Chapter 7
Green Energy Planning of Cities and Communities: New Paradigms and Strategies for a Sustainable Approach

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Abstract In green planning, the correct management of energy in towns and cities is a critical issue and is the topic of this chapter. In the first part, a general overview is provided, identifying the new paradigms to be pursued according to the needs of reducing, and possibly eliminating, the emission of greenhouse gases and those gases that have an impact on the environment, also considering the technological evolution currently in progress and opportunities offered by the market of energy generation and management market. In the second part of the chapter, a methodological approach to Green Energy Planning on a territorial scale is proposed and discussed. The chapter is completed by an in-depth analysis of the European project which promotes an approach to bottom-up energy planning, the Covenant of Mayors: its methodologies are discussed and a case study is analysed.

7.1 New Paradigms for Energy Planning on an Urban Scale

7.1.1 Affordable and Clean Energy

When discussing energy, one of the major causes of environmental pollution in cities and metropolitan areas and indeed the production of greenhouse gases (GHG) on a global scale, a paradox becomes apparent. On the one hand, the consumption of fossil energy must be reduced, with a drastic change of approach, which is not only technological but also economic and social, but on the other hand, access to energy is not yet guaranteed to a significant portion of the world's population: overcoming this deficiency means a potential increase in energy consumption.

One of the 17 Sustainable Development Goals, namely the SDG 7 aims to "Ensure access to affordable, reliable, sustainable and modern energy for all".

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The objectives to be achieved in 2030, established by the UN, are very ambitious but absolutely necessary[1]:

- ensure universal access to affordable, reliable and modern energy services;
- increase substantially the share of renewable energy in the global energy mix;
- double the global rate of improvement in energy efficiency;
- enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil fuel technology and promote investment in energy infrastructure and clean energy technology;
- expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states and land-locked developing countries, in accordance with their respective programmes of support.

The SDGs are measured every year through indicators, and in this way it is possible to check the progress. As for SDG 7, some results have been obtained (UN 2018):

- the global electrification rate rose from 83% in 2010 to 87% in 2015, with the increase in accelerating to reach 89% in 2017. The global share of the population with access to clean cooking fuels and technologies reached 61% in 2017, up from 57% in 2010; despite this progress, close to 3 billion people still rely primarily on inefficient and polluting cooking systems;
- the renewable energy share of total final energy consumption gradually increased from 16.6% in 2010 to 17.5% in 2016, though much faster change is required to meet climate goals. Even though the absolute level of renewable energy consumption has grown by more than 18% since 2010, only since 2012 has the growth of renewables outpaced the growth of total energy consumption;
- global primary energy intensity ratio of energy used per unit of gross domestic product (GDP) improved from 5.9 in 2010 to 5.1 in 2016, a rate of improvement of 2.3%, which is still short of the 2.7% annual rate needed to reach target three of Sustainable Development Goal 7;
- international financial flows to developing countries in support of clean and renewable energy reached $18.6 billion in 2016, almost doubling from $9.9 billion in 2010.

Despite the progress made, the targets to be reached are still very distant. Amongst the many critical points, a particularly worrying one emerges: around 800 million people still remain without electricity.

A problem that is increasingly common also in the industrialised countries is of an economic nature: even when energy is available, sometimes its cost limits its usage (so-called fuel poverty[2]). If human life without energy is impossible, what attributes

[1]The data are taken from: https://sustainabledevelopment.un.org/sdg7.

[2]In the UK, fuel poverty is defined by the Warm Homes and Energy Conservation Act as: "a person is to be regarded as living "in fuel poverty" if he is a member of a household living on a lower income in a home which cannot be kept warm at reasonable cost" (source: http://www.legislation.gov.uk/ukpga/2000/31/contents).

should energy have? The answer is to be found in SDG 7: energy must be affordable, reliable, sustainable and modern for everybody.

The energy planning of our cities, which we call Green Energy Planning, must start from this very objective, trying to provide a concrete answer, through its actions, to what is required to meet the SDG 7.

7.1.2 Towards a Green Energy Transition

Without the presence of human beings, the Earth's ecosystem would be self-sufficient in terms of energy: plants have always exploited solar energy and have become the basic elements of the food chain. The discovery of energy from fossil sources, initially at low cost, has allowed humanity to live better, for example in comfortable environments both in winter and in summer or to achieve absolute mobility through public transport, or indeed private vehicles.

The anthropization of the land masses, also through the use of energy which has grown exponentially over the years, has generated a conflict between the built environment (by human beings) and the natural one. Between 1971 and 2017, the world total primary energy supply (TPES) increased by more than 2.5 times (from 5.519 to 13.972 Mtoe) (IEA 2019). Comparing the world population between those two historical thresholds 3.76 trillion in 1971 and 7.9 trillion in 2017 one observes an increase of about two times: this means that over the years per capita energy consumption has increased. In addition to the environmental problem, or in parallel with them, one should consider the critical issue of the availability of fossil energy sources.

Renewable energy sources, whose contribution has been considered marginal over the years, show an interesting growth trend. According to Eurostat, the share of energy from renewable sources in gross final energy consumption has almost doubled in recent years, going from about 8.5% in 2004 to 17.0% in 2016.[3] Not only the difference expressed in percentage terms between the two reference thresholds but also the linear growth trend is interesting.

The use of renewable energy sources offers significant possible advantages, including a reduction in GHG emissions, diversification of energy supply and less dependence on fossil fuel markets (in particular those of oil and gas). The development of the use of renewable energy sources could (and indeed already has) also stimulate employment by creating jobs in new "green" technologies.

The "green energy" transition, supported by the energy policies expressed by many countries (e.g. the European Directives on energy efficiency and innovative energy sources) and by technological innovation characterised by interesting growth trends, should be one of the paradigms of Green Energy Planning.

Its success will be even greater if at the same time maximum efforts are made to reduce energy requirements by promoting action on energy efficiency. In the

[3]Source: https://ec.europa.eu/eurostat/databrowser/view/t2020_31/default/line?lang=en.

energy planning of towns and cities, all efforts must be made to promote priority position renewable energy sources, leaving behind what was their traditional role as an integrative source.

As far as the energy transition is concerned, an interesting scheme has been proposed by the Energy Atlas (Heinrich Böll Foundation 2018) which defines in 12 points the actions that can support an energy transition in Europe (Table 7.1).

Table 7.1 Twelve brief lessons on Europe's energy transition (Heinrich Böll Foundation 2018, graphic designer Bartz/Stockmar CC BY 4.0)

#	Lesson	#	Lesson
1	Energy has historically been a key driver of European COOPERATION. But current EU proposals are not enough. To comply with the Paris Climate Agreement, we MUST GIVE UP fossil fuels altogether by 2050	7	Digitalisation can make this transformation more DEMOCRATIC AND EFFICIENT and can reduce the bill for the end consumer
2	A 100% renewable energy system in Europe is now technically possible using existing STORAGE and DEMAND RESPONSE technologies	8	The European energy transition promises to increase PROSPERITY in a sustainable way (creating more local jobs) and boost Europe's global LEADERSHIP in green innovations
3	Stronger INTERCONNECTIONS of markets and infrastructure across Europe will make the energy transition cheaper for all Europeans	9	Since 2013, renewables have helped SLASH Europe's import bill for fossil fuels by more than a third, CUTTING ITS DEPENDENCY on unstable and unpleasant regimes
4	The biggest potential lies in INCREASING EFFICIENCY. Europe-wide we could reduce our energy demand by half by 2050	10	A SOCIALLY JUST TRANSITION is both essential and viable: all over Europe, the renewables sector already provides more well-paid, secure local jobs than the coal industry
5	A switch to 100% renewables in Europe will trigger SYSTEM CHANGE—away from centralised, monopolistic utilities to decentralised, community power projects and innovative business models	11	ENERGY POVERTY is being tackled by pioneering community power projects, acting in solidarity with those in their own community addressing this challenge
6	Framed by smart strategies and legislation, this system change can be driven by CITIZENS, CITIES AND ENERGY COOPERATIVES, leaving much more wealth in communities	12	Europe's Neighbourhoods Policy should INSPIRE AND SUPPORT other countries to decarbonise their economies. A socially just energy transition in Europe's neighbouring regions can stimulate their progress and stability

7.1.3 Making Connections for Smart Energy

Livio De Santoli, a professor of Università La Sapienza—Rome, argues that "Making connection represents today the path of change. Connections between the various disciplinary fields, to replace the image of the hierarchy amongst knowledge that of a shared knowledge. Connections between operators to limit the excess of specializations and disciplinary isolation, connections between individuals to foster communities, connections that determine bi-directional relationships between the nodes of a network. Connections of a smart network, an intelligent network" (De Santoli 2016).

Connection, therefore, a concept completely opposite to a hierarchical vision of energy management in large towns and cities adopted up to now, is a fundamental paradigm in Green Energy Planning.

In green cities and in green communities, **distributed generation of electricity** is the new energy paradigm. From a single generation point, for example, a thermoelectric power plant, there is a move to an architecture based on multiple generation points distributed throughout the territory, for example **solar photovoltaic power plants**, **wind power plants** or CHP/**cogeneration systems** (combined production of electricity and heat).

Distributed generation is conceptually similar to a computer network in which several terminals connected to a single network contribute to producing and exchanging information that can be used by the entire system. While in a centralised generation, the production of electricity is ensured by large-scale power plants, and in distributed generation the power plants are more numerous, each with a considerably lower power output and can be used locally.

Distributed generation paves the way for the diversification of energy carriers and the **intelligent use of renewable energy sources** which, due to their characteristic of diffuse sources, respond to the needs of small–medium-sized generation systems and favour the creation of micro-networks of transmission.

The network infrastructure compatible with distributed energy generation is the **smart grid** or intelligent network (Fig. 7.1).

Innovation allows electricity to travel between multiple nodes, rendering the network able to respond promptly to the demand for more or less consumption by one or more users and making its management as immediate and optimal as a real intelligent organism.

This characteristic is fundamental when we consider that many of the small electricity production plants that are connected to the grid are powered by renewable energy sources, i.e. random energy sources that generate and inject energy into the grid independently and cannot be controlled with respect to the request from users.

In the distributed generation scheme, moreover, the consumer can become a supplier and vice versa, and the new neologism "**prosumer**" has this meaning. The task of the smart grid is also to manage energy flows in directions that can vary continuously, unlike what happens in traditional centralised electricity generation systems.

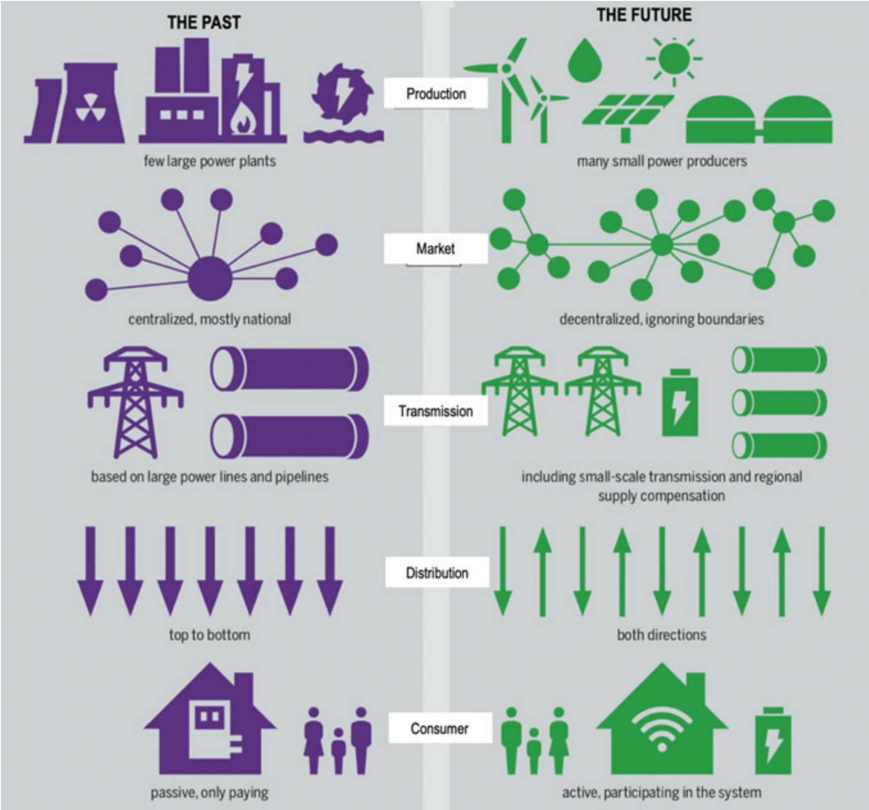

Fig. 7.1 Expected structural changes in energy management due to smart grids (Heinrich Böll Foundation 2018, graphic designer Bartz/Stockmar CC BY 4.0)

The intelligence of a smart grid stems from the fact that, in practice, there is an overlap or a juxtaposition between two technologies: that of electricity distribution and that of Information and Communication Technologies (ICT). Thanks to the latter, the self-production stations distributed throughout the territory or zone in question are able to communicate with the power plants, exchanging information with them on the energy produced and consequently regulating the dispatching of energy.

The management of smart grids is regulated by software capable of guaranteeing remote management and control functions.

As already happens in the mobile telephone sector, in the near future, it will become possible for a user to decide to make several supply contracts and activate them in different time slots, depending upon the related economic convenience. All using the same network and the same meter, which obviously must be set up for this function (**smart metering**).

A smart grid can respond to various technical needs, for example:

- balancing energy supply and demand (dispatching);

- integrating with the home or building automation system of the building;
- opening to the possibility for the user to use external services for optimised energy management.

The diffusion of energy production plants from renewable sources has stimulated applied research for the future execution of smart grids.

Some smart functions are already present in our networks, and renewable energy production systems can supply excess energy to the network and, thanks to the new generation of electronic meters, remote reading, fault detection and management of the contractually engaged power.

However, the current situation can be considered to be a transition phase in which the networks created with traditional architecture acquire, thanks to the technological development of ICT, a partial intelligence and thereby the capability for example to manage the energy introduced by the self-producers (Dall'O' 2014).

7.1.4 Energy Storage Systems

Energy storage is an essential factor in all applications where there is a mismatch between production and use. Storage systems can have a dual function: in the case of conventional energy sources, they can compensate for temporary drops in production or limit the number of generator starts, or indeed reduce peak values, while still guaranteeing the expected demand level and thus improving the level of efficiency of the plant to which it is connected.

In the case of the use of renewable energy sources, i.e. those of an intermittent nature such as solar energy or more particularly wind energy, energy storage systems make it possible to compensate for the mismatch between production and demand and are increasingly showing themselves to be indispensable in ensuring greater control of the production phases and improving performance, management and quality. They thereby reduce the costs of the electricity produced and used, a necessary ingredient for an open energy market.

As far as technologies are concerned, the storage systems which are currently prevalent can conserve energy in the following different forms (Piterà 2016):

- electrochemistral: batteries with aqueous electrolyte, high temperature, lithium and electrolyte circulation;
- mechanics: hydroelectric pumping, compressed air storage and flywheels;
- electrical: supercapacitors and magneto-electric superconductors;
- chemical (production): hydrogen and syngas (currently these are under intense development);
- thermal: molten salts, solar pond, solid accumulations and phase change materials (PCM).

The use of storage systems can greatly improve the performance of smart grids inserted in systems that use renewable energy sources.

7.1.5 Smart Metering

The term "smart metering" defines control systems based on sensor networks for real-time monitoring of light, gas and water consumption. Thanks to the possibility of computer and communication technology interfaces, it permits intervention on plants, in terms of regulating the exchange of both energy and information in plant operation, also offering the possibility to intervene remotely in case of problems or failures, without having to resort to actual on-site action.

Smart metering is a technology of great utility in the field of energy efficiency because it is a tool that can be used to measure the savings which can be achieved following efficiency improvements. Its application, in fact, makes it possible to accompany every intervention from the design phase, with the measurement and evaluation of the energy consumption and energy losses of a plant or a building before the redevelopment works, passing through monitoring during the phase of carrying out the works and finishing with the measurement and control of consumption in tele-management of post-redevelopment operation.

The technological items of which it is composed, in particular the sensors, involve technologies that are already mature, widely available on the market and accessible at reasonable prices. Therefore, the use of smart metering is desirable at every level of the distribution network of energy resources (Dall'O' 2014).

7.1.6 The Prosumer as a New Player in the Green Energy Strategy

The diffusion of plants powered by renewable energy sources, such as the solar PV, in the "grid connected" configuration required the connection of the systems to the public electricity grid. In cases where the electrical energy produced by the plant is higher than the user's needs, the excess is sold to the electricity system (grid), otherwise the user purchases energy from the same system. The user is therefore no longer just a consumer of energy but is also a producer of energy.

The neologism "prosumer" refers to an electricity consumer producing electricity for his/her own consumption (and possibly for feed-in into the grid).

The word is derived from a combination of "producer" and "consumer".

The Renewable Energy Directive (EU 2016) gives the following definition:

> Renewable self-consumer means an active customer or a group of customers acting together as defined in Directive (EU, 2016) who consume and may store and sell renewable electricity which is generated within their premises, including a multi-apartment block, residential area, a commercial, industrial or shared services site or in the same closed distribution system, provided that, for non-household renewable self-consumers, those activities do not constitute their primary commercial or professional activity… (Lettner et al. 2018).

The availability of smart grids, or in any case of devices that allow the use of electric current networks in a smart way, opens the energy market to prosumers, as individuals or organised in structures, allowing to obtain both economic and functional advantages also for the community. It is up to the prosumer, in fact, to carry out the initial economic investment on the energy production plant, and this avoids the construction of new power plants. The prosumer, on the other hand, achieves payback on the investment in less time by selling the produced energy.

When discussing prosumers, the reference is generally to the production of solar photovoltaic energy; however, other technologies can also be used, such as combined heat and power/cogeneration. In this case when there is a demand for heat (e.g. for winter heating), any excess electricity produced by the CHP plant is transferred to the grid.

7.1.7 Energy Communities as a Driver for Local Development

The concept of an Energy Community refers to a set of energy users who decide to make common choices in terms of satisfying their energy needs, in order to maximise the benefits deriving from this collegial approach, thanks to the implementation of technological solutions for distributed energy generation and intelligent management of energy flows.

In the context of the evolution of the electrical system towards the smart grid, the Energy Communities—although in general not limited to the electrical energy carrier—represent one of the constituent elements, being typically connected to the public electricity grid, although there are cases of so-called off-grid applications, in contexts where the electricity grid is not present in a widespread manner (e.g. isolated rural areas and islands).

There are many categories of energy users potentially interested in being part of an Energy Community. In particular, it is possible to identify:

- residential users, such as residential properties and complexes;
- industrial users, such as industrial districts;
- tertiary users, such as shopping/logistics centres and hospital complexes.

In particular, the aggregations of users that form an Energy Community can be either homogeneous, if they belong to the same category, or mixed, if instead they belong to different categories.

The creation of an Energy Community makes it possible to achieve a series of benefits for the energy users present within it, which range from improving the quality and reliability of the energy supply—understood as the possibility of guaranteeing the energy users of the Energy Community high power quality—to optimising energy expenditure—understood as the possibility of guaranteeing energy utilities a lower cost of energy supply than that of traditional procurement methods.

The different categories of energy users, based on their specific peculiarities, attribute a different relevance to the potential benefits, the relative weight of which allows to characterise the aggregations of energy utilities and, consequently, to identify the configuration of the Energy Community (Energy & Strategy Group 2014).

7.1.8 New Paradigms for Urban Mobility

The relationship between density and the viability of public transportation, with consequential benefits for the related energy consumption, has long been recognised, while the wider relationship between urban form and energy consumption has been less clear. However, new data is emerging which demonstrates a complex but significant relationship between the latter pair.

One study which drew upon data from 274 cities found the "economic activity, transport costs, geographic factors and urban form explain 37% of urban direct energy use and 88% of urban transport energy use". Applying these results to projected growth in urbanisation, the study found that there was a potential greenhouse gas savings "wedge" available from the application of appropriate urban planning and transport policies. The wedge represented a reduction of around 26% of greenhouse gas emissions compared with business as usual scenario (Creutzig et al. 2015).

The European Environmental Agency (EEA) has adopted an intervention strategy based on three pillars, the ASI strategy (Avoid, Shift, Improve) which challenges the current transport system (EEA 2016).

The first pillar of *Avoid* (reducing the need for mobility) refers to all actions aimed at improving the overall efficiency of the transport system, to avoid or reduce the formation of passenger and freight transport demand through the use of smart technology such as ICT and intelligent transport system (ITS).

The second pillar of *Shift* (moving to a more efficient transport model) refers to all actions aimed at improving the efficiency of the journey (more energy efficient, lesser emissions, safer).

The third pillar *Improve* refers to all actions aimed at improving vehicle and fuel efficiency through technological development or even by improving lifestyles. Alternative fuels (e.g. biofuels and electricity) should be the main energy carriers for reducing greenhouse gas emissions in the mobility sector (Meneghetti 2018).

The green energy transition of the cities cannot neglect the new paradigms of sustainable mobility that affect not only the energy aspects but also the infrastructural aspects of the city.

The technological evolution in the mobility sector is very rapid, and the infrastructures associated with the new models have difficulty in adapting to this evolution.

First of all, cities will have to develop public transport infrastructures which will increase the number of users, being both amongst residents of the urban area and citizens from extra-urban areas.

The densification of the cities will privilege the short routes: the network of pedestrian and bicycle paths will therefore become strategic transport infrastructures that will have to be equipped and integrated with the bike sharing services. The spread of power-assisted bicycles will require an increase in the associated electrical charging points.

The automotive sector has long been moving towards fully electric vehicles. Urban vehicle charging infrastructures must increase by an order of magnitude compared to the current situation. All this will involve a search for not only suitably equipped parking areas within the urban space but also electricity recharging infrastructures (Meneghetti 2018). The city of Lucerne in central Switzerland is a good example of successful implementation.

The transition from mobility powered by endothermic engines to electric mobility will involve the definition of an urban energy balance in which a portion of the electrical uses will have to take this transition into account. Energy to make vehicles move will no longer be an individual problem or a fuel service station problem but will become a problem for the city and its infrastructure. Electric cars better if not owned but used with shared modes (e.g. car sharing) will significantly contribute to the reduction of harmful airborne gases (and indeed of background noise). However, in a vision that goes beyond the city, an important aspect which cannot be overlooked is how this electricity is produced.

The decision to produce electricity from renewable sources, starting with solar PV, should be privileged.

Electric vehicles play a vital role because they can interact with the power grid. A fleet of electric vehicles can flexibly store and deploy power en masse. BMW's charge forward programme, running in California, is an example: the vehicle owners are paid an incentive if they agree to flexible battery recharging. This allows for "de-peaking", where cars are not recharged immediately, but at times of day when grid loads are at their peak.

Transferring power from vehicle batteries to the grid is also possible and desirable. Cars act as "batteries on wheels": the grid taps their batteries if it is short of power. Each vehicle needs only to return a small percentage of its stored energy to have an overall impact on the grid. However, the equipment required is still too costly: prices need to come down significantly if this approach is to be widely accepted (Heinrich Böll Foundation 2018). In Europe, the electrical infrastructure situation is such that this still appears as a somewhat distant possibility for private users.

So far, we have considered the energy and environmental aspects of mobility. In a truly green vision of mobility, we must also consider the aspect of accessibility: "*equity and inclusivity are at the heart of Universal Access. This objective accounts for distributional considerations and places a minimum value on everyone's travel needs, providing all, including the vulnerable, women, young, old, and disabled, in both urban and rural areas, with at least some basic level of access through transport services and leaving "no one behind… omissis … Urban transport systems and services need to be upgraded—and in some cases planned from scratch—in an integrated way, that ensures the balanced access of urban residents regardless of income, mode of travel, gender, or disability status. Urban mobility should foster and enable cities to flourish, without creating over-dependence on any particular* *mode of travel*" (SuM4All 2017). Indeed reduction of vehicle density and hence urban traffic congestion will represent an improvement in the quality of urban living.

7.2 A Methodological Approach to Green Energy Planning on a Territorial Scale

7.2.1 Defining a Green Energy Planning Strategy

In energy planning on an urban or regional scale, there is no valid reference model for all the realities of a given zone; specific situations can complete the study and definition of intervention projects according to priorities that vary from place to place. For example, the energy planning of a city like Helsinki requires a concept that is substantially very different from the model that could be applied to a city of considerable historical significance (having associated structures to be carefully preserved) such as Rome.

A peculiarity of Green Energy Planning (GEP) is to consider with great attention, through an in-depth analysis, the urban context not only from energy or environmental point of view but also from a social, historical and cultural point of view.

The energy balance of a city arises from a comparison between energy supply and energy demand. The reduction of the negative effects on the environmental impact due to the use of traditional energy sources (fossil sources) can take place on both fronts: on the supply side of energy by replacing energy from fossil sources with renewable energy and on the demand side by reducing consumption through strategies of efficiency and savings.

Acting on the demand for energy is important and appropriate but requires considerable economic inversions, furthermore, there may be physical impediments (e.g. limited spaces for the installation of solar systems).

A concept applied in urban energy planning is that of "integrated resources planning" or "least cost planning". The methodological approach outlines a series of actions of improvement that can be applied to the energy demand side.

According to these theories, it is more interesting and useful to make substantial and coordinated investments mainly for users or infrastructures that use energy resources.

Resources can be defined on the demand side as "demand side resources" and are those technological or operational opportunities which allow an increase in the efficiency of the supply of energy services.

Demand side management (DSM) concepts and methods of energy management have been developed in the USA since the 1980s, in response to problems encountered by companies producing and distributing electricity in relation to the high costs, environmental problems and layout constraints for new production plants.

DSM actions, conducted directly or indirectly by energy companies, can be considered as structured energy-saving actions, or energy-saving incentives, based on non-traditional economic assumptions (Chiesa and Dall'O' 2006).

The definition of strategies to reduce environmental factors is complex and must obviously take into account the specificity of the territorial context. The green energy transition of cities, however, may be more feasible and economically viable if demand side needs are reduced through energy retrofit improvement works.

Cities and large towns are expected to play a key role in achieving the ambitious energy targets, and Green Energy Planning is the tool to reach these targets. Urban planners can contribute to shape energy and efficiency and low-carbon cities. However, the complexity involved in such a broad task impedes the realisation of any simple solution. The paper of Cajot et al. (2017) has the aim of examining in detail the many interrelated challenges and obstacles which hinder efficient urban energy planning.

The Green Energy Green Planning strategy is divided into the following operational phases, some of which are developed in sequence while others can proceed in parallel:

- definition of the working group;
- data gathering;
- analysis of the sectors;
- examination of the energy infrastructures already present in the territory;
- sample energy audits;
- definition of the indicators;
- baseline definition (reference energy balance);
- definition of the action plan;
- checking of the consistency with regional, national and international legislation;
- economic evaluation;
- implementation of the Green Energy Projects;
- updating of the database;
- monitoring.

A typical flow chart of a Green City Planning Strategy is illustrated in Fig. 7.2 that defines four macro-phases: audit phase, design phase, implementation phase and monitoring phase.

7.2.2 Audit Phase

The audit phase deals with two aspects: the definition of the working group and the analysis of the current situation (reference energy balance) that constitutes the baseline, starting point and reference point on the basis of which to implement the actions (projects). It is important to create an operations team involving different individuals characterised by clearly defined positions of leadership, and thus able to take decisions.

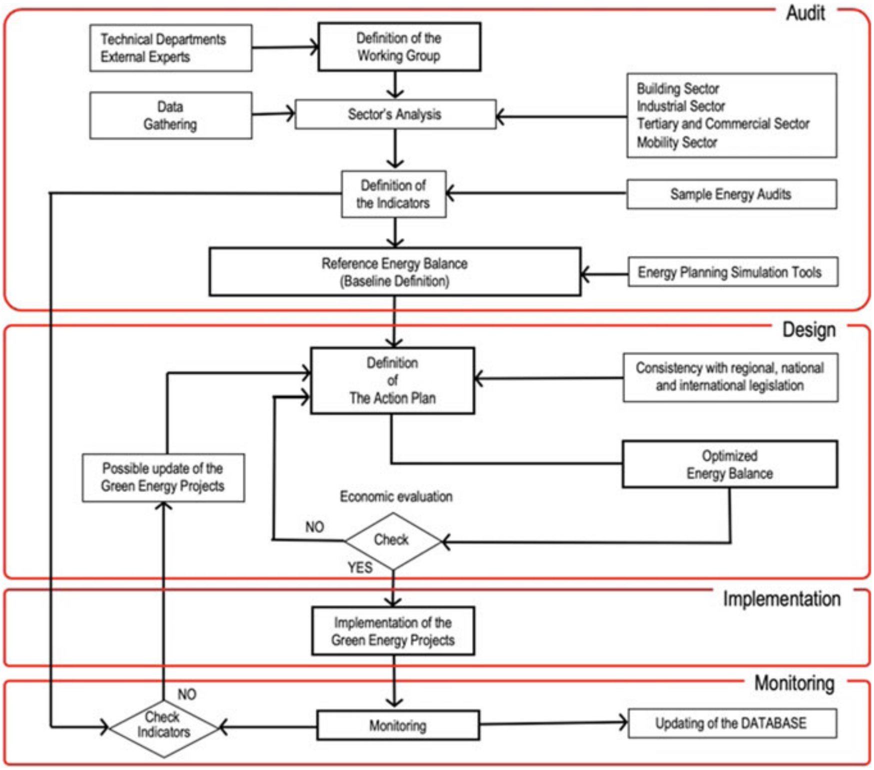

Fig. 7.2 Typical flow chart of a green energy plan for cities and communities: the actions are divided into three macro-phases: audit, design, implementation and monitoring

The managers in charge of the Technical Departments involved (e.g. City Planning Department, Building Department, Environmental Department, Mobility Department, City Manager, Mobility Manager) could be supported by external experts.

A Planning Secretariat should also be appointed, with the responsibility of managing and coordinating day-to-day operations. The chair of the Steering Committee should be entrusted to a high profile person, for example the city's energy manager.

Once the Steering Committee has been established, the audit phase should consider the data gathering for each sector (e.g. Building, Industrial, Tertiary and Commercial, Mobility). The information to be collected may concern:

- the physical and geographical characteristics of the territory (series of maps of various scales), possibly on digital support (e.g. a Geographic Information System (GIS) platform or a City Information Modelling (CIM) platform);
- general urban planning data (total surfaces, urbanised areas, number of inhabitants, population density, industrial and artisan craft development areas);

- the data relating to the changes in the urban layout (new buildings, new infrastructures, abandoned areas to be redeveloped, etc.);
- data relating to energy infrastructure in the area (e.g. district heating networks, district cooling networks, gas distribution networks, plant configurations for the supply of electricity, data relating to urban lighting systems, etc.);
- data relating to plants for renewable energy sources (solar thermal systems, PV solar systems, wind farms, etc.);
- the data relating to the thermophysical characteristics of the building stock;
- vehicle traffic data.

The data on energy consumption can be found at the utilities which supply the energy carriers (electricity companies, gas companies). The sample survey to define the detailed structure of the application can be carried out and must include the following activities:

- quantification and disaggregation of energy flows that affect the area in question;
- historical reconstruction of energy flows within the various sectors with territorial and sectoral breakdown;
- definition of energy indicators (kWh/inhabitant, kWh/m^3 of building, kWh/unit of product, etc.);
- territorial and sectorial analysis of flows to determine the consumption scenario;
- reconstruction of the theoretical energy requirement for each sector based on end uses and the energy carrier used.

The survey phase concludes with the elaboration of the reference energy balance which constitutes the baseline. The knowledge of how much energy enters the city (broken down by renewable energies and non-renewable energies) defines the supply of energy while the evaluation of how this energy is consumed defines the energy demand.

The reconstruction of energy flows divided up per sector is not simple and may require complex processing generally supported by energy planning simulation tools.

The supply of energy can be obtained from the data provided by the utility companies which provide the energy services while the demand for energy requires estimates on users and user equipment and therefore are based on theoretical assessments. Since it is not possible to perform detailed energy audits on all the users, it is advisable to define a suitable scheme of sampling amongst the users.

The reference energy balance is described with a diagram of the type shown in Fig. 7.3, which shows the subdivision of energy sources in various sectors of usage. The diagram takes into account not only conventional (non-renewable) energy sources but also renewable energy sources.

For the study of territorial energy reorganisation policies, it is necessary to reproduce a similar diagram for each of the sectors examined.

The territorial energy balance is the fundamental operational support to the planning activity and to the definition of the precise actions to be implemented, and therefore, it must also contain analytical and interpretative tools of the situation investigated.

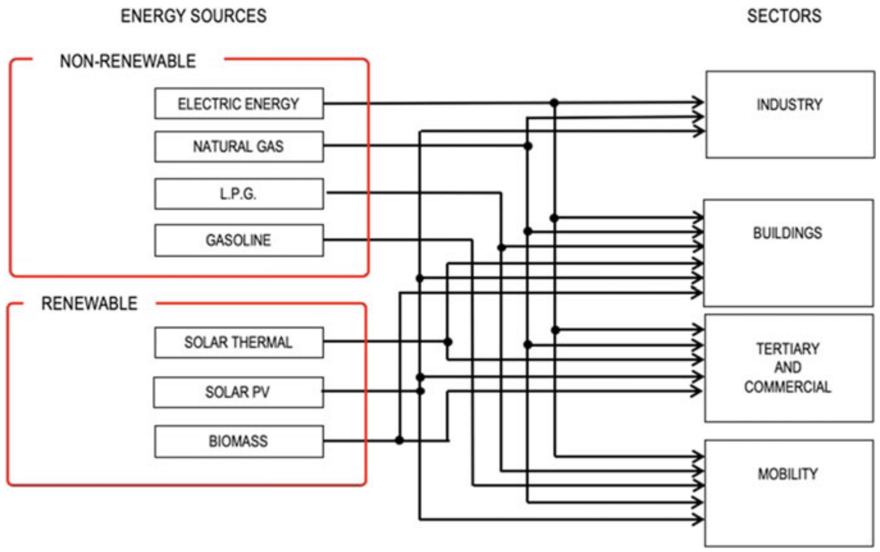

Fig. 7.3 Typical structure of a reference energy balance with the breakdown of energy sources by sector

7.2.3 Design Phase

The design phase defines the actions that can be implemented in the short, medium and long term.

At this stage, it is important to:

- define realistically achievable goals;
- define objectives that are not in conflict with legislative instruments and with guidelines approved by higher-level administrations (e.g. regional or national);
- define strategies consistent with the Sustainable Development Goals (SDGs) defined by the United Nations.

In choosing the actions to implement, the working group should ask itself the following questions:

- Is the proposed action strategic with respect to the needs identified in the audit phase?
- Is the implementation time compatible with the needs identified during the audit phase?
- Are there technical skills available within the Technical Departments capable of managing the action both from a technical and from an economic point of view?
- Is it feasible from an economic point of view? In other words, are the financial resources available to cover the costs not only of implementation but also of management and maintenance?

If the objectives to be achieved can be clear, the paths to follow, and therefore the actions to be implemented in order to attain those objectives, are various. For an examination of the actions and activities which can be implemented to reduce energy consumption, see Sect. 7.3 of this chapter.

7.2.4 Implementation Phase

In this phase, the projects are implemented, long-term actions, for example, the creation of an extended district heating or cooling network, may take several years. Long-term strategic planning makes it possible to allocate the available economic resources more effectively.

7.2.5 Monitoring Phase

By having a monitoring phase, it is possible to verify whether the actions implemented were truly effective in achieving the objectives: this is assisted by a verification over time of the partially implemented actions.

The Green Planning Strategy, although it may include the implementation of several sectoral projects, cannot be considered a macro-project, with a beginning and an end, but rather defines a continuous path of improvement that must be constantly verified through the monitoring of the results achieved.

The monitoring is performed by means of a comparison between the indicators periodically detected (e.g. every year) and the indicators obtained from the baseline that becomes the reference base. It is thus the presence of a monitoring phase which makes the difference between a project and a process.

Through a precise, detailed control, it is possible to identify the partial or global ineffectiveness of some actions, identify their causes and make corrections. All is done according to the typical quality systems approach which, using the Deming cycle (PDCA),[4] are recursive processes.

The use of an energy management system compliant with ISO 50001 (ISO 2018) makes it possible to manage all Green Energy Planning phases efficiently and effectively.[5]

[4]PDCA, an acronym for Plan–Do–Check–Act, is a four-step iterative management method used for the control and continuous improvement of processes and products.

[5]Standard ISO 50001:2018 provides a framework of requirements for organizations to: develop a policy for more efficient use of energy, fix targets and objectives to meet the policy, use data to better understand and make decisions about energy use, measure the results, review how well the policy works and continually improve energy management.

7.3 Covenant of Mayors for Climate and Energy

7.3.1 The Covenant of Mayors Project

The Covenant of Mayors (CoM), launched by the European Commission after the adoption, in 2008, of the 2020 EU Climate and Energy Package, is a unique bottom-up movement that succeeded in mobilising a great number of local and regional authorities to develop action plans and direct investments towards climate change mitigation measures. The objective of the project is to endorse and support the efforts deployed by local authorities in the integration and in the implementation of sustainable energy policies.

The CoM Project has had remarkable success over the years: to-date (www.covenantofmayors.eu, September 2019) 9664 local government and public administrative entities (municipalities, networks of municipalities, provinces/counties and regions), covering a population of 326,671,680 inhabitants, joined the pact of the mayors by signing the commitment.

The Covenant of Mayors for Climate and Energy is open to all local authorities democratically constituted with/by elected representatives, whatever their size and whatever the stage of implementation of their energy and climate policies.

Neighbouring small and medium-sized local authorities/councils can also, under certain conditions, decide to join as a group of signatories.[6]

The CoM Project, born within the European Union, has found international success worldwide. "*Since its launch in 2008, the CoM initiative has grown into the world's largest city movement. It has secured the commitments of thousands of cities across six continents and more than 120 countries, representing almost 10% of the world's population. The initiative was first extended to counties neighboring Europe to the East and the South and later to the countries of sub-Saharan Africa. In 2016, the Covenant of Mayors entered a major new phase of its history by joining forces with another city initiative, the Compact of Mayors.*

The resulting Global Covenant of Mayors for Climate & Energy now also covers North America, Latin America and the Caribbean, and much of Asia including countries in the South-East as well as China, India and Japan. Thus far, a total of nine regional and national Covenant Offices have been set up.

These regional and national Covenants operate as local chapters of a global alliance that is capitalizing on the experience gained in Europe and beyond".[7]

As of October 2015, Covenant signatories committed themselves to adopting an integrated approach to climate change mitigation and adaptation. They are required to develop Sustainable Energy and Climate Action Plans with the aims of cutting CO_2 emissions by at least 40% by 2030 and increasing resilience to climate change within the first two years of adhesion (Dall'O' et al. 2018). The CoM Project is developed in three steps:

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[6]Source: https://www.eumayors.eu/about/covenant-community/signatories.html.

[7]Source: http://www.climatealliance.org/activities/covenant-of-mayors/global-covenant.html.

Step 1: with the signature of the Covenant of Mayors that involves the creation of adequate administrative structures, development of a Baseline Emission Inventory, Risk Vulnerability Assessment and Action Plan (within two years);
Step 2: with the submission of the Sustainable Energy and Climate Action Plan (SECAP);
Step 3: signatories commit themselves to report progress every two years.

As illustrated in Fig. 7.4, the project develops and progresses in a cyclical manner which drives towards a continuous improvement of the sustainability level (Bertoldi 2018).

The SECAP is based on a Baseline Emission Inventory (BEI) and a Climate Risk and Vulnerability Assessment(s) (RVAs) which provide an analysis of the current situation. These elements serve as a basis for defining a comprehensive set of actions that local authorities then plan to undertake in order to reach their climate mitigation and adaptation goals.

SECAP monitoring must be done every two years while an update of the Inventory of Emissions is required every four years.

Fig. 7.4 Covenant of Mayors for Climate and Energy step-by-step process (Bertoldi 2018)

The monitoring phase, independently verified by the European operational support structure for project management, the Joint Research Centre (JRC) of Ispra, guarantees the quality of the project and is therefore strategic for its success.

By means of the monitoring, it is possible to check whether the actions provided by SECAPs have been implemented and have permitted the attainment of the programmed targets and whether the strategies need to be revised by modifying the actions or planning other actions.

Feedback derived from in-depth analysis of monitoring results can help to understand what the best strategies are for promoting a sustainability-driven development policy at local and regional level. The ideas that may emerge can be useful for public administrators but also for all stakeholders in the sustainability chain, such as designers, construction companies, contractors, sub-suppliers, energy and environmental service providers.

The interest of the scientific community for the theme of the European project Covenant of Mayors, and more generally for its implementation tool, the SEAP (or SECAP), is demonstrated by the presence of interesting papers on these matters in indexed databases of the scientific journals of reference.

The topic of monitoring the SEAP is critically addressed by Delponte et al. (2017). In the paper, the authors use as test case the implementation of the SEAP of the city of Genova (Italy) to verify the efficacy of the adopted approach. The authors consider the strengths and weaknesses of the tool, testing particularly cost-benefit analysis, bankability, peer review and participatory level. The aim of the paper is to propose some recommendation to better outline the "Monitoring and Evaluation" methodology and to help other cities to define a strategy for SEAP monitoring and fulfilment.

Berghi (2017) focuses on energy use in the urban transport sector within the SEAPs in three large Italian cities, Milan, Palermo and Rome, which are characterised by completely different cultural, economic and environmental contexts. The originality of this paper consists in having developed, through the comparison of different SEAPS, a preliminary multidimensional framework for their harmonisation at metropolitan level.

Pablo-Romero et al. (2016) analyse the effects of Energy Action Plans on electricity consumption in CoM signatory municipalities in Andalusia, the region of Spain with the most signatories. The study demonstrates that the Covenant implementation has a positive effect on reductions in electricity consumption, since the municipalities involved show greater rates of reduction in electricity consumption after signing it.

Interesting, finally is the contribution on the CoM topic provided by Croci et al. (2017) which analyses the emission reduction strategies of a sample of 124 cities with more than 100,000 inhabitants, signatories of the CoM, which delivered a SEAP by February 2014. In the study, more than 5500 actions planned by the sample cities are analysed and categorised, and the most relevant actions in terms of recurrence and mitigation impact are assessed.

7.3.2 Definition of the Baseline Emission Inventory (BEI)

The CoM focuses on reducing the energy consumption in the local territory, i.e. area administered by the signatory but also matching energy demand with the supply of sustainable energy by improving energy efficiency and promoting the use of local renewable energy resources.

The emission inventory represents a fundamental phase for the design of a SEAP because it defines the baseline values from which to elaborate the planning strategies of the actions that will lead to environmental improvement.

For the signatories, the BEI is an important opportunity to build an energy–environmental balance on a local scale, based on real data that is often not available beforehand, or was available but only partially and in a disaggregated manner. The construction of the EIB also becomes a strategic opportunity to stimulate cooperation and dialogue between the different departments of a municipality (e.g. urban planning, environment, transport, mobility, etc.) which often operate independently.

A complete guide for the preparation of the BEI, which can become a complex activity, is reported in Bertoldi (2018).

The geographical boundaries of the "local territory" are the administrative boundaries of the entity (municipality, region) governed by the local authority which is a signatory to the CoM.

The BEI must cover the CoM key sectors. While the baseline CO_2 inventory will essentially be based on final energy consumption, some non-energy-related activity sectors may also be included. The three main types of GHG emissions to be potentially included in the BEI are as follows:

- Direct emissions due to final energy consumption split into the macro-sectors of "Buildings, equipment/facilities and industry" and "Transport"(mandatory).
- Indirect emissions related to grid supplied energy (electricity, heat or cooling) that are consumed in the local territory.
- Non-energy-related direct emissions which occur in the local territory.

Greenhouse gas direct and indirect emissions are calculated for each energy carrier by multiplying final energy consumption by the corresponding emission factor (see Bertoldi 2018).

In line with the European Union Energy strategy, the new target for the reduction of GHG emissions proposed by the CoM for Climate and Energy is at least a 40% reduction by 2030. The reduction target, to be achieved through the implementation of the actions for those areas of activity relevant to the local authority's mandate, is defined in comparison with a baseline year, which is set by the local authority. While the emissions in the BEI and the reduction per action have to be calculated and reported as absolute emissions, the local authority can decide to set the overall CO_2 emission reduction target either as an "*absolute*" or a "*per capita*" reduction.

7.3.3 Definition of the Climate Risk and Vulnerability Assessment (RVA)

The Covenant of Mayors for Climate and Energy supports an integrated approach to local climate action. 2030 Covenant signatories have committed to the common goals of accelerating the decarbonisation of their territories, strengthening their capacity to adapt to unavoidable climate change impacts and ensuring their citizens access secure, sustainable and affordable energy.

Taking measures to reduce GHG emissions (mitigation) and adapting to the unavoidable climate change risks are complementary sets of actions addressing two aspects of climate change. One cannot be fully successful without the other, and there are numerous co-benefits between adaptation and mitigation measures (CoM 2018).

Assessing Climate Change Risk and Vulnerability (RVA) has gained significance since 2010, given its central role in the Cancun Adaptation Framework,[8] the EU Adaptation Strategy and the countries development of National Adaptation Plans.[9]

European cities are heavily vulnerable to the impacts of climate change. Heat, flooding, water scarcity and droughts (amongst others) can have an impact on health, infrastructure, local economies and the quality of life of the inhabitants.

The reduction of the impacts in the cities is a topic considered with great attention within the CoM Project that foresees the preparation of a Climate Risk and Vulnerability Assessment (RVA).

Before analysing this topic, it is useful to take on board two important concepts: *adaptation to climate change* and *resilience*.

The European Environmental Agency defines Adaptation to climate change as "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" and Resilience as "The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change".[10]

"*All levels of government, including cities and regions, need a sound understanding of the climate risks and vulnerabilities on their territory to guide their decision making and policy shaping.*

Assessing climate risks and vulnerabilities is one of the first steps in the adaptation cycle which provides the necessary information (What? Where? Why?) supporting tailored proactive measures for each site-specific context (How?)" (Bertoldi 2018).

On defining the RVA, one should consider the following steps:

1. Preparing the basis;

[8]UNFCCC (2010) CANCUN ADAPTATION FRAMEWORK (CAF)—Adopted at the 2010 Climate Change Conference in Cancun, Mexico (COP 16/ CMP 6). In the Agreements, Parties affirmed that adaptation must be addressed with the same level of priority as mitigation.

[9]https://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016/key-findings.

[10]https://climate-adapt.eea.europa.eu/help/glossary.

2. Assessing risks and vulnerabilities;
3. Identifying adaptation options;
4. Selecting adaptation options;
5. Implementation;
6. Monitoring and evaluation.

For each step of the adaptation cycle, signatories should go through a set of key actions, as illustrated in the following paragraphs. Of particular importance, and indeed the heart of the matter, is the assessment of the risks and vulnerabilities which is the second step.

The issues related to risk assessment and vulnerability are dealt with in Chap. 4 of this book, while for a discussion of the themes involved in drafting the documents supporting the CoM Project; see Bertoldi (2018).

The "Urban Adaptation Support Tool" jointly developed by the CoM—The European Office and the European Environment Agency, is the main adaptation resource for the Covenant community. It is a tool for the implementation of an adaptation strategy and has been tested and approved by Covenant signatory towns and cities.[11]

7.3.4 *Definition of the Sustainable Energy and Climate Action Plan (SECAP)*

In the Covenant of Mayors Project, the action planning tool to be promoted to reduce energy consumption, and consequently greenhouse gas emissions, and to reduce the risks associated with climate change is the Sustainable Energy and Climate Action Plan (SECAP).

This programming tool can be considered a green energy plan (GEP) and its structure, therefore, can be defined on the basis of the concepts already expressed in the previous sections of this same chapter.

The Covenant of Mayors adds two important elements to the basic outline of the GEP: the first is the climate risk and vulnerability assessment itself and the second is the fact that this is a voluntary instrument. Rather than depending upon an obligation determined by a law, it is a voluntary choice that the mayor makes in committing the zone administered by his local authority to achieve the objectives of reducing greenhouse gases, before 2020 and more recently, through to 2030. The characteristics of a SECAP are shown schematically in Table 7.2.

SECAP defines actions that, if implemented, can reduce greenhouse gas emissions, allowing targets to be reached by 2030.

Actions in a SECAP can be divided into three major categories: direct actions, indirect actions and regulatory actions.

Direct actions are those that the municipality carries out through its own funding: for example, a school's energy re-qualification or the refurbishment of a public

[11] Available on: https://www.covenantofmayors.eu/support/adaptation-resources.html.

Table 7.2 Features of a Sustainable Energy and Climate Action Plan (SIMPLA Project 2018)

Issue	Description
Time span	To 2030
Fields of actions	Municipal buildings equipment/facilities; residential buildings; tertiary (non-municipal) buildings equipment/facilities; mobility (private and public transportation); public lighting; green public procurement (GPP); local electricity production; local heat/cold production (district heating/cooling); others (e.g. industry, agriculture, forestry, etc.) land use planning; environment and biodiversity
Relevance of a local authority's territorial size	Urban contexts of such a size where a balanced development of all transport modes is feasible and realistic
Process steps	Political commitment; start of stakeholder involvement process; planning; baseline definition; adapting administrative structure; establishment of a long-term vision with clear objectives; SECAP elaboration; implementation of actions; monitoring and reporting process
Objectives	At least 40% of CO_2 emissions reduction by 2030 and climate adaptation
Definition of baseline	Comprehensive overview of energy generation and consumption. Risk and vulnerability assessment
Indicators	% reduction of CO_2 emissions; data regarding energy use, generation from renewable energy sources (RES) and saving indicators for each action (MWh); energy delivered by electrical vehicles charging stations (kWh/year); litres of water delivered by public water houses (litres); vulnerability-related indicators (i.e. length of transport network located in areas at risk, number of consecutive days/nights without rainfall, etc.) Impact-related indicators (i.e. % of habitat losses from extreme water events, % of livestock losses from pest/pathogens, etc.); outcome-related indicators (i.e. of transport, energy, eater, waste, ICT infrastructure retrofitted for adaptive resilience, % of coastline designed for managed realignment, % of forest restored, etc.)

(continued)

Table 7.2 (continued)

Issue	Description
Elaboration of scenarios	Limited relevance: initial and final (2030) scenarios and optional "long-term scenario" beyond 2030
Cost and benefit analysis	Recommended but not mandatory
Report	Monitoring Emission Inventory every four years, standardised and mandatory report submitted every two years

lighting installation. For these actions, success depends solely on political will and financial availability.

Indirect actions are the actions that the municipal administration encourages through information, technical support or coordination: for example, an information campaign at schools, the creation of an energy office to inform citizens or the planning of public meetings with citizens and stakeholders. The success of these actions is more difficult to estimate as initiatives depend upon the third parties involved.

However, the contribution of the municipality is important as demonstrated by the photovoltaic systems discussed in the previous section.

Regulatory actions. For these actions, the municipality establishes the mandatory rules that must be applied, such as a new building code. The success of these actions is certain if they are cogent actions. Their application, and the actual results measured with the reduction of energy consumption, depends on the evolution of the building market.

Public awareness and social engagement play a pivotal role for successful climate action. Measures to induce changes in behaviour and to provide education contribute significantly to the decrease in energy consumption, employing social and non-technological approaches that must be included in policies made in support of energy efficiency and energy savings. The creation of the Local Energy Agency to support citizens is a very important support action.

The key elements of a successful SECAP are reported below (Bertoldi 2018):

- build support from stakeholders and citizen participation: if they support the SECAP, nothing should hold it back;
- secure a long-term political commitment;
- ensure adequate financial resources;
- do a proper GHG emissions inventory: this is truly vital;
- make a Climate Change RVA, based on an analysis of the local/regional trends of various climate variables and city socio-economic and biophysical specificities;
- integrate the SECAP into the everyday management and administrative processes of the municipality: it should not be just another nice document, but part of the corporate culture;
- ensure proper management during implementation;
- assure that staff has adequate skills for the purposes and if necessary offer training;

- learn to devise and implement projects over the long term.

On the official website of the CoM (www.covenantofmayors.eu), all SEAP and SECAPS of the signatories of the pact are available as an example.

7.3.5 Case Study of SEAP Implementation

The SEAP implementation and monitoring case study described in this subsection are the result of a research study project promoted by the ABC Department of the Politecnico di Milano. The aim of this research was to evaluate the potential as well as the critical aspects of this energy and environmental planning tool in real cases (Dall'O' et al. 2018).

The territorial context in which the analysis was carried out concerns some municipalities located in the Lombardy Region, Northern Italy, within the provinces of Bergamo and Lodi and the Metropolitan City of Milan. Although the municipalities considered in the study are 12 (Table 7.3), it must be considered that the municipalities which have joined the Covenant of Mayors in these two provinces are numerous. The reason for this massive participation in the CoM scheme derives from the very great activity of the provinces of Milano and Bergamo in promoting the adherence of their municipalities to the Covenant of Mayors right from the initial stages of the project.

Table 7.3 General information of the municipalities under study (Dall'O' et al. 2018)

Municipality	Cod.	In. 2015	Area (km^2)	Density 2015 (in./km^2)	DD_W (°)	Date of signature CoM
Pioltello	# 1	36,912	13.11	2816	2404	05/03/09
Melzo	# 2	18,710	9.66	1937	2404	22/04/09
Bareggio	# 3	17,293	11.29	1532	2563	28/10/10
Lainate	# 4	25,708	12.93	1988	2505	30/04/10
Cinisello Balsamo	# 5	75,078	12.70	5912	2404	11/03/10
Cernusco S/Naviglio	# 6	33,436	13.32	2510	2404	20/05/09
Lodi	# 7	44,945	41.43	1085	2592	19/11/08
Canegrate	# 8	12,511	5.30	2361	2617	29/07/09
Cesano Boscone	# 9	23,792	3.99	5963	2404	31/03/09
Albino	# 10	18,171	31.32	580	2543	12/02/10
Villa Cortese	# 11	6,213	3.56	1745	2617	24/11/09
Garbagnate M.se	# 12	27,175	8.86	3067	2449	01/12/11

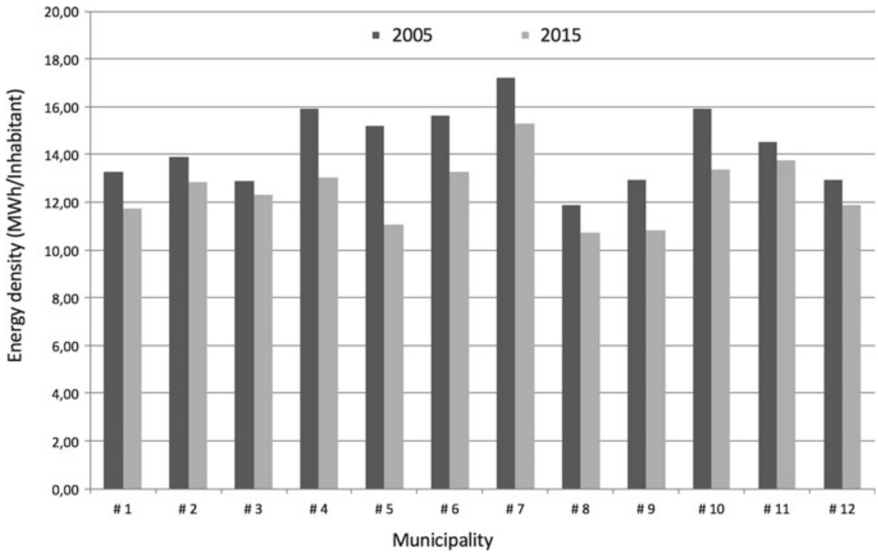

Fig. 7.5 Reduction of energy density between 2005 and 2015 (Dall'O' et al. 2018)

Considering the Italian context, the selected municipalities are of medium to small size. Regarding the winter climatic situation, responsible for energy consumption for winter air conditioning, the situation is homogeneous. Homogeneous is also the socio-economic situation of the chosen municipalities.

The reduction of energy density between 2005 and 2015 is shown in Fig. 7.5. The average reduction is around 10–15% except for the municipality of Cinisello Balsamo which marks a 27%: in this case, such a significant reduction could be the result of the construction of a new district heating system. For the municipalities of Melzo and Villa Cortese, however, the more modest reduction (around 5%) in consumption is due to a considerable expansion of the tertiary building sector (housing).

The calculation of energy consumption indicators of Fig. 7.5 refers to real consumption (end-users) based on the information officially provided by utilities which supply energy through networks (mainly electricity, natural gas, hot water supplied by district heating).

The data on the final consumption of the municipality intended as public administration (schools, public offices, public lighting, etc.) had to be added to the information contained in the energy bills for the reference year. According to the guideline for SEAP drawn up by the Joint Research Centre of Ispra (JRC), industry-related energy data has not been considered by all municipalities involved in our analysis.

The reduction in consumption between 2005 and 2015 depended on some objective factors that affected the 12 municipalities:

- implementation of energy planning policies (e.g. municipal energy plan);
- approval of a new building code that makes compulsory higher energy performance on higher buildings for both new buildings, renovations;

Table 7.4 General information of the municipalities under study (Dall'O' et al. 2018)

Energy vector	2005 (MWh/in.)	2010 (MWh/in.)	2015 (MWh/in.)	2005–2015 (%)
Electric energy	2.51	2.67	2.54	0.9
District heating	0.03	NA	0.22	538.4
Natural gas	8.24	7.20	6.64	−19.4
GPL	0.17	0.19	0.41	143.5
Heating oil	0.03	0.00	0.00	−99.9
Diesel	1.85	1.69	1.90	2.7
Gasoline	1.28	0.73	0.52	−59.5
Biofuel	0.02	0.06	0.14	672.5
Other biomass sources	0.22	0.20	0.16	−26.8
Thermal solar	0.00	0.00	0.02	11,611.8
Geothermal	0.00	0.01	0.01	70.2

- introduction of national economic benefits (e.g. financial support or tax deduction up to 65%) for citizens that invest in energy retrofit actions or invest in the use of renewable energy sources;
- diffusion of the energy labelling and promotion of energy audit of residential buildings;
- promotion of Energy Performance Contracts (EPC).

In the period 2005–2015, the energy sources used have evolved towards fuels with less environmental impact, as shown by the data in Table 7.4.

The economic benefits provided to citizens by the national government, mainly, greatly contributed to increase the market of energy retrofit and renewable energy sources in the residential sector (mainly substitution of windows, thermal insulation of the building envelope, thermal solar and PV solar, boiler replacement, installation of thermostatic valves on the radiators, etc.).

Research has focused heavily on this, and the summary of results is shown in Table 7.5 where the following evaluations can be obtained:

- identification of the actions included in the SEAPs of individual municipalities;
- identifying the most frequent actions in the different SEAPs;
- verifying the status of implementation of the actions (completed, ongoing, not yet started).

An examination of the table provides the following observations considering all the municipalities:

- 17 types of action have emerged, and none of these have been implemented on all municipalities;
- 30% of the actions are deemed to be completed, and 50% of the actions are ongoing;
- 20% of the actions are not yet started.

Table 7.5 State of implementation of planned actions in the municipalities considered in the study (Dall'O' et al. 2018)

	Public building energy audit	Design and implementation of energy-saving projects operated by ESCos	Design and implementation of energy-saving projects operated by ESCos	Acquisition of public lighting equipment and network	Public lighting equipment refurbishment	Interior lighting retrofitting
# 1	–	–	–	O	N	O
# 2	O	O	–	C	O	O
# 3	C	N	O	O	N	O
# 4	–	–	C	–	–	–
# 5	C	–	O	–	O	–
# 6	C	C	–	C	O	O
# 7	–	–	O	–	C	–
# 8	C	O	–	O	N	N
# 9	C	O	–	C	O	N
# 10	O	–	–	N	N	N
# 11	O	–	C	–	O	–
# 12	O	N	–	C	O	O

	PV systems on municipality buildings	Solar thermal plants on municipality buildings	Green public procurement	Gradual replacement of municipal fleet	Separated waste collection rationalisation	Pedestrian and cycle mobility development
# 1	O	N	O	O	C	O
# 2	O	C	N	O	O	O
# 3	–	–	–	O	C	O
# 4	O	O	C	O	–	C
# 5	–	–	O	–	–	O
# 6	O	O	N	O	O	O
# 7	O	–	C	O	–	O
# 8	P	O	–	O	O	O
# 9	O	O	N	C	O	O
# 10	C	N	–	N	C	O
# 11	C	–	O	O	–	O
# 12	N	–	–	O	O	O

(continued)

Table 7.5 (continued)

	Environmental zones, restricted traffic area	District heating realisation/renovation	Sustainable urban development—P.G.T. realisation and updating	Municipal Building Code (R.E.)	Urban Traffic Plan (P.G.T.U.)	Municipal Public Lighting Plan (P.R.I.C.)
# 1	O	C	N	–	N	–
# 2	O	–	N	O	–	N
# 3	O	–	N	C	O	–
# 4	–	–	–	C	–	–
# 5	C	C	C	C	–	–
# 6	O	–	O	O	O	N
# 7	O	O	O	O	–	–
# 8	N	–	C	C	O	N
# 9	C	C	O	C	N	N
# 10	N	–	N	C	N	C
# 11	–	–	–	C	–	–
# 12	N	–	C	C	N	–

	Energy front office for citizens	Web site and social network system	Zero miles to market	Events and training courses for energy stakeholder	Training courses for municipal technical staff	Environmental education for schools
# 1	C	O	C	O	C	N
# 2	C	O	–	O	C	C
# 3	C	–	O	O	O	O
# 4	O	C	–	O	C	–
# 5	C	–	C	O	–	–
# 6	C	O	N	O	O	O
# 7	C	–	–	N	–	N
# 8	C	N	N	O	O	O
# 9	C	O	–	O	C	O
# 10	–	–	C	N	N	N
# 11	O	C	–	–	C	–
# 12	C	–	–	–	O	O

C Completed; *O* Ongoing; *N* Not yet started

The scope of the COM was to accelerate the achievement of the target of reducing gas emissions by 2020. It is interesting to note that for as many as seven out of 12 of these municipalities, this target has been surpassed (some significantly) and the remainder is not far from this same target.

The overall assessment of the municipalities/local authorities of this study, taken as a group, is positive. The targets for the reduction of climatic gas emissions have been achieved by seven municipalities out of 12 with an advance of 2 years and the others are very close to this target.

Implementing and management of a SEAP have difficulties but the positive elements are many as follows:

- thanks to the SEAP, the municipalities are equipped with energy and environmental planning tools;
- thanks to the SEAP, municipalities implement and maintain an energy accounting function that involves the entire technical and administrative structure;
- the need to ensure a state of progress every 2 years (SEAP update and emission inventory update) makes this tool alive, which becomes a very useful tool for correcting the choices made.

This research has proven to be an element in comparison with what already exists: a comparison between sustainable planning policies is useful and synergistic, especially for small-sized communities such as those we have investigated.

7.4 Conclusions

This chapter has addressed the issue of energy planning on an urban and territorial scale, defined as Green Energy Planning. Considering the effects of energy on the environment, proper planning of energy resources contributes greatly to act against climate change.

In recent years, we have been living in a transition phase between a traditional energy model, based on the use of fossil energy sources and centralised power generation, and a sustainable model based essentially upon renewable energies, such as solar energy, biomass and wind energy and distributed power generation.

Imagining a new model of energy planning means referring to new paradigms, starting from the SDG 7, which aims to “ensure access to affordable, reliable, sustainable and modern energy for all”, and in the first part of the chapter some arguments have been provided which should be duly reflected upon.

However, energy planning cannot remain in the realms of theoretical speculation but is something for a concrete application. For this very reason, a reference model has been presented which obviously can be adapted to specific realities but which in its structure is fully functional for all cases.

In Green Energy Planning fortunately, we do not start from zero but many positive experiences have been made and many good practices can be used as models to refer to when defining actions. The Sustainable Energy and Climate Action Plans

(SECAPS), implementation tools of the European Project Covenant of Mayors, have been considered important references in this chapter, and for this reason they have been treated and deepened; in addition to considering the issue of decarbonisation, the SECAPS also take into account the climate risk and vulnerability assessment; dealing with these two closely related elements with an integrated approach is strategic.

Considering our urban areas, with their inefficiencies and their complexities, the energy transition towards a sustainable model is a process that will last a long time, but above all it is a process that requires an awareness and participation on the part of citizens. This is nonetheless the only strategy which can affect the necessary changes.

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