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Towards more sustainable patterns of urban development

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Towards more sustainable patterns of urban development

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Abstract. DETR, 1998, wrote in *Planning for Sustainable Development. Towards Better Practice*: “New settlements will enjoy a high quality of urban and landscape design. As well as integrated open space, there should be habitat areas, and environmental gains such as energy efficiency measures introduced in layouts and individual buildings”; but this claim is remained largely dissatisfied. There is a great interest (and large investments in research) for the *smart city*, which seeks to optimize the existing cities, while people go on to design urban developments with building typologies set ninety years ago by Modern Movement or little more. Urban Planning compares existing cities’ models and asseverates that densification has positive role for sustainability, but do not turns enough to account passive typologies for heating and cooling, which can turn down near to zero power-consumption, and at the same time can raise urban environment quality. Famous settlements too, as Malmö or Vauban in Freiburg, has been built with building typologies conventional, after all; German *passive Haus* have generally two, three or four building fronts and in reality, are simply hyper-insulated traditional buildings, furnished with mechanical controlled ventilation. For an urban extension of Potenza, we have used for the urban planning the sustainability assessment categories of ITACA’s Protocol, derivative from *GBTool* of GBC, people normally use to assess *ex-post* sustainability of projects and of realized buildings. The result is a settlement in which pedestrian, cycle and public transport’s network is fully integrated with adjacent urban areas; effective landscaping connects public and private green and kitchen-gardens/orchards are everywhere; buildings are made with new semi-underground typologies, nZEB and made with local, re-cyclable materials; rain water is collected, *in-loco* fito-depurated and reused; *in-loco* renewable energies (sun, earth, wind) satisfies remaining necessities.

1. The state-of-the-art of the sustainable city planning and the objectives of the research

“At least in Europe ... a clear institutional position – even if not shared by everybody – has been taken by the European Community, which openly declared for the compact city and for the strengthening of polycentrism. That’s what sustainable urban development and sustainable urban planning became over the Nineties key points of urban planning and integral part, sometimes a bit redundant and repetitive, of his vocabulary” [1]. “A high quality of urban design not only represents a general objective of planning, but it is a specific requirement for sustainable development. The success of urban regeneration to higher densities, for example, will depend on the skill of creating a more appealing environment” [2].

To tell the truth, beyond declarations of intentions, planning and urban design continue to plan urban expansions with building typologies developed ninety years ago from Modern Movement, in his search of a “democratic” balance between east and west exposure (“equisolar axis”) (both negative in terms of passive solar energy, as they cannot heat enough in winter, and are a source of overheating in summer)



[3]. Many recent urban development show little or nothing more [4], although already in 1991 a publication of widespread use showed that buildings, specifically designed to have a significant energy contribution from the sun, actually limit this contribution to 25-40% if they have a double-face type, with rooms facing either south, that to the north or other directions [5]. Urban planning specialist compare the models of existing urban cities and theorize about the greater sustainability of the denser ones [1], but do not enhance typologies that use passive systems for heating and cooling [6] [7] [8], which can lead to wipe out energy requirements and consumptions and, in the same time, to improve the quality of urban environment. Famous settlements, like that of Malmö or Freiburg [9] resort to building typologies all thing considered conventional, and the German *Passive Haus*, beyond calls to the necessity of a correct exposition, have as a general rule typology with exposition toward two, three of four fronts and, in reality, they are nothing else than conventional buildings, but hyper-insulated and provided with systems of mechanical ventilation with heat recovery [10, see especially Chapter “Urban Design”, pp. 68-75]. Solitary stands, as the paradigm of a new way of thinking the typology of multi-storey building too, the Ove Arup GmbH realization in Wittenberger Straße in Berlin [11], which has already more than twenty years.

And the *smart city* culture is still playing with informatic devices that would make intelligent cities that continue to be designed in a stupid manner. It is a typical case of what scholars of process optimization methods call “the inversion between the spoon and the bulldozer”: to open a way, it is first necessary to work with bulldozer and graeder; only at the end it is possible to work with the spoon to finish the gutter. That is, it is in no way useful to rationalize details of a non-rationalized process [12].

From the sustainability assessment point of view, international panorama offers methods both rating based (BREEAM, LEED, *GBT*ool, CASBEE, HQE), and analytical ones (Norms EN ISO 14000 series, in particular 14025 on EPD and 14040 on LCA), which allows of assess in an objective manner sustainability of a building both at the design level, and as built. In Italy, the norm adopted is a rating based one, a *GBT*ool of Green Building Challenge version, named ITACA Protocol, which expresses the judgment on the basis of a series of criteria, from the site quality to the materials and constructive choices. The challenge of the research has been that of adopt ITACA Protocol not as assessment criterion, but as design method, and of structure up with his guide the planning of a whole neighbourhood in Potenza, in the centre-south of Italy, from the town-planning level to the building and to the constructive one, with the target of checking possibility, in that manner, of attaining the result of a settlement not only sustainable, but also appealing and delightful, according to Louis Kahn’s lesson: “*What is measurable is in the service of what you can’t measure*”; and to Kevin Lynch’s one: “*It is necessary to learn what is desirable as much as to study what is possible: to act without target can be useless as much the idealism without power. Even the range of possible things can be extended by greater knowledge of what is desirable*” [13].

2. The site: environmental and town planning commitments

The site is a great area, covering 128.057 m², named *Zona “C2”* in the Urban Regulations of Potenza Borough, at the northern border of the city, at an altitude between 815 and 880 m o.s.l, with an average slope of 24%, lat. N 40,65°, long. E 15,79°, and a good exposure to the sun toward South (figures 1, 2, 3). Scheduled territorial density is of 0,50 m³/m², which allows building 64.028 m³, primarily dwellings, but also offices and shops. It is scheduled that buildings can have a maximum height of 10,50 m and a minimum distance from the vehicular roads of 7,50 m. It is planned the realization of neighborhood services, made up of primary school in an area of 3.170 m², common interest services (administrative and cultural) in an area of 2.000 m², public equipped green on 23.164 m² and public parking on 2.785 m². The soil is made of clay and silt grey-blue; it is stable, but it needs of foundation on piles. It is seismic zone I, with high dangerousness (acceleration with probability of exceeding of 10% in 50 years: $a_g \leq 0,25 g$). Potenza has a Mediterranean montane climate: cold and snowy in winter time, tepid in summer time. The coldest month is January, with an average temperature of +3,5 °C, hottest July and August, with average temperatures of 20 °C. Average rainy condition of the past decade has been of 753 mm/year, raising 100 mm with respect to the previous decade. Important is the relative average annual

moistness, equal to 71%: for the most of months (but July and August), she seizes between 60% and 88%. Therefore, it is necessary to forecast systems of mechanical controlled ventilation equipped not only with heat recovery device but also with a dehumidifier. During summer months the winds come from 240° (West-South-West) and in the rest of the year mainly from 220° (South-West), with speed between 2 and 5 m/s. Solar radiation is high, thank to air clearness. It is climatic zone E, with 2.472 degrees-day (heating from October 15 to April 15, 14 hours daily).

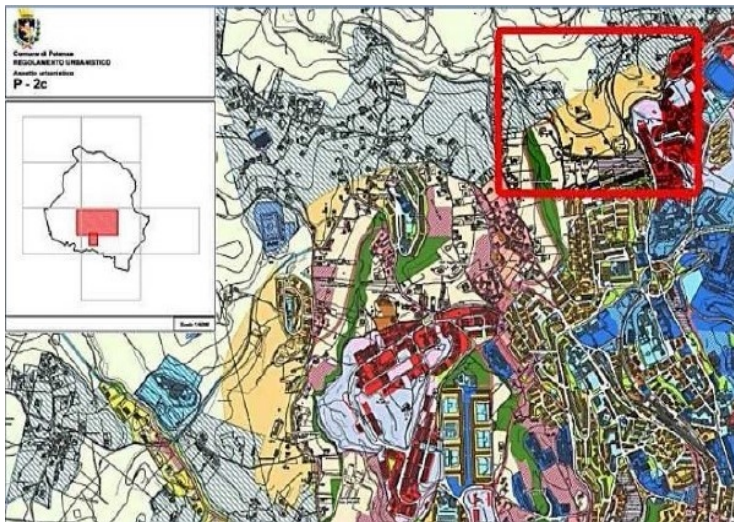


Figure 1. Excerpt from the urban regulation of the Municipality of Potenza.



Figure 2. Orthophoto of the area under study

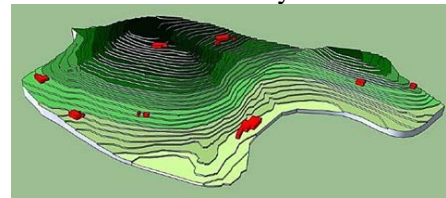


Figure 3. 3d reconstruction of the intervention area

Borough Administration has prearranged an Operative Plan [14] as guidance to the development of the area (figure 4), which presents all the defects typical of urban contemporary extensions, meaningless and lacking of soul, but also of culture of sustainable planning, of which we wrote in the premise: it lacks an overall conception and the hierarchic organization of the areas; there is not a pre-arrangement of a public transport network; the development of the vehicular roads is excessive (the majority of the parcels is served by two roads, both from downstream than from upstream); green areas, despite great surface on which they stand, are not connected in a unitary logic and are not easily enjoyable; school (grey zone in the figure) is set in the worse place as slope, exposure to the sun and accessibility; the Plan lacks an adequate mix of activities and an overall working logic; even though the layout of the building follows roughly contour lines, most of the buildings are not exposed to South and scheduled building typologies are all “*not-passive-solar*” (little towers with two or four flats every floor, oriented to the four cardinal points).



Figure 4. Operative Plan of Zone “C2”.

Demonstration of the fact that also a site with good exposure can be badly utilized and can be the Public Administration to stimulate disorder and fall out of love with the city, promoting the urban *sprawl*. As a matter of fact, it is impossible to understand why citizen would must undergo the greater cost of being involved in a “planned” urban extension, if he can get a product similar (or probably worse) than that he would obtain building by himself a house in the country.

3. The use in urban planning of the assessment criteria of ITACA Protocol

ITACA Protocol and its Standard Procedures [15] [16] [17] deal with five “areas” or significant macro-themes: A) site quality; B) resources consumption; C) environmental loads; D) indoor environmental quality and E) service quality (table 1).

Table 1. ITACA Protocol criteria applied and related impact levels

Criterion code	Criterion name (Area A)	Impact level P _k
A.1.5	Land re-use	18
A.1.6	Public transport accessibility	12
A.1.8	Functional mix of the area	4
A.1.10	Adjoining to infrastructures	6
A.1.12	Settlement sprawl	6
A.3.3	External equipped common use areas	4
A.3.4	Support to bike use	8
A.3.7	Use of local arboreal species	4
A.3.10	Incidence on the urbanized context	12
Criterion code	Criterion name (Area B)	Impact level P _k
B.1.2	Non-renewable primary energy	27
B.1.3	Total primary energy	27
B.3.2	Renewable energy for thermal uses	18
B.3.3	Energy in situ produced for electrical uses	18
B.4.1	Re-use of existing structures	27
B.4.6	Materials recycled / reused	18
B.4.7	Materials from renewable sources	12
B.4.8	Local materials	12
B.4.10	Materials recyclable or dismantlable	18
B.4.11	Certified materials	12
B.5.1	Drinkable water for irrigation	18
B.5.2	Drinkable water for indoor uses	18
B.6.1	Thermal energy useful for heating	27
B.6.2	Thermal energy useful for cooling	27
B.6.3	Average global coefficient of thermal exchange	18
B.6.4	Control of solar radiation	18
Criterion code	Criterion name (Area C)	Impact level P _k
C.1.2	Expected emissions in exercise	27
C.3.2	Produced solid waste in exercise	12
C.3.3	Reuse of the soils	8
C.4.1	Greywater piped in the sewage system	8
C.4.3	Permeability of the soil	8
C.6.8	Heat island effect	12
Criterion code	Criterion name (Area D)	Impact level P _k
D.2.5	Ventilation and air quality	9
D.2.6	Radon	9
D.3.1	Summer thermal comfort in air-conditioned rooms	6
D.3.2	Operative temperature in summer	6
D.3.3	Winter thermal comfort in air-conditioned rooms	6
D.4.1	Natural lighting	6
D.5.6	Acoustic quality of the building	6
D.6.1	Electromagnetic fields at an industrial frequency (50 Hertz)	6
Criterion code	Criterion name (Area E)	Impact level P _k
E.2.1	Services equipment	6

E.3.5	B.A.C.S.	18
E.3.6	Domotic plants	6
E.6.5	Availability of technical documentation of buildings	6
E.7.1	Design for all	6

Following methodological order set by ITACA Protocol, in the settlement centre a mechanized public route (cable railway with automatic control) has been arranged (figures 5 and 6); it allows to link fast, across intermediate and final stations, pedestrianised areas and bikeways, set beside the contour lines, to the existing city, also across a pedestrian bridge which, at the bottom of the neighbourhood, crosses the busy way lying at South border. The automotive traffic is confined to the border of the settlement and is linked to underground parking's, in strategic manner set to the West side and to the East side, connected to the pedestrianised areas and bikeways and covered by public urban vegetable garden and orchards (n. 78 parcels of 40 m² each) and private ones (n. 160 parcels of 40 m² each) in two great areas (9.520 m²).



Figure 5. General Plan of the District.

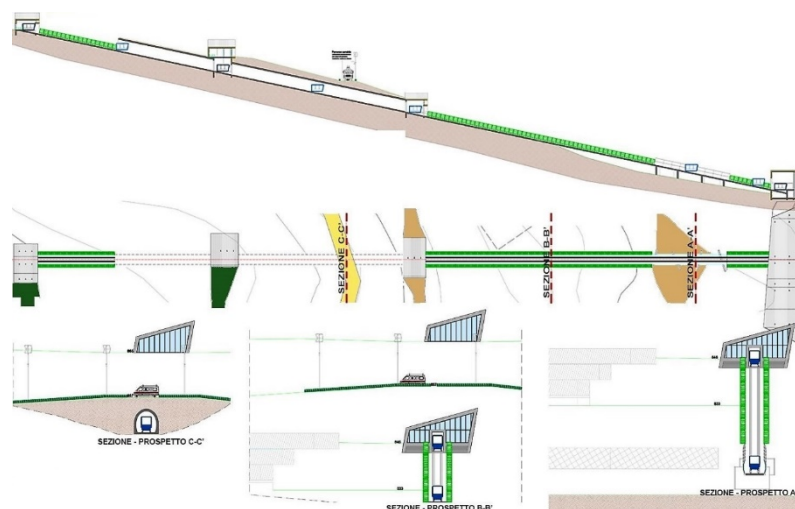


Figure 6. Plan and cross-sections of the cable railway with automatic control.

Parking's are intended for the most part to those residents in the neighbourhood and hence are equipped with closed stalls, each for two cars, in addition to those open, intended to the visitors. Only one road, however, paved with grating and grass, goes lengthwise, from West to East, at the centre of the settlement: it is intended to the security service (ambulance, Fire Brigade) and to the separate refuse collection. Green fabric (figure 7), structured on a wide range of local essences, both of first height (*Fagus Sylvatica*, *Quercus Cerris*), and medium / small ones, with permanent leaf or deciduous and flowering, makes a pervasive belt along the cable railway and spreads on branches in horizontal matter, with a playground on the top and a stronger presence at the bottom, where is also a little artificial lake, connecting to the gardens and private vegetable gardens, set in front and upon the houses, becoming a zone for free physical activity and "life course" for fitness in the zone with the outmost slope, on the roof of a great parking. In the central bottom part are set out offices and shops, with the school and common interest services, you must cross for connecting with the existing city.



Figure 7. Planning of public green areas

Building's typologies forecast many sizes of dwellings, from 45 m² to 95 m², and are designed based on established criterions of solar passive architecture (figure 8), so that they warm themselves "at direct gain", and they get cold themselves with radiative passive cooling from the ground. The dwellings (figure 9) have only ground floor, partially under-ground, set diagonally following the slope of the hill so that the roof of a dwelling is the garden of the dwelling upon.

The top floor has *maisonettes* in which roof are set out thermal solar panels (producing hot water for sanitary purposes and supplement to heat pump heating) and PV panels. The interface with the ground and the retaining walls are in reinforced concrete. Buildings have been designed with structures pillar-beam in local glued laminated timber made of hardwood *Quercus Cerris*, thermo-hydrrometrically modified following procedure set by the Authors, with very high structural performances (it is a GL 42), with external walls highly insulated, 20 cm mineral wool, and ventilated rainscreen for maximum

protection from the dampness and the sun.

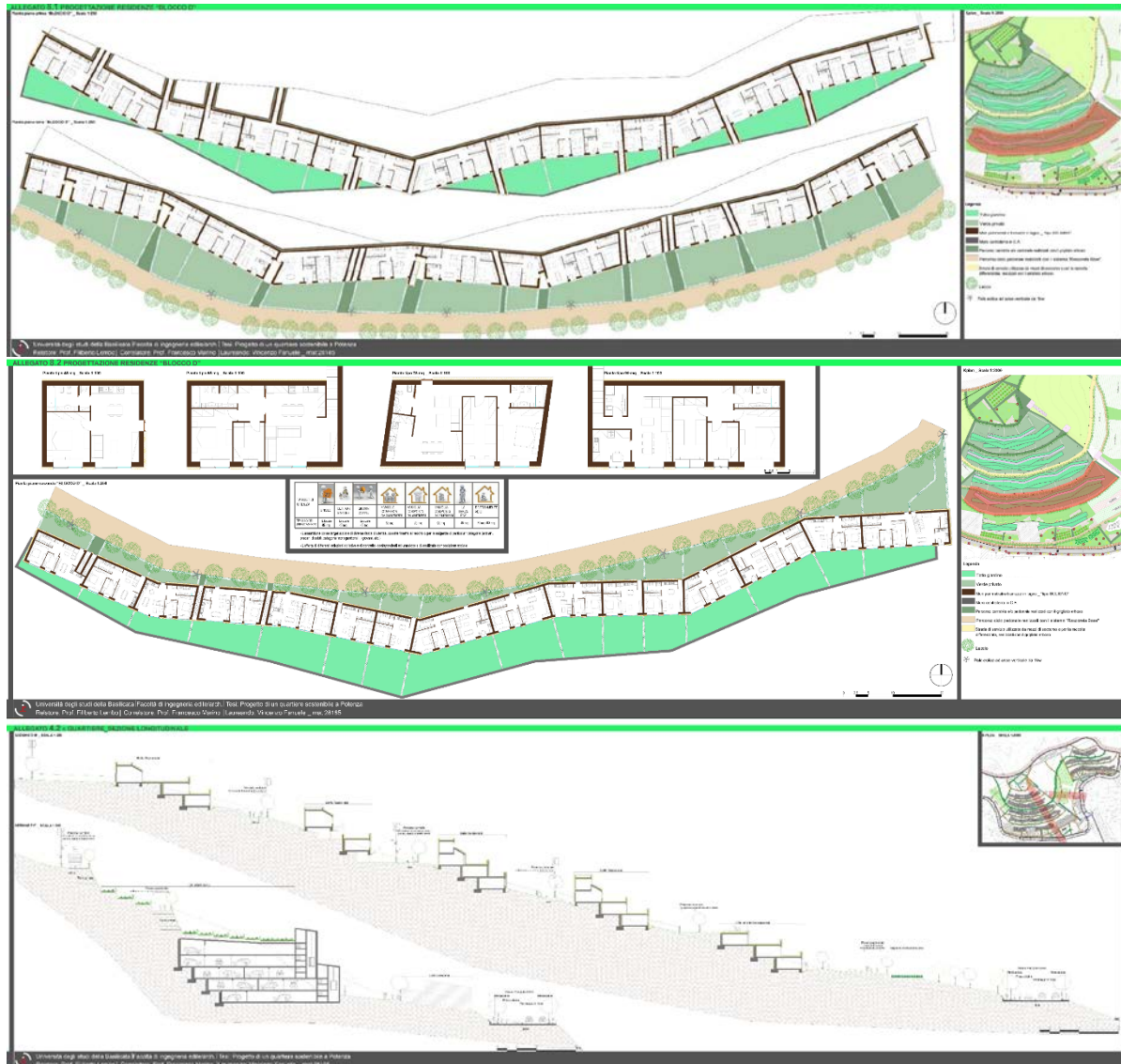


Figure 8. Building's typologies: plan view of the first and ground floors (top), second floor and distribution schemes (in the middle), dwellings' and parking longitudinal sections (below).

Dwellings offer all the main rooms to the light, the air, the sun, even if they are covered by earth for reducing the ΔT . Insulating shielding with opening “to the knee” protect doors and windows from excessive solar radiation, isolate by night and protect against breaking and entering, given the layout at ground floor of the dwellings. Only bathrooms and corridors, set toward the earth, are not naturally illuminated. Gypsum boards containing Phase Changing Material in microcapsules, boards for false ceiling with paraffin PMC, insulation 30 cm thick in wood fibers at roof, panels in local hardwood with dry joists, without glues, 180 mm thick at the perimeter and 120 mm thick for dividing internal spaces and wooden floors, 260 mm thick, maximize thermal inertia of the passive accumulation system.

They are all nZEB, with U ranging from 0,151 W/m^2K of the external walls and roof garden, to 0,128 W/m^2K of the walls against earth. Windows and doors are in wood/PU/aluminium with triple glass, with $U_w = 0,62 W/m^2K$. The insulation against earth is only perimetrical, extended 3,00 m outside the built contour (figure 10). Sailing sunshades for living external zones, Controlled Mechanical Ventilation with

heat recovery device and dehumidifier, heat pump air-water with very high efficiency. Local materials, you can recycle in full.



Figure 9. Residential cell type, distributed on three levels (top view) and a *maisonette* (bottom left) for a total gross area of 600 m²; roof plan (bottom center) and cross-section (bottom right)

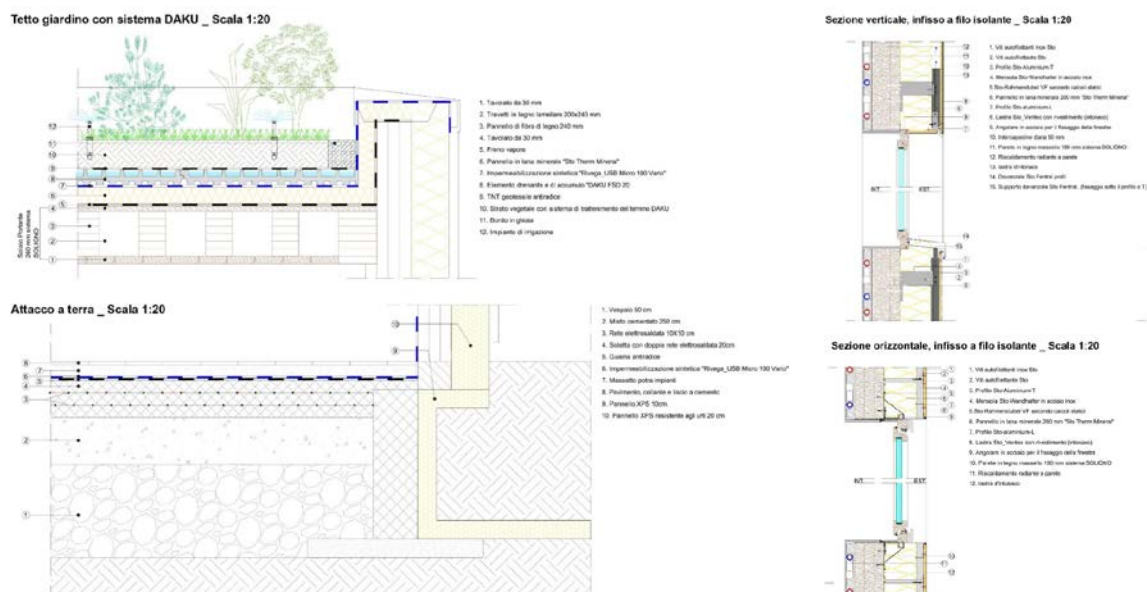


Figure 10. Details: "roof garden" coverage (right top); ground attack (right, bottom); external vertical wall in the vertical section (upper left) and horizontal (bottom left) on the frame.

It is scheduled the recovery of meteoric water, collected, to be fito-purify with a vertical submerged flow system and piped in accumulation reservoirs in the service of different buildings, re-used for feeding flushing cisterns of wc, washing machines and irrigation of gardens and vegetable gardens. Grey waters originated from houses and from other activities (average 600 people in all) it is expected to collect and pipe to be fito-purify in two plants of 160 m² each, able to handle 42 m³ / day of grey water, re-utilized not for vegetable gardens, but for decorative ones. Public lighting installation rest on energy acquired by mini-Eolic plants with vertical axis, integrated into the street lamps; their electrical production, more than demand by led light, it is scheduled to supplement cable railway supply.

4. Conclusions

Assessed with ITACA Protocol criterions, the settlement gains rating of 4,5/5. It does not rank at full score only because it is placed on a virgin area, not before urbanized or polluted. The research shows the usefulness and effectiveness of the use of the ITACA Protocol as a support methodology for the design of sustainable urban developments.

It is a neighbourhood where it is possible to move walking or by bike, or by a mechanized public transport service; public and private green, orchards and vegetable gardens are everywhere, on the roof of the parking's and of the homes too; the "heat island" effect is banned; buildings are nZEB, built with local materials, re-usable, re-cyclable; meteoric waters and grey ones are collected, fito-purified and re-used, and renewable energy available *in loco* (sun, earth, wind) satisfy limited requirements which remain after having used passive solar typologies for heating and for cooling. In fact, the climatic study and the privileged solar exposure of the site have directed the design towards unified elongated volumes developed along the East-West axis, with the South front totally free and the North front buried to optimize the thermal contributions and reduce the need for artificial lighting and heat loss, so as to minimize the use of heating and cooling systems. The buildings are terrace type that provide a variety of solutions from the typological point of view: they are planimetrically articulated according to a geometry with broken lines, redrawn on the level curves that shape the existing ground and on the basis of generating lines that are incident to them, and thus allow to take advantage of the high slope inclination between 20 and 30 degrees.

Research indicates the need, in order to achieve the highest energy efficiency, as a first rule, to overcome the building types of nineteenth-century city and of Rationalism and Modern Movement.

But, most of all, it remains established that, if just you want, it is possible to plan a more sustainable city, more joyful and healthier too, also remaining in the actual city planning Regulations, and that the true *smart city* is not that stupid existing, just cabled and informatized, but that which use at the best resources of a specific culture and of intelligence.

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Contributions

Filiberto Lembo coordinated the research and provided the objectives. Francesco Paolo R. Marino developed the research project, methodological and operational tools, analysed and verified the results. Vincenzo Fanuele made specific analyses in his degree thesis. The authors' contribution in drafting and writing the text of the article was the same.

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Preface

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Preface

Sustainable Built Environment conference ‘SBE19 Helsinki’ debated emerging concepts for a clean planet, happy people and shared prosperity. It was organized by the Finnish Association of Civil Engineers RIL and Sustainability Laboratory Oy SLAB 22-24 May 2019 in Helsinki. It is part of SBE conference series that were held during 2018-2019. These events organized in different regions in our planet are expected to bring their highlights to the World Sustainable Built Environment conference that will be held in Gothenburg, Sweden in June 2020.

SBE19 Helsinki conference brought together 120 experts from 23 countries to share latest knowledge in sustainable built environments. The objective was to introduce also novel approaches to climate change mitigation, adaptation and resilience, circular procurement, social license to operate and nature-based solutions for healthy indoor and outdoor environments in exciting and inclusive cities.

SBE19 Helsinki proceedings contains 50 scientific papers structured under the conference topics and sub-topics as follows

- Emerging concepts
- Shared prosperity
- Positive stimulation and well-being
- Clean planet
- Climate change mitigation
- Material life cycles and circularity
- Adaptation and resilience to climate change
- Happy people
- Healthy and comfortable indoor and outdoor spaces.

The organizers want to take the opportunity to thank the authors of the published articles, the Scientific Committee members for their improving comments to the submitted papers in the review process and all active conference participants for interesting discussions during the sessions and breaks that contributed to the SBE19 Helsinki success.

Pekka Huovila
Scientific Committee Chair



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All papers published in this volume of *IOP Conference Series: Earth and Environmental Science* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

