Technologies for creation or rehabilitation of urban neighbourhoods in energy-efficient communities

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Due to the rapid urbanization process, more than 50% of the world population lives today in urban areas, and considering the case of Portugal, this figure exceeds even 70% and with a tendency to increase. This continuous search for cities and the urban lifestyle, generates an increasing consumption of resources, and many of these are non-renewable. Energy is now intrinsically linked to technological development, given it powers all such systems. The use of fossil fuels to supply the required energy is causing global environmental and health issues and is impacting on all life forms on the planet. Therefore, it is necessary to replace fossil fuels with renewable energies, biofuels and eco materials and related technologies and to try and find a way to develop sustainable zero emission solutions for all urban areas.

The energy matrix in which cities were established is based on non-renewable and highly polluting forms. In this way, it is necessary to create urban strategies and technologies that allow the creation of energy efficient urban communities. So, this article aims to discuss energy-efficiency in communities, management systems and energy use strategies. As an example, they are presented Portuguese case studies of recognised merit.

Keywords: Efficient communities; Energy communities; Smart Grids; Urban districts.

1. Introduction

Buildings are still responsible for several negative impacts on the environment. Facing this, the need to improve buildings efficiency arises in order to reduce their environmental impacts, their resources use as well as contribute to reach the existing environmental goals.

It is necessary to extend the scale of

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action (from the building to the neighbourhood) and search for solutions to improve the energy efficiency of urban areas. This study presents several technologies that contribute for the creation of urban neighbourhoods in energy-efficient communities. It explains the benefits from these type of communities for the 3 dimensions of the Sustainable Development. Additionally, it also presents some examples of energy-efficient communities in Portugal with recognised merit.

2. ENERGY-EFFICIENT COMMUNITIES

Energy-efficient communities are communities which have adopted techniques and technologies that allow energy sustainability in a given urban area. This concept cannot be dissociated from the concept of efficient buildings.

2.1. Measures and Technologies

The following section presents some measures and technologies to act in the several fields of a community in order to turn it energy-efficient.

Passive design – These measures aim to turn new buildings more efficient and sustainable, through: building implementation and orientation to maximise solar gains and natural ventilation; building shape and design to maximize solar gains and natural ventilation; incorporation of passive solar systems; natural lightning potentiation; natural ventilation potentiation; and architectural elements.

Thermal Energy Transformation, Storage and Distribution – In a community there are buildings that produce an excess of heat. That heat surplus can be used to support buildings which present a deficit of heat production.

Domestic Hot Water – A similar scenario as the previous measure happens for Domestic Hot Water (DHW). Buildings like Hotels or Restaurants have high DHW needs. On the other hand, service buildings do not have such needs for DHW. Thus, there might be an interaction between these buildings' typologies, where the ones which have less DHW needs, provide the surplus for the one which needed the most.

Rain Water Reuse – Regarding the rain water reuse, again, synergies may be feasible. Lower buildings typically have higher catchment areas when faced with taller buildings (usually with less implementation areas). The collected rain water can them be shared in order to optimize is (re)use in the community. Likewise, at the public space level (as gardens or parking areas), rain water reuse systems can be implemented for irrigation and floor washing.

Grey Water Reuse – Grey water can also be reuse in the community through the existence of a treatment and filtering system (with shared costs by the community) and storage tanks. Grey water can be reused for irrigation, washing, toilet bawls, among others uses.

Solid Waste – To improve the waste collection efficiency, it is necessary to exist a common system for solid waste capture and storage. This kind of system avoid the waste cumulation on the streets (door to door collection), as well as the resources used in the waste collection (Figure 1).

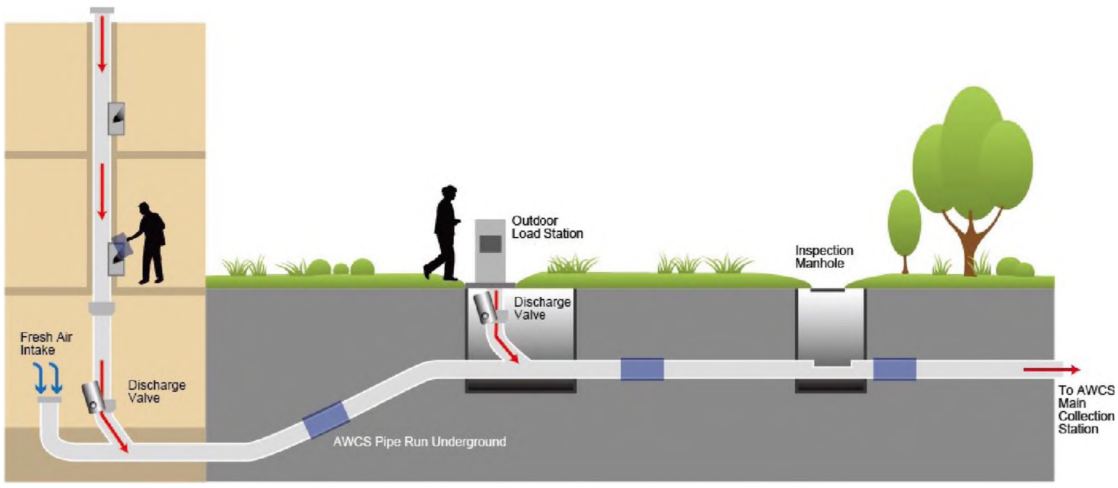

Figure 1 – Central system for solid waste collection

Electric Energy Transformation and Storage – Energy-efficient communities should be able to produce and use their own electric energy. To do so, it is necessary to optimise energy transformation in buildings and urban furniture/equipment's that have proper sun exposure. The transformed energy can them be used directly to supply the building or equipment in question and the excess storage in a central system or transferred directly to other buildings or equipment's with less or none energy generation capacity.

Electric Energy Distribution – The adoption of a parallel alternating (AC) and direct (DC) current system for electric energy supply to service buildings allow to directly supply lower tension DC equipment's.

Energy Use – All the community buildings must have smart energy meters. By proving information about the tariff, users will know the most economical time to turn on electric equipment, according to the current community energy transformation.

Mobility Management – Concerning the mobility, there are three main measures that can be adopted in energy-efficient communities: Parking lots share; Parking tariffs; Electric cars batteries can function as energy storage.

For the efficiency and application of such measures and technologies, a central management and control system must be defined. The system must also have jurisdiction over individual systems. The suggested measures are focus on new communities but, some of them, can be also applied in existing communities in order to increase their efficiency.

3. STRATEGIES AND MANAGEMENT SYSTEMS

The electricity sector is currently being strongly pressured by the current macroeconomic context. Thus, it has generated the creation of new challenges, which have led to the revolution of electrical networks and their way of interacting with users. In this context, the main concepts driving change in the electric sector are (MESSIAS, 2009): Environmental Sustainability; Consumer Empowerment; European Energy Market; Reliability and Quality of Supply.

3.1. Smart Grids

With the process of adapting and modernising energy supply networks to criteria of efficiency, sustainability, capacity, resource optimisation and reliability, the Smart Grid (SG) concept emerges. This concept is based on: the efficient use of energy, supported by effective demand management; in the bet on renewable energies; and the focus on micro production that reinforces the role of the user.

Unlike the traditional electric power system, which is based on large power transformers, close to the fuel sources, and which transmits the same through extensive high voltage lines, SG allows the integrated and secure automation of the networks by distributed energy generation, measurement and storage systems. This allows the network to automatically reconfigure itself through real-time analysis and diagnostics to effectively respond to the needs of society and the electrical system itself. SG benefit both the users and the companies providing the electricity supply service (ALVAREZ et al., 2016). Thus, SG promote strategic changes in the electric energy value chain, interconnecting all their stakeholders and potential stakeholders, as shown in Figure 2.

Smart grids enable strong functionalities on the network. These grids generating new services and optimised management and control, which count on the user participation. In this context, the European Parliament has been publishing directives promoting the development of Smart Grids. Of note is the most recent publication, Directive 2018/844, of 30 May 2018, amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency (EU, 2018).

4. RECOGNISED EXAMPLES

Modern power grids apply high standards to the ability to control all installations. In these networks, the distributed power generated requires a high degree of flexibility during distribution. In addition to the ability to control the electricity supply, these networks offer users new ways of influencing demand. Thus, there are already some different examples in Portugal of recognised merit.

4.1. InovGrid

EDP started in 2007 the development

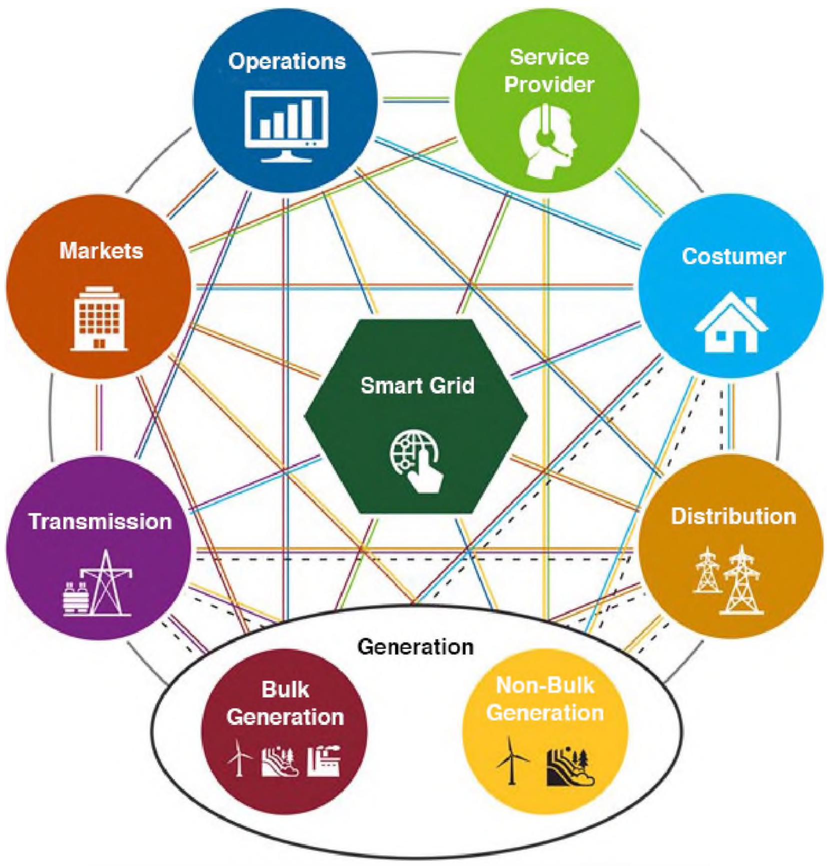

Figure 2 – Smart Grid connections (based on IEEE, 2018)

of a pioneering project that revolutionized the networks and its form of interaction with consumers, InovGrid. This project came about because of the growing need for energy optimization, the creation of more efficient and reliable energy management models, and the transformation of cities into innovative and intelligent spaces.

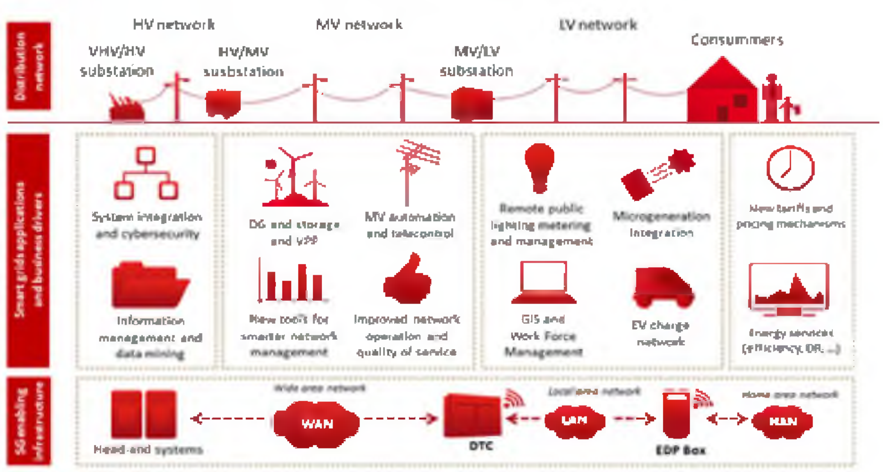

Figure 3 – The InovGrid project (CMS, 2018)

The technological innovation represented by this project has been implemented through InovCity, which enabled EDP to introduce the concept of Smart City in Portugal, Spain and Brazil. In Portugal, Évora was the first city to enjoy an intelligent and integrated electrical system. This experience covered 54 thousand inhabitants and installed 340 controllers of transformation stations and more than 30 thousand smart meters.

The implementation of InovGrid allowed to solve problems verified in traditional networks, with advantages at several levels:

- Housing - programming the operation of appliances for more convenient periods; manage real-time usage; to enjoy services and price plans adjusted to the usage profiles; using integrated home automation solutions to interact with the devices; remotely activate services such as tariff and power changes; transforming energy at home, for own use or for sale to the grid; to make energy management more efficient, through the online consultation of the balance of use and transformation;
- Enterprises - creation of industrial projects and job creation and export skills centers and scientific research projects in collaboration with academia; use of innovative tools for detailed and reliable control; adjust energy use to activity; offer more and better products;
- Public spaces - replacement of traditional lighting and traffic lights by LED technology, allowing the reduction of electricity use; regulation of lighting according to natural lighting conditions; the adoption of dynamic control systems that manage the luminous flux depending on the road or human presence, the state of ambient light and the environmental conditions.

4.2. ClimaEspaço

ClimaEspaço is a company of the ENGIE Group, which produces and distributes cold and heat to the buildings of the *Parque das Nações* for twenty years, in the form of cold and hot water. This is responsible for the introduction in Portugal of the concept of centralised distribution of thermal energy to urban scale. The thermal energy is produced in a high efficiency trigeneration plant, distributed to 150 buildings through a network of pipelines with 85 km of extension, some of which are installed in technical galleries, being its main use for the production of hot sanitary water. The cold production equipment is cooled by water collected in the Tejo river, which is then returned to the river without environmental impact (ENGIE, 2017).

Parque das Nações is known for the architectural quality of buildings, and it was thought safeguarded that, through specific legislation (Ordinance n. ° 1130-B/99), the use of conventional climate control systems in buildings was prohibited. This network of cold and heat allows the existence of free facades, as well as free terraces and balconies from air conditioning units. This new area is expanding, which was initially confined to the perimeter of EXPO'98 exhibition park. Thus, with it, membership in this Network has also been growing, as shown in Figure 4.

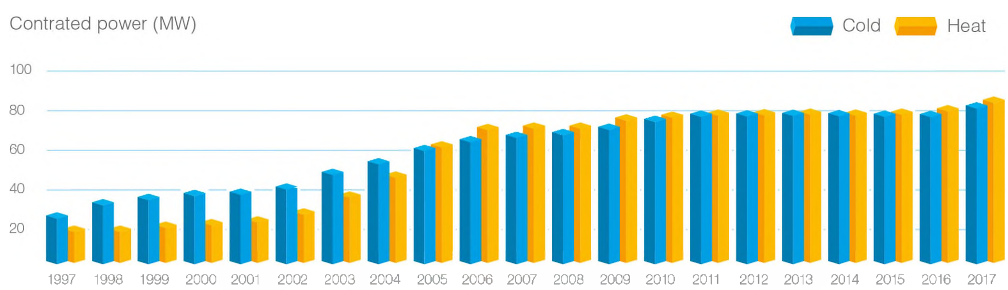

Figure 4 - Evolution of contracted power (ENGIE,2017)

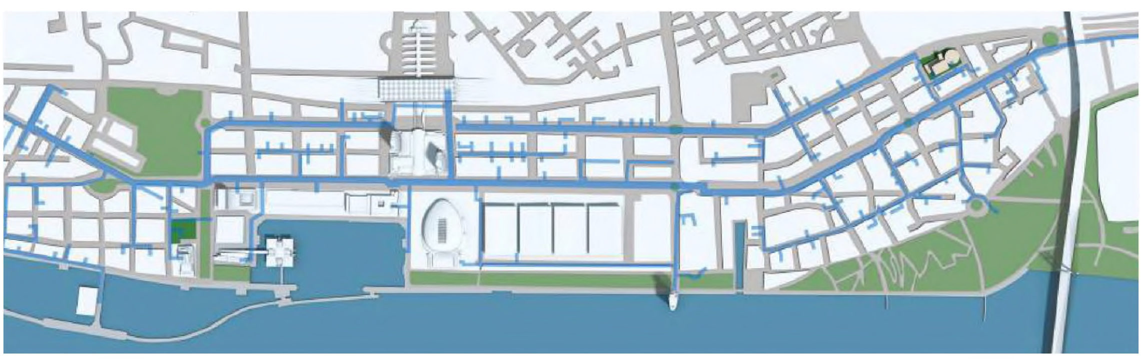

Figure 5 - Network of distribution of cold and heat of the Parque das Nações (ENGIE, 2017)

The distribution network is 21 km long and is composed of four pipes (going and return of cold, going and return of heat). The main sections are installed in technical galleries in order to facilitate maintenance operations and avoid trenching on the public road. Thermal energy is distributed as ice water (4 °C) and hot water (90 °C) (ENGIE, 2017).

Contrary to what happens in conventional thermoelectric power plants, the trigeneration plant takes advantage of the heat released at the exit of the turbine, taking advantage of an amount of energy that would otherwise be wasted. In this particular case, this energy is used to heat and cool buildings, to produce hot water and for other purposes, such as heating swimming pools or cooling the tanks of the Lisbon Oceanarium. This results in an important gain in efficiency, minimising primary energy consumption and pollutant emissions (Figure 5).

5. CONCLUSIONS

Many efforts have been made to make the built environment more sustainable, meeting human needs from an environmental, social and economic point of view. For this, methods of sustainability assessment were developed, first the evaluation of the performance of buildings and later to a larger scale, the urban scale. From the urban scale point of view, at the community level, there is a need to adopt more efficient and sustainable processes and technologies that lead to a reduction in the use and waste of resources and energy, among others. In this way, there is a need to seek solutions to improve the energy efficiency of urban areas.

This article presents a few technologies that contribute to the creation of energy-efficient communities. The benefits of these communities are notorious at the three dimensions of sustainable development: Environmental (reduction of consumption of natural resources; reduction of waste production, and reducing the emission of polluting gases); Social (social welfare, efficient mobility, and security); Economic (economic development; and reducing costs with shared-use infrastructures). In addition, two examples of recognized merit developed and implemented in Portugal were presented, InovGrid, developed by EDP in 2007, and ClimaEspaço, developed in 1998.

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