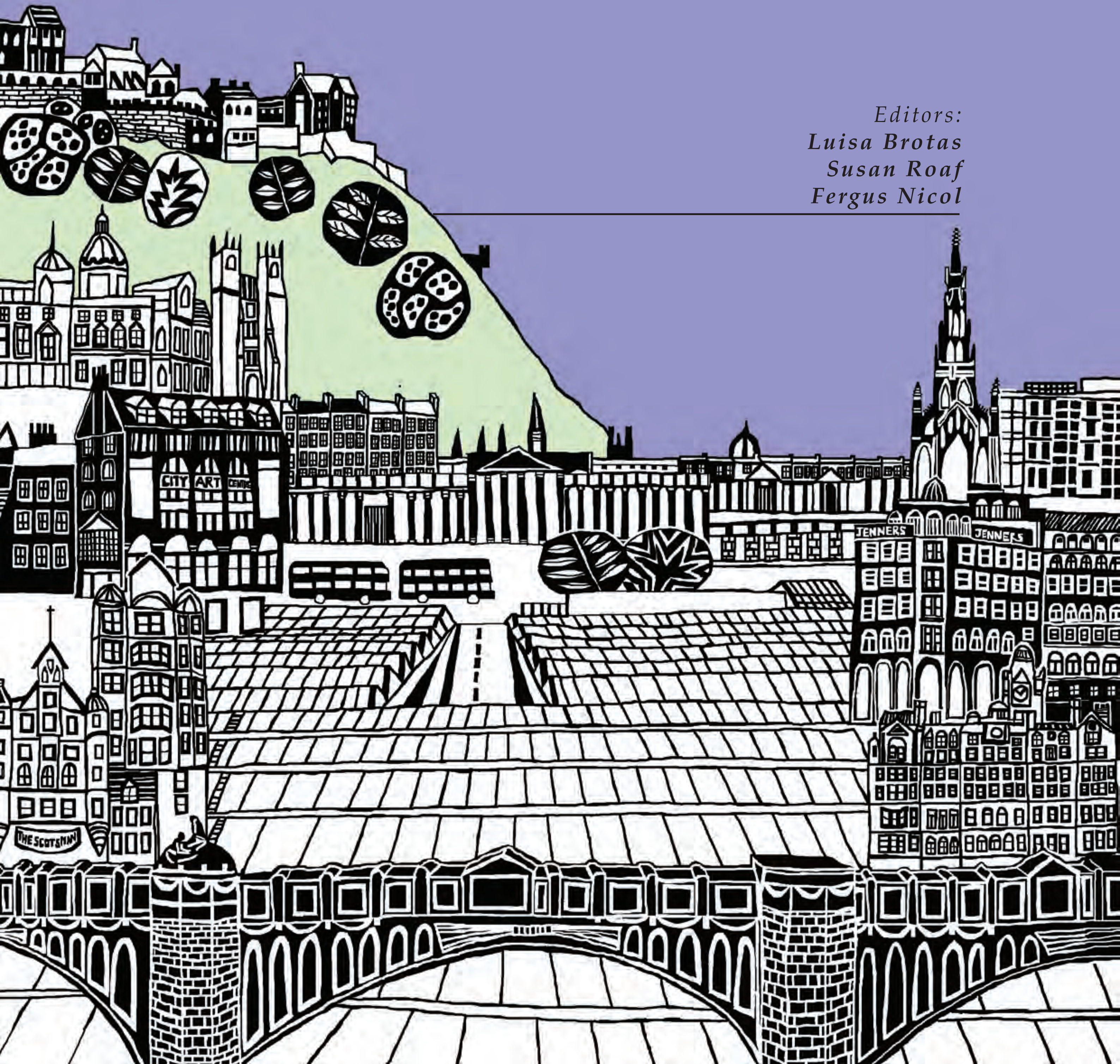
PLEA
EDINBURGH 2017

DESIGN TO THRIVE

Proceedings
Volume I

PLEA 2017 Conference

Editors:
Luisa Brotas
Susan Roaf
Fergus Nicol



Design to Thrive - PLEA 2017

Proceedings of 33rd PLEA International Conference
Design to Thrive
Edinburgh, 2th-5th July 2017
PLEA 2017 Conference www.plea2017.net

Published by NCEUB 2017
Network for Comfort and Energy Use in Buildings http://nceub.org.uk
to download go online to www.nceub.org.uk

ISBN xxx-x-xxxxxxx-x-x

Microcity, an Innovative Building Integrating Sustainability Issues from Urban Design to Constructive Detail

Emmanuel Rey[1,2]

[1] Bauart Architects and Planers Ltd, Bern / Neuchâtel / Zurich, Switzerland, rey@bauart.ch
[2] Laboratory of Architecture and Sustainable Technologies (LAST), Ecole polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland, emmanuel.rey@epfl.ch

Abstract: The Microcity building, which houses the new branch of the EPFL in Neuchâtel (Switzerland), is the result of a synergy-generating strategy based on partnerships, experimentation with innovative processes and the continuous integration of sustainability-related challenges. Ranging from urban design to construction details, this approach has integrated diversified notions such as institutional synergy, technological innovation, urban densification and high environmental quality. Through urban densification in the vicinity of public transport stops, this realization has played an essential role in stimulating the revitalisation of the entire neighbourhood (new public spaces and soft mobility facilities). At the building level, the strategy is based on solutions that focus on rational resource use and minimize environmental impacts (compactness, thermal quality of the building shell, natural light enhancement, high-performance electrical devices, and materials with favourable LCA). A large part of the structure is based on a hybrid, prefabricated system (wood and concrete), which allows a reduction of embodied energy and provides a high level of flexibility for future adaptations. Microcity is also a driving force for integrating renewable energies going beyond its own limits (photovoltaic centre on the roof and underground canal ring that uses water from the lake to reduce the impact of cooling).

Keywords: sustainable architecture, prefabricated construction, renewable energy, free cooling

Introduction

Public institutions set a strong example for sustainability with their specific programme and emblematic status and can generate a driving force that goes far beyond their own spatial limitations. In this respect, the development of Microcity in Neuchâtel, Switzerland, reflects the huge potential of innovative moves like these ranging from its territorial strategy to the smallest construction details. Its conception owes a lot to the joint determination of local authorities and the EPFL to develop a skills hub for micro- and nanotechnology. This partnership ties in with the university's expanding network strategy, which aims to strengthen its presence throughout French-speaking Switzerland with the creation four new branches to generate innovatory dynamics.

Urban integration and high-quality public areas

Criteria for choosing the site for the EPFL's Neuchatel branch were mainly the availability of land reserves in urban areas and the desire to optimize proximity with strategic actors in the field of microtechnology. The building programme also integrates spaces for Neode, the science and technology research park promoting the creation of start-ups. Bearing in mind the stakes in terms of image for the region, the undertaking was not restricted to constructing an emblematic building to house the new centre of excellence but was also committed to overall neighbourhood redevelopment based on a masterplan with generous emphasis on public areas.

Another important feature of the process set in motion for development of this project was undoubtedly the special attention paid to interactive and iterative approaches. A working group was formed with representatives of the project supervisor, the City of Neuchâtel and both chairpersons of the two neighbourhood associations. Local inhabitants were thus able to follow the progress of the masterplan, express their concerns, expectations and preferences and influence the definition of certain planning measures. These iterative and interactive approaches ensured that the masterplan and general architectural project were well accepted by the population as a whole, as well as contributing to crucial coherence between the new complex and urban planning; indeed, Microcity has stimulated redevelopment of the surrounding public spaces by the City of Neuchâtel authorities. Street landscaping, linked with various traffic-calming mechanisms (a meeting area and a 30 km/hr restricted zone), ensures smooth cohabitation of all public sector functions and gives the entire perimeter a homogenous identity. In this context, public space is not just a mere extension of the architectural project but combines with the new building to form a strong identity serving the users of the site, the inhabitants of the neighbourhood as well as enhancing the international aura of the city and Canton (Van der Poel, 2014). In addition, several facilities connected with sustainable mobility are available for users such as a self-service bike station (Velospot), car-sharing (Mobility) and an electric-car-sharing station (ElectricEasy).

Figure 1. Site plan and public spaces in the surroundings of Microcity (Document: City of Neuchâtel, Department of Urban Planning).

Figure 2. Insertion of the building into the urban fabric (Picture: Yves André).

Conceptual interweaving and constructive hybridization

The building's strategic position contributes to the urban densification process by creating new hubs in the immediate vicinity of public transport stops. It makes sense in the urban layout as a meaningful polarity. Resulting from the conceptual encounter between a regular inner pattern, due to its polytechnic vocation, and local features linked with the geometry of the site, the building's shape fits in with the specificities of its immediate environment (Rappaz, 2014). Thanks to site topography, associated with the compactness of the building proposed and the creation of new landscaped areas, a central non-built space at the heart of the site has been laid out as a public meeting area. Landscaped with native plant species and featuring a storm-water retention pond, this public garden builds community ties with the surrounding district and acts as a representational space for an evolving urban area.

The notion of hybridization can also be seen in the structural and constructive development of the edifice. Three cores were built in situ in reinforced concrete in order to accommodate heavy laboratories, vertical distribution axes (staircases, lifts and elevators), sanitary facilities and the main technical ducts. By contrast, the rest of the structure is supported by a hybrid construction system combining wood and concrete which allows a reduction of grey energy, and offers a greater degree of flexibility for future adaptation (Veillon; Rey, 2012, 2015).

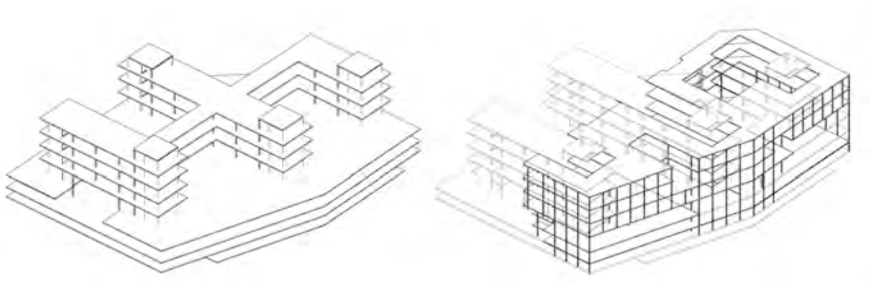


Figure 3. Structural principle including a hybrid construction system combining wood and concrete (Document: Bauart).

The fact that the composite wood-concrete elements were prefabricated in a workshop ensured greater accuracy, enabled faster production and reduced disturbances for the neighbourhood caused by construction work. In practical terms, approximately 4,000 m^2 of beams measuring 3.50 m by 5.00 m and 7.20 m were produced on the basis of a wooden assembly into which a 10 cm-thick layer of concrete was then poured. This combination meets high static requirements while reducing the quantity of grey energy used and providing the necessary soundproofing between floors.

Figure 4. Assembly of the hybrid elements on site (Picture: Yves André).

Based on the use of a wooden frame covered with fibre-wood-cement panels enclosing a layer of thermal insulation made of mineral wool, the façades were also produced in a workshop. Associated with wood-metal-framed glazing, this choice ensures regular continuity of the thermal shell, while rapidly achieving a weather- and air-tight building. Set up on the spot, an outer layer of rigid, recycled-glass plates on which glazed ceramic tiles have been fixed protects the inner layers of the shell and allows the building to benefit from the advantages of a ventilated façade.

Energy efficiency and environmental quality

Microcity is so compact and its thermal envelope so efficient that its overall thermal performance is excellent. Taking into account a weighting between the building's different affectations, its basic heating needs (Qh) are 27.3 kWh/m^2 whereas the Minergie label requirement in this respect is equivalent to 30.2 kWh/m^2. Thanks to dual-flow ventilation with heat recovery, controlled air renewal of the whole building greatly reduces loss of heat by ventilation during heating periods and covers a large part of heating needs by re-use of waste heat rejected by processes specifically linked with a research centre. This system allows air circulation from rooms producing more heat to other parts of the building, as well as transferring heat from one air flow (waste stale air expulsion) to another (incoming fresh air) without mixing them. For remaining heating needs during the cold season, the building has access to Neuchâtel's remote network of which approximately 30% is wood-generated (Rey, Frei & Baumann, 2013).

To minimise electricity requirements linked essentially with artificial lighting and laboratory equipment, several complementary measures were included right from the start in the design of the building including notably, for example, optimization of natural light thanks to long windows all along the external façades and two large skylights at the heart of the building, the integration of an artificial lighting system based on high-performance luminaires (with control over internal energy gains), use of natural ventilation in office areas and high-efficiency electrical devices.

But looking beyond its own quest for efficiency, Microcity is a driving force for the integration of renewable energies outside its own perimeter. It notably took part in the HOLISTIC approach (Holistic Optimisation Leading to Integration of Sustainable Technologies In Communities), a European research project whose primary objective was to reduce fossil energy consumption in the three cities of Neuchâtel (Switzerland), Dundalk (Ireland) and Mödling (Austria). In Neuchâtel, within five years, the approach has resulted in a reduction of over 23% of the fossil energy consumption in an area of approximately 1,5 km^2 between the railway station plateau and the lake (Consortium HOLISTIC 2013).

Covering Microcity's entire roof surface a large photovoltaic power plant – with 804 panels for a total of 1'271 m^2 – plays a key role in this dynamic approach.

Figure 4. Photovoltaic central on the roof connected to the city's power grid (Picture: Yves André).

The installation supplies 224'500 kWh annually to the Viteos electricity network, i.e. the equivalent of the consumption of some 64 households. 84 of the 804 panels on the roof are used as a testing platform devoted to research led by the EPFL's Photovoltaic and Thin-Film Electronics Laboratory (PV-LAB). In addition, the construction of Microcity played an important role in developing an underground canal loop using lake water for the ecological cooling of several buildings in the district. Thanks to this free-cooling, an annual electricity saving of 2.2 million kWh/yr, i.e. the equivalent of the electricity consumption of some 630 households, is expected by the electricity grid.

Table 1. Criteria of sustainability according to ranking in Recommendation SIA 112/1 (SIA, 2004).

Environmental criteria		
Building materials	Availability of raw materials	Analysis of life cycle, use of part of the excavation materials on the site
	Environmental impacts	Minimisation of environmental impacts (non-renewable primary energy NRE, CO emissions)
	Pollutants	Minimisation of pollutants in building materials
	Deconstruction	Use of separable, recycles and recyclable materials
Operational energy	Heating or cooling requirements	Reduction of heating and cooling requirements
	Hot water energy requirements	Reduction of domestic hot water requirements (e.g. only cold water in sanitation areas)
	Electricity	Reduction of electricity requirements (natural light, natural ventilation, passive cooling, free cooling, high-performance appliances)
	Coverage of operational energy requirements	Use of renewable energy sources : photovoltaic solar roof, link-up with a loop using lake water for ecological cooling
Ground, landscape	Amount of land	Optimal density on the site (land-use coefficient of 2,0 = maximum for the City of Neuchâtel)
	Exterior spaces	« Green » garden with native species, providing habitat for local wildlife
Infrastructure	Mobility	Optimization of public transport use (bus-stop nearby)
	Operational waste	Selective sorting and optimization of building site waste materials, sorting plant for waste generated once operational
	Water	Ecological management of rain water (infiltration, retention pond in the garden)
Socio-cultural criteria		
Communal life	Integration, diversity	Diversity of users thanks to a mix of functions (offices, laboratories, auditorium, schools, restaurant)
	Social contact	Public garden for all users of the neighbourhood (researchers, employees, inhabitants, students, visitors)
	Involvement	Implication of users and neighbourhood associations in planning processes
Planning	Identity of the place, belonging	Recognition of the specific lay of the land, creation of a new urban landmark
	Customisable planning	Planning flexibility for the various laboratories
Operation, services	Proximity and functional diversity	Proximity of all services for users (e.g. shops, schools, nursery facilities, sports, leisure)
	Soft mobility	Link-up with transport network for pedestrians and bikes, 30 km/hr speed-reduced street zones around the site, self-service bike, car-sharing and electric car- sharing stations
	Accessibility and usability	Architectural details for wheelchair access and/or the visually impaired
Comfort, health	Security	Optimized security (controlled access, night lighting)
	Light	Optimization of natural light (e.g. long windows, skylights at the heart of the building)
	Indoor air quality	Choice of materials to reduce interior emissions (e.g. solvent-free paint, linoleum)
	Emissions	Reduction of magnetic fields
	Summer sun protection	Movable exterior sun protection
	Noise, vibrations	Optimized soundproofing, absorbers on all ventilation machines
Economic criteria		
Substance	Site	Optimal use of the site (simultaneous creation of an institutional building and public spaces)
	Building structure	Creation of a new centre for a strategic urban site
	Structure and installations	Functional flexibility of buildings, possibility of extension in the masterplan
Investment costs	Costs and life cycle	Synergy and partnership between the contracting authority (Canton of Neuchâtel), the operator (EPFL) and the users
	Funding	Cost management integrating subsequent costs (renovation fund)
	External costs	Reduction of external costs through reduction of environmental impacts (mobility, energy, waste recycling)
Running and maintenance costs	Operation and maintenance	Reduction of running costs through reduction of energy consumption
	Renovation	Clear distinction between load-bearing parts (e.g. cores, pillars), and non-load-bearing and movable elements

Technically, a pumping plant was built near the lake in the water treatment plant compound; it was linked up with an under-lake pipe, which extracts water at a depth of 55 metres. At this depth, water remains at a practically constant 6° all year round and can thus supply a 1 km-long cool-water distribution network linking the many buildings concerned (Frésard, 2013).

In addition to energetic issues, the project is more broadly involved in simultaneous, optimized consideration of environmental, socio-cultural and economic criteria, which are synthesized according to ranking in "Recommendation SIA 112/1" (SIA, 2004).

Environmentally, the approach is based on solutions championing rational use of resources and minimisation of environmental impacts. Special care has been taken in the choice of materials presenting positive eco-balances. Close attention was also paid to the ecological management of building site waste materials (selective sorting at source and waste-to-energy process) and to subsequent deconstruction possibilities of the building components (severability of various parts and reversibility of assemblages). Great emphasis was placed on the ecological management of rainwater and the preservation of biodiversity, both in landscaping of outside areas (retention pond, native species) and regarding the roof (installation of nesting-boxes for bats in a technical element). Awarded the Minergie-ECO label, the proactive monitoring of these different challenges from the outset of the competition enabled the project managers to meet stricter requirements in the field of sustainable construction, while respecting the particularly short deadlines for completion (Rey, Frei & Baumann, 2013).

Conclusion

From its conception right up to its implementation, the creation of this new branch of the EPFL in Neuchâtel was lucky enough to benefit from numerous territorial, political and institutional synergies. But, beyond these contextual opportunities, the approach has demonstrated that such synergies can enhance the pursuit of overall quality and more effective integration of sustainability criteria in project management.

This type of procedure is inherent in the very notion of a sustainable architectural project : it is what radically distinguishes it from the simple addition of resources, the mere juxtaposition of disconnected expertise and skills or the coordination of ad hoc solutions for a series of problems considered independently (Aiulfi, Rey, 2010). This route implicitly recognizes the importance of creativity in the complex processes of urban densification and the creation of sustainable buildings (Rey, 2013).

This vast area of research implies integrating an increasing number of skills in the development of the project, ideally from the programme's initial design sketches right up until the building becomes operational. In this regard, strategies tested within the framework of the Microcity project highlight the specific relevance of proactively integrating urban, landscape, architectural and construction issues from the start with the choice of an architectural project. The project process is thus fuelled by technological and operational considerations linked to other disciplines than architecture, without abandoning the spatial and expressive coherence, which is indeed its essence (Rey, 2014). In this spirit, far from being a burden, sustainability challenges can actually provide a "raw material" for architectural creativity and trigger dynamic commitment on the part of the various actors involved in finally putting the approach into practice (Rey, 2015).

Acknowledgements

Microcity was designed by the architectural firm Bauart (W. Frei, R. Graf, S. Graf, P. C. Jakob, E. Rey, Y. Ringeisen), in collaboration with the construction firm ERNE Holzbau AG. This innovative project has involved numerous partners, in particular the Canton of Neuchâtel, the City of Neuchâtel, the EPFL, Viteos and Neode.

References

Aiulfi, D. & Rey, E. (2010). Les technologies vertes, matières premières pour la créativité des architectes. In : *Conférence MICRO 10*, Aula des Jeunes-Rives, Neuchâtel, September 2, 2010.

Chevalley, M. (2014). Microcity à Neuchâtel. Palais de la microtechnique. *Bâtir*, 6, (pp. 29-35).

Consortium HOLISTIC (2013). HOLISTIC : Retour d'expérience. Neuchâtel : *HOLISTIC, Rapport de synthèse.*

Frésard, J. (2013). HOLISTIC, un laboratoire urbain de développement des énergies renouvelables. In : *Conférence des partenaires du projet HOLISTIC*, Neuchâtel, November 21, 2013.

Rappaz, P. (2014). Microcity, le jeu de l'imbrication. *TRACES*, Dossier 05, (pp. 28-45).

Rey, E. (2012). Swisswoodhouse, an innovative concept for sustainable modular housing. *PLEA 2012*, Lima, Peru, November 7-9, 2012.

Rey, E. (2013). Vers une architecture durable. In E. Rey (Ed.), *Green Density*. (pp. 181-184). Lausanne : Presses polytechniques et universitaires romandes.

Rey, E. (2014). Du territoire au détail. Lucerne : *Quart Verlag*, Collection Notatio.

Rey, E. (2015). Sustainable architecture : towards integrated strategies from urban design to building component. In A. Khan, Allacker Karen (Ed.), *Architecture and sustainability : Critical perspectives*. Brussels : Sint Lucas Architecture Press.

Rey, E. & Graf, S. (2015). Swisswoodhouse, innovative experimentation in sustainable modular housing : from interdisciplinary research to post-occupancy monitoring. *PLEA 2015*, Bologna, Italy, September 9-11, 2015.

Rey, E., Frei, W. et Baumann, C. (2013). Hybridations durables. *TRACES*, Dossier 05, 46-57.

SIA (2004). Construction durable - Bâtiment. *Recommandation SIA 112/1.* Zurich : SIA.

Van der Poel, C. (2014). Processus convergents et identité urbaine cohérente. *TRACES*, Dossier 05, 18-27.

Veillon, E. (2012). Microcity: un projet hybride en bois-béton. *Batimag*, 1, 6-10.