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Abstract. By describing an experimentation carried out on a 'informal' settlement in the far north east outskirts of the Municipality of Rome, the paper aims to demonstrate in which way outskirts can become an extraordinary opportunity to activate processes of smart urban regeneration. The paper describes a project developed on the area of Tragliatella in Rome, with the aim of developing a codified design methodology for the recovery of unauthorised residential settlements in the outskirts of the city, lacking primary urbanization works and essential services, and requiring redevelopment processes in order to ensure their liveability. The project proposes a smart model linked not only to the energy performance of the buildings, rather to all the other environmental parameters of the urban settlement (i.e. soil permeability, heat island effect, micro-climatic comfort in outdoor spaces, etc.). The experimental design approach, outlined in this paper, could be effectively transposed to other fragmentary suburban settlements, characterized by the low quality level of the houses, whose origin is not necessarily spontaneous.

Keywords: Energy districts, Energy positive blocks, Renewable energy sources, Informal city, Smart grids

Research framework

In this paper the term “informal city” refers to those areas, part of the outskirt of large cities, developed in unauthorised fashion. Illicit constructions, born as a spontaneous remedy to the shortage of housing, over time become a full-fledged part of the urban construction system, to the point of being acknowledged by government bodies and authorities as well. In the case of Rome, more than a third of all residential housing was built in unauthorised fashion, and more than a third of the city's population lives in areas originally developed without legal approval (Celamare, 2013).

The present research focuses on the recovery of these settlements, through a set of sustainability strategies not limited just to the energy issues, but aimed at rebalancing the flow of resources within the system and with the rest of the city. By operating in systematic fashion to increase the density and complete the fabric of the “informal city”, a process of renewal that aims to restore the environmental balance of the city can be set in motion. Most importantly, promoting the transformation of these areas of spontaneous growth can favour a reconversion of the city's energy system. By means of neighborhood and building-scale regeneration operations, such settlements can generate most of their energy from renewables but, moreover, be able “to generate sufficient flows of energy, water, and waste to enable potential borrowing, balancing, and stealing among systems” (Fraker, 2013). This approach is part of the international literature framework of design studies and experimentations on sustainable neighborhoods, conducted over the past 20-30 years. A context characterized on one hand by experimentations on the creation of new self-sufficient settlements, such as: Bo01, between Copenhagen, Denmark, and Malmö, in Sweden (1996-2001); Hammarby Sjöstad in Stockholm (1993-2015); the Solar City Linz (1995-2002); BedZED in Wallington, London (2002);

the Vauban in Freiburg (1998-2000). On the other hand, the most recent experiments concern the regeneration of urban sectors with the achievement of eco-district standards, as in the particularly relevant case of the *Clichy-Batignolles* district in Paris (2002-2020); or even systematic urban-scale interventions to reduce CO₂ emissions, such as the *Glasgow City Energy and Carbon Masterplan*.

In line with these experiences, the experimental project proposed in the paper introduces innovative construction and technological systems but above all specifically declines the sustainability strategies on the spontaneous settlements of the Roman metropolitan context. In this way, environmental strategies are adapted to the crucial objective of the recovery of the informal city, in which the consumption of soil has generated imbalances to be recomposed with a systemic approach that looks to the suburbs as a resource for the environmental rebalancing of the whole city.

Tragliatella: a case study for the regeneration of unauthorised settlements

This experimental research has been solicited by the Municipality of Rome with the aim of developing a codified design methodology for the recovery of unauthorised residential settlements in the outskirts of the city, lacking primary urbanization works and essential services, and requiring redevelopment processes in order to ensure their liveability. The unauthorised suburban areas, built as spontaneous settlements in response to the lack of social housing in the outskirts of Rome, have been under attention by the administration for over 30 years. In the last decade the administration of the Municipality of Rome has proceeded to the delimitation of their perimeter. Named *Toponimi*, these built areas of illegal origin occupy about 4.000 hectares of the Roman metropolitan area, subdivided into 71 zones¹. The Municipality has defined a specific regulatory procedure for the recovery of these areas, named *Executive Plan*², which regulates the completion of the urban fabric by increasing its density³ with the construction of new houses. At the same time, the Plans identify the areas for the missing primary and secondary urbanization works. Through the tool of the *Executive Plan*, the Administration tries to fill the structural deficiencies of public and private services that characterize the *Toponimi*. The aim is to “mend” the fragmentary urban fabric, enhancing their vocation as “autonomous” settlements, in an overall vision of Rome as a polycentric metropolitan city.

Citizens are an active part of the recovery process: they participate and monitor the hypotheses of the public administration through specific associations called *Consorzi di Autorecupero*⁴.

The area of this experimental research, the Toponimo of Tragliatella



01 | Tragliatella's Geographical Context

tella, was identified through a process that involved the University, the Municipality of Rome and the local Consorzi di Autorecupero, who participated in the development of the project and evaluated its outcomes.

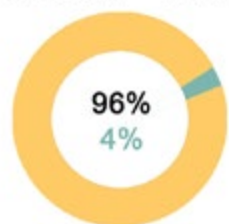
Tragliatella is a formerly illegal settlement, located in the north-western sector of Rome, on the border with the Municipality of Anguillara Sabazia. Tragliatella has an overall extension of about 147,04 ha, of which 22 ha are destined by the *Executive Plan*⁵ to accommodate public spaces and services, including schools, as well as to the completion of the road network. Currently, Tragliatella has about 3.900 inhabitants while, according to the *Executive Plan*, at the end of the recovery process it will host 7.794 people.

The first illegal buildings in Tragliatella were built in the 70s. The relative proximity to the city of Rome (about 50 minutes by car), the presence of small urban centres bordering the area, reachable in a few minutes by car, the agricultural and rural context and the possibility of glimpsing the sea were the main elements of attraction for the new inhabitants. In a historical period of deregulation, they counted on the possibility of a fast *Condono* (regularisation procedure) and on the subsequent realization of the primary infrastructures by the Administration. The settlement grew spontaneously with continuity until 2003 without the necessary infrastructures (roads, sewers, public lighting, water

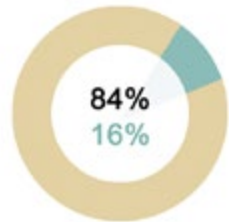
purifiers, schools). Today the area is affected by a significant state of decay, with the existing buildings having a poor quality and low energy performances. Public spaces and services are lacking, most of the roads are unpaved, without public lighting, and only part of the settlement has been equipped with a sewage system.

Objectives of the project and stakeholders' involvement

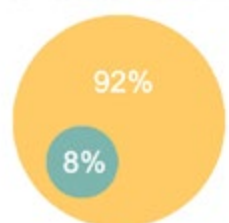
Through an experimental project carried out on the case study of Tragliatella, the Research Group⁶ has developed a set of strategies to turn the neighbourhood into a model sustainable suburban settlement, self-sufficient in terms of energy, resources and economy, by enhancing the rural characteristics of the context. This objective derives from a systematic dialogue between the Research Group and the stakeholders involved in the process: Municipality of Rome - Urban Planning and Implementation Department, Alessandro Coppola; Roma Resiliente, Coordinator Iolanda Fiori; Consorzio Periferie Romane, Luciano Bucheri; Comitato di Quartiere Tragliatella, Nino Bufalini. The whole Working Group shared the will to integrate the *Executive Plan* with sustainability strategies, in order to boost the environmental, social and economic potentialities of the neighbourhood. Through periodical meetings, the Working Group progressively checked



POTENTIAL S.U.L. mq 996.937
84% residential 16% non residential



OVERALL S.U.L. mq 3.276.070
92% residential 8% non residential



Research methodology and design strategies

The present experimental research was carried out according to an iterative model, which required the application of methods and tools, useful for representing the information in a reticular form and for evaluating alternative regeneration scenarios applied to the study area. The first phase of the research has seen a confrontation for the selection of the Tragliatella pilot case with the Operative Unit dedicated to the Recovery Plans of the *Toponimi* within the Municipality of Rome, and the *Consorzi di Autorecupero*. In the subsequent research phase of methodological formalization, the Research group organized a series of surveys on the area, interviews and questionnaires with the citizens and meetings with the stakeholders. Afterwards, two different levels of analysis and design experimentation were tackled, at the urban scale and at the building scale, in order to produce a masterplan proposal.

Urban level

At the basis of the development of the masterplan there is the application of qualitative and quantitative analysis of the characteristics of the territory, with reference to both the metropolitan area of Rome and to the specific area of the Tragliatella district. In fact, only through a targeted cognitive analytical investigation, it is possible to define an innovative settlement model, both on the environmental and on the economic and social side by identifying the local sources of renewable energy available, the characteristics of the territory that can activate small-scale economies, the potential of urban spaces to foster social inclusion and quality of life.

The analysis of the *Natural System at the urban scale* made it possible to verify the presence and size of extensive crops (cereals

and adapted the proposed development model for Tragliatella. The research was presented in several public meetings attended by the Municipality of Rome and the *Consorzi*. Among these, the most important are the one held in an intermediate stage of research development, aimed at communicating the proposed intervention methodology for the regeneration of Tragliatella⁷; the second one dedicated to the presentation and discussion of the results of the application of the methodology itself⁸. Both meetings were an opportunity to establish a dialogue between the stakeholders involved, not without moments of strain due to the need to combine different positions.

Finally the model was considered appropriate both by the Administration and by the citizens' associations: the first in fact had sensed the possibility of recovering a compromised territory, consumed by a disorderly construction, while simultaneously reducing the burden of travel to the city; the second believed that a more ambitious process than the realization of the basic infrastructures would allow the economic and social development of the community of Tragliatella, the increase of the architectural quality and the consequent valorisation of the area.

Based on this premise, the project aims at turning Tragliatella into a model of *circular district*, replicable in the recovery of urban suburbs, achieving a high level of:

- functionality and liveability of the urban habitat;
- architectural, environmental, energetic and technological quality of buildings and open spaces through affordable solutions;
- energy efficiency and ecological effectiveness of the proposed urban structure through the application of networks for the distribution of information and energy.



03 | Typical Tragliatella's Buildings

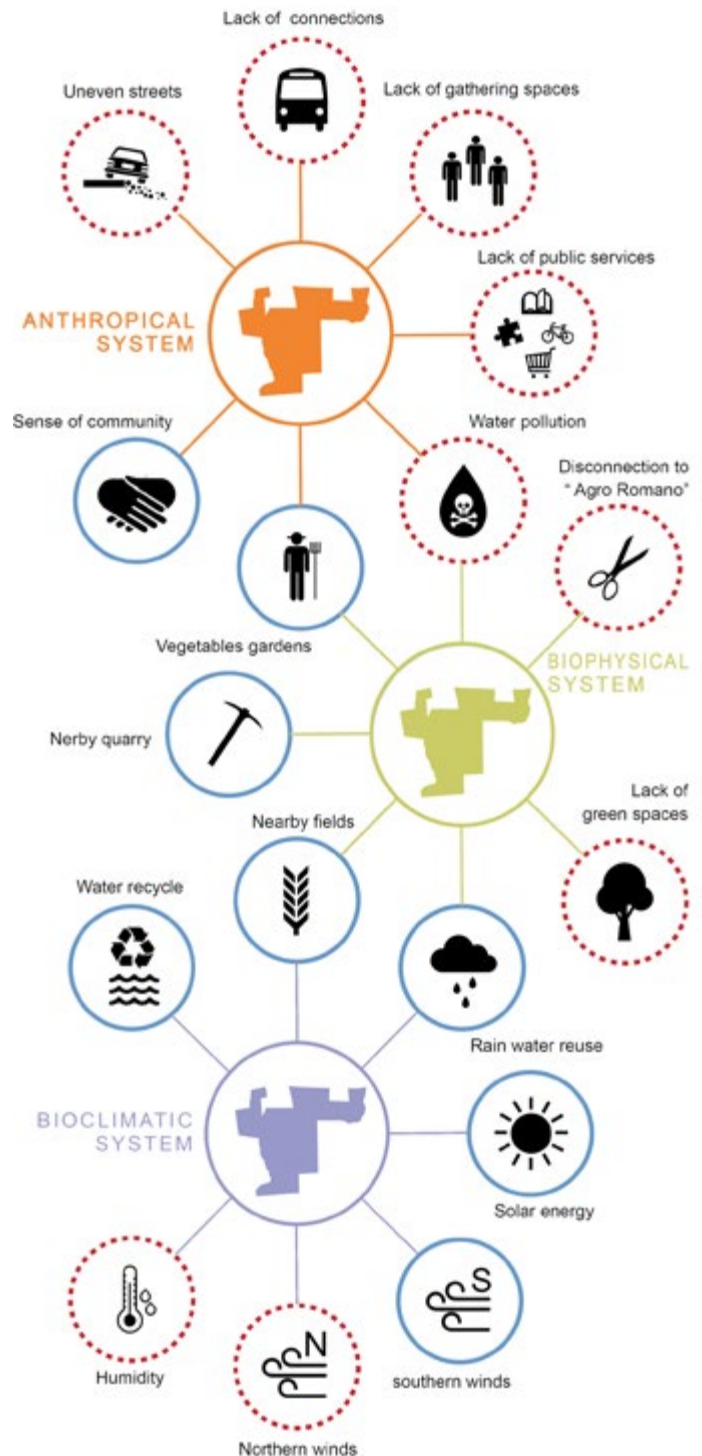
and hay) and of intensive crops (olive groves and vineyards). This led to identify the possibility of exploiting the Roman countryside both from the perception point of view (as landscape) and as an engine for the development of new production cycles, linked to food and energy.

The analysis of the *Anthropic System at the urban scale* highlighted both critical issues to be solved and potentialities. The services present on the territory and their accessibility in terms of travel times were mapped, verifying the presence and quality of the existing public transport networks. From this analysis, an uneven distribution of services was found, exacerbated by the discomfort of having to travel long distances without the support of adequate public mobility. On the contrary, if the district was equipped with the services that are lacking today, it could benefit from its position at a crossroad of flows that from Rome move northwards, and be integrated with the neighbouring centres of Bracciano and Anguillara. A great potentiality was revealed by the analysis of the landscape: Tragliatella is close to the Archaeological Park of Veio and to the Regional Natural Park of Bracciano, which represent a relevant landscape resource and, together with the Roman countryside, constitute a system needing to be preserved and enhanced. The proximity to the lake villages, Bracciano and Anguillara, are a further resource for the *Toponimo*.

The results of the analysis on the specific area of Tragliatella highlighted different issues related to low population density, poor architectural quality, security problems that occur in the construction of fences and gates, the absence of public spaces for aggregation, the isolation of the *Toponimo*, due to the lack of an internal road network and interchange nodes with external mobility. At the same time, some potentialities were found concerning: the orthogonality of the road fabric favouring the recognisability of the road network and the new constructions' orientation; the presence of many green plots, currently uncultivated and abandoned, which can be included in a program for the development of public parks and domestic vegetable gardens. Following these analysis, a general masterplan for Tragliatella was produced, defining the layout of a settlement, drawing resources for its development from the rural context, through theoretical and technical insights on:

- diffused and renewable energy production technologies to enhance the environmental characteristics of the context, for example in terms of biomass produced in the immediate proximity of the settlement;
- innovative methods of economic development linked to the specific features of the context, such as self-production and farm-to-table sale of locally produced food;
- solutions for sustainable mobility, both in terms of proximity and connection with the rest of the city;

CRITICALITY AND POTENTIAL



04 | Strengths and Weaknesses of the Area



05 | Visions of Different Areas of the Tragliatella's Project

- technologies for the sustainable management of resource flows, including water, materials and waste.

Thus the idea of an *Agricultural Community* emerged, enhancing the potentialities of the *Toponimo* in order to develop:

- *local economic networks*, based on a short food supply chain, redefining the relationship between producer and consumer;
- *local energy networks*, able to exploit not only the energy sources normally available such as sun and wind, but also the most typical sources of the specific context, such as a not intensive production of biomass from agricultural and forestry residues (crops mowing and pruning) and waste from the farms and agri-food industries present in the area;
- *social networks* aimed at increasing the sense of community among the inhabitants of Tragliatella through shared vegetable gardens and local agricultural activities;
- *cultural networks* through the creation of outdoor public spaces and paths links to the nearby relevant parks and natural areas, with the aim of enhancing the suburban ecological potential and promoting environmental awareness.

The masterplan transforms this vision into punctual strategies of intervention:

- the equal distribution of new public services inside the district, with the creation of educational services, in addition to the kindergarten and primary school outlined in the *Executive Plan*, such as a research centre on agriculture and food;
- the insertion of aggregation spaces throughout the urban fabric, such as squares, small gardens and playgrounds for children;
- the reorganization of the internal road structure, a new hierarchy of roads according to three different types of streets, based on the vehicle flow, and the implementation of advanced solutions for sustainable mobility;
- technologies for the sustainable management of the water cycle, such as small watercourses along the roadways' sides, with the double function of the recovery and disposal of rainwater and of the control of microclimatic comfort of outdoor areas during summer;
- infrastructures for closing the different loops of resource pertaining to the urban metabolism, first and foremost the waste cycle.

The masterplan finally defines new construction sectors differentiated through two main types of residences:

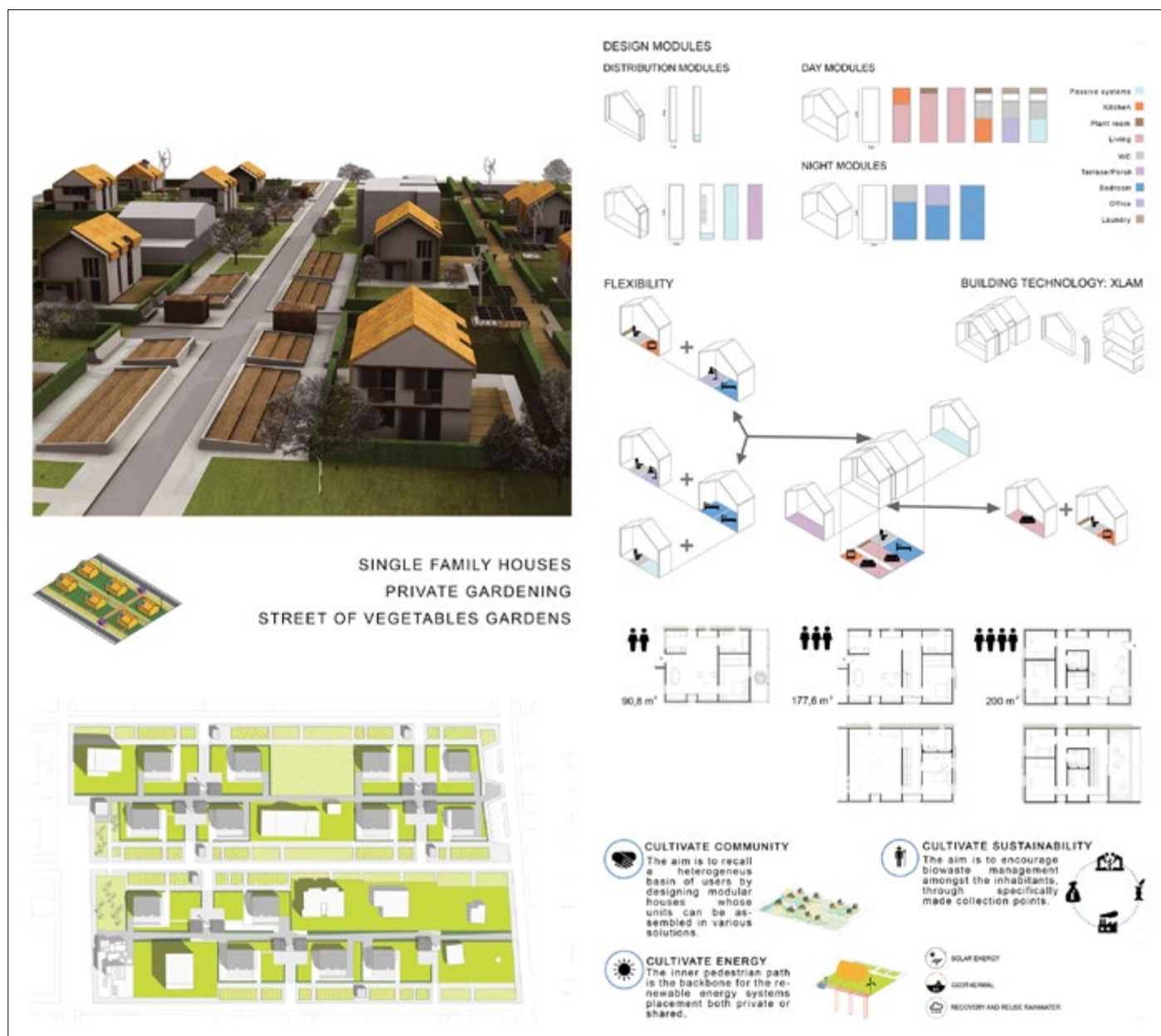
- *Agro-Houses*: houses related to agricultural activities, placed in proximity to common spaces used for urban gardens and animal farms;
- *Urban-Houses*: more compact and intensive houses, compared to Agro-Houses, hosting small commercial spaces.

Building level

In response to the main objective of creating a self-sufficient urban settlement, and to the request of the local associations of citizens of having specific recommendations for the development of the new houses, the project addresses the building scale as well. Thus, the main experimental result consists in the definition of 'Positive Energy Housing Models', replicable in a designed pattern. The models are low-cost houses, appropriate to Tragliatella's context, with specific architectural and technological characteristics, and defined environmental and energy performances. In particular, they satisfy bioclimatic criteria and integrate renewable energy systems and coordinated exchange of energy with smart energy grids. The model houses use innovative prefabricated construction systems⁹ taking into account the entire life cycle of the building. Being active in terms of energy production, fully integrated into the overall energy network, and achieving optimal management of water and waste, the model houses also balance the related operating costs.

Results: "Positive Energy Housing Models" within a circular district

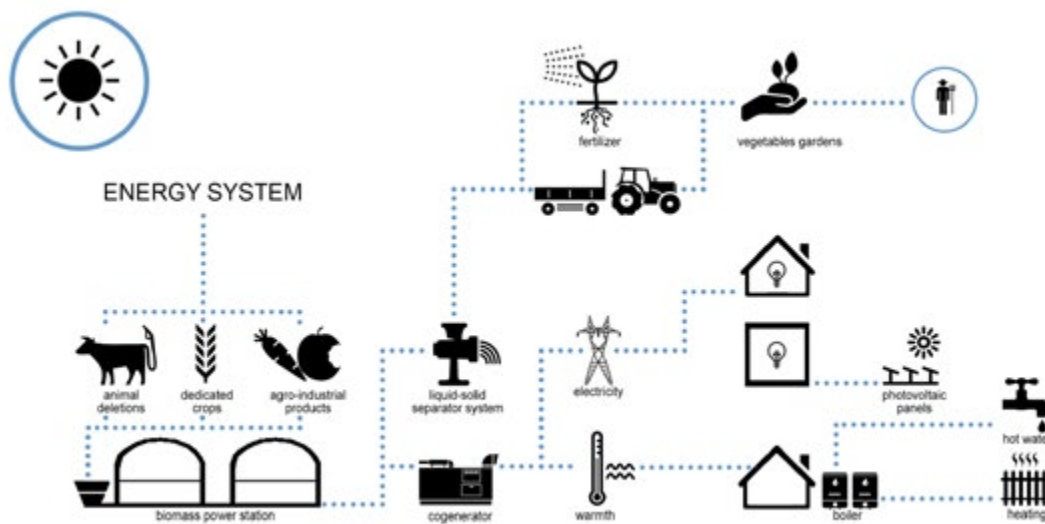
The project proposes a smart model linked not only to the energy performance of the buildings, rather to all the other environmental parameters of the urban settlement (i.e. soil permeability, heat island effect, micro-climatic comfort in outdoor spaces, etc.). The critical analysis of the *ex ante* status of the districts, allowed to identified the most appropriate innovative solutions for closing the loops of materials and other resources inside the system. Thus new virtuous economic cycles can be created, simultaneously limiting environmental pollution. The project actions must involve, as happened with Tragliatella, local administration, citizens, designers and cultural organizations to find practical and durable solutions.



06 | Single Family House Positive Energy Model

As regards the energy issue, which was one of the major topics of the research, the overall energy model has been developed starting from the detection of the energy consumption of the existing housing in Tragliatella. Currently the buildings have very low levels of efficiency (200 Kwh/sqm/yr). The objective of the project is to cover the energy needs of both present and future buildings with renewable energy production systems, possibly producing a surplus of energy, to cover part of the consumption of the neighbouring areas. The energy supply is ensured by the extensive use of integrated photovoltaic systems on the buildings, combined with two potential other renewable energy sources: low-enthalpy geothermal energy, or a biomass power station, using waste from the local farms and agricultural activities. The solutions adopted in the “Positive Energy Housing Models” and the retrofit strategies for existing

buildings, verified through simulation, certify a possible 75% reduction of energy needs for the new houses, compared to the existing building stock in Tragliatella, and a 20-50% reduction for existing buildings after retrofit¹⁰. The buildings could also be connected to a smart grid which enables a dynamic energy distribution in real time. In this scenario the users can easily monitor their energy consumption while improving their environmental behaviour. Thus the houses potentially provide a surplus of energy which can be used for the neighbouring areas. Thanks to the new national regulations concerning the Vehicle to Grid system¹¹, the direct involvement of the owners as small energy producers also allows to encourage citizens to purchase and use electric cars, which can also be used to enter energy in the network. This can contribute to the energy supply balance as a sort of distributed storage.



07 | Layout of the Energy System

Conclusions

The outcomes of the analysis and design method, developed in the experimentation, represent a virtuous and repeatable example. Based on the premise of the Tragliatella project, the experimental approach outlined above could be effectively transposed to other fragmentary suburban settlements, characterized by the low quality level of the houses, whose origin is not necessarily spontaneous.

Regarding the process of implementation of the Tragliatella project, the experimentation, begun in 2014 and continued throughout 2016, has paid the sudden change in the political Administration of the Municipality of Rome, with a temporary stop in the project approval process. The administrative continuity is in fact necessary to guarantee the completion of the process, while the Municipality of Rome has suffered a continuous political turnover in the last years. However recently the administration has shown a renewed interest in the regeneration of *Toponimi* areas, reactivating participatory processes with the consortia and citizens' committees. Despite the lack of decision-making continuity and resources, today all the stakeholders are willing to reactivate the recovery process of the *Toponimi*.

NOTES

¹ These areas have been identified in the general plan of the Municipality of Rome approved with the Resolution no. 18 adopted by Municipal Council on the 12th February 2008.

² The process of approval of the Executive Plans by the Municipality of Rome took place through three important participatory steps: the first in December 2009 (Resolution No. 122); the second in July 2010 (Executive Resolution No. 513) and the most recent in September 2010 (Executive Resolution No. 276).

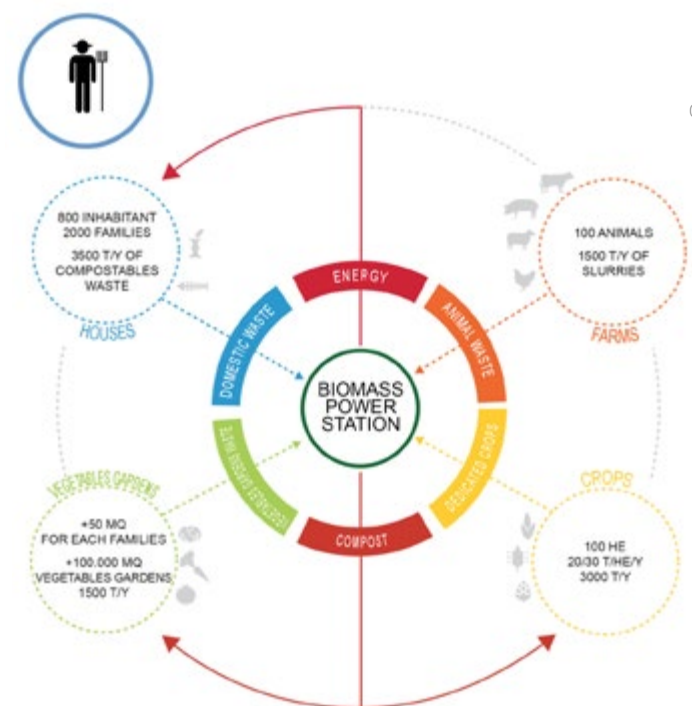
³ At the end of the implementation of all the Executive Plans it is expected that the general gross floor area will increase from the current 2,279,133 sqm (96% residential and 4% non-residential) to 3,276,080 sqm (92% residential and 8% non-residential), with a significant increase of public services and spaces. The population will pass from 58.462 to 80.765 inhabitants. Source: <http://www.urbanistica.comune.roma.it/toponimi-stato.html>.

⁴ The Consorzi di Autorecupero are associations of citizens who illegally built their homes and afterwards got together, in compliance with the Na-

tional Law n. 724/1994 (Secondo Condono Edilizio) and a subsequent series of Municipal resolutions, with the aim of collecting the concession fees due to the Municipality of Rome to use them for the urbanization works to be realized in their settlement. Source: https://www.comune.roma.it/pcr/it/dip_pol_riq_per_zone_op.page.

⁵ Source: Municipality of Rome, "Piano Esecutivo per il recupero urbanistico del nucleo di edilizia ex abusiva: n. 19.08 denominato "Tragliatella" adopted by the Municipality of Rome with Resolution No. 35/2013, available at: <http://www.urbanistica.comune.roma.it/partec-tragliatella.html>.

⁶ The research has been developed at the Department of Planning, Design, Technology of Architecture of Sapienza University of Rome. Principal Investigator Eliana Cangelli, Research Group architects Paola Altamura, Francesco Antinori, Massimiliano Coccia, Michele Conteduca, Caterina Reccia.



08 | Supply of the Biomass Power Station

⁷ Conference “Next City. La nuova periferia di Roma, tra sostenibilità e sviluppo”, Casa dell’Architettura, Rome, 03/12/2013.

⁸ Conference “AbitareVerde. Bioarchitettura e urbanistica sostenibile”, Casa dell’Architettura, Rome, 04/04/2014. The results of the educational experimentation conducted in parallel with the research were also rewarded with the Urbanpromo Prize in 2015 (<http://urbanpromo.it/2015-en/urbanpromogiovani/tragliatella-flip-a-coin-for-a-toponimo-in-rome/>).

⁹ The model houses are based on wood construction technologies (Xlam), hemp-based insulation and high recycled content materials for the finishing. These solutions, combined with photovoltaic and geothermal energy systems, allow to reduce the overall energy consumption to a maximum of 35-40 kwh/sqm per year. Bioclimatic solutions such as large screened windows to the south orientation ensure heat gains in winter while avoiding overheating in summer. Buffer spaces and solar greenhouses, whenever used in the housing model, are designed in order to ensure their complete opening in the summer.

¹⁰ The estimate of the reduction of the overall energy consumption of the Toponimo was led through a comparative method based on the estimate of the average consumption for the different energy functions (electricity, heating, cooling) of existing buildings provided by the ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development).

¹¹ This system has been introduced for the first time in Italy through the National Budget Law 2018.

ACKNOWLEDGMENTS OF VALUE

Luciano Bucheri

Director of Consorzio Periferie Romane (Roman Outskirts Consortium)

Tragliatella is one of the 29 Toponimi for which the Municipality of Rome has defined and pre-approved an Executive Plan. It is the second largest of the 69 Toponimi identified by the Rome Town Plan. Tragliatella has an area of 145 hectares and has 3,880 inhabitants, which means about 1,175 families. At the end of the implementation of the Executive Plan, the total expected residents will be 8,500, which means 2,775 families.

Almost 78% of these families (2,164) formally subscribed to the Executive Plan, acting as owners of lots of land or of existing houses associated in the “Consortium of Tragliatella”. This implied a complex level of discussion and a certain quality of the involvement of many citizens, certainly not on generic subjects, looking for a consensus to be torn out in some way, but on complex technical-urbanistic aspects, on problems directly concerning their future life conditions! Dozens and dozens of assemblies, held over many years, were needed to reach a level of consensus of such relevance. In these years, both the awareness of being part of a collective body and of the undoubted technical complexity of the issued involved in this process has matured. This in fact made it possible to strengthen the dialogue between institutions and citizens, not just expressed by slogans or in sterile contraposition between rulers and governed citizens, but in a real collaborative experience involving sustainability issues.

Thanks to the Tragliatella’s project, as well as to akin processes in the other Toponimi, the civil conscience has grown positively. Nevertheless, as is known, every goal achieved increases the level of responsibility. On the part of the Institutions, not to follow up to these innovative processes with the due conviction and intelligence, could lead citizens’ disappointment to turn into conscious anger.

PICTURE CREDITS

Michael Emiliano, Vincenzo Guarini, Pasquale Iaconantonio, Valentina Iaquinandi, Antonietta Innella, Fabio Lamanna, Marco Lucci, Giuseppe Lucisano, Giulia Menditto.

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