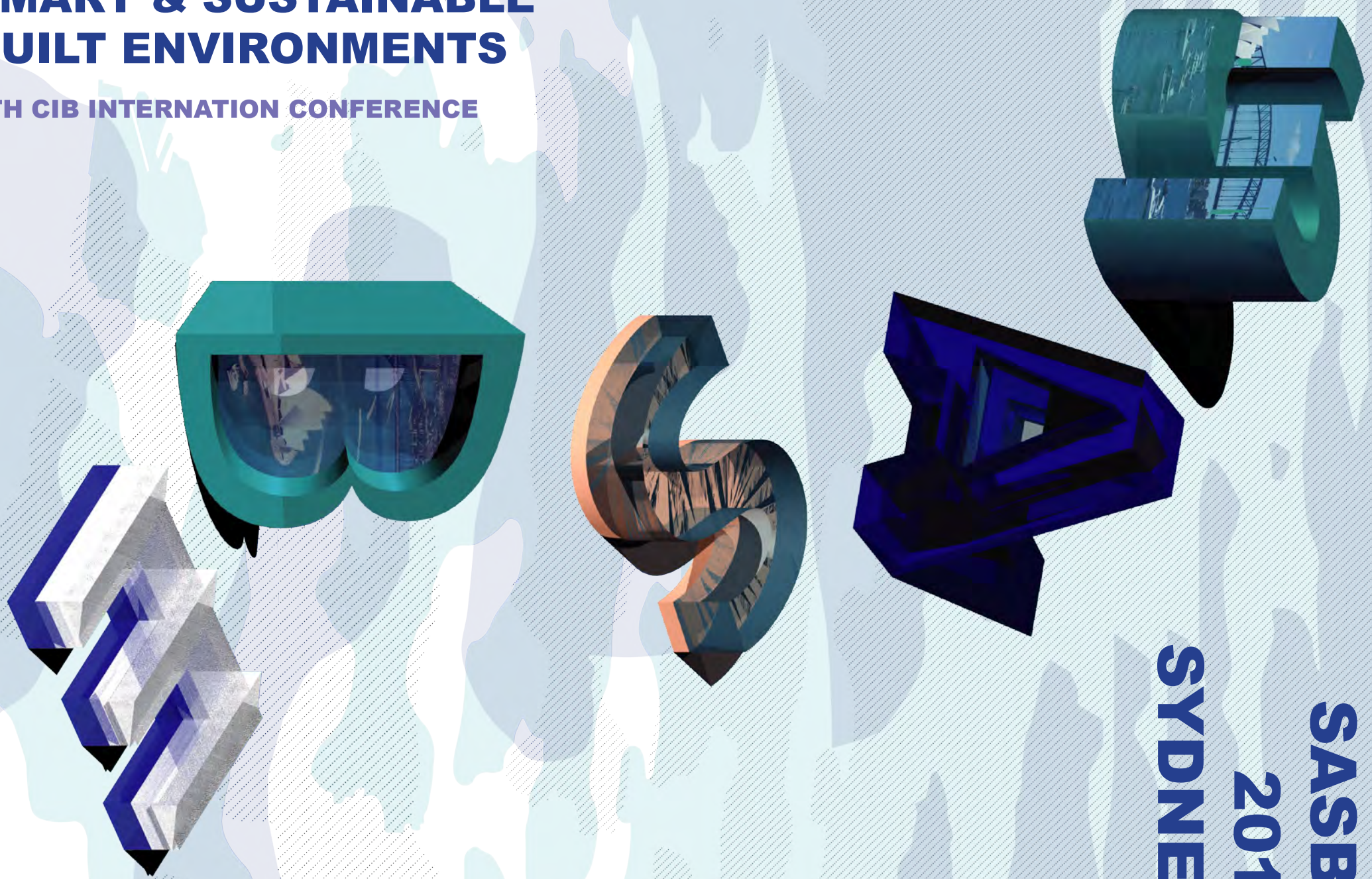
# SMART & SUSTAINABLE BUILT ENVIRONMENTS

## 6TH CIB INTERNATION CONFERENCE



SASBE 2018 SYDNEY

**WE ACKNOWLEDGE THE TRADITIONAL CUSTODIANS OF THE LAND ON WHICH THE INSTITUTION IS LOCATED, THE GADIGAL PEOPLE OF THE EORA NATION.**

**WE HONOUR AND CELEBRATE THEIR ELDERS AND THE ELDERS OF ALL ABORIGINAL AND TORRES STRAIT ISLANDER NATIONS PAST AND PRESENT.**

## FOREWORD

The 6th Smart and Sustainable Built Environments conference returns to its origin. With the first conference being organized in Brisbane, followed by Shanghai, Delft, Sao Paulo and Pretoria, Sydney is the 2018 host of researchers and practitioners in the field of Smart and Sustainable Built Environments (SASBE).

This year's conference is lucky to have a large response of high-quality papers which will all be presented at the conference. It becomes clear that the traditional group of academics, interested in technologies, buildings and modelling indoor climates and energy performance is now balanced with a growing group interested in the sustainability and smartness of planning and design of cities. Though it has always been the ambition of SASBE it is good to see this development continuing and leading to a real broad community.

This year's conference pays tribute to the traditional custodians of the land. This is important to acknowledge, and not in the way it often is practiced in Australia: with an aunty or elder that welcomes the delegates on the first morning on their traditional land. After which he or she can leave and the conference, or meeting, can really start. Especially when we speak about sustainable development it is a very Western attitude to neglect history, in particular when this history is over 40,000 years. Did you know that aboriginal people built settlements, practiced agriculture and developed smart and sensitive relationships with nature. They even made a deal with killer whales to jointly hunt for fish. After catching the fish, they were so smart to share the catch with the killer whales, who then would drive the fish into the aboriginal settlement next time. This mutually beneficial model ended the moment one of the English first settlers shot a killer whale. They never returned again. This and many other stories, exemplifying the relationship of Aboriginals with land, and nature is captured in the book 'Dark Emu' by Bruce Pascoe. A real recommended read!

This also gave us reason to develop the conference as a real mutual experience. The welcome is more than superficial and will give all delegates an impression of traditional Aboriginal thinking. We are extremely happy that Chels Marshall will induct us in some of the basic rituals and thought leadership. Throughout the conference we will have Aboriginal food and reminders of the traditional values and sustainability of treating the land and our built environment. I truly hope that this will be an experience you will always remember. Not only because it is impressive, but because it will influence your daily working life.

In this document you will find all the papers that will be presented during the conference. It gives you an overview over the most recent research into Smart and Sustainable Built Environments, at the scale of individual buildings and cities alike. Selections of the submitted papers will be published in a book, published by Springer, and two special issues of the SASBE journal. Hence, not only during the conference the research is presented but also afterwards this research will find its way to the academic channels as appropriate. We also will honor two best papers, one for academic rigor and one for the best practice. Each will be awarded with a prize, provided by Springer and Emerald Publishing.

Sydney in December is an excellent time for a visit and we have worked hard to make the conference a success. I sincerely hope you will enjoy the conference, the city and your fellow delegates. Here, I want to thank all that have played an important role in preparing for the conference: all the reviewers, members of the organizing committee, members of the scientific committee, and Stewart Monti, who has worked tirelessly to communicate, organize, email, call, skype and who knows what else to create a silken smooth conference. In the meantime, he finished his Masters of Architecture, which is something to applaud! Please meet up with him, thank him and if you can hire him!

I hope you have a great time in Sydney, enjoy the talks, the food, the company and the weather! I wish you the best of success during the conference and after.

Yours sincerely,

Rob Roggema
Conference Chair, SASBE 2018

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Nori Yokoo, PhD | Utsunomiya University, Japan

# PROGRAM

## Day Zero: Tuesday 4 December 2018

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| 5:00 - 7:00 pm<br>**Welcome** | **Reception and Registration**<br>*UTS Design Innovation Research Centre*<br>*Building 15, Level 2, 622-623 Harris Street*<br>*Ultimo, 2007* |

## Day One: Wednesday 5 December 2018

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| 9:00 - 10:30 am<br>**Opening Session** | Welcome to Country<br>***Aunty Ann Weldon***<br><br>Welcome to SASBE 2018<br>***Chair: Rob Roggema***<br><br>Keynote: Removing the brown stains from sustainability<br>***Chels Marshall, Australian National University***<br><br>Keynote: Towards Sustainable Cities: about Redundancy, Emptiness and the Potentials of the Land<br>***Rob Roggema, chair SASBE2018*** | |
| 10:30 - 11:00 am | **Morning Tea** | |
| 11:00 am - 12:30 pm<br>**Parallel Sessions** | **Session A: Inclusivity**<br>*Chair: Sumita Ghosh*<br><br>A model for assessing the social impacts of building upgrades in China<br>***Chenyang Li, University of Technology Sydney***<br><br>The role of public participation in the future of Sydney Olympic Park as a sustainable place<br>***Eveline Mussi, University of New South Wales***<br><br>Adaptation of "participatory method" in design "for/with/by" the poor community in Tam Thanh, Quang Nam, Vietnam<br>***Nguyen Hanh Nguyen, Ho Chi Minh City University of Architecture***<br><br>Fifty years of inclusive transport<br>***John Harding, WSP***<br><br>Enabling smart participatory local government: preliminary findings<br>***Tooran Alizadeh, University of Sydney*** | **Session B: Energy**<br>*Chair: Andy van den Dobbelsteen*<br><br>The total cost of living in relation to energy efficiency upgrades in the Dutch, multi-residential building stock<br>***Thaleia Konstantinou, Delft University of Technology***<br><br>The optimization of active/passive energy-saving in the hotel atrium<br>***Guan Yaming, South China University of Technology***<br><br>Sharing urban renewable energy generation systems as private energy commons<br>***Craig Burton, University of Melbourne***<br><br>Identifying bottlenecks in the photovoltaic systems innovation ecosystem – an initial study<br>***Kristian Widén, Halmstad University*** |
| 12:30 - 1:45 pm | **Lunch** | |

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| 1:45 - 3:15 pm<br>**Parallel Sessions** | **Session C: Resilient City**<br>*Chair: Rob Roggema*<br>The influence of landscape architecture on landscape construction health and safety<br>***John Smallwood, Nelson Mandela University***<br>Globalization and transformations of the city of Sydney<br>***Shahadad Hossain, Western Sydney University***<br>Post-earthquake recovery in nepal, a study and analysis of post disaster perception and needs for housing recovery after 2015 earthquake<br>***Rupesh Shrestha, Kathmandu Valley Preservation Trust***<br>Towards a circular economy in the built environment: an integral design framework for circular building components<br>***Anne van Stijn, Delft University of Technology*** | **Session D: Comfort**<br>*Chair: Michiel Smits*<br>Outdoor comfort in metro Manila: mitigating thermal stress in typical urban blocks by design<br>***Juanito de la Rosa, Architectural Association***<br>Markov logic network based group activity recognition in smart building<br>***Hao Chen, Incheon National University***<br>Impacts of highly reflective building façade on the thermal and visual performance of one surrounding office building in Singapore<br>***Jianxiu Wen, National University of Singapore***<br>A field study on occupants' comfort and cold stress in CLT school buildings<br>***Timothy Adekunle, University of Hartford*** |
| 3:15 - 3:45 pm | **Afternoon Tea** | |
| 3:45 - 5:30 pm<br>**Parallel Sessions** | **Session E: Urbanity**<br>*Chair: Dominique Hes*<br>Evaluating factors influencing the uncontrolled growth of urban-rural belt – a case study of Delhi, India<br>***Mukesh Ray, University of Technology Sydney***<br>Implementing a new human settlement theory: strategic planning for a network of circular economy innovation hubs<br>***Steven Liaros, University of Sydney***<br>Density and quality of life in Mashhad, Iran<br>***Fereshteh Moradi, University of Technology Sydney***<br>The city-zen urban energy transition methodology – the Amsterdam roadmap towards a zero-carbon city<br>***Andy van den Dobbelsteen, Delft University of Technology*** | |
| 5:30 - 6:15 pm | Keynote: Smart and Liveable Cities: A socio-technical perspective<br>***Nimish Biloria, University of Technology Sydney*** | |
| 7:00 - 10:00 pm | **Conference Dinner** | |

## Day Two: Thursday 6 December 2018

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| 9:30 - 10:15 am<br>**Opening Session** | Keynote: Walking country: landscape and walkability as the basis for urbanity<br>***Rod Simpson, Greater Sydney Commission*** |
| **10:15 - 10:45 am** | **Morning Tea** |

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| 10:45 am - 12:15 pm<br>**Parallel Sessions** | **Session F: Smart cities**<br>*Chair: Nimish Biloria*<br><br>Application of Fuzzy AHP for ranking and selection of innovation in infrastructure project management<br>***Mohammadali Noktehdan, , University of Isfahan***<br><br>Smart city initiatives: a catalyst for meaningful collaboration<br>***Homa Rahmat, University of New South Wales***<br><br>A techno-economic analysis on applying smart distribution network for solar photovoltaic systems in educational buildings<br>***Hongying Zhao, RMIT***<br><br>A user-led approach to smart campus design at a university of technology<br>***Alfred Ngowi, Central University of Technology*** | **Session G: Green Building**<br>*Chair: John Smallwood*<br><br>Data management using computational building information modelling for building envelope retrofitting<br>***Taki Eddine Seghier, University of Technology Malaysia***<br><br>Towards self-reliant development: capacity gap within the built environment of Mt. Elgon rural inhabitants<br>***Michiel Smits, Delft University of Technology***<br><br>Mainstreaming real sustainability in architecture<br>***Luke Middleton, EME Design***<br><br>Green buildings in australia: explaining the difference of drivers in commercial and residential sector<br>***Tayyab Ahmad, University of Melbourne*** |
| 12:15 - 1:15 pm | **Lunch** | |
| 1:15 - 2:45 pm<br>**Parallel Sessions** | **Session H: Urban Ecology**<br>*Chair: Greg Keeffe*<br><br>Australia's urban biodiversity: how is adaptive governance influencing land-use policy<br>***Hugh Stanford***<br><br>Mapping the permeability of urban landscapes as stepping stones for forest migration<br>***Qiyao Han, Queens University Belfast***<br><br>Potential of trees to mitigate climate change impacts in a railway corridor case study in sydney<br>***Sumita Ghosh, University of Technology Sydney***<br><br>Urban agricultural practices in the megacities of Dhaka and Mumbai<br>***Tazy Momtaz, University of Technology Sydney*** | **Session I: Construction**<br>*Chair: Luke Middleton*<br><br>Challenges to the implementation of sustainable waste management practice in the construction industry<br>***John Smallwood, Nelson Mandela University***<br><br>Producing work-ready graduate for the construction industry<br>***Sadegh Aliakbarlou, Unitec Institute of Technology***<br><br>Cradle to cradle building components via the cloud: a case study<br>***Adam Jenkins, University of South Australia***<br><br>The impact of leadership on innovative culture in the construction industry<br>***Hossein Sadeghzadeh, University of Auckland*** |
| 2:45 - 3:15 pm | **Afternoon Tea** | |
| 3:15 - 4:45 pm<br>**Parallel Sessions** | **Session J: Space and Place**<br>*Chair: Kiran Kashyap*<br><br>A multiple criteria analysis-based framework to evaluate public space quality<br>***Peijun He, Singapore-ETH Centre***<br><br>Preventing urban open space encroachment: the case of Bloemfontein, South Africa<br>***Lindelwa Toba, Central University of Technology***<br><br>A new model for place development – bringing together regenerative and placemaking processes<br>***Dominique Hes, University of Melbourne***<br><br>Re-imagining urban leftover spaces<br>***Jasim Azhar, Victoria University of Wellington*** | **Session K: Performance**<br>*Chair: Anne van Stijn*<br><br>Tower blocks in groups of different patterns -the aspects of daylight and view<br>***Bengt Sundborg, Norwegian University of Science and Technology***<br><br>Assessing the lighting performance of an innovative core sunlighting system<br>***Liliana Beltran, Texas A&M University***<br><br>Vertical light pipe potentiality for buildings in Surabaya, Indonesia<br>***Hanny Pratama, Khon Kaen University***<br><br>Energy efficiency of a high-rise office building in the Mediterranean climate with the use of a double skin façade<br>***Tanya Saroglou, Ben-Gurion University of the Negev*** |
| 4:45 - 5:00 pm | **Contemporary Urban Design Thinking, The Australian Approach - Book Launch** | |
| 5:00 - 5:45 pm | Keynote: Born and not made: designing the productive city<br>***Greg Keeffe, Queens University Belfast*** | |

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| 5:45 - 6:00 pm | **Prize ceremony and closing** |
| 6:00 - 7:30 pm | **Farewell Drinks** |

## Day Three: Friday 7 December 2018

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| 10:00 - 2:00 pm<br>**Technical Tours** | **Central Park**<br>*Central Park Mall, 28 Broadway*<br>*Chippendale, 2008* | **Parramatta Ferry**<br>*Wharf 5, Circular Quay, 2000* | **The 'Paper Bag Building'**<br>*Dr Chau Chak Wing Building*<br>*Building 8, 14 - 28 Ultimo Road*<br>*Ultimo, 2007* |

## KEYNOTE SPEAKERS

### CHELS MARSHALL

**Removing the brown stains from sustainability**

In uncertain times of global capital, political uncertainty, environmental instability, food insecurity, profound species loss and ecosystem breakdowns in natural systems essential to our existence and survival such as forests, oceans , rivers and air, continue to decline and diminish on our watch!

The unknown factors are too much to ignore, or to leave to someone else to fix or deal with, we are now at the point where mass social paradigm shift through mind frame and actions are required to bring balance back to eco centric lifestyles and existence.

In our Western timeframe we think we are working on sustainability, and using all kinds of performance systems on energy efficiency, indoor climate and comfort, waste management, while the real sustainability is almost out of sight; namely that the land, earth and sea which all consists of a holistic and whole systems approach. This is the system Indigenous people have thrived and survived in sustainably for thousands of years through social practices and structures which placed the environment and its species in levels of equity and of superior creation, with the notion of cyclic existence in which everything relates to each other, in which collaboration is more important than ownership, and that if you give you will get back.

In design and planning owning land should not be the main goal, and will definitely not lead to sustainability, as there is only a very few people that profit from developing land. Shared ownership will automatically conserve the land and together the 'owners' will make sure that the land will give back for eternity. It is now time for those with innovative intellect in design and the built environment to step up in altering the perspectives from individual wealth to that of a shared ownership and a holistic acknowledgement of land, nature, humans, all as part of one system.

*Chels is a leading Indigenous ecologist in cultural landscape management and design. Having over 27 years of professional experience in cultural ecology & integrated environmental planning, design and management, within government agencies, research institutes, Indigenous communities, environmental consulting companies and industry. Chels has spent many years investigating, developing, writing and implementing policy and governance frameworks for indigenous bio-science, cultural ecology, co-management, partnerships and traditional cultural knowledge principles. Chels is an expert in her field of cultural ecology and has spent 25 years in interpretation and design of public spaces in cultural contexts, developing cultural protocols for community partnerships and designing governance frameworks and methodologies for cultural knowledge exchange and application.*

## ROB ROGGEMA

### Towards Sustainable Cities: about Redundancy, Emptiness and the Potentials of the Land

In our western society we are used to plan. Plan for the future. After analyzing problems, the cure is then determined, and we can build the city in a way that we want. Much is based on power relations, land-ownership and maximization of profit. Over the years this has led to cities that are completely fixed and inflexible and build according a development model that consists of the built typology offered by developers. Consumers just have to take it or leave it. Sustainability is limited within this frame, we will adjust housing to make them more energy efficient, limit the use of water resources and try to design a public space that offers people enough space to exercise.

How different a real sustainable city looks like. This city incorporates future uncertainties by increasing its flexibility and conserves space for future uses. This calls for emptiness, redundant spaces and using landscape according its best potentials. The analysis should chart the best possible collective use of land providing resources to the community, and safeguarding supplies being regenerated. The design of the city will then no longer be determined by land prices and short-term benefits but be focused on building a long-term relationship with what the land has to offer. By sharing resources and returning to the natural system what it requires to recover, people can develop a longstanding relationship with their environment. This city will look different from the ones we currently know as it has to open its urban systems to change.

*Prof. dr. ir. Rob Roggema (1964), Landscape Architect, is an international renowned design-expert on sustainable urbanism, climate adaptation, renewable energy landscapes and the design of urban agriculture. He held positions at several universities in the Netherlands and Australia, State and Municipal governments and design consultancies. Per 1 January 2019 he is appointed as Professor Sustainable Spatial Transformations at Hanze University Groningen, the Netherlands. In 2010 he became the inaugural visiting fellow at the Victorian Centre for Climate Change Adaptation Research, in 2014 he was the Chair of the 6th International AESOP Conference on Sustainable Food Planning in Leeuwarden and in 2018 Chair of the 6th Smart and Sustainable Built Environment (SASBE) conference in Sydney. His PhD-thesis has been selected for publication in Springer's 'Recognising Outstanding Research'-series (2013). He is Global Distinguished Professor at KEIO University, Japan (2019), Lead Expert in the URBACT III program, expert for RESURBE, Editor-in-Chief of SABE-journal (Emerald Publishing), member of several Editorial Boards, Guest-Editorships and acts as external monitor for different Universities, processes and projects.*

## NIMISH BILORIA

### Smart and Liveable Cities: A socio-technical perspective

Rapid urbanisation globally has resulted in the insatiable demand for developing cities. Such large scale built environments consume 75% of the world's natural resources, 80% of the global energy supply and produce approximately 75% of the global carbon emissions. This, comes with a baggage of associated complexities in the domains of urban mobility, spatial density, sustainable energy production and consumption as well as urban health and wellbeing. Maintaining a healthy ecological balance between the built and the natural while aiming for equitable and participatory urban growth are thus becoming issues of serious concerns in both the developing and the developed world. Within this context, the usage of smart tools, techniques and methodologies to envision Liveable Cities or rather cities which, are humane, resilient and joyful, which, focuses on addressing/identifying broader performance criteria such as 'Quality of Life' and 'Wellbeing' and thus provides a more user centric perspective on cities are becoming increasingly important. The lecture shall try and dissect the term 'Smart' and its implications within the existing urban landscape to envision Liveable Cities. Understanding and treating the city as a Laboratory where competitive growth and informed development from a social, spatial, economic and environmental perspective is deemed essential shall thus be discussed and elaborated upon. This, in essence implies a democratic view towards building our cities wherein a balance between qualitative and quantitative aspects of a city and its related user centric key performance indicators are aimed at promoting a healthy and equitable society. The lecture shall encourage us to collaboratively explore novel data-driven research and design approaches for identifying and establishing synergies between factors that add up to a community's quality of life including the built and natural environments, economic prosperity, social stability and equity, educational opportunity, and cultural, entertainment and recreation possibilities.

*Dr. Nimish Biloria is an Associate Professor at the, Faculty of Design Architecture and Building at the University of Technology Sydney, Australia. Prior to this, he served as an Assistant Professor at the world-renowned Faculty of Architecture and the Built Environment, Delft University of Technology, The Netherlands. He has over 15 yrs of experience in the Emergent Technologies and Creative Industry sectors across Europe and Asia and is currently leveraging his global network and expertise within the Australian context. Dr. Biloria holds a PhD from the Delft University of Technology, The Netherlands, in Real-time interactive environments and a Master in Architecture in Emergent Technologies and Design from the prestigious Architectural Association, London, UK.*

*Dr. Biloria firmly believes in digitally driven bottom-up methodologies for developing performance driven sustainable and energy efficient design solutions at variable scale. He has designed and implemented various inter-disciplinary education and research agendas in the areas of Smart Cities & Urban Informatics, Computational Design, Urban Health and Wellbeing, Social Robotics, and Real-time Interactive Environments. These interests are clubbed under his research and education umbrella 'S.M.A.R.T. Environments' - acronym for 'Systems and Materials in Architectural Research and Technology', which investigates the intricate relationships between information flow and associative material formations. Investigations under this research umbrella include: Smart and Liveable Cities, Interactive Architectural Systems, Interaction Models and Cognitive Systems, Material Systems, and Performative Architecture.He has lectured and published his inter-disciplinary research and design deductions at several prestigious institutes, in scientific journals, design and technology conferences, scientific books, and magazines globally. His latest book offering comes in the form of a five-year Springer book series on S.M.A.R.T. Environments.*

## ROD SIMPSON

### Walking country: landscape and walkability as the basis for urbanity

Roderick Simpson, the inaugural Environment Commissioner of the Greater Sydney Commission, will present on how and why starting with a consideration of landscape is both a necessity and an aspiration for the remaking, improvement and planning of cities.

'Starting with landscape' through an ethos of 'caring for country', consideration of the 'blue and green grids' and prioritising walkability is a true challenge for Western Sydney. Treating the West as an 'urban lab' to develop new and improved planning processes will also inform the remaking and improvement of the existing city.

*Roderick is an architect and urban designer, an Adjunct Professor in the Faculty of Design Architecture and Building at UTS after directing the masters of Urbanism and Urban Design Programs at the University of Sydney.*

*He has been an advocate of sustainable development since first winning equal first place in the international design competition for the Olympic Village for the 2000 games, and first place in a national housing design competition on behalf of Greenpeace in the early 1990s. Rod is a Member of the Australian Institute of Architects, Australian Institute of Landscape Architects and the Planning Institute of Australia and a Trustee of Sydney Living Museums.*

## GREG KEEFFE

### Born and not made: designing the productive city

The city is changing: no longer is it an aesthetic creation, nor purely an industrial powerhouse. It is becoming a living, breathing super-organism, with a myriad of multiple, competing functions enabling the city to dwell within its particular ecology. As a super-organism, the future city will be defined more by its metabolism, than purely its primary function or spatial form. These biospheric flows of energy and materials will drive the new city and create new synergies for living.

In the future, we will need to see the city as the technology by which we live: not as a landscape full of technologies. The old city is a mechanical/cultural hybrid, the new city is different: it will be a geological/biological/informational/technical/cultural landscape, a productive environment so complete that it will be indistinguishable from nature. This smart city of the future will become as essential as a smart-phone: life without it is unimaginable, because we will need it in every aspect of life.

In order to be so complete and essential, its constituent parts: transport, industry, commerce, social functions etc, must fit within it and be seamless in use. Urban designers must view the city as a body or super-organism: a whole, rather than a collection of parts.

Process-based, this new city will be born and not made.

*Greg Keeffe is an academic and urban designer with 25 years experience in sustainability, energy use and its impact on the design of built form and urban space . He currently is Professor of Architecture + Urbanism and Head of the School of Natural and Built Environment at Queen's University, Belfast UK.*

*Greg has extensive experience of working closely with architects and planners to develop exciting ways of re-invigorating the city through the application of innovative sustainable technologies, informing his work on the sustainable city as synergistic super-organism. In this way, he has sought to develop a series of theoretical hypotheses about our future existence on the planet, through a series of technological and spatial interventions. Most of his work comes out of a free-thinking open-ended discussion about how things should be.*

*He is author of the books 'Means Means Means' and 'Urban Evolutionary Morphology'; which develop a model of a new city, one that is a cyborg created out of mutually compatible, technological and biological functional elements.*

## CONTENTS

## URBAN ECOLOGY



## SPACE AND PLACE

## ENERGY



## COMFORT



## GREEN BUILDING

# DEEP RENOVATION IN SUSTAINABLE CITIES: ZERO ENERGY, ZERO URBAN SPRAWL AT ZERO COSTS IN THE ABRACADABRA STRATEGY

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## Summary

Energy efficiency challenge in buildings mainly concerns the energy efficient refurbishment and investments in its existing buildings. Yet, today, only 1,2% of existing buildings is renovated every year in Europe. The actual investment gap in the deep renovation sector is due to the fact that high investments are required up-front and they are generally characterized by an excessively high degree of risk, by long payback times and by the general “invisibility of the energy benefit”. ABRACADABRA is an H2020 project that aims to activate a market for the deep renovation of existing buildings through a major transformation of the buildings aiming at the increase of the real estate value. This increase is essentially given by a volumetric addition (Add-ons) whose added value, once capitalized in terms of selling or renting, is able to reduce the payback time of the investment. Several pilot case studies have been used to test the efficacy of the strategy. At this stage of the project, also a challenging sector like the social housing sector is being explored to verify if a retrofit strategy including add-ons and densification could help to boost the renovation of the public and residential hosing stock. The process is based on the cost-effectiveness analysis. In this paper, to demonstrate how the densification action could be an effective solution to promote energy efficiency interventions and new business models to shorten the payback time of renovation investments, five different building have been studied. The simulation made on these case studies is divided in three steps: a feasibility study, the energy saving analysis and a payback time calculation. In the last phase of the study the financial assumptions are fundamental. In the case of the social housing the sale, rental and social values were considered and combined to find the best opportunity of incomes and the shortest payback time. Moreover, additional issues were taken into account regarding the regulatory aspects and the technical feasibility of this type of approach. Implementing this strategy means to add new units on the rooftop or on the side of an existing building, and this might face obstacles, such as urban regulation restrictions and the consensus among tenants. To overcome these obstacles, the project promotes new policy recommendations that municipalities could approve and counterbalanced measures to help residents to embrace the ABRACADABRA strategy.

Keywords: Energy retrofit, urban densification, add-ons, housing, market attractiveness

## 1. Introduction

It is widely acknowledged that the residential stock in Europe is one of the most energy consuming sectors. The EU is trying to reverse this trend by promoting energy retrofit actions on the existing buildings, notably though the implementation of the Energy Efficiency Directive [1] and the Energy Performance of Building Directive [2]. Despite these efforts, deep renovation actions cover only about 1% of the construction sector activities [3]. There is clearly a lack of investments from the potential investors in deep renovation activities. This is due mostly to the high up-front costs, long payback times and legislative barriers. The European H2020 project ABRACADABRA has identified these key obstacles and aims to overcome them, based on the assumption that an increase of the real estate value of the renovated building could trigger deeper renovation interventions. ABRA strategy is based on volumetric Add-ons and Renewable Energy Sources (named AdoRES), such as aside or façade additions, rooftop extensions or even an entire new building construction, that "adopt" the existing buildings (the so-called "Assisted Buildings") to achieve nearly zero energy and to activate a new real estate market decreasing payback times. In this paper, we will describe how this strategy is applied in two challenging sectors: the private owned buildings and the social housing showing the results obtained in different cases: two case studies of residential housing in Reggio Emilia, the Student House in Athens, and two cases of residential private buildings in Bologna; demonstrating how the AdoRES can increase the attractiveness of deep renovation market reducing payback times increasing their real estate value and adding new units [4].

### 1.1. Challenges and barriers of energy retrofit in the residential sector

Building renovation is a challenging sector whether in private and social housing sector. Although the social housing sector presents specific character, some of the reasons of the lack of investments in such activities are common to both sectors and are both of social and economic nature. Literature to explain the low renovation rate in the housing sector is abundant. The financial aspects, such as the high upfront costs, long payback times, the lack, instability or complexity of available funding or fiscal incentives are often considered as the main barriers to renovation. But they are not the only ones. Despite the acknowledged non-energy related benefits of energy efficiency renovation – such as health and comfort, architectural and aesthetic improvements, end-users might not recognize the benefits of an energy efficiency renovation. They might also mistrust new technologies and constructions professionals or simply might not be aware of the possibilities. Hence the importance of awareness-raising campaigns about all the benefits of energy efficiency renovation. On top of that, regulatory factors and administrative procedures further hinder renovation. This includes urban planning rules, constructions permit procedures, but also rules linked to property and housing law, such as decision-making rules in multi-apartment block buildings, contractual obligations towards the tenants (including rent increase limitation and relocation obligations). Such barriers are considered to influence the low renovation rate in the entire housing sector, although at different level depending on the sector. Overcoming them has become a political priority in order to foster a more energy efficient building stock. Taking these challenges into account, it is necessary to promote a cultural change among owners and tenants, by informing them about which benefits they might gain after the intervention and by promoting a good habits regarding energy consumption. A non-informed user could indeed make unsuccessful a renovation action (i.e. energy waste) [5]. ABRA strategy promotes a user-orientated renovation to overcome all this difficulties, providing counterbalancing measures such as adding extra-room, balcony or sunspaces (facade addition) to existing units. From a social point of view, it could be an opportunity to reduce social exclusion and a general renovation of the urban area. The specific challenges that energy retrofit has to overcome in public buildings are linked to property regime. It is, in fact, necessary that public bodies start the action and in some cases is very difficult to have a short payback time because they have particular business model to capitalize the additions. It also true that, in general, municipalities and public bodies can burden long-term investments. The simulations in this case have to be modeled on each specific case, taking into account technical, social and market limits.

## 1.2. The methods and the tools

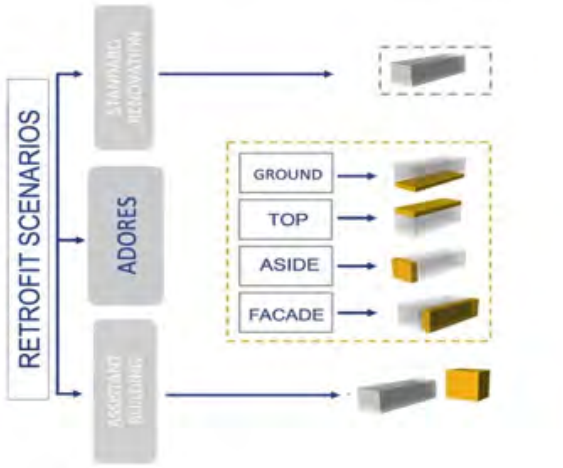



*Figure 1 Renovation scenarios.*

The research study was carried out following the same process for both the case studies with the following steps:

i. An architectural feasibility study of the possible Add-ons for the building;
ii. The energy consumption analysis before and after the deep renovation using a Simplified Energy Model (SEM);
iii. The calculation of the renovation and construction costs;
iv. The Payback time calculation for different scenarios;

Fig 1 illustrates the different renovation options that are ideally possible in a punctual densification at the scale of the building. Starting from the standard energy renovation of the original building, which is also assumed as a constant in all the incremental scenarios, other five options are displayed. This feasibility study is the starting point of the ABRA strategy since it is very rare that all the AdoRES can be applied to one single case study due to regulatory or architectural issues. In addition, for a renovation resulting in a successful intervention it is necessary to know the amount of possible surfaces that can be added. The renovation measures include action on the envelope (external coating, windows replacement) and the HVAC system. The necessary actions are identified by targets to maximize the energy savings (i.e. specific U-values for each opaque surface). Subsequently the energy consumption analysis was conducted using a Simplified Energy Model (SEM) calculator. The calculation is conducted in stationary mode according to EN ISO 13790 [6] and ISO EN 52016-1 [7]. The main inputs needed for calculation are the principal climate and energetic data (geometric values of the building, heat sources, transmission and ventilation properties, set points etc.). As a result of the calculation model, the SEM gives as outputs monthly and annual energy needs of the building before and after the deep renovation. All energy parameters are calculated as monthly mean values and then used to calculate seasonal values (Fig, 2).

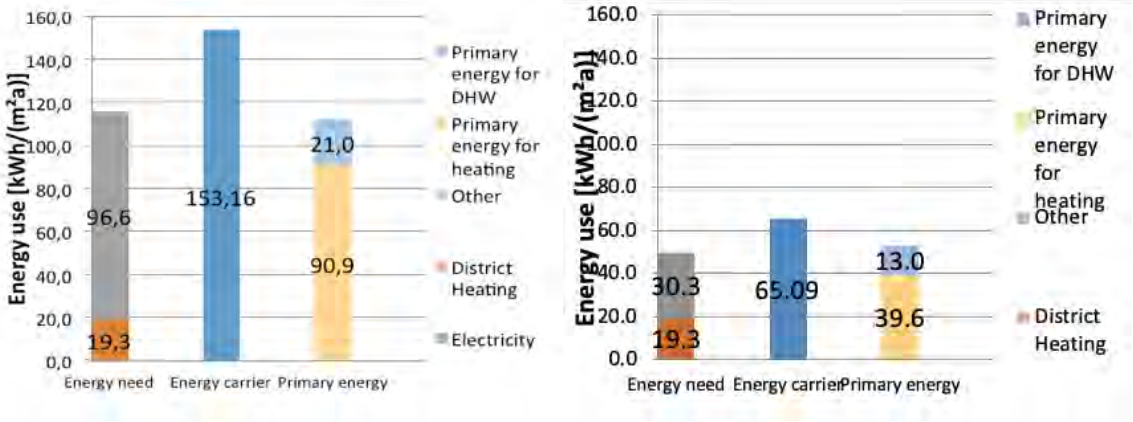



*Figure 2 Energy use BEFORE (on the left) and AFTER the deep renovation (right)*

Those results are fundamental for the economic evaluation of the deep renovation; in fact, since there is a standard to reach, every case study will have different parametric renovation cost (€/m2) depending on the current state of the building. Regarding the construction cost, it is obviously necessary for conducting the feasibility study to have an idea of the intervention, and to agree on a standard construction. The Add-ons are built with timber panel for opaque surfaces and aluminum triple glaze windows filled with argon in order to reach a zero energy target with the use of PV panels and heat pump for heating and cooling. Renewable Energy Sources (RES) like photovoltaic panels are also installed in the existing building to reach the nZeb target. Renovation and construction costs [8] and the energy consumption are the principal inputs for the assessment and the calculation of the payback time. Energy savings compensates the negative cash flow linked to the renovation and construction costs and the profit realized from selling or renting the added units. In the case of sale transaction we simulated that all the new dwellings would be sold in the first two years (this is a hypothesis based on the state of the market). This cost-effectiveness comparison allows for immediate identification of the most relevant scenarios for the investors and stakeholders. Fig. 3 shows the cost estimation units and input for the deep renovation and construction.

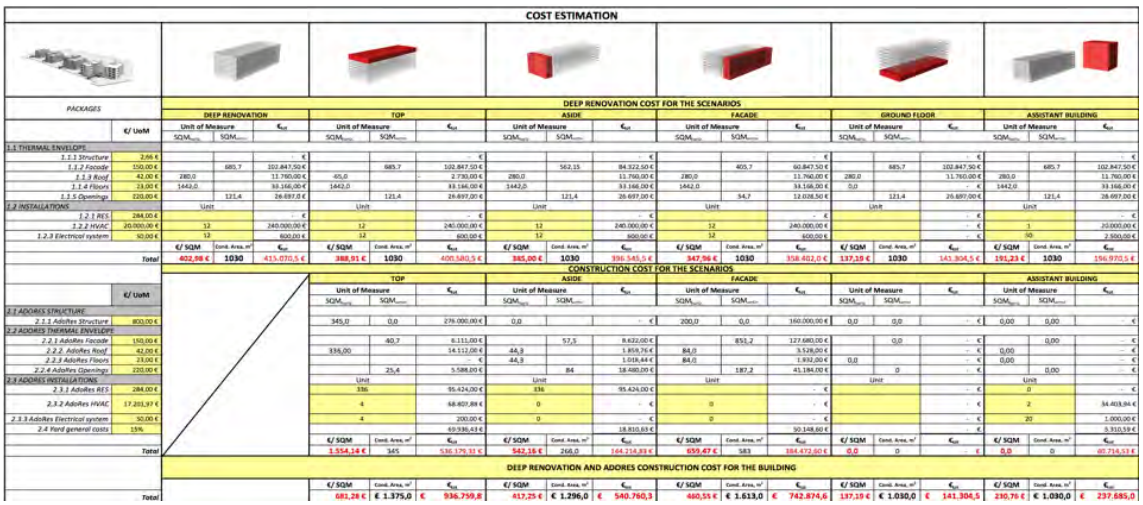



*Figure 3 Cost estimation summary*

## 2. Residential housing case studies

Several case studies have been used to test the retrofit action trough Add-ons or ADORES, as named in the ABRACADABRA project. The first two cases shown in this study are both owned by ACER RE (a social housing corporation), in Reggio Emilia area, Emilia Romagna, Italy. Here, in case of the construction of a stand-alone assistant building, they could sell or rent at market prices. To prove the technical and architectural feasibility of the Add-ons, the building and the additions have been 3D modeled.

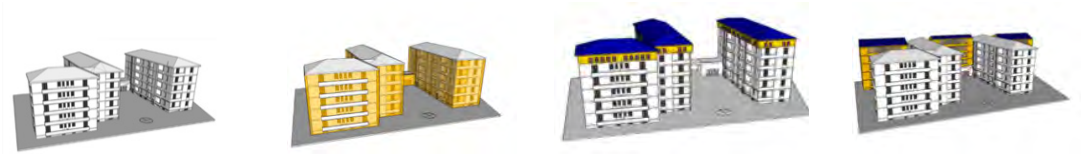



*Figure 4 3D model of the ADORES illustrating the possible options for the Reggio Emilia case of Viale Magenta*

As fig 4 shows, in this case, it is not possible to add a facade addition or an assistant building. Therefore, the only scenarios that can be taken into account to calculate the payback times are the top addition and the aside addition. As the figures demonstrate, in this case the optimal scenario is the one that maximize the densification (aside addition). Similar results have been performed in other residential buildings, both public and private owned buildings: Bagnolo in Piano, Zografou in Athens, tower buildings and block buildings in Bologna.

The main economic data assumed for the calculations are reported in table 1.

*Table 1 Economic data assumed for the calculations of the pay back time and the real estate value*

| | |
|---|---|
| Real estate value | 1.800,00 €/m2 |
| Real estate value (add-ons) | 2.800,00 €/m2 |
| Monthly rent for new units | 8,80 €/m2 |
| Social monthly rent for new units | 5,00 €/m2 |

Based on the values provided by the economic data illustrated in table 1, a comparison between the value of the building and the investment can be achieved, as illustrated in fig. 5.

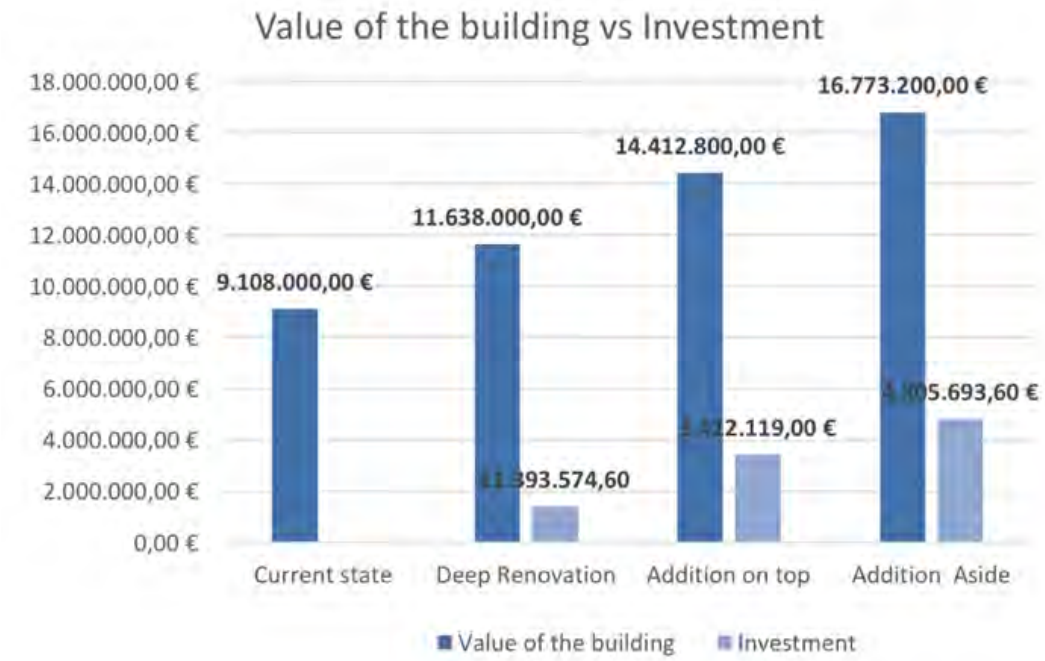



*Figure 5 Add-ons Feasibility tables in different cases*

However, the most interesting results are provided by the assessment of the different volumetric options in relation to the pay back times in the various market contexts, as displayed in fig. 6.

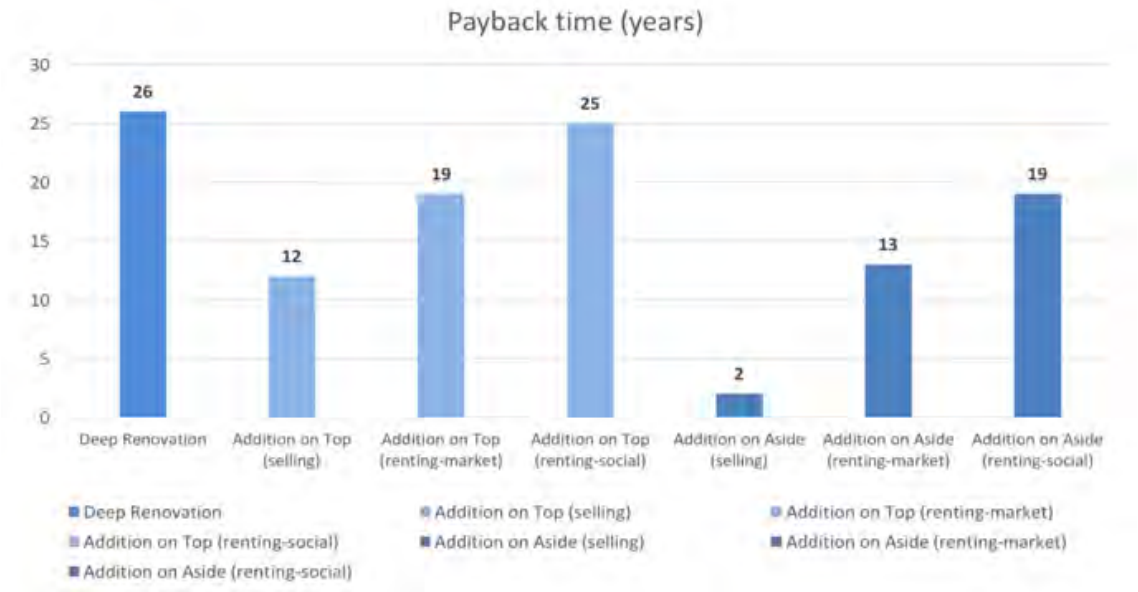



*Figure 6 Comparison of the payback time in the different volumetric options in the various market contexts (selling – private market; renting at market prices and renting in the social housing sector)*

As the results in fig. 6 demonstrate, each scenario is competitive if compared to the deep renovation option. However, the optimal scenario is the aside addition, as it maximizes the densification and the rentable/selling surfaces.

Similar studies have been performed in other residential buildings, in particular for other two buildings on the social housing market (Bagnolo in Piano, in Reggio Emilia, and Zografou in Athens) as illustrated in fig. 7, and the tower buildings and block buildings in the private market of Bologna, reported in fig.8.

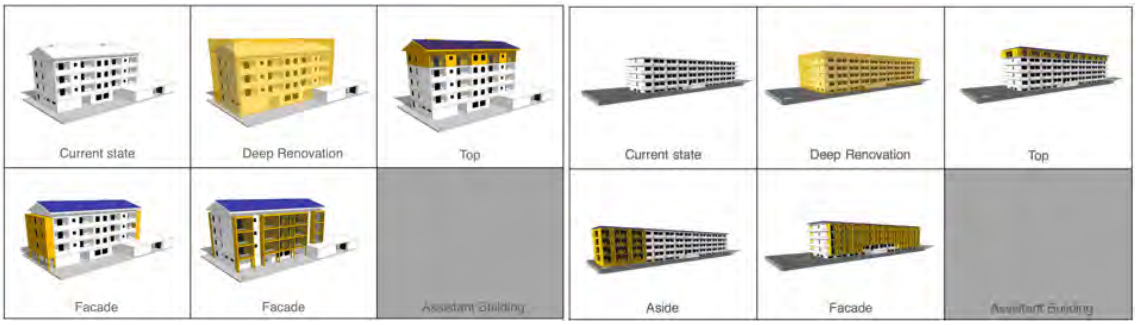
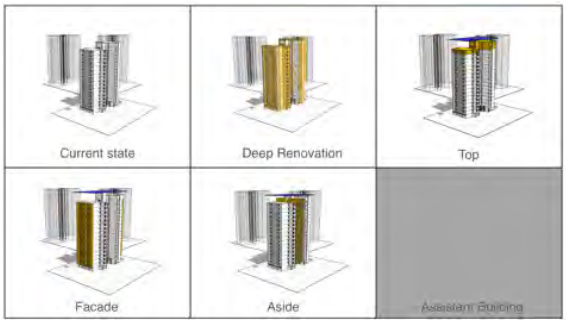


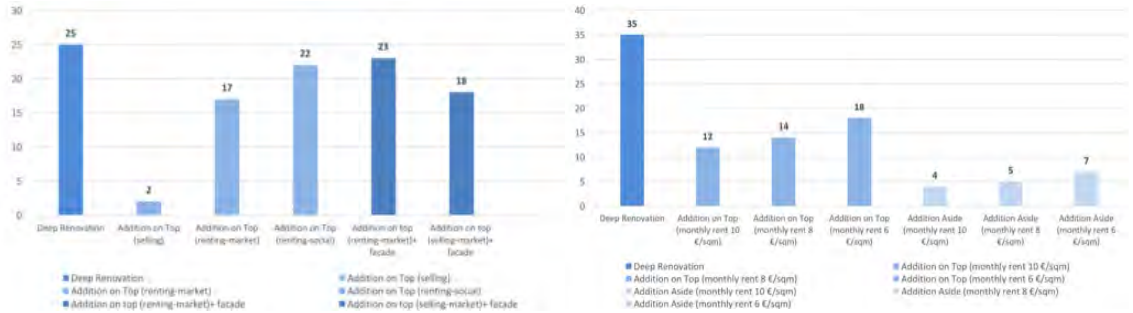

*Figure 7 Add-ons feasibility studies for Bagnolo in Piano, Reggio Emilia on the left and the students' house in Zografou, Athens, Greece, on the right*




Tower building, Bologna Block buildings, Bologna

*Figure 8 Add-ons Feasibility tables in two different cases of the private market in the city of Bologna, Italy*

As for the case of Viale Magenta, the most interesting results are provided by the assessment of the different volumetric options in relation to the pay back times in the various market contexts, as displayed in fig. 9.




Bagnolo in Piano, Reggio Emilia Zografou, Athens

*Figure 9: Comparison of the payback time in the different volumetric options in the various market contexts (selling – private market; renting at market prices and renting in the social housing sector) for the second case of Reggio Emilia (on the left) and the Students house in Athens (on the right)*

As for the previous cases, also for the private real estate market, the most interesting results are provided by the assessment of the different volumetric options in relation to the pay back times, as displayed in figures. 10 and 11.

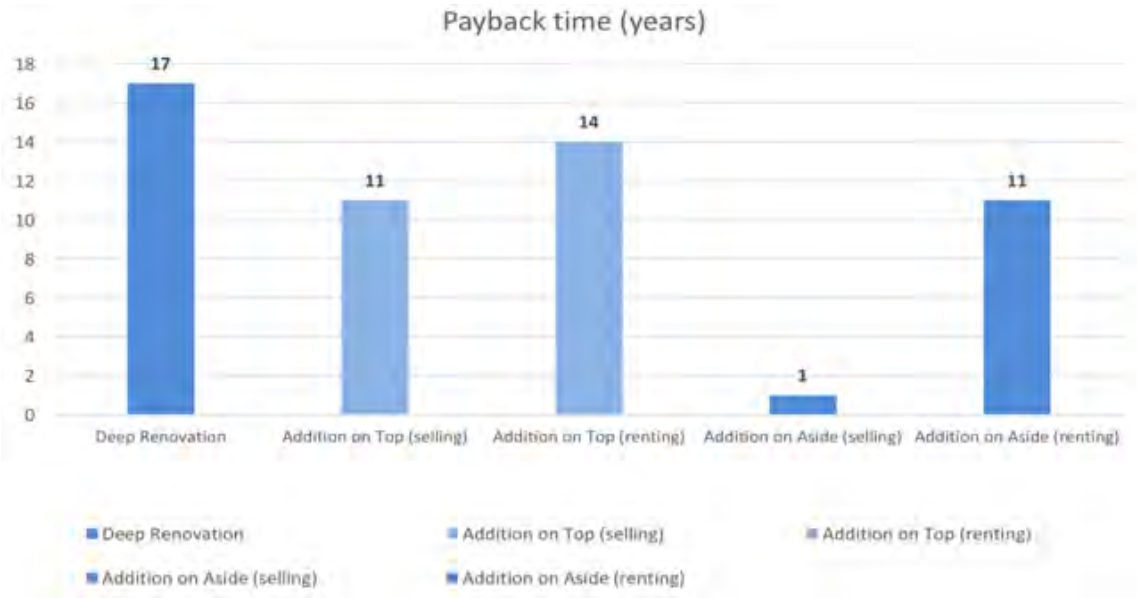



*Figure 10 Comparison between the payback times in the two different volumetric options (on Top and Aside) in the private market context (selling – private market; renting at market prices) for the case of the Towers in Bologna.*

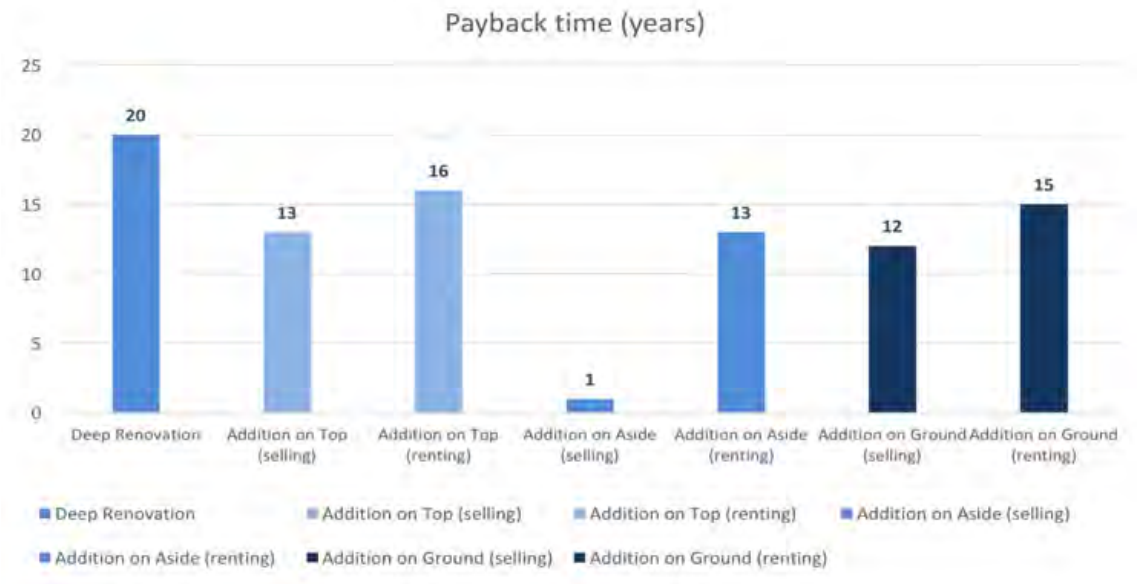



*Figure 11 Comparison between the payback times in the three possible volumetric options (on Top, Aside and ground) in the private market context (selling – private market; renting at market prices) for the case of the block buildings in Bologna.*

As the results in fig. 10 and 11 demonstrate, each scenario is competitive if compared to the deep renovation option. However, the optimal scenario is given by the aside addition, as it maximizes the amount of rentable/selling surfaces.

## 3. Brief discussion of the results and conclusions

the simulations in the different scenarios have been conducted with specific assumptions. Clearly, using social prices for renting and selling does not have the same effectiveness of using market values. However, the facade addition when combined with the vertical extension (top addition) has various benefits, such as a major increase of the real estate value of the existing building and the space extension in the existing units, that is certainly a measure to encourage the acceptance of the roof-top addition from the tenants. From the obtained results it can be observed that the real estate value of the building is always far higher than the value of the deep renovated building in all the cases. Although the results are very different in terms of quantity, which are in turn depending from the possible amount of space addition in the different cases, there are many common aspects. In almost all the cases the aside addition is the best option for the building, presenting the major increase of the value of the building with a minor investment. This case is an example of a valid implementation of renting business model and densification actions that can be replicated in other public buildings of the same typology.

Moreover, in all the cases the cost-benefit evaluation has been proved to be a valid method to identify the optimal scenario [10]. Implementing such an approach would allow the addition of new surfaces avoiding soil sealing, and could be a strategy for the urban and architectural renovation, including the social housing sector. In this framework though, there are some issues to be solved. Some are specific to social housing sector other might be more general and linked to the split incentive dilemma. A possible solution is to create a new business model where the Social housing associations could act like ESCO (Energy Service Company). In the case of public buildings, it would be a very interesting option to add new spaces to rent in order to shorten the payback times. Furthermore, there is the possibility to implement this strategy on other typology of building not only the ones with residential function. Altogether, the results of ABRACADABRA, very briefly discussed in this paper, demonstrate that Add-ons are a solution that can help to boost deep energy efficiency renovation. The impact of these solutions will however vary according to the local market(s). The estimated payback time will moderately or considerably differ if the property renovated and its extension are to be sold or rented, if the rents are subject to market restrictions – as it is the case in the social housing sector and in rent-controlled housing regimes.

## ACKNOWLEDGEMENTS

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