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The Organization of a "Learnscape" Node in the Cognitive University Campuses Network in Poveglia Island

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ABSTRACT

Regeneration of existing buildings and abandoned areas is a governmental and European key objective. This research focuses on Poveglia: an abandoned island in the Venetian lagoon, Italy. The underpinning idea concerns the upgrade of Poveglia to a zero energy Cognitive University Campus, connected to other educational institutions in the lagoon. The vision aims at reusing abandoned islands combining architecture, learning environments and digital networks, to demonstrate the potential of new technologies for the transformation of abandoned areas. The case study demonstrates the effectiveness of employing improved and revised systems and tools, developed in eLUX lab at the University of Brescia, for the regeneration of the island. The inclusion of the island in a smart campus network results in triggering positive synergies both enhancing energy efficiency and the learning environment. A further development concerns the setup of strategies for historical preservation, energy efficiency and renewable energy production.

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KEYWORDS

Cognitive campus, User centered design, Zero energy building, Retrofit strategies, Digital networks.

INTRODUCTION

Universities around the world have the mission to provide future professionals with an integrated education that facilitates the adequate development of their abilities in favor of the social community in which they are located and worldwide. The values that govern the educational institution constitute an essential factor for young people that are facing the decision of entering in a specific university.

In this sense, more and more universities around the world have started paying attention to the importance of incorporating sustainability as a part of their organization, culture and even their architecture, so that students live sustainable actions as daily practices and a growing culture of sustainability would become an essential part of the social awareness. In fact, the key role of higher education institutions such as universities in the transition of the society towards sustainability has been highlighted and boosted in the last three decades [1] and sustainability programmes have been diffused to lead to post-carbon resilient campuses. In response to the most urgent urban challenges to increase sustainability in procedures, procurement and operational phase [2], universities have been identified as key hubs for innovation and environmental education, representing a huge opportunity for leading and enabling the necessary generational behavioural change to bring more sustainable attitudes in the users' daily lives [3] and promote lifestyles which are supported by digital environments and mobile applications to control and enhance the users' environmental impact and energy consumption [4]. A number of initiatives are related to carbon dioxide (CO_2) emissions as carbon footprints of the cities of tomorrow and contests at district level are trying to regenerate urban sections and fragments. The users' satisfaction and involvement is thus one of the main parameters to predict the success of sustainability programmes into the university campuses where the staff and students' groups have to cooperate towards common objectives defined by the governance. The guiding role of the universities is made credible by a promotion of responsible behaviours and wise sustainable management of the issues related to energy and human resources of the campuses.

The definition of sustainable university can be indicated as follows: a higher educational institution that addresses, involves and promotes, on a regional or a global level, the minimisation of negative environmental, economic, social, and health effects generated in the use of their resources in order to pursue the specific functions related to teaching activities, research programmes, outreach of innovative initiatives, external partnerships, and efficient stewardship with the aim to help the society to evolve lifestyles in the direction of sustainable management [5]. At the same time, Cole [6] highlighted the key role of sustainable campus communities, since "they actively engage the knowledge of the university community to address the ecological and social challenges that we face now and in the future". The future leading generations could have a crucial role in reaching sustainability levels for the society [7] and introducing new habits and routines [8] that can implement the understanding of the holistic and trans-disciplinary approaches that address the four dimensions of sustainability (economic, environmental, social, and cross-cutting themes) and their correlations [9].

Nevertheless, the transition to the social responsibility that the campuses have to include in their principles need an adaptation of their built environment that is not so trivial [10] because of the age of the buildings, the standardized procedures and resistance to innovation in the decision making layers. For instance, educational functions account for 17% of the overall non-residential building stock in the European Union (EU) [11]. Knowing that buildings are responsible for about 40% of total final energy requirements in Europe, the educational sector accounts for 6.8% of the total EU energy consumption.

Where expansion is stronger, for example in China, the educational sector accounts for 40% of the total energy consumption in public buildings [12], with a learning population of about 30 million of students and 1.87 GJ/m^2 of energy consumed in the previous decade [13].

In this way, universities are not only hubs for innovation and environmental education, but important actors within the urban setting, which must draw on a complex set of accounting indicators, dealing not only with environmental performances, but also addressing critically economic, political, social and ethical issues [14]. In this context, Campus Sustainability Assessments (CSAs) have been emerging, and have been used for more than a decade, as tools for identifying best practices, communicating goals and experiences, and measuring progress towards achieving the concept of a sustainable campus. Even if the literature in the late 1990s proposed detailed environmental reports, mostly by different North American universities voluntary initiatives (one of the first was "The Student Environmental Action Coalition-Campus ecology in 1993), there was not much relying on empirical data or common reference frameworks [15, 16]. However, with the growing interest in campus environmental impacts, as a consistent part of the built environment, many projects launched wider initiatives for cross comparison and campus assessment [17]. The Ca' Foscari University of Venice is included in several sustainability networks, promoting the sustainability concepts while always considering its educational responsibilities [18]. In the last decade, different CSAs have been proposed at national and regional scales around the globe [19], varying greatly in purpose, scope, function, state of development and closeness to an "ideal tool" [20]. Recent research on CSAs has focused on defining and examining the role of metrics, even questioning the necessity of them [21-23]. Shriberg [20] reviewed 11 assessment tools and found that many excel in capturing data on environmental and sustainability performance, as well as process-oriented information, or they also provide the grounds for strategic planning, by stating goals and methods. However, they do not provide mechanisms for comparison (nationally and internationally), because they traditionally stress material utilization, CO_2 emissions, and regulatory compliance, which is different from country to country. Furthermore, measuring sustainability requires a major leap beyond the energy efficiency paradigm, addressing social, economic and environmental impacts. For instance, an eco-efficiency indicator would provide the amount of kWh per square meter per year, while a sustainability indicator should look at the trend in consumption reduction over the years, or the percentage of people satisfied with the comfort level in their working environment [24]. Because of this, CSAs could be powerful tools for both triggering and supporting the organizational change process, or dangerously used as a mere façade, contributing to green-washing the business as usual unsustainable campus management [25].

The educational campuses are naturally suited to experiment innovation and connect the users' need of knowledge to new concepts and systemic vision. Moreover, they present a further specific problem, which is linked to energy efficiency and buildings' management. University buildings are often prone to errors in the prediction of the energy consumption in the design phase for new construction or renovation because of the incidence of occupancy variability in the thermal and electrical consumption balance. Educational facilities are a very interesting field of application because of the relevance of the thermal behavior of the building related to comfort conditions and learning performance of the users. The performance gap that can be reported reaches +68% in the estimation of thermal consumption and +53% for electrical consumption (https://www.carbonbuzz.org/). A huge portfolio of buildings has a common vocation towards innovation and enhancement of the conditions to promote a better learning environment and sustainable campuses.

The present research broadens the idea developed at the Smart campus of the University of Brescia, proposing the organization of an educational network in the lagoon of Venice, Italy [26] where historical heritages and decadence cohabit in a significant natural and built environment [27]. The educational network is based on cognitive principles [28] and Internet of Things (IoT) networks and devices [29] connecting the different educational facilities which are nowadays a reality in the place and which could become the future development of a rich and vivid cultural environment (the lagoon of Venice is one of the favourite location for artistic and architectural worldwide known and participated events that take place every two years as Biennale expositions) [30].

The purpose of the project is to reuse the abandoned islands [31] in the lagoon by combining innovation in architecture with digital network development with the goal to investigate the potential of new technologies within the transformation of existing structures into adequate and innovative locations for contemporary learning happenings. The project adopts a user-centred approach and the User eXperience (UX) and involvement becomes crucial to enhance the level of learning improvement and the use of innovative tools and organizational schemes has a strong role. The social outcome of a renovated approach to learning spaces and networking is to create new leaders able to interact in a more effective and collaborative way, used to mixed environments and to manage multidisciplinary teams and groups. The new job of the future needs new skills and advanced management techniques which can be supported by technologies (e.g. augmented and virtual reality to promote collaborative environments and shared analyses) [32]. The concept of "Learnscape" is depicting a learning environment in which the immaterial network underpins the physical assets and the users interactions. It is a multidisciplinary field where knowledge, teaching activities and learning practices are flipped and merged in formal and informal spaces and where the psychological and emotional needs are take into account (e.g. cooperation, isolation, individual work and collective debate, etc.).

The renovation of Poveglia could be seen as a driver to link the universities activities to the cultural landscape of the territory [33, 34] to encompass the possibility to foreign students to have a contact with history, architecture, advanced technologies, smart campuses and the city. In the last years, the universities campuses in Italy are becoming a specific hot spot in the cities and an instrument for renovation and upgrading of out of the centre areas that could increase their appeal through the location of innovative and valuable architectures (e.g. Bocconi University, IULM-Free University of Languages and Communication, MIND-Milan Innovation District Arexpo are some examples of reskills of abandoned areas through architectural interventions with both re-centring vocation and connection to the main urban centres).

The island of Poveglia has been chosen as a case study for the implementation of a suitable framework in which systems and tools are organized to enable the refurbishment of the local areas and they might be seen as an opportunity [35] for scalable applications in the entire Venice lagoon, an international hot spot of the Italian territory [36]. In this scenario, Poveglia is part of the 'Smart city, Smart campus network' in a bigger context, requiring both strategies for historical preservation as well as for energy efficiency [37] for new and existing buildings to promote the dialogue with historical pre-existing buildings with the aim at reducing the environmental impact of new construction that can be introduced in the fragile natural and built environment [38, 39].

On the island scale, users and architecture establish a constant and fertile discussion, interchanging preferences and needs (the users) and setup (the buildings) by integrating 'cognitive agents' (e.g. sensors and actuators), communicating and mediating by smartphone applications [40, 41]. The new media are permeating the learning actions and the whole user life: in a University Campus where culture, innovation and student buzz is in constant development the new technologies play the role of enabler of cultural, interconnection and future development of a 'common data environment' to upgrade the UX [42].

Network essentials – Essential networks

The notion of "network" can be defined in very different ways, which depends on whether it is taken in a more specific or a wider sense. They can be described as systems where elements and nodes are connected with each other exchanging information in short periods [43] or in real time. The definition comprises not only sociological but also technological matters. Elements and nodes can be represented by many things: individuals in a social context as well as components in a high-tech platform. One node can be part of one or many networks at once and in the Smart city it is required to develop complex structured networks to take advantage of the data and perform on time data analytics to balance and organize the exchange of the energy flows [44].

Thinking of a pre-Internet era the network was limited to fixed and mobile telephony, faxes and text messages through the Short Message Service (SMS). The first step ahead was the World Wide Web (WWW), enabled by adding smartness to the network, which primary focus was the sharing of contents (Google 1998). Adding smartness to Information Technologies (IT) platforms and services the WWW has evolved in the WEB 2.0 in which the focus was to provide services through the network. In the early 2000s the smartness in phones and applications raises and the focus of the network moved to allowing people to be connected through the social media (Facebook 2004, Twitter 2006, iPhone 2007).

The evolution step that can be noticed today is triggered by the rise of smartness inside the devices which are permeating the everyday life. The focus now is mainly directed to a machine-to-machine level of communication (identification, tracking, monitoring, metering) [45] commonly addressed as the IoT [46]. The huge amount of data collected by IoT systems enables the pervasive use of machine learning algorithms [47]. The consequent integration of Artificial Intelligence (AI) systems into the network, will allow data evaluation on a big scale [48], trying to bridge the problem of unstructured data that are a huge amount of unusable information and a grey quantity of information which is redundant and with no added value.

It is possible to benefit from the described technological progress and apply it to the abandoned island of Poveglia with the aim to turn Poveglia Island into a node within a broader university network that has an impact both on the digital as well as on the physical world as Cognitive Campus (Figure 1).

Figure 1. Vision of a Cognitive Campus network with Poveglia as a node of the network

The Cognitive Campus principle is transferred by the Smart campus of the University of Brescia which is the first national experience in this direction.

In this University Campus a local smart grid is providing energy to the buildings and the pilot building eLUX lab has been used as a demonstrator of technologies for renewable energy production, green vehicle electricity supply, learning spaces equipped with sensors to monitor the indoor comfort conditions and enable control actuations to increase the real time responsiveness of the building. A probabilistic approach to evaluate the users' influence on energy consumption of the building has been implemented and tested [49-51]. The Cognitive Campus Network extends the management at campus level to increase the scale of the intervention and broaden the possibility to connect and to utilize the resources of knowledge distributed in the network. The idea is to have all the buildings that can interact with the users and between them to communicate useful information to servitize the daily activities of the users/students with the goal to increase the learning engagement, proficiency, wellbeing, health, security and social improvement.

Cognitive principle – Internet of Things and Artificial Intelligence

Cognitive Buildings respond to changes imposed by external and internal variables such as climate or user behaviour, optimizing processes that influence the overall performance of the building, considering the comfort issues and the environmental impact. The idea of Cognitive Campus goes beyond and envisions the combination of several Cognitive Buildings into a network in which IoT technologies are combined with AI agents to achieve a dialogue between buildings and end-users as well as between one building and another. The key elements of a cognitive process involve understanding, reasoning and learning. Computers are nowadays able to handle large volumes of structured and unstructured data, analyse it and generate outputs that are "conscious" of the evolutions of the problem. One of the most advanced examples of such an AI system is currently coming from researchers of IBM who have developed the cognitive agent Watson [52] able to process big data and it received the higher scores in information ingestion, inter intelligence, relevancy intelligence and tuning criteria compared to other similar tools and it is able to give value to the amount of dark data generated and often unexploited. The users data are not always clear and the use of AI to analyze and explore the feedback has a relevant impact on how to renspond to their needs and expectations. For example in the Customer eXperince (CX) in which Watson is now widely adopted, it is possible to identify the positive-negative sentiment to delineate positive and negative experiences contained in the same feedback comments or other data sources. This would revolutionaze the possibility to interpret and renspond to the users' requests (directly or indirectly formulated).

The research programme of eLux at the University of Brescia, deals with the idea to integrate Watson as part of the cognitive concept for the Smart campus. This idea has been the base concept from which the project "Maritime Oasis" for Poveglia has been developed [36]. As an example, in the eLux Cognitive Building, sensors are used to control the indoor air quality and number of people related to prevent high levels of CO_2 concentration that is obstructing both an optimal cognitive and learning performance and wellbeing. The sensors are gathering data which are processed and analysed to produce a deep knowledge of the building management and use of the spaces made by the students and the activation of actuators to eventually provide additional ventilation is based on the gathered information about the concerned devices [53] such as Air Handling Unit (AHU) fan controls, windows opening, Indoor Air Quality (IAQ) indicators, etc. The further step of the cognitive process is to predict when the critical conditions will be registered based on the historical series of data and set up of the fan and ventilation to prevent the issue (Figure 2).

In Maritime Oasis, Watson can be employed to analyse the collected information from both the built environment and the end-users through web App. AI systems could analyse measures and feedbacks to select the suitable instructions for actions that adjust the buildings to react towards users' needs and preferences.

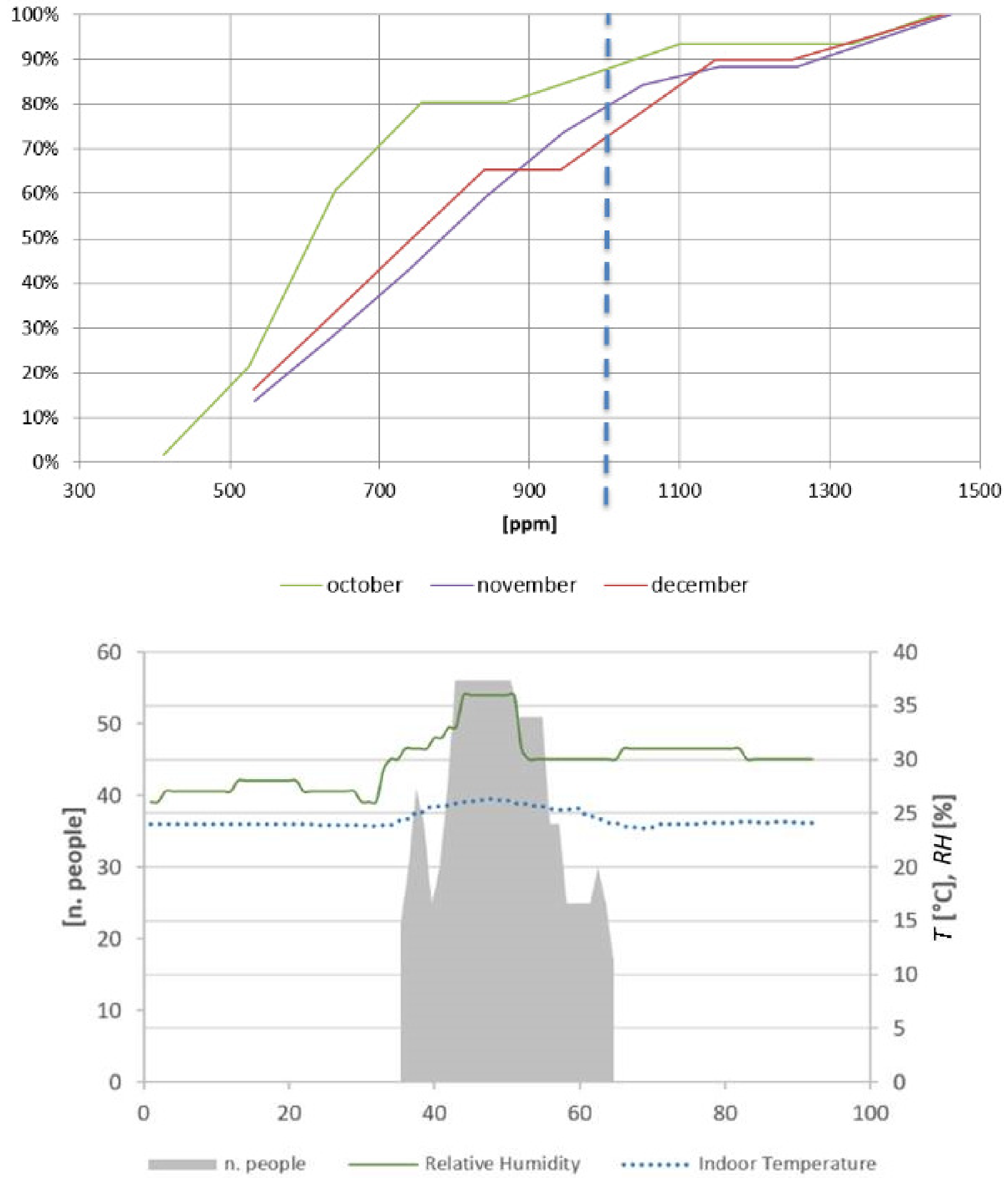

Figure 2. Cumulative curve of CO_2 concentration and sample day where temperature and relative humidity are plotted with n. people

The aim is to integrate users and their behaviour into an overall self-managing building system. Latter is passing through an appropriate infrastructure up to the computation centre that organizes and evaluates the incoming data. Subsequently, the computation centre triggers the actuators. The aim is to endorse the enhancement of the conditions to improve living quality and UX while saving energy and possibly reach the load matching of the renewable energy production and the electrical use of the building. In this direction the integration of vehicles for green mobility into the University Campus to act as storage is exemplified [54].

Applied to architecture this would translate into smart buildings that aggregate into a common network. The ubiquitous computing agent which analyses all the data collected from various sensors maximizes their potentials. All the users involved in this network will be able to send their feedback directly to Watson. Such feedback is considered for the building automation, whereas the system can deduce certain patterns of behaviours.

Throughout forecasts the system can predict the necessary changes for the building performance and consider external factors [55] (i.e., weather station data, green vehicle pattern use, predicted occupancy based on weekly schedule, etc.). Either in real time or in a programmed time period, the actuators that control part of the buildings will be activated under commands of the AI agent to develop predictable actuations based on learned users behaviours and patterns which as example are repeated in the didactic week whilst are changed during the graduation days [56].

MATERIALS AND METHODS

The overall idea underpinning the research is to extend the offer for public institutions by a new University Campus that can benefit current and future citizens of the lagoon. Thus, Poveglia becomes a place of intellectual retreat with accommodation options on-site. The "learnscape" should be hosted in Cognitive Buildings and supported by IoT technologies creating a multifaceted network connecting the entities in the lagoon.

The Cognitive Campus is developed as a complex of new facilities integrating parts of the existing structures and organizing novel concepts of spaces for learning activities in an energy self-sufficient built environment. The digital models of the buildings are used in the design phase to test the energy efficiency solutions while in the running phase of the campus the models could become the Digital Twins [57] through which the data are collected, stored, visualized and would inform the decision processes in the a Product Life Cycle Management (PLM) vision [58].

The main framework for the Poveglia project is based on IoT and AI and for the supply of sufficient input data, two main systems are envisioned. On the one side there is a series of Sensors & Actuators [59], whereas on the other side there is a Mobile Application [60]. Figure 3 shows in a simplified way how different participants are wired up in the Cognitive network. The core of the system is the Cognitive Agent (IBM Watson), which interacts with both the Sensors & Actuators (Environment and Architecture) and the Mobile Application (Users).

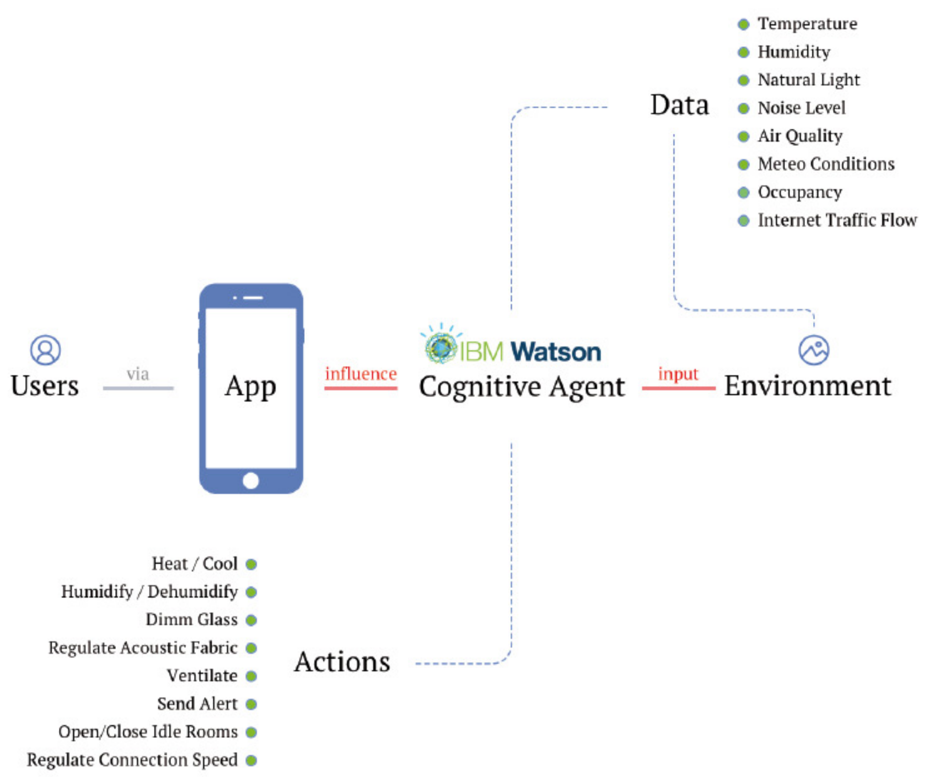

Figure 3. Data collection and concept app for Poveglia Smart campus

The activities involved in the Cognitive Campus include educational spaces, residential facilities, services (e.g. library, canteen, theatre, etc.) and whilst the island will become more densely built, certain existing buildings will get extended. Every building should address the energy production needed for its functioning, however, a global balance can be acceptable considering the complexity of the settlement and the different schedule of use of the different spaces. An optimization strategy to minimize energy waste and reduced occupancy hours for some building will be developed considering the space programming procedure [61] during the design phase implemented by the Business Intelligence (BI) [62, 63] to provide insights to realize service-providers smart buildings [64].

Urban strategies applied

The main urban strategies developed are the following:

- Urban vs. Wilderness. Based on the existing formal system of the island there will be a strong contrast between urban condition and the wild part in the north and north-east. The existing nature is hereby preserved as authentic layer of the past. The campus is a densified evolution of old buildings, extensions as well as completely new constructions. The housing units will be scattered in nature and linked between each other by slightly elevated pathways. These are made with metal grids that do not seal the ground. Moreover, they give to the vegetation the possibility to merge with the new and keep walkability during different weather conditions;
- Generative Campo. The heart of the university will be a precisely circumscribed open space serving as a 'trading zone'. A trading zone is a space for crossing, gathering and interaction. The reference for this spatial element is the Venetian 'Campo': the presence of wells is transformed into a landscape of water, stone and benches that provide the setting for intellectual exchange. The campo separates and connects the neighbouring building at the same time and refers to historical traces;
- Spatial Sequence. The perimeter of the urban form is reinforced by a spatial sequence. It accommodates different urban qualities that reach from 'intimate retreat' to 'generous representation'. Above all, they connect different realms such as the outside world with the island, the wilderness with the urban and the northern with southern part. Different pavements distinguish the campo and the perimeter spaces: whereas the campo is paved with traditional stones, the others feature wood block surfaces that allow water to infiltrate into the ground.

Nearly Zero Energy Building concept in Poveglia

The planning process is accompanied by an extensive Building Energy Model (BEM) study, based on dynamic simulation aimed at optimising buildings envelope and smart scheduling. The main challenge regarding an architectural intervention on Poveglia island is definitely its remoteness to the mainland. It requires additional efforts compared to conventional settings. Such efforts include first of all infrastructural measures to connect the island to water and electricity supply, sewage and IT systems besides the transport of construction materials by boat and the necessity for extra strong piled foundations.

It is of high importance to consider strategies that ensure a certain degree of self-sufficiency for the energy needed by the buildings. In this way, the initial high investment can be amortised by low running costs during the life-cycle of the project. The major concern is the energy supply and production which constitutes one of the most important factors to guarantee the operational life of the buildings in the remote island connected with immaterial resources to the nodes of the Lagoon. High standard for all buildings to attain excellent performances has been set.

Self-sufficiency does not imply, however, that the island should stand on its own. Quite the contrary, it should be connected as much as possible so that the island can provide benefits far beyond its own boundaries. To utilise the full potential of the island it is required to use the grid as a storage for solar electricity even though the load matching in the case of a University Campus is not a critical concern. In this way, Poveglia becomes a productive part of the lagoon and can be a role model for other islands that enter into the grid in the future development.

The decentralisation of the energy production is commonly referred to as 'smart grid' [65]. This term highlights the manifold positive implications of having variety of operational and energy measures including smart meters, smart appliances and renewable energy sources [66] integrated in a major system of smart management. The direct benefits are among others the quicker restoration of electricity after power disturbances [67], the reduced operations and management costs for utilities, the environmental impact reduction, and ultimately lower power costs for consumers [68].

The general approach adopted for the energy concept [69] can be divided in two main parts:

- The reduction of the demand side by high performance of components;
- The onsite generation of energy from renewable sources.

Considering the planning of an efficient settlement [70] the first measure to assume is to design the buildings to gain good volume-surface ratios and configure envelopes with a low thermal transmittance, to shrink the thermal transmission losses, secondly the implementation of efficient systems such as groundwater heat pumps that has been considered to provide energy to all the settlement with an electrical balance towards zero energy goal.

The electricity production is promoted through the integration of photovoltaic modules on the buildings to cover the energy demand during most of the year considering also the use of energy storage systems [71] with light green mobility [72] as transition to Zero Energy Emission Districts (ZEED) [73]. The roofing systems are conceived to install surfaces for renewable energy exploitation optimizing the slope and configuration and the settlement design.

Poveglia's energy model provides an overall picture of results from different aspects: heating and cooling calculation of each building (both in real and fractional values), calculations of energy needed for electricity, equipment and Domestic Hot Water (DHW) and predictions of energy supply by photovoltaic systems [74] considering the technological solution as the preferred one when cost-optimal evaluation is concerned [75].

The renovation strategies for the new campus

The underpinning idea of the research concerns the application of a 3-step grading system to both roof and facade. The three steps determine the current condition reaching from intact over damaged to destroyed state. By the combination of these two parameters, it can be stated that there are some buildings which cannot be restored without disproportional measures. The case of complete destruction applies, however, just to a small amount of buildings. The condition of the remaining ones will be the basis to articulate different strategies for their reuse.

The project in Poveglia aims at introducing the idea of the shelter as leitmotif relating back to the 3 categories which have been identified for the current state of the existing buildings. In this way each category – desolate, damaged, intact – corresponds to one approach, i.e., one type of shelter. The architectural articulation of the three types has been developed considering that different spaces with varying atmospheres should be able to provide different uses. Moreover, the existing buildings have been treated with care, yet through a contemporary approach [76]. Three approaches and corresponding types have been developed and conceptualized to propose new interventions in Poveglia, considering the natural and the built environment characteristics. The three approaches range from the preservation (1) to new construction (3) adopting suitable strategies to

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integrate existing buildings into new built solutions, to the development of new environments for students' learning activities.

The first approach deals with the buildings which have preserved both facade and roof. Making full use of their potential main appearance and most of its physical fabric is preserved. The intervention consists of an insertion of a new nucleus inside the shell of the existing. The interference of the house-in-house principle creates a layering of spaces which is enhanced by the mediating function of the generated thresholds. Decisive openings allow more light to enter and mark the renewal of the building also on the exterior.

The second approach remedies the situation for the buildings which suffered the most: a second skin will create a covering layer all around the old parts and encase them completely with a transparent closure. The formerly collapsed roofs will be substituted with intermediate ceilings which can be easily regulated according to visual and acoustic comfort. The extension by the second skin increases the amount of usable space for academic activities.

The third approach provides further type of shelter which applies for all new constructions made on the island. It is mainly built in wood offering a warm and welcoming atmosphere. It can easily adapt to a wide range of spatial configurations reaching from housing units up to big gathering spaces for lectures, assemblies and large-scale events such as conferences, graduation days, PhD defence days, proclamation days.

In the following Table 1 the concept for refurbishment and new construction are summarized for each approach.

Table 1. Approaches to renovation and definitions of the architectural concepts

N. approach	Definition
1	The Cave Type is characterised by a two layer system: On the outside the original brick masonry is maintained which features a timber roof construction with tile cladding. The openings are double glazed windows and wooden or glass doors (depending on their orientation). The inside is an insulated concrete shell with ceiling height openings.
2	The Tent Type follows the described stratification principle: The outside is defined by a structural glazing as façade, whereas the roof is a steel girder construction with a trapezoidal sheet metal with a casted concrete layer, insulation and photovoltaic panels on top. The vertical load-bearing is ensured by steel columns positioned every 3.5-5 m (varying in each building). The inner part preserves the existing brick masonry walls covered by lightweight polycarbonate panels which serve as horizontal noise barrier and thermal conclusion of the classroom spaces.
3	The Hut Type can be described as: Timber board cladded wood stand construction supported by concrete skeleton (in the smaller units, the concrete is substituted by a wooden frame). The acoustically separated inner core is made of cross laminated timber panels which are attached to the vertical load-bearing system or are suspended from the roof.

Finding the right balance can be complicated. In fact, the aim to keep the existing buildings is by nature diametrically opposed to pure contemporary requirements. Values are not universal and depend on the point of view: preservation is a matter of appreciation for historical entities [77], an attitude and by no means absolute necessity [78]. Differentiating between value and valorisation can be hereby a first step to get the situation under control [79]: whereas the term 'to value' implies the appreciation of existing, 'valorising' is intended as 'giving added value'. That is to say that the specific values of the project are supplemented by 'added values' that should enhance and boost the first ones instead of diminish them [80].

Phenomena of innocuous colour and material alterations will be preserved since they are part of the material authenticity and can trigger age value. Internal partitions will be considered for the new layout, existing flooring and roofs kept were possible. These measures are indispensable to guarantee the aspired historical continuity not only as idea of the old but as tangible physical fabric. The crucial point is to make Poveglia's architecture readable to the users which will enable the buildings to acquire and then to maintain sufficient appreciation for continuous care and future preservation.

The interior of the canteen recalls the spatial experience of being in a naturally formed cave. It surrounds the user entirely with a solid shell which gives you a unanimous tactile experience: rough, unpolished and primitive. The impression of an edgy space is obtained by triangle-shaped panels which unify ceiling and walls to a unique architectural language. Sun rays infiltrating a cave through narrow slots are simulated by stripes of light which are built in the joints of the panels to generate a diffuse illumination.

DESCRIPTION OF THE REGENERATED AREA OF THE CASE STUDY

Located in the lagoon, Venice is caught between the contrast of memory and modernity: there are historical buildings and canals, while modern mobility and mass tourism are prominent. Venice is subject to strong prejudices, which affect incentives for future developments, as first it is considered a "senior city", which impedes many investments, i.e., it is incompatible to keep up with the contemporary world, but it is true, maybe the compatibility can be demonstrated [43] with pioneering projects?

The divergence between memory and modernity has been always radical in Venice and if an extreme position is to completely abolish the old, at the opposite, with Internet, increased evidence that digital networks start playing an important role in reshaping the city (i.e., the employment of platform as AirB&B to facilitate the touristic flows) can be found. It is important to ask whether these networks are able to become not only a tool for commercial activities but also for urban transformation and social development. The lagoon of Venice is an excellent example to study networks since it is by nature a setting where physical isolation (islands, archipelago) is present in a rather extreme way. Abandoned islands such as Poveglia are hereby potential nodes to (re)create a strong network for the future.

The isolation of the segregated territories could become a barrier to connection and services. However, the possibility to benefit of a high level of services in an elitist place where the mass of tourists that are always running Venice are near but they are not stressing the learning landscape. This can be seen as an optimized situation, a perfect quite place where to access to all the services without queuing up.

The abandonment of the island brought decay and deterioration to Poveglia and precious buildings have perished (Figure 4). Not only the physical image was literally ruined but also the presence in the collective memory as being a meaningful place. At this point it is possible to trace certain leitmotif reappearing in the history of Poveglia: firstly, there is the role of the island as symbol of 'white hope'. That is to say that Poveglia served as last resort, a place of cure and rehabilitation in critical times. By that it assumed a significant social relevance serving the common good of the whole city. The fatal connotations of illness and death triggered a presence that has been commonly suppressed. It can be argued that the claim to keep the island public alludes to a strong anxiety: losing Poveglia for the public is put on a level with losing its social value.

The second important 'fil rouge' is the slow but constantly expanding stratification, which means that it is possible to find out many heterogeneous layers. The newer parts relate back to the existing ones by means of reinterpretation and re-composition. Powerful examples are the artificial infill of the northern extension beyond the canal and the octagon in the south which completely changed the appearance of the island.

Figure 4. Poveglia Island: the island in the Venice Lagoon and the local decadence of the historical heritage

Furthermore, a successive addition of buildings with different languages, materials and construction techniques can be found. The heterogeneity is reinforced by a broad spectrum of diverse facades reaching from rather austere to highly decorated, neo-gothic ones. The tower on the island is a perfect example of the historical superimposition of older and newer layers. Among the newer layers there is also the vegetation which has grown literally to a dominant and considerable extent [36].

In 2016 an architectural competition for Poveglia Island has been the opportunity to focus on this fascinating place and to promote the cultural evaluation on the topic of building refurbishment for learning purposes. The island is thus the perfect place where to deploy the technological range for the use of renewable sources and to work with immaterial networks to distribute the services to the users.

Concerning the strengths of Poveglia there are first of all the precious existing buildings which are not only a living witness of the past but can also host new functions that benefit from the strong identity of the architectural features. The island is, furthermore, the perfect place for retreat because of its private spaces and its relatively small area and manageable scale. The architectural topic is unavoidably related to energy efficiency and use of renewable energy sources and thus the design has been developed considering the energy dynamic simulation as a support to architectural choices and detailed performance assessment in an iterative process to implement and enhance the design optioneering.

The regeneration strategy

The planning of the new campus enhances the dialogue between old and new buildings in order to create a harmonious yet intriguing composition [81]. Traces of existing formal systems, such as the regular central square as well as remaining perimeter walls become the basis for new extensions [82]. Vice versa there are changes to the old buildings which originate in the adaption to the added buildings to keep a set of resilient proportions of volume and height. The open spaces that embrace the buildings follow the central issue of offering a stage to the public and facilitate heterogeneity and connectivity [83]. The social integration and cooperation are dominant issues [84] considering the campus as a user-centred learning environment [85].

There is something to the setting of the island: the abandoned ruins and the dominance of nature, they make one think about the essential things in life, the struggle for survival and the most basic needs for a primitive shelter. It is most probably the hostile exposure to rain, wind, fog and the isolation from the outside world. In this sense, Poveglia brings the visitor back to an old tale: the story of Laugier's Adam as described in his Essay on Architecture published in 1755. The Abbé argued with his 'Primitive Hut' in favour of a man-made shelter that served as a meteorological defence in a solitary, individual experience. 'Houses come before temples. (...) Pragmatism comes before ritual. Structure comes before space' [86]. Compared to the proposed project, there are intriguing parallels to Laugier's primordial scenario. Most notably there is the necessity of creating shelters for human activity in a difficult environment. The powerful imaginary of such a quest suggested the idea of shelter as guiding theme in the development of the architectural language [87] coupled with high performance standards [88]. Whereas in the tale everything is made ex-novo, Poveglia raises an additional question: what is the role of the existing, the 'found-spaces', as shelter?

Since its abandonment in 1968, buildings started to deteriorate progressively due to missing maintenance and the vandalism of occasional visitors. It was, however, a matter of time until the built fabric would give in to both alteration and serious decay.

The major factors for decay have been the exposure to weathering and the high level of humidity in the lagoon. Over the years many roofs have partly or completely collapsed. Finishing disintegrated and exposed brick or concrete surfaces directly to the rough conditions. Decomposing windows and doors enhanced the decay further on by allowing vegetation to enter. In addition, the soil has been chemically contaminated due to accumulation of waste and orphaned items. Signs of decay reach, moreover, from biological colonisation such as lichens, mosses and ferns, rust stains up to delamination and cracks in wood pieces, as well as spalling, efflorescence on both brick and concrete. Given this broad amount of decay and the restraint of evaluation sources the implementation of a simple but sound classification to assess the potential for reuse has been promoted [89].

RESULTS

The concepts and strategies explained before are applied to the whole new University Campus of Poveglia and the buildings have been simulated with dynamic calculation models to define heating and cooling demands (kWh/m^{2}year) and the air-conditioned area for each building (Figure 5), according to the BEM approach explained in the Materials and Methods sections.

Figure 5. Building design of the educational facilities in the new campus

Every building in the campus has been simulated and analysed with dynamic calculation model (Figure 6). The three approaches proposed for the buildings also imply the possibility to integrate solar systems and produce energy for the same building or for the campus's buildings. The Smart campus is thus a system where new buildings are able to provide energy for the refurbished and protected buildings in an energy collaborative environment. In Figure 6 it is worthy to note that the minimum value of the energy consumption is 28 kWh/m^{2}K and the maximum value is 58 kWh/m^{2}K.

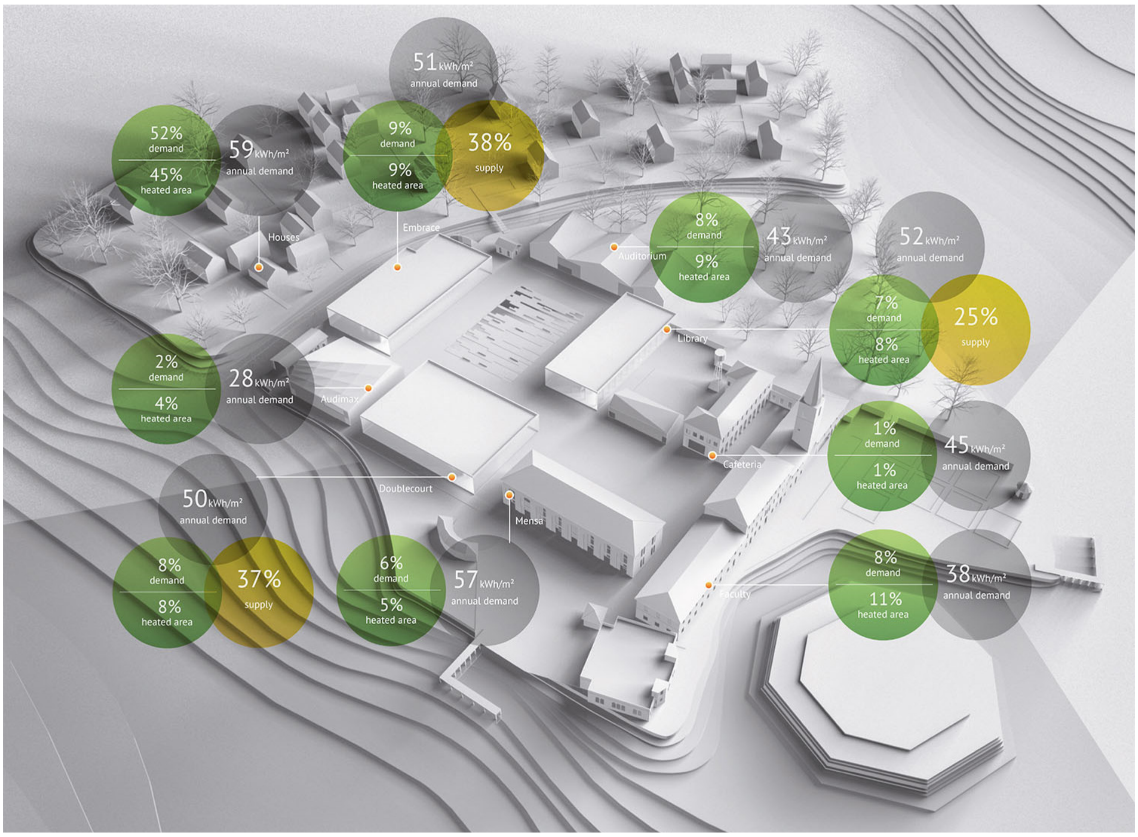

Figure 6. Energy balance of the University Campus in Poveglia

It is useful to understand also the daily schedule of the buildings because the students' residence and the university buildings have different peak-hours of occupancy and a load matching approach should be considered while planning the renewable energy sources that can be deployed for the real-time support of the energy consumption. The hypothesis of a hybrid system with storage systems and grid connection could be feasible and suitable to face the variable load changing during the didactic activities and seasons (lectures, graduation sessions, preparation of the exams, etc.). The calculated data highlights three main remarks:

- In general, the project has a low value of energy demand (47 kWh/m^2 year) which in many EU building codes fulfils high performance criteria;
- The energy demand of heating is much higher than the cooling due to the shading strategies adopted for the buildings;
- Annually speaking the estimated energy supply on-site by renewable sources (1.8 million kWh/year) is greater than the energy demand (0.65 million kWh/year) giving the possibility to support the fluctuation of electrical needs of the campus and the variability of occupancy and consumption in the long-term period. Moreover, the campus network in which Poveglia is included could benefit of the energy management plan to yield energy when needed in the variable pattern that can be forecast and needs a real-time management in the Smart city framework.

The positive result from the first observation shows the competitiveness of Poveglia project, especially considering that preservation is the core topic. The project benefits from climate conditions and high-performance envelope solutions and systems efficiency. Venice lies in Mediterranean climate zone which implies relatively dry summers and mild winters. Well-designed building envelopes and well-sought materials result in low thermal transmittance. The absolute energy needed for heating or cooling is consequently low (between 11 kWh/m^{2}year and 32 kWh/m^{2}year).

Additional measures help to improve the energy performance. The campus is closed during the hottest month (August) and it is optimised with usage schedules (as low occupancy would be detected/predicted the facility manager closes some of the rooms).

The second observation has surely many causes. Regarding the Cave and Hut types the percentage of heating energy has a much bigger share in the overall energy demand. This can be traced back to high opacity in the case of Hut (given by the auditorium function). In the case of Cave, the existing building works as a second skin and reduces solar heat gain and thus protect from overheating in the middle and summer season.

Energy consumption and clean energy production calculations

Simulations have been performed in order to define the suitable building envelope to achieve good energy performance. Since the retrofit intervention includes three architectural typologies, it is necessary to have a precise definition on the exact material included in the project [64].

BEM allows to define the energy consumption of each building in the campus with the contribution of photovoltaic systems. The calculation engine used is Energy Plus by Lawrence Berkeley National Laboratory, USA and the solar electrical production is calculated by PVGIS portal by JRC – Joint Research Centre, Ispra (https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html), the results are resumed in Figure 6 and Figure 7 where the positive energy balance of the buildings is shown.

It is possible to organize a new campus on an abandoned island applying a Net Zero Energy Building (NZEB) concept providing a new life to the buildings and changing the nature of the node which becomes attractive for people and active into producing energy.

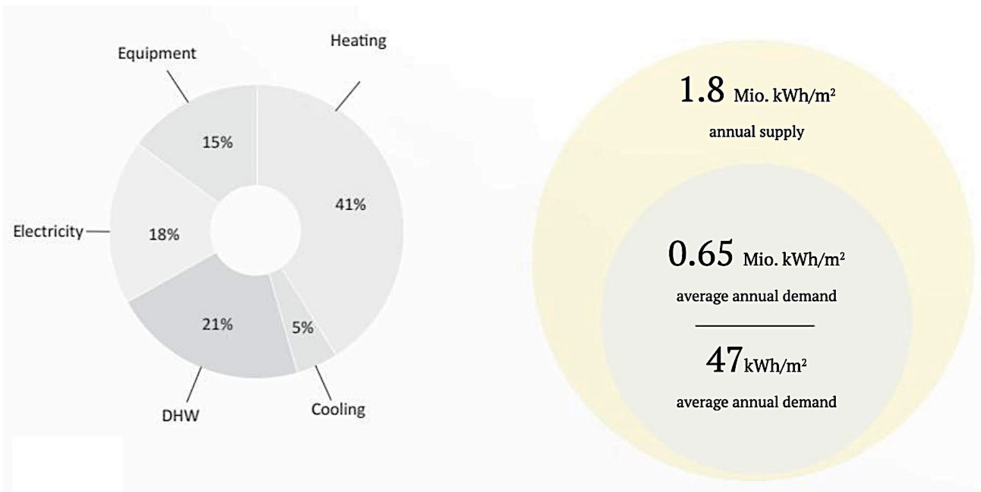

Figure 7. Energy consumption distribution of the University Campus in Poveglia

'Maritime Oasis' [36] creates a scenario in which the cognitive principle realized at eLUX lab is applied and extended to Poveglia Island university settlement [90]. The maritime environment suggests principles that cover a larger rehabilitation circle than on the mainland especially because of the heavily decayed buildings [91]. Figure 8 shows, for one sample building, the key data resulting from the simulation carried out: the percentage of energy for usage, the number of users and the monthly distribution of energy demand (kWh/month). Figure 9 shows for the topology of buildings "Mensa", "Cafeteria", "Faculty" and "Houses" the key data in terms of uses, occupancy, energy consumption distribution and configuration. Depending on the assumed occupancy profiles for the number of users considered for the different buildings the energy consumption distribution varies consistently depending on the use and the refurbished or new construction buildings.

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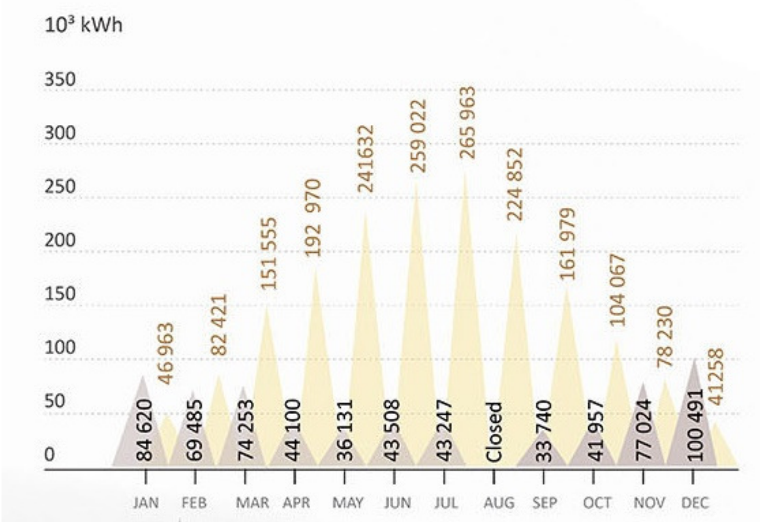

Figure 8. Monthly energy consumption (grey) and production (yellow) over one year

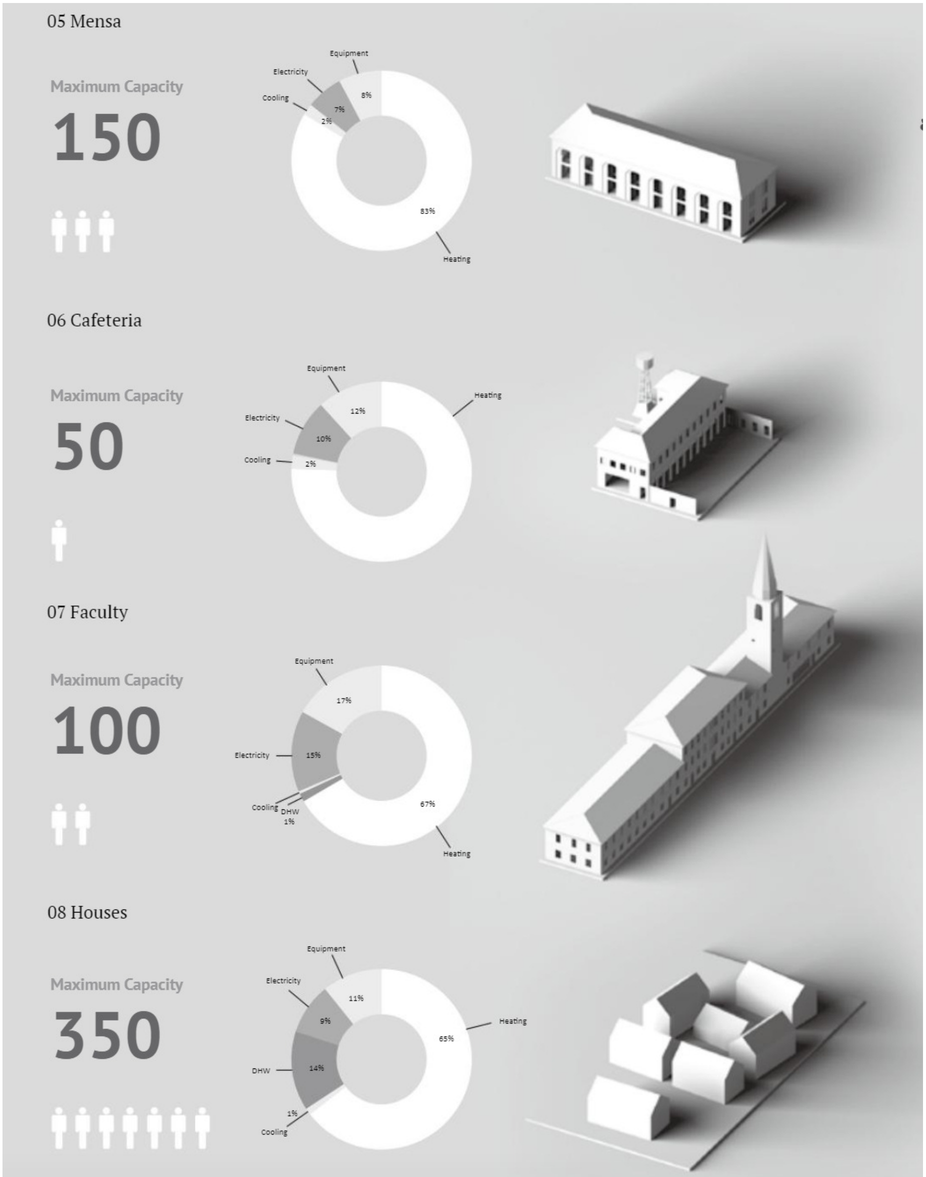

Figure 9. Buildings in the University Campus: uses, occupancy, energy consumption distribution and configuration

Internet of Things and Building Management Systems

The sensors will translate environmental conditions into data and deliver to Watson. After analysing the data, Watson will give commands to trigger direct actions from the actuators. As soon as sensors installed in classrooms detect a poor air quality, Watson will trigger a higher ventilation rate in order to improve the air quality in short response time. In another scenario, where too much people are waiting in an underground station, the access systems and signals could be reconfigured to manage the temporary peak of affluence maintaining a suitable level of service.

Users can exploit a dedicated mobile application to interact in real-time with both the information from Watson (translated into a user interface that has been designed according to rules for a better UX) and each other (an integrated inter-com service and social networking).

They can see the energy performance, the room comfort level or the occupancy rate of the buildings they are interested in, or even they can benefit from shared services provided by different university structures (e.g. canteen, library or even the equivalent services from other universities in the lagoon area). The users' involvement could be beneficial to reduce the rebound effect and performance gap detected in NZEB buildings [92, 93] and achieve an actual result in reducing the energy consumption and the environmental impacts as well as to enhance and regenerate the place.

The sensors applied in the project are monitoring all parameters concerning the room comfort conditions. Additionally, sensors connected to weather forecast will allow Watson to monitor severe weather changes ahead. Internet traffic will be also monitored as part of the sensors applied in the project. As corresponding actions commanded by Watson, the actuators will regulate heating and cooling, activate humidifier or dehumidifier, open or close the shading devices, increase or decrease ventilation rate and also give alerts to users that their focused rooms are heavily occupied.

The role of the sensors and actuators on Poveglia Island is to empower the vision of a greater network of 'Smart city and Smart campus'. Implementing these technologies in the design phase it is possible to simulate the response system in the use phase of the buildings. The connectivity and networking of both the facilities and the academic services will be shared within the greater network. It is somehow helping rejuvenating Venice and breaks the stereotype of being a 'Senior city'. A vivid and vibrant public institution is definitely a good example for reutilisation project of abandoned islands in the lagoon area. Poveglia is the perfect place for testing a cognitive system that connects various spots in the Venetian Lagoon and reinforces the historical bond between the islands.

Installed actuators will respond in real time with incoming commands, which have been deduced, from sensors, user preferences and external data [94]. Virtual reality devices will help to simulate architectural interventions and help to facilitate maintenance based on Building Information Modelling (BIM) model for facility management. The settlement will be described by a Geographic Information System (GIS) model in which the university buildings and residential units are included and data managed at island level and building level.

User Experience design for energy awareness and user involvement

As long as the buildings are operating, a smartphone application will be designed according the UX principles to facilitate the communication between users and the AI agent. The cognitive system needs to communicate to the users, as in general, over 90% of the data generated by IoT network are unstructured. Since the buildings are designed with high energy efficiency standard, one of the interface's aims is to translate by AI the unstructured data and withdraw meanings from the data, in order to provide the users with comprehensive infographics, useful for understanding the functioning of the built environment.

Various academic institutions have been involved in the 'Smart campus' network. The University Campus imagined for Poveglia is encompassed in the scenario of an extension of Ca' Foscari University, which could access the resources present on Poveglia Island. For the pan-lagoon area, an interface to visualise the application for different universities (e.g., VIU-Venice International University, Accademia and other Ca' Foscari campuses) (Figure 10) has been designed on the basis of the eLUX bi-directional app [95].

Figure 10. Mockup of the bi-directional App for the Cognitive Campus in Poveglia to collect and analyse the users' feedback and provide information about building energy management

CONCLUSIONS

User data is crucial for digital networks. In the case of the 'Cognitive Campus' users are constantly producing data during daily campus life [96]. This raises the question of what the implications of this process are. It can be argued that by choosing and reacting to the environment, the act of living turns itself into an involuntary critique. Surely there has always been a certain degree of such critique. The main difference is that the critique is nowadays accessible throughout endless data flows. The data is coming directly from users who are monitored in their movement and behaviour. Accepting the 'Terms of Conditions' and agreeing to data exposure becomes a major concern. How could be assessed the value of data in our contemporary networks?

As the digital networks grow, both in dimension and in potential, a process of 'commodification' is taking place. In the contemporary example of the digital network the main commodities are resources of network owners and data of the users. Users give their personal data (sometimes rather unconsciously) to service providers in exchange for services (sometimes claimed as 'free'). If data are considered as commodity with a definable 'value', it is possible to envision the listed below three main possible scenarios.

The first considers data as part of the 'Gift Economy principle' [97] where a 'gift' is never for free, it creates a strong social bond between two participants. One party gives away goods as a gift, the social bond will lead to the receiver giving back something in return, no matter if it is a favour or goods as well. In the case of digital network, users by accepting the terms and conditions accessing free online service for instance (e.g., Wi-Fi hotspot, social networking, or cookies when they browse online content) consent to objectification of their personal data because in a gift economy, nothing is for free.

The second scenario sees data as an exchange product within the framework of a commercial contract. The economic act ends with the exchange of 'goods' is executed. This implies that as soon as users give away their data, there could be some sort of 'reward' that indicates a defined value. In the university environment, students could be rewarded with educational coupons for courses but also for services such as cloud storage, etc., or with cryptocurrencies as well.

The third scenario sees a strong role of public institution and the affirmation of the open-data paradigm in which data are shared, free of charge, through standard interfaces and formats. This behaviour will be mandatory for data generated by public services, as they have already been paid by taxes, but their integration form private sources will generate a prosperous ecosystem that will stimulate the development of innovative solutions.

To conclude, it can be stated that the article presents the vision of a University campus node included into a wider network because the cultural environment of educational point and Universities is a field of development for communication and cognitive technologies. The framework includes the need of cyber security to protect the network and the users' data [98].

The educational use given to an abandoned place with environmental potential and value incudes a layered stratification of benefits. As the first benefit it is possible introduce new approaches to define new spaces and 'Learnscapes' for students and users of a wider community. Secondly, it is possible to promote virtuous behaviours and organise a reduced impact community by means of new technologies and architectural heritage improving social outcomes. As third point, it is possible to enhance the users' experience with the added cyberspace. The eLUX lab experience at the University of Brescia represents the first examples of Cognitive Campus in Italy, a model that, despite the further improvements, could be exported abroad as part of an international network.

The Universities network introduces the issues and potentials of the Smart city [99] into the educational environment and can increase the value of learning with new business models based on knowledge rewards promoting culture and engagement in the knowledge process. However, also strategies to involve the users and gamification systems to implement data exchange and training/learning experience should be tested and refined during a first phase.

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