

The Sustainable Energy and Climate Action Plan (SECAP) design and development: the case study of the Municipality of Grosseto (Italy)

Michela MARCHI, Ecodynamics Group, University of Siena, Italy
Enrico NOCENTINI, Ecodynamics Group, University of Siena, Italy
Fabiola TROPEA, Ecodynamics Group, University of Siena, Italy
Asia TONIELLI, Department of Economics and Statistics, University of Siena, Italy
Nadia MARCHETTINI, Ecodynamics Group, University of Siena, Italy
Federico Maria PULSELLI, Ecodynamics Group, University of Siena, Italy

Abstract

In 2013, the Municipality of Grosseto in Italy became a member of the Covenant of Mayors, fulfilling its Sustainable Energy Action Plan (SEAP) by the year 2020. By 2022, the Municipality reaffirmed its commitment to the Covenant of Mayors by launching the Sustainable Energy and Climate Action Plan (SECAP), which aims for new goals: a 40% reduction in greenhouse gas (GHG) emissions by 2030 compared to 2008 levels, and achieving carbon neutrality, meaning negative net emissions, by 2050. This case study outlines Grosseto's pathway to decarbonization. The SECAP begins with the elaboration of a Baseline Emission Inventory (BEI), which in this case derives from the combination of two accounting methods: 1) the Intergovernmental Panel on Climate Change (IPCC) guidelines; and 2) the Global Covenant of Mayors methodology. Combining these two methods gives policymakers a deeper understanding of the sources of emissions and the perspective of final users. The second step of SECAP is the preparation of the mitigation plan, which will identify measures for optimizing policies to prevent and compensate for GHG emissions. The third step involves systematic monitoring to validate these policies and gradually engages a wide range of stakeholders in an Alliance for carbon neutrality. The experiment aims to promote environmental awareness through enhanced knowledge.

Keywords

Renewable energies, Environmental strategies, Baseline emission inventory, Systematic monitoring, Public Organization

1. Introduction

In 2007, leaders of the European Union set forth the main objectives for the 2020 Climate-Energy Package, which aimed for a 20% reduction in greenhouse gas (GHG) emissions, a 20% boost in energy efficiency, and a 20% increase in energy production from renewable sources. The following year, during the second Sustainable Energy Week (EU, 2008), the EU launched the Covenant of Mayors, a voluntary initiative aimed at bringing local entities together to achieve the goals of the 2020 Climate-Energy Package. This effort was carried out through the implementation of a Sustainable Energy Action Plan (SEAP). The European Commission launched in 2014 the Mayors Adapt project to encourage cities to respond to climate change adaptation. Their two initiatives were consolidated into one the same following year (2015) leading to the Covenant of Mayors for Climate and Energy which meant equal attention both to mitigation and strategies for climate change adaptation (EU,2015). In 2016, the Covenant of Mayors for Climate and Energy was

joined by the Compact of Mayors, established a few years prior in the United States (UN 2014). Following this partnership, the Global Covenant of Mayors for Climate & Energy (GCoM) was created (2019). The initiative's focus is on three key areas established at the regional level: 1) mitigation of climate change; 2) adaptation to the adverse impacts of climate change; and 3) ensuring universal access to secure, clean, and affordable energy. The local authorities that wish to become a part of GCoM should then develop a Sustainable Energy and Climate Action Plan (SECAP).

1.1. Case study background

In 2013, the Municipality of Grosseto in Tuscany (central Italy) became a member of the Covenant of Mayors and began working on its Sustainable Energy Action Plan (SEAP). By 2022, the municipality decided to build on the technical and administrative framework set by the Covenant of Mayors by reviewing the actions taken and creating a new management tool called the Sustainable Energy and Climate Action Plan (SECAP). The SECAP has enabled the Municipality to pledge a reduction in GHG emissions of 40% by 2030 in comparison to 2008 (reference year) levels, allowing for the current environmental condition to be identified and future interventions to be planned (Grosseto, 2024). The long-term objective of the local Administration is to achieve Carbon Neutrality (i.e., negative net emissions) by 2050. To achieve this goal, the Municipality plans to implement a series of strategic policies designed to mitigate emissions, adapt to climate change, and compensate for any residual emissions.

The drafting of the SECAP and the related monitoring inventories was entrusted by this public organization to the Ecodynamics Group of the University of Siena. The partnership began during the 2019–2021 triennium to produce tools to support the elaboration of territorial GHG emission reduction policies in key economic sectors, namely electricity generation and use, transport, heating, waste, and forestry (Marchi et al., 2023).

This case study aims to demonstrate the progress made by a public administration in reducing greenhouse gas emissions and addressing climate change.

2. Material and Methods

Each SECAP includes a Baseline Emission Inventory (BEI) of the reference year, as well as climate risk and vulnerability assessments, which are key to informing strategic decisions (Neves et al., 2016).

The BEI serves as the foundation of the SECAP, identifying priority areas for action. This case study BEI is based on the combination of the two accounting methodologies:

- 1) the Municipality-Scale GHG Inventory, which has been compiled following the Intergovernmental Panel on Climate Change (IPCC) guidelines, represents a standardized approach that is valid at the international level and is one of the most widely used (IPCC, 2006, 2019). It provides a perspective on emission sources (Sporchia et al., 2023);
- 2) the Global Covenant of Mayors for Climate and Energy methodology, which is focused on the final user's perspective (GCoM, 2019).

These two accounting methods combined enable informed decisions on climate action to be made at the local level.

Furthermore, the SECAP includes the programming of a mitigation plan, which means the measures and actions that the municipality will implement to mitigate its climate impact and to compensate for what emissions remain, thus participating in global climate change efforts.

The effectiveness of the implemented mitigation strategies is monitored and assessed through the regular compilation of monitoring emission inventories. This constant tracking allows results to be continuously updated, and progress to mitigate against GHG emissions-cutting targets to be measured, creating a dynamic and responsive approach to tackling climate change.

The incorporation of all the human activities typically excluded from the survey (e.g. Industrial Processes and Product Use (IPPU) and Agriculture, Forestry, and Other Land Use (AFOLU)) enhances the potential for GHG emission reduction and facilitates stakeholder involvement (Sporchia et al., 2023).

3. Results and Discussion

3.1. BEI and GHG monitoring of the Municipality of Grosseto

In 2008 (baseline or reference year) the Municipality of Grosseto recorded gross GHG emissions amounting to 462,103 t of carbon dioxide equivalent (CO₂eq). The removals, amounting to 69,329 t CO₂eq, were found to be lower than the gross emissions, resulting in a net accumulation of 392,773 t CO₂eq in the atmosphere. This scenario indicates a balance with an emission removal of approximately 15%.

Table 1 shows the historical series (2008, 2017-2022) of GHG emissions and highlights key sectors responsible for emissions reduction. Particularly, the analysis of these temporal changes points out the sectors where the greatest emissions reductions have been achieved and where actions need to be strengthened (Sporchia et al., 2024).

Table 1. Historical series of GHG monitoring by the Municipality of Grosseto: 2008 (Baseline), 2017-2022.

Human activity	2008 (BASELINE)	2017	2018	2019	2020	2021	2022	Variation (2008-2022)
	t CO ₂ eq							
ENERGY	403,754	331,493	340,468	349,751	284,940	350,524	349,021	-13.6%
Transport	198,860	188,184	194,227	216,628	189,298	208,748	206,796	4.0%
Heating	62,496	59,388	61,418	58,805	55,444	56,549	52,459	-16.1%
Combustion for industrial activities	14,667	7,608	11,244	8,476	7,672	6,886	6,140	-58.1%
Waste-to-energy plant	10,108	8,629	10,688	10,608	3,757	8,301	2,670	-73.6%
Electricity imported from the grid	112,030	57,648	52,557	45,015	20,014	61,716	72,835	-35.0%
Anaerobic digestion	145	3,142	3,138	3,106	2,519	2,488	2,432	1,582.5%
Fugitive emissions	5,447	6,894	7,196	7,113	6,237	5,836	5,689	4.4%
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	0	0	0	0	0	0	0	—
WASTE	22,175	18,344	19,548	18,870	15,591	16,202	17,524	-21.0%
Landfill	19,638	15,790	17,015	16,194	13,114	13,781	14,615	-25.6%
Composting plants	401	428	420	543	517	590	959	139.2%
Selection plants	1,083	1,278	1,296	1,185	999	859	741	-31.5%
Wastewater treatment	1,054	847	817	948	961	972	1,209	14.8%
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)	36,173	45,722	41,748	38,119	33,803	31,436	29,948	-17.2%
Carbon loss (harvesting, fires)	7,323	10,621	7,323	4,561	4,585	4,957	5,752	-21.5%
Urea use	416	356	279	168	180	174	55	-86.9%
Enteric fermentation	19,049	24,016	22,740	23,044	18,583	18,126	17,149	-10.0%
Manure management	2,674	3,500	3,875	3,700	2,954	2,462	2,442	-8.7%
Nitrogen addiction to the soils	5,078	4,925	5,779	4,979	4,679	3,590	2,495	-50.9%
Wetlands	424	522	522	522	411	411	411	-3.0%
Rice cultivation	1,129	1,694	1,144	1,057	895	201	209	-81.5%

Aquaculture	80	87	87	87	80	80	0	-100.0%
Land use change	0	0	401,764	0	1,436	1,436	1,436	
GROSS EMISSIONS	462,103	395,559	401,764	406,740	334,334	398,162	396,493	-14.2%
UPTAKE	-69,329	-67,600	-67,550	-67,551	-71,326	-70,888	-70,888	2.2%
NET EMISSIONS	392,774	327,959	334,214	339,189	263,008	327,274	325,605	-17.1%
PERCENTAGE ABATEMENT	15.0%	17.1%	16.8%	16.6%	21.3%	17.8%	17.9%	

In particular, the Municipality recorded an overall reduction in gross emissions of 14.2%, which can be attributed to a few factors:

- the decrease in heating consumption due to building energy efficiency and renewable resources exploitation (-16.1%);
- the adoption of more efficient technologies, the modernization of production processes, and the use of less polluting energy sources in industrial activities (-58.1%);
- the increase in local electricity production from renewable/alternative resources and the reduction of local consumption of the energy imported from the national grid (-35%);
- an increase in waste recycling and material reuse practices (-21%);
- an emission reduction in the AFOLU sector due to an improvement in manure management and the nitrogen distribution to agricultural soils from the application of fertilizers and crop residues (-17.2%).

Conversely, the reduction of transport emissions necessitates the implementation of sustainable urban mobility policies, which should encourage a reduction in the overall number of vehicles on the road, while simultaneously improving engine efficiency and reducing dependence on fossil fuels.

3.2. Pathway for the GHG emissions mitigation plan development

The procedure for identifying the environmental policies to be included in the SECAP Mitigation Plan of the Municipality of Grosseto has commenced with an exhaustive analysis of all emission sources and their intensity. The hotspots have been identified, covering more than 95% of cumulative emissions.

Once the major emission sources have been identified, the focus has shifted to the identification of potential stakeholders to whom policies should be addressed. The identification of stakeholders is of paramount importance to target tax and regulatory benefits at specific final user classes.

The Italian municipalities that have joined the Covenant of Mayors and that have published an Action Plan for achieving their GHG emission reduction targets were identified. From the Action Plans identified in the literature, a list of the main actions implemented has been extracted, with the policies divided into sectors or areas of intervention. Furthermore, experiences from other territories at the international level have been analyzed to gain a broader understanding of successful mitigation strategies (EU, 2024).

The environmental action proposals were selected by a methodical step-by-step process in collaboration with the technical staff of the municipal Administration. Each proposed action was subjected to a rigorous examination to ascertain its practical feasibility and compatibility with local resources (e.g., data availability, implementation capacity, political consistency, and economic feasibility).

The main criteria that have informed the selection of policies to be incorporated into the SECAP are as follows:

- the coherence of the policies planned in the SECAP with the missions reported in the Single Programming Document. This guarantees that the actions are integrated into a long-term strategic vision, coordinated with other planned interventions, avoiding duplication and wasted resources;
- the possibility of giving a comprehensive economic report of the activities undertaken. Transparency and traceability of actions allow for continuous and accurate evaluation of the effectiveness of policies. Detailed reporting is essential for internal monitoring, but it is also needed to communicate the results achieved to citizens and funders.

3.3. The mitigation actions

The mitigation actions, outlined in Table 2, have been selected for the SECAP and have been developed to reduce GHG emissions by 40% compared to 2008 levels. The action plan foresees a reduction of at least 97,000 t CO₂eq by 2030, compared to the average values for the period 2017-2019. This ambitious plan includes 21 different strategic actions involving various sectors and activities:

1) *Energy Renovation of Public and Private Buildings*

The policies E1-E6 are designed to enhance efficiency and curtail consumption in public and private buildings. One of the principal planned interventions is the thermal retrofitting of constructions, which includes the installation of insulating windows. Another key is replacing old heating systems with modern ones (condensing boilers, heat pumps, central heating). Also, low-energy electronic equipment and lighting (such as LEDs) are urged. These not only use less energy but are also longer lasting and therefore operate with a lower running and maintenance cost.

2) *Energy Efficiency and Renovation of Public Lighting*

Policy L1 replaces the old lighting infrastructure with LED lighting, to improve energy efficiency and reduce environmental impact. It will be used to make public lighting more up-to-date and will also have a significant impact on energy use and longevity of the devices.

3) *Production of Electricity from Renewable Resources*

Policies R1 and R2 are concerned with producing electricity from renewable resources. They have twofold objectives: the installation of photovoltaic systems on public buildings and the promotion of photovoltaic technology among private citizens and businesses. The objective of these policies is to encourage the adoption of renewable energy sources, promoting energy self-sufficiency.

4) *Sustainable Mobility*

Policies T1-T8 focus on ensuring infrastructure for sustainable mobility and on actions to minimize the use of personal cars. Among the many aspects of these policies is encouraging people to use bicycles for transportation to work, school, and recreational destinations. Moreover, charging stations for electric vehicles help the change to a greener fleet with support from adequate infrastructure and buying incentives. Besides this, the introduction of electric public transport, with improved services to make urban buses more accessible and attractive to people is also planned. The "30 km/ha Zones", as well as Limited Traffic Zones (LTZ) and pedestrian areas, are introduced to curb the traffic in the cities and consequently reduce road accidents and improve air quality. The policies also encourage work from home, which can substantially reduce traffic congestion as you don't have to commute daily anymore.

5) *Waste Management*

Policies W1-W3 focus on sustainable waste management. That encompasses a series of programs and initiatives aimed at reducing, reusing, and recycling materials, to minimize landfill disposal.

6) *Conservative/Organic Farming Techniques*

Policies A1-A3 encourage local production ("km 0") and promote agronomic practices focused on conservation and organic farming. This is done to support the local economy, reduce environmental impact, and improve the quality of food products.

7) *Tree planting*

The F1 policy entails the planting of native trees within the municipal area, to remove carbon dioxide (CO₂) from the atmosphere and adapt to climate change (extreme heat and the reduction of heat islands in urban environments).

8) *Communication*

The S1 policy emphasizes the dissemination of knowledge and the involvement of communities in climate mitigation actions. Through awareness campaigns targeted at citizens, service sector operators, and businesses, the policy seeks to encourage the adoption of sustainable behaviors and the implementation of efficient technologies.

Table 2. Summary of mitigation actions (The values of saving/increase and CO₂eq reduction are calculated concerning the average of the period 2017-2019 or the last years with data availability).

# ^a	Environmental policy	Savings/Increase	Local electricity production	Avoided emissions
			MWh _E	t CO ₂ eq
E1	Reduction of electricity consumption for residential buildings	-8,262 MWh _E avoided	\	-2,759
E2	Reduction of electricity consumption in the tertiary sector	-3,496 MWh _E avoided	\	-1,168
E3	Reduction of electricity consumption in the industry	-1,271 MWh _E avoided	\	-424
E4	Replacement of window frames in public buildings (pentagonal hall, locker room in the sports hall)	-13 MWh _T avoided	\	-3
E5	Energy efficiency of the building stock - Energy Performance Certificate (EPC)	-29,759 MWh _T avoided	\	-5,960
	<i>EPC – Residential buildings</i>	-27,703 MWh _T avoided	\	-5,549
	<i>EPC – Commercial buildings</i>	-2,055 MWh _T avoided	\	-412
E6	Boilers and heat pumps	-2,676 MWh _T avoided	\	-510
	<i>More efficient boilers</i>	-1,884 MWh _T avoided	\	-483
	<i>Heat pumps</i>	-792 MWh _T avoided	\	-26
L1	LED street lighting	-3,819 MWh _E avoided	\	-1,276
R1	Photovoltaic panels currently installed	\	94,320	-31,501
R2	Installation of new photovoltaic panels to cover residual consumption	\	41,521	-13,867
T1	Cycle paths	-101 km avoided/car	\	-801
	<i>Using cycle paths to get to work</i>	-8 km avoided/car	\	-65
	<i>Using cycle paths to go to school</i>	-0,44 km avoided/car	\	-4
	<i>Using cycle paths to go to the sea</i>	-92 km avoided/car	\	-732
T2	30 km/ha Zone	-347 km avoided/car	\	-3,893
T3	Limited Traffic Zones (LTZ)	-61 km avoided/car	\	-687
T4	Smart working	-546,260 km avoided	\	-80
T5	Increase in pedestrian areas	-876,47 km avoided/car	\	-8
T6	Electric city buses	-210,55 t diesel avoided	594	-682
T7	Replacement of vehicle fleet owned by	-101,230 km avoided	\	-17

	the Municipal Administration			
	Renewal of private vehicle fleet with electric vehicles	\	38,868	-27,887
T8	<i>Gasoline</i>	-2,054 t gasoline avoided	8,931	-6,572
	<i>Diesel</i>	-6,148 t diesel avoided	27,446	-19,901
	<i>Liquefied Petroleum Gas (LPG)</i>	-274 t LPG avoided	1,384	-842
	<i>Natural gas</i>	-200 t natural gas avoided	1,107	-572
W	Waste management	-17,760 t waste avoided	\	-4,762
W1	Increase in separate collection of organic waste	475,89 t waste added	\	43
W2	Reduction of undifferentiated waste in the selection plant	-7,427 t waste avoided	\	-677
W3	Reduction of landfill disposal	-10,808 t waste avoided	\	-4,128
A	Conservative/organic farming techniques	956 ha added	\	-1,048
A1	CO ₂ sequestration (Reduced tillage in croplands with temporary forage)	474 ha added	\	-427
A2	CO ₂ sequestration (Crop residues in the fields, cultivated with cereals)	370 ha added	\	-420
A3	CO ₂ sequestration (Grassing in croplands with tree crops)	112 ha added	\	-201
F1	Planting 2 ha of oak forest	2 ha added	\	-36
S1	Awareness, involvement, and dissemination	Unquantifiable	\	Unquantifiable
TOTALE			214,170	-97,367

^a E = Energy efficiency; R = Renewable energies; L = Public lighting; T = Transport; W = Waste; A = Agriculture; F = Forests; S = Other.

Figure 1 shows the contribution of specific actions to achieving the 2030 target. In particular, the contributions due to the implementation of renewable energies (R1 and R2; 46.6%), mobility actions (T1-T8; 35%), and energy efficiency of buildings (E1-E6; 11.1%) are relevant. The implementation of actions aimed at sustainable waste management (W) contributes to the achievement of the 4.9% reduction target. Sustainable agricultural practices (A) and the upgrading of public lighting (L1) each provide a marginal contribution of approximately 1%.

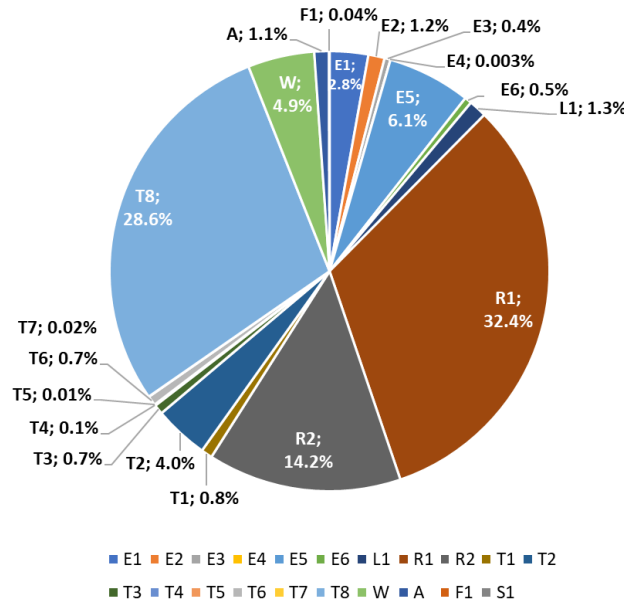


Figure 1. Percentage contribution of actions to 2030 target.

The target set for 2020 with the SEAP has been met, yet it is imperative to implement a comprehensive plan of policies to achieve the ambitious goal set for 2030 with the SECAP (Figure 2).

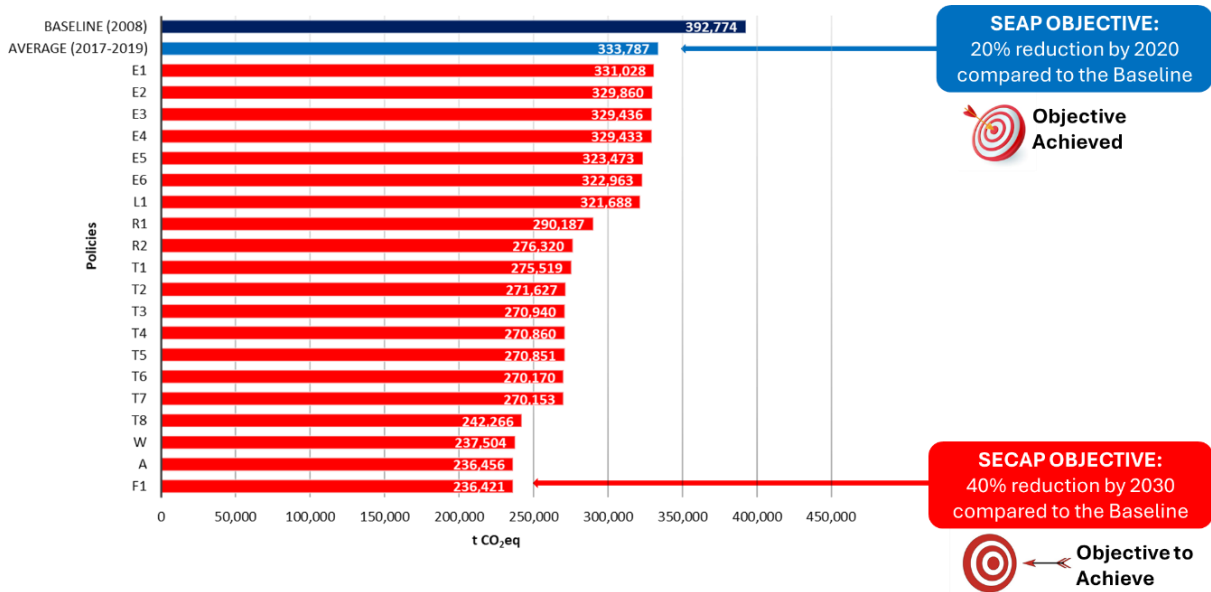


Figure 2. Simulation of GHG emission reductions through the mitigation plan

4. Conclusion

The proposed decarbonization plan is founded upon robust scientific knowledge, and it is anticipated that it will serve as a model for replication in different territorial contexts. The plan provides for the involvement of different components and actors in urban planning:

- 1) A science-based contribution to the adaptation/improvement of the GHG inventory methodology and its practical application at the local level, through external support from the University of Siena;

- 2) An organizational contribution of the city's technical managers to the implementation of the plan and a progressive involvement of all possible stakeholders;
- 3) An active role of the Grosseto City political institutions in the design and development of the strategies within the framework of the program (from the formal signing of the Covenant of Mayors to the approval of environmental measures and policies to be implemented).

The proposed experiment demonstrates a method to spread environmental awareness and responsibility through improved knowledge and research outcomes. Such insights can be translated into tangible strategies and measures that directly or indirectly benefit urban infrastructure, activities in the productive sector, citizens, and ultimately the entire territory. This establishes a framework for the formation of an Alliance for carbon neutrality between diverse actors.

5. Acknowledgments

I would like to acknowledge the use of OpenAI's ChatGPT-4o for assistance in refining the grammar and improving the academic quality of the English language in this document. This support was accessed on 16 September 2024 at 10:30 AM, and its contributions were limited to language editing, without influencing the content of the work.

6. References

- ChatGPT-40 (2024). ChatGPT-40 for translation and correcting grammar. OpenAI. Available at: <https://www.openai.com/chatgpt> (Accessed: 16 September 2024).
- EU (2008). Sustainable Energy Cities Take the Lead on Climate Change: The European Commission Launches the Covenant of Mayors, IP/08/103. European Commission: Brussels, Belgium.
- EU (2015). Cities Unite for Energy and Climate Action: New Integrated Covenant of Mayors Launch. European Commission: Brussels, Belgium.
- EU (2024). Covenant of Mayors – Europe. Available at: <https://mayors.ec.europa.eu/en/home> (Accessed: 30 September 2024).
- GCoM (2019). Global Covenant of Mayors Explanatory Note Accompanying the Global Covenant of Mayors Common Reporting Framework. Available at: https://www.globalcovenantofmayors.org/wp-content/uploads/2019/04/Data-TWG_Reporting-Framework_GUIDANCE-NOTE.pdf (Accessed: 18 September 2024).
- Grosseto (2024). Covenant of Mayors. Available at: <https://new.comune.grosseto.it/web/sezioni/patto-dei-sindaci/> (Accessed: 16 September 2024).
- IPCC (2006). *IPCC 2006 Guidelines for National Greenhouse Gas Inventories*. In Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (eds.); IGES: Kanagawa, Japan; ISBN 4-88788-032-4.
- IPCC (2019). *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. IPCC: Geneva, Switzerland.
- Marchi, M., Capezuoli, F., Fantozzi, P.L., Maccanti M., Pulselli, R.M., Pulselli, F.M., Marchettini, N. (2023). GHG action zone identification at the local level: Emissions inventory and spatial distribution as methodologies for policies and plans. *Journal of Cleaner Production* 386, 135783.
- Neves, A., Blondel, L., Brand, K., Hendel Blackford, S., Rivas Calvete, S., Iancu, A., Melica, G., Koffi Lefevre, B., Zancanella, P., Kona, A. (2016). *The Covenant of Mayors for Climate and Energy Reporting Guidelines*. Climate-ADAPT: Luxembourg.
- Sporchia, F., Marchi, M., Nocentini, E., Marchettini, N., Pulselli, F.M. (2023). Sub-national scale initiatives for climate change mitigation: refining the approach to increase the effectiveness of the Covenant

**Marchi, M.; Nocentini, E.; Tropea, F.; Tonielli, A.;
Marchettini N.; Pulselli, F.M.**

**The Sustainable Energy and Climate Action Plan
(SECAP) design and development: the case
study of the Municipality of Grosseto (Italy)**

of Mayors. *Sustainability* 15, 125.

Sporchia, F., Marchi, M., Petraglia, A., Marchettini, N., Pulselli, F.M. (2024). The pandemic effect on GHG emission variation at the sub-national level and translation into policy opportunities. *Journal of Environmental Management* 349, 119539.

UN (2014). Mayors at UN Climate Summit Announce Pledges towards Major Carbon Cuts in Cities. UN: New York, NY, USA.