante)	[8]
			759000	49.4	149		388.9	Alella (Barcelona)	[8]
	Management and regulation of the public lighting system		35937	25	75.6		197.1	Basauri (Bilbao)	[8]
Local heat/cold production	Connection of residential buildings to district heating		369222	64.4	241.3			La Pobla de Lillet (Barcelona)	[8]
	Establishment of district heating		1950000	7850		33500	37222	Soria	[35]
			1300000	6800		27000	29997	Valladolid	[35]
Local electricity production	Electricity generation from solar power		3000000	1800		4000	9472	Lepe (Huelva)	[8]
			250000	336				Marchal (Granada)	[8]
	Electricity generation from the wind power		200000	135		300	710.4	Galera (Granada)	[8]
			6000	3.6				Pujalt (Barcelona)	[8]

ANNEX C- Input data gathered for cost benefit analysis for Latvia

		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Municipal buildings, equipment/ facilities	Installation of solar thermal collectors		18000	16,84				Ozolnieki	[12]
			1003542	648		3400		Jekabpils city	[8]
	Thermal insulation of municipal building envelopes and roofs		313839		186.5			Jelgava	[14]
			20923		199.4			Jelgava	[14]
Residential buildings	Thermal insulation of residential building envelopes and roofs		700000	110.7	370.5			Jelgava	[18]
			267326		168.9			Jelgava	[18]
Tertiary buildings equipment/facilities	Installation of solar thermal collectors		1003542	648		3400		Jekabpils city	[8]

		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Transport	Purchase of electric vehicles		52000	7.32				Bauska	[12]
			52444	3				Tukums	[12]
Public lighting	Replacing outdated lighting fixtures with energy-efficient and more environmentally-friendly lighting fixtures		710659	92.93				Jelgava	[8]
			146511	320.93	419			Jelgava	[36]
Local heat/cold production	Installation of wood biomass boiler		2678458	11090		40000		Tukums	[8]
			7000000	14391		71241		Jurmala	[8]
	Installation of biomass CHP		15000000	7754		22550		Liepaja	[8]
			77931921	108612		544645		Jelgava	[8]
			4564420	2840		44000		Jekabpils city	[8]

ANNEX D- Input data gathered for cost benefit analysis for Norway

		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO_2/year]	Annual final energy reduction [MWh/year]"	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Residential buildings	Phasing out remaining oil heating in buildings		2558380	38333				Oslo	[37]
			204000	12000				Trondheim	[38]
Transport	Replacement of vehicles powered by conventional fuels with vehicles powered by biomethane	Low-emission waste transport	1053014	1066				Bergen	[28]
		Fossil-free bus fleet	2661800	5900				Oslo	[37]
		Transition to zero emissions light vehicle	410000	4667				Trondheim	[38]
		Transition to zero emissions heavy vehicles	307500	3000				Trondheim	[38]

ANNEX E- Input data gathered for cost benefit analysis for Belgium

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Municipal buildings, equipment/ facilities	Installation of photovoltaic systems		6175660	675				St-Jans-Molenbeel	[8]
			97997	126				Overijse	[11]
	Integrated refurbishment of municipal buildings		3000000	309				St-Jans-Molenbeek	[8]
			1718000	246				Nijlen	[8]
			1094500	215				Balen	[8]
	Replacement of inefficient lighting with energy efficient lighting		29300	36.2				Hoogstraten	[8]
Residential buildings, equipment/facilities	Integrated refurbishment of residential buildings		18164	10.75				Herk-De-Stad	[8]
	Thermal insulation of residential building envelopes and roofs	Promotion of roof insulation	190814	183				Zwijndrecht	[8]
	Energy efficiency education for the citizens		10000	56.98				Beersel	[8]
			7000	61.06				Kruibeke	[8]
			11500	30.83				Edegem	[23]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Residential buildings, equipment/facilities	Installation of photovoltaic systems	Promotion of installation PV panels	90000	142				Zwijndrecht	[8]
			353600	85.5		300		Ville De Herve	[8]
	Purchase of energy-efficient electrical appliances for residential buildings		165900000	15300					[24]
Tertiary buildings, equipment/facilities	Thermal insulation of the tertiary building envelopes and roofs		3500000	800				Brugge	[24]
	Integrated refurbishment of tertiary buildings		3106026	602		2961		7 Municipalities of Klimaatoverleg Midwest	[26]
	Replacement of energy-ineffective windows on tertiary buildings		9900000	3400				Brugge	[24]
	Installation of solar thermal collectors		7800000	1700				Brugge	[24]

Measure		Additional description	Implementation cost [€]	Annual CO_2 reduction [tCO2/year]	Annual final energy reduction [MWh/year]	Annual renewable energy production [MWh]	Annual primary energy reduction [MWh/year]	Municipality	Source
Transport	Construction cycling path		96809	86.7				Oud-Turnhout	[8]
			1065294	1411				Balen	[8]
Public lighting	Replacing outdated lighting fixtures with energy-efficient and more environmentally-friendly lighting fixtures		15900	4.4				Lille	[8]
Local electricity production	Electricity Generation from the wind power		54000000	14000				Mechelen	[31]
			16200000	2926		14000		Bree	[32]
			32400000	8778				Diepenbeek	[33]
			162000000	43900				Brugge	[24]

Conclusion

The report presents the literature review and results of analysis of impacts which certain measure could have on final and primary energy savings, job creation, as well on CO_2 mitigation. The analysis is based on data published in several reports, documents and databases detailing the good practice examples. The cost-effectiveness analysis has been conducted for all five partner countries: Croatia, Norway, Spain Belgium and Latvia. In order to have a representative overview, municipalities of different sizes and from different regions have been selected for the analysis. Furthermore, in order to enable separate analysis and have better insight, the measures have been grouped by the sectors.

The measures which proved to have the lowest specific cost per annual CO_2 reduction and final energy savings are educational measures, thermal insulation of residential building envelopes and roofs, installation of solar thermal collectors, replacement of inefficient lighting with energy efficient lighting and measures for encouraging the use of public transport and. On the other hand, measures with the highest specific cost per annual CO_2 reduction and final energy savings are purchases of electric vehicles and integrated refurbishment of municipal buildings.

Prioritising the most economically beneficiary measures is not straightforward because apart from cost-effectiveness calculations, several other benefits have to be taken into account. Job creation is considered as one of those benefits, since investment in renewable energy generation and improvement of energy efficiency, has a positive economically effect on job creation. The employment factors presented in this report enable the assessment of number of jobs created, according to the installed peak capacity or achieved energy savings.

All the mentioned data provide a comprehensive database, which can be used as the guidelines for prioritizing measures that should be implemented first, according to their estimated impacts. During the PentaHelix project duration, this database will be continuously updated with the findings from task force members and other stakeholders.

Sources

[1] IRENA, “Renewable Energy and Jobs (2013),” 2013.
[2] J. Rutovitz, E. Dominish, and J. Downes, “CALCULATING GLOBAL ENERGY SECTOR JOBS 2015 METHODOLOGY UPDATE,” 2015.
[3] C. Econometrics and C. Garden, “Assessing the Employment and Social Impact of Energy Efficiency Final report,” vol. 1, pp. 1–139, 2015.
[4] A. G. Gaglia, C. A. Balaras, S. Mirasgedis, E. Georgopoulou, Y. Sarafidis, and D. P. Lalas, “Empirical assessment of the Hellenic non-residential building stock , energy consumption , emissions and potential energy savings,” vol. 48, pp. 1160–1175, 2007.
[5] I. I. Ã and M. S. Al-homoud, “Parametric analysis of alternative energy conservation measures in an office building in hot and humid climate,” vol. 42, pp. 2166–2177, 2007.
[6] C. A. Balaras, A. G. Gaglia, E. Georgopoulou, S. Mirasgedis, Y. Sarafidis, and D. P. Lalas, “European residential buildings and empirical assessment of the Hellenic building stock , energy consumption , emissions and potential energy savings,” vol. 42, pp. 1298–1314, 2007.
[7] C. A. Balaras, K. Droutsa, A. A. Argiriou, and D. N. Asimakopoulos, “Potential for energy conservation in apartment buildings,” 2000.
[8] Covenant of Mayors for Climate & Energy, “Good practices.” [Online]. Available: https://www.covenantofmayors.eu/plans-and-actions/good-practices.html.
[9] Regionalna energetska agencija Sjever, “Akcijski plan energetske učinkovitosti grada Šibenika za razdoblje 2017. – 2019. godine.”
[10] Junte de Castilla y León, “Energía y minería en Castilla y León.” [Online]. Available: https://energia.jcyl.es/web/jcyl/Energia/es/Plantilla100/1267710822752/_/_/_.
[11] Overijse, “Futureproofed Cities.” [Online]. Available: https://overijse.futureproofed.com/measures/408.
[12] Zemgales Reģionālā Enerģētikas Aģentūra (ZREA), “Internal project documentation.” .
[13] Grad Rijeka, “Akcijski plan energetske učinkovitosti grada Rijeke za razdoblje 2017. – 2019. godine.”
[14] “Sākums : Jelgava.” [Online]. Available: http://www.jelgava.lv/lv/sakums/.
[15] Regionalna energetska agencija Sjeverozapadne Hrvatske, “Godišnji plan energetske učinkovitosti grada Karlovca za 2017. godinu.”
[16] REGEA, “Godišnji plan energetske učinkovitosti Karlovačke županije za 2017. godinu.”
[17] Razvojna agencija Šibensko-kninske županije, “Godišnji plan energetske učinkovitosti Šibensko-kninske županije za 2018. godinu.”
[18] Zemgales Reģionālā Enerģētikas Aģentūra- ZREA, “Technical design/energy certificate.” [Online]. Available: http://www.zrea.lv/.
[19] Ministarstvo zaštite okoliša, Fond za zaštitu okoliša i energetsku učinkovitost, and Ministarstvo graditeljstva i prostornog uređenja, “PRIMJERI DOBRE PRAKSE projekata energetske učinkovitosti.”
[20] Regionalna energetska agencija Sjever, “Godišnji plan energetske učinkovitosti grada Varaždina za 2016. godinu.”
[21] Istarska Regionalna Energetska and Agencija d.o.o, “Akcijski plan energetske učinkovitosti Grada Pule 2017.-2019.”
[22] MENEA, “Godišnji plan energetske učinkovitosti Međimurske županije za 2018. godinu.”
[23] Gemeente Edegem, “Klimaatactieplan.” [Online]. Available: https://www.edegem.be/product.aspx?id=7018.
[24] Futureproofed, “Energie Actieplan Brugge.”
[25] Energetski institut Hrvoje Požar, “Godišnji plan energetske učinkovitosti Grada Zagreba za 2017. godinu.”

[26] Burgemeestersconvenant, “Nulmetingen.” [Online]. Available: http://www.burgemeestersconvenant.be/co2-inventarissen.
[27] turizam Služba za gospodarstvo and međunarodne i europske fondove, “Prijedlog Godišnjeg plana energetske učinkovitosti Grada Splita za 2016. godinu.”
[28] “Framsikt.” [Online]. Available: https://pub.framsikt.net/2019/bergen/bm-2019-høp-19-22/#/generic/summary/c1d3ca45-0105-4972-b87a-7c2a2a5ecf16-cn/?scrollTo=t-7.
[29] Regionalna energetska agencija Sjever, “Akcijski plan energetske učinkovitosti grada Šibenika za razdoblje 2017. – 2019. godine.”
[30] Regionalna energetska agencija Sjever, “Akcijski plan energetske učinkovitosti grada Zadra za razdoblje 2017. – 2019. godine.”
[31] Mechelen, “Ondertekenaars.” [Online]. Available: https://www.burgemeestersconvenant.eu/about-nl/cov-community-nl/signat-nl/action-plan-sign-nl.html?scity_id=5531.
[32] Stad Bree, “Klimaatplan,” 2011.
[33] Diepenbeek, “Klimaatplan Diepenbeek.”
[34] Covenant of Mayors, “Akcijski plan energetski održivog razvitka grada Zagreba,” 2010.
[35] “SOCIEDAD PÚBLICA DE INFRAESTRUCTURAS Y MEDIO AMBIENTE DE CASTILLA Y LEÓN S. A.”
[36] Jelgavas pilsētas pašvaldības iestāde, “Gada pārskati – PILSĒTSAIMNIECĪBA.” [Online]. Available: https://www.pilsetsaimnieciba.lv/iestade/gada-parskati/. [Accessed: 11-Mar-2019].
[37] Oslo kommune, “KLIMABUDSJETT 2018.”
[38] TRONDHEIM KOMMUNE, “Rådmannens forslag til handlings- og økonomiplan 2018-2021 v2.”