Urban Renewable Energy Communities and Energy Poverty: a proactive approach to energy transition with Sun4All project

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Urban Renewable Energy Communities and Energy Poverty: a proactive approach to energy transition with Sun4All project

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Abstract. The transition to an environmentally sustainable, low-carbon economy requires fundamental transformations in various sectors such as industry, technology, and especially in society as a whole. Adopting and encouraging community energy are the key policies to facilitate sustainable energy and ecological and social transition. The Sun4All methodology aims at the design, promotion and building of energy communities based on solidarity, to contrast energy poverty and foresee the engagement of vulnerable households that normally have many difficulties in becoming active members of an energy sharing project realising PV plants. The selection of the beneficiaries' families in the urban context is a process both technical, including socio-territorial GIS-based analysis, and social, activating the participation of grass-root associations, local schools, and facilitators. The strategic role of the municipality is coherent with the SECAP and results in the offers of several public building roofs with PV plants that are the cores of the Sun4all Energy Communities and will ensure the delivery of economic benefits for the vulnerable households, while through workshops, site visits to the plants, and communication activities will increase the citizens' knowledge. The purpose of this paper is to explore the benefits that go far beyond energy efficiency, which is only the starting point.

1. Introduction

Climate change poses an existential threat to Europe and the whole world. Global, European, and national institutions are aware of this change and have set targets in the direction of carbon neutrality.

The Paris Climate Agreement (PA), adopted by 196 Parties at COP 21 in Paris, set the goal of limiting the increase in global average temperatures to less than 2 degrees Celsius above pre-industrial levels, preferably 1.5 degrees Celsius [1].

The Clean Energy for All Europeans package, adopted in 2019, by the European Union, stands as a landmark in the new era of energy policies. The European key targets for 2030 include a 40% reduction in greenhouse gas emissions, compared to 1990, 32% share of renewable energy sources in energy consumption and a 32.5% improvement in energy efficiency. Achieving these ambitious goals poses challenges and opportunities for the development of innovative supply systems [2] or improving the existing ones [3] that put European consumers 'at the centre', as the main actors in the energy transition, to reduce carbon emissions and attain carbon neutrality [4] in compliance with the available local sources [5].

An equitable and inclusive energy transition is part of the Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda [6]. An equitable and inclusive energy transition can catalyze transformative co-benefits for the achievement of the Sustainable Development Goals (SDGs), in particular SDG 7: Affordable and Clean Energy [7]. Energy can create transformational opportunities [8] if connected to the resources [9] and their sustainable use [10] as well as supported by data [11].

Access to affordable, reliable, sustainable, and modern energy for all enables the achievement of the other SDGs; for example, transforming the energy system can reduce inequalities, create new jobs to combat poverty, promote economic growth, and promote responsible consumption and production [12].

One of the objectives of the recent European Directives in this area ((EU) 2018/2001 and (EU) 2019/944) is to facilitate the creation of new energy communities to promote self-consumption of electricity and decentralized activities in the sector, namely: producing, consuming, storing, sharing, and selling electricity [13] [14]. The EU legislative framework defines two specific types of community energy: "renewable energy communities" and "citizen energy communities". Both definitions indicate a way of 'organizing' the voluntary cooperation of an energy-related activity, with specific ownership and governance. They are non-profit and their main purpose is to provide environmental, social, and economic benefits to the community by matching load and production [15] and to provide eventual energy efficiency measures [16]. Renewable energy communities (REC) can generally be seen as a subset or particular type, of citizen energy communities (CEC). This contributes to defining a specific geographical scope of the activities of RECs compared to CECs [17].

The RED II enables the acceleration of an equitable and sustainable energy transition by facilitating the implementation of "Renewable Energy Communities" (RECs), key to combating climate change and energy poverty. [18]

2. Energy community and energy poverty: a virtuous model between energy efficiency and social justice

When households are unable to meet the energy costs necessary for domestic consumption (heating, cooling, lighting, and energy to run domestic appliances), there is a social problem: energy poverty, a widespread and internationally known phenomenon.

Energy poverty is a significant socio-economic problem and one of the major residential challenges in the building sector for the EU; an EU-wide survey concluded that in 2020, 8% of the EU population said they were unable to heat their homes adequately. [19]

The European Commission defines energy poverty as "a situation in which households are unable to access essential energy services" and as the "inability to keep homes adequately warm" [20].

In France, for example, the "Grenelle II" Act defines energy poverty as "a situation in which a person has difficulty obtaining the necessary energy in their home to meet their basic needs because of inadequate resources or living conditions". [21]

An Integrated National Energy and Climate Plan, Italy define energy poverty as "understood to mean the inability to purchase a minimum energy basket of goods and services or a situation where access to energy services entails a diversion of resources (in terms of expenditure or income) higher than the socially acceptable level" [22]. This definition, in line with those adopted by the main Member States of the European Union, defines a perimeter of citizens which could largely coincide with that identified by the notion of poverty tout court.

The fight against energy poverty is particularly relevant in the context of EU energy policies.

Directive 944/2019 requires Member States must implement measures to address energy poverty.

The main instruments for fighting energy poverty used in Europe can be grouped into the following categories:

- Support for the energy efficiency of residential buildings;
- Bill payment support and social tariffs;
- Energy advice aims to promote the rational use of energy, in some cases also through the distribution of low-consumption appliances [23].

In Italy, the position paper 2019 by ENEA (National Agency for Energy and Environment) presents a very complex set of measures to contrast energy poverty operating both for the tools used and for the division of responsibilities between the various levels of government of the territory, as well as related availability of energy sources [24] and grid interaction [25]. Among these measures is not only the bonus in terms of energy bill reduction but also the access to public incentives for energy rehabilitation of households. It should be noted that incentives in the form of a tax deduction do not allow families in economic hardship to benefit, also due to the difficulty of their accessing bank credit to anticipate spending.

Worldwide, the emergency resulting from the COVID-19 pandemic and the subsequent economic crisis is increasing the number of poor people. The situation in the EU Member States is different. European people most affected by energy poverty were recorded in Bulgaria (30.1%), followed by Lithuania (26.7%), Cyprus (21.0%), Portugal (18.9%), Greece (17.9%), and Italy (11.1%). This number is almost three times higher when we consider the population below the poverty line – below 60% of the median equivalent income [26].

Energy communities represent an innovative strategy to respond to the growing need to fight energy poverty and citizens' participation in the energy transition, with a view to self-consumption and collaboration [27]. Each energy community has its own specific characteristics, but they all have the same goal: to self-produce and provide affordable renewable energy to their members.

Wind, photovoltaic, biomass and hydroelectric plants are all forms of electricity generation from renewable sources, as is distributed generation (DG). The main goal of energy supply is to ensure its reliability for users and minimize their expenses, but many renewable energy sources are variable on short and long-time scales (hourly, daily, monthly). The choice of renewable energy sources to fight energy poverty and improve environmental sustainability depends mainly on the geographical and climatic characteristics of the context.

For example, wind energy can be produced in energy communities in two ways: with micro wind turbines at the household level or with large-scale wind turbines at the EC level. There are a few examples in the literature of ECs powered solely by wind microturbines [28], mainly in Northern Europe (Belgium, Denmark, France, Germany, and Sweden), as a wind turbine with both a vertical and horizontal axis requires a minimum wind speed (cut-in) of around 4 m/s in a constant direction. Studies have shown very low performance for a micro-wind turbine in an Italian urban area for most of the year, and the technology has been deemed unsuitable or economically disadvantageous [29].

An example of communities using biomass from local agriculture and forestry resources is found in Germany: Bioenergiedorf Jühnde is the first village. Hydroelectricity is the least widespread energy source. In Sweden, for example, eight rural communities operate various forms of production with a local focus, in particular hydropower, heat or energy-saving schemes.

According to a European Energy Communities 2020 report, solar and wind are the most widely used technologies [30].

Energy community members become active players in the management of energy flows and are therefore defined as prosumers [30]. Indeed, it is crucial to know how the loads are composed [31] and what strategies to implement [32] to make them enablers of the energy transition [33] in relationship with the National Power Grid [34].

Walker and Devine-Wright [35] identified two main dimensions of the energy community: one is the "process", which involves the financial participation and the development control of an energy initiative by local people, and the other is the "outcome," which is more about how the benefits are distributed in the community.

Community energy and collective energy self-consumption initiatives are emerging all over the world [36]. For example, Solar for All is a program administered by New York State that allows vulnerable consumers to be an active part of the energy transition by enabling their participation in community solar projects. Solar for All builds on the New York State Energy Research & Development Authority's (NYSERDA) extensive experience with community solar [37]. Taking advantage of virtual net metering facilities in place in the state, community solar allows anyone in the vicinity of a solar

power plant to subscribe to and access clean and affordable power and get tangible benefits on their energy bill.

This approach benefits households that want to invest in solar projects but do not have the capacity due to investment limitations or space limitations on the rooftop. Using available areas in the region, community solar can also deliver scale benefits, making the projects' finances more attractive and adding benefits to subscribers. Indeed, the larger the scale, the larger the storage and the self-consumption is [38]. The project can be financed by a private company and/or the members/subscribers. Shared ownership is also a possibility, as is the possibility of being a simple subscriber. Given the fact that this approach has limitations regarding the inclusiveness of all citizens, New York State launched the Solar for All project. It is similar to community solar but targets users who could not or would not participate in these initiatives. This means that a large part of the investment is made by the New York state budget, which, after a competitive bidding process under New York State procurement rules, selects a company to deliver the project and sell the electricity. This is then bought by NYSERDA on behalf of low-to moderate-income households across the state. Households that qualify under the Solar for All scheme will then receive the electricity at no cost, which amounts to $5–15 dollars a month. To be eligible, households must rent or own their home and check income eligibility. The program relies on voluntary applications from customers and is boosted by significant on-the-ground outreach, extensive digital marketing, and support from local/regional partners such as housing providers or local community organizations.

There are some 3,500 so-called renewable energy cooperatives—a type of energy community—in Europe, mainly located in north-western Europe [39]. Germany and Denmark have the highest number of citizen-led energy organizations.

In Italy, before the RED II directive, there were already many communities and energy cooperatives focused on the sharing of energy, also renewable energy, among the associates. Located mainly in the northern peninsula, some of them, were active already in the first decades of the twentieth century, such as the 'St. Magdalena Electricity Company," founded in 1921 in the small municipality of Funes by three farmers and a craftsman.

3. Sun4all project methodology

Decarbonization, through the replacement of fossil fuels with renewable energy and the creation of Energy Communities, has been addressed for many years at the international level and also at the national level through, for example, participation in European projects for elaborating the techno-economic framework [40] and driving energy refurbishment [41]. Ensuring that vulnerable households have access to renewable energy is equitable, helps to cover energy needs, and can support multiple policy goals, such as affordable energy, job creation, and improved public health. Although the need is great, many households may not be able to afford RES installations or may be inhibited from participating in the energy transition for other reasons such as lack of access to information, difficulties accessing finance or ownership patterns.

Energy Communities are at the heart of the European Sun4All project[1] [42]. The Sun4All projects build upon the Solar for All New York programme and will deliver 4 different pilots where a similar methodology will be tested, implemented and adapted to the European and local context (Barcelona, Communes du Coeur de Savoie, Rome and Almada). By coupling this approach with direct energy advice to consumers and community involvement, an inclusive approach to energy transition will be attained, bringing extra benefits and improving the living conditions of those involved.

The Sun4All project aims to increase access to renewable energy generation and its environmental and economic benefits for vulnerable energy-poor households that would otherwise be unable to invest in solar installations.

[1] This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 101032239.

This project supports an inclusive energy transition process towards sustainable energy production in Europe by offering financial, as well as non-financial support, to beneficiaries. The financial support provided by making participants co-owners of local photovoltaic systems at no cost and the solar energy produced by the photovoltaic systems will lead to a reduction in actual energy costs.

The project participants will also receive advice on efficient energy management at home and will be able to participate in energy efficiency workshops; this will promote the empowerment of participants.

Sun4All support project will be scaled up across Europe.

Figure 1 explains the methodological approach developed within the European Sun4All project.

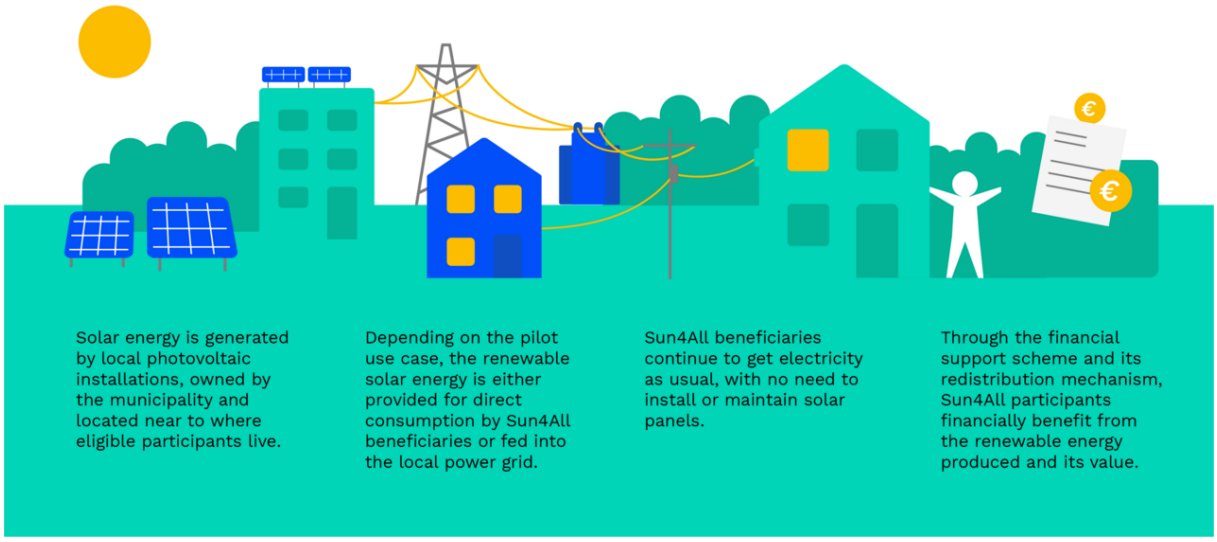

Figure 1. The main concepts of the European SUN4ALL project (Source: https://sunforall.eu/about/sun4all-project)

4. Case study: a pilot project in Rome

Rome has a population of about three million inhabitants, split into 15 town halls as large as an average Italian provincial capital.

The Sun4all Rome pilot is structured to implement the following tasks:

- Selection of 200 beneficiaries/end-users through a public open call coordinated by the Department of Social Policies and Health;
- Selection of PV plants on municipal roofs in the proximity of beneficiaries/end-users;
- Promotion and citizen engagement: activities carried out by experts, with competencies in socio-territorial animation;
- Definition and monitoring of energy poverty (KPI);
- Communication addressed to beneficiaries and other new participants.

According to its local Energy and Climate Action Plan (PAESC – Piano d'Azione per l'Energia e il Clima), around 100,000 households, located in Rome and its suburban areas, are affected by energy poverty [43]. Therefore, the City of Rome, one of four pilot locations of the Sun4All support scheme, aims at complementing already existing measures against energy poverty by establishing the Sun4All program.

The beneficiaries will be identified through a multi-criteria procedure. Among the criteria of selection are the low income, the previous request of the family to benefit from Bonus Energia, the declaration of willingness to actively participate, and other energy poverty indicators, i.e. belonging to social housing blocks, the state of preservation of the buildings. ISEE indicator (equivalent economic condition indicator for families) will be used to finalize the public Open Call to select the beneficiaries

of the Sun4All Energy Communities, in coherence with the criteria to access Bonus Energia (24.000 families have already requested and accessed these incentives until 2021).

Vulnerable urban contexts will be privileged during the process of beneficiary selection.

The initial proposal foresaw two cycles for 50+50 beneficiaries, but several operational aspects, including management procedures, and the intention to have an impact proportioned to the size and resources of the city, forced an increase in the number of beneficiaries to 200 vulnerable households.

Rome's strategy is to select buildings managed by Roma Capitale, mainly schools, with photovoltaic systems on their roofs as PV plants for the pilot.

Thanks to a spatial analysis with GIS tools for the territory of Rome Capital clusters of vulnerable households around available PV plants can be identified.

The proximity approach is pursued in synergy with the aggregative capacity of the schools in the territory where the pilot falls, so school buildings hosting PV plants will be privileged within the assets of the Rome Municipality. Schools will play the role of local identity and cultural-educational centres.

Through a GIS analysis led by CITERA-Sapienza GIS-BIM laboratory in the first phase of the work, it was possible to identify several areas meeting the requirements of S4A Energy Communities in terms of PV plants and specific socio-urban characteristics. An overlay analysis has been started to map:

- distribution of households (24.000) already benefiting from the "Bonus Energia 2019" that represents the main indicator for energy poverty in Rome.
- area with municipal PV plants accessible within a distance of 1 km.
- areas/districts with low-quality buildings and socio-economic disadvantages
- Presence and location of grass-root associations and other initiatives that can be considered cores of aggregation to facilitate citizens' engagement.

The more recent initiative to be considered as a strategic plan is the SECAP 2020-2030 adopted by the municipality, which, in compliance with the Covenant of Mayor's requirements, assesses the whole action plan with the Energy Poverty analysis key, and the plan foresees specific actions to develop Energy Communities in Rome.

In the SECAP of Rome, the integration of initiatives for energy sharing and energy poverty contrasting is well envisaged resulting in strong support for the Sun4All project.

Roma Capitale administration is adopting the definition of “energy poverty” applying several indicators following the suggestion coming from the JRC report on Energy poverty.

To improve the energy efficiency of the beneficiaries’ houses and their behaviours the energy consumption will be collected (Bills and data from 4G meters). These data will consent to assess profiles and to orient through a direct communication the energy efficiency best practices case by case as demonstrated in other studies for innovative energy strategies [44]. GDPR procedure adopted will grant the use of this data for the project purposes.

Data coming from PV plants and related to the self-consumptions of school buildings are collected by Infrastructure Development and Urban Maintenance Coordination Department – SIMU (Municipality Roma Capitale) and will be used, compared to the end user’s consumptions profiles, to evaluate the energy sharing quote.

All stakeholders involved – institutional, technical, educational, third sector and civil society – will contribute to engaging households with specific attention to the needs related to energy poverty conditions and to the importance of turning them into active actors for the energy transition.

4.1 The main strategy to implement the Pilot in Rome

The local distribution system operator (DSO) in Rome is ARETI (Group ACEA owned 51% by the municipality) and represents the privileged player to enable the Bonus Energia (Reduction in the Energy Bills of Vendors) in favour of the selected beneficiaries. The municipality can transfer part of the public incentives derived from the existing RES plants to the DSO. The DSO will move quotes to the Vendors that will reach the beneficiaries with the benefits and with focused communication (see figure 2).

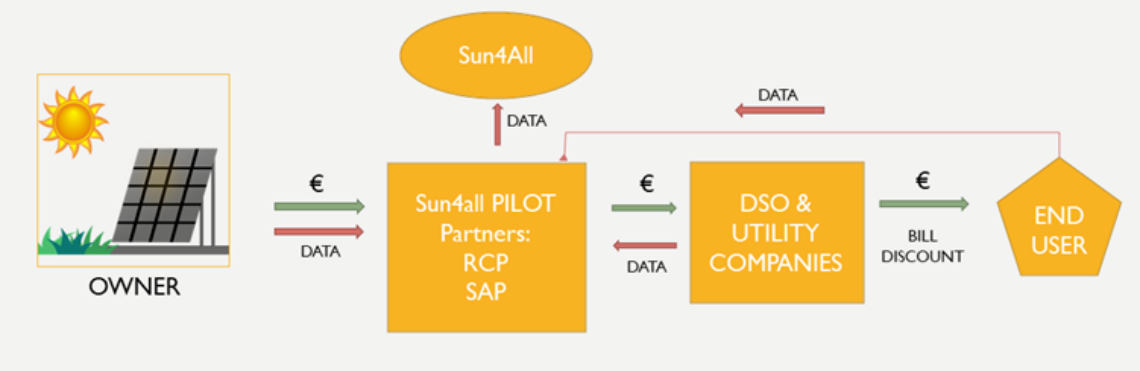

Figure 2: A schematic approach to Rome use case "DSO & Utilities"

The formal REC is not necessary for this scheme and is not admissible, as it is using existing PV plants built before March 2020. Energy Communities are enabled through citizens' engagement around the selected PV plant.

Rome Municipality will establish several energy communities with the selected beneficiaries and with the support of GSE, SGAte and ACEA-ARETI DSO will be responsible for managing the data flows and monitoring the financial flows to the end-users to provide them with the benefits (discounts, REC membership, services foreseen in the S4A pilot). The direct connection with the beneficiaries will also be provided by facilitators and social animators coordinated by CITERA Sapienza research centre which will support the management and overall activities of the communities.

5. Conclusion and Future Development

Energy is a fundamental issue within the challenges and opportunities of today's world because it is closely linked to all dimensions of sustainable development; energy is the main contributor to climate change; in fact, its production and use account for 75% of EU emissions and has an impact on society's health and work, education, gender equality, and security [45]. The energy transition entails a social transformation in which citizens will play a crucial role [46] together with the crucial role of energy modelling [47]. Environmental degradation is closely linked to social degradation, which can be measured by the decrease in social equity. Social equity includes social justice and economic equality, which are closely linked to energy, and indispensable for defining human identity [48]. The goals of the project presented here, in line with the main policy documents, start from the decentralization of energy production to strengthen citizens' sense of responsibility and increase their economic, social, and technological autonomy. Environmental and energy crises must be able to generate bottom-up responses in new forms of energy management, self-production, and sharing. In this context, the opportunity to organize energy communities for the sharing of renewable sources is an opportunity for all civil-society components to boost innovative actions based on solidarity and knowledge. Solidarity and participation are the levers that should be integrated with information and training initiatives to improve the living conditions of the part of the urban population in energy poverty and to build an environmentally sustainable society.

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