Windows of Opportunity for Smart City Solutions in the Urban Fabric

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Abstract

This paper focuses on the development of a methodology for identifying the windows of opportunity for smart city solutions within the current urban fabric. Advanced ICT and the wealth of urban data offer unprecedented opportunities nowadays for smart urban (re)design, smart operations of urban infrastructures as energy and transport, and for smart interaction with citizens. However, most successful examples of application of smart city solutions come from greenfield developments or comparable situations such as redevelopment locations of substantial size, where the legacy of the past in the form of building characteristics and specific choices for supply of mobility and energy, do not hinder full-scale application of smart city solutions. It is not common practice yet for cities to identify systemically where smart city solutions could be applied within the current urban fabric while planning its management and maintenance. This is a missed opportunity, as the financial flows in management and maintenance programs in the built environment are far larger than investments available for use of innovative solutions in experimental situations of limited size, such as pilots and living labs. Therefore a methodology is needed which identifies local windows of opportunity from spatial and economical perspective. Prospected outcomes of this methodology are citywide hotspot maps and generic business cases at district level. This paper outlines the proposed methodology and describes the next steps in its development.

1 Dynamics in the urban fabric

Each city has to address its current and future challenges being equipped with an urban morphology and with infrastructures designed for the past. In Europe, most cities are defined by a core from medieval or industrialisation time. They have developed subsequently in rings or sectors around this core, depending upon specific physical constraints to construction, transport options, culture, housing and business preferences, social requirements and planning principles. Wegener et al. (1986) describe the temporal characteristics of dominant urban change processes in terms of a stimulus-response scheme, shown in Table 1.

It demonstrates that changes affecting the physical stock of the city have the longest response time and the most long lasting impacts, with small, almost irreversible changes, usually in the range of 1-2% replacements of the existing stock per year (Wegener et al. 1986). What is more, an increasing demand is often fulfilled by adaptation of existing buildings instead of demolition and rebuilding (Grover and Grover, 2013).

Frequently the building stock and urban infrastructures even outlive their economic value for a variety of reasons, such as aesthetical, social or operational motives, which reduce the perceived need for development and substitution, see for instance Zhu and Bostic (2009). Altogether, even in areas with demographic and economic growth where urban change and expansion are significant, overall the pace of change in the urban fabric is often surprisingly low.

Because low or zero energy neighbourhoods and advanced ICT are essential elements in many smart city plans of European origin, critical infrastructures for energy supply, production and distribution, and for ICT should be added to the overview composed by Wegener et al. (1986). Key features to be included in Table 1 describe change process, stock affected, response time, response duration, response level and reversibility of these infrastructures. Most of these infrastructures are characterised by the same slow level of dynamics as buildings and the transport system. For instance, the average lifespan of electricity grids is approximately 45 years, distribution networks for natural gas are used for more than 50 years, heating and cooling networks for 40 to 80 years, and ICT networks 10-25 years.

Level	Change Process	Stock Affected	Response Time (years)	Response Duration (years)	Response Level	Reversibility
1 Slow	industrial construction	industrial buildings	3-5	50-100	low	very low
	residential construction	residential buildings	2-3	60-80	low	low
	transport construction	transport system	5-10	>100	low	nearly irreversible
2 Medium Speed	economic change	employment/ unemployment	2-5	10-20	medium	reversible
	demographic change	population/ households	0-70	0-70	low/high	partly reversible
	technological change	transport equipment	3-5	10-15	medium	very low
3 Fast	labour mobility	workplace occupancy	<1	5-10	high	reversible
	residential mobility	housing occupancy	<1	5-10	high	reversible
	daily mobility	traffic	<1	2-5	high	reversible

Table 1: Urban change processes. Source: Wegener et al. (1986), p. 4

This means that the larger part of the urban building stock, utilities and infrastructures have not been designed for current contexts, lifestyles and technologies, are more often than not, unable to meet current performance standards, for instance in the field of energy savings and production of clean energy.

Therefore, cities are ill equipped to respond to current or future challenges, such as adaptation to and mitigation of climate change, the ever-increasing demand for transportation and the on-going digitisation of our society. While building stock, energy and transport infrastructures, play a dominant role in emission of greenhouse gasses (GHG), the abundance of legacy systems in urban morphology and infrastructures may hamper the transition towards smart and sustainable cities. Thus, in order to meet the Europe wide objectives of at least 20% respectively 40% GHG reduction, a share of more than 20”% respectively 27% of renewable energy sources in energy consumption, and of 20% respectively 27% energy savings compared to 1990 by 2020 and 2030, both building stock and physical infrastructures need to be deeply renovated, adjusted or operated in a fundamentally different way.

Given the slow pace of urban dynamics discussed above, this is not an easy task. For instance, Hajer (2016) describes how, despite the vital role of urban infrastructures in improving resource efficiency, governance of their alteration is highly complex because long periods of cumulative investments have made them static and make changes very costly, not to mention the consequences of interrupted daily use during refurbishment. For that reason, he expects more from using urban infrastructures in a more sustainable way through smart technologies. In the light of the EU's energy roadmap's eventual aim of an 80 to 95% reduction of GHG emissions by 2050, it can be said that the desired transition to a low-carbon economy with low-carbon cities, will take an enormous effort.

This research will focus predominantly on those physical entities in the built environment, which are relevant to implementation of smart city solutions and subject to low levels of change, as shown in the first row in Table 1. For that reason, this table will be complemented with additional information on these objects, for instance energy and ICT infrastructures.

2 Focus on energy efficiency and renewable energy in cities

This paper departs from the EU's perspective on smart cities, where the reduction of GHG emissions in the built environment by application of smart, in particular ICT-based, technologies, plays a dominant role (see section 3). For that reason, it will not go into the wide range of other application domains of smart city technologies, for instance health, environmental quality, inclusiveness and parity of access, and economic competitiveness. While their importance from a societal perspective is clear, this research wants to stay closely aligned to the EU interpretation of the smart cities concept.

Many authors have demonstrated that investments in energy savings and renewable energy systems (RES) can very well have viable business cases, especially when they offer substantial co-benefits; see for instance Gouldson et al. (2018). However, the slow pace of change in the built environment and the lack of a widespread transition to smart sustainable cities (EC Directorate-general for Internal Policies 2014, Loorbach et al. 2016), indicate that the business cases might not yet attractive enough compared to regular investments. This in spite of the prospected size of this market (Gouldson et al., 2015, McKinsey Global Institute, 2018) and the significant potential to reduce GHG emissions. For instance, Hoornweg and Freire (2013) calculated that wide scale deployment of smart city technologies could reduce CO2 emission by 7.8 gigatonnes, nearly 20% of global emission in that year.

It is clear the local governments can at best only partially bear the full costs of investments of a transition to smart and sustainable cities. This means that for the realisation of their aims, local governments have to rely on strategic allies and co-initiators of plans for smart sustainable cities, such as housing associations, energy suppliers and energy network operators, transport providers, local businesses, tenants and owner-occupiers in housing. Besides, a different governance philosophy is needed where civil society and private parties actively contribute to the realisation of public goods as sustainability (Hajer 2011). So far, urban stakeholders are often insufficiently involved in decision-making, while implementation cannot be forced upon them, and knowledge and creativity of non- governmental parties is insufficiently used. Only by exploiting the potential of an «energetic society» of articulate, creative citizens and by acknowledgement of society's learning abilities, can governments realise public objectives as sustainability (Hajer, 2011).

3 Definition of the Smart Cities concept

There is a wide range of different definitions of smart cities, and thoughts about what constitutes them and makes them smart, see for instance excellent overviews of definitions and concepts by Albino et al. (2015) and Mora et al. (2018). Generally spoken, the smart city concept assumes the emergence of a new layer of urban data and advanced, interoperable, ICT's on top of the traditional physical elements in the built environment, opening up new possibilities for (re)design, operation and use of the built environment, and for interaction

between citizens, or between government and citizens, what can lead to new or better services and new business opportunities.
However, despite increasing popularity of the term smart cities in science and practice, there is no agreement yet on a common accepted definition. Albino et al. (2015) attribute this to the fact that the term smart cities has been applied to both the “hard” domain of urban morphology and its infrastructures, where ICT fundamentally influences the functions of systems, and the “soft” domain of education, social inclusion, culture, innovation and administration, where ICT application is less decisive. Nevertheless, common features of smart cities can be defined, such as a citywide, networked infrastructure enabling political efficiency and social and cultural development, room for business and creativity-led urban development, attention for social aspects of urban development, and the natural environment as key strategic component (Albino et al., 2015).

In their bibliometric analysis of the smart city research field, Mora et al. (2018) found specific thematic clusters, each related to a specific understanding and conceptualisation of smart cities, which is reflected in a particular strategic perspective for smart city development. They observe a distinct European path, where ICT’s are seen as a key factor in improving energy efficiency in the built environment. Thus, smart cities are defined as cities that create the conditions for market acceleration and widespread uptake of energy-efficiency technologies in cities, eventually leading to a transformation of the currently unsustainable energy system (EC, 2009). Contrary to the Ubiquitous, Experimental, Corporate, and Holistic Paths, the European Path does not embrace as many domains as possible, but focuses on the deployment of low-carbon technologies in transport, buildings and energy distribution networks (Mora et al., 2018).

4 Smart cities in Europe

In EC policy, smart city policies are anchored in a number of directives and agreements. At first the Strategic Energy Technology (SET) plan (EC, 2017) and the climate and energy policy objectives for 2020, 2030 and 2050 (EC, 2010a, 2012, 2016b). At second, smart city policies are linked to the Digital Agenda for Europe (EC, 2010b). Lastly, ambitions for low emission mobility and logistics as laid down (EC, 2016a).

Experiences from successful earlier programs, such as CONCERTO and CIVITAS, have been very important for further articulation of EU smart city policies. CONCERTO has proved in 53 pilots that a district-based approach to deep refurbishment and clean energy can deliver more than 50% reduction in energy consumption and GHG emission with a viable business case (EC, 2014). CIVITAS has amply demonstrated the feasibility of sustainable transport solutions. Subsequently, more integrated, cross-domain smart city projects have been part of Framework Program (FP) 9 and Horizon2020 SCC-01. The first generations of these lighthouse projects as Triangulum, SmarterTogether and REMOURBAN, have now successfully implemented plans integrating smart transport, smart buildings and smart infrastructures, usually in a specific district. Common ingredients of most Horizon2020 SCC-01 plans are installation of smart meters, smart thermal and/or power grids, and RES in combination with thermal insulation and deep retrofitting, smart lighting, introduction or extension of car sharing systems, promotion of private and public electric vehicles, Intelligent Transport Systems (ITS) and instalment of urban platforms. The urban platforms connect the different domain subsystems through interoperable ICT and provide new services to both citizen and government, or support co-design and co-creation of solutions to urban challenges (Borsboom-van Beurden et al., *forthcoming*, 2018).

A host of excellent projects, programmes, initiatives and networks has worked on low energy districts and smart cities in the EU, not only the aforementioned CONCERTO, CIVITAS, FP9 and Horizon 2020 projects and programmes, but also networks as C40, ICLEI, Covenant of

Mayors, 100 Resilient Cities, and European Innovation Partnership on Smart Cities and Communities. A learning environment has been created, where knowledge, best practices, and lessons learnt are shared and jointly brought to the next level. Nevertheless, the pace of adoption of new methods and technologies is still too slow to achieve EU goals on energy savings, renewable energy and emission of GHG's for 2030 and particularly for 2050 (EEA, 2015). Not only should new policies be implemented earlier, also should the supply of energy, food, transport and housing be restructured, substantial investments made in RES, smart meters and energy saving appliances be used more widely, high standards set for energy performance of buildings, and alternative fuel vehicles, public and slow modes of transport promoted (EEA, 2015).

While many European cities are embracing the smart city concept, developing smart city strategies and implementing smart city projects, a widespread breakthrough seems not yet to be taking place ((EC Directorate-general for Internal Policies, 2014, McKinsey Global Institute, 2018). A couple of persistent barriers and obstacles result in lengthy planning and implementation phases, or sometimes even in cancellation of smart city and low energy district projects. These barriers and obstacles have been analysed, for instance for CONCERTO programme by Mosannenzadeh et al. (2017), and for smart city projects by consultants as PWC et al. (2016) and McKinsey (2018), and by the Action Cluster Integrated Planning/Policy and Regulations of the European Innovation Partnership on Smart Cities and Communities (Borsboom-van Beurden et al., *forthcoming,* 2018).

The most common barriers are 1) high initial and operational costs of smart city solutions, 2) lack of financing and appropriate business models, 3) siloed governments, 4) lack of technical skills in staff, 5) risk aversion by financial organisations, 6) split incentives, 7) inconsistent government policies, 8) prohibitive legislative frameworks, for instance for pre-commercial procurement, 9) lack of proven solutions and validated examples, and 10) difficulties with engagement of local stakeholders. The latter can be in particular a problem in highly privatised European countries. The multitude of interdependencies existing between urban actors makes it even more complicated to align interests and create a common operational picture, especially when concessions are granted to best-value-for money without sustainability criteria.

What is more, the direct impact of implemented smart city projects can be limited due to their usual "pilot-like" character: more or less singular, tailored to a specific context and situation, with a limited scope, subsidy-dependent, quite small and sometimes lacking a truly holistic perspective. While these complex projects provide invaluable information and lessons learned, and are quintessential for building a learning community, market acceleration of successful technologies, products and methods is lagging behind. A pattern of "islands of smartness" seems to prevail, as Snøhetta director Kjetil Trædal Thorsen labelled it during a panel discussion at Nordic Edge 2017 conference.

5 The need for a systemic citywide scan of windows of opportunities

A couple of reasons have inspired this research to focus on upcoming changes and adjustments in the urban fabric and the investments involved. At first, local governments have insufficient resources to finance full-scale transformation of the built environment and its infrastructures to a smart and sustainable state. At second, the volume of investments by local governments, owners and operators into maintenance and management of buildings and infrastructures, is a multitude of the volume of so-called innovation pilots, and they will happen anyway, so why not make maintenance and management measure vehicles for smart and low energy solutions? At third, lengthy preparation phases can be shortened and success rates of implementation improved if possibilities for smart city solutions are included earlier in policy and decision making processes, for instance because relevant stakeholder are identified and engaged earlier. At fourth, by making pilots part of a larger systematic approach to smart cities and low energy districts, the potential for replication within a municipality's jurisdiction increases. Currently, pilot projects are often more or less incidentally chosen, often more on political than on strategic grounds. By selecting those areas that are highly representative for the city's building stock and urban infrastructures, most in need of adjustment and having the largest potential for improvement, future replication can be fostered.

However, more mundane reasons for transitions to smart and low-carbon cities not taking off could also be in play. Current policy and decision-making processes by key stakeholders in the city might simply overlook possibilities for such investments, especially in very early phases of policy and decision making processes, because they are recognised too late. As these phases contain the seeds of future change, the question is whether smart city solutions would be implemented more widely, if rudimentary information on the potential of smart city solutions would be available during these very early phases. These considerations have led this research to focus explicitly on the pre-phase of actual planning and decision-making, and on the role of information on viable business cases and models for smart city solutions in this pre-phase. It aims to identify which dynamics and changes can be expected in the urban fabric, which stakeholders are involved, and how the opportunities that urban dynamics and changes offer for useful application of smart sustainable city solutions, can be seized by identifying them at a very early stage. In that way, such investments can be made part of novel practices in planning, real estate development and exploitation, and lastly maintenance and management of building stock and urban infrastructures during its lifecycle.

The following sections discuss the different building blocks that could compose a systemic citywide scan of the windows-of-opportunities for introduction of smart city solutions.

6 Potential windows of opportunity made explicit

The term «window of opportunity» is stemming from political sciences, as part of the Multiple Streams Framework (MSF), or Multiple Streams Analysis (MSA), which explains policy changes under multi-actor and multi-level conditions (Kingdon, 1995; Zahariadis, 1999). Three more or less independent streams, that is, a problem stream identifying problems, a policy stream containing ideas about possible solutions, and a politics stream reflecting the "national mood", produce these policy changes together. When there is simultaneously high attention for the problem, a viable solution available and a policymaker motivated and able to select it, a window of opportunity is open for major policy change (Zahariadis, 1999; Cairney and Zahariadis, 2016).

The MSF has been applied at many different scale levels and in other situations than national government agenda-setting studies, with varying degrees of success (see Cairney and Zahriadis, 2016). It is obvious that the multi-actor, multi-sectorial and often multi-level policy and decision-making required to create a smart and sustainable built environment, is endlessly more complicated, and maybe even too complicated, to apply the MSF. Nevertheless, the concept "window of opportunity" offers a powerful metaphor for the unique opportunities, both in space and in time, now and in the future, where policy and decision-making in cities can bent towards more effective sustainable and smart options. Exactly for its metaphorical power, the MSF concept of a "window of opportunity" has been chosen here as point of departure for a systemic, citywide analysis of spatial and temporal possibilities to incorporate smart and sustainable methods and technologies in joint policy and decision-making processes.

As follows from the MSF, one of the conditions for a window of opportunity is the existence of a viable solution, which is known to the initiator of the policy change. One of the reasons for not being on track for the 2030 and 2050 GHG emissions, energy savings and share of renewable energy, might be that strategic windows of opportunities for the introduction of sustainable and smart city solutions are missed, and that business as usual prevails often in practice. Given the incredible slow pace of change regarding vital urban objects as buildings and infrastructures, this is a missed chance. For that reason, it is of paramount importance that viable solutions are known at the very moment that a window of opportunity arises, and preferably even before.

A comprehensive overview of expected dynamics and adjustments at object level in building stock and urban infrastructures reflecting stakeholder's agenda's, combined with an overview of relevant smart and sustainable solutions, and a generic business case and exploitation model, will provide policy and decision makers with an evidence base when windows of opportunity are popping up in future.

7 Main changes in the urban fabric identified

Altogether changes in demography, lifestyles, and economy, translate into continuous development and adjustment of urban morphology and urban structures, often quite gradually. Spatial planning puts preconditions to these developments and channels it. It can be expected that the dynamics in cities as described in section 1, will offer many possibilities for implementation of smart low-carbon technologies in cities, by local governments, and strategic allies such as citizens, energy suppliers and transport network operators, and for enablers such as investors. Policy processes might be for instance the implementation of the mandatory Sustainable Urban Mobility Plans (SUMP's) or the Strategic Energy (and Climate) Action Plans, where local governments commit themselves to in the Covenant of Mayors.

Section 8 summarises the usual actors in integrated planning and management of smart city projects. In order to be able to define the windows of opportunity now and in the future more precisely, this paper distinguishes the main processes of change in the urban morphology and urban infrastructures, and in their operation, which might open up new possibilities for introduction of smart city solutions. Table 2 is a first attempt to make an overview of typical smart city solutions applied in Europe. Table 3 summarises the main processes of change from a holistic perspective, and relates these to specific objects in the built environment and potential windows of opportunity. These tables will be validated and completed later.

Objects	Typical smart city solutions
Residential, buildings; Commercial, social, educational, medical buildings; Industry buildings and installations	Low-, zero- and positive energy construction and refurbishment technologies, installations and appliances, e.g. thermal insulation, passive houses, heat recovery from ventilation; Integration with renewable energy production; Making buildings more intelligent through sensors, actuators and interoperable ICT, smart meters; Creating uni- or bi-directional charging infrastructures for electric vehicles as cars and bikes; Providing collective solutions for energy supply, such as solar plants, geothermal or district heating; Make operation and use of the building smarter, e.g. through sensorised smart lighting; Using clean mobility and logistics solutions to provide transport, e.g. electric vehicles, smart parking, clean "last mile" in logistics, Applying principles or smart (re)design, integrated planning and implementation at district level, e.g. based on holistic energy and transport designs which have been co-designed with stakeholders; Smart process technology in industry, e.g. allowing re-use of excess heat and by-products as hydro
Infrastructures	Enable smart operation and use of the infrastructures with sensors and actuators, other urban data and ICT, i.e. intelligent transport systems; Make thermal and electric grids smart(er) so they can respond real-time; Enable exchanges, conversion and co-production of energy, e.g. with data centres, or using combined heat power (CHP); Adding sensors and actuators to the physical infrastructures; Organise interoperability between physical infrastructures and buildings through protocols, standards, e.g. Internet of Things, Internet of Everything; Organise smart operations, smart (re)design and improved/novel services to citizens through urban platforms

Table 2: Typical smart city solutions applied to urban morphology and urban infrastructures

At this stage of the research, specific windows of opportunity are not yet linked to specific smart city solutions, appropriate for that situation. These linkages will be made explicit later.

Change processes	**Objects**	**Potential windows of opportunity** if decisions are taken on:
***Construction: large scale development** of* new objects on greenfields or comparable tabula rasa, e.g. obsolete harbour areas, or large scale demolition and substitution by similar object(s) with similar function at district level		
Development or substitution of housing and social, educational and medical facilities Development or substitution of offices and business parks Development or substitution of industrial buildings	Residential buildings; Commercial, social, educational, medical buildings; Industry buildings including installations	Densities, land use, form, mobility and logistics; Design of buildings (i.e. building envelope, use of materials, construction technologies, design of installations and choice for appliances, energy performance of the building, (re-)use of resources and circularity) Design of energy supply for electricity, heating and cooling to buildings and district (individual and/or collective systems, central or decentral solutions, exchange of energy between buildings and electric vehicles, use of excess heat and cold, recovery of heat and electricity) Design of provision of other utilities to buildings and districts ((hot)water, sewage and waste treatment and collection, ICT connectivity), process technology Business cases; use and operation, contracting future maintenance and management, facilities and asset management
Construction of new roads; new (light)rail; new utilities such as sewage; new energy networks and distributions grids; ICT connectivity	Infrastructures for transport, energy supply and distribution, utilities, ICT	Selection of design and construction technologies; Standards regarding (re-)use and circularity of resources, e.g. waste treatment; Desired level of energy performance, i.e. of lighting, of equipment and installations Operation of the infrastructures and business cases Desired level of intelligence in infrastructure Integration of infrastructures through ICT
Upgrading, updating and periodical maintenance: original objects adjusted and upgraded to meet new needs and standards		
Refurbishment, upgrading and adjustment of existing buildings and their installations (thermal insulation, , different degrees: can be minor or major adjustments	Residential, commercial, social, educational, medical buildings	25-30 year deep refurbishment cycles and updating to current living standards Proposed changes to building envelope, i.e. thermal insulation Renovation, replacement and upgrading of installations and appliances to up-to-date technical and legal standards, i.e. energy saving solar boilers or smart meters and sensors, or new EPBD Improvement of energy efficiency of building and district, e.g. through recovery or exchange of heat Extensions of the building Transformation into other, more profitable or useful functions, e.g. redundant office space to housing
Renovation, upgrading and adjustment of networks and utilities; also major and minor adjustments	Infrastructures for transport, energy supply and distribution, utilities, ICT	Improvement and rationalisation of management by adding sensors and actuators to the infrastructure; Improving the performance and robustness of infrastructures, e.g. upgrading district heating networks to multi-commodity grids Development of new services and business opportunities on urban platforms connecting and integrating information on infrastructures and buildings;
Demolition, out phasing and possibly replacement of redundant buildings and infrastructures after the end of their life-cycle, often substitution by newly constructed object(s), probably with another function,		
Stepwise, small-scale replacement and redevelopment of buildings in the urban fabric	Residential, commercial, social, educational, medical buildings	Legal requirements and fulfilment of policy obligations, aiming to improve liveability, sustainability, health, comfort, or affordability for residents Problems in use and operation of the building due to outdated installations and appliances, e.g. sick building syndrome Building(s) no longer in demand, changed preferences or needs of customers Economic and financial reasons, profitability of substitution and redevelopment
Phasing out and replacement of existing infrastructures,	Infrastructures for transport, energy supply and distribution, utilities, ICT	Legal changes, e.g. motivated by sustainability, safety or affordability reasons, which induce exploration of alternatives, e.g. for instance substitution of natural gas networks by all-electric or going off-grid by decentral energy supply Economic and financial reasons, profitability of substitution and redevelopment Changes in procurement and licenses to operate Infrastructures no longer in demand, e.g. due to new technologies or lifestyles, e.g. promotion of walking and cycling, or public car sharing replacing own car

Table 3: Overview of main changes in urban fabric in relation to windows-of-opportunity

8 Relevant actors

Nearly all smart city projects are founded upon collaboration in the triple or quadruple helix of local administrations, knowledge institutes, industry and citizens. This means involvement of relevant stakeholders and governance play a dominant role in the successful implementation of any smart city project. The complexity of most smart city projects means that many stakeholders need to be involved, and the fact that many interdependencies exist between these stakeholders, implies that a large variety of interests have to be aligned (Nijman, 2014). Figure 1 depicts a non-exhaustive overview of common stakeholders.

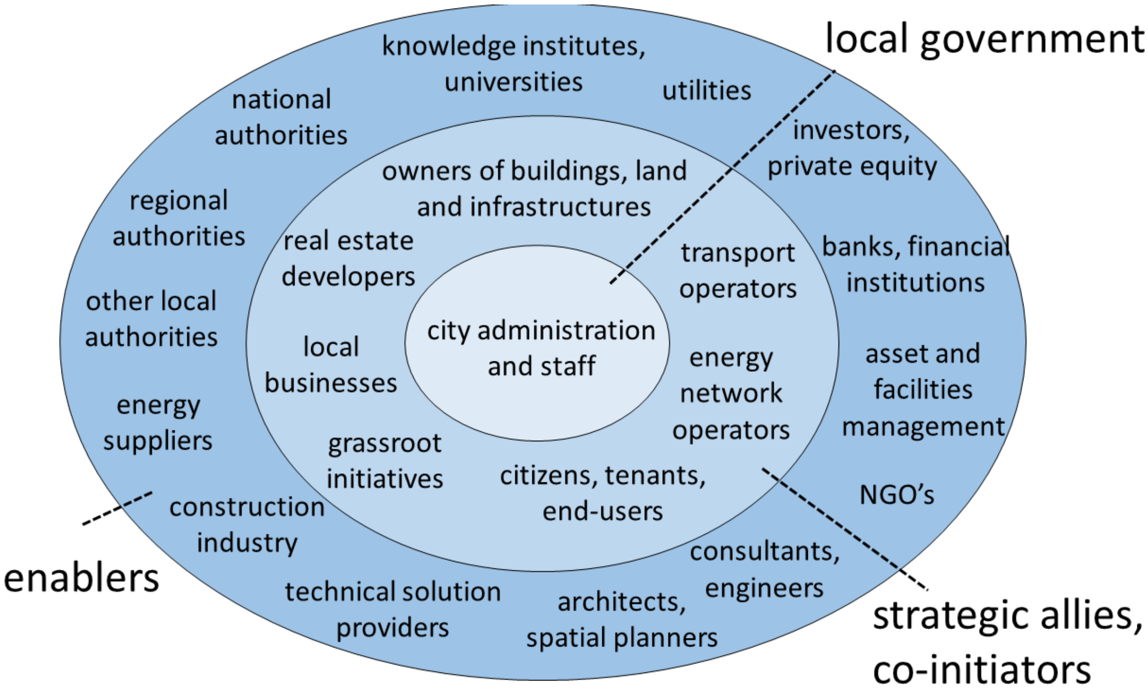

Figure 1: Overview of stakeholders in planning and implementation of smart city solutions
Source: Borsboom-van Beurden et al. (forthcoming, 2018)

9 Contours of a methodology

The key objective of this research is to develop a methodology for identifying the windows of opportunity in districts and cities for the most common smart city solutions on a systemic and long-term basis, inclusive financial aspects, which deliver best value for money and can be easily coupled to investments that are planned anyway. Such a systemic scan during very early, explorative phases of policy and decision-making, will enable local governments, their strategic allies and their enablers, to better exploit specific dynamics and developments as vehicles for bringing about an urban transition towards smart and sustainable cities. The proposed methodology combines elements derived from four methods:

- *Geo-ICT and geodesign*: central to the proposed methodology are spatial data representing the building stock and urban infrastructures. With geo-ICT possible windows of opportunity in future are made spatially explicit, for instance by creating maps of hotspots. In addition, current representation, collaboration and visualization features of Geo-ICT can support transition management by providing detailed information on buildings and infrastructures, by showing interests and positions of different actors and owners, and by showing the possible impact of specific solutions. Geodesign, "*an iterative design and planning method whereby an emerging solution is influenced by (scientific) geospatial knowledge*,… *integrates the exploration of ideas with direct evaluation in the same moment, generating an advanced design solution"* (Lee et al., 2014), will be used as a method during stakeholder workshops.

- *Transition management:* this governance approach is increasingly applied in cities and aims at "*1) Bringing together frontrunners from policy, science, business, and society to develop shared understandings of complex transition challenges; 2) developing collective transition visions and strategies; and 3) experimentally implementing strategic social innovations"* (Wittmayer and Loorbach, 2016). Elements from the transition framework will be borrowed and used in an adjusted form to create a joint appreciation and understanding of urban challenges, and to develop a joint strategy how to address these challenges.
- *Impact assessment:* standard methods and protocols for impact assessment, for example from Societal Cost-Benefit-Analysis, will be applied to analyse not only the spatial impact of expected dynamics on building stock and infrastructures, but also the impact of smart city solutions at GHG emission, share of renewable energy, energy savings, reduced use of fossil fuels and potential co-benefits.
- *Value chains*: standards methods for value capturing will be applied for drafting business cases and value propositions at district level for technically feasible smart city solutions. See for instance Brouwer (2017) for methods to assess the financial aspects of future-resilient and sustainable urban development.

The methodology will eventually support the following stages:

Snapshot	• Define area (street, neighbourhood, district, village or city) • Collect spatial data on objects in the urban fabric (land, buildings, infrastructures for energy, transport, utilities and ICT, other relevant physical objects) • Collect attribute data on ownership, operational and legal responsibilities, and use per object
Dynamics & investments	• Draft list of transport and urban planning interventions by local/regional authorities • Draft list of regular and foreseen refurbishments and adjustments by owners and operators of physical objects as buildings and urban infrastructures • Make timeline of interventions, and expected refurbishments and adjustments • Chart spatial impact of this on physical objects and map corresponding stakeholders (owners, operators, users) • Estimate the value of planned and expected investments per object • Visualise dynamics and investments in GIS «Dynamics» and «Investments» layers • Draft timeline for urban dynamics and investments • Identify hotspots where robust opportunities occur in future, rank these • Validate hotspots and ranking with experts and strategic allies, which most-promising?
Windows of opportunity	• Draft list of applicable smart city solutions given foreseen dynamics and ajustments • Assess suitability, technical and economic feasibility and potential impact of smart city solutions for objects, select most-promising options with owners, operators, users • Visualise high-feasibility, high-impact solutions in GIS in «Feasibility» and «Impact» layers • Create combination map by overlaying «Dynamics», «Investments», «Feasibility» and «Impact» layers, flag objects with high scores • Map these «spatialised» upcoming windows of opportunity on the timeline
Negotiations and financing	• Share outcomes with strategic allies and key enablers, select most-promising solutions • Develop roadmap for integrated planning and implementation • Engage stakeholders, analyse appropriate financial schemes, PPP's, start negotiations

Figure 2: Proposed methodology for a systemic, city-wide scan of windows of opportunities for smart city solutions

Not all stakeholders included in Figure 1 will be end-users of the envisaged systemic, citywide scan. Nevertheless, it is possible to identify some key actors as potential end-users:

- Those who have specific responsibilities in the built environment as *municipalities and regional authorities, r*esponsible for public goods as accessibility, and environmental and spatial quality. They give permission for changes to buildings and infrastructures. Municipality-owned housing associations also belong to this category;
- Stakeholders that are responsible for *operation, management and maintenance of urban buildings and infrastructures*, such as local energy producers, transport operators, non-municipal road authorities, and utility providers. These stakeholders might be public or private, as provision of basic needs as water and electricity to inhabitants and local businesses is organised very differently per country;
- *Owners of land, buildings and urban infrastructures*. Not only can they initiate planning and implementation of smart city solutions themselves, they have to agree on the plans when proposed by others, and possibly share the financial burden of implementation. This category is very heterogeneous, depending upon planning system and culture, and can range from pension funds owning rental housing to housing cooperatives and farmers still owning plots of land in the city. Residential owner-occupiers can be a difficult category to convince if the plan does not fit their own interests and ambitions, or just does not suit their timeline.
- *Users of the built environment*, who come in many forms, making the “citizens” a difficult group to define: tenants, who often are required by law to approve of plans, local businesses and their staff, commuters, visitors and tourists.
- Those who have ensured *financing*, such as investors, banks who gave loans, private equity, and want to secure the profitability of their current and future investments.

10 Conclusions and next steps

Transitions to low-carbon cities are hampered and delayed by costs, uncertainties and risks, sunken costs, path dependencies and legacies, and non-aligned stakeholders. The possibilities to smartify cities by making investments in a different way through alignment with planned and upcoming adjustments and interventions is enormous. This paper proposes a geodesign based methodology, which scans the possibilities for deployment of smart city solutions at a very early stage. This helps to take better decisions far in advance. Further development of the methodology will take place with the following steps:

1. Desk research on expected dynamics and adjustments to the urban fabric during the lifecycle of its physical objects in the case study areas;
2. Interviews with the aim of collecting more information on how are decision making is prepared in different change processes by local governments and their strategic allies, in particular during very early phases. In addition, interviewees will be asked to reflect on the design of the methodology and potential end-users. This input will be used to extend Wegener’s table with buildings and infrastructures relevant for smart city solutions and to adjust the proposed methodology;
3. Selection of three to four cases across Europe, representing different geographies, planning cultures, city sizes, governance models, and local challenges;
4. Working out the methodology as depicted in Figure 2 for every case;
5. Testing of the methodology in workshops with stakeholders in the case study areas;
6. Evaluation of the outcomes together with local governments and key stakeholders and refinement of the methodology.

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