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## **Integrated sustainable urban infrastructures in building projects**

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### **Abstract:**

Current strategies in urban planning and development merely promote standardized building solutions, while failing to prioritize innovative approaches of integration between building projects and sustainable urban infrastructures. As a result of this, urban infrastructures – the urban veins – are outdated from a sustainability perspective. This paper looks into more holistic ways of approaching building projects and discuss whether this provide a basis for an increased integration of urban infrastructures within building projects. In our study, we especially emphasise how conventional ways of approaching building projects are influenced by lock-in of existing infrastructural systems and compare this with two examples of more holistic ways of approaching building projects, developed by two architecture firms. The paper points out that such holistic perspective in building projects provide an improved breeding-ground for more innovative integration of sustainable urban infrastructure, but we also point out other important issues to be dealt with.

*Keywords: sustainability, urban infrastructures, strategic planning, design management*

## **Biography**

### **From the Technical University of Denmark**

Susanne Balslev Nielsen, Maj-Britt Quitzau, Morten Elle and Birgitte Hoffmann are all civil engineers working at the Department of Civil Engineering at the Technical University of Denmark. They are part of the research group: planning and management of building processes, and they are specialised in sustainable urban development.

### **From Arkitema**

Architect MAA Mette Rødtnes is head of innovation and Architect MDL Jan Peter Becht is head of Urban Space and Landscape at the Danish architect firm Arkitema.

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## Introduction

In the future of cities, new environmental challenges will have to be met. Our urban infrastructure is currently inadequate to meet these challenges. An example of this is that our sewage system is not able to cope with the increasing amounts of rain. In Denmark, this problem has been especially severe this year, having had 255% more rain than usual at this time of year (DMI 2007). As shown in figure 1, these heavy rainfalls led to overflowing of houses and streets. A crucial problem is that current storm water systems have not been designed to cope with these increased amounts of rain. Within an urban area local storm water percolation is very little because the area is covered by buildings, tiles, asphalt and other impermeable surfaces. Often, urban areas are expanded without attention to storm water management, and this leads towards a development, where sewers have to drain larger and larger areas of impermeable surfaces. Also in other countries in the world, climate change is putting extra stress on all urban areas and cities' drainage systems. Besides, other urban infrastructures are challenged by similar environmental problems, like shortage of groundwater and the green house effect.



**Figure 1: Illustration of an overflowed street in Denmark. (Foto Jan Grarup, [www.ekstrabladet.dk](http://www.ekstrabladet.dk))**

It is human to grow comfortable with the way things are and the way we are used to looking at things. It is all right to stick with old cognitive frameworks as long as the world stays the same, but as soon as the rules of the game change, and fresh thinking is needed we become challenged. Doing anything but incremental innovation is extremely difficult, because of the inertia that exists around known, familiar, and previously successful practices (Tushman & O'Reilly 1996). And an infrastructural transition is necessary, if future cities are to cope with these environmental challenges and be more sustainable. By urban infrastructures we mean the large and complex socio-technical systems to provide adequate water supply, reliable energy supply, a healthy environment, proper handling of sewage and wastes while managing a rich and diverse natural environment. Existing infrastructures were not constructed with sustainability in mind, but rather, with the intention to provide certain services to citizens. Even today, such infrastructures stand out as conventional systems, where merely optimization of existing systems have been carried out in order to improve their degree of sustainability. We especially note how the potentiality of such technical systems is overlooked in building projects, where the relation between the buildings and the technical infrastructures is simple: the building is connected to the technical system and benefits from its services.

In this paper, we look into, what we believe to be, lack of innovative thinking of urban infrastructures in building projects. We believe that key players in urban planning and development (politicians, architects, engineers, public authorities, utilities, developers, citizens, NGO's etc.) need to see building projects in relation to its urban context and explore the possibilities of synergy between the building project and the urban area as a whole. In this we use the term building project for building projects at all scales. The aim of the paper is to contribute to the debate on implementation of sustainable city management and our paper highlights challenges for integrating building projects and urban infrastructures in order to promote sustainable city development. In the paper we address three key questions:

- What is the conventional relation between building projects and infrastructure?
- How does new and more holistic design processes open for integration of building projects and urban infrastructure?
- What are the possibilities and barriers in concrete building projects for integration of sustainable urban infrastructure in building projects?

In the first section, we point out some of the problems with conventional ways of thinking of urban infrastructure and with how these systems are linked to building projects. In the second section, we look specifically into two emerging strategies, from well established architectural firms, aimed at assuring a more holistic approach to building projects and point out how this may represent a potential opening for new ways of integrating utility systems. In the third section, we discuss more widely the potentials of such new strategies in provision of an improved breeding-ground for innovations within building projects, which at the same time contributes to a transformation of urban infrastructure in a sustainable direction.

### **Conventional approach**

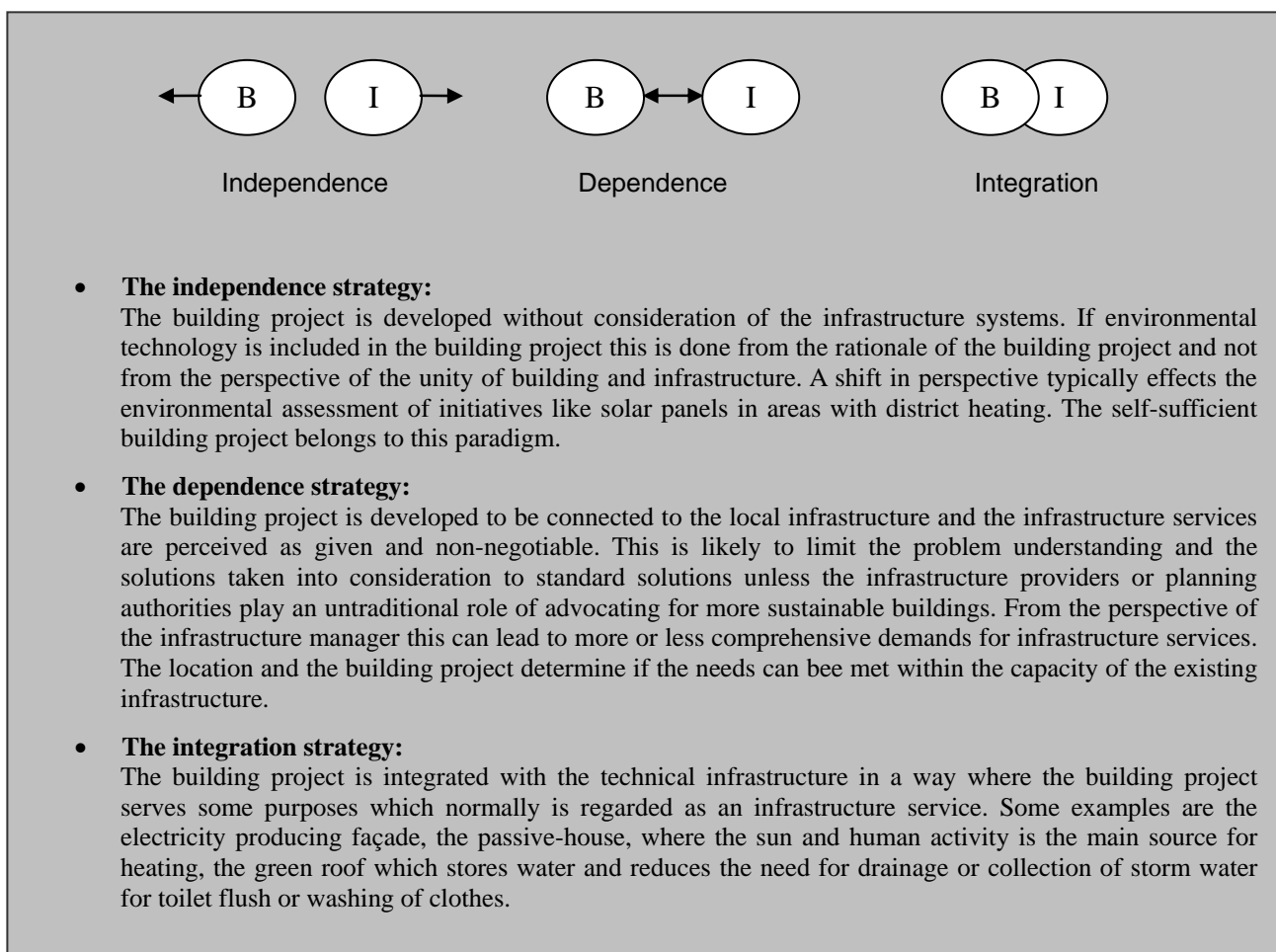
The conventional way of thinking about implementation of infrastructures is marked by a high degree of lock-in of these systems. This means that such systems have taken form as large technical and organizational entities, which are taken for granted, when it comes to operation and use of the systems. This kind of stabilization of a system may occur, when specific historical events push towards a self-reinforcing process (David 1985 and Arthur et al. 1994). Several of the urban infrastructures have been shown to have followed such a path of development. These systems were typically established between the late 1800s and early 1900s and have over time gained a certain 'momentum', as Hughes (1983) would express it. This means that investments have been made at different levels in society, which are not easily changed. At the material level, investments have been made in implementation of a physical system with a long lifetime. At the organizational level, investments have been made in relation to knowledge and establishment of certain institutions to service and maintain this system. At the level of daily practices, investments have been made into specific routines and ways of doing, as people have grown accustomed to these systems (Quitau 2007). Such investments influence future paths of development, since contemporary decision-makers are bound up by the realization of past practices in the construction and use of such a technical system (Melosi 2000). This show how certain general rules or paradigms – called regimes – have been shaped that frame actions and beliefs about what might be possible in the future (Hughes 1983). Such regimes represent a challenge for the idea of thinking urban infrastructures in new ways, since current ways of doing are deeply embedded in the city itself and in the procedures of those planning and using the systems.

Currently, infrastructural systems are invisible and taken-for-granted structures of the cities. Even though these urban utility systems are vital for a city – and for the life quality of city users – the potentiality of such technical systems are overlooked in building projects. One reason for this is that existing utility systems are taken for granted, when designing buildings and public spaces. Instead

of designing individual utility systems in a specific building project, the existing centralised systems are most often implemented without further consideration. This underlines our argument of withholding existing infrastructures, rather than considering more innovative and sustainable ways of integrating such technical infrastructures into the area or building in order to meet the service requirements of users. This is although alternative ways of integrating infrastructures exist, like utilizing solar cells as building materials, collecting and re-using rainwater within the building or designing public spaces as capacity for storing storm water in case of extreme rainfall.

When it comes to implementation of sustainable utility systems into building projects two different strategies can be identified in existing practices. In some occasions, typically in rural areas or large building complexes, sustainable systems are being developed more or less independently of the building project and possibly establishing local self-supply systems on nearby areas. In urban areas, utility systems are mainly developed in dependence of each other, eventually carrying out incremental innovations in existing systems. Instead, as shown in box 1, we suggest more radical forms of innovation aiming at an increased integration between the building project and the infrastructure. We believe that such a focus on integration between the design of the building, the public space and the infrastructure is needed in order to assure a rethinking and reshaping of the city in a sustainable direction.

**Box 1: Illustrations of strategies in relation to implementation of infrastructure (I) in building projects (B).**



At BYG-DTU we have had several research projects about transformation of technical infrastructure and the potential as well as barriers for implementing more new and sustainable technologies and social practices. In most building activities in Denmark today the dependence strategy is the most widespread. However a look only at building projects addressing sustainability issues generally reflects the independence strategy. The idea of integrating urban infrastructures into

building projects breaks with a long tradition of having centralized provision of services like water-, heating- and electricity supply, and sewage- and solid waste handling. By ignoring the potentials for integrating buildings and infrastructure important steps in transforming urban infrastructures is missed and the needed transformation to sustainable infrastructures are delayed or becomes more expensive.

### **Openings for integration**

Having, so far, looked mainly at the dynamics behind infrastructural systems, we now turn towards the process within building projects. We believe that any building project could be seen as a change agent for a more sustainable infrastructure, but the typical linear way of thinking and planning buildings and building systems represents a barrier, since the utility system is taken for granted. However, this linear approach currently seems to be challenged by the notion of 'integrated planning', which has become a new buzzword in building projects (Daniels 1997). Integrative planning is meant to combine different disciplines in the pursuit of truly optimum total building concepts, where interactions between environment, building and building systems are brought together in the design of the building. In this section we will look into different approaches to holistic design management, which we find are promising in order to promote urban infrastructure thinking in the early phases of a building project. We have chosen to illustrate this new line of thought through the work of two leading architectural firms in Denmark: ARKITEMA and Ladingarkitekter+konsulenter (La+K).

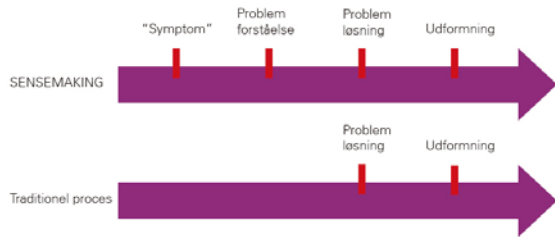
#### *ARKITEMA sensemaking : a holistic approach to building project development*

ARKITEMA is an architecture firm established in 1969 with 290 employees. Even though the firm has, at least not yet, addresses the challenges of integrating infrastructure in building projects, they have developed a working method that support a holistic approach to design management which easily could include consideration of the relations between building project an urban infrastructure. Their vision is to create values in four directions, when working on a building project: for their customer, the user, the owner and society. In order to manage these many – and sometimes conflicting – stakeholder interests, they have developed an innovative process which they call 'sensemaking'.

In ARKITEMA the goal of accommodating the interests of customers, users, owners as well as society is reached by making sure that representatives from all these parties participate from the very early stages of a project, as well as a range of specialists from different fields. This assures that the most urgent issues are addressed, but it also assures that innovative approaches are supported, because new and previously unrecognized issues and possibilities are uncovered; issues that was not on any single person's agenda, but rather emerges as a result of the shared process of coupling diverse courses of knowledge and different perspectives.

The overall principle behind the sensemaking process is to postpone the thinking of solutions until the problem is properly understood. If an architectural solution is thought as an answer to a question, their approach is to ensure that they are in fact answering the right, or the most important, question. The traditional process of architects is to work from a problem definition as presented by the customer, where as the sensemaking process introduces new activities in the work of the architect namely, to work explicit with "symptoms" and the problem understanding from different stakeholder perspectives. The sensemaking process is compared to the traditional process in figure 2.

The sensemaking process consists of five phases as illustrated in figure 3. In the defining and discovering phases, different methods (including anthropological) are used to create a wide and



**Figure 2: Sensemaking versus traditional process. (ARKITEMA)**



**Figure 3: The sensemaking process. (ARKITEMA)**

nuanced picture of the needs, potentials and challenges that the specific building project may influence. This insight is created through a multidisciplinary process, by means of external experts as well as workshops with participation of a broad representation of stakeholders. With the sensemaking process ARKITEMA has developed a process to prevent, what at the end turns out to be bad decisions, because decisions was made without knowledge about the impact in a larger context. The intention of the process is also to support innovation and the development of more comprehensive solutions at the end for their customer as well as owner, user and society. In the ‘Emilholms Canal’ in Ørestad North, ARKITEMA worked together with representatives from the local stakeholder group ‘Ørestad Nord’. The purpose of this specific project was to realize the canal street as an attractive and lively urban space. Two main activities were carried out in the project. First, a registration of the canal street and its urban context was carried out in order to create a frame for dialogue and generation of ideas. Second, a workshop was held in order to discover and define inhabitants and user experiences and expectations to the canal street and its surroundings. Although, in this specific project, infrastructure was not considered specifically, the sensemaking process represents an opening for integration of infrastructure, because the technical aspects could be a point for reflection in the early stages of a building project.

An emerging business area in architectural firms is consultation of municipalities in the development of strategic tools or plans for urban development. This is another opening for addressing issues of integration. At the strategic level, some municipalities have different initiatives to support implementation of more sustainable building projects ex. guidelines, sustainability targets in local plans and green accounts, but very few municipalities has formulated strategies for infrastructure development in anything but their mandatory sector plans and their municipal plan.

The general approach to strategic urban planning in ARKITEMA is similar to the sensemaking process

- Firstly: registration of urban qualities, values, potentials and threats (typical themes: aesthetic, function, pragmatic conditions, events, social issues, ethical issues, landscape, history, culture and commercial issues)
- Secondly: developing and exploring different scenarios
- Thirdly: formulations of strategies to guide urban development in a certain direction.

As demonstrated above the approach already includes a wide range of dimensions in urban development (aesthetic, functional etc) where many relate directly to the visible city, but also other and not as visual aspects. Our point of view is that consideration of urban infrastructure could relatively easy be added as a theme in urban strategic planning.



ARKITEMA experiences that the customer – the one who pays the architectural firm – is not always in favour of opening the decision processes for other stakeholders. This is typically in situations where the building project is initiated by an investor, for whom e.g. minimizing risks and



maximizing short term profit is more important than e.g. long term user satisfaction or long term advantages to society.

The two examples illustrated in Box 2 show that infrastructural considerations are taken in relation to building projects, when the sensemaking process is applied. In both examples, we observe how carrying out a broader analysis of the urban context leads to involvement of infrastructure elements in the analysis. In Gellerupparken, storm water management was pointed out as a way to improve the outdoor area, establishing visible facilities for drainage and storing of storm water. In Ørestad North, new metro stations were designed with consideration for the broader transport infrastructure and the urban context. Having a broader perspective within the building project seems to lead to more innovative and creative solutions, when it comes to infrastructure elements.

**Box 2: Illustrations of openings for integrating infrastructure and buildings. (Photos: www.ARKITEMA.dk)**

<b>Example 1: Gellerupparken – urban renewal project of improving outdoor areas</b>	
	<ul style="list-style-type: none"> <li>- <i>Involved stakeholders:</i> ARKITEMA and dwellers from the social housing community</li> <li>- <i>Purpose:</i> Renewing the outdoor areas from a social as well as technical perspective. Providing greater variation in the area. The final plan included redesign of walking and cycling paths, parking facilities, sports facilities, playgrounds and changes in the nature and landscape design.</li> <li>- <i>Infrastructure elements:</i> visible facilities for drainage and storing of storm water designed to improve biological diversity, provide aesthetic variation and a better local climate.</li> </ul>
<b>Example 2: The architectural programming of the new metro stations in Copenhagen</b>	
	<ul style="list-style-type: none"> <li>- <i>Involved stakeholders:</i> ARKITEMA, the Municipality of Copenhagen and the Copenhagen Metro company.</li> <li>- <i>Purpose:</i> Identify the criteria to be included in the competition material for the enlargement of the Copenhagen metro with 14 new metro stations. In the process, existing metro stations were analysed in order to learn from previous experiences and find inspiration to future possibilities. At each of the locations common identities as well as unique local qualities were identified. The analysis made it possible to talk concrete and qualitatively about the locations and point to the future design of the urban space around the stations, without talking about a specific design solutions.</li> <li>- <i>Infrastructure elements:</i> The metro stations were seen in relation to the broader transport infrastructure and urban context. What can a metro station do for its urban context as well as for its users and its neighbours?</li> </ul>



*LA+K: site-specific assessment of sustainable buildings*

LA+K is one of the outstanding architectural firms in sustainable building design and planning in Denmark. They work primary with development projects, processes, evaluations, strategies and communication about holistic and resource conscious building projects. This firm was established in 1997 and has 6 employees. One of their projects is presentations of large sustainable buildings

for a Danish audience, to demonstrate that sustainability design is not only for a minority of especially environmentally aware people and to inspire Danish building owners to sustainable building design. This section is based on Lading (pers. comm.).

LA+K uses holistic and dialogue oriented processes similar to what they do in ARKITEMA, but their speciality is to develop new understandings of how to ensure the building project contributes to the development of sustainable cities as a whole. The starting point is that sustainability is site-specific because the urban context of a building project influences the evaluation of benefits/disadvantages of different design solutions. LA+K use the concept of sustainable buildings with reference to Klaus Daniels (Daniels 1997), and describe sustainability of a building project is described according to: energy use, materials, waste, climate effect, air pollution, indoor climate and other factors.

**Box 3: Illustrations of openings for integrating infrastructure and buildings. (Photos: [www.Ladingarkitekter.dk](http://www.Ladingarkitekter.dk))**

<p><b>Example 1: Consultation for future building owners in Ørestad (Nordkran)</b></p>	
	<ul style="list-style-type: none"> <li>- <i>Involved stakeholders:</i> LA+K, the municipality of Copenhagen and a working group with representatives of research institutions and consulting engineers.</li> <li>- <i>Purpose:</i> Strengthening sustainability thinking by offering consultation and evaluation in the early phases of a building project with specific focus on reduction of energy use and environmental impact. The consultation is free for the building owner, who receives a suggestion for an action plan to reduce energy use and environmental impact. The project will show to what extent it is possible to include sustainable building design and otherwise conventional new building close to the city centre of Copenhagen.</li> <li>- <i>Infrastructure elements:</i> A central idea was to create synergies between business and housing by sharing facilities. For example, surplus heating from the business may be used to warm up the housing section.</li> </ul>
<p><b>Example 2: Stilledal – preparing social housing from the 1950s for the future</b></p>	
	<ul style="list-style-type: none"> <li>- <i>Involved stakeholders:</i> LA+K, current dwellers, the social housing association KAB and the social housing association SAB.</li> <li>- <i>Purpose:</i> The project is to demonstrate how a housing complex from the 1950s, can be renewed to be attractive housing according to current and future standards. The building complex is typical for the period and is supposed to be a scholarly example of how to renew this type of buildings. Sustainable design is taken into consideration and the planning of the renewal process includes intensive communication with current dwellers.</li> <li>- <i>Infrastructure elements:</i> the heating system remains intact, but a greater degree of insulation is ensured in order to bring down heat consumption.</li> </ul>

The two examples illustrated in Box 3 show that site-specific assessments of sustainable buildings do not involve direct infrastructure elements, but rather, consider the overall consumption of water and energy. Instead of implementing specific changes to the technical infrastructure, solutions are carried out, which optimize the use of the services of these infrastructures. The idea of making use

of surplus heating is especially interesting, whereas the idea of providing better insulation of a building is a more traditional solution. These examples illustrate holistic and dialogue oriented processes often spur other considerations than those related to infrastructural concerns. For example, in the case of Stilledal (example 2), emphasis is mainly put on the degree of attractiveness of the dwelling, providing improved living conditions for the dwellers. In the following we will discuss why this opening for integrating infrastructure does not result in a greater degree of consideration of infrastructural issues in the building project.

### **Potentials and barriers**

Our two case stories of ARKITEMA and LA+K indicate an interest in thinking building projects beyond the building project itself and to include the building projects' relation with its urban context, in contrast to conventional thinking. This essentially represents an attempt not to take anything for given, and instead open up for creativity and other sources of inspiration than the customer and architectural firm. However a more holistic perspective as practiced above does not necessary lead to a better integration of infrastructure in building projects as illustrated by the examples of building projects. In the following will present some of our reflections about this.

A crucial point is the conventional way of understanding buildings and infrastructure as separated urban constructions and each their professions, and the fact that these vital socio-technical systems are not visible in the urban landscape, explains why urban infrastructure transition is not included in current work of architectural firms. Still we argue that any building project is a potential agent of change, if only the relation between buildings and infrastructure is reflected upon and negotiated, instead of being ignored (independent strategy) or taken for granted (the dependent strategy). Another fundamental barrier for implementation of sustainable urban infrastructures is the lack of strategic plans of how to manage a transformation towards sustainable urban infrastructures. If such plans existed, holistic approaches could promote innovative thinking about integration of sustainable urban infrastructures in the early phases of a building project and integrated strategies could be incorporated in briefings and the architectural solution.

To innovate beyond a 'do better' perspective, i.e. innovate to improve existing infrastructures and building design, and make a 'do different' perspective possible, i.e. innovate to radically change the way we perceive and do things, it is necessary urban decision makers are forced to question old beliefs and assumptions. It can be done for example by avoiding working with innovation within a certain envelope or discipline, but rather at a *system* level. From daily practice we have experienced this is as a rewarding approach which makes it possible to discover issues and possibilities that *we didn't know that we didn't know*. This imply the necessity of developing capabilities to work at a network or systemic level, where there is interaction with a wide diversity of stakeholders and disciplines, with different courses of knowledge and specialist expertise, and with users and those who influence users etc. (Phillips et. al. 2005). In projects, where this type of innovation is desirable, it seems necessary to carry out very open processes, to uncover the issues that 'you don't know that you don't know'. A way of securing such a process, and rendering probable the discovery of issues and possibilities not yet considered, can be by selecting a wide, diverse and cross-disciplinary team of participants (White & Bessant 2006).

In theory all building projects are openings for change, but as we demonstrate in this paper, this potential is not exploited in practice. Changes have to be made in order to ensure building projects contribute to the long term development of sustainable urban infrastructures. The questions are then: who should be responsible? How can it be done in practice, and what kind of incentives can facilitate this development? These are overlooked challenges in current debates on future cities.

## Conclusions

The main point of this paper is to highlight the need for rethinking buildings, urban space and infrastructure as a complex unity. Our argument is that the invisible city is just as important as the visible city for developing attractive sustainable cities.

Based on theories of large technological systems and examples of current practice of the architect firms the paper implies that the technical infrastructure should be addressed in the early stages of any building project and innovative thinking is needed develop new ways of integrating buildings and urban infrastructures.

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