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Energy use in Urban Transport sector within the Sustainable Energy Action Plans (SEAPs) of three Italian Big Cities

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Abstract

Promising Renewable Energy solutions could be installed in cities, but they require specific morphological conditions as well as architectural integration. Transport sector is still neglected from a strong policy initiative. A first attempt along with a defined framework to attract economic resources as well as interested stakeholders is the Covenant of Mayors (CoM). Within this agreement, the Municipality has to design a plan, the so-called Sustainable Energy Action Plan (SEAP). The plan must contain a clear outline of the strategy and relative actions to be taken by the local authority to reach its commitments in 2020, in terms of sustainability goals set by EU 20-20-20. The aim of this paper is to discuss and evaluate the differences of fuel usage and transport sector interaction in Italian urban scenarios, taking into account geographical and morphological constraints, and to compare the forecasts for 2020 and 2030scenarios, in accordance with European and National laws in force.

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Keywords: Transport; fuels; energy planning; SEAP.

1. Introduction

Changes in urban policies by means of law-driven Renewable Energy Sources (RES) deployment deal with infrastructural and architectural constraints. So, high care should belong to any policy and act which affects urban special areas such as natural zones, protected areas, cultural heritage or, simply, existing and well-established built-up areas. Nowadays, in Europe even if the environmental crisis is taken seriously, a huge request for more

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environmental and energy resources is rising. Cities play as the main requester for planning the consumptions and its allocation, especially in the transition towards future scenarios [1]. Large Research frameworks (Horizon and strategy documents, i.e. Energy Union Package) are dealing with the energy topic in the cities. Furthermore, Recent research lines investigated on role of municipal energy efficiency plan [2] together with tools for profitable renewables use along with the required fossil fuel share in the transition scenario[3].

Metropolities have high importance since their size and concentration of energy producers and users as well as networks and facilities. High renewables penetration scenarios are studied at this level and their results are then scaled up to national framework [4]. Promising technologies such as wind energy could contribute to achieve sustainability levels even when they require specific auxiliaries such as the improvements of wind turbine installations [5] and environmental issues related to big scale such as effects on ecosystems [6] call for a dedicated and wise energy planning instrument. Furthermore, new attention to human wellbeing in built environment requires performance indicators to be taken into account for monitoring innovative energy systems applications [7], effects of new materials on building energy performance [8] as well as impact on urban energy networks connected to the neighborhoods [9].

Conventional urban policies are not able to answer those multi-disciplinary questions since their complexity belong to new demands: an economically sustainable integration of renewables at building scale [10], the preservation of cultural heritage as well as restoration by using natural high-performance materials [11], even simulating the damages coming from established pollution [12], the de-carbonization of existing building stock by means of cutting-edge technologies [13], even in the field of listed buildings, no more excluded for minimum interventions of energy retrofitting [14].

Energy infrastructures are not directly mentioned in urban planning tools. So, only recently, the voluntary initiative of Covenant of Mayors represents the first attempt to fill this gap in planning tools. Moreover, transport is not even considered an urban issue within a mobility plan but just a traffic one. That means the only vehicles' flows are analyzed rather than associated energy and pollution quantities.

Energy Union Package, National energy strategy acts, regional energy and environmental plans are too high-level documents to regulate and drive local energy transition in metropolitan contexts. The Covenant of Mayors collects more than 6,000 signatory municipalities. Each one to participate to it, designed the so-called Sustainable Energy Action Plan (SEAP). It consists of a Baseline Emission Inventory (BEI), the strategy and the actions to be taken.

The BEI takes a picture of the consumption, production and emissions in the municipal context and in a chosen reference year. Starting from this status, the City elaborated how to achieve the EU 20-20-20 targets and, where possible, to go beyond them. Quite recently, a new aspect became part of this process: the adaptation strategy. The SEAP involves the adaptation and mitigation measures to cope with climate change and subsequent risk disaster. For instance, emergency program could be decisive to make a city ready for environmental resilience and its management [15].

The strategy is based on three pillars: energy efficiency (EE), Renewable energy sources (RES) greenhouse gas emission reduction which is measured in equivalent carbon dioxide emissions (CO_2).

This study addresses a specific framework able to consider transport energy use in order to consider this further emission activity more than a simple vehicles flows. Indeed, SEAPs programs, monitoring, implementation and actions could be the codified tool to consider the aforementioned aspects as well as to identify the potential for achieving the EU 20-20-20 requirements. The above-mentioned framework starts from Italian context analysis since half of submitted SEAPs in Europe are from those municipalities.

Three Cities were considered and analyzed: Milan, Palermo and Rome. They are the right mix of all the Italian urban governance characteristics and the related Regions represent large part of climatic and road conditions. Therefore, Lombardia, Lazio and Sicily are located in the North, Central and South Italy, respectively accounting for all the general cities layouts of the Country.

2. Materials and methods

Urban morphology, climatic conditions and economic structure affect the emission inventory of each city. The reference year and scenario are shown in Table 1 along with the reduction target by 2020.

Table 1. CO_2 Emission reduction target of SEAPs to 2020 (year of reference).

City	Year of reference	Total emission (kt CO_2)	Emission target to 2020 (kt CO_2)
Milan [16]	2005	7,418	1,484
Palermo [17]	1990	1,864	400
Rome [18]	2003	10,999	2,200

Each Sustainable Energy Action Plan was analyzed in terms of measures mix to achieve the minimum goal set by 2020 EU strategy: reduction of energy consumption and associated emission of 20%, increase of energy production from renewables equal to 20% and improvement of transport sector emissions of 20%.

The word improvement is crucial to analyze since it is not generally clear how to cut transportation emission as well as introducing low-carbon solutions which can be easily spread at market accessibility for citizens.

This provided analysis is the first step to plan a specific methodology to enhance the accuracy of transport status quo and for implementing different ways such as shared transport as well innovative hybrid engine-based cars, electric vehicles towards a future autonomous-driven sector. Governance plays a key role in this field.

Having said, the first methodological step is the analysis of the SEAP$_S$ of Milan, Palermo and Rome. In this context the targets, fixed from SEAPs to 2020, were highlighted. In Table 2, specific reduction goals of each City were reported focusing on: Energy efficiency (EE) public and private sectors, RES, Street lighting, Transport and Waste cycle.

Table 2. Emission reduction target of SEAPs to 2020 (kt CO_2/year).

City	RES	EE (public)	EE (private)	Street lighting	Transport	Waste	Total
Milan [16]	121	64	816	55	368	60	1,484
Palermo [17]	15.2	9	134	1.8	240	-	400
Rome [18]	520	90	760	30	720	-	2,120

The SEAP of Milan [16], under approval, plans an overall reduction of 1,484 kt of CO_2 in 2020 compared to the year of reference 2005. It is focused on supporting EE in private building (commercial and residential final consumptions) with a share of 816 kt of CO_2 representing the 55% of the total (Table 3). The Transport sector follows with 368 kt of CO_2 and a share of 24.8%, then below in decreasing order measures for RES, EE in public buildings, Waste (with a relevant share of 4.0%) and Street lighting at least. As it is possible to notice, the Transport is a large contributor but the data available does not allow to identify public and private share. This lack of knowledge is valid for all the cities. A further investigation on public transport companies can help understanding the quality and more reliable numbers.

The SEAP of Palermo considers as reference emission values the ones from 1990 estimated to be 1,864 kt of CO_2 [17]. This is the only SEAP where the main field of action is Transport, with a share of 240 kt of CO_2, accounting more than 60% of the total and affects public companies and private mobility stakeholders (Table 2). The EE in private building ranks second with a 33.6% share and 134 kt of CO_2 while RES, EE in public buildings and Street lighting owns small shares (absent the waste sector). It is noteworthy that the city with high car ownership ratio is the one which tends to plan for making efforts in transportation since its magnitude can be a change-driver.

Finally, the SEAP of Rome takes into account the year 2003 for emissions baseline which is equal to 10,999 kt of CO_2 [18]. The expected savings, amounting to about 2,200 kt ofCO_2, mainly concerns EE in private building (residential and tertiary) with a 35.8% share and Transport with a share of 34% (they together represent 70% of the total). Follow RES planning (including measures at building and at district scale) with a share of 520 kt CO_2 (share of 24.5%), EE in public buildings and Street lighting (absent the Waste cycle). The share in the Rome energy system is similar to classic national level description where 3 thirds represent the general division among consumptions.

Table 3. Emission reduction target of SEAPs to 2020 (share of CO_2/year).

City	RES	EE (public)	EE (private)	Street lighting	Transport	Waste	Total
Milan [16]	8.2	4.3	55.0	3.7	24.8	4.0	100
Palermo [17]	3.8	2.2	33.6	0.4	60.0	-	100
Rome [18]	24.5	4.3	35.8	1.4	34.0	-	100

The three different SEAPs taken into consideration, share common features: two SEAPs (Milan and Rome) concentrate the greatest effort on EE interventions in the private sector (mainly residential, tertiary and industrial buildings) due to the difficulty of financing public investment (EE in the public sector is in fourth place with reduced values in all the 3 SEAPs).

The second area of investment generally consist of the Transport (in second place in Rome and Milan) therefore RES stands at third place with varying shares of the emission targets (Table 3).

Milano dedicates close attention to the waste cycle (completely absent in the other two SEAPs) with a relevant share of 60 kt of CO2 and Street lighting with measures and actions already in progress [16]. Palermo, however, gives high priority to Transport, with a meaningful withdrawal from RES with a share of just 15.2 kt of CO2 (in particular PV and ST) notwithstanding its wide geographical and climatic potential (Table 2). Rome belongs a more balanced strategy among RES, EE in private buildings and Transport and reserves a 520 kt of CO2 share of expected savings to RES, both at the building level (measures of retrofitting and regeneration) and at the district scale (planning of district heating and new urban expansion).

The next step of the methodology involves the evaluation of all the planned actions within the SEAPs concerning the implementation and dissemination of carbon-free fuels used in transports on municipal scale. The collected data were organized according to the several sources considered (Electric, Electric hybrid, Hydrogen and Methane/Liquid natural gas), the typology of intervention (direct and indirect) and its size (building, district and local scale).

The Actions planned by the SEAP of Milan [16] provide the implementation of Electric and Hybrid vehicles mostly through indirect measures (tax reductions). These actions are provided by existing planning instruments, therefore the SEAP only records their benefits and related emission savings. Special attention is dedicated to deploy new charging stations by specific actions (some of which already planned in the previous SEAP) and pilot projects on car sharing for goods and people (Electric City Movers project). Also planned is using the existing street lighting grid to feed electric charging stations (Table 4).

In Palermo, the actions are focused exclusively on Electric and Methane/LNG fuels through direct interventions (by replacing part of the fleet of public buses) and indirect interventions supporting private initiatives (charging stations and mobility management policies) already provided by the current regulations. The SEAP of Palermo does not foresee any significant action in the field of Hydrogen fuels.

The SEAP of Rome is composed by an interesting electric fuel section which involves many actions on the application of non-conventional fuels, such as Hydrogen and Methane mixture ones, also as results of thermos-chemical storage of renewable energy. Specific strategies involve both the private buildings by implementing PV plants, both the public through interventions dedicated to PV integrated to a new charging stations network (electric vehicles).

Electricity and Hybrid solutions, widely present in all the three SEAPs considered, concerns both actions in public initiative (characterized by light investments, direct projects and special focus on fleets and charging stations) and the private sector (promoted through tax incentives, indirect support and focus on individual transport). Indeed, due to the economic crisis and the contraction of Italian national incentives on innovative projects, the SEAP point consistently on the private sector's dynamism through reductions on fees (measures already provided by municipal sustainable mobility plans).

Table 4. Measures and actions of SEAPs regarding Transportation by fuel.

Fuel	Milan [16]	Palermo [17]	Rome [18]
Electric	Charging stations Car sharing for goods and people (Electric City Movers project)	Charging stations	Charging stations (integration with PV local power plants)
Electric Hybrid	Tax reductions Charging stations (dual use of the street lighting grid)	Public transport fleet	-
Hydrogen	-	-	Distribution/production facilities (hydro-methane fuel)
Methane/ LNG	-	Public transport fleet Distribution facilities	Distribution/production facilities (hydro-methane fuel)

The SEAP of Milan centers its attention on projects related to Electric/Hybrid fuels combined with Street lighting grids and to the enlargement of the municipal car sharing electric fleet.

These measures originate from the industrial fabric of the city and establish a significant interrelationship between transportation and district electric grids. Palermo represents the less dynamic reality on the development of carbon-free fuels and proposes actions regarding Methane/LNG new distribution facilities and Electric vehicles.

The SEAP in force not adequately values the wide potential of the territory and plans small-sized interventions at local scale. Rome is the only city considered to correlate the development of the PV to a distributed generation model integrated to a charging stations network (Electric vehicles). Also in Rome SEAP focuses on Hydro-Methane mixture fuel production and distribution in a metropolitan development perspective.

3. Results and discussion

The obtained results, by analyzing the actions concerning fuel (reported by type, intervention size and field of application), allow to conceive a preliminary schematic framework.

A further scaling-up for an inter-municipal coordination for high RES share penetration could be promoted by each SEAP by three steps. The framework, that will take place in a specific section of the metropolitan city SEAP, mixes several municipal SEAPs checking the structured behavior of decision-making and mutual feedbacks, as depicted in Figure 1. The structure is formed by three dynamic data base (Potential, Planning and Scenario) which correspond to the three structural elements of SEAPs (Inventory, Measures and Actions), which follow in brackets:

- Potential data base (collects SEAPs inventories): BEIs of each SEAP are standardized and flow into a Geographical information system (GIS) based metropolitan inventory. Hence data about mobility flows and commuting-based shock for the system and economic data (from national and European sources), are also included. The overall picture obtained allows to estimate the potential for new mobility strategies from changing the way to use sharing economy – based services such as car pooling to innovative electric vehicles connected to homes and common parking areas so as to establish the fleets as common good.
- Planning data base (compares SEAPs measures): starting from the Potential data base structure, each municipality puts the measures fixed in its SEAP according to the emission savings objectives and local directives (according to participative and voluntary nature of SEAP). Therefore the metropolitan SEAP inserts into the Planning data-base information about a more detailed mobility picture. This is the first step to clarify the assumed quantities and set a more reliable database. The data is processed, each measure of municipal SEAP receive a score and any critical issues is highlighted. In this phase, the metropolitan city, according to the principle of subsidiarity, selects the more efficient measures dedicated to public and private transport in each municipal SEAP and plans offering a centralized knowledge hub for technical and financial issues faced by Public Administration and citizenship.

- Scenario data base (integrates SEAPs actions): processed on the basis of the Planning data base, Scenario brings together all of the specific actions planned by each municipal SEAP. The several actions indicate, according to a standardized pattern, time frames, responsibilities of different actors, allocating large-scale budget and measures of monitoring about future transport solutions with an open input-box to be harmonized with high-level regulations. Within this scenario the actions, through processes of feedback and validation, integrate crosswise creating synergies of scale, optimize costs and execution times and build up inter-municipal activities (Fig.1).

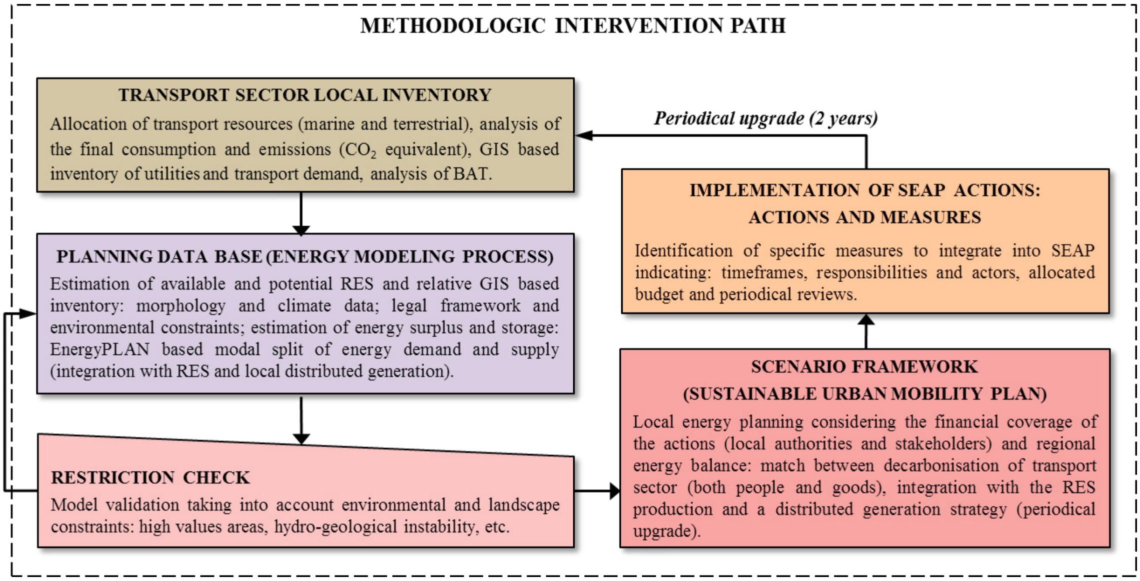

Fig. 1. Metropolitan energy planning framework for supporting SEAPs assessment .

The schematic framework thus identified is the first step to design a platform for the structuring and review of municipal RES-based and hybrid fuels by accompanying the local authorities in the drafting of each pillar of SEAPs (assessment of BEIs, measures and actions). Every two years, after the end of its definition cycle, framework will be reviewed by upgrading the Transport Sector Local Inventory described above. This dynamic configuration will allow to receive new SEAPs, update existing ones and equip them with more accurate and shared strategies for the implementation of each non-conventional or hybrid fuel policies.

4. Conclusion

The originality of this paper consists in having developed, through the comparison of different SEAPS, a preliminary multidimensional framework for their harmonization at metropolitan level. Next step of investigation will test this methodology through the analysis of a significant sample of Italian municipal SEAPs (belonging to different structural and economic contexts) with the actual metropolitan city SEAP in order to get more reliable information for fuel and transport implications. This approach, focusing on subsidiarity principle and participative processes, will allow SEAPs to empower and adapt mutually through an overall energy planning policy. The goal will be develop an integrated tool able to harmonize municipal SEAPs for endorsing new mobility and distributed generation at metropolitan level. Only, in this way, the idea to include the transport as demand side management strategy could be effectively understood and optimized for each urban energy systems.

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