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# Energy planning for metropolitan context: potential and perspectives of Sustainable energy action plans (SEAPs) of three Italian big cities

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**Abstract**

Energy retrofitting of existing building stock and new expansion of urban settlements entail a new relationship between consumption and production sites. Especially, new production facilities linked to the renewables boom are not taken into account by the urban governance. Energy planning instruments could be the viable tool to manage the new energy transition focusing on territorial resources. The Sustainable Energy Action Plan is the most common and widespread due to its voluntary nature. The study analysed the SEAPs of three big Italian Cities to assess an integrated framework for planning renewables at the metropolitan scale.


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*Keywords:* SEAPs; RES; Metropolitan city; Distributed generation; Energy planning.

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## 1. Introduction

Nowadays, in Europe even if the crisis slowed down the GDP growth, a huge request for environmental and energy resources is still rising. Urban contexts are the core of those demand and consumption requiring new planning tools, especially in the transition towards future scenarios [1]. Last Research programs (Horizon and strategy documents, i.e. Energy Union Package) are coping with the energy model in the cities. Recent research lines investigated on role of local energy efficiency plan [2] together with tools for profitable renewables use [3].

Metropolitan contexts play a key role due to their extension and concentration of energy producers and users. Indeed, foreseeable high renewables penetration scenarios are studied at the aforementioned level and their results are then scaled up to national framework [4,5]. Promising technologies such as wind energy could contribute largely to achieve sustainability levels but, required auxiliaries to improve wind turbine performance such as stators [5] and environmental issues related to big scale such as effects on birds migration [6] call for a dedicated energy planning instrument. Furthermore, new attention to human wellbeing in built environment requires performance indicators to be taken into account for monitoring outdoor thermal comfort in specific conditions[7], effects on building energy performance [8] as well as impact on urban energy infrastructures [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.

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 5,000 signatory members. 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. At the end of 2015, 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 emergency 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 manage the metropolitan context by harmonizing the municipal scale, i.e. cities and their SEAPs into programs, monitoring, implementation and actions. The above-mentioned framework starts from Italian context analysis since half of submitted SEAPs in Europe are from Italian municipalities.

Three metropolitan environments were identified: Milan, Palermo and Rome. They encapsulate all the features of Italian urban governance and related Regions: Lombardia, Lazio and Sicily.

## 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 Eu 20-20-20: 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%.

Actions related to renewable energy sources were analyzed in terms of scale factor, i.e. building, district and metropolitan scale as well as share of each technological solution, i.e. Solar thermal (ST), Photovoltaic (PV), Bioenergy, Heat pump and others.

This provided analysis is the first step to plan a specific methodology to implement a new variety of SEAP adequate for metropolitan scale along with the guidelines for sub-SEAPs belonging to cities included in its governance area.

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 (year of reference 2005) and 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.

In Palermo the preparation of the SEAP dates back to 2013 and refers to the emission values of 1990 estimated to be 1,864 kt of $CO_2$ [17]. The main field of action is Transport, with a share of 240 kt of $CO_2$, represents 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).

The strategy developed in the SEAP of Rome refers to 2003 emissions of 10,999 kt of $CO_2$ and was drafted in 2013 [18]. The expected savings, amounting to about 2,200 kt of$CO_2$, 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) .

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 top 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 RES on municipal scale. The collected data were organized according to the several sources considered (PV, ST, Heat pump and Bio-gas and Bio-fuels), 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 PV and ST plants exclusively through indirect measures (reduction on planning fees and recognition of building benefit extra-area). These actions are provided by existing planning instruments, therefore the SEAP only records their benefits and related emission savings. Special attention is dedicated to Heat pump through specific actions (some of which already planned in the previous SEAP) and pilot projects on Aqueducts, Water treatment plants and District heating network (district scale). Also planned is a production of Bio-gas from the municipal Waste cycle (Table 4).

In Palermo, the actions are focused exclusively on PV and ST through direct interventions (related to installations on public buildings) and indirect interventions supporting private initiatives (expansion and refitting at the building scale) already provided by the current building regulations (consisting in reduction on planning fees). The SEAP of Palermo does not foresee any significant action in the field of Bio-energies and Heat pump.

The SEAP of Rome, In the section named "Actions for renewable energy sources", plans extensive actions on all mostly diffused classes of RES except for the Heat pump [18]. Specific strategies involve both the private buildings by implementing PV plants, both the public through interventions dedicated to PV and ST in schools, nurseries and municipal buildings. There are also important actions in the field of Bio-energies at the district scale: bio-mass from agricultural waste and bio-fuels linked to EE interventions (hospital cogeneration systems), to District heating grids and regeneration of existing districts (Table 4).

Table 4. Measures and actions of SEAPs regarding RES.

| RES | Milan [16] | Palermo [17] | Rome [18] |
|---|---|---|---|
| PV | Reduction on planning fees (Expansion and refit) | Reduction on planning fees (Expansion and refit) | Distributed generation grid (Expansion and refit) |
| | Building area benefit (Expansion and refit) | Public buildings | Public buildings |
| | | | Residential buildings (technical support) |
| ST | Reduction on planning fees (Expansion and refit) | Reduction on planning fees (Expansion and refit) | Schools and nurseries |
| | Building area benefit (Expansion and refit) | Public buildings | |
| Heat pump | Reduction on planning fees (Expansion and refit) | - | - |
| | Building area benefit (Expansion and refit) | | |
| | Water treatment plants | | |
| | Aqueducts | | |
| | District heating | | |
| Bio-gas | Waste (organic) | - | - |
| Bio-mass | - | - | Agricultural waste |
| Bio-fuels | - | - | District heating |
| | | | Cogeneration (hospitals) |
| | | | Distributed generation (expansions and refit) |

PV and ST, widely present in all the three SEAPs considered, concerns both actions in public housing (characterized by light investments, direct projects and special focus on schools and nurseries) and the private building (promoted through tax incentives, indirect support and focus on residential housing). Indeed, due to the economic crisis and the contraction of Italian national incentives on RES, the SEAP point consistently on the private sector's dynamism through reductions on fees (measures already provided by municipal building regulations plans).

The SEAP of Milan centers its attention on projects related to Heat pump combined with Aqueducts and Water treatment plants works and to the enlargement of the municipal District heating grid. These measures originate from the industrial fabric of the city and establish a significant interrelationship between RES plants and district networks. Palermo represents the less dynamic reality on the development of RES and proposes actions regarding PV and ST new plants. The SEAP in force not adequately values the wide potential of the territory and plans small-sized interventions at building scale. Rome is the only city considered to correlate the development of the PV to a distributed generation model for regeneration interventions and new district expansions. Also in Rome SEAP focuses on Bio-mass from agricultural waste (Rome belongs the largest farming district in European municipalities) and on Bio-fuels to supply new District heating and existing hospitals (cogeneration systems) in a metropolitan perspective.

## 3. Results and discussion

The obtained results, by analyzing the actions concerning RES (reported by type, intervention size and field of application), allow to work out a preliminary schematic framework. The aim is to structure an inter-municipal coordination matrix able to integrate each other the different SEAPs into three progressive phases. The framework, that will take place in a specific section of the metropolitan city SEAP, mixes several municipal SEAPs staring hierarchies and mutual interrelationships (Fig.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 all local RES available and exploited, considering plants installed, morphological data, climate models (influence of climate changes), and economic data (from national and European sources), are also included. The overall picture obtained allows to estimate the net metropolitan potential of RES, to properly distribute it, to empower the knowledge of municipalities and to provide useful elements for processing statistics at regional scale.
- 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 RES from Regional energy and environmental plan, national targets and all of the existing vast area restrictions about landscape, hydrogeology and land consumption. The data are 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 the RES in each municipal SEAP and plans a further support at technical and financial level.
- 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, allocated budget and measures of monitoring about implementation of RES. 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).

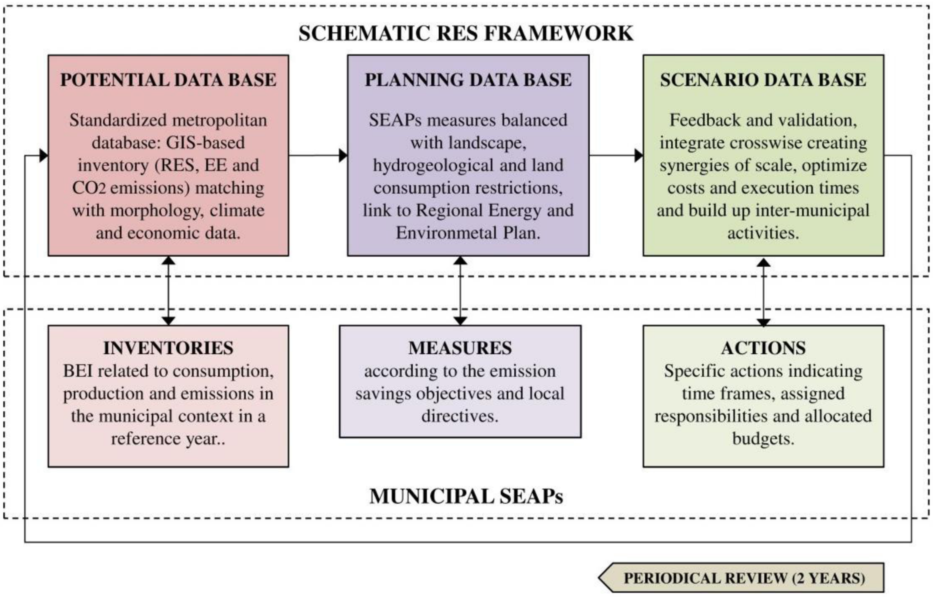


Fig. 1. Metropolitan energy planning framework for supporting SEAPs assessment .

The schematic framework thus identified is the first step to design a platform for the structuring and review of municipal RES 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 three data bases 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 local RES planning.

## 4. Conclusion

The originality of this paper consists in having developed, through the comparison of different $SEAP_S$, 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 (within this sample takes place). 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 RES-oriented distributed generation at metropolitan level.

## References

[1] Nastasi B, Lo Basso G. Hydrogen to link heat and electricity in the transition towards future Smart Energy Systems. Energy 2016.
[2] Aste N, Buzzetti M, Caputo P, Manfren M. Local energy efficiency programs: A monitoring methodology for heating systems. Sustainable Cities Soc 2014;13:69-77.
[3] Nastasi B, de Santoli L, Albo A, Bruschi D, Lo Basso G. RES (Renewable Energy Sources) availability assessments for Ecofuels production at local scale: Carbon avoidance costs associated to a hybrid biomass/H2NG-based energy scenario. Energy Procedia 2015;81:1069-1076.
[4] Prina MG, Garegnani G, Moser D, et al. Economic and environmental impact of photovoltaic and wind energy high penetration towards the achievement of the Italian 20-20- 20 targets. Proceedings of 10th International Conference on Ecological Vehicles and Renewable Energies, EVER 2015 11 June 2015, Article number 7112993.
[5] Burlando M, Ricci A, Freda A, Repetto MP. Numerical and experimental methods to investigate the behaviour of vertical-axis wind turbines with stators. J Wind Eng Ind Aerodyn 2015;144:125-133.
[6] Astiaso Garcia D, Canavero G, Ardenghi F, Zambon M. Analysis of wind farm effects on the surrounding environment: Assessing population trends of breeding passerines. Renew Energy 2015;80:190-196.
[7] Rossi F, Anderini E, Castellani B, Nicolini A, Morini E. Integrated improvement of occupants' comfort in urban areas during outdoor events. Build Env 2015;93(P2):285-292.
[8] Rossi F, Morini E, Castellani B, et al. Beneficial effects of retroreflective materials in urban canyons: Results from seasonal monitoring campaign. J Physics: Conf Series 2015;655(1):012012.
[9] Lo Basso G, Salata F, Nastasi B, Golasi I. How to couple CHP and HP for thermal management in energy retrofitting – an analytical and graphical method for systems rating and off-design operation. Energy 2016.
[10] de Santoli L, Mancini F, Nastasi B, Piergrossi V. Building integrated bioenergy production (BIBP): Economic sustainability analysis of Bari airport CHP (combined heat and power) upgrade fueled with bioenergy from short chain. Renewable Energy 2015;81:499-508.
[11] Rosso F, Jin W, Pisello AL, Ferrero M, Ghandehari M. Translucent marbles for building envelope applications: Weathering effects on surface lightness and finishing when exposed to simulated acid rain. Constr Build Mater 2016;108:146-153.
[12] Pisello AL, Rosso F. Natural Materials for Thermal Insulation and Passive Cooling Application. Key Engineering Materials 2016;666:1-16.
[13] Nastasi B. Renewable Hydrogen Potential for Low-carbon Retrofit of the Building Stocks. Energy Procedia 2015;82:944-949.
[14] Nastasi B, Di Matteo U. Innovative use of Hydrogen in energy retrofitting of listed buildings. Energy Procedia 2016.
[15] Di Matteo U, Pezzimenti PM, Garcia DA. Methodological proposal for optimal location of emergency operation centers through multi-criteria approach. Sustainability 2016;8(1):1-12.
[16] Comune di Milano. *Piano di Azione per l'Energia Sostenibile*. 2015. Available at: www.comune.milano.it
[17] Comune di Palermo. *Sustainable Energy Action Plan*. 2013. Available at: www.comune.palermo.it
[18] Roma Capitale. *Piano di Azione per l'Energia Sostenibile della Città di Roma*. 2013. Available at: www.comune.roma.it