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Framework Study League of International Testbeds

Final Report

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Foreword

This framework study explores and defines the possibilities for setting up an international league of testbeds between Sweden and Netherlands. Its final aim is to enlarge the possibilities for both national and international scaling of Dutch and Swedish smart sustainable solutions demonstrated in testbeds, and to create societal impact through a faster transition to smart sustainable cities. The study has been executed upon request of the Dutch Embassy of the Kingdom of the Netherlands to Sweden, Netherlands Enterprise Agency, and Vinnova.

Scaling of innovative solutions beyond test beds, demonstrators, living labs and field labs in the highly fragmented smart sustainable cities market, is often not easy, potentially resulting in a waste of resources or in companies defaulting. At the same time, the uptake of smart sustainable solutions in cities is often slow, with limited replication and upscaling of successfully demonstrated innovations, despite appreciation of their value by industry, city administration and other key stakeholders. This results in maturing of the market for innovative smart sustainable urban solutions insufficiently taking place and the climate-neutrality and sustainability goals for 2030 and 2050 becoming further out of reach.

This report explores how setting up an international league of testbeds between Sweden and Netherlands can help to overcome these persistent problems by shaping international market opportunities for Dutch and Swedish companies. It provides insight to businesses, investors, research institutes, testbed organisations, city administrations and regional development agencies (RDAs) and national governments in what such an international league of testbeds might offer for realising their ambitions and goals, and what it would take to organise this.

The execution of this framework study and the development of this report, proved to be an exciting journey. Not only did we discover the incredible richness of all innovative smart sustainable urban solutions currently being tried out and validated, but we also found how interwoven innovation and urban sustainability challenges are within local ecosystems, and how relevant the outcomes are for a wider national and international community of businesses, city administrations, research institutes and other stakeholders. Highly interesting were also the similarities and the differences we observed between Sweden and the Netherlands in approaches to local and regional innovation, in terms of policies, organisation, financing and engagement of businesses, cities, research and civil society. The multitude of various terms relevant to our research proved not always easy to navigate; test beds, living labs, field labs, demonstrators, pilots, regulatory sandpits and the like were sometimes interpreted differently in each country, making it more difficult to compare. Nevertheless, we think we have succeeded in providing a good overview of how the land lays regarding the validation and uptake of smart sustainable urban solutions, and in collecting the building bricks for the next steps.

The authors would express their heartfelt thanks to the initiators of and Advisory Board for this study, consisting of Jacobine de Zwaan – Netherlands Enterprise Agency, Catharina Zajcev - Vinnova, Anne de Vries – Innovation Quarter, Wouter van Rooijen - City of Rotterdam, Eva Blom and John Dekker– Dutch Embassy of the Kingdom of the Netherlands to Sweden, and Diana van Altena – Ministry of the Interior and Kingdom Relations. We are very thankful for all their useful comments and suggestions during the execution of this study. Not all comments and suggestions could be included within the scope and timeline of this research, but they are important elements for a next stage.

In addition, we would like to express our gratitude to all persons and organisations that have freed up their precious time for us to share their valuable experiences, insights and ideas with us (in alphabetical order): Johann Beelen - Brainport Eindhoven, Annika Bergendahl – Vinnova, Lars Bern - Business Region Gothenburg, Jos den Besten – Hamwells, Chalmers University, Willem Drost - Enterprise Solution/TechLeap, Yvette Entius - Living Lab Scheveningen, Arjen Hof - WeCity (before Civity), Johanneberg Science Park – City of Gothenburg, Marian Kreijns - Green Village, Peter Kisch - City of Lund, Peter de Kruik - ROM Amsterdam, Tijn Kuyper – Living Lab Scheveningen, Sofia Målberg - Research Institutes of Sweden, Marine waste testbed Sotenäs, Sebastian Marx - Connectivity Alliance, MTC Umeå, Hans Nouwens – Connectedworlds, Jonny Paulsson – Vinnova, Eli Prins - CleanTech Delta and ConnectSME, RISE Processum, Kerstin Rubenson - Research Institutes of Sweden, Linda Svanhed – Vinnova, Stockholm Electricity, Swedish Agricultural University, Corinne van Voorden – Netherlands Enterprise Agency, Jan-Willem Wesselink – FutureCity, and the Dutch Workgroup Trade and Innovation.

We wish you a great reading journey!

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Executive summary

Scaling of innovative solutions beyond test beds, demonstrators, living labs is often not easy, at times resulting in a waste of resources or in companies defaulting. Simultaneously, the uptake of smart sustainable solutions in cities is often slow, with limited replication and upscaling of successfully demonstrated innovations. The market for innovative smart sustainable urban solutions is insufficiently developed while climate-neutrality and sustainability goals for 2030 and 2050 drift further out of reach.

In both Sweden and the Netherlands, we find many testbeds that are, each on their own, very well suited for catering to experimenting with sustainable technologies. However, they are neither interconnected nor strategically aligned, which leaves ample room for improvement to secure the highest possible positive impact on the sustainable developments of our society. This particularly pertains to the lack of international exchange of knowledge, shared space for innovation, and boosted acceleration of innovative products and services through multi-stakeholder processes.

This report is designed to provide understanding of the practices and opportunities of testbeds both on operational and system level, how the testbeds interact with surrounding city innovation ecosystems, identify challenges and synergies that might come from international collaboration between testbeds, set the basis for such an international and operational pilot collaboration between Sweden and the Netherlands, and outline a potential roadmap for how international collaboration, such as a *League of International Testbeds* could spread to additional countries.

The 'League of International Testbeds (LIT) has been initiated by Cleantech Scandinavia, InnovationQuarter and Netherlands Enterprise Agency with the aim of building and growing a platform of international testbeds and facilitators which can accelerate international scaling of innovation.

The LIT focusses on supporting growth and scaling of innovative companies through collaboration and exchange between testbeds internationally. For most testbeds, in particular those focusing on urban solutions, a *system vs operational* approach yields perspective on both necessities and challenges. Although similar, many are particular to either Sweden or Netherlands and therefore listed separately.

Swedish system level

The Swedish testbed system level is strong, and is well positioned towards real-world testing, , however we see a need for more focus on internationalisation and operational results, building on entrepreneurial talent in the testbeds, a better understanding of what it takes to go international, and resources for frontrunners to embark on that journey. We also see need for new functionality in the overall system to support this, a functionality that would benefit from development of new work models, new tools and additional stakeholders to complement the three main players RISE, Vinnova and the cities, as well as a need to operationalise the experiences and the structural capital that is built within key projects like the Innovation platforms and Viable Cities.

Swedish operational level

Clearly, the situation for Swedish testbeds on the operational level remains ambiguous: High willingness and a positive attitude towards internationalisation, a movement towards exchange of experiences and avoiding double-work, raising efficiency in innovation management meet several disadvantageous impediments towards a simple, lean, and quick implementation of either receiving

a foreign company or aiding a domestic in reaching other markets. Some of the hindrances are a palpable level of restraint when it comes to approaching foreign markets, specific actors, or ecosystems without a specific mandate or budget for such action. In addition, other hurdles feature, such as national regulations and legalities, unclear or unguarded intellectual property rights, and/or secrecy concerns.

Adding to that are concerns about IPR and particularly regulations which differ considerably from market to market, the on-going COVID19 crisis and the lack of a unifying and centred player providing an objective-as-possible overview over the opportunities, the actors involved, and the quality/feasibility of the innovation.

Dutch system level

Although interest in international markets is a constant in the Dutch ecosystem, the majority of businesses in testbeds remain cautious due to the lack of information on procedures, opportunities, possible pitfalls, legislation, and procurement rules. Creating oversight to connect the dots in the fragmented testbed scene would help bridge international collaboration gaps (via a LIT) as well as aid the domestic Dutch connectivity. A variety of Dutch actors, such as RVO, IQ, Brainport, Ministry of Interior Affairs, RDAs, etc should be engaged in a collaborative liaison.

Dutch operational level

International collaboration between testbeds will mostly benefit SMEs. It is often not in the direct interest of cities and large companies have their own means.

Regarding the needs, there seems to be a strong need to segment these more, as one-size-fits-all does not work. Testbeds need to adapt their offers to the varying degree of company development level, from early to late stages.

Non-synchronised processes between matched start-ups and corporates present a challenge.

Lastly, interviewees confirm that usually city administration, province or national organisations are the scaling customers. This often leads to an overall convoluted process aggravated by the fact that municipalities as organisations are rather fragmented and siloed.

The city as a market, the barriers, and the potential of LIT

The global market for smart cities is estimated to be worth over €1.78 trillion by 2025 (For the Netherlands alone, the total costs for the transition to a climate-neutral country by 2050 amounts to 460 Billion Euros). These figures show there is a huge market potential and yet the city market is not an easy one - replication and upscaling not being in the core interest of cities, SMEs must start all over again in every city. And despite impressive real-world testbeds, market uptake and acceleration of successfully demonstrated technologies and solutions beyond the confined testbed environment, are often hindered by afore-mentioned barriers.

A LIT could contribute to scaling of businesses and creating economic, environmental, and societal impact if it manages the closing of this gap by providing go-to-market services that tackle the barriers wherever possible and in conjunction could also provide services to cities, connecting to their local ecosystem of real estate owners, construction companies, transport operators and energy providers. It could help to overcome the barriers to replication and upscaling. For example, sharing of information on best practices, organisation of public-private partnerships, development of business cases for sustainable solutions, mitigation of financial risks, procurement of smart sustainable solutions, co-design of solutions with key stakeholders, training, and capacity building with city administrations.

This study shows the complexity of systems around testbeds and smart sustainable cities and how interdependent different parts of these systems are leading to a variety of solutions and approaches.

Key findings of this study are:

- The concept of testbeds for smart sustainable cities varies considerably, and the boundaries are blurry towards other test and demonstration activities. More research and testing of different models for collaboration and governance could bring better system understanding and create a better basis for interventions.
- There are considerable differences concerning testbeds between Sweden and the Netherlands when it comes to definitions, overview and coordination, ownership, and operations as well as legal and governance models. This creates opportunities for learning, on system level and operational level in each country, and for bilateral collaborations. Potentially, the learnings can also contribute to a broader international development of testbeds and collaboration between testbeds.
- There is a deficit of internationalisations of testbeds in both countries, in face of the need for urban solutions, and the potential expressed by testbeds and innovative companies.
- There is a clear need and interest expressed from operational level for increasing international activity and collaboration, as well as a need for procedural support, such as knowledge sharing, practical experiences, support services and resources. Currently, there is no single stakeholder offering these kinds of services and support.
- There is interest from several testbeds to engage in internationalisation efforts. We have identified a number of key factors that together constitute a first checklist of functions and services that a testbed would benefit from offering in order to internationalise. Some have started to develop this, but most will need considerable support to establish themselves internationally.
- There are expressed needs from national level for increased internationalisation of testbeds, though differing motivations. In the Netherlands primary focus is on helping innovative Dutch companies to grow, in Sweden primary focus is on increasing the number of international clients to Swedish testbeds.
- Innovative companies from both countries want to enter the other country's markets, but there remain a lot of uncertainties on potential and best practices. Guidance is needed.
- There is a clear potential for increased involvement of private partners in the governance of testbeds, as well as a potential for closer collaboration with testbeds and the private sector concerning test, demonstration, implementation, and scaling. New business models and governance models can be built on public-private-partnerships.
- There are a few challenges concerning increased international collaboration between testbeds, such as lack of relevant support services on internationalisation, lack of flexible budget resources to support the process of testing, demonstrating, implementing and scaling innovative urban solutions, lack of overview of testbeds and their offers to innovative companies, lack of information in English, and to some extent cultural differences.

1. Introduction and background

Hardly anyone ever benefits from experimenting without the perspective of implementation. To create strong European cities, we need smart sustainable solutions that are affordable, scalable, and feasible. We can achieve this far more effectively with international collaboration. However, scaling in an emerging international ecosystem presents its own challenges: many successful smart city initiatives are local stars, successful in their hometown, but facing difficulties with scaling, both nationally and internationally. In addition, Smart Cities innovators are often told that they should not only supply technology but need to collaborate with integrated solutions. These solutions should make cities not only smart, but also safe, sustainable, and inclusive.

In both Sweden and the Netherlands, we find many testbeds that are, each on their own, very well suited for catering to experimenting with sustainable technologies. However, they are neither interconnected nor strategically aligned, which leaves ample room for improvement to secure the highest possible positive impact on the sustainable developments in our society. This particularly pertains to the lack of international exchange of knowledge, shared space for innovation, and boosted acceleration of innovative products and services.

The 'League of International Test Beds' is initiated by Cleantech Scandinavia, InnovationQuarter and Netherlands Enterprise Agency with the aim of building and growing a platform of international testbeds and facilitators which can accelerate international scaling of innovation. During 2020 a number of very productive preparational webinars were conducted with stakeholders from Sweden and Netherlands, setting the basis for a joint project.

In order to align with both the Green Deal, the Mission on Climate-Neutral and Smart Cities and Horizon Europe, our starting point is a European one. Within this perspective we start our initiative by investigating two countries, Sweden and the Netherlands. After this research and several pilots, the initiative can be rolled out in other countries.

The objectives of this project are to

- Build a framework on Dutch-Swedish test bed exchange, with a focus on continuous learning and education, that could be expanded internationally.
- Gain insights into methods to implement Dutch solutions (technology/expertise) into Swedish test bed projects (and vice versa).
- Finding synergy and common ground on specific subjects where we can we raise bilateral enthusiasm to work together and scale business.
- Develop a structure for a marketplace on the exchange of tangible testbed projects within a European framework.

The aim is to achieve this during spring 2021, and then decide on coming steps.

Scope

Testbeds, living labs, field labs, system demonstrators – whatever we call them in different countries – that help innovative companies test, demonstrate, implement and scale their solutions for smart sustainable cities, are the focus of an internationalised collaboration between them. If such a “testbed” has continuity and offers different kinds of services and support to the innovative companies that help them succeed, we see them as a tool to support the transformation of cities, a tool that has the potential to help in driving that transition quicker and more efficiently. This becomes particularly relevant in an international, collaborative context. Such sharing of examples through international collaboration can also have an impact on national level: the involved national governments can play a role in enabling dissemination of key learning outcomes and know-how to industry, city administrations and research within their respective countries.

This report is designed to provide understanding of the practices and opportunities of testbeds both on operational and system level, how the testbeds interact with surrounding city innovation ecosystems, identify challenges and synergies that might come from international collaboration between testbeds, set the basis for such an international and operational prototype collaboration between Sweden and the Netherlands, and outline a potential roadmap for how international collaboration, such as a League of International Testbeds could spread to additional countries.

Target group

The outcomes of this project are relevant for a wide range of actors. First of all, for any smart city-oriented business based in the Netherlands or in Sweden with the ambition to do business in the other country. Besides, it is relevant for any organisation engaged in testbeds, demonstrations and living labs that wants to promote the viability and uptake of the solutions tested beyond the testbed environment. Further, the outcomes of this research are relevant for local authorities considering implementation, contracting and procurement of innovative smart solutions. For example, city administrations, local politicians, directors of unit, smart city project managers and other local authorities, e. g. public transport, housing, utilities or waste management. However, it can also be very useful to all partners in the cities’ innovation ecosystem, such as businesses (e.g., energy network and transport operators, real estate developers and facility managers, solution providers), civil society. Lastly, the outcomes indicate which role enabling organisations at national and regional level can play to promote scaling of smart city solutions.

Methods

The research has been executed in two parallel parts: a Swedish research, which focused on the potential for Swedish companies and testbeds to operate in the Netherlands and collaborate with Dutch cities, and a Dutch counterpart that focused mainly on the potential for Dutch companies and testbeds to operate in Sweden and collaborate with Swedish partners. The Swedish part has been executed by Cleantech Scandinavia, the number one network for cleantech innovation companies and investors, and the Dutch part by Locality, an SME focusing on research, innovation management and capacity building in the field of smart cities within Europe. In executing the research, several methods have been used, in particular desk research and review of literature, semi-structured interviews and a number of workshops.

This document

Chapter 2 sketches the field of smart sustainable cities in Sweden, the Netherlands and Europe. After that, we delve in Chapter 3 into what a testbed entails and compare it with similar concepts as for example Living Labs. Following, chapters 4 and 5 describe the Swedish and the Dutch testbed situations on both a systemic and an operational level. The next chapter 6 explores into detail the urban aspects and context relevant for this framework study. Based on all this information, Chapter 7 outlines the potential for bilateral collaboration in a LIT between the Netherlands and Sweden, and analyses opportunities and constraints. Subsequently, chapter 8 proposes a roadmap for this LIT. Lastly, chapter 9 presents the overall conclusions of this study and gives recommendations for the next steps.

2. Testing, demonstrating, implementing and scaling smart sustainable city solutions

With cities as key in the transition to a smarter and more sustainable and climate neutral society, the testing, demonstrating, implementing and scaling of new solutions need to be supported. This is already a strength in Europe, gaining increased focus through the new research and recovery initiatives coming. As order to put LIT in context, we here provide an extremely compact overview of important initiatives on EU level and in the Netherlands and Sweden within the smart sustainable city realm.

The smart sustainable city landscape

A smart sustainable city is a place where buildings, infrastructures and services are made more efficient by using low carbon, cleantech, digital and telecommunication technologies for the benefit of its inhabitants and businesses. A smart sustainable city deploys these technologies for better resource use and less emissions. It means smarter and decarbonised urban transport and energy networks, upgraded water supply and waste disposal facilities as well as more efficient and renewable ways to light, heat and cool buildings.

The following sections describe the smart sustainable city landscape in Europe, the Netherlands and Sweden.

Europe – short overview

Europe has played a very important role in the development, demonstration and replication of smart sustainable city solutions. Climate-neutral, sustainable and smart city policies are anchored in its core directives and agreements, in particular the climate and energy policy objectives for 2030 and 2050, the digitalisation agenda of Living.in.EU, the ambitions for low emission mobility and logistics as laid down in the Clean Mobility Package, the Strategic Energy Technology (SET) plan, the Urban Agenda, and EIT's Climate-KIC, KIC InnoEnergy and EIT Raw Materials. Close collaboration exists with related European and global programmes and networks working on climate-neutral, smart and sustainable cities, e.g. C40, ICLEI, Covenant of Mayors, 100 Resilient Cities, CIVITAS, Open and Agile Smart Cities, the Smart Cities Marketplace including the Smart City Information System, and JPI Urban Europe. A learning environment has been created, where knowledge, best practices, and lessons learnt are shared and jointly brought to the next level. Importantly, Horizon2020 featured the so-called smart city lighthouse projects, which successfully demonstrated an integrated approach to smart and low carbon transport, buildings and infrastructures in cities, with in-depth engagement of and co-creation with stakeholders.

Common ingredients of most plans are installation of smart meters, smart thermal and/or power grids, and renewable energy systems in combination with thermal insulation and deep retrofitting, smart lighting, mobility and logistics hubs combining electric vehicles and clean transport, electrification of fleets and private cars, autonomous vehicles, Intelligent Transport Systems (ITS) and establishment of urban data platforms with real-time data and cyber-physical systems. 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 with the help of visualisation tools and urban data. To ensure replication and scaling-up afterwards, demonstrations in 2 to 3 lighthouse cities are closely followed by 3-5 fellow cities that have the obligation to develop plans for replication of successful solutions.

Since 2015, nearly 20 projects have been funded encompassing around 50 cities with lighthouse projects and more than 80 fellow cities aiming to adopt and replicate the innovative solutions. While only a few projects have finished, the programme had in 2019 already achieved 53% energy savings, up to 88% CO2 reduction, more than 17500 smart meters installed and over 1 Mio m2 floor space refurbished, more than 5270 e-vehicles introduced, nearly 500 e-charging stations installed, and more than 260.000 citizens engaged in this transformation.

While many European cities have embraced the smart sustainable city concept, developed strategies and implementing projects, a widespread breakthrough is not yet taking place (EC Directorate-



Figure 1: Lighthouse (blue) and fellow (green) cities (2019). Source: SCC-01 Coordinators/Veronika Cerna

general for Internal Policies, 2014, McKinsey Global Institute, 2018). A couple of persistent barriers and obstacles results in many projects eventually not taking off, lengthy preparation and implementation phases, or underperformance after realisation. Summarised, 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 is in particular a problem in highly privatised European countries, where many urban actors have to align

interests and create a common operational picture while concessions are often granted to best-value-for money without sustainability criteria. As a consequence, the pace of adoption of new technologies and solutions is usually too slow to achieve EU and national goals on energy savings, renewable energy, clean mobility and reduced emission of GHGs for 2030 and particularly for 2050.

Also, the direct impact of implemented smart sustainable city projects is often 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.

The Mazzucato and Moedas reports (Mazzucato, 2018, European Commission, 2019) advocated the establishment of missions to increase the impact of European R&I. For that reason, the content of the Horizon Europe Programme will be co-created by the Mission Board on Climate-neutral and Smart Cities. In addition, this Mission Board has presented a plan for achieving 100 Climate-neutral Cities by 2030 by means of contracts with a budget of around 1 Billion Euros. It is expected that this plan will trigger large-scale investments in smart sustainable solutions in the built environment. This transition will also require intensive collaboration in each city between city administration, businesses, citizens and end users, and research.

The Netherlands - short overview

According to the Global Competitiveness Index van het World Economic Forum (2019), the Netherlands is the 17th economy in the world and one of the most competitive economies in Europe and the fourth most competitive economy in the world. What is more, the Netherlands is also the fourth innovative economy in the world according to the Global Innovative Index of among others Cornell University (2019). Besides, the Netherlands is the sixth-largest exporter of goods on the world (2018, CIA World Factbook). Its favourable location within Europe, its big seaports and airports, and a strong digital and physical infrastructure make the Netherlands an excellent springboard to other countries (Topsectoren, 2021).

Being a highly urbanised and growing yet small country, with half of the area below sea level, has resulted in a Dutch way of working that can be characterized as (Topsectoren, 2021):

- Open: freedom, transparency and clarity are valued
- Resourceful: the Dutch seek innovative and pragmatic solutions
- Inclusive: The Dutch seek win-win-win through collaboration with everybody who can add something, regardless of sectorial or country boundaries.

These features are rooted in the Dutch history and the continuous threat of flooding, which necessitated an in-depth collaboration between different stakeholders to achieve consensus, leading to such mutual collaboration being deeply anchored in the Dutch culture (“polderen”).

The Dutch Climate-neutral and Smart City testbed and living lab landscape is very active and dynamic, and at the same time highly varied and also rather fragmented. However, despite matching the characteristics of testbeds for this study as set out in Chapter 3, the term testbed is not regularly used in the Netherlands, but real-world testbeds are generally referred to as living labs, pilots,

“proeftuin” or field labs. Only the field labs are an official policy instrument for implementation of the Dutch R&I agenda. Here we summarise the main categories of relevant testbeds, deep demonstrators and living labs in the field of climate-neutral, smart and sustainable cities:

- *Multi-stakeholder long-term Living Labs:* Amsterdam Metropolitan Solutions Institute (circularity, mobility, energy, robotics), Brainport Smart District, Strijp-S in Eindhoven, City of Rotterdam (many), City of The Hague (Living Lab Scheveningen), Healthy Urban Living in Utrecht, Metropolitan Region The Hague-Rotterdam, Buiksloterham Circular Economy in Amsterdam, Airport Eelde in Groningen, Sensor City in Assen, Stratumseind Smart City Data in Eindhoven, Climate Adaptation in Province of Overijssel, CleanTech Regio Apeldoorn-Deventer-Zutphen, etc. (see Maas et al, 2019).
- *Topsector-related Living Labs:* Topsector policies concern the strengthening of key economic areas in the Netherlands. Interesting for smart sustainable cities are for example the eight Living Labs in the field of sustainable mobility and logistics which recently have been approved.
- *Campus-based Living Labs* – among others Green Village Delft, RDM Campus and Mobility Campus in Rotterdam, Universities Leiden-Delft-Rotterdam with Province of South-Holland, Yes Delft, Brightlands Chemelot Campus and many more.
- *Six Horizon 2020 Smart City Lighthouse projects:* funded by EU R&I budget the Netherlands has six so-called lighthouse projects covering clean mobility, energy efficiency, smart IT and infrastructures at district level in Eindhoven (Triangulum), Amsterdam (Atelier), Rotterdam (Ruggedised), Utrecht (IRIS), Groningen (MakingCity) and Alkmaar (POCITYF). Rotterdam and Utrecht have in these lighthouse projects established a 5-year collaboration with Umeå respectively Gothenburg.
- *Testbeds:* The Hague Security Delta and Intelligent Transport Systems in The Hague
- *Field Labs and “proeftuinen”:* more than 120 field labs are part of the Dutch Digitalisation Strategy. A few dozen of them are related to smart sustainable cities through a focus on low carbon energy, clean mobility and automotive, water management, circularity, valorisation of big data, etc., e.g. electrification and hydrogen in transport. The partners in this framework study are engaged in many of these field labs. For instance, Rotterdam hosts and participates in among others alternative fuel transport with electric and hydrogen vehicles, the mobility campus with autonomous vehicles, large-scale innovative construction, Feijenoord City, Dutch wind wheel (building generating its own wind energy), RDM campus, Merwe4havens, Kleinpolderplein, Plant/Part One.
- *Aardgasvrije wijken:* special type of field labs, 27+ neighbourhoods phasing out natural gas and becoming low carbon, as part of the policy of the Ministry of Interior Affairs and Kingdom Relations.
- *City and Region Deals:* are related to the implementation of the Dutch and European Urban Agenda since 2016 through public-private partnerships with per City Deal different cities, industry, research and NGOs. Ongoing City Deals among others in the field of smart cities, circular and conceptual construction, e-car sharing in new urban developments, low carbon and inclusive neighbourhoods, and urban mobility (in preparation). City Deals want to

promote collaboration within the quadruple helix for tackling wicked problems, but have no formal connection with the Dutch R&I agenda. Beside City Deals, Region deals exist: collaboration between the national government and the region to reinforce regional strengths with respect to themes as health care, education, safety and entrepreneurship (Rijksoverheid, 2021).

- *Incubators/Accelerators/Science Parks/Centres for Entrepreneurship*: organise an incubation process to accelerate growth of promising starters to successful businesses by offering workspace, services, coaching, access to networks and capital etc. Most universities have one, can be the same organization as a campus-based Living Lab.
- *Other relevant key players*: Start-up delta, CleanTech Delta, TechLeap, GIST, WorldStartup, HollandStart-up, Start-up in residence, Climate-KIC

In 2016 and 2017, the Dutch Smart City Strategy (NL Smart City Strategy – The future of living, 2017) was developed upon request of the Dutch Prime Minister Mark Rutte. It evolved in an extensive co-creation process with policy makers at different government levels, research and businesses. Its main recommendations are to:

- Create a backbone for a safe and standardised digital infrastructure
- More public-private collaboration based on novel business models, more upscaling of good practices and innovations, more room for experimentation
- Develop new inclusive and integrated governance models, enabled by cross-sectoral collaboration between ministries, one-stop shops and overviews
- Offer Smart City-adjusted education and training to increase employability
- Ensure more regional collaboration and fostering of replication through standardisation and the establishment of an innovation fund.

Unfortunately, the impact of this strategy seems to have been limited so far due to lack of concretisation in actions, for example a roadmap was missing (Teuben et al, 2020). The Dutch Association of Municipalities Networks hosts a couple of relevant Dutch networks linked to this strategy, such as the Smart City workgroup led by Rob Schmidt, and the G40 (40 largest cities). Last year, all Smart City projects in the 40 largest cities have been analysed, and recommendations have been given by Teuben et al (2020) about bottlenecks and accelerators for the uptake of smart city technologies by cities. It observes that:

- Municipal competences, attitude and role division for proper collaboration in local ecosystems do not suffice, while inter-municipal learning is rather limited.
- Broad political support needs to be organised to avoid risk-aversion to application of new technologies
- Current legal and regulatory frameworks do not always offer sufficient leeway for digital innovation, so analysis of development and validation of smart city initiatives in living labs must clarify where regulation and ethical frameworks might need adjustment
- Capacity building and expertise pools can help to overcome gaps in knowledge and competences in the field of finance, data-driven working, privacy and cybersecurity

The urgency to work on these points, has been recently confirmed by a report of the Council for the Environment and Infrastructure (2021). The report indicates insufficient attention of local, regional and national policy makers for the link between digitization and sustainability and for the impact of digital platforms on the organization of the living environment, and points also to the lack of

competences and knowledge within governments. It advocates a closer consideration of sustainability challenges in the Dutch digitalization policies.

Partly as a consequence of the points raised above, scaling of businesses offering smart sustainable solutions is not easy. Although there are no separate figures for these businesses, the ScaleUp Dashboard of the Erasmus University Rotterdam provides some interesting insights. In 2019, the Netherlands counted around 3,000 scaleups, amounting to 232.000 FTE jobs. Most of them are located near the largest cities (Amsterdam 350; +9%), Rotterdam (120; -13%) and The Hague (70; -18%). Nevertheless, it appears the growth in the number of scaleups already stopped before the outbreak of the Corona crisis, probably as a result of more than 90% of them being more than five years old and encountering the so-called second “Valley of Death” while a decreased survival rate due to the Corona crisis in the near future can be expected based on earlier research. Energy transition is one of the two sectors with the most traction (EUR 2020a, 2020b).

As we speak, April/May 2021, the attention for the topic Smart and Inclusive Cities at a governmental and political level is at the point of potentially reviving attention. Ahead of the elections for the House of Representatives, the Network of the 40 mid-sized Cities (G40) launched a proposal on how to move forward with the topic in the Netherlands. Focussing on governance, finance and Smart City Themes such as governance, economy, mobility, environment, citizenship and living. It’s to be seen how this approach will be taken up and result in the organisation of governance of the topic at national level.

Sweden - short overview

Sweden is among the leaders on smart sustainable city development, and frequently among the top 3 most innovative countries in the world (Cornell University; INSEAD; World Intellectual Property Organization, 2020). With lead lighthouse cities (Stockholm, Gothenburg, Umeå) collaborating on international level, and many more having worked in this field since the 1990’s, there is an abundance of projects and experiences. In this short overview of the current development two initiatives are of special interest.

The first is Vinnova’s project on innovation platforms for smart sustainable cities. It started 2013 and is now in the last phase, at the moment with 6 cities participating (Lund, Borås, Göteborg, Stockholm, Umeå, Kiruna) but only the first three being part from the beginning. The different cities have chosen different strategic roadmaps for their platforms, something that creates eat learning opportunities.

All along research has been linked to the innovation platforms, and reports have been published (in Swedish). They give valuable input to the challenges and opportunities the platforms have encountered. Furthermore, a common learning and experience sharing program has been set up, coordinated by Research Institutes of Sweden (<https://www.ri.se/sv/vad-vi-gor/projekt/nationell-samverkan-innovationsplattformar-for-hallbara-attraktiva-stader>). Last year also a project about innovation leadership in the same field was initiated and financed by Vinnova. Together all this builds a structural capital of knowledge, experiences and practice on how to drive innovation within the smart sustainable city realm.

The second interesting initiative is the 12-year strategic innovation program Viable Cities (<https://en.viablecities.se/om-viable-cities>), financed by the Swedish Energy Agency in close collaboration with Vinnova and Formas. Viable Cities is a strategic innovation programme focusing on

climate-neutral and sustainable cities. The programme's mission is to accelerate the transition to climate-neutral cities by 2030 with a good life for everyone within the planetary boundaries. Viable Cities is a catalyst for new forms of cooperation between cities, industry, academia, research institutes and civil society. At the moment the group consists of nine cities, but the intention is to expand that number to twenty.

Also, this initiative has a common learning process in order to build structural capital, with regular activities called Transition labs.

In both these strategic, large-scale and long-term initiatives, testing, demonstrating, implementing and scaling have been in focus, even though cities have taken different approaches to it. An important feature is the following research and the learning processes that build structural capital both on systemic and operational level.

The innovation platforms are now in their last year of financing of operational work. Viable Cities is not yet halfway and has during 2021 started also emphasising investments and financing issues, as well as linking this to Climate Contracts as a tool to drive the transition. In that way it converges with the EU 100 Climate Neutral cities initiative.

However, these two important initiatives, have so far had limited focus on how to engage with start-ups and SMEs to implement and scale with innovative solutions for smart sustainable cities. Activities like innovation procurement and match-making, have of course been carried out, but learning and structural capital is more focused on municipality-internal organisational issues and processes than on how to collaborate with companies in new ways, and on uptake of new solutions from this group of stakeholders. International exchange and collaboration have not been a prominent feature so far.

Here is a clear opportunity for Sweden to take a next step through an international collaboration of urban testbeds to contribute both with best practices on an operational level, and shared learnings for the systemic level, as well as background knowledge on the affiliations, dependencies and interactions between the two levels.

3. Testbeds

If we want to use testbeds as a tool for creating impact in testing, demonstration, implement and scale solutions for smart sustainable cities, we need to understand how testbeds are defined and used in different contexts, as well as how they interact with the surrounding city systems. In this section we look into different aspects of testbeds that relate to urban solutions.

There are many definitions of what constitutes a test and demonstration infrastructure, or "test bed", that supports new solutions. As quicker and more widespread uptake and implementation of new solutions is to some extent depending on market context, we need to look both at TRL and CRI. The companies should as an indication be on Technology Readiness Level (TRL) 6-9, and on Commercial Readiness Index (CRI) 2-5. See appendix 2 for a short explanation of TRL and CRI.

While many innovative solutions can be tested immediately in real-world situations, this is more challenging when testing in a complex system where the challenges of complexity arise in any interactions among institutional, technological, and human systems. This is important to have in mind when analysing how testbeds can support scaling and spreading of new solutions.

In order to better understand what kinds of testbeds are best suited for this purpose follows a short overview of a couple of different views on testbed characterisation. The focus is on testbeds that are close to real environment and close to market conditions, as the solutions are supposed to have potential for immediate scaling and spreading after test or demonstration, and so should be fit for close to real world and close to market conditions.

Different "definitions" of testbeds

Vinnova

Vinnova's definition is that a test bed is *"a physical or virtual environment where companies, academia and other organizations can collaborate in the development, testing and introduction of new products, services, processes or organizational solutions in selected areas.*

In a guide for testbed developers (Vinnova and Test Site Sweden, 2017) Vinnova presents three main categories of testbeds

- 1. Test bed as a "laboratory" where specific technical properties and performance can be tested in isolated, artificial and controllable environments. A distinctive feature is that the tests are usually limited to sub-functions and components rather than to systems and products. Specialized laboratory equipment at research institutes, universities and college or in companies with their own test labs / rigs are typical examples in this category.*
- 2. Test bed as "designed / simulated user environment" for testing and verification at system, process and product level. Separate areas and specially prepared test tracks in northern Sweden for winter tests of vehicles are well-known examples in this category. Common to these is that the test environment offers / simulates as close to use and reality but still separate and controllable conditions as possible.*

3. *Test bed as a “real user environment” where technology is developed in collaboration between users and suppliers and tested in the environment where the technology is intended to be used.*

In a mapping and needs inventory of test & demonstration infrastructure by Vinnova (Olof Linde and Jan Persson, 2015) it was also required that the test bed:

- *is or can be made available and open to users outside the test bed's own operating organization*
- *has a duration that extends beyond a single project*
- *has an area of use that is not limited to a single specific product, service, process or user*
- *is not a locked display object / demonstrator that cannot be adapted for testing new products, services and processes.*

Nordic Council of Ministers

The Nordic Council of Ministers define test and demonstration facilities as *“physical facilities associated with innovation activities or initiatives encouraging innovation (Jakobsen, o.a., 2108). As the physical facilities are linked to organisations supporting innovation and innovative activities, the definition must be related not only to the physical facilities but also to the “innovation infrastructure”. Moreover, the “innovation infrastructure” embeds facilities at a higher “technology readiness level” than the “research infrastructure”.*”

JPI Urban Europe

JPI Urban Europe (JPI Urban Europe, 2021) in a call text define living labs in the following way. JPI *“uses the notion Urban Living Labs to describe methods, approaches and projects that involve high level of stakeholder participation, co-creation, co-production, learning-loops and experimental approaches to improve urban life. It is hence an umbrella notion for methodological tools when the challenge at hand is understood to benefit from or even require experimental approaches and substantial co-creation between stakeholders and urban actors. Participants in ULLs shoulder the role of co-creators to explore, examine, experiment, test and evaluate ideas, scenarios, processes, systems, concepts and creative solutions in complex everyday life settings.”*

NESTA

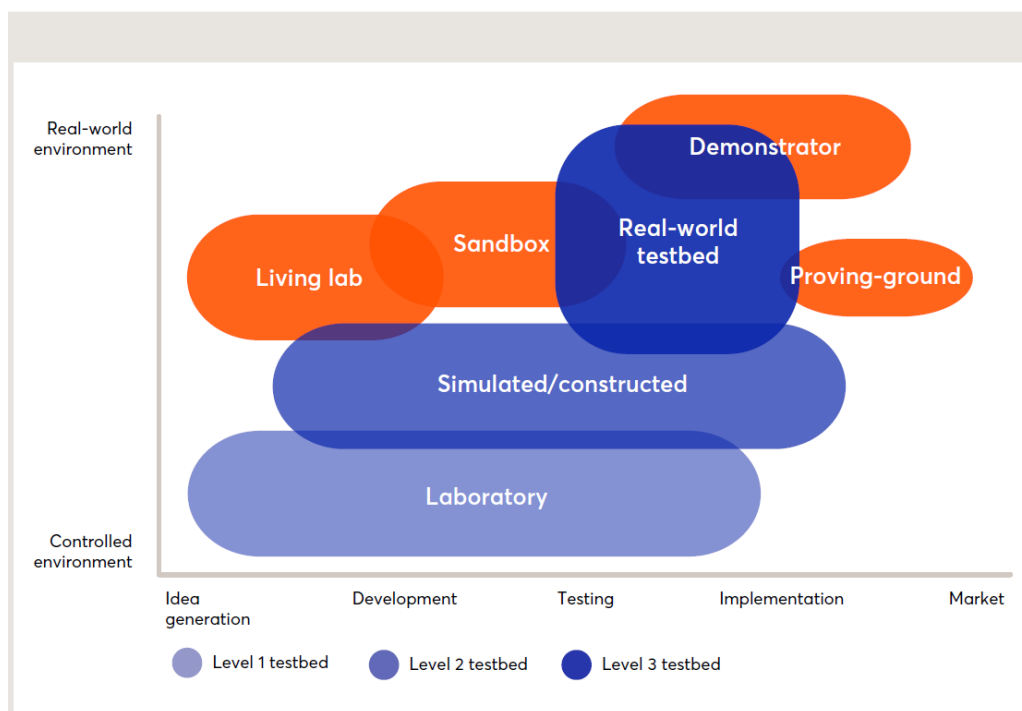
NESTA, the innovation foundation in Britain, in a recent report (Siri Arntzen; Zach Wilcox; Neil Lee; Catherine hadfield; Jen Rae, 2019) gives the following definition of real-world testbeds *“Controlled or bounded environments for testing innovation in real-world or close to real-world conditions in the manner (or close to the manner) in which they will be used or operated.”*

- *They reduce the barriers to testing by helping manage risk, changing regulation, allowing access to user groups, or providing a specific physical environment.*
- *They are particularly suited for technologies which operate in complex systems or in challenging ethical contexts. The use of a testbed allows the management of risk, experimentation, evaluation, and failure.*

- Because the focus is on testing in real-world environments, they are suitable for higher technological readiness levels, where technologies have already been tested in simulated environments.
- Because they allow technologies to be tested in a manner in which they would not otherwise be tested, they encourage investment in innovation.

Nesta also provide this model of different types of testbeds mapped on real-world and market axis, while at the same time pointing out that “the concept of real-world testbeds overlaps with the concepts of demonstrators, sandboxes and proving grounds, but are relatively analytically distinct from living labs and laboratories”.

Figure 3: Real-world testbeds placed among other test and demonstration terminologies



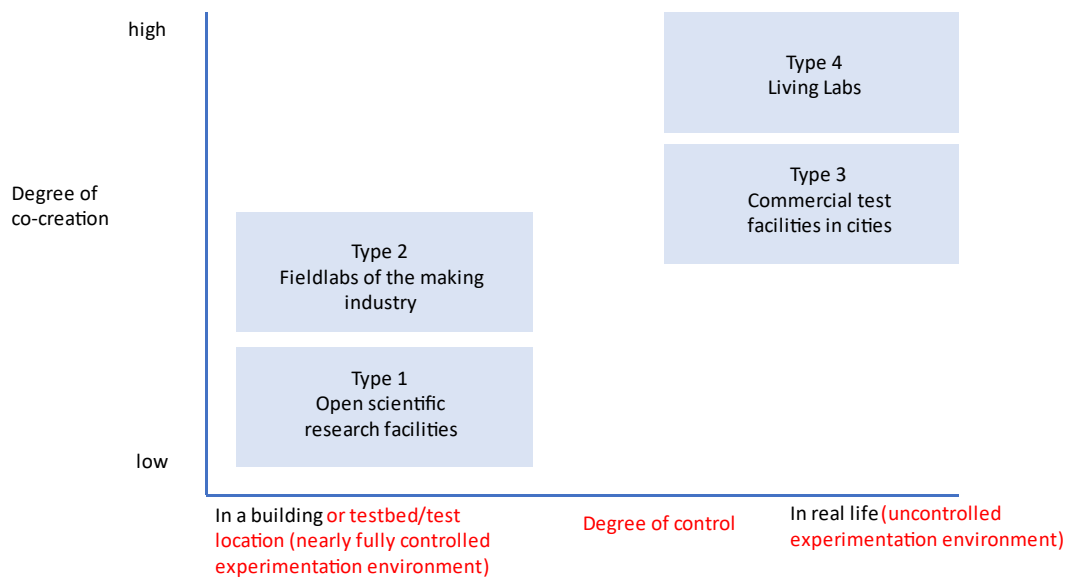
In the report UK and the Nordics are mentioned as frontrunners in working with real-world testbeds, with Sweden having real-world testbeds representing around 40 % of all the available tools for enabling testing of innovation.

For a complete list of definitions on different testing environments in the NESTA report see appendix 2.

Rathenau Institute

The Rathenau Institute (Rathenau Institute, 2017), categorising four basic different types of test environments give this model based on the Netherlands, plotted on the intensity of collaboration/co-creation and the closeness to real world environment.

Figure x: Four basic types of collaboration initiatives



(red text is additions by the authors of this report)

In addition to thinking about different types of testbeds, there are boundary issues to other ways of testing, demonstrating and implementing new solutions. The most important of these is pilot projects. The boundaries between real-world testbeds/living labs and pilot projects are not clear, as pilot projects often have a similar purpose, but mostly are conducted as individual projects, with more limited support functions, less of continuity in coordination and learning, less of structured processes etc. Also, a pilot project might be done within a testbed.

GUST, Governance or Urban Sustainability Transitions

Finally, it is worth mentioning the GUST project (<http://www.urbanlivinglabs.net/>), as it has case studies from both Sweden and the Netherlands. In a handbook (Kes McCormick; Christian Hartmann, 2017), they provide the following characterisation of urban living labs.

CHARACTERISTICS OF URBAN LIVING LABS

Five key characteristics of urban living labs can be identified.

- 1. Geographical embeddedness:** Urban living labs are placed or embedded in a geographical area – they are predominately not virtual platforms.
- 2. Experimentation and learning:** Urban living labs test new technologies, solutions and policies in real world conditions in highly visible ways.
- 3. Participation and user involvement:** Co-design and engagement with stakeholders often appears in all stages of the urban living labs approach.
- 4. Leadership and ownership:** It appears that having a clear leader or owner is crucial for urban living labs, although a delicate balance exists between steering and controlling.
- 5. Evaluation of actions and impact:** Evaluation underpins the ability of urban living labs to facilitate formalised learning.

System demonstrators

System demonstrators (testbeds) are tools for testing and demonstrating changes on system level. They are intended to engage broad groups of stakeholders that together can innovate on multiple interacting systems in parallel. This might be technical, organisational, financial, legal, cultural, policy, social, political or other systems, that need to change in order to make it possible for new innovations to be implemented. As the interdependencies and effects are harder to analyse and predict the more complex a system is, system demonstrators are more challenging, harder to set boundaries for, and requires broader competencies as well as portfolios of innovative solutions in coordination between systems to be successful. Still, transforming cities is a key area where obviously a system demonstrator perspective is necessary.

As this is an emerging field, inspiration might be drawn from Vinnova's Innovation platforms for sustainable attractive cities or from Climate KIC's deep demonstrations (EIT Climate KIC, 2018).

“By systems innovation we mean integrated and coordinated interventions in economic, political and social systems and along whole value chains through a portfolio of deliberate and connected innovation experiment.”

Climate KIC

“A portfolio approach means supporting many different but connected initiatives, less on their individual potential, and more as a spread of options for exploring alternatives and connections and test our way forward.”

Climate KIC

Cities and testbeds

Many cities are working with test and demonstration setups within the city boundaries in forms that in practice are testbeds, but not formally seen as such. Here, the boundaries with pilot projects are especially blurry. These kind of test and demonstration activities should also be looked into, to identify environments that in practice have the capacity and the characteristics that are relevant. A key conclusion from Cleantech Scandinavia's experience in working with innovation companies and city uptake of new solutions is that internal organisational factors in the local government administration are important (Edelstam, City Cleantech Uptake Report , 2016). The system perspective is needed and should be the responsibility for a city innovation team, rather than the companies providing solutions or stakeholders providing the testing grounds (see also Chapter 6). Vinnova has also published (in Swedish only) a report (Lisa Andersson;Heiti Ernits; Anna-Karin Stoltz Ehn, 2018) that dive into different aspects on how to integrate testbeds/living labs with broader city processes and what characterises such test and innovation environments.

Individual testbed characteristics

The individual testbed characteristics is also a key issue. Different testbeds have different focus and services. Depending on this they will have different capacity, ability and interest to help international companies. In this report we have, based on interviews and other material, tried to set up a first categorisation of aspects that are important for judging if a testbed is ready for international exchange and collaboration. This include how the testbed is organised, what facilities and services are provided, what financial means to support test and demonstration setups that are available, if it is open for international exchange and other aspects.

This preliminary categorisation is presented in chapter 7.

The surrounding innovation ecosystem

The innovation ecosystem around the testbed is also very important, as this is the context where the testbeds and the companies in the testbed shall succeed. So, testbeds need to be understood in that context. A report produced in the partnership of the Smart Cities Marketplace (former EIP-SCC) (Edelstam, 2016) describes local innovation for smart cities in the following way.

“Defining or setting boundaries for a local innovation ecosystem can be done at different hierarchic levels, for different thematic areas, in more or less inclusive ways. When working with smart cities, a local innovation ecosystem needs a broad as well as flexible “definition” that includes at least the following:

- *The diversity of stakeholders including public sector, business sector, universities, citizens and civil society organizations (penta helix), from organizations to individuals*
- *The existing multitude of networks*
- *The competencies and capabilities among those stakeholders and networks*
- *Existing institutions, policies and practices, as well as value chain of different kinds in commercial, political, research, administrative and civil sector “markets”*
- *Physical assets such as incubators, labs, test and demonstration sites*
- *Existing technologies, products, services and systems*
- *Relations within, as well as outside, the local context with stakeholders, competencies and markets*
- *Ideas and perceptions that constitute the mindset among stakeholders about what to do and how to do it*
- *The multi-faceted and cross-sectorial challenges that the innovation ecosystem is already working with”*

This description also adds another layer to testbeds, which is the surrounding system that the testbeds interact with, and the stakeholders that are part of that system. This is similar to the system demonstrator perspective, but focuses on the innovation layer of the total city system, to make it more actionable. Here, as in the case with pilot projects, boundaries are porous.

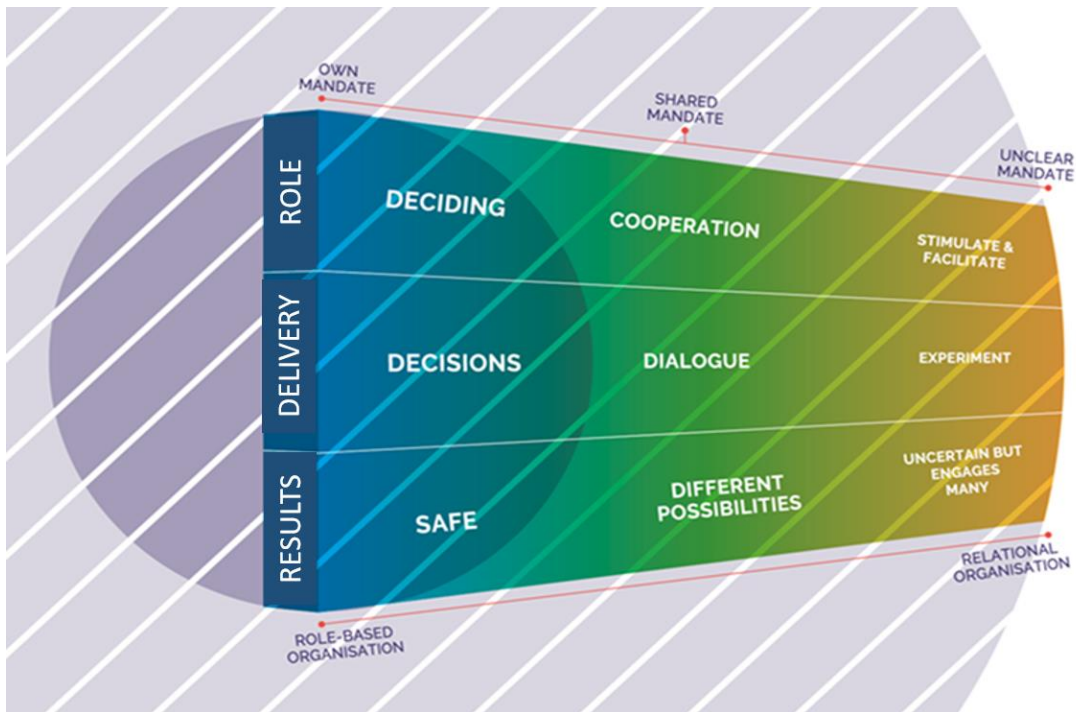
Stakeholders

Testbeds can be owned and run by different stakeholders. In the context of smart sustainable cities the ownership of the premises, financing of the intervention, and operational responsibility are often shared between different stakeholders depending on the individual solution that is tested or demonstrated, and yet other stakeholders for scaling and broader implementation. Sometimes the discussion about smart sustainable city testbeds tends to forget that a large part of the test, demonstration and financing is done by the private sector, and focus too much on the local government's part of this system of stakeholders.

For this to work well and benefit both the innovative solution, the company (or other organisation) providing it, the users of the solution and the transformation of the city, collaboration between the stakeholders is key. The governance of both the local innovation ecosystem and the test-and demonstration need to work efficiently. For example, a clear goal for all participants, clear milestones, a pre-approved budget, and a not-too-distant time-limit are essential for bringing together diverse stakeholders. These factors become ever more important the higher the number of participants in a project is. For a deeper discussion about this, and how to work with governance and collaboration issues, also see the EIP SCC report mentioned earlier (Edelstam, Report on Local Innovation Ecosystems for Smart Cities, 2016).

Understanding roles and mandates in the “playing field” for innovation, testing, demonstration, implementation and scaling is necessary. A city should also support collaboration, innovations and solutions that deliver results outside and independently from the government domain. For many challenges or testing opportunities the municipal mandate for action is shared with others, or non-existent.

The three-colour playing field model, developed by *Future by Lund*, the innovation team of the City of Lund, Sweden, illustrates this. It can be used to identify where different aspects of the challenge need to be negotiated and solutions can be co-created. City of Lund uses it to analyse different aspects on smart sustainable city development, what stakeholders need to be involved and what role they might play. If there is need for something to happen that is outside the local government mandate, they try through dialogue processes to initiate groups of stakeholders that can drive initiatives in response to that need. Sometimes this is facilitated by the administration by initial funding, or by opening resources within the administration to the external stakeholders. To successfully work with governance of stakeholders and the local innovation ecosystem often requires advanced practitioner experience.



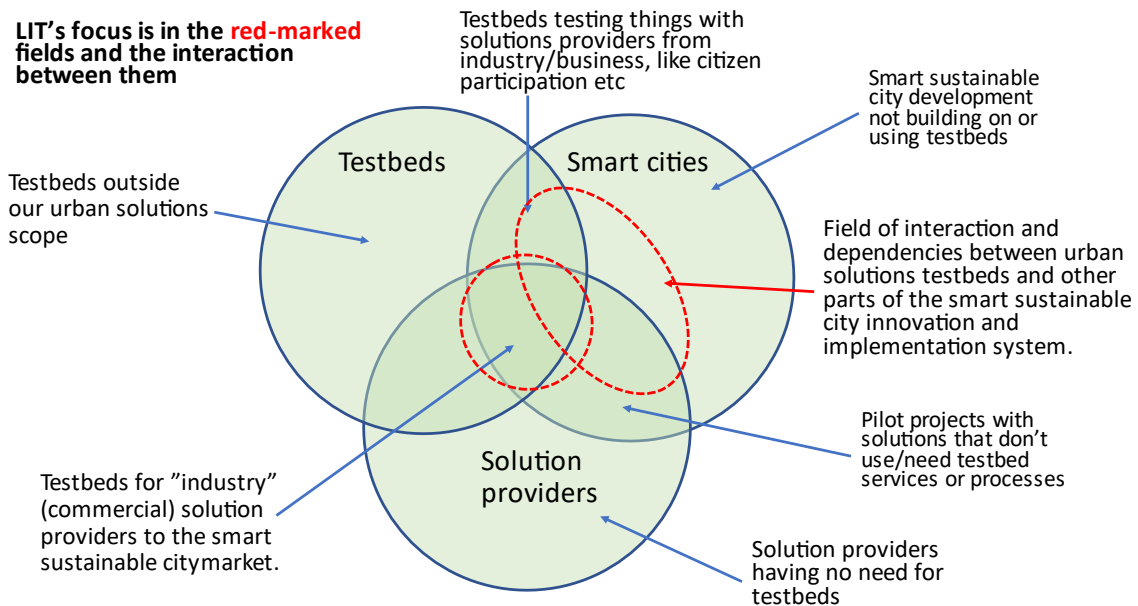
Future by Lund's visualisation of the "playing field" for city innovation. In the blue field the local government is in charge. In the green and yellow part of the playing field you need to collaborate and balance different governance models in order to engage stakeholder in work with new innovative solutions. (It is also possible to see the playing field in the same way for a private company or other organisation – you have control in your own (blue) domain, in other parts you need to collaborate.)

Combining the understanding of the "playing field" and the different tools and testing environments available would be a way to both create quicker and more efficient impact, and to inform policy development.

League of International Testbeds' focus

The League of International Testbeds' (LIT) focus is on supporting growth and scaling of innovative companies through collaboration and exchange between testbeds internationally. For testbeds focusing on urban solutions a system approach perspective is both necessary and challenging. The necessity comes from the insight that a city is a web of different systems, and new solutions interact with that web to a smaller or larger extent, and those effects and dependencies need to be understood. The challenge is that boundaries for testing and demonstration are hard to set, and the governance issues including portfolio management is a key factor. So, understanding the role of the more clearly defined urban testbeds as described in the first part of this section, needs to be complemented with an understanding of how these interact with the surrounding city systems, and where interventions are needed in that whole system in order to support implementation, scaling and spreading of solutions. This perspective needs to be part of the LIT project.

So, trying to illustrate the focus of LIT in a simplified way can look like this.



Even though the above gives in some aspect clear indication of what kind of "testbeds" to look for, and how to put them in a city-wide context, there are more factors to consider.

With the League of International Testbeds, we will focus on testbeds/living labs, not pilot projects or other similar interventions, but be aware that the distinction is not always clear. Looking at the different ways to categorise testbeds, the following aspects seem to be the most important for the purpose of LIT, and so should be in focus when looking at what testbeds to engage in the work onwards.

- Real, or close to real, environment. This is the first factor that really tests the solutions potential for being implemented and scale.
- Close to market. This is the second factor for success, as commercial viability is necessary.
- Collaboration complexity. As many solutions for smart sustainable cities need to work within systems of the overall system, there is often (but not always, certain solutions can be implemented without much interaction with other technology or stakeholders) a strong collaboration and complementarity factor in succeeding, and this should be part of a testbed environment (e.g., cross-domain, multi-disciplinarity and complementary to other technologies)
- Potential for positive impact

It should be noted that a company already doing business on an individual national market, might need to adapt products or services to another market, and so can be seen as having different maturity on technical solutions or commercial maturity depending on context.

As LIT is intended to help companies to test, demonstrate and scale also international, the aspects from the Vinnova study (Olof Linde and Jan Persson, 2015) also apply to the choice of suitable testbeds to engage:

- is or can be made available and open to users outside the test bed's own operating organization
- has a duration that extends beyond a single project
- has an area of use that is not limited to a single specific product, service, process or user
- is not a locked display object / demonstrator that cannot be adapted for testing new products, services and processes.

So, in order to speed up the spreading and scaling of new solutions for smart sustainable cities LIT should focus on real world testbeds / living and field labs in line with the above characteristics and definitions. Moreover, the project should also take both internal factors and the local innovation ecosystem into account, as well as the system demonstrator perspective.

It should be as close to market conditions as is possible in the individual solution case, but different factors for testing and demonstrating might be more favourable than “absolute normal market basis”. This can include aspects like information sharing, governance support for collaboration, special permits/exemptions from normal legal or policy framework, common learning, availability of test space, broader information/sourcing of solution providers etc.

Identifying and analysing suitable testbeds to engage for coming phases of the project will be a key factor for success, as well as understanding the complex city system context and dependencies – where, how, at what time and with which stakeholders to make interventions.

When it comes to consider which city test and demonstration environments that would be interesting for LIT to consider, the NESTA recent report (Siri Arntzen; Zach Wilcox; Neil Lee; Catherine hadfield; Jen Rae, 2019) criteria for including cases in the report would be a good point of reference.

Box 1. Criteria for inclusion of testbeds in the bank of examples for this study

- | | |
|--|--|
| • Does it test a new technology or an existing technology in a new or innovative context? | • Is it in a real-world (or close to real-world) environment? |
| • Does it lower barriers to testing through one or more of the following: <ul style="list-style-type: none">• Risk management.• Regulation.• Access to user-groups.• Access to physical/technical infrastructure? | • Does it allow failure, learning and evaluation in a testing phase? |
| | • Has it got some form of public sector involvement? |

The report includes detailed case studies from both Netherlands and Sweden.

The characterisation checklist for testbeds' internationalisation readiness level presented in chapter 7 will also be a valuable tool to find the best candidates for participation.

4. The Swedish testbed situation

Based on interviews, reports and own extensive experience of working with innovation, implementation and scaling of smart sustainable city solutions, we think it is useful to look at urban solutions testbeds on two levels. In a project as limited in time and resources as this, we acknowledge a need to do shortcuts in descriptions and level of detail, and that the analysis in some aspects could be more extensive. We still see the results as useful for preparing next steps of LIT, for programme, policy and financing considerations on national, regional and local level, as well as for development initiatives in individual testbeds.

The first we call system level, where national and to some extent regional programs for stimulating and supporting urban testbeds, strategic policy development and politics in the field is handled. This is where experiences and insight from LIT can be useful for new initiatives.

The second we call the operational level, where day-to-day work in the individual testbeds (or city test and demonstration environments) is done by testbed staff or by companies or partner organisations in the testbed. This is where LIT will connect if starting a next step establishing a prototype for operational testbed exchange and collaboration.

The basis for discussing the Swedish testbed situation in relation to LIT

There are some good web-based overviews of existing testbeds in Sweden that this report builds on. This covers mainly testbeds that are dominantly owned or operated by public or semi-public sector stakeholders. Some prominent websites for getting and overview are the following (Vinnova, u.d.), (Smart Built Environment; IQ Samhällsbyggnad, u.d.), (Research Institute of Sweden, u.d.), (Invest in Gothenburg, u.d.).

We also build on a couple of reports focused on testbeds in Sweden (Olof Linde; Jan Persson, 2015), (Filip Kjellgren; Benjamin Ståhl, 2019) and the Nordic countries (Leif Henrik Jakobsen; Benita Kidmose Rytz; Stig Yding Sørensen; Göran Hallin; Pär Lindquist; Janne Antikainen; Valter Laasonen; Anandasivakumar Ekambaram, 2018).

Further we build on interviews with key individuals with insight in the Swedish testbed system, and/or the operational day-to-day work in testbeds, see appendix 6.

Finally, we build on a ppt-presentation of existing testbed projects on societal challenges, financed 2018-2020, provided by Vinnova (Vinnova, 2020).

In addition to this Cleantech Scandinavia's staff engaged in LIT have together 40+ years of experience in smart sustainable city development and in urban innovation and public-private-collaboration in this field, working with national, regional and local government, large industrials, start-ups and investors, in Sweden and internationally.

The Swedish testbed system level

The most prominent stakeholder when it comes to operating testbeds is Research Institute of Sweden. The most prominent national agency involved in testbed development and financing projects in testbeds or in urban test and demonstration settings is Vinnova.

As mentioned before the websites and reports mainly cover testbeds operated by public or semi-public stakeholders. Industrial testbeds that are run “inhouse” and university testbeds in the form of laboratories are not covered in the same way by existing websites or reports. The same goes for city test and demonstration environments that have clear testbed characteristics, but are not formally classified as such.

This lack of overview for important parts of the total system is a significant challenge for international exchange. Much of the test and demonstration of urban solutions, as well as the following implementation and scaling, will occur in settings that are privately owned by companies in housing and construction, energy, water, mobility, ICT sector or others, or in cities’ testbed-like environments. To successfully create test, demonstrate, implement and scale innovative urban solutions the whole web of interactions between stakeholders need to be working, but also the link to financing, and the openness for international solution providers to enter the system.

Through interviews and reports the following has come up that creates a simplified SWOT of the testbed system level in Sweden, looking at it mainly through an “internationalisation lens”. For some of the SWOT headings we think the analysis benefits from including many bullet points, so results is not presented in a traditional “four-field” template.

Strengths

- Many testbeds, covering broad fields linked to smart sustainable city issues
- High number of testbed-like city projects (most of them lacking continuous and well working testbed service support functions)
- Good overviews of existing testbeds linked to research institutes and public sector
- Some local testbeds already started internationalisation
- Increasing system understanding and focus on system level issues (though complexity increases)
- Strong on public sector test and innovation
- Vinnova focuses on testbeds in real environment, and is also developing understanding of system demonstrators, which is important to understand the urban context for testing, demonstration, implementing and scaling.
- Sweden seen as ahead in sustainability, attractive to enter the market
- Test and demonstration prioritised in last governmental proposition on research
- City challenges match-making with solution providers has become a new normal (but geographical reach for sourcing solutions often limited)
- Development of structural capital in city test and demonstration environments starting in early phases (Viable Cities’ work with climate neutral cities, Vinnova’s work with Innovation leadership for smart sustainable cities).
- Signs of stronger “urban system testbeds” evolving (Gothenburg and Lund as examples)
- Interest to learn from best practice

Weaknesses

- Fragmentation is challenging, coordination organisation and responsibility for the testbed system unclear

- Need for better analysis of what works and not when it comes to programs, work methods, financing models, stakeholder constellations, individual testbeds, governance models etc.
- Weak focus on going operational on internationalisation and learn from that practice
- Lack of coordinated efforts for internationalisation of testbeds
- Very limited financing support to give flexible budget resources in testbeds for trying new solutions/initiatives
- Need for increased interaction within Vinnova between testbed work with societal challenges on one hand, industry and innovative business ecosystems on the other
- Vinnova's work with testbeds programs linked to cities main focus is on public sector/societal challenges, supporting recruiting testers/customers rather than internationalisation as two-way process. Testbed success is in focus, business sector success seen as secondary effect.
- Learning processes on national level could be more focused on operational results
- Sometimes unclear lead roles and boundaries on testbed system development – RISE mainly on industrial testbeds, Vinnova mainly on public sector testbeds
- No structured overview of city “testbeds” or industry testbeds with urban applications matching overview of traditional testbeds
- City real world testbeds don't have clear/strong “offers/resources” for testers
- Very few testbeds have a clear offer to international customers
- Testbeds operated by institutes often want research on test, less like real world testbeds where this “burden” is not put on companies
- Interest from central government unclear (change of minister) even though the interesting initiative “Testbed Sweden” exists.
- Full commercial services dominate as business model (rest of Nordics have more subsidies for customers)
- Too low use of testbeds from SMEs
- Lack of collaboration with private sector on financing testbeds/testbed activities linked to both developing structural capital on test and demonstration, governance of testbeds and scaling opportunities with high impact
- Lack of competition as RISE has a dominating position and special financing rules compared to private sector stakeholders working in the field of test and demonstration support for innovative companies providing urban solutions, as well as their internationalisation

Opportunities

- Interest from Vinnova for both collaboration on testbeds and broader learning on smart sustainable cities with NL
- RISE started a project about international outlook on testbeds (just started, runs to end of 2022)

Threats

- Public sector complex to sell to, tenders etc often available only in Swedish
- Real or perceived slowness/low interest for internationalisation.
- Lack of strong internationalisation initiatives, creating risk that Sweden misses collaboration and exchange opportunities.

Discussion

The Swedish testbed system level is strong, and is well positioned towards real-world testing, as well as starting to build structural capital in that field. However, there are clear opportunities for improvements. Development needs and opportunities have been discussed in other reports, especially in “Study for creating the national function Testbed Sweden” (in Swedish) (Filip Kjellgren; Benjamin Ståhl, 2019) there is a comprehensive overview of different development needs. Here we will focus on some aspects where that in our view need more attention, especially concerning internationalisation. We do acknowledge the description below is a simplification, written in that way to reveal issues that in reality are more ambiguous.

The first is the collaboration between system level stakeholders and operational level stakeholders in individual testbeds. We can see broad system support for developing more testbeds to go international, but less of practical advice and coaching efforts. Broad development of the collective system is in focus rather than developing forerunners that can lead the way and bring in experiences to the rest. This applies both for the individual testbeds and for individuals in those testbeds. Resources for flexible financing of passing opportunities, for international exchange and outreach is not there in a way that drives testbeds towards a more entrepreneurial and internationalised mindset. This is linked to a traditional role of national agencies, setting up programs and calls, deciding on financing of projects, and receiving report afterwards. A more active role, engaging in key projects, continuous coaching and learning along the way, supporting with networks, tools or other resources is normally not applied. If done, it is franchised to an external part, where quality in coaching, and transfer of learnings might be weak. The differences can be compared to how a passive and an active investor work with a start-up. Here we see opportunities for developing new ways to work that can contribute to better results

The second is the focus on developing the testbeds as such and secure occupancy rate in order to cover the investments made, leading to a focus on bringing in more business in the form of international clients. As this is a natural interest from testbeds also in other countries it creates more of competition than collaboration. It also misses the point that the testbeds in a Swedish perspective can support companies in establishing innovations and expand on the market. The outbound perspective of Swedish clients going international is not in focus.

The third is focusing more on development of models and methods, with less focus on operational results. This risks building a culture of focusing on the “theoretically best models” for operating testbeds, rather than on creating operational results. Operational results often come from dedicated and talented individuals working in the testbeds. To develop and use that talent, other support methods are needed compared to development of best models.

The final point is the weak international presence. If you want to be an international player, you need to be out there, learn about best practice, learn about how other organisations operate testbeds, build your network and establish yourself as international player. This requires both resources and continuity. The system level doesn't seem to have strong focus on pushing this or make resources available for it.

If picking three main stakeholders on system level that would be Research Institutes of Sweden as owner of many testbeds, Vinnova as the national agency with most activity in the field, and the cities' municipality centred test and demonstration environments.

RISE applies a balance between research and practice, and also have strong focus on standards and methods. We understand from interviews that the operational and internationalisation aspects might not be fully covered from RISE.

Vinnova works on broader system development, sets up programs and financing opportunities. The flexibility to enter into more operational exercises or quick flexible financing of rising opportunities is limited.

The municipalities have legal restrictions on what they can do with tax money and so are restricted in what types of international activities and exchange they can engage in. Implementation and scaling of new solutions on international markets is not their core competence.

So, boiling it down, we see a need for more focus on internationalisation and operational results, building on entrepreneurial talent in the testbeds, a better understanding of what it takes to go international, and resources for frontrunners to embark on that journey. We also see need for new functionality in the overall system to support this, a functionality that would benefit from development of new work models, new tools and additional stakeholders to complement the three main players RISE, Vinnova and the cities, as well as a need to operationalise the experiences and the structural capital that is built within key projects like the Innovation platforms and Viable Cities.

The Swedish testbed operational level

From inception efforts for international innovation management collaboration need to be designed to diminish the insufficient scaling of innovation and dissemination of novel technologies. To collect valuable information about product/service properties and functionality is an intrinsic part of testing of soon-to-be-launched, scaled-up business ideas. Furthermore, the chance to acquire knowledge about performance on other markets and in other societal contexts is highly valued by companies; this particularly holds true for sustainability technology that should be, and considering the SDG targets needs to be, applicable on a global scale.

The vision was, and remains, to be able to achieve this with the backing and capacity of testbeds in other countries (NL and SWE were chosen to begin this process for ambition, market, and innovation-culture being similar as well as prior well-established partnerships). To re-invent the wheel in every nation when it comes to testing and developing innovation would result in a superfluous, costly and time-consuming exercise, one that appears increasingly outdated in a highly coordinated and ambitious EU context. Internationalisation as such revolves not merely around sales markets and supply chains but begins very much at the inception of new technologies. An international innovation program/marketplace/initiative intrinsically builds on that premise and should foster collaboration between international testbeds and, naturally, with companies wanting to integrate the international into their product/service from the get-go.

The above is therefore understood to form the background for this study's *operational level*, which is ascertained by targeted interviews with a range of Swedish testbeds.

In the following a SWOT-like listing of insights into the characteristics of the Swedish operational testbeds will provide information on the real-life barriers and drivers for any international partnership co-creating innovation. It is built on both a short questionnaire (Appendix X) to a number of testbeds and interviews with key individuals (Appendix X). We have chosen this form as the responses is mixed in detail and content, and so we found more traditional SWOT less useful.

Strengths

The Swedish testbed scene is already well developed when it comes to intra-national networks and mapping of the various activities. RISE has listed a large number of testbeds in various mappings and many testbeds approached in this project are indeed liaised with others in one or more associations/networks.

This stems from a general *exchange culture* and an approach to open innovation, breaking down silos of thinking and organisational lock-ins that were more prevalent in the past. Modern innovation processes, particularly those linked to incorporating business ideas into existing organisations, are increasingly sought out and are, on the whole, very positively received, e.g. Volvo Truck's Lab X which aims to provide an influx of innovation via a collaboration process with external companies towards incorporating it into the corporate mothership. This is also expressed in larger testbeds building on a member-based structure of corporations and cities backing them and providing in-kind professional, and financial input for operations. We also see more and accelerated connections between municipalities and innovation clusters contributing to a general atmosphere of *willingness to invent through co-operation*.

Specific technical knowledge, expertise in handling of processes and otherwise costly-to-obtain permits are yet another forte of the Swedish testbeds. To access this wealth of professional input should be understood as perhaps the most important de facto advantage for testing companies. Particularly specific permits, such as for special-waste handling or high-current electricity testing, imbue a testbed with an attractive proposition towards the open economy looking for development partners.

This connects straight to a general high-tech focus, perhaps unsurprisingly given the overall level of development and in which areas innovation is most featured and needed. Still, it is worth mentioning that the Swedish operational testbed scene has high-tech firmly in its sights and integrated in its processes as well as internal structures (e.g. universities such as Chalmers or SLU with direct operational links to research units).

Weaknesses

When it comes to weaknesses in view of creating an active LIT, the results of interviewed testbeds are speaking a clear language, offering *themes* of hurdles that are reiterated by most interviewees. Chief among them is the access to international networks. Although all interviewed expressed a specific need and willingness to connect to other countries' systems and operational partners, with some (e.g. *Västra Götalands testbäddar*) having made some first, tentative steps towards exposing their networks to international linkages, the reality is somewhat bleak in terms of actually having executed exchanges, be it of companies or mere experiences to start with. Coupled to this, we have

recorded expressed wishes to offer such link-ups through the LIT or similar activities and active networks.

From the Swedish viewpoint Dutch markets need to be better understood and presented to them, as well as possible test-sites and partners for collaboration, such as city or national agencies or industrial corporates.

Sometimes, the innovation culture, as much as it is open within the national system, can be locked in a specific research context with its own limitations in terms of proprietary developments and long-term grant application processes. In short, should a testbed like, for example, Chalmers University be coupled to an internationally testing company, finding the right type of funding on a short-term basis might prove problematic. The quickly available funds needed to ensure accelerated scaling of technology are in contradiction to the academia-style funding cycles for basic research, which means not every testbed is applicable to every type of innovation.

Interviewed parties expressed a clear frustration about the absence of governmental incentives and funding programmes for internationalisation of (any kind of) innovation management. Neither is there a (well-known and openly accessible) structure in place to foster the exchange between EU countries (or globally for that matter), nor are specific funds provided to either support home-grown companies in their international R&D efforts or to attract and receive foreign start- and scale-ups in Sweden.

This is mirrored in a general attitude of “not invented here and therefore not interesting”, a viewpoint not only myopic and outdated but arguably dangerous in light of the global social, economic, and environmental challenges humankind faces. Often the perceived borders of innovation management are drawn in line with the corporate, the region or latest the national boundaries of existing stakeholder frameworks and partnerships. This seems, on the surface, contradictory to the points made above about open innovation culture, however, it is important to remember that these are subjective perceptions of people involved in the interviews and such they can exist in parallel – the question remains as to how to operationalise one attitude while constructively doing away with the other. Thus, follow the opportunities that come with this playing field:

Opportunities

Although, as mentioned earlier, a significant number of Swedish testbeds are already mapped, interviewees expressed an explicit wish for further listings and categorisation of their counterparts in other countries. This is coupled to a drive for collaboration (building on the national strengths in open innovation culture) with partners and institutions rather than eying the R&D processes solely through the lens of competitive businesses and regions. Furthermore, said mapping should contain a clear theme or sector focus and provide the LIT or similar services with a nuanced way of presenting available options for collaboration.

Interestingly, the general EU vision to spread knowledge and innovation through collaboration is a theme often picked up upon by testbeds. For example, the Mission 100 for Climate Neutral Cities foresees a “spearhead” of cities pacing the way for the rest of the union by testing technologies on a small scale first. Although the exact process of how to connect to such a policy drive is yet to be

determined the interest, willingness, and practicality in connecting a LIT or similar network to grander EU policies is certainly present.

Another opportunity that presents itself is the willingness, and indeed call for, working holistically on a project, both from an operational point of view (technoeconomic calculations and early-on integration in available systems/frameworks/policies) and from a personal point of contact. This implies to establish partnerships through linking individuals with other individuals in the target country/testbed to create trust-levels needed for progressing with an exchange and joint development practices. The hurdle that needs to be overcome is the insecurities about the *unknown foreign culture*, and the opportunity is clearly there to counter this basic human instinct by fostering relationships between individual go-to contacts on both sides.

In terms of financially sound project planning, SLU, RISE PROCESSUM or SOTENÄS for example, offer ways to create co-financing through their networks and active members backing up the organised testbeds. Such collaborative applications can provide higher chances of success and also play a role in bolstering the outcome of testing through possibly adding expertise drawn from said networks.

Finally, a crucial building block in the make-up of an international exchange and collaboration scheme would be to designate an objective and neutral actor weighing the quality, application-opportunity, and (as far as can be established) chances of success of any innovation before it passes through any process – this would not only save time and effort but also add trust and value to participating testbeds and other actors by providing an understanding of the innovation as such. Generally, it should be added that such an innovation-focus would provide a clear-cut and neutral red thread by which the maze of possible international co-development scenarios could be navigated more efficiently.

Threats

There are some obvious threats in the realm of a proposed international testbed community. Clearly in the lead for the main reservations shown is the lack of (long-term) financing structures. It is risky to bank on an internationally connected network with the aim to drive collaboration if there is no government money backing up a medium- to long-term operation. After all, internationalisation efforts need to, partly at least, stem from the realm of national agencies' funding whose role it is already now to either import/export companies or drive innovation beyond borders. There is a reliance of the testbed scene on government actors built-in from the start, an automatic expectancy that will be hard to ignore and even harder to replace with market-driven incentives.

The current funding insecurity is, quite obviously, a worry for participating testbeds, companies, cities (who would be the next in line for being approached by funding-seeking parties) but also for the entity organising a community and conducting the operations on the backend to keep the exchanges on-going and fruitful in nature.

Applying for funding from authorities, be it EU, regional, or governmental is then the primary reflex a project development would resort to, this often coupled with a consortium of actors working together to raise the chances of receiving the funding. However, this not only severely undercuts any quick and lean efforts to test a specific technology with as little as overhead and project preparation as possible but furthermore often takes immense time – time which a start-up that needs to become

a scale-up does not necessarily have. Many projects flounder and are held back because of funding running out at a critical stage in a company's development.

This leads directly to a factor that originates from the companies' internal readiness. To engage in a productive testing and development process, particularly one that involves relocating for a certain timeframe and collaborating with international partners on the ground, a company needs to be sufficiently developed. Some testbeds interviewed need to be able to gauge in how far a company can actually provide a service or product once it has been found to be of interest to potential stakeholders, for example Stockholm Electricity would require a certain level of market-proof and proven technical applicability to give the green light for a novelty to be tested in their environment. Fundamentally, this poses a catch-22 as precisely the proving of said readiness is the goal for any testing start-up.

Adding to that are concerns about IPR and particularly regulations (such as private/public data usage) which can differ considerably from market to market. Not all these issues are hard issues, many are culturally derived or even merely a matter of perception. (To focus on the Swedish-Netherlands axis of collaboration makes sense particularly due to the similar business culture in general.)

Then, of course, there is the on-going COVID19 crisis with all the limitations on physical travel, meetings, and thus also physical testing of a technology in a different geographical location. It is, at the time of writing, impossible to say when the situation will ease and allow for resuming (quite literally) business as usual. However, there are grounds for hoping to being able to starting limited exchanges by fall 2021.

Discussion

The one thing one clearly can observe is that the situation for Swedish testbeds on the operational level remains ambiguous. On one hand, the actors interviewed alluded to high willingness and a generally positive attitude towards internationalisation; indeed, such movement towards exchange of experiences and avoiding double-work, raising efficiency in innovation management and being inspired by other actors is expressed by every single testbed interviewed. The general willingness to cooperate and sprouting open-silo innovation models in many places contribute to foster the ground for these aspirations. There are clear advantages in international collaboration, such as exposure to global networks and access to larger markets for Swedish companies, a raised global profile for the testbed/municipality/region, and the possibility of companies eventually opening an office in Sweden. Clearly business models, innovation development, and political goal-setting can be attained in unison. Some have, to reinforce that willingness with palpable capacity, exhibited some early-stage preparations for receiving companies, such as office space (so-called soft landing), joint financing possibilities, and networking capabilities for industrial connections to be made from the very start of a company beginning to work in the testbed.

On the other hand, the Swedish testbed scene, organised among themselves or not, faces a number of disadvantageous impediments towards a simple (in the best connotations of the word), lean, and quick implementation of either receiving a foreign company or aiding a domestic in reaching other markets.

Some of the hindrances derive from within what could best be described as the socio-cultural aspects of business - there is a palpable level of restraint when it comes to approaching foreign markets, specific actors and simply reaching out to other ecosystems without being endowed with a specific mandate or budget for such action. There is a predilection for levels of trust having to be provided as a step-in crutch rather than something that can (arguably should) be established through active, open approaches towards international stakeholders.

Other issues are based on rather objective and mundane hurdles such as national regulations and legalities, unclear or unguarded intellectual property rights, and/or secrecy concerns; the latter being generally an accompanying phenomenon when engaging in multilateral, open innovation processes. Where indeed does the figurative yellow band start and where does it end when innovation is transgressing borders, organisations, laws, and culture?

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Then, there is the lack of a unifying and centred player providing an objective-as-possible overview over the opportunities, the actors involved, and the quality/feasibility of the innovation. Not only would a place offering some sort of data on the opportunities lend a focal point for action, e.g. an online marketplace for squaring off diverse demands and supplies, but also the by no means trivial matter of (quickly and unbureaucratically administered) economic support would ideally lie with a central actor organising the opportunities on offer. As governmental funding, at the point of writing, for such endeavours is virtually non-existent, reliance on a continuous arrangement of accessible mini grants would be needed. These could cover bilateral (or multilateral) organisational efforts, mapping, updated networks & events, possibly offsetting (some) office and accommodation costs for the testbeds, all in order to establish and uphold a continual flow of innovation in both directions.

5. The Netherland testbed situation

This chapter provides a snapshot of the Dutch situation regarding testbeds. Similar to the description of the Swedish testbed situation, the analysis of the Dutch testbed situation also makes a distinction between the system level and the more operational level.

Both the analysis at the system level and at the operational level are followed by an assessment of the situation.

The basis for discussing the Netherland's testbed situation in relation to LIT

The charting and analysis of the Dutch testbed situation is based on the following elements:

- Outcomes of four meetings with the Sounding Board, which provided guidance for sources of information and key players to speak to and gave indications for directions to go.
- Desk research of key sources of information, guided by the research questions to set priorities for the selection of materials. Particularly useful documents in this context were the overview of bottlenecks and accelerators for Smart City solutions in the 40 largest Dutch municipalities (Teuben et al, 2020), Erasmus University Rotterdam's investigation of the cleantech innovation systems of Rotterdam/South Holland and Flanders (Van de Vrande, 2020), the Roadmap Next Economy of the Metropolitan Region Rotterdam/The Hague (Roadmap Next Economy, 2016), overviews of Living Labs and upscaling provided by the Rathenau Institute (Maas et al 2017; Van den Broek et al 2020), and the results of the stakeholder consultation of the European Innovation Council (EIC, 2020). Besides, due to more fragmented nature of Dutch testbeds, many websites containing overviews of real-world testbeds and living labs have been consulted, among others the ones on Field Labs (including natural gas-free districts), City Deals, project websites of the testbeds themselves and of lighthouse projects.
- Semi-structured interviews with key players in the Dutch real-world testbeds and living labs using a joint questionnaire developed in collaboration with CleanTech Scandinavia. The key players represented different real-world testbeds and living labs, delegates from different levels of government responsible for business internationalisation and innovation, the private sector, and academia (see Appendix 4).
- Locality's experience of more than 20 years in research, project and business development, and capacity building in the field of smart sustainable cities, in particular insights into best practices across Europe for adopting smart sustainable solutions through quadruple helix collaboration in cities collected with nearly 100 city administrations and networks, businesses and research partners. Further, valuable insights were gained by Locality's engagement in the Smart Cities Marketplace support team and participation in the Taskforce on Replication of the European Board of Coordinators of Smart City Lighthouse projects.

The Netherland's testbed system level

Strengths

First of all, although geographically limited, the Netherlands is the 17th economy in the world. Due to its history of trade, the Dutch economy is very open and internationally oriented, what manifests itself in close connections with neighbouring countries in terms of goods and services and a large hinterland. The tech industry has a relatively large share in the economy compared to other countries. The Netherlands has an entrepreneurial, innovation-oriented culture.

The Netherlands has a large number of cities, many of them medium to large-sized, and has a dense urbanisation pattern with short distances. As a result, there is a political tradition of working together on agglomeration level on topics as mobility, economy and urban development, for example the Metropolitan Region The Hague-Rotterdam. Quadruple helix collaboration, often a prerequisite for a successful integrated approach to developing, validating and implementing smart sustainable solutions, is common (“polderen”).

In terms of real-world testbeds, as sketched earlier, there is a multitude of activities and initiatives taking place in Dutch cities, in the field of sustainable energy, energy-efficient buildings, clean mobility and logistics, smart integrated infrastructures, circular economy, safety and security. These testbeds and living labs are supported by a wide range of policies and instruments at all government levels, ranging from local to national.

The R&I agenda of the Netherlands 2018-2021 (Kennis- en Innovatieagenda 2018-2021, 2017) prioritises many topics relevant for smart sustainable cities, for instance:

Urban Energy: smart grids, electric transport, heat pumps, efficient (bio)HR heating appliances, hydrogen and wind power in the built environment, heat-cold storage, PV, energy storage and conversion, system integration, thermal insulation, prefabricated building elements, high and low temperature thermal grids, 12V AC at home environment.

Mobility: Intelligent transport systems, deep integration of transport modes for goods and persons, sustainable accessibility of cities through electrification, optimization of traffic flows using real-time data.

In addition, innovation and internationalisation are strongly supported at national level through instruments as Start-up Delta, TechLeap and the Netherlands Enterprise Agency but also through funding of numerous Green Deals, City Deals and Field Labs developing and implementing smart sustainable solutions locally.

At the regional level, the eight Regional Development Agencies or RDAs (“Regionale Ontwikkelings Maatschappijen, ROM”) play an important role in this in a more practical way. An RDA is a not-for-profit corporation with public shareholders whose aim is to strengthen a region's economy and bolster employment. RDAs as Innovation Quarter, Brainport Eindhoven and Amsterdam, help SMEs with innovation, investments and internationalisation so that they can accelerate their growth, thus promoting sustainable growth of regional economies and helping to create jobs.

RDAs can help to support real-world testbeds by:

- Making connections, for example between companies and domestic or foreign players
- Providing market information to companies or set up a specific organisation to do this for a particular type of technology and market innovation. Market reports may also inform trade missions.
- Setting up partnerships with organisations
- Identifying relevant communities and stakeholders, and how domestic and foreign markets work
- Organising regional and international activities linking companies and prospective customers around specific economic clusters
- Being the liaison between national and local level for living labs and field labs

Specifically for the Metropolitan Region Rotterdam-The Hague (MRDH), a collaboration of 23 municipalities, the Roadmap Next Economy has hitherto been very important as a framework for testbeds. It outlines the long-term vision for South -Holland to become a sustainable and competitive economy by five major transitions pathways in the field of digitalisation, sustainable energy, circular economy, next education and next society, inspired by the Third Industrial Revolution of Jeremy Rifkin and enriched by and made specific with many parties in the regional ecosystem (Roadmap Next Economy, 2016). The Roadmap works with system breakthroughs required for each transition, and indicates which projects and investments are needed to achieve these system breakthroughs. RDA Innovation Quarter is responsible for its implementation since 2018, which is taking place among others through Field Labs and City Deals.

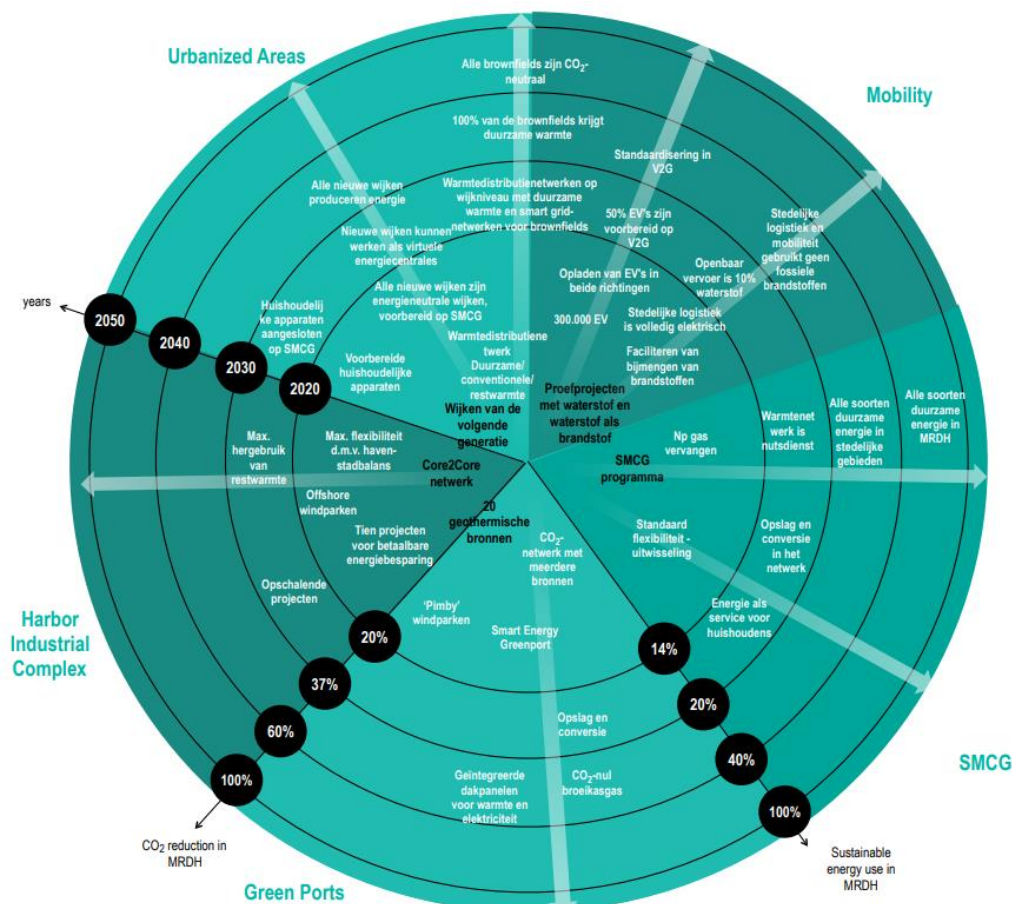


Figure 1 System breakthroughs and planned projects for transition pathway Smart Energy Delta

At local level, an enormous amount of experience has been built up over the years with real-world testbeds and similar. Amsterdam is a well-known forerunner for over 15 years with a high degree of internationalisation in its voluminous testbed activities with a focus on IT and urban data, circular economy, smart cities and creative industry e.g. gaming. Rotterdam, The Hague, Utrecht and Eindhoven follow suit, having sometimes slightly other foci (resp. maritime and logistics, international justice, life sciences, automotive and making industry).

Although the degree of internationalisation varies greatly among testbeds, several of them have experience in working with foreign companies or have developed internationalisation strategies. In interviews, not only representatives of testbeds but also other stakeholders expressed an interest to work with Nordic countries, and in particular with Sweden, which is considered ahead in terms of sustainability, and in political and societal support for it.

Lastly, in the slipstream of local research institutes and RTOs as TNO, larger Dutch cities and local businesses have been more than average successful in securing EU funding for R&I projects in the field of smart sustainable cities. Eindhoven, Amsterdam, Rotterdam, Utrecht, Groningen and Alkmaar all secured funding for implementing highly ambitious integrated Horizon2020 smart city lighthouse projects.

A detailed analysis of RVO of all Horizon2020 projects with both Swedish and Dutch partners shows that there already a strong collaboration between Sweden and the Netherlands, in particular in the fields of health, demographic change and well-being (164 projects), smart green and integrated transport (91 projects), climate, environment and raw materials health (92 projects) and information and communication technologies (91 projects). Nearly 40% of all projects had both Swedish and Dutch partners, with a total budget only for these partners of 1.8 Billion Euros over 6.5 years. Most active partners come from research: for the Dutch side TNO, Technical Universities of Delft and Eindhoven, Radboud University, Wageningen Research, and University of Utrecht, and for Swedish site Karolinska Insitut, KTH, Chalmers Technical University and Lund University. Successful other organisations are for Sweden GKN Aerospace Sweden AB, RISE AB, Swerim AB, Saab AB, and European Spallation Source ERIC, and for Netherlands the Netherlands Aerospace Centre. However, despite research being in general active in more projects, businesses play an important role as well: around 32% of Swedish partners comes from business and 34% of Dutch partners.

A comparable analysis of ITEA-3 reveals that 113 Swedish and Dutch parties have been or are working together in 13 projects in the field of smart engineering, smart health and smart mobility.

This collaboration can provide a backbone for setting up the LIT, e.g., by recruiting partners from Sweden and the Netherlands already working together, in particular businesses, and defining new R&I projects for Horizon Europe and ITEA.

Weaknesses

An overview of real-world testbeds, pilots, field and living labs similar to the one available for Sweden is lacking. Dutch testbeds and related are haphazardly or not connected and often non-aligned. For one of the interviewees, that was the reason to found the Dutch Association of Field Labs for exchange of knowledge and experiences. Despite the plethora of real-world testbeds, mutual learning is limited for this reason. This is reinforced by decentralisation of most policies and implementations on smart sustainable cities to municipalities, making it difficult for companies and innovations to take the next step as they have to start again from the beginning in every municipality. This decentralisation is not beneficial for innovation as that requires uniformity, if

possible, even at international level as the Dutch market itself is small. A more central coordination and clustering is wanted to be able to pick low hanging fruit and enable a learning environment, where businesses can grow and knowledge and know-how on transition pathways towards smart sustainable cities is shared. Despite a promising beginning, the Dutch Smart City strategy has apparently so far insufficiently been concretised and implemented and cannot really act as a backbone for LIT for that reason.

Partly related to this lack of overview and more central coordination, entrepreneurs often see each other as competitors while they are stronger if they work together and can provide a fully-fledged joint alternative for a multidimensional problem or desired systems breakthrough. In the field of smart sustainable cities, such an integrated concept or approach is often more successful than an individual partial solution. However, the value of complementary collaboration among companies in value chains is frequently underestimated, also due to a rather individualistic culture in the Netherlands. From ecosystems as Silicon Valley, it is known that this collaboration and mutuality underpins not only local but also many international business opportunities. It seems the limited overview hampers development of larger, more effective clusters and possibilities for complementary collaboration are easily missed. Stakeholders and prospective customers in cities are often not interested in one specific technology or solution, but in a combination of different solutions providing a complete answer. This also gives a much better basis to lobby for adjustment of legal and regulatory frameworks which frequently hamper acceleration and market uptake, and for common branding of a set of solutions (e.g., cities coming to a showroom).

Further, while being the 17th economy in the world, often key Dutch actors think too narrow as the Netherlands is geographically a small country and tend to underestimate the potential and value of Dutch solutions and technologies for other countries. When interested in international opportunities, there is a tendency to focus heavily on countries further away with highly different contexts (US, China, Singapore), in particular in the start-up sector, and less on the potential for collaboration with neighbouring EU countries as Germany, Belgium, Denmark and Sweden, while the latter have a much more comparable situation and context. In addition, especially in the digital sector, unicorns are seen as exemplary, while high-grade EU TechChampions have much more economic impact and for the latter cross-border tech partnerships with nearby countries makes much more sense.

An inherent problem with testbeds is that their local solution is often too adapted to specific local situations. While there is a big need for scaling of smart sustainable solutions and it is of huge importance to small companies, this is not in direct interest of cities and big companies that can take care of themselves.

Lastly, when considering EU funding for implementation of smart, climate-neutral and sustainable city agendas, there seems to be a strong focus on EU R&I funding, while other possibilities for finance and funding as the ERDF seem to be underexplored in this respect, and alignment and synergies with regional smart specialisation strategies seem to be underexploited. As a result, the financial basis for uptake of smart sustainable solutions beyond the testbed through funding seems limited.

Opportunities

The Netherlands has currently an enormous housing shortage of around 330.000 dwellings, possibly increasing to 415.000 dwellings in this decade. Urbanisation strategies flowing from the national spatial planning policy will lead to large-scale investments in housing, transport and accompanying

facilities. Locally, many city administrations have policies for making cities more sustainable, circular and climate-neutral in a smart way, e.g., by the concretisation and implementation of the recently delivered regional energy visions and investments in smart transport systems to combat congestion and noise and air pollution. Potentially, this offers huge prospective markets (see for example Ros and Daniels, 2017, for costs of energy transition).

Although not yet sufficiently concretised, the *Dutch Smart City agenda* (NL Smart City Strategy, 2017) might receive more attention when a new coalition is in place. This strategy sees joint experiments based on public-private collaboration with corresponding new business models and distribution of risks, as an important precondition. Upscaling of promising local initiatives must be supported financially, while the diversity in cities offers the possibility to validate concepts in different urban contexts but needs regulatory leeway. The document also proposes an analysis of economic opportunities in other countries in coordination with the national export strategy. Matching international needs with the offer present in Dutch cities, clarifies the international potential for business and can inform on suitable topics and ecosystems for trade missions.

A main opportunity for Dutch testbeds at system level, are current and new EU and national funding possibilities for R&I and cross-border tech partnerships, where smart sustainable cities are seen as one of the key enablers for the transition to a low carbon economy. At EU level, this concerns mainly the Green Deal, Digital Transformation, post-Covid recovery funds, JPI Urban Europe, restructured ERDF, and Horizon Europe (including funding for 100 Climate-neutral Cities by 2030). This will be discussed in more detail in Chapter 7.

At national level, this concerns the recently established national growth fund, the policy of Field Labs and ERDF-funded smart specialisation strategies which offer opportunities for science-industry-city clusters and synergies with national R&I priorities. There is a plan to promote the Netherlands as one giant testbed under the flag of Living-in.EU, the so-called Dutch Societal Innovation Hub, which could be considered as a Dutch "mini" LIT, as it encompasses a wide variety of real-world testbeds (). The initiative comes from the Dutch Association of Municipalities, IPO, Eurocities, Open and Agile Smart Cities, and European Network of Living Labs. With *societal innovation* it refers to a systemic change in the interplay of the state and civil society, where the state is a much more important co-creator in achieving sustainable systemic change than in social innovation. It wants to achieve sustainable & resilient ecosystems by community-driven neighbourhoods, human-centred services in mixed reality, and virtual scenario planning and predictive maintenance. Technology modules are developed and validated within specific ecosystems and subsequently applied in all ecosystems, while knowledge transfer and upscaling take place through living-in.eu.

Further, the Covid-19 pandemic has made governments all over the world aware of their vulnerabilities in global supply chains, and hitherto there is increased attention for in-shoring and re-industrialisation at national and European level, but we have to wait for the new government coalition to see how this will influence R&I policies at national level.

Experience learns that for routes to scaling, technologies and solutions tried out in a field lab hardly ever directly result in paid customers after the field lab. Nearly always one or two intermediate steps are needed in the form of subsidised pilots. An opportunity for LIT could be to provide possibilities for such (up)scaling of successfully tested technologies and solutions in the form of a pilot subsidised by national funds. This could be done in parallel in Sweden through LIT, with the Dutch pilot financed by field labs policy, SDE+ etc.

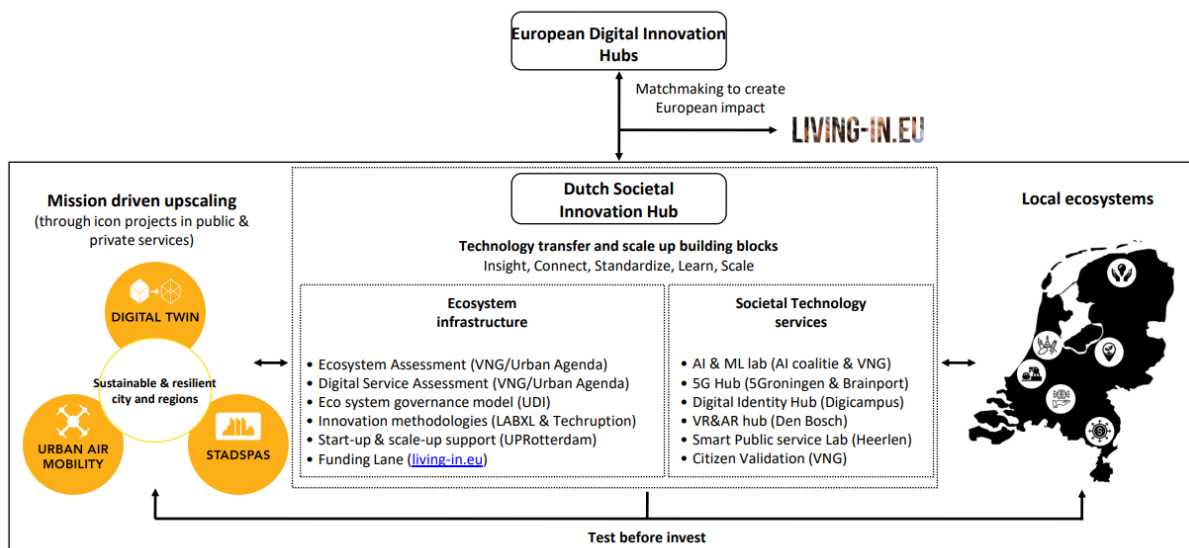


Figure 2 Dutch Societal Innovation Hub. Source: Living-in.NL

Besides, if there is already a testbed collaboration where we can build upon, that would be a good starting point. We should prevent duplication but use the most optimal setting and combination. International testbed collaboration in LIT is useful for replication in different context and leads to more mature market development. More validations in different cities provide valuable information to businesses, who can subsequently tweak their solution. Companies want to prove that their solution works in different contexts. LIT can offer this different context. LIT could also enable benchmarks of different solutions for the same problem, offer a double reference: not only different context but also different solutions compared. This can help to build trust for risk-averse investors, city administrations and other prospective customers. A collaboration between the Netherlands and Sweden could be complementary to the existing Nordics collaboration.

To prepare for national and EU funding, Dutch and Swedish clusters of companies could be created or enlarged by inviting companies from the other country. A model like the US uses with its universities could be useful. Companies often test at different locations hosted by different universities. Organisation of research funding in combination with companies can provide a more long-term basis for development, and more strategic thinking on and management of technology. For instance the Gaia x data rooms were a big success at the Hannover Messe, and have been embraced by German and French industry. Such a scalable model with European Tech Champions creates much more economic value and employment than unicorns. DeepTech and emerging technologies can be facilitated by coupling of science clusters through LIT. In a similar vein, ETF has recently been approved, with 100 Million offering also opportunities for SMEs in the field of circularity, smart cities and energy transition.

Testbed: Living Lab Scheveningen

This Living Lab is part of The Hague Security Delta and the City Deal Urban Security and was officially launched in September 2020. It wants to simulate the City of the Future in a broad sense, by testing technology but also looking into legal, regulatory and ethical aspects. Innovations being developed or tested here are smart street furniture, robots for cleaning the beach, sensors measuring noise hindrance and communicating the results with the users of public space, local exchange of energy in smart microgrids, smart on demand lighting beneficial for nearby biodiversity, visualisation of data with the Arts Academy, multiple use of smart infrastructures as cameras, technology and urban (re)development.

The municipality is also testing the effect of this smart city infrastructure on municipal processes and investigating how the business community can connect to the infrastructure. The aim of this living lab is to discover the social benefits of this new development and how it contributes to improving and maintaining the safety and quality of life in the seaside town. Use cases play a prominent role in linking the solutions to the urban development agenda. In collaboration with experts, the municipality of The Hague has devised a completely new digital infrastructure for living lab Scheveningen. This makes it possible to power sensors and connect them to computer systems while they are concealed in the street furniture. The North Boulevard will be the first test area where smart technology is combined with a beautiful outdoor space. The municipality will first conduct its own research into social issues and the impact of this innovation on its own processes. At a later stage, other parties, such as companies and citizens' initiatives, may also join in (source: Hague Security Delta, 2021)

Threats

Lack of organisation and oversight is an important threat, leading to limited exchange of knowledge, know-how and experiences, fragmentation of markets and lack of insight in complementarity of solutions and technologies within (new) value chains. Already within the Netherlands, real-world testbeds have difficulties finding each other, and this goes for businesses as well as cities. The Dutch Societal Innovation Hub might be a vehicle to remedy this, by connecting it to the LIT.

This lack of organization and oversight makes it also difficult to judge where overlap and competition exists with smart sustainable solutions already developed and on offer in Sweden. Besides, "Not invented here" and "own companies first" are definitely threatening potential collaboration within LIT. Swedish partners might prefer to work with their own local start-up or scale-up, and scope is often on the own city and region.

Related to this, individual starters and start-ups in the Netherlands are often much younger than abroad and many times fresh from university. This makes that frequently start-ups do not have a clear vision on their value proposition, or the product-market fit for their solutions and cannot position themselves well in this playing field, let alone in another country. A pivot needs to be made.

Getting access to real-world city testbeds and markets is difficult and takes often a lot of time, especially for small companies with limited resources. And when companies are successful in getting access to a city, they have to start all over again when approaching the next city. LIT could facilitate this access and possibly take some of these costs.

Regarding prospective markets for smart sustainable solutions, the main barriers have been briefly sketched in Chapter 2 and will follow in more detail in Chapter 6. Many smart sustainable

technologies and solutions have large upfront investment costs, a long(er) pay-back time and sometimes relatively low return on investment. This leads to less attractive business cases and makes it often initially difficult to operate outside testbeds and living labs without any subsidies. Besides, many other factors make cities risk-averse towards implementing such innovative smart sustainable solutions in testbeds and for real, for example lack of political leadership and commitment, key stakeholders not being sufficiently aligned, lack of skills to assess the merits and consequences of specific solutions. Politicians are not willing to defend public money has been wasted. This can be mitigated by LIT providing different references, models for risk-sharing and develop solutions scalable solutions that work for Sweden and the Netherlands.

Linked to this, regulatory and legal frameworks will differ per country. This is often an important stumbling block. Insight into how legal and regulatory frameworks play out for specific solutions and technologies, is one of the key questions where LIT could provide an answer. For example, is a specific solution allowed in Sweden or the Netherlands? Is there from regulatory perspective undesired impact of a specific solution that can be expected? Without insight into this, it is difficult to assess if internationalisation makes sense as a solution might be simply not allowed or suffer from complex planning and implementation.

Another often-mentioned threat are the limited resources of small companies for taking part in internationalization activities, both in time and in budget for travel.

Discussion

Many organisations and businesses in testbeds are mainly focused on the Dutch market and have not yet considered to go abroad. There is certainly a latent interest, that has not manifested itself yet so raising wider awareness of opportunities and advantages is an important next step. For instance, that the creation of an additional international network offers opportunities to match to customer's demand can enhance the possibilities for start-ups as the chance to enter another market is not so high otherwise. Nearly all interviewed testbeds and other stakeholders were in principle positive about the possibilities of a LIT, but would need more information on the Swedish possibilities, markets, and potential pitfalls for market development as legislation and procurement of smart sustainable solutions. Insight into where no/less competition exists and potential for collaboration is present, is highly needed. Furthermore, some cross-border partnerships indicated that cross-border aspects were not always perceived as attractive by SMEs, especially when it was compulsory due to funding. As a consequence, it was not easy to recruit sufficient suitable SMEs. This study delivers some insights, but this needs to be done in more detail, with a focus on commonalities between the Netherlands and Sweden and parts of the value chain where you can collaborate in a cross-border fashion. For its future success, LIT needs cases where real commitments exist. One solution could be to start small with prototype of LIT comprising a kind of "mini" smart sustainable lighthouse cities, and then extend the scheme.

Further, creating such an oversight and connecting the dots in the fragmented world of testbeds, field and living labs would definitely help to plot the potentially interested companies to specific themes, locations, clusters etc., not only for the collaboration in LIT but also for connectivity and coordination within the Netherlands itself. The National Growth fund wants to cluster businesses. For 30 Million Euros many parties can be brought together and helped to work across borders in clusters on specific topics. However, the question is which partners need to be brought together. Clustering

of forerunners in a particular theme or solution can help to work better across the border. For example, energy transition and hydrogen could be clustered with Germany, Norway and Sweden.

All relevant government levels are participating in the Sounding Board. To think and collaborate in an international way, we have to connect these levels in a successful chain ranging from city (e.g., Rotterdam and The Hague) to RDA (e.g. Innovation Quarter, Brainport Eindhoven) to Netherlands Enterprise Agency and the Ministries of Interior Affairs and Kingdom Relation and of Foreign Affairs. The RDAs are a crucial linking pin in such a collaboration. This will also help to create short lines for entrepreneurs, e.g., by having a sort of digital Golden Pages on who to contact for what. This is linked to the acting perspectives briefly described in Chapter 7.

Scalability of solutions will be an important aspect when considering companies. Sweden is a larger country, so the company that can offer the most scalable solution would be a good candidate for participation in LIT.

Language barriers are not really expected as both Sweden and the Netherlands speak English very well. However, when engaging with city administrations, this might be a bigger problem, as they usually prefer to talk in their own language. It is striking that much of the overview information on websites on Dutch real-world testbeds is only available in Dutch, this makes it difficult for interested Swedish parties to explore possibilities.

Testbed: the Green Village

The Green Village in Delft is a living lab at the campus of the Technical University of Delft, which aims to provide an environment for researchers and innovative companies to develop their ideas further and prevent failures during the implementation and upscaling phases. Innovations are made more societally robust by engaging all relevant parties in the innovation process and by addressing all aspects: not only technology, but also business models, legal and regulatory frameworks and social acceptance. Further, the Green Village is a physical test location with houses where students live. It can be legal and regulation exempt, to allow for testing of things (Van den Broek et al, 2020). So far it has hosted dozens of innovations at building-street-neighbourhood level, in particular on clean energy, sustainable construction and urban infrastructures, mobility and adaptation to and mitigation of climate change, such as low temperature heating networks and preparation of the building stock for the energy transition (see www.thegreenvillage.org).

The Green Village is a place where many different innovators meet and connect: start-ups, students, companies, academic research programmes, attracted by the Technical University of Delft begin nearby. It offers exchange of knowledge, networking, communication and dissemination and being part of and developing a local ecosystem. As a foundation under the holding of the university, it is financed by a variety of sources: a part basic finance for running the office and location, EU structural funds via ConnectSME, and fees paid for research and testing. The Green Village has proven to be key to achieve better outcomes for SMEs. Support it provides consists of: finding subsidies, begin an incubator, being a marketplace brokering between investors and start-ups, publicity for each innovation halfway and at the end of its trajectory, visibility (more than 6000 visitors per year), legal services and IPR support by the university, help in recruiting employees, and coupling of trainees and graduates to businesses.

Foreign SMEs are welcome to test in the Green Village, depending upon their offer and how it fits within the overall goals. Currently, one Italian company is active in the Green Village. Spin-offs of the Technical University of Delft are in general highly interested to work with Swedish universities, as happened already via Climate-KIC (University of Lund, Chalmers University, University of Copenhagen).

Regarding the embassies, they help to provide information on markets and opportunities. However, to be successful in seizing these opportunities, often more detailed information is needed. This takes a lot of interaction with project managers of planned new investments in the built environment and urban infrastructures to source this detailed information that cannot be found on websites. This takes a lot of time and energy. Maybe LIT could be instrumental here, by flagging upcoming market opportunities far in advance (see for example also the Roadmap Next Economy for the Netherlands, which indicates where future investments will take place).

Lastly, the new EU programming period offers a lot of opportunities for funding that could be seized on top of national possibilities, however, this needs preparation in advance, for example setting up the right networks and engaging the right partners. Synergies between local, regional, national and EU funding can be achieved in this new programming period but need time for preparation.

The Netherland's testbed operational level

Strengths

The existence of hundreds of real-world testbeds (here also encompassing field labs, living labs, deep demonstrators etc.) and their thematical variety, means there are many possibilities for Dutch-Swedish collaboration. Apart from so-called Living Labs, the so-called “proeftuinen” – or field labs – which are an important policy instrument for digitalisation in many domains, already amount to 118, with dozens of them working on smart sustainable cities (e.g., slimstestad.nl). This is inclusive the 27+ neighbourhood testbeds where natural gas will be phased out (“aardgasvrije wijken”) and six field labs established for experiments within the new Environment law (“Omgevingswet”), which has replaced much physical planning and environmental legislation.

In general, Dutch testbeds are based on a public-private partnership. Nearly all field and living labs work together with industry partners, some of them foreign, and have an array of support services, often in collaboration with RDAs. For example, Living Lab Scheveningen issues tenders for contracting start-ups. A use case manager couples the smart sustainable solution to the implementation agenda of the City of The Hague on maintenance and management of public space and urban development. Start-up in Residence helps to recruit the right start-ups and scale-ups. For specific topic larger companies are on board, for example because of requirements to technology and open data as is the case with the multi-use camera. Usually, companies have to bring their own finance and can use the location, while they are supported in the process and participate in networks with the city, e.g. during events.

Dutch real-world testbeds are rather good embedded in municipal decision-making. For example, Living Lab Scheveningen undertakes only activities that match with implementation of local policy agendas, and the Lab itself is under responsibility of the Vice-Mayor.

A number of Dutch testbeds have the possibility to switch of legislation and regulations, for example in the Green Village. This gives the possibility to experiment and work with solutions that are not officially allowed in the real world and cannot be tested in another way. Also, large urban (re) development projects can offer better possibilities for another handling of regulations.



Figure 3 Clusters of field labs - interactive map shows their precise location when zooming in. Source: <https://www.nederlanddigitaal.nl/initiatieven/kaart-met-proeftuinen-in-nederland>

Another strength is that there is already experience with interesting models for LIT-wise collaboration, such as the CleanTech Delta model, in particular ConnectSME, and Growing Industry through a Sustainability Transition (GIST), a collaboration between the Netherlands and Flanders. In the same vein, there are already a number of successful collaborations between the Netherlands and Sweden on smart sustainable cities, where LIT can build upon. For instance, the SCALE-UP project and smart city lighthouse project collaboration between Utrecht and Gothenburg, and between Rotterdam and Umeå, but also successful ongoing collaborations between cities, research and businesses in Horizon2020. Likewise, Green Village works with in Climate-KIC with University of Lund, Chalmers University and Copenhagen.

Support services are available but vary between testbeds and are often provided in collaboration with the city administration, university, RDA or other agencies.

Weaknesses

A point often mentioned is that due to the lack of overview, testbeds cannot find each other yet properly. For this reason, IQ organises seminars and other activities where companies working in different testbeds can meet. However, it is clear that more overview and coordination between different types of testbeds would be beneficial for individual companies.

The contribution of GIST and the project Supporting Cleantech Innovators in Accessing Large Enterprises through Unlocking Procurement (SCALE-UP) to fostering further innovation within their respective ecosystems, has been recently analysed by Erasmus University Rotterdam. It was concluded among other that:

- current regulations are often an important bottleneck for cleantech entrepreneurs;
- the government should play an orchestrator role in connecting the myriad of initiatives, for example by providing a clear overview of what is happening there and what they can offer to cleantech entrepreneurs at different stages of their development;
- how different initiatives are linked to the broader and overarching innovation agenda, thus enhancing the collaboration between clusters

Further, like in the rest of Europe, “not invented here” hampers exchange between testbeds and interest in learning from what has already been done in other places. Sometimes SMEs consider the local network as more interesting and do not have much need to test in another context. Local processes might be ill-equipped for innovation, a problem that is often exacerbated by siloed governments.

Support services are often based on “one size fits all”, while needs might differ enormously between different innovations, for example if it concerns a physical or digital innovation. So, they need to be layered. Related to this is that companies usually have different needs at different stages of scaling, and insufficient attention is paid to this. Lastly, follow-up on found matches is often poor, which reduces the effectivity of the efforts put into the matchmaking.

In the Netherlands local project development and decision making is organized differently from Sweden, what means different stakeholders have to be engaged. For example, urban development and infrastructure construction and refurbishment are in Sweden usually done with by large construction and engineering companies while in the Netherlands there is a tradition to work with small(er) architectural and engineering firms.

Opportunities

LIT should focus on sharing knowledge and approaches (e.g., how to run a testbed or living lab), and help to create valuable references. It can also help to make a more optimal use of existing testbeds, by organising complementarity and as such a more optimal use of them.

Swedish companies are welcome to Dutch testbeds, depending upon their offer and how it fits in the testbeds’ strategy. A number of testbeds already is already working with industry partners from abroad. Living Lab Scheveningen works with foreign partners on the beach robot. They think that for international co-development in the LIT relevant topics could be connectivity, 5G, AI, blockchain, Urban Data Platforms, 3D models and VR, and sensor technology, nearly everything would be suited for Swedish companies. Green Village works already internationally with Italian, Spanish, Belgian and UK partners on innovations.

Some interviewees stressed that the integration of different systems is an enormous challenge, in particular for the energy system in its entirety and the role of hydrogen in it. Usually this leads to new partnerships and collaboration.

National and EU funding as Interreg and smart specialisation strategies in Sweden and the Netherlands might offer seed money to set up LIT operationally.

Business: Hamwells

Hamwells produces sustainable wellness and shower appliances and systems that recover energy from hot water or recycle water. The products have to fulfil different norms per country regarding water quality, safety, public health etc., to be allowed to enter the market. These different norms in combination with sometimes lengthy procedures to get approval, reduce the market potential.

The systems are very suitable for colder climates and the company is working on a broader internationalisation strategy to large-scale roll-out of the products. There is a lot of interest from Scandinavia, where also comparable products recirculating water are made in Sweden, Finland and Denmark, however with lower efficiencies. Begin a frontrunner, Hamwells expect competition to be beneficial for market growth due to larger acceptance of the products. In Sweden Hamwells works in partnership with a Swedish partner specialised in energy transfer and heat recovery.

Via round tables co-organised by IQ and the Dutch Embassy to Sweden in March, Hamwells got into contact with testbed Johanneberg Science Park in Gothenburg and is now in the process of applying for participation. An important reason is that the Scandinavian market prefers performance data from their own countries which indicate exact how much energy or water is saved, as data from other countries are trusted less. The testbed enables Hamwells to show what can be expected under local circumstances so it can better enter the Swedish market. However, it brings also a reference for new markets. Inhabitants use the shower with heat recovery in two houses, the appliances have been installed in two different ways. Sensors monitor vital information and are read out from the Netherlands. Besides, feedback of the fitter, for instance on ease of installation, is valuable information. Because regulation can be made exempt, the system can still be tested even if there are minor aspects where the norm is not met. That aspects can then be addressed at a later stage.

The process of application to test in Sweden is not without problems. The contact person is reacting slow, and the forms, information needed and criteria for admission are not always clear. Information on norms, standards and regulations is usually only available in the Swedish language. Also, it is difficult to judge the importance of specific documents as an outsider. For example, a voluntary code was mentioned and at first instance not deemed vital, however, it appeared that without adhering to this voluntary code, it would be impossible to do business in Sweden, despite the obliged national code being met. This is something you only discover after you have talked to different parties. A legal and regulatory scan would help enormously. The construction and installation industry is rather conservative and often prefers local technologies they know. There are many policies aims and regulations, but it should be checked more often how these turn out for the construction sector at local level. *Interview Jos den Besten, Business Developer Hamwells*

Threats

Cultural and language differences can play a role, next to rules on innovative and sustainable procurement and different legislations and regulations.

As main practical obstacles to scaling are concerned:

- Technology not being mature, e.g., for integration in energy systems
- Unclear business model, price and market insufficiently specified
- Legal and regulatory frameworks creating uncertainty if products will be allowed, e.g., through norms. Vested interests can lobby against such norms
- Unclear of public will accept a specific solution: in some testbeds hardly real inhabitants, for example in Green Village only 12.

- Acceptance by governments as municipalities, which are often very siloed. This means that for an innovative solution not only the innovation departments need to be involved, but many other departments including communication services. Some smart solutions are adopted, for example the quay walls reinforcement by Water Boards and City of Amsterdam. Usually this is done by public or semi-public organisations, so mostly B2G and less B2B. In the latter, it is large construction companies working with social housing. There is a lot of regulation including BIM requirements, the most sustainable option is only chosen and procured if it has been included in the specifications beforehand.

Related to the latter point, participation in a testbed is often not enough to take the step to the market, but a few subsidised pilots are needed in between. The scaling customer is often a public or semi-public organisation such as a municipality, province or agency as the National Road Authority (the Netherlands has privatised many former government agencies and services that are private now, e.g. housing associations, energy supply etc.).

Another threat is that the smart sustainable solution offered by a company is often only a partial solution to a problem, and in fact a bigger consortium is needed that collaborates over the value chain and consists of multiple parties that contribute. Industry partners are more used to work like this. For more complex, integrated problems a partial solution does not suffice, an integral concept and offer is needed e.g. noise and areal sensors combined with cameras for detecting exposure to environmental pollution. Related to this, scaling takes place easier if a multi-national company is behind an SME. If that is not the case, being part of a larger consortium working on different parts of the value chain is even more important.

In most real-world testbeds, capacity to work on internationalisation is limited or going through other channels. Green Village's internationalisation strategy is mainly done by the Technical University of Delft, building upon the strong interlinkages between universities within Europe for large research projects and (academic) collaboration structures to find SMEs. Living Lab Scheveningen has just started officially and has to free up capacity to be able to work on internationalisation.

Finances to run the testbed can be limited and the financial basis is sometimes rather short-term. Activities have to be financed somehow while free ridership can be a problem sometimes.

Discussion

International collaboration between testbeds will mostly benefit SMEs. It is often not in the direct interest of cities and large companies have their own means.

Regarding the needs, there seems to be a strong need to segment these more as one size fits all does not work. There should be a degree of "layered-ness" in the offer of testbeds for scaling up, that facilitates the different needs at different stages, for example by providing different offers from early to late stages (proof of concept, demonstration). The SCALE-UP project (Scale-up, 2021) developed systematics which might serve as an inspiration here and can evolve further by using the following elements:

- Use a grid as a basis to indicate the different stages in scaling and specific themes
- Make a distinction between physical and digital technologies and solutions, e.g., or blockchain
- Add a link to investment readiness programmes: X = start-up, Y = degree of intensity of programme
- Indicate focus on focus on cleantech, sustainability or smart cities if desired
- Specify commitment to upscaling
- Position Dutch and Swedish testbeds on this grid by asking partners to plot themselves. This can be the basis for linking them to each other, for example in a Miro session
- Analyse where are the overlaps and is potential competition, where are the white spots and is nothing happening.

UP-Rotterdam has used a comparable methodology.

Green Village confirms needs of Dutch companies for fieldlab-2-fieldlab exchange are dependent upon the stage in the innovation chain. They will vary from getting acquainted with the Swedish situation: knowing more about the issues in Sweden and about the local context. Depending upon that, more in-depth information might be needed, e.g., what is already available in Sweden for heat storage. Intermediate steps facilitated by testbeds as Green Village usually render better results than when start-ups and starters have to do it all themselves. A LIT could thus support the scaling of businesses by providing the connections, information on the local situation, and help to analyse what already exists and where no added value can be achieved for a business.

A challenge can be that sometimes scaling is not taking place due to non-synchronised processes between matched start-ups and corporates. After the match where the corporate business was interested, no immediate reaction follows from the corporate business after the start-up has shared more information about the smart sustainable solution, as processes take longer within the corporate business. As a result, the start-up stops with following up and the match fails. Management of expectations is needed to prevent start-ups from becoming frustrated. Corporates often do not realise how important new projects are for start-ups. The other way around, start-ups do not always realise that getting a mandate from the management within corporates takes time. However, if the momentum is in place, projects can grow very fast. LIT might help to make entrepreneurs aware of this, leading to more impactful matches.

Lastly, interviewees confirm that usually city administration, province or organisations as the National Road Authority are the scaling customer. However, to achieve this is often also a very unruly process with a lot of pulling and pushing next to showing that the smart sustainable solution works. This is aggravated by the fact that municipalities as organisations are rather fragmented and siloed. Many different departments being involved that all have an opinion, but also many other stakeholders being involved, make it complex to develop these markets. LIT could also be instrumental here by providing references, and streamlining or moderating such processes, based on experiences of businesses in the past. It could also advise on pre-commercial or sustainable procurement. In parallel, someone within a municipality or water board is needed who can couple internal processes and connects projects (for example matchmaker function in City of Rotterdam).

Companies: WeCity and Civity

Arjen Hof, founder of Dutch SME WeCity and until recently engaged in Civity, explains his experiences with scaling on the Swedish market with sustainable water management. Civity is part of the Horizon-2020 funded smart city lighthouse project IRIS, where Utrecht and Gothenburg participate. He sketches how utilities and infrastructural solutions are becoming more and more smart. WeCity offers services in this field as brokering between supply and demand by providing catalogues of quality-proved, certified and validated smart solutions that meet open standards, next to services as management of sensor hotels, humble lampposts etc. in terms of responsibilities, service level and maintenance agreements, and contracting.

Civity is already active on the Swedish market in collaboration with Lund-based company Sensitive, which works with Internet of Things platforms and Fi-ware standards. The companies work together on urban data platforms in Stockholm and Malmö. Barriers experienced in entering the Swedish market are procurement and contracting in the local language and lack of access to local networks. For that reason, collaboration with local partners that know the local market as Sensitive and RISE (city as a platform project) is considered by Arjen a key success factor.

Experiences in testbeds (i.e. Internet of Things in Sciencepark in Stockholm) are valuable but cost a lot of time and do not always yield sufficient outcomes. This is partly a result of a still immature market for smart city solutions, many of them being still in the proof-of-concept phase begin small scale or financed by EU-projects. Cities do not have substantial smart city procurements yet. At the same time, the wheel is often re-invented due to specific local procurement conditions and lack of scaling through limited standardisation. A horizontal platform could facilitate this, but might be difficult to connect to. A local agent of business as a sales partner is very important, to connect to the right people and enter the foreign market. Costs for developing this market can be shared then. The culture in Sweden and the Netherlands regarding open standards, open sources and preventing vendor lock-in is similar, this is an opportunity.

6. The city context

In this chapter, we discuss in more detail the parts of the smart sustainable city innovation and implementation system, that might influence how a LIT is set up, which services it intends to deliver, and which economic and societal impact it can realise.

Innovation and market uptake beyond demonstrations and real-world testbeds

Market potential

In the field of smart sustainable cities, innovation processes take place in an entirely different way than between industry partners only. It is important to realise this, as it significantly influences the possibilities for eventual scaling of smart sustainable solutions and technologies beyond the testbeds and living labs, where the market for these solutions is estimated at least on average 1 Billion of investments per average-sized city (C40).

Frost and Sullivan estimated the global market for smart cities to be worth over €1.78 trillion by 2025 (Frost and Sullivan, 2018). For the Netherlands alone, a study from 2017 by the Netherlands Environmental Agency calculated the total costs for the transition to a climate-neutral country until 2050 as amounting to 460 Billion Euros (Ros and Daniels, 2017). These figures show there is a huge market potential.

As already mentioned in Chapter 2, since 2014 more than 120 cities with their local ecosystems have been working together in Horizon2020 funded smart city lighthouse projects. They are demonstrating nearly 700 smart sustainable city solutions and technologies with good results: with most of these 5-year Smart Cities Lighthouse projects still in progress, the programme had achieved 53% energy savings, up to 88% CO₂ reduction, more than 17500 smart meters installed, over 1 Mio m² floor space refurbished, more than 5270 e-vehicles introduced, nearly 500 e-charging stations installed, and more than 260.000 citizens engaged in this transformation by the end of 2019.

Combined with 17 JPI Urban Europe-funded smart city projects, this means hundreds of industry, research and civic society partners have been involved so far, even not counting comparable initiatives such as EITs Climate-KIC, InnoEnergy and Urban Mobility. The experiences of this large community have spawned many reports on and evaluations of replication and upscaling of the smart sustainable solutions and technologies demonstrated in these real-world testbeds and living labs. It is widely acknowledged that, despite many successful demonstrations and a huge market potential, **replication and upscaling are rather limited so far** and a widespread breakthrough has not yet taken place (McKinsey Global Institute, 2018). Unfortunately, the indirect impact of implemented smart sustainable city projects is often limited due to their “pilot-like” character: more or less singular, tailored to a specific context and situation, with a limited scope and territory, and subsidy-dependent. Apart from this, persistent barriers limit the realisation of the afore-mentioned market potential and thus hamper indirectly the possibilities for scaling of businesses.

Common barriers to uptake of smart sustainable solutions and technologies in cities

These barriers have been extensively summarised (e.g., by DiNucci et al 2010, Dijk et al 2016; PWC et al 2016; Mosannenzadeh et al 2017; Borsboom-van Beurden et al 2019). Vandevyvere (2018)

gathered experiences on why it is so difficult to replicate successful smart city projects in other cities, making it challenging to create solid business models, and making investments much more expensive than they need to be. He summarises the five main barriers as follows (Vandevyvere, 2018):

- First of all, continuation of **business-as-usual** is too easy for city administrations and other organisations, due to lower risks and transaction costs, while behavioural change, not only by citizens and local businesses but also by other stakeholders, is hard to accomplish.
- At second, too much emphasis is put on the unique local context and situation, resulting in many smart sustainable city projects being highly tailor-made and on a rather limited scale, the "**not-invented here syndrome**". This makes them expensive to realise.
- Thirdly, **financial viability** assessments of energy efficiency and CO₂ reduction measures, the latter playing a major part in many European smart city projects, follow a narrow pay-back logic that neglects secondary benefits for society, for example for health, and neglects the willingness to pay of citizens and other local stakeholders for refurbishment measures for other reasons than financial ones. As a result, business cases and models are perceived as unattractive, while innovative value capturing methods are still in their infancy.
- Fourthly, **regulatory frameworks** and routines following from them are often designed to maintain the status quo rather than for change.
- And lastly, **politicians at different government levels are often insufficiently on board**, leading to a lack of concretisation and implementation of announced measures.

Additional factors prohibiting widespread replication and upscaling of smart sustainable city solutions are (Dinges et al, 2020; Mosannenzadeh et al, 2017):

- More often than not, the **timeframe of policies and decisions is limited to the current political cycle**, what makes it difficult to realise long-term smart sustainable city plans and make corresponding investments in technologies and solutions. Moreover, in a common municipal culture of outsourcing, tendering and contracting, the contribution of bids to the long-term plans and ambitions is often not taken into account.
- As investments are costly and operational savings as avoided energy costs alone are often insufficient to compensate for this, **business cases and business models might be less attractive or viable**. Compared to conventional solutions, they often higher initial and operational costs, and a longer payback time. Besides, the financial burden of making urban infrastructures, buildings and public space smart and sustainable can be too heavy for their owners and operators. Additionally, benefits can be experienced by others than the party bearing the costs (split incentives). At the same time, proposed investments in projects are often too small for finance industry, leading to higher transaction costs and thus less profitability. What is more, innovative solutions are often perceived as riskier, while financial industry might lack the technical skills for proper assessment of perceived risks. As a result, an **aversion to these risks** makes it difficult to get smart sustainable city projects financed. It is hoped that the new EU Taxonomy for Sustainable Activities, will improve this situation. It helps investors, issuers, project promoters and policy makers to understand whether a project is meeting robust environmental standards and to report on this once finance is attracted. It is expected that increasing amounts of capital will be looking for projects that align with this EU Taxonomy.

- While city administrations are often the driver and “gatekeeper” of smart sustainable city plans, their organisations are usually organised along specific themes, such as Transport, Environment or Economy. Many smart sustainable city projects cover several domains and need to integrate competences and knowledge of several disciplines and sectors. The involvement of many government sectors many times lacking experience in interdisciplinary collaboration or having unclear mandates, can lead to the so-called “**siloes**”, **hampering smooth collaboration**. Poor organisational embedding of smart sustainable city projects in terms of responsibilities and procedures, can exacerbate this and lead to power struggles or lack of ownership. This problem does not exclusively concern city administrations and other government bodies, but also larger businesses and research, complicating collaboration.
- For successful preparing and executing smart city projects, local governments are often highly dependent upon a wide range of stakeholders, such as citizens, tenants and local businesses, owners and users of land, buildings and infrastructures, operators of infrastructures, and other authorities, e.g., utilities, water board or region. They are also key partners in new ways of co-developing and co-delivering products and services in this expanding market (Economist Intelligence Unit, 2016). These **key stakeholders might be difficult to access and engage, having other priorities or having limited financial carrying capacity**. Many interdependencies exist among these stakeholders during the planning and implementation phases of projects and each stakeholder has a piece of the jigsaw puzzle but must be willing to put it in place. Deregulation and privatization of (parts of) former governmental organisations or the split between the ownership of energy and transport infrastructures and their operation and exploitation due to European competition rules, does sometimes not only lead to a proliferation of the number of key stakeholders, but also to these parties having other priorities now, such as operational reliability and profitability, over energy efficiency and sustainability.
- Lastly, **national and EU legal and regulatory frameworks** can be significant handicaps when applying smart sustainable solutions and technologies and scaling them beyond the testbed, by not allowing specific products or specific applications due to laws, norms and standards. Well-known examples concern the possibilities for trading of excess electricity, what might not be allowed, or specific devices not meeting the norms of another country. Related to this are the rules on state aid and low boundaries for procurement (50.000 Euro in the Netherlands, 30.000 Euro for Interreg).

As a result of these persistent obstacles, urban transformations and transitions are usually quite difficult, complicated and time-consuming to bring about.

Collaboration in and beyond testbeds

It is clear that the city market is not an easy one. With replication and upscaling not being in the core interest of cities, SMEs have to start all over again in every city where they want to do business. Several interviewees emphasized that there is currently a gap between successful testing and demonstrating and between what prospective customers in local ecosystems consider as proven technologies, leading to difficulties in finding finance for launching customers as cities.

This means that despite impressive real-world testbeds, market uptake and acceleration of successfully demonstrated technologies and solutions beyond the confined testbed environment, are often lagging behind due to the persistent afore-mentioned barriers. Government funding of innovation should take this phase more into account, and address financial, performance and acceptance risks perceived to create more impact beyond the real-world testbed.

A LIT can contribute to scaling of businesses and creating economic, environmental and societal impact if it manages to help closing this gap at least in the Netherlands and Sweden by providing go-to-market services that take account of these factors and tackle them where possible.

Further, next to services provided to businesses and possibly research partners, a LIT could also provide services to cities (including their local ecosystem of real estate owners, construction companies, transport operators and energy providers) and help to overcome the barriers to replication and upscaling as sketched in this section. Such services could entail for instance sharing of information on best practices, organisation of public-private partnerships, development of viable business cases for sustainable solutions, mitigation of financial risks, procurement of smart sustainable solutions, engagement of and co-design of solutions with key stakeholders, training and capacity building with city administrations.

Scaling and implementing innovative urban solutions

As indicated in section 3 about testbeds, LIT's focus is double;

- Urban testbeds for industry/commercial solution providers to the smart sustainable city market.
- The field of interaction and dependencies between such urban solutions testbeds and other parts of the smart sustainable city innovation and implementation system.

The interviews and reports that this project builds on have been selected for their focus on the first focus area, and this focus has been the root for starting the project. The results have been presented in the sections on testbed system level and testbed operational level.

The second focus area is a result from the conclusion that testbed interaction with the surrounding system is necessary for success, and that deeper understanding of that interaction is needed. In this field we rely mainly on the groups extensive experience from the field of interventions and projects on smart sustainable city development.

Concerning test, demonstration, implementation and scaling new solutions for smart sustainable cities there is a rapidly increasing number of interesting experiences and reports, many of them from the EU Lighthouse projects. A map-based overview of Lighthouse projects can be found here (<https://smartcities-infosystem.eu/scc-lighthouse-projects>).

One example is a report from Lighthouse projects Ruggedised (Johansson & Haindlmaier, 2019). They present the following framework for Innovation and implementation of solutions for smart cities.

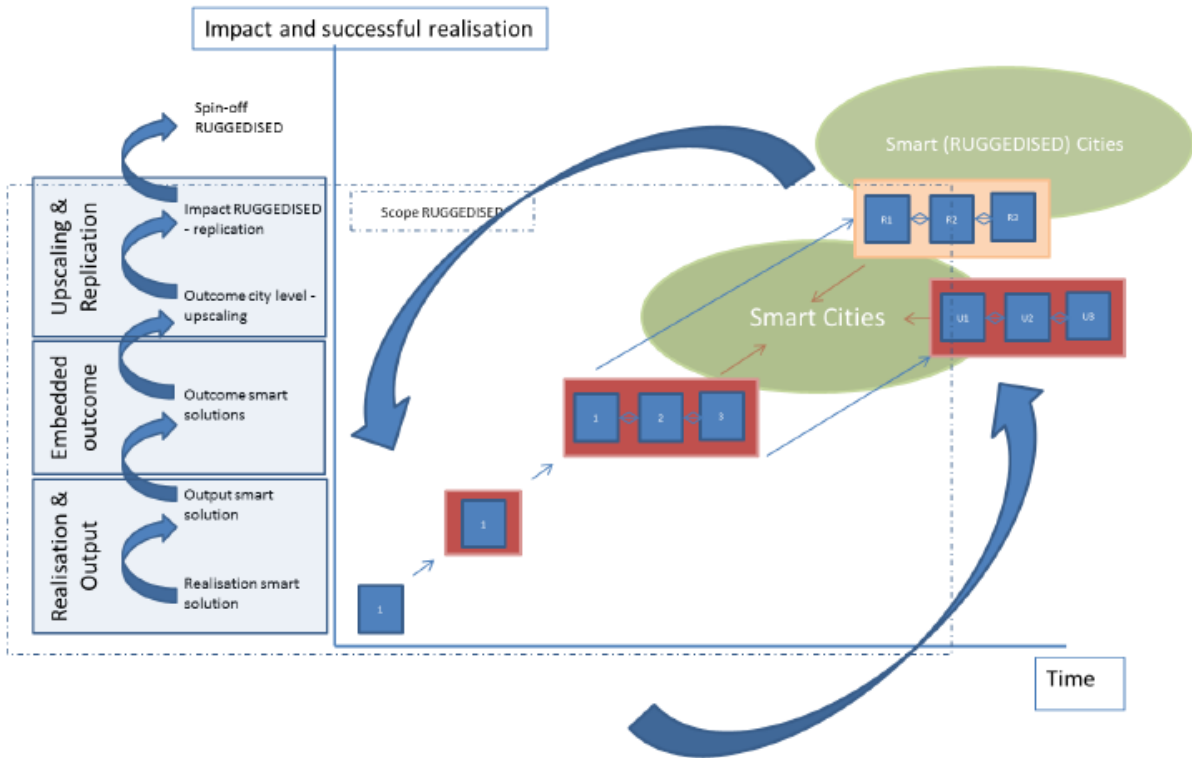
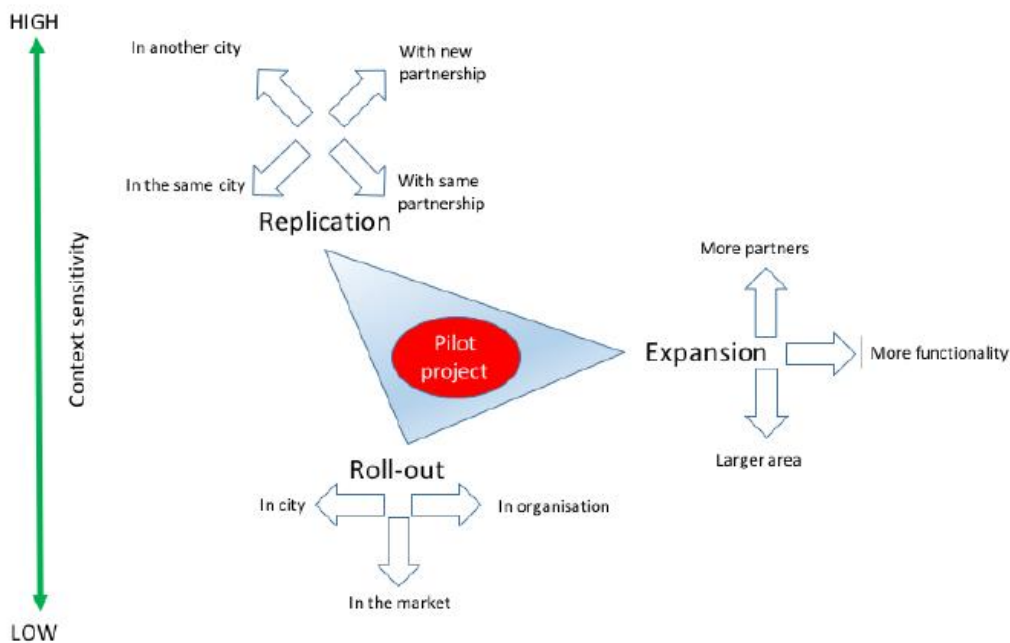


Figure 1. Overarching Innovation and Implementation Framework (RUGGEDISED, 2017)

This is just one among many examples of models exploring how to understand and support the road from innovation to established solution being spread on the market. It might also be interesting to build on research by Willem van Winden (Winden, 2016) presenting different types of upscaling of urban pilot projects, as this is a main objective for LIT. How this interacts with testbeds would be a potential field of continued analysis.

Figure 1 Three types of upscaling



There is also growing understanding that the internal organisation of local government is an important factor for how cities work with uptake of new solutions. Without going into detail, the following logic might be applied to understand city maturity on testing, demonstrating, implementing and scaling innovative solutions (adapted from (Edelstam, Chapter 4, Full report: urban mobility challenges during COVID-19, 2021)).

1. Urban smartness and sustainability constitute a complex system with a diversity of stakeholders with different knowledge, roles and responsibilities that need to collaborate – no one can steer the system by own mandate or decisions. It constitutes a wicked problem, so collaboration is necessary.
2. The requirements on city systems and services, is changing rapidly from the effects of climate change, technical development and digitalisation etc. New stakeholders are entering the playing field.
3. Planning and investments in this field hold challenges and risks. The large investments needed in future-proof cities, and the large amount of capital becoming available for those investments with new EU programs, and from an increasingly interested private sector, make it important to handle both challenges and risks.
4. To analyse and plan for this a broader group of stakeholders, new knowledge and new skills are needed, as well as more data and new ways to organise work in collaboration between stakeholders. There is a clear link between practices on data collection and use with innovation practices. The OECD study (Observatory of Public Sector Innovation., 2017) shows that *“The use of data to enable policy work was the most clearly correlated with a city’s familiarity with innovation work of all the variables considered in the survey”*. The result stresses the link between data collection and use, with innovation capacity and practices.
5. Within local government readiness to meet this development vary on a scale from not using data to well organised data collection and use, from lack of innovation work to advanced innovation practices, from only using only traditional internal municipality financing resources to innovative public-private-partnerships and new business models.
6. Organisationally cities span from traditional internal siloed work practices to dedicated cross-silo teams and strong collaboration with external stakeholders. This depend on size and resources of the city as well as on how advanced local government are in preparing for the transition needed.
7. Cities need to move up this “maturity scale” in order to meet the future requirements on urban sustainability. So, they need new competencies linked to transformation – process design, public-private-partnerships, governance of data, new business models, collaboration methods and tools, innovation leadership etc. Building this will take time, getting it done requires high level political support and financing.

In this broader process, LIT might have an interesting role to play in supporting cities in moving up this “maturity scale”.

Adding to this is the need to follow and participate in the international development in urban innovation. Putting city innovation in an internationalisation context requires an understanding of also how collaboration between subnational government institutions like cities and urban testbeds. According to NESTA (Moonen, Cosgrave, Nunley, & Zanetti, 2020) *“an increasingly important*

mechanism for SNGs to innovate has been direct international collaboration: networks of cities, regions and local governments innovating through a wide range of formal and informal strategic alliances, peer groups and platforms.”

Here we just want to present the recommendations that have the closest bearing at LIT, and concerns how collaboration ready initiatives are.

*Focus resources on collaborations that **are innovation-ready, including:***

- *Credible leadership and expert facilitation to negotiate international differences, provide challenge and rigour, and tease out local implications and innovation potential.*
- *Tight definitions, durations and objectives, with a clear account of what is required of network members in terms of commitment, responsibilities, ambitions and measurable outcomes.*
- *The profile and appetite to engage a wider stakeholder base, including citizens, business, investors, universities and other levels of government.*

If we would try to find a nexus of the different aspect discussed in this report it might be in creating a dynamic overlap between the following

- The advantages of well working and operationally focused testbeds with continuous services and support mechanisms for innovative companies
- Increased resources for flexibility in financing arising opportunities and for internationalisation.
- The maturity scale as a direction indication for where to go for cities
- The wider network and local innovation ecosystems in cities with all the real-world opportunities they present on testing, demonstration, implementing and scaling
- The system demonstrator approach in order to cover the broader system aspects of policy etc
- The need to involve the financial community in long-term collaboration on investments and business models
- NESTA’s analysis of how to work with international collaboration.

A starting point for setting up different routes to scaling could be based on the framework developed by Van den Broek et al (2020). They discern four different routes for scaling of innovations tested in testbeds and living labs: growth, replication, circulation and institutionalisation. Intermediary organisations play a key role in each route for technological, economic, regulatory and socio-cultural embedding of successfully tested innovations. Each route also offers different possibilities for scaling of businesses. Recommendations from this study pertinent to the architecture of a LIT are:

- To set explicit learning goals about what works and what not in terms of technological, economic, regulatory and socio-cultural embedding, reserving room for proper evaluation and also allowing for failures
- To anticipate in time on follow-up needed for scaling, e.g., by engaging specific stakeholders
- To make real-world testbeds and living labs part of a wider environment by a programmatic approach, e.g., coming from (inter)national innovation strategies or complementary and overarching initiatives

- To timely identify and engage intermediary organisations in the four different routes to scaling. This will enable societally robust learning about wide embedding of innovations and connections to wider networks

Relevant recommendations can also be derived the results of the recent stakeholder consultation on innovation ecosystems across Europe (European Innovation Council, 2020). The report propose concrete actions pertinent to both the system and operational level of our analysis in Chapters 4 and 5, among others:

- the consolidation of a structured and international network to foster internationalisation;
- improving the connectedness between cities and regions at one hand and between local public entities and local innovation stakeholders at the other hand;
- addressing the lack of innovation capabilities within public stakeholders;
- reduction of regulatory burden and fostering European regulatory sandboxes;
- stimulation of public procurement for innovation.

Further work on how to make this happen in practice in urban contexts will be needed.

7. Potential for bilateral testbed collaboration

This chapter analyses more in-depth how international opportunities can be seized for stimulating bilateral international testbed collaboration between Sweden and the Netherlands, and which constraints need to be addressed to be successful in this and which preconditions should be in place for successful business development in both Swedish and Dutch cities.

Benefits LIT can offer for scaling

Based on the interviews conducted with Dutch and Swedish key players, this section describes the main benefits that a LIT can offer for different stakeholders. These benefits are at one hand overall benefits of having a testbed, and at the other hand benefits of international exchange between testbeds. These two categories are interwoven and therefore difficult to distinguish.

Beneficiary	Benefits for scaling
For all	<ul style="list-style-type: none"> • Providing overview & insight on who does what in the Netherlands and Sweden, e.g., through website on testing opportunities, what is on offer at each testbed and how you can participate, so companies and other stakeholders can find the right testbed and also each other more easily • Common branding, visibility • Offer of common services as IP and legal advice • Physical location provides opportunity for networking with potential partners and active participation in a community (organisation of meetings and events, working groups important for that, e.g. Northern collections)
SMEs: start-up, starter, scale-up	<ul style="list-style-type: none"> • Getting a soft landing • Access to knowledge exchange, mutual learning and education • Support for valorisation of innovations • Receiving information on opportunities and what it needs to seize them (prospective markets, market players, how decision making is taking place, conditions as regulations, contracting and procurement, both for Netherlands and Sweden) • Attracting talent and finding expertise • Finding complementary partners and synergies to work along value chains, to come with a better and more complete offer, higher business value • Possibility for mentoring, coaching and matchmaking • Fast validation of smart sustainable technologies under different conditions and contexts (sometimes not possible or allowed in own country), and possibility to create more references that the solution works • Learning about non-technological aspects as marketing, regulations and social acceptance • Sharing of (possibly expensive) test equipment and infrastructures • Matchmaking of supply and demand (B2B and B2G to help companies scale, testbed being bridgehead to B&G customers) • Support for protection of IPR • Access to capital and funding/financing possibilities • Funding/financial means for trips and missions
Corporate	<ul style="list-style-type: none"> • Getting a soft landing • Access to knowledge exchange and mutual learning • Valorisation of innovations • Learning about non-technological aspects as marketing, regulations and social acceptance

	<ul style="list-style-type: none"> • Receiving information on opportunities and what it needs to seize them (prospective markets, market players, how decision making is taking place, conditions as regulations, contracting and procurement in Netherlands and Sweden) • Finding complementary partners and synergies to work along value chains, to come with a better and more complete offer • Matchmaking of supply and demand (B2B and B2G to help companies scale, testbed being bridgehead to B&G customers) • Attracting talent and finding expertise • Fast validation and possibility to create references under other conditions, possibility to validate smart sustainable technologies and solutions under different conditions and contexts (sometimes not possible in own country) • Sharing of (possibly expensive) test equipment and infrastructures
Investor	<ul style="list-style-type: none"> • Getting a soft landing • Scouting of investment opportunities • Field visits help to understand how smart sustainable solutions work and build trust
Research	<ul style="list-style-type: none"> • Attracting talent and finding expertise • Access to knowledge exchange and learning, e.g., through contact with practitioners and businesses • Providing educational possibilities • Access to test equipment and R&I infrastructures • Learning about non-technological aspects as marketing, regulations and social acceptance • Support for protection of IPR
Testbed	<ul style="list-style-type: none"> • Possibility to engage new innovative parties to use their facilities as test equipment and R&I infrastructures • Not re-inventing the wheel (which permits need to be approved for a testbed, partnership needed, which legal form, which financing and business model, what fee, which thematic meetings on topics important for everyone, how to run a testbed) • Possibility to organise (international) learning between projects • Possibility to foster clusters and complementary value chains through in-depth exchange between companies
City administrations and other local authorities	<ul style="list-style-type: none"> • Access to knowledge exchange and learning, collecting references on smart sustainable solutions and technologies, e.g., through field visits • Sharing as space for experimentation to observe how smart sustainable technologies work • Learning about non-technological aspects as marketing, regulations and social acceptance • Providing employment and possibilities for vocational training • Better access to finance for transitions as tested and validated innovations considered for implementation can be more easily financed (investors are more confident on well-performing projects in the city) • Programmatic approach results in more effective use of city administration resources for local innovation and economic growth than ad hoc customised approach
RDAs	<ul style="list-style-type: none"> • Supporting strong clusters of regional growth where innovations are valorised • Attraction of FDI and other capital
National government	<ul style="list-style-type: none"> • Realising national R&I agendas • Helping to realise agendas in the field of smart sustainable cities, e.g., through references fostering upscaling and replication of innovation smart sustainable solutions in other places, production of public goods (e.g. less air pollution, lower costs for public transport)

International representations of Sweden and the Netherlands	<ul style="list-style-type: none"> • Providing handles for more targeted economic diplomacy (promotion Dutch and Swedish businesses, insights on industry and urban contexts for market studies and business opportunities, information for trade missions and events) • Providing opportunities for international and intercultural exchange and collaboration
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Topics

It seems there is figuratively speaking a lot of energy around the following topics, which lend themselves for a LIT around smart sustainable city solutions:

- **Smart and sustainable transport:** in particular intelligent transport systems, smart logistics, mobility as a service, and autonomous vehicles. But also facilitating slow modes of transport in a smart way e.g., cycling seems underexplored (GPS-based planning of cycling routes, safety, concepts of seamless multi-modal mobility) and alternative fuels (e.g. green hydrogen passenger ferries interesting for Sweden and the Netherlands, large scale use of hydrogen and electric power in urban public transport);
- **Energy transition:** smart buildings, smart multi-commodity thermal and power grids, re-use of waste heat, low temperature district heating, compact energy storage in cities (e.g., Texel energy storage), Positive Energy Blocks and Districts;
- **Circular economy:** closing of resource loops at local level, smart waste collection, re-use and recycling, link to in-shoring and re-industrialisation, bio-materials;
- **Urban data and smart IT solutions:** cameras and Artificial Intelligence for crowd surveillance and management (related to crime, events and covid-19). See Living Lab Scheveningen for crowd management and reduction of the environmental footprint of beach tourism. Further, new smart sustainable solutions using sensors and actuators, cyber-physical systems and real-time georeferenced data in Urban Data Platforms for better maintenance and management of buildings and infrastructures in the built environment. Closely related to this, smart technologies on digital twins, Augmented Reality and Virtual Reality for in-depth simulation and co-creation with key stakeholders. Lastly, wider uses of robotics, Artificial Intelligence, and blockchain within the built environment.

A couple of topics are definitely part of the family of smart sustainable solutions, but maybe not suited for inclusion in a LIT at first instance. For example, by being part of the energy-food-water nexus, the topic of *smart water management* (grey and blue water infrastructures in cities, decentral purification, energy and nutrients recovery from wastewater) is a likely candidate. Similarly, smart solutions for *healthy urban living* are closely related to environmental stressors, quality of public space, access to health care, possibilities for sports and exercise, and prevention of obesity, respiratory diseases and mental health problems.

Characterisation of individual testbeds suitable for international collaboration

In the section about testbed types, we identified a couple of characteristics that real-world testbeds should have in order to be focused on delivering support to testing, demonstrating, implementing and scaling solutions for urban transformation in interaction with the surrounding city system.

Both desktop study of reports and, maybe foremost, interviews done with key individuals both working on system level with testbed development, and staff in actual testbeds, complements that picture with additional aspects.

The interviews with operational staff in individual testbeds show a wide diversity on how they focus and work on daily basis, and what services they provide as well as their international engagement. Built on this we here present a first draft proposal for characterisations factors that can be useful when analysing the individual testbeds that might be engaged in a community of international testbeds collaborating on supporting urban innovative solutions for smart sustainable cities. The focus is on what can be offered to international companies, so it can be seen as an international collaboration readiness checklist.

Testbed offer	Short explanation	Comment
Real world testing opportunities	Opportunities to test and demonstrate innovative solutions in real application environments, that is out in the city with its full complexity. Close to real environment can also work if done right.	Here, interaction and collaboration with the surrounding innovation ecosystem and the cities different actions need to be used.
Soft landing	Opportunities for innovative companies to get normal office support services	The most commonly offered service.
Networking	Opportunities for meeting local and regional stakeholder from public, private and academic sector in order to establish relations and collaborations necessary to be successful.	As urban solutions often depend on integration into existing systems of different kinds (technical, policy, cultural etc) quick and efficient guiding is very important.
Financial support	This includes a range of services from different kinds of public sector funding or financing opportunities,	Specification should be provided, as this is a

	to open up networks of private sector financing/investors.	broad filed of economic issues.
Legal services	As legal systems might be a key factor on new markets the testbed should be able to offer access to both legal services and to knowledge about the different legal requirements on the local/national specific market	A wide field, where possibly the testbed service might be “know who knows”
Market insight	Understanding the market and how it works is key for establishing in a new country.	Local market needs and preferences, and existing invisible networks might be obstacles to understand. Cultural differences also.
Customer sourcing	Support in identifying and contacting potential customers will help the company to quicker understand customer demands, and ow to enter the market.	More focused than just networking
Recruiting	In new markets being able to recruit staff or buying consultancy services with knowledge about local context is key to success.	Seems very few testbeds provide this
Lab/test equipment	For certain innovations availability of specific equipment might be necessary.	Specification should be provided
Permits	Testbeds can have different permits to run tests or use specialised equipment, which make it possible to help companies that requires this.	Specification should be provided
IPR handling	Intellectual property is a key asset for many innovative companies, and advice on strategy to protect business secrets, patent services etc is of importance.	Could be by collaboration with specialised IPR advisers.
Mandate and willingness to take on international clients	Some testbeds are for political or funding reasons mainly focused on supporting local or national companies, or have staff with a low interest for international collaboration. Dedicated staff for internationalisation is a strength.	Support to local growth and jobs often dominate over sourcing the best solution available internationally

The list is not exhaustive and so need further detailing, but still cover main aspects in a way that make it useful for LIT and other exchange projects between urban solutions testbeds. It is a kind of wish-list, as none of the interviewed testbeds check all the boxes. Especially in the Netherlands, as observed earlier, there are currently very few or no testbeds that offer all of these services. Often this is done by the local ecosystem or RDA. Still, the checklist can be used in a couple of ways:

- When identifying suitable testbeds for engaging in the LIT, the list can help finding the ones that are most “mature”.
- When companies look for a suitable testbed to establish themselves in, they get a better understanding of what services are offered
- For the individual testbed that want to engage more in international collaboration it might be used as a SWOT help and identify opportunities for development
- If used for a larger national sample of testbeds it can be used to identify strengths and weaknesses in the system of testbeds, and so be helpful in designing policy, support programs or other interventions

For the LIT project, the list could be used to identify 3-5 suitable testbeds from Netherlands and Sweden respectively, to contact and engage in the next step, establishing a first operational prototype collaboration community. That prototype can then be run as pilot scheme for learning and developing a broader collaboration including more testbeds and countries. A first, very simplified, try to characterise a few Swedish testbeds according to this checklist is available in Appendix.

It should be noted that this might be applied also to test and demonstration environment in cities that are not formally organised as testbeds in the form of a special organisational entity, but still have an organisational context with continuity and showing the different aspect of testbed characteristics discussed in chapter3. Examples for consideration could be the innovation platform for smart sustainable cities in Lund (City of Lund, u.d.), Sweden, or Green Village, Living Lab Scheveningen, Brainport Smart District and Strijp-S and -T , the Amsterdam Smart City (Amsterdam Smart City, u.d.) and the Start-up in Residence programme running in nearly all large Dutch cities (City of Amsterdam, u.d.), Netherlands.

Opportunities and constraints for LIT at European level

In chapter 4 and 5, the opportunities and constraints for Sweden as well as for the Netherlands have been extensively discussed. Therefore, this section will focus specifically on the European level. The LIT ambition is to establish a European network of testbeds, with a bilateral collaboration between the Netherlands and Sweden as a first step. This collaboration can then be subsequently expanded by integrating new countries, for example Germany which is a forerunner in sustainable urban mobility. This section highlights the opportunities and strengths for LIT at a European level, based on a SWOT-analysis of the material from interviews and key reports.

Strengths

The strong focus on achieving European climate and energy goals and on urban sustainability as reflected in the Green Deal and official endorsement of the UN SDGs by the European Commission, means that the focus of a Swedish-Dutch LIT as envisaged now is well-aligned with EU policy priorities. LIT is also well-placed to help realising the R&I and digitalisation agendas of the EU.

For Sweden and the Netherlands, a level playing field exists within the European Economic Area (financial, export/import etc.) and European certification and standardisation of smart sustainable solutions and technologies. This facilitates the testing of prospective solutions as their eventual market uptake.

Dutch and Swedish testbeds are generally well-connected to and participating in key European structures, repositories and platforms, such as deep demonstrators and flagships of Climate-KIC, the CIVITAS Knowledge Hub, and European Network of Living Labs. The Netherlands and Sweden have been very successful in securing EU-funded smart city projects: nearly 50 highly ambitious smart city lighthouse projects (six in NL and three in Sweden) and nearly 80 prospected adopters, one of them located in Sweden (Malmö). These cities collaborate and exchange information through the Smart Cities Marketplace and Board of Coordinators. Collaboration between the Netherlands and Sweden in these projects has been very successful with a high level of trust. Results of these projects are accessible for everyone through repositories as the Smart City Information System (now integrated in the Smart Cities Marketplace). What is more, both the Netherlands and Sweden have been active participants in other networks focusing on smart sustainable cities, such as URBACT, Climate-KIC, KIC InnoEnergy, EIT Raw Materials and JPI Urban Europe-funded projects. This means there is a structure to built upon for LIT as both countries are already well-integrated and can mobilise this knowledge for new innovations.

Lastly, the “European way” of implementing smart sustainable technologies, based on respecting GDPR and realising transitions in a just and inclusive way resonates very well with the values of Swedish and Dutch societies.

Weaknesses

From the analysis in Chapters 4 and 5, it is clear that organisation of and access to testbeds is still a major obstacle. Information on testbeds and demonstrators is dispersed over many platforms, databases and repositories, especially in the Netherlands.

Further, not all actors in testbeds have equal access to knowledge and information to be able to use networks and EU-funding. Universities, research institutes, companies, cities and regions with a Brussels representation usually know the way and are more successful in access to knowledge and funding. This is particularly a problem for small and medium-sized local authorities.

R&I funding usually promotes pan-European collaboration over regional collaboration, the latter supposed to get support from national governments and EU Structural Funds. This might hamper innovation at the local and regional level. For example, for municipalities it often makes much more sense to work with neighbouring municipalities than with municipalities in other countries which might have totally other mandates, regulatory frameworks and contexts. This goes for companies as well and influences also the potential for real-world testing. Further, securing R&I funding from Brussels takes some time and this might not be in line with the timeline and expectations of companies operating in testbeds. In Horizon 2020, there are eight months between submission of a proposal and signing the grant agreement.

Finally, a considerable deal of urban policy and decision making by local governments falls under the subsidiarity principle, meaning that it is not harmonised within the EU. This means that different conditions apply to real-world testbeds and urban markets within Europe.

Opportunities

In 2021, a new programming period has started, and EU policies and funding instruments have been revised. In this new 7-year programme of the EC, huge budgets have been made available for decarbonisation of cities and economies and for post-Covid-19 recovery through the Green Deal and Recovery Funds. Green Deal budget will also flow into cities according to national Swedish and Dutch policy priorities as indicated in the EU Semesters. InvestEU might be of particular relevance here as it provides 372 Billion of public and private finance through EU guarantees to promote recovery, green growth, employment and well-being at local level .

What is more, the new R&I funding programme Horizon Europe kicks off with ample attention for realising smart sustainable cities according to the European model (just, inclusive, sustainable, GDPR). The content for Horizon Europe will be co-created with the so-called Mission Boards, and with the Mission Board 100 Climate City Contracts will be prepared. New partnerships related to the work of the Mission Boards are currently established, such as the Driving Urban Transitions Partnership based on national research and innovation funding agencies already participating in JPI Urban Europe, but also including other partners as Climate-KIC, Eurocities etc.

Revised and new policy and funding instruments help to implement the EU goals on smart and sustainable cities, such as the European City Facility for Energy Transition, Urban Innovative Action, Renovation Wave, Digital Innovation Hubs, 100 Intelligent Cities, Living-in.EU, JPI Urban Europe calls on Positive Energy Districts, GAIA-X data rooms, etc.

Besides, for the first time there is a possibility to couple several ERDF and Cohesion funds (e.g., Interreg) with Horizon Europe funding, where rules on state aid have been relaxed to promote local and regional innovation and transition towards sustainability. This opens the possibility for collaboration of testbeds with other partners in the region as part of the smart specialisation strategies (RIS-3, e.g., Kansen voor West in the Netherlands). EU programme targeting emerging technologies and SMEs as ITEA and EASME will be continued. EU funding is in many testbeds and important means for financing the basic operations, such as a secretariat, director and communication officer.

Threats

Developing partnerships and proposals funded by EU, takes considerable time. EU-funding can also be quite competitive, for example in Horizon Europe the average success rate lies usually around 10-20%. ERDF funding fares a bit better at slightly more than 20%, and the Netherlands has financed around 180 testbed projects (60 Mio Euro) by it, but some testbeds experience accounting rules as extremely strict in the Netherlands. Finally, rules on state-aid and competition can make ERDF-funding less attractive, but have recently been relaxed. So, it needs to be investigated if this makes access to EU-funding and the connection to regional smart specialisation strategies for testbeds easier.

8. Roadmap for LIT

Building bricks and timeline

The following phases could be foreseen for preparing and establishing a LIT.

Follow-up investigation:

May-July 2021

- “Market research” for LIT to check if there is really a demand, and further exploration (pre)conditions. This in combination with detailed actor/beneficiaries mapping and validation of benefits for all actors/beneficiaries, and development of a detailed value proposition
- Based on this, definition of services the LIT could provide to beneficiaries
- Summarise information pitching LIT in a slide deck, focusing on conclusions and recommendations, with pro’s cons/ opportunities, threats and ROI, including aspects of governance. The slide deck explains for various beneficiaries what is in it for them and for the “Netherlands Private Limited Company”(BV Nederland) and “Sweden Private Limited Company”. It is an instrument to convince various parties to invest time, money, capacity, policy scope etc. in it
- Solicit support of enablers, e.g., relevant ministries, agencies, business associations with this slide deck
- Establishment of a Sounding Board active until launch
- Expression of interest of companies, test beds and cities via RDAs
- Selection of key topics for collaboration and performing a market scan in Sweden and the Netherlands for these topics that enables future matches
- Exploration possibilities to link to existing comparable networks, e.g., as partners in ENoLL (Dutch and Swedish chapters) or Driving Urban Transitions partnership, or platforms as SmartCityPlaza and Bable
- Positioning towards national and EU networks and opportunities, e.g., new City Deals, 100 Climate City Contracts, Digital Innovation Hubs, JPI Urban Europe etc.
- Scout possibilities for national and EU funding (and submission dates) such as Dutch National Growth Fund, InvestEU, Green Deal, ERDF and smart specialisation strategies, Recovery Funds, Positive Energy Districts call Fall 2021
- Definition of the public-private partnership and business model
- Defining rules of engagement by creating templates for the profile of a suitable company, the process a company goes through whilst in a testbed, and when it is time for the next step beyond the testbed, next to developing criteria for selecting companies and testbeds sufficiently mature to participate and for assessing their commitment to participation. The LIT needs a programmatic approach instead of a series of customised ad-hoc trajectories, and the intake should reflect that
- Organisation and legal forms, roles and mandates, designation of broker/intermediary role(s)
- Risk assessment, e.g., different regulatory frameworks
- Detailed timeline
- Evaluation of feasibility

Outputs:

Detailed Terms of Reference for LIT, approved by relevant enablers both in Sweden and the Netherlands. Go/no-go decision for the next phase.

Preparation detailed implementation plan:

September-December 2021

- Based on input collected preparation of detailed plan for implementation of LIT
- International communication activities
- Plan for management of and secretariat for LIT
- Plan for stakeholder management
- Plan for recruitment of companies, testbeds and urban stakeholders
- Plan for operational activities and services of the LIT, also working out different routes of scaling and role of intermediaries as discussed earlier
- Build a coalition of the willing (3-4 companies, testbeds and cities that want to collaborate)
- Ensuring finance/funding, e.g., through RDAs, national and European possibilities
- Preparation evaluation performance of the LIT
- Proposal for risk management
- Go/no go for LIT (who must decide this? The Ministries?)

Output:

Detailed implementation plan and go-no go decision for the next phase

Inception:

January-March 2022:

- Launch of the LIT
- Branding
- Marketing plan
- Development and implementation of management and communication procedures
- Development and implementation of services
- Development and implementation of tailed multi-annual operational activity plan
- Recruitment of companies, testbeds and urban stakeholders
- Exchange of staff to better understand how the systems work on the other side
- Establishment Ambassadors Group with representatives from key organisations and stakeholders

Operation:

April-December 2022

- Operating the LIT with the Netherlands and Sweden
- Half-yearly evaluation of performance
- Amendments where needed
- Development of new services and activities
- Ongoing recruitment of companies, testbeds and urban stakeholders

Expansion:

January-December 2025(?)

- Further evolvement, adjustment to new topics and possibilities
- Extension of LIT with other countries, e.g., Germany

Financing and organising

At the moment, it is difficult to provide detailed information on this, as this framework study is too small. For that reason, we discuss here possible models for LIT that have to be investigated more in-depth in a new round:

1. Connect SME model

- started December 2020, funded by Interreg (ERDF for cross-border economic collaboration)
- cross-border collaboration between Belgium and the Netherlands with Green Village, Brainport, TUD, TUE, VITO, CleanTech Delta
- one cluster of three field labs in the Netherlands, one cluster of three field labs in Flanders
- Green Village involved a testbed
- If successful cross-border match between SME and field lab, budget becomes available for the SME
- LIT as a field lab would fit well in this

2. GIST:

- Flemish-Dutch collaboration that accelerates the transition to a clean process and manufacturing industry
- Runs from 2018 to 2022, funded by Interreg
- Partners CleanTech Delta, City of Rotterdam, RVO, Ministry of Economic Affairs, many small companies
- Develops and co-finances 25 FEED-feasibility studies for sustainable innovations which require investments to bridge the 'Valley of Death' for technological innovations otherwise not reaching the market due to high development costs and (technological) risks
- Maximum size feasibility study 80 kEuro, max 50% subsidised

3. Super "City deal"

- Develop the LIT under the umbrella of the current City Deals as a special public-private partnership
- Financing comes from national Swedish and Dutch governments

Roles and responsibilities

Acting perspectives

This section describes the acting perspectives of key stakeholders involved in the preparation phase of a LIT.

Cities:

City administrations interested to work with LIT can contribute through collecting expressions of interest of companies and real-world testbeds in their city and by giving recommendations or selecting companies, testbeds and cities. Further, they can state begin prepared to extend their economic policies and their services to LIT (e.g. soft landing, UP Rotterdam). Besides, city administrations and other stakeholders in the local ecosystem can express their interest to participate in LIT (share information on needs, indicate and provide locations and opportunities for testing, adoption of technologies and solutions validated in LIT, contracting and procurement, etc)

RDAs:

RDAs can contribute by collecting expressions of interest for participation from companies and real-world testbeds in their region. Like city administrations, they can also make recommendations or select companies, testbeds and cities. In addition, RDAs can use their internationalisation and innovation activities to advance the case of LIT. Further, RDAs are well-positioned to foster complementarity across the value chain by linking different companies and can advise the LIT from that perspective. In addition, they can help to attract capital and talent, and provide information on markets. Lastly, they can help by being the liaison between companies, stakeholders in the urban ecosystem and government levels. RDAs can be a crucial intermediary and broker for the LIT, and for example scout interested Dutch parties, not only companies and real-world testbeds but also city administrations and key stakeholders/prospective customers in their local ecosystems, such as construction companies, energy providers, waste collectors, water boards and transport operators.

National government:

Ministries and agencies can provide subsidies to get LIT started. Besides, RVO can help by opening its instruments for Swedish partners, providing information on markets and doing business in the Netherlands, and international opportunities.

Europe:

Enterprise Europe Network can help to recruit suitable companies and testbeds for LIT. Other relevant networks as ENoLL can provide useful information on running real-world testbeds, knowledge exchange, mutual learning, and upscaling and replication of successful innovations.

Embassies:

Economic Departments of Embassies and Consulates can support the creation of LIT by connecting to the right partners in other countries.

Industry:

can provide Letters of Support or Letters of Intent to the detailed LIT proposal stating their interest to participate in LIT.

9. Conclusions and recommendations

Here we present a number of recommendations. In order for them to be more actionable we tried to separate them on different segments, even though there are overlaps and interdependencies between some of them.

Through the work with this project, we came to realize there are interesting differences between system level and operational level, as well as between the Netherlands and Sweden. These insights go beyond the next steps of the League of International Testbeds and should so be used to think about also broader development opportunities. Thus, we have separated recommendations on both the two levels and the two countries.

The results and analyses in the report might also be used for a broader discussion about potential interventions and development opportunities for smart sustainable city development linked to implementation and scaling of innovative solutions, but we have restricted our recommendations to issues concerning real world testbeds on urban solutions, and the interaction between such testbeds and closely related initiatives on smart sustainable city development.

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Conclusions

The work on this study has shown how complex the systems around testbeds and smart sustainable cities are, and how interdependent different parts of this system are. This also goes for potential interventions and actions that might be taken. Acknowledging this, we still would like to point to a number of conclusions that we have come to, that might help in building a baseline for the recommendations.

- The concept of testbeds for smart sustainable cities varies considerably, and the boundaries are blurry towards other close-to-real-world test and demonstration activities. Here is a field where more research and testing of different models for collaboration and governance could bring better system understanding, and create a better basis for interventions.

- There are considerable differences concerning testbeds between Sweden and the Netherlands when it comes to definitions, overview and coordination, ownership and operations as well as legal and governance models. This creates opportunities for learning. The learnings can be applied both on system level and operational level in each country, and for collaborations between Sweden and the Netherlands. Potentially the learnings can also contribute to a broader international development of testbeds and collaboration between testbeds.
- There is a deficit of internationalisations of testbeds in both countries, compared to the need for spreading of urban solutions, and also the potential expressed and latent interest from testbeds and innovative companies.
- There is a clear need and interest expressed from operational level for increasing international activity and collaboration, as well as a need for support on how to go about this. The needs include knowledge, practical experiences, support services and resources. At the moment there is no clear stakeholder offering these kinds of services and support in a comprehensive way.
- There is interest from a number of testbeds to engage in internationalisation efforts. We have identified a number of key factors that together constitute a first checklist of functions and services that a testbed would benefit from offering in order to internationalise. Some have started developing this, but none has a full value proposition, and most will need considerable support to establish themselves internationally.
- There is also expressed needs from national level for increased internationalisation of testbeds, though with a bit of differences in motivation. In the Netherlands primary focus is on helping innovative Dutch companies to grow, in Sweden primary focus is on increasing the number of international clients to Swedish testbeds.
- Furthermore, there is interest from innovative companies from both countries to enter the other country's markets, but still a lot of uncertainties on potential and on the best way to do it. Guidance is needed.
- There is a clear potential for increased involvement from private partners in the governance of testbeds, as well as a potential for closer collaboration with testbeds and the private sector concerning test, demonstration, implementation and scaling. New business models and governance models can be built on public-private-partnerships.
- There are a number of challenges concerning increased international collaboration between testbeds. Among these are the lack of relevant support services on internationalisation, lack of flexible budget resources to support the process of testing, demonstrating, implementing and scaling innovative urban solutions, lack of overview of testbeds and their offers to innovative companies, lack of information in English, and to some extent cultural differences.

Recommendations

Initiatives on operational level in Sweden

- Operational actions for increased internationalisation should contain the following:
 - work on further detailing for analysing and characterisation of internationalisation readiness level in urban testbeds (can be applied also for other sectors than smart sustainable cities, but adaptation of criteria might be needed)

- development of support services in order to help individual testbeds develop their readiness level.
- develop a learning/training/development support program for that have strong potential for international collaboration and exchange, but still lack a number of the prerequisites and services to be successful and attractive for international companies. Draw experiences and learnings from the LIT prototype project below for this, as well as learning of operational best practice in an international context
- initiatives on two-way exchange of innovative start-ups/scaleups providing solutions for smart sustainable cities

Initiatives on system level in Sweden

- The activities on operational level and with a LIT prototype project will contribute to an overview of status on international collaboration readiness in the sample of analysed testbeds. Use this for
 - working on policy considerations concerning overall testbed development in the national system. Give special attention also to the urban test- and demonstration environments that have testbed character but are not formally testbeds, as it in this field might be strong potential for international exchange on both urban solutions and learning processes.
 - Identifying the “high potential readiness” testbeds/urban test and demonstration environments can also establish a first basis for starting planning for clearer value propositions and increased marketing/positioning of them towards international testers, and so strengthen the Swedish test and demonstration profile and increase number of international testers that come to Sweden.
- As there are both similarities and differences in how Sweden and Netherlands work with living labs/real world testbeds, including urban testbed-like environments, a broader learning project should be considered. Such a learning project should look at both national system and policy level and the operational execution in urban testbeds/city test and demonstration settings.
- Create a better overview/mapping of internationalisation ready urban solution testbeds and “testbed-like” city environments. Clarify the terminology on different testing environments, based on the NESTA definitions, but also adding different types of smart sustainable city test- and demonstration environments, like pilot projects etc.
- Start working on understanding the interdependencies and interaction with testbeds and the surrounding city system, in order to build understanding of what strategies, tools and methods that can be used to increase uptake/implementation and scaling of new solutions from testbeds to broader city context. Cities as system demonstrators can be a basic perspective to use. Doing this in a two-country context will contribute with more diverse perspectives, practices and experiences.
- As urban solutions implementation and scaling is heavily depending on collaboration between public and private sector, executed in the local city context, it might be important for Vinnova to look into how Vinnova’s testbed programs and policy on societal challenges and Vinnova’s work on industry and innovative business ecosystem can create synergies and increased value/effects, and potential links between these areas of work.

- To successfully create test, demonstration, implementation and scaling of innovative urban solutions the whole web of interactions between stakeholders need to be working, but also the link to financing, and the openness for international solution providers to enter the system needs to work. This field requires more work on methods and tools to analyse what interventions work, and how to take actions on different level, from legislation and policy to practice on local level in cities, in order to support transition to a more efficient development, implementation and scaling of innovative urban solutions. Vinnova and RVO should analyse how to start working on this. Some aspects might be
 - Tools and methods for governance of PPP on testing, demonstrating, implementing and scaling solutions for smart sustainable cities.
 - Special focus on how to build collaboration between local government and financial sector on this, including new financial instruments, risk sharing methods, value calculation tools etc.
- Set up a process for increased collaboration with the financial sector, with the long-term objective to significantly increase private investments in testbeds and the go-to-market chain from test to scaling.

Initiatives on operational level in the Netherlands

At an operational level, it is recommended to deploy the following activities as next steps:

- First of all, in the rich landscape of different testbed-type of environments and public-private partnerships in the Netherlands **a much better overview is needed** of which ones could be relevant for the LIT. For that reason, it is recommended to make a comprehensive overview based on the current innovation landscape for smart sustainable cities as sketched in Chapter 2, and analyse which testbed-like environments and partnerships fall within the scope of smart sustainable cities and are relevant to the LIT.
- Based on this analysis, a more detailed study of those testbeds should be performed: which technologies and solutions are validated, how is the partnership structured, which actors are participating, which legal forms are used, how are they financed, what are preconditions for participation, is it possible to participate as non-Dutch partner. The latter is related to the work on defining internationalisation readiness levels as proposed for Sweden and could be done jointly with Swedish partners. It is strongly recommended to do a **detailed actor mapping** as part of this analysis and consolidate the results of the detailed study in factsheets per testbed. The overview thus created, would at the same time also be extremely useful for **creating a learning environment between Dutch stakeholders**, e.g., for implementing innovation and digitalisation agendas, realising the energy transition, making local economies more circular and making mobility and logistics cleaner.
- Once this overview is created, it is recommended to **more thoroughly validate the needs** as observed in this study of companies, cities and their stakeholders, RDAs, national governments, and maybe also research, related to international collaboration. For the Dutch side, it appears that while some testbeds are internationally oriented and working with partners from abroad and SMEs are open to the idea of cross-border collaboration, the interest in Swedish collaboration and its potential advantages are not always manifest. Besides, from the interviews and our analysis in Chapter 7, it follows that the needs and

interests of different actors might vary considerably per actors, and for companies per stage in the innovation chain. In-depth insight into these needs is essential, not only for assessing the basis for establishing a LIT, but also for **identifying and designing the services the LIT could offer** and mobilising relevant actors in the preparation phase by providing more information on the advantages of LIT. Building on visualisations such as grids used in SCALE-UP could help to stratify and analyse these needs (Scale-up, 2021).

- In case there are too many testbed-like environments in the field of smart sustainable cities in the Netherlands for this thorough validation of the needs, what would not come as a surprise, it is recommended to take a cross-topic representative sample for this validation of needs. In this light, it should be considered that the LIT might also provide services to city administrations and local authorities as water boards, for example advice on the introduction of smart sustainable solutions and technologies, providing references, offering knowledge and innovation vouchers, managing and moderating innovation projects, training of practitioners and policy makers. Lastly, related to the services LIT has to provide, **language aspects have to be considered**. Key information for SMEs as publication of tenders, is in Swedish. Good quality machine translation of websites and documents as Tilde software, can be instrumental in overcoming these problems, also for Swedish parties interested in Dutch information.
- In parallel, it is recommended to gain **more insight into how the market of smart sustainable cities looks like in Sweden**. This information could for example by can help to convey better to potentially interested testbeds and SMEs where current opportunities exist. A starting point could be to investigate **which current trade and exchange relations exist between the Netherlands and Sweden in the field of smart sustainable cities** to know what is the current basis for cross-border collaboration and which key players are already active. Databases as RVO's Achilles can provide this information. As this study concludes that LIT can also contribute to scaling by supporting go-to-market, it is recommended to scan upcoming market opportunities beyond the more confined testbed environments as well. What are big investments that can be expected in the built environment and urban infrastructures?
- Lastly, SMEs need better insight into what is more or less needed to do business in Sweden. Regarding companies, it is advocated to focus on SMEs as they need more help in scaling than large companies. A few in-depth interviews on the experiences of companies can **shed light on practical obstacles for cross-border collaboration** encountered, which will probably be pertinent to SMEs and testbed-like environments and partnerships interested in this cross-border collaboration. For instance, legislation, norms and standards play an important role in permitting specific products and technologies. How does this play out for the solutions provided by companies interested to participate in Swedish testbeds and enter the Swedish market?

Initiatives on system level in the Netherlands

In parallel to Swedish activities addressing the system level, comparable Dutch activities could entail:

- Develop a **concise slide deck**, focusing on conclusions and recommendations, with pro's cons/ opportunities, threats and ROI, including aspects of governance. The slide deck

explains for various beneficiaries what is in it for them and for the “Netherlands Private Limited Company”(BV Nederland).

- Contact and **mobilise relevant networks and initiatives in the Netherlands and within Europe**, such as other RDAs through the Workgroup Trade & Innovate, TechLeap, the recently established Dutch association of field labs, European Network of Living Labs, and Enterprise Europe Network. For example, with TechLeap, a collaboration on smart sustainable cities could be started regarding collection of information on the market in Sweden (so-called market entries). Maybe representatives of key networks and organisations could be invited to an Ambassadors Group, that guides further in-depth investigation and subsequent preparation, and thinks about the form the LIT should ideally take. In this respect, establishing a LIT through collaboration with existing platforms such as SmartCityPlaza, Bable, and BeeSmart is something that should be considered as well.
- Elaborate what would be needed to enable the different routes to scaling as mentioned in Chapter 6 (i.c. growth, replication, circulation and institutionalisation) to already plan for the phase beyond the testbeds. The framework of Van den Broek et al (2020) gives very practical, hands-on recommendations on this, e.g., how to fill in these routes with activities preparing for scaling beyond real-world testbeds, how to engage intermediary partners that play a key role in each route for technological, economic, regulatory and socio-cultural embedding of successfully tested innovations, and how to set up a learning environment. In this respect, the NESTA approach (Arntzen et al, 2019) as sketched in Chapter 3 and the actions recently recommended by the European Innovation Council to promote robust innovation ecosystems, could also be instrumental.
- In parallel but related to the above, it is recommended to start a **process that defines who decides what**. Which organisation or set of organisations can take an official decision on whether and how the LIT will be established? This can also be linked to the question who should do what: what useful management models for are the LIT, including role division, responsibilities and mandates, ownership. If it is more efficient to link to existing networks, which networks could that be? During this process, it is recommended to define how the **overall performance for LIT could be expressed in SMART-defined Objective Key Results (OKRs)** and how it can be monitored, to make amendments if needed.
- Also, in parallel, it would be wise **to explore funding and financing possibilities, both from the private sector and public sector**. For the public sector, possibilities at regional, national and EU level must be scrutinised. These possibilities need to be systematically scanned, and their applicability, pros and cons, conditions and feasibility need to be summarised in the light of the overall performance of the LIT as foreseen. Besides, the possibility to combine finance and funding must be investigated (e.g., is it possible from the viewpoint of rules on state aid and level playing field). For the Netherlands, the City Deals, Field Labs related to the Dutch digitalisation strategy and energy transition, and the National Growth Funds might offer interesting opportunities, apart from regional budgets allocated to the RDAs. Within Europe, the Green Deal, Covid-19, Recovery funds allocated to the national level according to the priorities for the Netherlands and Sweden as indicated in the Semester, the Digital Innovation Hubs, and ERDF funds as Interreg will provide opportunities, depending upon the alignment between different government levels and agencies. InvestEU, ITEA3, EUREKA and

EASME also offer different possibilities, e.g., the Eureka Clusters AI call 2021 (deadline 28 June). The 100 Climate City Contracts will probably be made directly with local authorities, so it is not sure if this source of funding might be relevant for LIT as it is meant to finance direct implementation of validated solutions.

- **Assess the role of norms, standards and regulatory frameworks** regarding access for Dutch companies to Swedish markets, e.g., in collaboration with the National Institute for Norms, CEN/CENELEC and ETSI
- A more **detailed investigation on and selection of topics suitable for LIT** is strongly recommended. These topics should be of importance for both Sweden and the Netherlands and be validated with external parties. A set of criteria for their selection is needed (e.g., size of prospective markets, potential to create societal impact, etc. etc.) to prevent scarce resources being stretched too thinly. Also, leadership should be created upon the eventually selected topics.
- To increase the support for a LIT and its chances for funding, it is advised **to clarify links to relevant policy agendas**, foremost in the field of research and innovation policy, but also regarding the implementation of policy goals on low carbon and circular cities, clean mobility and logistics. Priorities defined in the recently updated regional smart specialisation strategies will play a role here as well.
- Lastly, it is recommended to already engage RDAs and city administrations in **scouting parties possibly interested to become part of the LIT**. RDAs and cities might also be tasked with proposing companies and testbeds for suited for participation in the LIT. Applicability and scalability of solutions on the Swedish market, next to overlap and competition with current businesses, should be criteria for solutions.

Recommendations for the next step of LIT

A common Dutch-Swedish collaboration framework for LIT has to be established first, based on the more detailed information collected for the Netherlands and Sweden, both on the operational and system level. Once this framework has been established and the decision to implement LIT has been taken, an operational prototype project can be set up. However, it can also be considered to do this in parallel to or integrated with the initiatives recommended above.

Starting an operational prototype project between Sweden and the Netherlands with a perspective and financing of 2-3 years

- identify 4-5 testbeds in each country that are ready for international collaboration, using the testbed characterisation checklist from this report
- identify 3-4 topic areas of relevance for smart sustainable cities to focus on. First proposals are
 - Energy transition
 - Sustainable mobility
 - Water management
 - Digitalisation in cities

- identify a number of interested and suitable innovative companies and offer them to participate in the prototype project
- create an internationalisation training program for key individuals in the participating testbeds
- initiate a dialogue with national agencies to find a solution for how flexible budget/financing resources can be linked to the prototype for financing concrete activities supporting the testbeds and/or the companies participating
- link a learning process to the project, in order to see this for the larger context on international collaboration for testing, demonstrating, implementing and scaling of solutions

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Appendix 1 NESTA definition of different testing and demonstrations environments

The report's first three definitions are based on Vinnova's 3-level definition.

Laboratories (Level 1 testbed) are strictly controlled test sites where innovators can test specific technical properties in isolated, artificial and heavily controlled circumstances. They are often limited to part-functions and components rather than systems or production methods. They tend to be clearly distinguished from our definition of real-world testbeds, but they are commonly referred to under an umbrella 'Testbed' term which encompasses all environments that allow testing of innovation.

Simulated/constructed testbeds (Level 2 testbed) are areas for testing and verifying systems, process and product levels. The environments are closed-off areas and test facilities (e.g. closed-off tracks for testing autonomous vehicles). They often offer a simulated or constructed version of reality, still closed off and able to control by the testers. Figure 3 places these testbeds in spanning from development to implementation in the innovation process, between fully controlled and real-world environments. Simulated testbeds often overlap with real-world testbeds as they sometimes occur in combination (a testbed offering both simulated and real-world environments).

Real-world testbeds (Level 3 testbed) are controlled or bounded environments for testing innovation in real-world conditions in the manner (or close to the manner) in which they will be used or operated.

Sandboxes are described as follows by Ribiere and Tuggle (Ribiere, V. and Tuggle, F., 2010)

"The idea behind the innovation sandbox is to create a 'space' (often virtual) in which developers can play around with an innovation to get a feel for how it might be used, add/delete features to it, comment to one another about it, ask a variety of 'what-if' questions of others playing in the sandbox about the innovation and related innovations... (and)...show it virtually to prospective purchasers/users of the innovation to get their reactions, ideas, and suggestions."

Some sandboxes operate in close to real-world environments, for example through testing regulation in closed-off elements of financial systems, while others such as the CAA sandbox operate as an advisory service for innovators wanting to operate in the commercial drone landscape. As illustrated in the figure, they stretch across controlled and real-world environments, available in the development phase and the testing phase of various innovations.

Living lab is the term that is most fuzzy and difficult to pin down into one, agreed definition. The European Network of Living Labs defines them as "user-centred open innovation ecosystems based on a systematic co-creation approach, integrating research and innovation process in real-life communities and settings."¹⁴ Based on this and other definitions,¹⁵ Living labs operate in simulated or real-world environments focussing on the co-production of products. This is in an earlier stage of the innovation process than real-world testbeds.

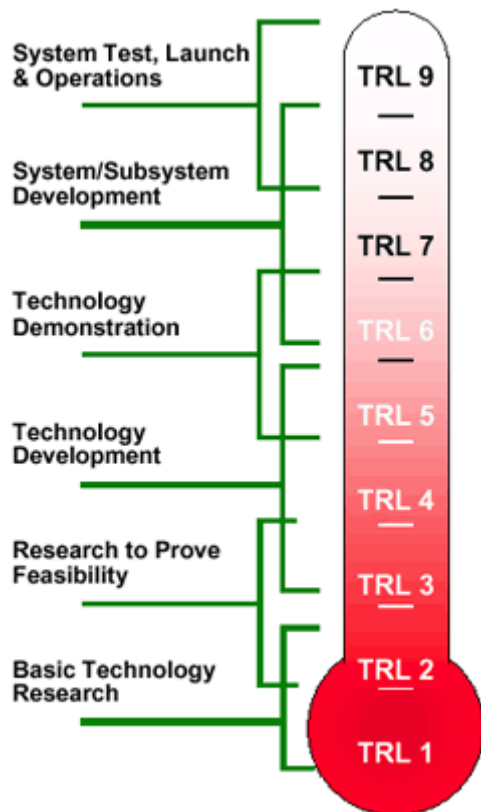
Proving ground is the tool often used to test products within transport, to ensure they fulfil industry requirements and standardisations. Definitions are often found within the specific industries, for

example by General Motors:¹⁶ “proving grounds exist to enable us to establish indisputable facts about automobiles in general. In other words, it is necessary to provide facilities for the comparison of all cars; a place where we can evaluate GM cars against all other products.” We have placed Proving Grounds in the ‘implementation’ stage of the innovation process, in simulated or real-world environments.

Demonstrator is the term that most closely overlaps with real-world testbeds and is sometimes used interchangeably. The European Commission described the purpose of a Demonstrator “*to validate the technical and economic viability of new or improved technology, product, process, service or solution in an operational (or near to operational) environment, whether industrial or otherwise, involving where appropriate a larger scale prototype or demonstrator.*” Examples of Demonstrators suggest that the most apparent distinction from real-world testbeds is that Demonstrators focus on more mature technologies and can thus operate in more real-world environments, demonstrating

Appendix 2 TRL and CRI

Excerpt from Wikipedia about TRL and CRI



The TRLs in Europe are as follows:^[6]

- TRL 1 – Basic principles observed
- TRL 2 – Technology concept formulated
- TRL 3 – Experimental proof of concept
- TRL 4 – Technology validated in lab
- TRL 5 – Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – System prototype demonstration in operational environment
- TRL 8 – System complete and qualified
- TRL 9 – Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Technology Readiness versus Commercial Readiness

The HLG-KET and the H2020 Work Program interpret the path from TRL 1 to TRL 9 as the path from “idea to market”. However, increasing technology readiness does not mean nearing a successful product. TRL 9 means that the system in question is proven in its operational environment with some stretching of the scale that might include conformity to all market regulations. However, it is not understood to mean that the product is properly branded, the product is still fashionable, there is purchasing power present to buy the product, there is no disruptive competition and so on – elements of market readiness. In the original HLG Report, it is assumed that these will all be given because the high-TRL projects will be defined in the first place by commercial parties in that know the market. In Australia, to tackle this problem, the Commercial Readiness Index (CRI) was created (ARENA, 2014). CRI was developed with the renewable energy market in mind but also aims to be useful in other areas. The problem that ARENA is addressing with CRI is the risk that still remains after a technology has achieved TRL 9. These risks concern whether successful scale-up and commoditization will be achieved. The 6 levels of CRI measure the maturity of a technology by the financial arrangement of its deployment. The stages are as follows:

Level 1 - Hypothetical commercial proposition
 Level 2 - Commercial trial
 Level 3 - Commercial scale up
 Level 4 - Multiple commercial applications
 Level 5 - Market competition driving widespread deployment
 Level 6 - "Bankable" grade asset class. The first stage co-occurs with TRL 2-8 and the

second stage with TRL 8-9. In these stages, there is little empirical evidence that proves the commercial value of the technology. Rather, the technology is pushed by technology advocates based on hypothetical commercial propositions, and the development is funded by government or equity sources. In levels 3-4, the technology initially is still financed by emerging (high-risk) debt finance or by government policy. Later, the technology requires less and less subsidization, and the accumulated – and more publicly available – information about the technology attracts new means of financing. In levels 5-6, the technology is commoditized in the sense that it will attract more regular financial products. At CRI 6, the commercial performance of the technology is so well known that the risk is no longer a major factor in the financial decisions about it.

Appendix 3 Matchmaking & Project Development Database Questionnaire

Dear LIT partner,

To facilitate the best-possible outcome of LIT matchmaking and to develop meaningful projects between like-minded partners we want to ask you a couple of questions.

Please answer as concisely as possible, bullet points are perfectly alright where applicable. The information will help to secure results in the quickest time possible.

To get to the action, we need your help here, to provide us with some concrete indicators – we will do our best to make the most of your input.

NOTE If, due to Corona, the actual exchange of innovation will have to be postponed, let's not forget that the build-up towards it is just as important.

Basic Information

Testbed / Organisation Name:

Address:

Contact person (LIT partner):

Mobile:

Email:

Technical support person (your guy on the ground, if not the same as above):

Mobile:

Email:

Your input to the LIT

1. The Elevator Pitch - How would you describe your testbed (or testbeds) in two sentences?
2. What sort of innovations are being developed in your testbed / central themes?
3. Which ones would you like to concentrate on/suggest for international co-development within the LIT projects?
4. How would you describe the processes involved in developing/aiding innovations in your testbed? (e.g., how are startups/ideas received, tested, evaluated, linked to corporates etc)
5. Are there specific certificates your testbed has obtained (e.g., waste handling)?
6. How do the structures supporting your internal processes look like?
How are startups financially supported, if so at all?
What immediate network capacities do you have (e.g., accelerators or corporate actors closely connected to your operations)?
7. What sort of assistance would you offer to startups from international partners? (e.g., welcoming packages, soft landing, development space or lab machinery, living space, etc.)
8. Do you have any ideas, wishes, or project suggestions?

Thank you for all your efforts, we will further explore opportunities together in person with you!

Appendix 4 Interview form testbeds/innovative companies/internationalisation/scaling

This form was used as a help for conducting interviews and cover important aspects, not as a list of questions that must all be asked in every interview. Pick the questions that work for the interview.

Begin with asking permission to record interview if you want to do that.

Short background about the person to understand experience/role

1. Role
2. Experience with testbeds, start-ups, scaling and internationalisation

First section – to all individuals that in any aspect represent an “operational testbed environment”, and so work I practice with companies, testing, demonstration and scaling issues.

9. The Elevator Pitch - How would you describe your testbed (or testbeds) in a few sentences?
10. What sort of innovations are being developed in your testbed / central themes?
11. How is it funded/financed?
12. Which ones would you like to concentrate on/suggest for international co-development within the LIT project n- related to smart sustainable cities?
13. How would you describe the processes involved in developing/aiding innovations in your testbed? (e.g., how are start-ups/ideas received, tested, evaluated, linked to corporates etc)
Are there specific certificates your testbed has obtained (e.g. waste handling)?
14. How do the structures supporting your internal processes look like?
15. How are startups supported, e.g., financially (if so at all)?
16. How many are there and how many make use of the support?
17. What immediate network capacities do you have (e.g., accelerators or corporate actors closely connected to your operations)?
18. What sort of assistance do you offer to startups from NL and SE? (e.g., welcoming packages, soft landing, development space or lab machinery, living space, etc.)
19. Do you have any companies that are suitable for the NL-SE exchange?

Second section

Which challenges and obstacles do you perceive?

- Obstacles you see today
- Collaboration between or establishing in testbeds internationally
- Scaling internationally between Sweden/Netherlands
- Local government as testbed/scaling customer
- National agency/similar as testbed/scaling customer
- Industry/private company as testbed/scaling customer
- Partnerships with other companies
- Partnership challenges

Ideas about opportunities/support

- Establishing in testbeds internationally
- Scaling internationally (especially in Sweden/Netherlands)
- Desired learning outcomes
- What different roads to scaling do you see, and which of these do you think would be most promising?
- Local government as testbed/scaling customer
- National agency/similar as testbed/scaling customer
- Industry/private company as testbed/scaling customer
- Best advice to companies wanting to enter the Swedish/Dutch market?

Third section

Advice to our project

- Could you describe a logic for setting up a successful project like this?
- What would be the key things for a long-term support mechanism/project/function to include/think about
- What would a successful result look like?
- Which “testbeds” would you recommend that we try to include in the first phase of the projects, and why?
 - Name, focus, contact person, services provided etc
- Any companies you recommend that would be suited for participating in the test phase?
- Which thematic areas would be best to focus on?
- Which existing organisations/structures/similar should we link up with?
- How should we source/choose the best start-ups to bring along?
- How should a program be organised?
- Who would be a suitable operator?
- How to finance the basic operations, and the different functions/stakeholders in the system?

To round up

- Any more advice for us?
- Proposals for key individuals to speak to?
- Any websites or reports you recommend?
- May we quote you?

Variation for city representatives

- How is work with smart sustainable city innovation organised in your city?
- What kind of solutions are you looking for?
- How do you source them?
- In what way do you work with or support innovative companies in early stages or in growth phase?
- What kind of testbed facilities or testing and demonstration opportunities do you provide? Examples of how it works?
- Do you have any function or staff responsible for uptake of new solutions/innovations?
- What kind of knowledge would you need to test, demonstrate or implement more innovative smart sustainable city solutions or to scale such solutions?

Variation for companies

- What scaling opportunities are you looking for?
- What kind of support/services would be interesting for establishing in an international testbed?
- What is your preferred road to scaling and enter the Swedish/Dutch market?
- Who would be the customer?

Appendix 5 interviews Sweden

Individuals

- Eva Blom, Dutch Embassy
- Wouter van Rooijen, Rotterdam
- Anne de Vries, Innovation Quarter
- Annika Bergendahl, Vinnova
- Jonny Paulsson, Vinnova
- Linda Svanhed, Vinnova
- Lars Bern, Business Region Gothenburg
- Kerstin Rubenson, Research Institutes of Sweden
- Sofia Målberg, Research Institutes of Sweden
- Peter Kisch, City of Lund

Testbeds

- Johanneberg Science Park, Gothenburg
- Chalmers University
- MTC Umeå
- Marine waste testbed, Sotenäs,
- Swedish Agricultural University
- Stockholm Electricity
- RISE Processum
- IVL Water Testbeds

Appendix 6 Interviews the Netherlands

	Name	Affiliation
1	Anne de Vries	Innovation Quarter
2	Corinne van Voorden	Netherlands Enterprise Agency
3	Wouter van Rooijen	Gemeente Rotterdam (SCALE-UP and GIST)
4	Yvette Entius	Living Lab Scheveningen (testbed)
5	Sebastian Marx	Connectivity Alliance
6	Marian Kreijns	Green Village (testbed)
7	Hans Nouwens	Connectedworlds
8	Workgroup Trade and Innovation	Regional Development Agencies (ROMs)
9	Peter de Kruik	ROM Amsterdam (testbed)
10	Johann Beelen	Brainport Eindhoven (testbed)
11	Willem Drost	Enterprise Solution/TechLeap
12	Eli Prins	CleanTech Delta/ConnectSME (testbed)
13	Jan-Willem Wesselink	FutureCity
14	Arjen Hof	WeCity (before Civity)
15	Jos den Besten	Hamwells