triangulum

DEMONSTRATE · DISSEMINATE · REPLICATE

D2.1 Common Monitoring and Impact Assessment Framework

VERSION 2.0

WP 2, Task 1

February 2017

H2020-SCC-2014-2015/H2020-SCC-2014: "Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration - first of the kind) projects"

Collaborative Project – **GRANT AGREEMENT No. 646578**

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About this version

Many thanks to the Project Officer for the constructive and helpful feedback Work Package 2 received through the 18 month review. This document outlines the updates and revisions that have been made to D2.1 Monitoring and Assessment Framework as part of this process.

D2.1 Monitoring and Assessment Framework was originally submitted in M6 and sets out the approach used to monitor and assess the Triangulum modules. D2.1 has been extensively updated in the revised deliverables to respond to the PO comments, and to include details about the methodology that were not available in M6. The key updates include: the insertion of new methodology section, and aligning indicator terminology with D2.3 for consistency. This cover note provides a list of revisions that have been made, and a table that shows how they respond to the PO comments provided as part of the 18 month review.

Summary of revisions to D2.1

1. Inserted a new methodology description in D2.1 (pages 21-26) that describes the process of consulting with the cities, the process of developing and defining indicators and outlines the data intake process. This includes a clarification that WP2 focuses on impact indicators rather than key performance indicators.
2. Checked the terminology throughout to ensure consistency when distinguishing between impact, impact indicator, and quantifiable units.

Details of revisions addressing PO comments during the review process

PO Comments	*Details of revisions addressing comments*
The framework proposed is extensive in the initial number of KPIs but the trimming process has the danger of oversimplifying the assessment and diminish the impact and replication potential of deployments.	The revised D2.1 has inserted a new methodology section (pages 21-26) that describes the process of developing, defining and trimming indicators. The revised D2.3 has captured new indicators and datasets that will enhance the impact and replication potential of the modules (see revised D2.3 cover letter for details).
It is good that the selected framework is shared by the SC community and follows ISO standards.	The revised D2.1 has inserted a new methodology section (pages 21-26) that describes the process of

	aligning with other SC frameworks. The revised module impact tables in D2.3 have a column for each indicator stating how it aligns with the SCIS indicator framework (see revised D2.3 cover letter for details).
However, failing to quantify starting values on the KPIs and targets as well as final values will lower the impact and potential for replication.	The revised D2.1 has inserted a new methodology section (pages 21-26) that describes the process of developing and defining indicators and the focus on impact indicators rather than key performance indicators. Updated details of indicators, including baseline (i.e. starting) values where available, are given in the revised D2.3 Baseline Report (see revised D2.3 cover letter for details).
KPIs are not sufficiently categorized from operational and strategic level	The link between the project level assessment and broader organisations goals will be explored in D2.6 Final multi-level impact assessment and monitoring summary report.

Executive Summary

Triangulum proposes a novel form of smart district development that integrates energy, ICT, and transportation to improve the efficiency of commerce and governance as well as reduce greenhouse gas emissions. The goals of WP02 are to rigorously monitor and assess the impacts of the demonstration projects in the lead cities of Manchester, Eindhoven, and Stavanger in order to support learning within and between them, and to underpin the Triangulum replication model being developed in WP06. The framework for monitoring and evaluation presented here will provide a basis to assess the successes and challenges of projects can be assessed, enabling the construction of a cohesive reference architecture through which smart city districts can be replicated in the follower cities of Prague, Sabadell, and Leipzig. This report is organised into five sections.

Section 1 summarises the project and the role of WP02 within the broader context of the SCC funding programme and smart city agenda, emphasising the need to align smart cities with sustainability goals.

Section 2 explains the monitoring and assessment approach, which focuses on a bottom up approach to monitoring of the individual demonstration projects. Version 2 includes a more detailed description of the methodology that was adopted to develop the impacts and indicators, including details on how consultation was managed with Triangulum partners and alignment with other Smart city indicator frameworks. It also provides a detailed summary of progress towards the tasks outlined in the DoW.

Section 3 summarises the findings from the smart city monitoring and assessment literature review, including the methodology that was used to construct the review. It presents an overview of key FP07 projects and current H2020 projects in this field and identifies key opportunities and challenges for monitoring and assessment within Triangulum. Triangulum offers a unique opportunity to study real world smart city demonstration projects in considerable depth, supported by a data platform, and to use these insights to develop a robust and innovative replication model based around a modular approach. Key challenges include capturing socio-economic, public engagement and wellbeing impacts more fully, striking a balance between the need for a shared framework that can reflect the specificity of each city and demonstration project, and monitoring the integration across projects and domains. This report presents a starting point to work with cities to strengthen these aspects of the project.

Section 4 presents the impact and data mapping process that has been conducted across the lead cities to identify the specific expected impacts, impact indicators, preferred metrics to measure them and potential datasets. These have been mined from the proposal and then updated through consultation with the cities. This process highlights commonalities across cities in terms of preferred impact indicators but also distinctiveness in terms of the focus of the demonstration projects and the overall approach. An important task within WP02 is to better understand what cities want and

are able to measure and, as the impacts of the demonstrations become apparent, what is most important to measure. Through this, Triangulum will develop a bottom up understanding of the most important impact indicators and feasible metrics for smart district development that will support replication in the follower cities and complement initiatives such as CityKeys.

Section 5 identifies key tasks ahead, which include re-mapping impacts, impact indicators, associated metrics, and datsets by demonstration project to support the work of WP06, finalising the set of impact indicators, and determining the timeline and schedule for data gathering and reporting for the baseline reports due in month twelve.

The report includes two appendices. The first summarises WP02 activities with each city including the detailed impact mapping and data tables, while the second provides an example of the social impacts qustionnaire being developed in Eindhoven that may provide a useful example for partners.

1. Introduction

Triangulum proposes a novel form of smart district development that integrates energy, ICT, and transportation to improve the efficiency of commerce and governance as well as reduce greenhouse gas emissions. Cross-sectoral smart city pilot projects will be demonstrated in Manchester, Eindhoven, and Stavanger. The diverse set of urban forms and economies across the three lead cities provides a test bed for new business models, technologies, and strategies of citizen engagement. The goals of WP02 are to rigorously monitor and assess the impacts of the demonstration projects, to support the work of the lead city partners and learning between them, and to inform the Triangulum replication model. The framework for monitoring and evaluation presented here provides the basis for assessing the successes and challenges of projects, enabling the construction of a cohesive reference architecture through which smart city districts can be replicated in the follower cities of Prague, Sabadell, and Leipzig.

Two key factors are central to Triangulum project development: smartness and sustainability. This priority echoes the European Innovation Partnership on Cities and Communities of 2013[1], which defines smart cities as:

> "(S)ystems of people interacting with and using flows of energy, materials, services and financing to catalyse sustainable economic development, resilience, and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society."

From this definition, smartness can be understood as multifaceted, yet it clearly includes the integration of ICT and infrastructure to improve city services and economies. Additional dimensions of smartness include responsive and user-friendly governance systems and skills training through schools, universities, libraries, and public-private partnerships to facilitate environmental and digital literacy among the populace. Smartness is measured both by the technological advancement of urban infrastructural systems and the adaptiveness of citizens in the transition to knowledge-based economies.[2] Going beyond the commonly cited Bruntland Commission definition of sustainable development, as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs,"[3] the Triangulum project holds that sustainability must be considered in the context of the 'triple bottom line' — people, planet, and prosperity. People and prosperity are integrated into the framework proposed here

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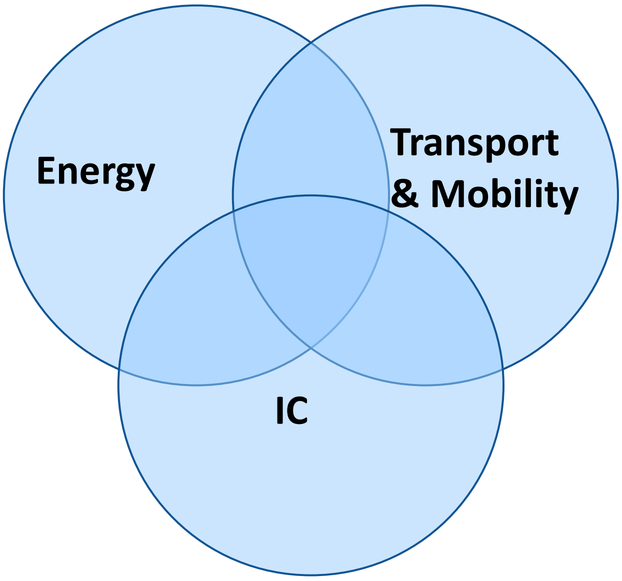
[1] European Innovation Partnership on Smart Cities and Communities, 2013: 3

[2] Batty et al., 2012; Herrschel, 2013; Shapiro, 2006; van den Berg and van Winden, 2002; van Winden et al., 2007

[3] Report of the World Commission on Environment and Development, 1987: 16

through distinct categories that consider the socioeconomic and financial impacts of smart city developments; specific decarbonisation standards of each city under the 20/20/20 commitments of the EU are also incorporated. Integrating strategies for greenhouse gas reductions into the Triangulum framework advances traditional smart city initiatives to plan for the future realities of space and resource constrained urban growth.

Scaling-up from FP07 initiatives funded by the European Commission, the Horizon 2020 Lighthouse cities represent a new phase of smart city implementation and research, moving from isolated projects to a “cross-sector approach” that incorporates sustainable urban mobility and “integrated infrastructures and processes across energy, ICT, and transport” in distinct smart districts.[4] The districts function as living labs, which are deignated areas of the city itself that forms testing grounds and allow cities to experiment at a manageable cost and scale.[5] Within these districts, the traditional infrastructural sectors of transportation, energy, and communication can no longer be divided but rather are linked together to improve efficiency (see **Figure 1**). Some of the many examples include energy saving in electrical and transportation systems from sub-second ICT monitoring; the incorporation of renewable energy sources into public transit to reduce greenhouse gas emissions, and the expansion of GPS tracking systems to inform public transit users about service changes. A systems approach emphasizes the interaction between these three areas as key to sustainable innovation.[6]



4 European Innovation Partnership on Smart Cities and Communities, 2013: 3

5 Cosgrave et al., 2013: 671; Voytenko et al., 2015

6 Piro et al., 2014; Shahrokni et al., 2015

Figure 1 Integrative relationship between impact domains

Smartness is achieved not only through the introduction of ICT, but also through improved responsiveness to the needs of user and stakeholder groups, including urban residents, students, business owners, managers, and policymakers. Smart district stakeholders thus become part of a collaborative process of urban design, in which citizen engagement modifies the system and creates opportunities to improve socioeconomic well-being for individuals, firms, and institutions participating in the smart district. Triangulum posits five key impact domains for smart cities and districts: ICT, energy, transportation, citizen engagement, and socioeconomic well-being. The success of the smart districts will be evaluated through progress towards environmental, citizen engagement, and socioeconomic impacts.[7]

1.1 Overview of WP02

WP02 is tasked with the development of a common monitoring framework that will assess the success of the demonstration projects in delivering their expected impacts, and identify impact indicators to compare amongst the Lighthouse cities. This includes three distinct tasks over the five-year duration of the project:

1. Monitor the impacts of the demonstration activities;
2. Assess the level of success of the demonstration activities, and;
3. Evaluate the sustainability of processes of data generation, monitoring, and usage in each city.

These tasks will be led by the University of Manchester with coordinating assistance from university liaisons in each partner city. In addition to collaborating with their respective cities, the universities bring the following expertise to WP02:

- The University of Stavanger bring ICT expertise;
- The Technical University of Eindhoven bring building and mobility assessment expertise, and;
- The University of Manchester bring urban governance and sustainble innovation expertise.

The University of Stavanger is specifically tasked with developing the Cloud Data Hub, which will house the data required to monitor the demonstration projects as well as a wider set of open data from each of the Lighthouse cities that can be used to support smart innovation. Baseline data collection, impact assessment, and the Cloud Data Hub role and architecture will further be

[7] European Commission, 2014: 18

coordinated with WP06 to aid in the preparation of a reference architecture for dissemination to follower cities (see **Figure 2**).

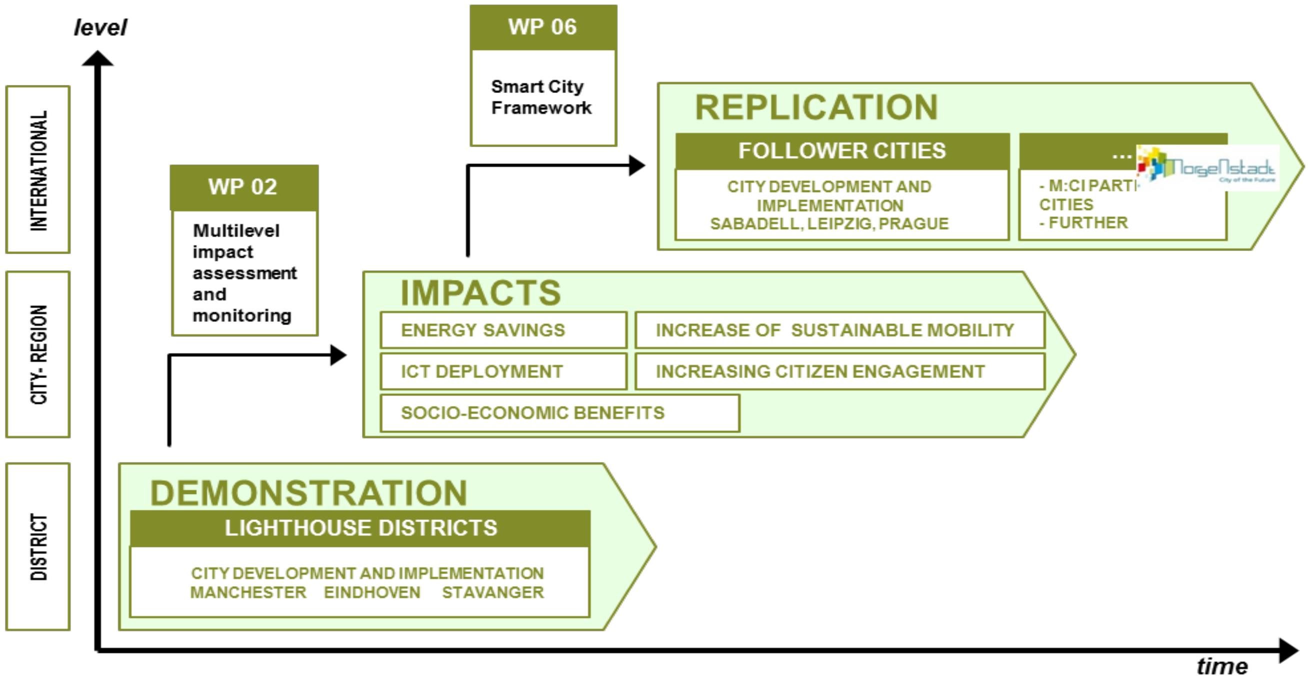


Figure 2 Scale, role, and timeline of WP02

The activities mentioned will occur through a coordinated set of smart projects. In contrast to past EU projects, Triangulum will not focus on a broader public policy agenda of smart city development, but rather work from the micro-scale up to the city level to determine how modular projects fit together to achieve smartness, sustainability, and in the long-term contribute to the creation of a smart city overall. As with any assessement, certain definitional problems exist. Public policy creation effectively boils down to identifying and ranking values.[8] Evaluation then becomes a political task of managing public priorities. Different evaluation strategies are used across the EU, including value for money, cost benefit analysis, best value, and post-performance management.[9] None of these evaluative criteria fit the direct goals of Triangulum,; instead, success will be assessed at three levels: first in relation to the environmental targets set by the cities / projects themselves, second in relation to levels of citizen engagement and infrastructure integration, and third in relation to broader socio-economic impacts.

8 Anderson, 2011: 389

9 Gillroy, 2011; HM Treasury, 2011; Levy, 1996

The first level focuses on the tangible commitments of each project to changes in transportation, ICT, and energy infrastructure. Each city has identified project goals and objectives that will be monitored for completion, such as reduction in tons of CO_2 emitted annually from a shift to renewable energy sources and the number of electrical vehicles put on the road. Second in relation to the impacts of the projects goes beyond these technological and infrastructural improvements. While physical changes seek to improve the sustainability and smartness of the built environment, central to this is a process of co-creation through citizen engagement and integration to facilitate new buiness opportunities and usability. Citizen interaction with new smart systems thus becomes the second level of project evaluation. Finally, the core value at the centre of Triangulum is a desire to improve the quality of life for Lighthouse city residents, which can be measured through monitoring of citizen well-being and changes in socioeconomic indicators. This final area of evaluation for project success is highly subjective and will necessitate both qualitative and quantitative analysis.

Triangulum will start by focusing exclusively on the demonstration projects, with the aim to capture a very wide range of impacts that reflect the cross-cutting approach of the projects and integrated systems understanding or Triangulum. Triangulum will rely on a data-driven approach to measure impacts close to the source to overcome problems with ungoverned data abridgement on one hand and data privacy on the other. Identifying and assessing these distributed impacts will enable WP06 to identify key beneficiaries from each demonstration project, which will in turn form the basis for developing an innovative business model based on demonstrating the value of these distributed benefits that is translatable to the three follower cities and beyond. The close relationship between WP02 and WP06 is reflected in the decision to develop a joint operational plan at the WP02/WP06 meeting in Stuttgart on 7 July 2015.

1.2 Monitoring and Assessment Approach

Monitoring and Assessment

Mointoring and assessment approaches distinguish between evaluating impacts and processes.[10] The objective of assessing impacts is to 1) understand what has been achieved and to justify funding; 2) identify strengths and weaknesses and learn from errors; 3) ascertain cost effectiveness; 4) generate knowledge and share lessons 5) to influence policies and sectoral priorities. The objective of assessing processes are to 1) improve communication, information and the relationship between clients and extension organizations; 2) create an environment of critical self-reflection and a culture of learning; 3) empower clients and 4) generate knowledge and share lessons and new concept inside the system. WP02 aims to fullfil both a formative and a summative evaluation role in

[10] Hoffmann et al., 2009

Triangulum[11], assessing both the impacts of demonstration projects in each city and the process through which they are monitored. This will enable WP02 to:

- ☐ Support the work of the lead city partners by feeding back on the performance of demonstration projects and engendering learning between them about different monitoring solutions;
- ☐ Support the Triangulum replication model of WP06, and;
- ☐ Support the follower cities by advising on appropriate impact indicators and feasible monitoring strategies.

Assessing Impacts

Given the unique formulation of Triangulum, the first phase under task 2.1 entails the development of a novel monitoring and assessment framework to track the project level impacts. **Figure 3** depicts the process that WP02 has used to move from the expected impacts to specific monitoring procedures for each city:

EXPECTED IMPACT ⇒ IMPACT INDICATOR ⇒ METRIC ⇒ DATA SET ⇒ MONITORING PROCEDURES

Figure 3 WP02 flowchart from expected impacts to monitoring procedures

The expected impacts, impact indicators, preferred metrics and data sets have been determined by mining the original proposal; consulting with city partners to identify changes to plans and verify information from original proposal; and reviewing the literature to identify key gaps and solutions to gaps.

Each city is required to identify a data set to match up with each metric. This process is being managed by the University of Stavanger through the data audit, which is identifying available datasets in each city including key metadata. **Appendix 1** shows the detailed progress for each city, including the impact mapping and data tables, while Section 4 of this report identifies key findings from across the four cities. This process is scheduled to be completed by month 10 and will provide the basis for the monitoring procedures for each city.

This monitoring and assessment framework directly corresponds to the unique architecture of the Triangulum projects. Building from the concept of Living Labs, Triangulum proposes a novel form of smart district development that frames the city as a series of modular units.[12] There exist clear

11 Duignan, 2009

12 See WP06

channels that stitch together the urban fabric, including a common culture, education system, public policy agenda, road and infrastructure network, industry, labour market, and so on. However, the geographic impacts of transportation, energy, and improvements to the built environment tend to be highly localized. Attempting to understand these broader impacts at the scale of the city presents enormous conceptual challenges, not only as to how to define the boundaries of the city, but also the very concept of the smart city itself, which is an expansive and discursive conceptual framework enveloping the intersecting flows of transportation, energy, governance, business, technology, sustainability, culture, education, and people that contribute to the vibrancy of urban environments. The complexity of these interactions makes smart city initiatives notoriously difficult to quantify because the borders are porous and the flow of information continuous. It is well-understood that some impacts will only be experienced at the project level. For example, if a project retrofits buildings to improve the insulation and reduce heatings costs, these energy saving gains will only benefit that building, institution, or block. Other impacts will influence the greater metropolitan area. For example, a reduction in particulate matter in the air as a result of a "cash for clunkers" style public policy program to improve average fuel efficiency of cars will benefit all users of an urban environment. These policy impacts will also be felt in a wide arc downwind from the city in a gradually descending degree. Thus, evaluating the expansive nature of smart city initiatives presents several conceptual challenges for social science researchers as summarised below. While these conditions are not novel and must be addressed in the evaluation of any public policy program, the Triangulum evaluation framework represents a novel response to the limitations of social science research in the context of smart cities.

1. *The counterfactual challenge and determining an experimental control:* This challenge questions what would have happened in the absence of a specific smart city intervention. Would the infrastructural systems have developed anyway as part of a distinct policy initiative? What does the city gain by having a codified smart city programme? Effective analysis requires comparison to a city, region, or area that did not receive the same treatment to meet the counterfactual challenge and determine what would have happened in the absence of the public policy. Within Triangulum, the estabishment of unique smart projects allows cities to compare performance against other similar buildings, streets, or neighbourhoods that were not modified, creating a natural experiment. Furthermore, the cities will serve as comparators to each other. Although this does not establish a perfect scientific control, it does indicate the relative effectiveness of various programs, as each city will concentrate on different sectors of the urban ecosystem. Therefore, in Manchester, which has a strong emphasis on transportation policy, can be compared to Eindhoven, which has decided to prioritize energy efficiency of buildings. The relative success of each in meeting the goals of improving citizen engagement and well-being will provide valuable commentary on the relative value of different infrastructural strategies in contributing to different smart city goals.

2. *Statistical confounding*: This challenge refers to the process whereby socioeconomic and technological changes are impacted by factors outside of the project boundaries. Under this evaluation framework, it is impossible to avoid the concept of statistical confounding, as a successful project will create linkages across the city and across impact domains, contributing to an ecosystem in which innovation and ideas intersect on different project sites. Data-driven approaches to measuring impacts will help to minimize confunding where possible. Triangulum will assess project level impacts, which effectively requires review on two levels: first examining the success of each modular unit and secondly how well these units, which comprise a broader urban fabric, fit together. Thus, confounding represents a positive project impact that signals contribution to the wider city. Triangulum does not attempt to measure the specific impacts of smart city programming, but rather progress towards smarter and more sustainable cities that results from the modular implementation of smart district, living lab style projects.

3. Geographical *porosity*: This presents one of the most difficult challenges in calculating benefit from smart city programs as the benefits are wide-ranging and impactful across the greater metropolitan area. The boundaries of a smart city project will undoubtly be too narrow to measure its impacts given that individuals, pollutants, ideas, and technological systems travel in and out of cities and can spark inspiration in other areas or from an environmental perspective affect neighbouring ecosystems. Additionally, resources concentrated on a specific area can have positive spill-over effects or negative shadow effects in other geographical areas, particularly given the prioritization of investment and tax incentives that often are attached to public policy initiatives to kickstart new enterprise. While the specific impacts of improvement to transportation and energy are largely geographically specific, integrative ICT systems attempt to reduce lopsided geographical impacts through the provision of distributed benefit. The Cloud Data Hub will allow researchers from any part of the world to access data about the Lighthouse cities. The spillover benefits of this cannot be quantified, but the system of evaluation selected does not require them to be captured . The Triangulum approach addresses the challenge of geographical porosity by adopting a network ontology that views the city as a flattened space of nodes and connections, rather than as a set of nested scales. Within this understanding, nodes (in this case the demonstration projects) can be connected to any other node, whether that be another project, an actor, or a policy. Effectively, any ripple effect that results from a project, whether it be matching private investment in clean energy or the extension of digital literacy curriculum to a new set of schools outside the pilot programme, are net positives stemming from that project implementation, regardless of their geography. This approach seeks to capture the myriad ways in which the demonstration projects are embedded in the city to develop an understanding of their *overall* or *total* benefit to support the replication framework proposed in WP06. Negative

shadow effects may arise through distorting incentives for private investment, which are difficult to precisely quantify with or without geographical specificity. The researchers acknowledge the existance of such negative externalities and will consider all glaring and adverse effects in forthcoming deliverables.

4. Geographical *specificity*: Each demonstration project was implemented in a specific geographical context defined not only by the physical topography of the natural and built environment but also the historical and cultural patterns of its citizens. Reactions to and uptake of technology will differ in each city based on the environmental and digital literacy of each city. Rather than being a barrier to the analysis of smart districts, however, the framework devised will capture and record these differences. The impact indicators selected should provide the flexibility to monitor the specific goals in each city, while also providing a basis for comparison between the districts. WP06 will use the Morgenstadt framework to fully capture the geographical specificity of each city, to understand the contextual determinants of fit for each demonstration project.

To summarise, Triangulum adopts a monitoring and assessment approach with a focus on the scale of demonstration project. It adopts an innovative modular approach based on a network ontology that is aimed to capture the range of impacts that charactise integrated smart city solutions. Capturing the range of distributed impacts is necessary to support the development of the 'Holistic Value Model' / Smart Solutions business model in WP06.

Process Monitoring

The production of baseline, interim and final reports assessing the impacts will inform both the work of WP06 in identifying benefits and replicating demonstration projects in follower cities, but also perform a formative role in evaluating the process through which each city is delivering its projects and to help them improve. The former will be achieved though the identification of a clear set of metrics and suveying procedures for each expected impact. The latter will be achieved by feeding this performance information back to the cities and projects in a timely and organised fashion, and also through the capturing of process factors relating to the working dynamics between the city partners and the sustainability of the process. This will be captured through the use of an amended survey produced by the FP07 Peripheria project that WP02 members were involved in and will focus on stakeholder experiences and perceptions of the governance process.[13] The questions in this survey will also be used to evaluate the sustainability of processes of data generation, monitoring and usage in each city.

[13] Greene, 1988

1.3 Progress Towards Commitments of Task 2.1 Outlined in the DoW

The WP02 evaluation framework was developed based on the Fraunhofer assesment of impact domains initally provided in the DoW. Explanation of the procedure to build this monitoring framework and progress towards the objectives listed in the DoW is provided below. The evaluation framework is discussed in detail in Section 4.

1. *Review existing smart city monitoring frameworks and review monitoring capacity across Lighthouse Cities to develop a common framework. Review existing smart city assessment frameworks and key expected impacts across the demonstration activities to develop a common framework for assessing success of the demonstration activities in the Lighthouse Cities.*

Researchers at the University of Manchester conducted an extensive literature review of academic and gray literature, including an analysis of existing frameworks from past EU smart city projects. The methodology and results of the literature review are detailed in Section 0. The capacity of the Lighthouse cities to develop a common monitoring framework was realized through a collaborative process to determine project priorities, appropriate impact indicators, and as a next step the process for data collection and on-going monitoring.

2. *Develop monitoring procedures*[14] *and clearly identified and quantifiable metrics to capture key impacts of demonstration activities that can be deployed in each city. See below for an indicative list of assessment metrics.*

The list of quantifiable metrics initially prepared as part of the DoW (see **Table 5**) was elaborated upon based on a thorough review of the partner city commitments in the DoW. Expected impacts stemming from the five major impact domains were added to the initial table with corresponding impact indicators as indicated by the literature review. The result was a table of five impact domains, subdivided into 21 areas of expected impact, with 81 impact indicators (see Appendix 1). Given the enormous diversity of the on-going projects in the three smart districts, not all impact indicators will apply to each city. Therefore, each impact indicator was ranked for each city on a sliding scale of 1 to 3 (see **Table 1**). If a city indicated that they would adhere to a specific target and gather the corresponding data, they were ranked a score of 3 for that impact indicator. A score of 2 was given to indicate implied areas of benefit, in which the cities may not be directly gathering data but would be likely to see some change. A score of 1 indicates that a city will not be gathering data in that area. This ranking system was used to highlight the relative priorities of each city, as well as indicate what

[14] The term 'procedure' has been substituted here with 'protocol' to avoid confusion with the technical meaning of 'protocol' being used in the development of the Smart City Reference Architecture in WP06.

information each city will gather from the extensive list of impact indicators. For example, one of the 81 impact indicators is presented in **Table 1**. It indicates that Manchester and Stavanger are obligated to collect data on the change in total carbon emissions per building. While Eindhoven will not collect this piece of data, it is still likely to see a reduction in total carbon emissions per building in the smart district given its other commitments to energy reduction. On areas in which all cities are ranked with a 3, the corresponding impact indicators are comparable.

Table 1 Sample impact indicator from Monitoring Framework

Impact Domain	Area of Expected Impact	Impact indicators	Quantifiable Units	MAN	EIN	STA	TRI
Energy	Reduced Carbon Emissions	Carbon Emissions per Building	Tons of CO_2	3	2	3	3

The complete version of **Table 1** for each lead city (see **Appendix 1** for the complete impact mapping and data tables) will form the basis for the city monitoring guidelines). Based on the commitments assigned in this framework, cities will be obligated to collect information on the corresponding data points. While the provisional quantifiable metrics have been established, the precise procedures for data gathering and reporting remains under review until the Cloud Data Hub is activated and the impact indicators are finalised based on the availability of data. Aggregating this information presents an on-going task for each city and the Cloud Hub overall as some information will be gathered at sub-second intervals, while other information will be captured gradually through user surveys or through periodic review of programs. WP02 is focused on the longitudinal change in smartness, sustainability, engagement, and well-being over time. Therefore, a full review will be expected every six months to one year, based on the availability of information and funding for more complex data monitoring.

3. *Develop Cloud Data Hub to store data, including metadata requirements, prioritisation, design including interfaces, formats and procedures and deployment.*

The University of Stavanger designed a data audit form and tested its implementation. The solution was presented to the partners in charge of data delivery. The data audit will be conducted in Stavanger to verify systematically the metadata deliveries generated by the data-audit form. This is an on-going process as responses continue to come in from partner cities and programmes. Requirements concerning the data formats and data transfer have been explained to the partners.

Nevertheless, this will remain an on-going process to standardize data input and correct errors in future data entries. Currently, most of the data suitable for the project appears to have common formats and can be transferred in the original format for further processing in the Cloud Data Hub. The researchers are also working to identify and avoid transfer and coupling of personally sensitive data to the Cloud Data Hub. The GIS department of the Stavanger municipality has delivered a metadata database containing the description of 90 data sources. The University of Stavanger is now working with the Stavanger GIS Department to structure and evaluate the relevance of in-coming metadata for the project. The assessment of data sources and formats suitable for the project from the Manchester and Eindhoven City Data Hubs is also on-going, in parallel with evaluating the sustainability of data generation in Stavanger.

4. Deploy the Cloud Data Hub in the smart city districts.

The data transfer procedures and routines were tested with one of the key partners in Stavanger. A small scale test of the data acquisition in an experimental data hub began in May this year and is on-going. The researchers will continue to write and test interfaces for non-standard, real-time data acquisition and back up existing historical data to upload to the Cloud Data Hub. As part of this process, efforts have been taken to evaluate the volume of raw data for hardware dimensioning as coupled with the inputs generated by the data audit. The ensuing hardware acquisition and building reshaping processes follow the graph outlined in the DoW.

5. Identify actions to monitor and assess the sustainability of data generation, monitoring and use in each city.

The impact indicators were initially selected and vetted by the Fraunhofer Institute and then by the University of Manchester to determine the feasibility of on-going data collection based on relevance, availability of data, measurability, reliability, familiarity, non-redundancy, and independence. Partners in each city then edited the provisional impact indicators in the evaluation framework based on their capacity and current monitoring. These recommendations to change certain indicators were taken into consideration and the WP02 team will continue to identify alternative measures that the cities may be able to measure more affordably and reliably than those initially recommended. The finalised set of impact indicators will be determined after the Cloud Data Hub is activated. A key task for the next four months invoves matching data streams in the Cloud Data Hub to the provisional impact indicators selected to measure each expected impact in order to identify where gaps exist in the data being collcted by each city and if data gathering is sustainable. Each impact indicator will be individually assessed based on its relevance to elucidating the project level impacts on smartness, sustainability, engagement or well-being, availability of data, measurability, reliability, familiarity, non-redundancy, and independence.

6. Formulate long-term monitoring procedures for smart city districts in the Lighthouse cities to cover years four and five of the project.

WP02 is in the first stage of formulating the long-term monitoring procedures as the impact indicators have yet to be finalised. For areas in which the city is not already monitoring data but has committed to do so and is unsure of which methodology to use, the WP02 team has provided recommendations for data gathering strategies in Section 3. In addition, the WP02 team will provide consultative services for cities that are still uncertain as to how to capture project-level data for the identified impact domains and impact indicators. The advantage of the project-level smart city review is that not all cities have projects in each area, and thus have not committed to and will not be required to monitor all of the 80+ impact indicators recommended in the evaluation framework. Rather, they can choose the impact indicators best suited to their needs and a corresponding system to gather data. Once the impact indicators are finalised, and the cities have submitted their review strategies, the final timeline for dates to collect, submit, and analyse data will be determined. The goal is to have a final version of the evaluation framework ready for final review by the cities at the Steering Committee meeting on 15 September 2015 to allow the WP02 researchers time to determine the provisional schedule for data gathering before Deliverable 2.3: Baseline Reports, due in month 12 (see Section 5).

7. Identify streamlined monitoring procedures that can be replicated cheaply and effectively by the Follower Cities and more widely to underpin a longer-term smart urban transition to sustainability.

Section 3 reports the findings of the literature review and offers recommendations for cities as to how to gather this information, from gamification and mobile apps to distributed physical and online access points for city services where users are polled about satisfaction with services. While these stand as recommendations based on case studies from other EU and international projects, the exact strategy for the collection of data will be determined by each city. However, the WP02 team will undertake an evaluation of the different strategies used in years four and five to make an informed recommendation to the follower cities about how best to gather data based on the lessons learned from the first round of Lighthouse cities.

2. Impact Assessment Methodology

2.1 Principles Guiding Impact Assessment

Triangulum's approach to smart urban development is distinctive in focusing on module replication, and the WP2 Impact Assessment Methodology has been developed to support replication. The methodology adopts a bottom up approach to working with city stakeholders, whereby the impact assesssment framework and indicators are co-produced to document the impacts of each module in terms of the partner's own ambitions. This approach is in accordance with COP21, which emphasises bottom up approaches to urban transformation, best practice in sustainability indicator development, and leverages the unique opportunities of the Lighthouses to learn through working with partners on live demonstration projects.

The methodology for indicator development focuses specifically on impact assessment (Duignan, 2009), as outlined in the DoW, rather than key performance indicators for the buildings, districts or cities in which the modules are implemented. Impacts and their indicators are designed to reflect the effectiveness of the module in terms of the partner's intentions, by comparing values at the project's baseline with those at completion. This has implications for establishing the baselines against which impact can be assessed.

- For modules which create a new form of physical, social or digital infrastructure the baseline will be set at zero. For example, in one of the Manchester modules new transport infrastructure is being created; a new cargo-bike sharing scheme is being implemented with the Corridor District of Manchester which has no pre-existing cargo-bike sharing schemes. Hence, the social and environmental impacts of this module can be measured against a baseline of zero.
- For modules which retrofit existing physical infrastructure baseline data will need to be gathered. For example, in one the Eindhoven modules residential properties are being retrofitted with digital technologies to reduce energy demand and promote behaviour change. In this case the impacts of this module can be measured against a non-zero baseline, i.e. pre-implementation energy demand data for the properties being retrofitted.

Within and beyond Triangulum the impacts assessed by WP02 will be able to serve as a comparative baseline for assessing the relative performance of modules replicated in the follower cities and other cities across Europe.

The Impact Assessment Methodology is designed to engage the task groups developing each module as active partners in the co-production of the impact assessment framework (Patton, 2008). This ensures that the indicators are tailored to the modules and districts which host them and are relevant and usable to the partners involved (Ugwu, 2006). In accordance with design principles for sustainability indicator development, the multi-staged methodology includes an iterative process of co-production, whereby Lighthouse City (WP3, 4 and 5), Follower City and WP6 partners feedback on indicator development and application to validate and make further adjustments based on usability (Rametsteiner et al., 2011). The development and validation of indicators uses various instruments such as surveys, electronic consultation and interviews with stakeholders, outlined in more detail below. The multi-staged methodology has been designed to ensure compatibility with generic smart city assessment frameworks such as CityKeys and SCIS (the Smart City Information System). Where possible, Triangulum indicators will be aligned with these frameworks to allow effective sharing of Triangulum data.

2.2 A Seven-Stage Methodology for Developing Indicators and Calculating Impacts

The seven stage methodology adopted by WP2 for developing impact indictors and calculating impacts is shown in Figure 4 and described in detail below. Table 2 shows the timescales, key input required for each activity from partners, and the key instruments used at each stage.

1. **Review of existing literature and frameworks.** WP2 conducted a desk based review of the key literatures on sustainability and smart city indicator development and assessment. WP2 conducted a review of on-going sister projects developing smart city indicator and assessment frameworks. The desk study was used to determine the general framework and parameters for the work, as presented in sections 3 and 4 of this report.

2. **Identify and document expected outcomes.** WP2 will engage with the city task groups delivering the modules to identify the scope and expected outcomes of each module. In each Lighthouse City, a local university researcher is tasked with developing impact indicators and associated reports for the modules of the local partners. Engagement will be aligned with the operation of the task group. Methods used will include contributing to task group meetings, conducting workshops and semi-structured interviews, electronic consultation and opportunities to feedback on draft WP2 documents.

3. **Co-produce and document impacts, indicators and datasets.** Based on the expected module outcomes and review of existing literature and frameworks WP2 proposes impact indicators including quantitative units. The task groups will also be invited to propose impact indicators. The set of indicators for the module is then collaboratively refined by WP2 and the task group through workshops and inviting comments electronically on draft WP2 documents. Follower Cities also provided input to this process at the GA in Berlin 2015.

4. **Align and verify impacts, indicators and metrics.** The impact indicators for each module will be included in analyses which identify opportunities to align: with other indicators across energy, ICT and mobility activities across the three cities; established smart city indicator

frameworks (CityKeys and SCIS); and, WP6 replication metrics. The aligned impacts, indicators and metrics will be verified with the task groups through electronic consultation.

5. **Prepare for impact calculation.** With support from task groups WP02 preparation for impact calculation will including: gathering baseline data; defining the approach to calculating impacts; and, identifying datasets that could be used in the calculation of the impacts. Two modes of engagement will be used: (1) ongoing collaboration through workshops and interviews; and, (2) task groups completing a *data intake form (see below)* which formally specifies the indicators and approach to be taken to calculate them. The data intake form will be used for more complex data sets that go beyond individual data points or simple spreadsheets. Additional work may be required to facilitate documentation and transfer of data, but partners will not be asked to perform additional work to generate the data.

6. **Store data to be used in impact calculation.** Based on the details provided by stakeholders and in the data intake form WP2 (Stavanger) will import datasets required for impact calculation into the cloud data hub.

7. **Calculate impacts.** The cloud data hub will support the calculation of quantitative values for each impact indicators where sufficient data and metadata has been provided by the task group delivering the module.

	Impact assessment activity (WP2)	Timescale	Input required from other WPs and partner organisations	Key methods used by WP2 staff
1.	Review of existing literature and frameworks	M1-M6	N/A	Desk study.
2.	Identify and document expected outcomes	M3-M9	Articulation of module scope and expected outcomes (WPs 3, 4 and 5)	Participation in task group meetings, email consultation on module outcomes.
3.	Co-produce and document impacts, indicators and datasets	M6-M12	Input to identify, review and validate indicators (WPs 3, 4, 5 and 6, and follower cities)	Semi-structured interviews, electronic consultation on module impact tables.
4.	Align and verify impacts, indicators and metrics	M12-M24	Feedback on alignment and verification of impacts indicators and metrics (WPs 3, 4, 5 and 6)	Alignment with SCIS and CityKeys. Electronic consultation with task groups.
5.	Preparation for impact calculation	M24-36	Engagement with Data Intake Form to review and validate impacts and indicators (WPs 3, 4 and 5) Collect and provide access to baseline data (data owners within and outside the Triangulum consortium)	Webinars and email support to partners to complete Data intake form. Electronic requests for data and meetings.
6.	Store data to be used in impact calculation	M12-36	Provide access to datasets required to calculate impacts (as detailed in the Data Intake Form) (WPs 3, 4 & 5)	Email reminders and communications through Triangulum steering committee.
7.	Calculate impacts	M36	N/A	N/A

Table 2: Impact assessment methodlogy overview

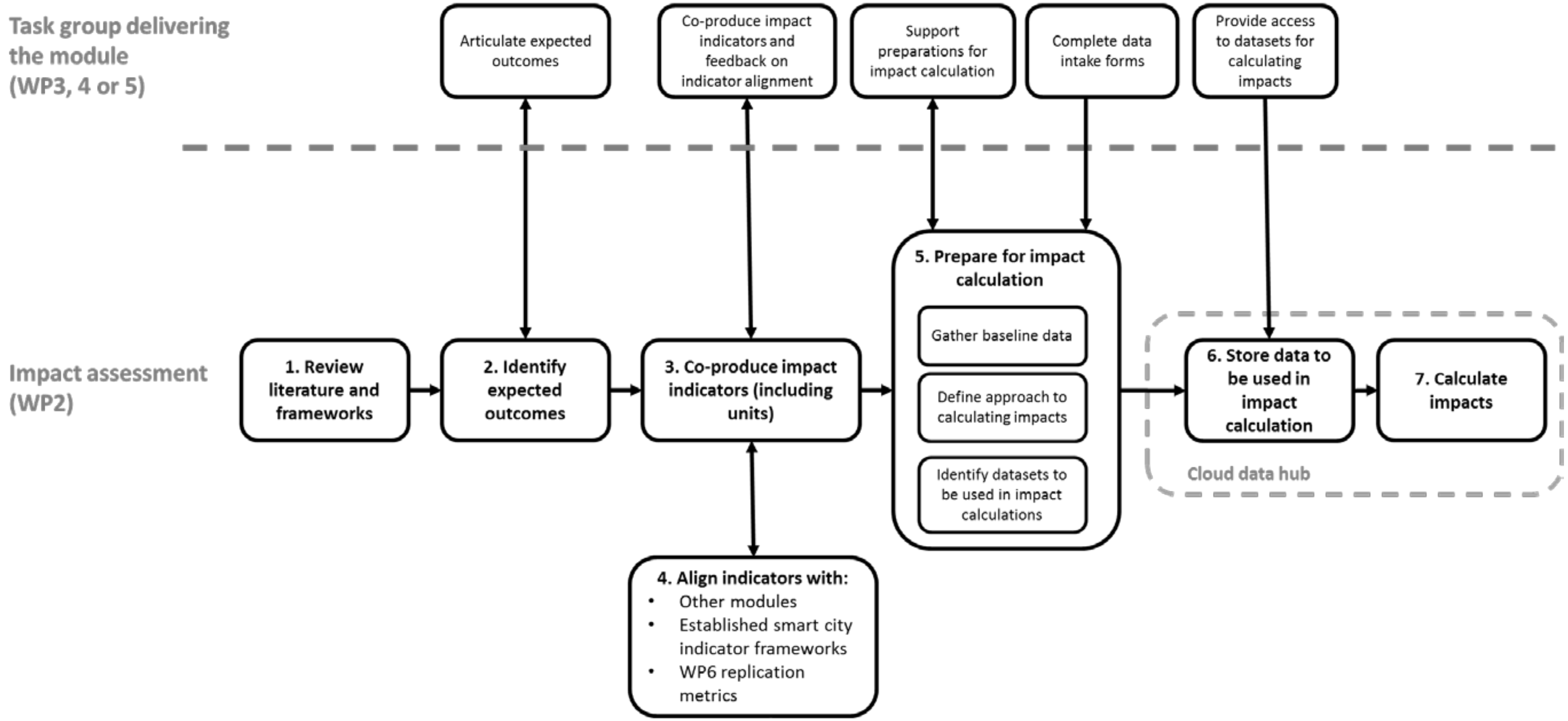


Figure 4: A Seven-Stage Methodology for Developing Indicators and Calculating Impacts

3. Review Methodology and Findings

The primary literature review for the delivery of WP2 resulted in a database of relevant literature on smart city evaluation frameworks and metrics. The literature review had two primary objectives: 1) determine the optimal impact indicators to capture project impacts and 2) explore methodologies for data collection and monitoring. The researchers initially searched Google Scholar, JSTOR, Elsevier, Science Direct, and Blackwell Wiley databases with the following search terms: 'smart city framework', 'smart city evaluation', 'urban evaluation framework', and 'triple-helix model'. Articles selected for review included two of the three elements from: specific impact indicators, systems of monitoring during implementation, and/or strategies for evaluation. Priority was given to European case studies. Following the initial selection of articles, additional sources were identified through the snowball method. The researchers searched the same databases for specific authors, projects, and journals based on the most relevant findings of the initial literature review. In total, a database of 160 academic articles was created. These articles were reviewed for indicators, monitoring tools, and data gathering strategies relevant to the five impact domains of Triangulum.

The initial review provided a wealth of information on smart city governance and ICT implementation but lacked case studies related to wellness and greenhouse gas reduction. The search terms were expanded to capture strategies to measure sustainable development, environmental impact assessment, and greenhouse gas reporting. Significant attention also was given to identify strategies to measure wellness, happiness, and citizen satisfaction. Finally, the research team compiled gray literature from past and current EU-funded projects under the FP06, FP07, and Horizon 2020 funding schemes. Working from available deliverables, the frameworks for CASCADE, CityKeys, CITYADK, EPIC, FIRE, iCITY, PEOPLE, Peripheria, and REMOURBAN projects were identified as directly relevant to Triangulum, in addition to the Fraunhofer assessment framework authored in 2015 as part of WP06 of Triangulum. The findings of the literature as it relates to each impact domain will be briefly discussed. Below, each of the frameworks from other EU projects is also presented, before explaining why the indicators chosen for this evaluation framework were determined. Recommendations for data gathering strategies are presented at the conclusion of each section.

3.1 Review of Smart City Assessment Literature

The key theme emerging from the academic literature is that definitions of smart cities, and therefore associated characteristics, are multi-faceted owing to the particular social, economic, and political characteristics of the city which in turn feed in to their specific vision.[15] The literature suggests that it is difficult to compare cities using specific indicators due to the individual nature of city plans. Thus, it is unwise to abandon city-specific assessment, which are required to complement any common assessment frameworks. The first insight from the literature is that geography is key. Because of this spatial specificity, common assessment frameworks tend to look at how well the smart city has been implemented as an ideological project, rather than the human impacts,

[15] Albino et al. 2015

with the result that people are absent from many frameworks[16]. Similarly the smart city label acts as a facade for an agenda of high-tech urban entrepreneurialism, "blindly believing that IT itself can automatically transform and improve cities".[17] A more ciritical social science literature has highlighted that citizen wellbeing and citizen empowerment are key to ensuring the input and contribution of various groups of people. Human-centric evaluation and city specific evaluation needs to be front and centre. Early initiatives prioritized the education of the local population under the assumption that access to higher education and on-going skills training would contribute to the vibrancy of the local economy. To this were added efforts at sustainable and smart regeneration, which incorporated reskilling of employees and the development of resilient economies based around knowledge and creative sectors following deindustrialisation. Some initiatives wrongly depicted ICT as a panacea solution to the complex problems of urban regeneration, while other programmes have sought to incorporate it into the urban environment through a process of engaged research, co-creation, and shared learning between citizens, local governments, universities, and businesses.[18] The second insight from the literature is that people are key.

A more specific literature relates to urban living labs, which are areas of cities designated to host smart and sustainable experiments and demonstration projects. The three lead cities involved in Triangulum are all staging their demonstration projects in urban living labs, reflecting their increasing role as drivers for smart and sustainable transitions. The appeal of experimentation is that testing out new technologies and policies under real world conditions in highly visible ways can prompt radical social and technical changes aimed at transforming urban governance.[19] Urban living labs represent a specific form of experimentation, whereby processes of innovation and learning are explicitly specified and directed rather than emerging as side effects. This sets urban laboratories apart from more general policy experiments.[20] Urban living labs are characterised by geographical embeddedness, experimentation and learning, and participation and user involvement, but while they are proliferating, their origins, impacts, and implications for urban governance remain largely unexamined.[21]

Urban living labs can be defined as physical regions 'in which different stakeholders form public-private-people partnerships of public agencies, firms, universities, and users collaborate to create, prototype, validate, and test new technologies, services, products, and systems in real-life contexts".[22] They are characterised by a focus on 'urban' or 'civic' innovation, which strengthens the public elements of urban innovation. Research highlights the risk that overly techno-centric demonstration projects fail to produce innovation or learning and can be easily co-opted by dominant economic interests.[23] This literature supports the emphasis in the broader literature on involving people (or 'users' of a service) in projects, but also highlights the need to rigorously monitor impacts and evaluate processes.[24] A final relevant finding from this literature is that the turn to more discrete, project-based

[16] Caragliu and Del Bo, 2012

[17] Hollands, 2008: 315

[18] Southern and Townsend, 2005; Lombardi et al., 2012; Komninos, 2011; Allwinkle and Cruickshank, 2011; Deakin, 2011

[19] Baccarne et al., 2014

[20] Evans and Karvonen, 2011

[21] Voytenko et al., 2015

[22] Juujärvi and Pesso, 2013

[23] Evans and Karvonen, 2014; Hodson and Marvin, 2009

[24] Schliwa et al., forthcoming

approaches to smart urban development creates a greater need for strategic management to ensure that they work together.[25] In terms of monitoring and assessment within Triangulum, this highlights the need to capture integrative impacts across projects and domains.

3.2 Review of FP07 and Horizon2020 Frameworks

PEOPLE

PEOPLE (Pilot smart urban Ecosystems leveraging Open innovation for Promoting and enabling future E-services) operates across four pilot sites, Bilbao (Spain), Bremen (Germany), Thermi (Greece), and Vitry sur Seine (France).[26] The project aims to hasten the uptake of smart cities through the implementation, deployment and uptake of innovative internet-based services. Deliverable 3.1(a) is a framework for benchmarking across the four pilot sites. The 'scoreboard' will serve as an implementation tool for future pilots. Indicators are structured around "demonstrating their impact on the society of the Smart City".[27] Development of indicators emerged out of discussions and studies with pilot sites using "tools such as the Internal Social Network (ISN), the Wiki, and synergy meetings" (ibid:3). From this initial identification of indicators, numerical scales were assigned to each indicator.

For the initial indicators, a range of tools were considered. A 'PEOPLE Wiki' compiled the knowledge generated throughout the pilot to help identify indicators for the scoreboard. The ISN is a knowledge sharing tool amongst pilots, the scoreboard will pay attention to relevant pilot projects and the evolutions of concerns and topics discussed by the ISN members. A close following of synergies amongst pilot sites also serves to inform this. PEOPLE therefore seeks to understand common indicators throughout the pilot sites, through an iterative methodology with preliminary indicators that will evolve over time (**Table 3**).

25 Cugurullo, forthcoming

26 PEOPLE, 2011

27 PEOPLE, 2011: 3

Table 3 Preliminary Indicators in PEOPLE[28]

Education and skills of the population	Knowledge and innovation institutions	Digital infrastructure and e-services	Innovation performance
1. Population with tertiary level education (25-64)	1. Number of university students	1. City area covered by cable networks	1. EPO patents applications
2. Participation in life-long learning (25-64)	2. Number of university staff	2. City area covered by WiFi networks	2. New trade marks
3. New S&E graduates (20-29)	3. Total R&D expenditure	3. City area covered by xDSL networks	3. Innovative enterprises manufacturing
4. Researchers in industry and services	4. Public R&D expenditure	4. Computers	4. Innovative enterprises services
5. Researchers in the public sector	5. Business R&D expenditure	5. Internet connections	5. Enterprises having internetl R&D department
6. Researchers in the private sector	6. Business spending for licensing	6. Broadband connections	6. Sales of new-to-market products
7. Employment of tertiary level graduates	7. Number of incubators	7. Users of e-gov services	7. Sales of new-to-firm not new-to-market products
8. Employment in medium and high tech manufacturing	8. Number of S&T Parks	8. City enterprises owning a website	8. New companies creation
9. Employment in high-tech services	9. Number of Technology Transfer and innovation centers	9. City enterprises involved in B2B or B2C	9. Exports high-tech products
10. Creative class	10. Venture capital funding	10. Digital services providers	10. Exports high tech services

In their understanding, human capital is a key conduit of economic and social development. As such, new requirements of education are needed in the transition to a knowledge-based economy. Adaptability, seen as a key enabler of competitiveness, necessitates lifelong learning in particular.[29] Similarly, social capital is connected to knowledge and innovation that can identify food practices. Digital infrastructure is seen as a prerequisite to digital innovation performance. They are also considering aspects referring to quality of life and citizen engagement and the evolution and growth of pilots (although these are not represented in **Table 3**). PEOPLE typifies the previous focus of FP07 Smart City projects on e-governance and digital infrastructure. A key challenge for Triangulum involves integrating these considerations with a range of energy and mobility infrastructure

28 PEOPLE, 2011: 3

29 United Nations, 2005

considerations. There is a key opportunity here to develop a framework that effectively shows how smart city interventions can deliver sustainable city goals.

CITADEL

CITADEL was a project commissioned through the ICT Policy Support Programme to create open data access in cities to promote mobile app development. The goal of the project was to encourage policies for open data access that support sustainable digital growth. Given the data-driven emphasis, the project initially sought to look beyond the implications for physical infrastructure generally prioritized in smart city projects and devised a questionaire, based on the priorities listed in Figure 5, to contextualize in the areas data where collation would be most useful.

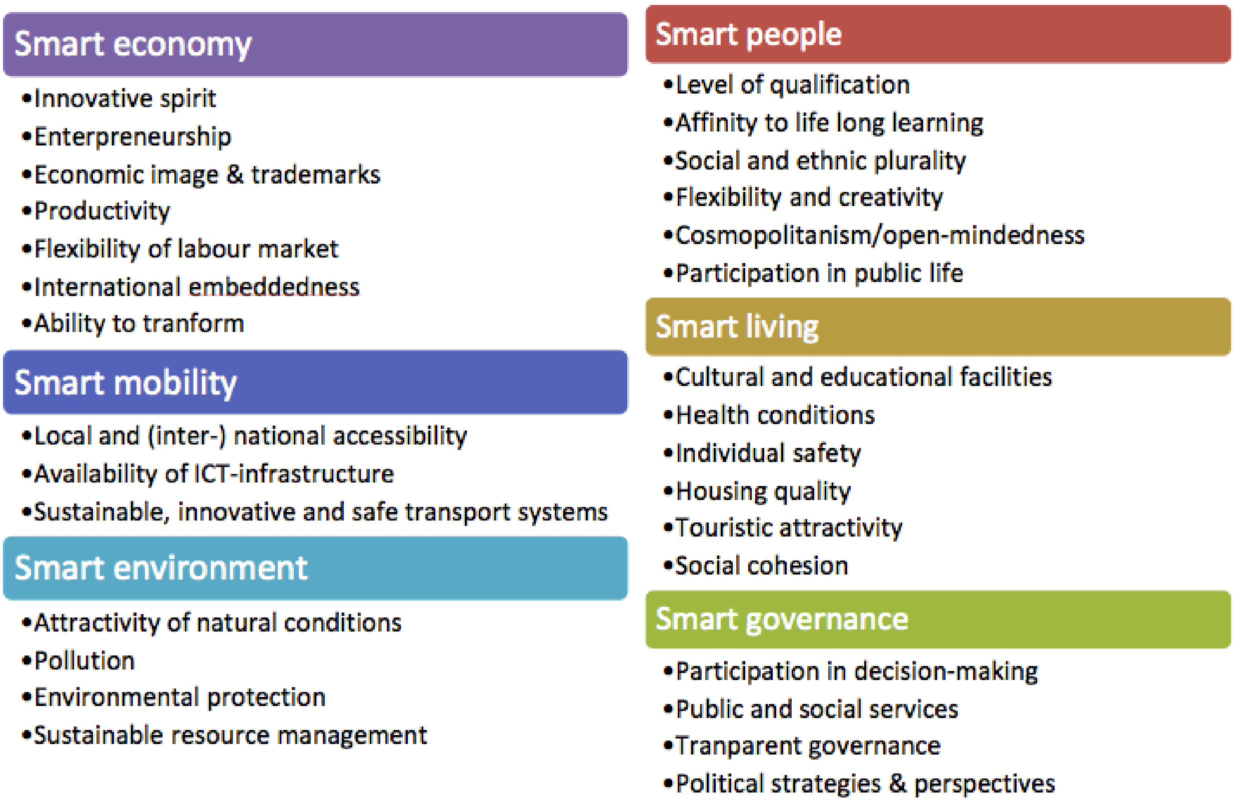


Figure 5 Citadel—Dimensions of a Smart City[30]

The evaluation framework was based on a benchmarking approach in which pilot projects were reviewed through a rigourous evaluation framework to be "conducted in each cycle using a triangulation of data, based on the

[30] Ferguson and Buyle, 2012: 12

literature review (and DoW), which combines the quantitative data from questionnaires and logging (website, applications) and qualitative data from interview scripts, journals, focus groups and participant observations".[31] Corrective actions were then developed at the end of each evaluation cycle to optimise the use of the platform easier in accordance with a variety of concerns about accessibility to non-professionals. Opportunities for feedback were included in the evaluation framework to improve usability during the course of the project and the recommended tools for outreach are valuable take-away strategies from this project.[32] Given the scale and complexity of Triangulum initiatives, qualitative data gathering is being conducted through intense citylab visits to each city under WP06.

EPIC Strategic Evaluation Methodology

The EU Platform for Intelligent Cities (EPIC) is one of seven projects funded under the 2010 Europen Comission Competativeness and Innovation (CIP) objective.[33] "The overall aim of the EPIC project was to develop a flexible, extensible, future-proof cloud computing platform maximising the use of open standards. The platform would host, manage and deliver a diverse range of smart-city applications to citizens and businesses, deliver smart-city data services to support innovation among SME developers and improve efficiency in city administration".[34]

WP8 of EPIC is a review of the requirements of WP2 which "analysed, categorised and prioritised" the requirements to meet the project objectives.[35] The evaluation strategy of EPIC is multimodal and reflects a broad array of stakeholders. Key aspects of the project have been identified in terms of security, usability, interoperability, ethics, smartness, privacy, and performance. These have been clustered to the stakeholders who are most relevant as demonstrated in **Figure 6**.

Key to their methodology is to measure user experience and acceptance of EPIC. For this they adopted the Technology Acceptance Model (TAM), which has been verified in technology acceptance studies. It is noted that there is little empirical evidence on the voluntary use of technologies. Their evaluative framework seeks, therefore, to extend the TAM to technological acceptance amongst private and public stakeholders. The following measures were identified to evaluate user experience and acceptance: the perceived usefulness of a particular system, the perceived quality of the system, attitudes towards the system, the degree to which the system does not undermine the intention of its use, and the degree to which the system enables or disables the user in their job. These insights were incoporated into the recommendations for further monitoring of user experience.

31 Veeckman et al., 2014: 35

32 Veeckman et al., 2014

33 EPIC, 2012

34 EPIC, 2012: 1

35 EPIC, 2012: 13

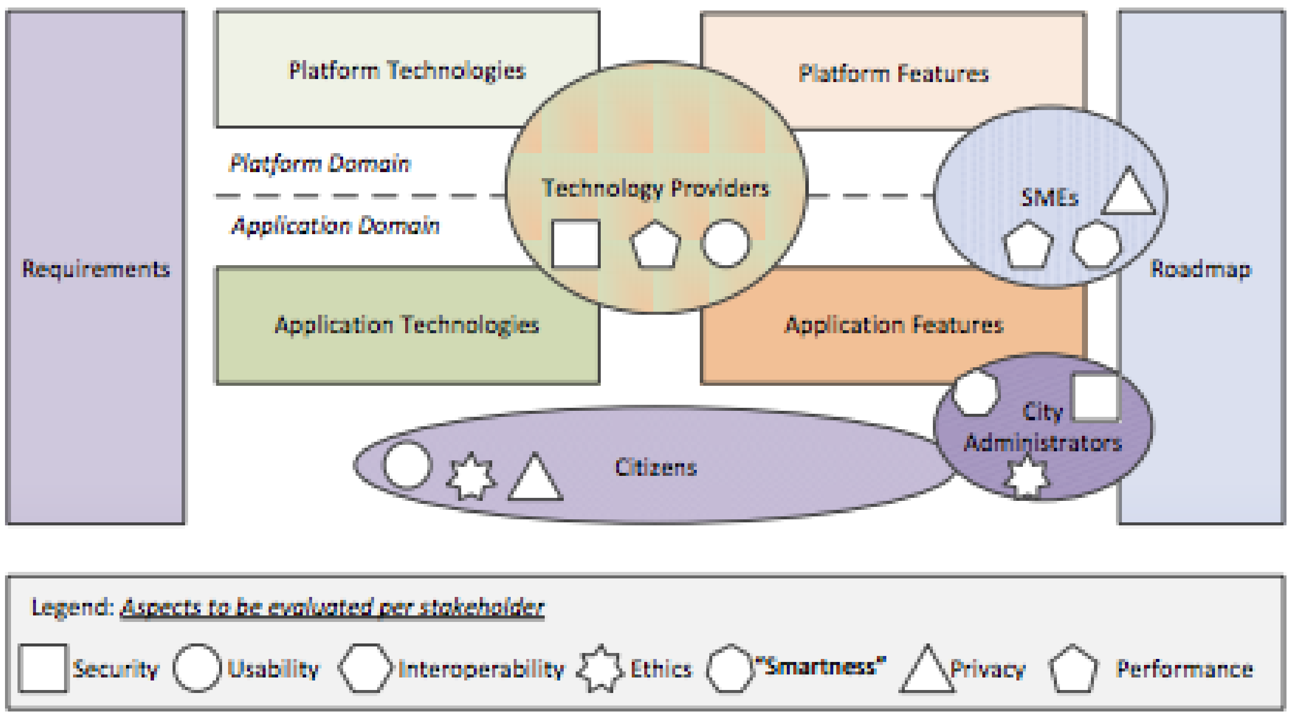


Figure 6 EPIC Evaluation Aspects[36]

Levels of 'smartness' are also key to assessing progress but this is predicated on establishing a concept of what a 'smart' city is. In their understanding, a smart city is demarcated by "the use of innovative ICT-based technologies such as the Internet of Things or Web 2.0 to deliver more effective and efficient public services that improve living and working conditions and create more sustainable urban environments".[37] EPIC's levels of smartness are based upon the Giffinger model, allowing them to qualitatively evaluate success, as also used in CITADEL (see **Figure 5**). **Figure 6** allows EPIC to identify dimensions under which the platform and pilots can be categorised alongside measures that can be qualitatively evaluated, as shown in **Table 4**.

Table 4 EPIC 'Smart' dimensions[38]

Dimension	Measure	Pilot or platform
Smart mobility	Reduce mobility need and better mobility planning local, national and international accessibility	Urban planning – relocation
Smart environment	Environmental protection by reducing energy consumption	Smart environment
Smart living	Improving quality of life	Relocation – urban planning

[36] EPIC, 2012: 14
[37] EPIC, 2012: 19
[38] EPIC, 2014: 20-21

Smart economy	Entrepreneurship, innovative spirit and flexibility of labour market	Urban planning – relocation – smart environment
Smart governance	Legal barriers, privacy, efficient online social and public services, security of authentication and authorization processes	3 Pilots and platform

The methods that will be followed for platform evaluation will include surveys and interviews with the target groups, observation, review of documentation (written material, documents, records, etc.), and statistics and performance tests for the platform elements (where applicable).

Fraunhofer Assessment Guidelines

Fraunhofer researchers have identified 108 indicators across multiple sectors to measure the social, economic and environmental states of the city.[39] City indicators were identified in each sector based on a modified version of the Driver-Pressure-State-Impact-Response (DPSIR) framework. Simultaneously indicators for environmental, social and economic analysis were compared with existing sustainability indicators. Indicators were then broadly categorised in three categories: pressure indicators (social, economic and environmental stressors from different sectors on the city system), state indicators (the state of the economy, environment, society and technology sectors), and impact indicators (the impact of a city on the environment, society and economy). All identified indicators follow the SMART criteria (Specific, Measurable, Attainable, Relevant, and Trackable).

By comparing fields for action amongst their selected cities 83 key action fields were identified for smart and sustainable development to form the core of the assessment process. The indicators describe the state of a city while the key actions describe the response of the city in view of becoming both sustainable and smart. These were identified across three categories: "urban leadership (policy, planning, management & structuring of smart city development), levers (urban planning, business tactics, incentives, regulations, R&D tactics, information & education etc.), points of action (smart grids, resilience engineering, urban big data systems, electronic ticketing, renewable energies, district heating, energetic refurbishment, storm water management etc.)".[40] By relating key action fields with indicators, it is possible to assess whether the response of a city is truly proportionate to the pressures that it experiences.

The Fraunhofer model also identifies what it terms as 'impact factors', individual characteristics that represent the specific circumstance, or 'DNA', of a city that cannot be brought in to a comparable model applicable to another city. Over 170 impact factors have been identified which can inform researchers on where to focus when analysing a city (**Figure 7**).

39 Fraunhofer, 2015

40 Fraunhofer, 2015: 18-19

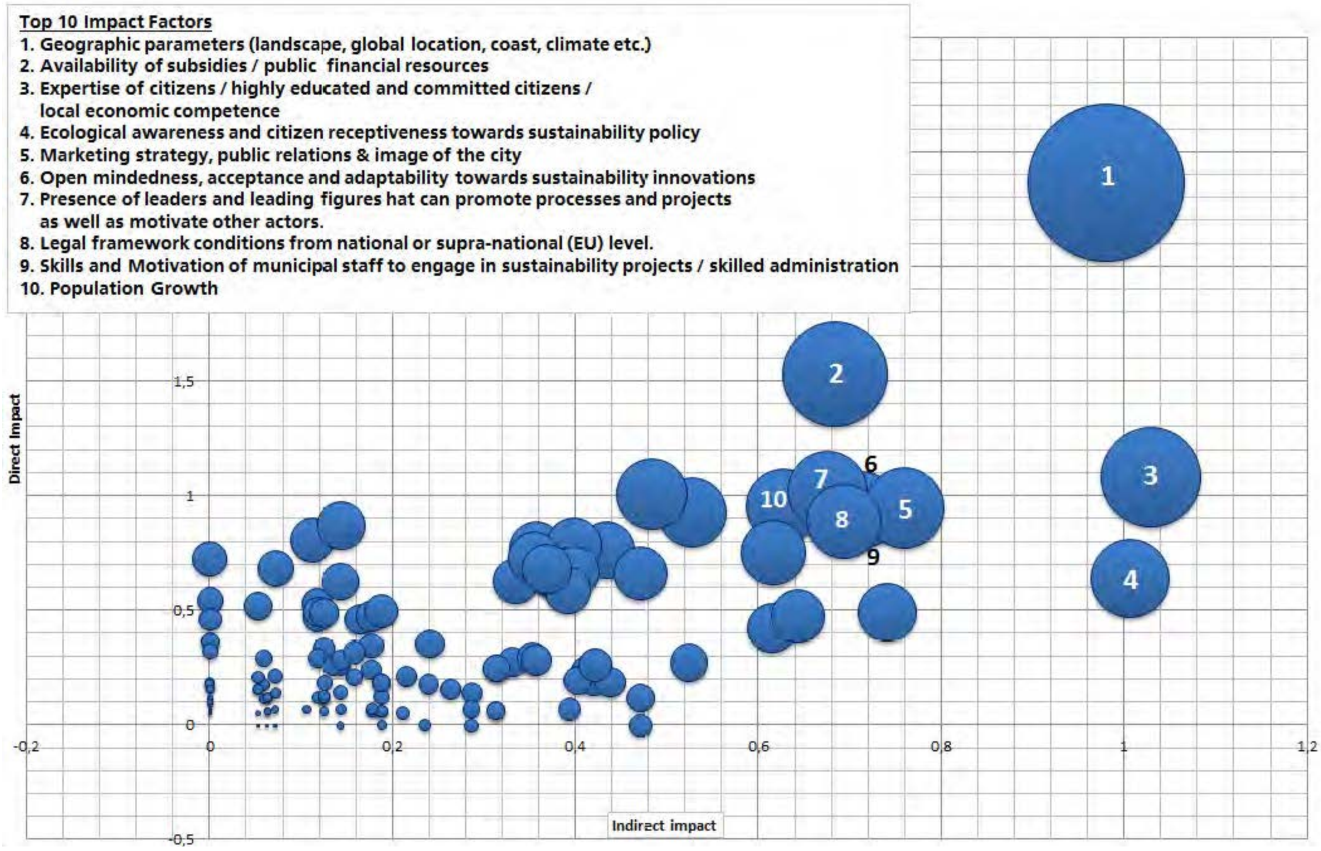


Figure 7 Impact factors for smart & sustainable urban development[41]

REMOURBAN

The REgeneration MOdel for accelerating the smart URBAN transformation (REMOURBAN) project is one of the European Commission's Horizon 2020 projects. Its main objective is to "accelerate the transformation of European cities (urban areas) into smarter places of advanced social progress and environmental regeneration, as well as places of attraction and engines of economic growth".[42] WP2 of REMOURBAN entails developing "a framework to classify performance indicators that can be representative of the city and allow to measure and quantify its sustainability and smartness"[32].

The work package acknowledges that there is no one size fits all method for evaluating sustainability and smartness as each city has its own specific needs attributes and context. However, there are certain common aspects that can be identified when developing a holistic methodology. It also acknowledges that indicators must occur on numerous scales to view interventions in context and account for externalities, and focuses on systems integration, considering the city as a whole. Local authorities are key actors to achieve these goals. In REMOURBAN, they seek to develop smartness and sustainability indices, which they see as distinct.

[41] Fraunhofer, 2015: 20

[42] CityKeys Workshop, 2015

CityKeys

CityKeys is another Horizon 2020 project with an aim to "develop and validate, with the aid of cities, key performance indicators and data collection procedures for the common and transparent monitoring as well as the comparability of smart city solutions across European cities".[43] In contrast to the Lighthouse approaches that the European Commission has supported in other projects, CityKeys adopts a more horizontal approach addressing specific challenges such as regulatory barriers to the standardisation of performance monitoring.

CITYKEYS aims to engineer city and project level indicators, as depicted in **Figure 8**. At minimum, these are the two levels for which indicators are necessary. The project team is considering the addition of a third level for the neighborhood level (this has proven necessary in Rotterdam). Among the already well-known indicators, such as greenest, most attractive, success of strategies over time, and governance, there is a need for more specific indicators at the project level particularly given that many projects are related to securing funding and are governed by the expectation of certain deliverables. Thus, evaluation is intended to ensure that investment will guarantee sustainability, requiring benchmark assessments and on-going monitoring.

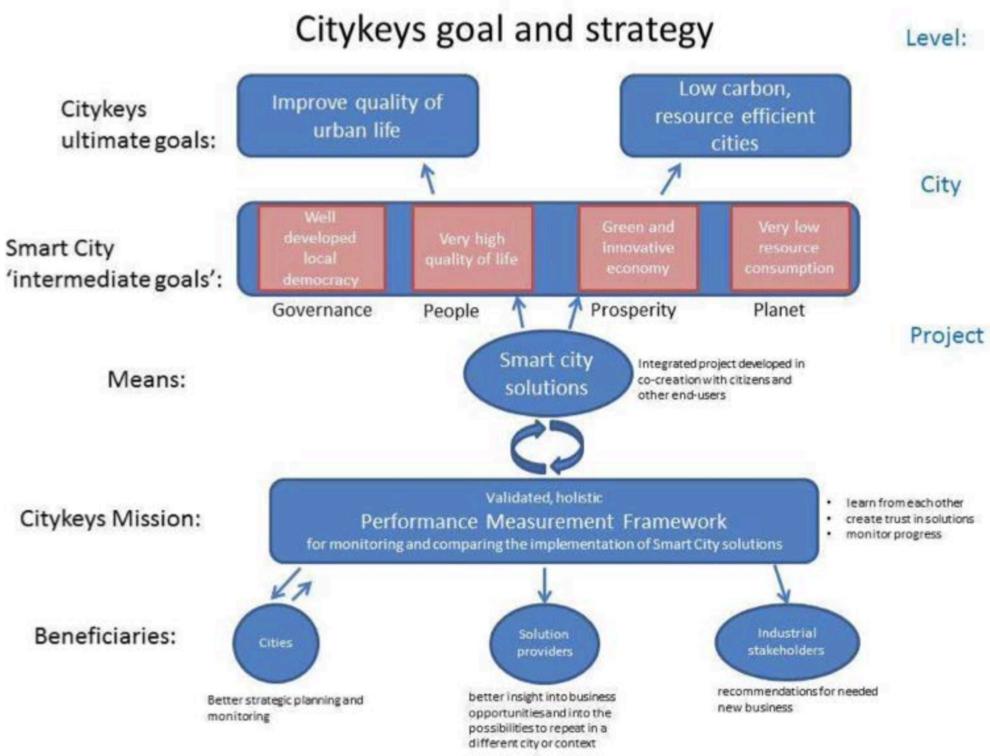


Figure 8 CityKeys Goals and Strategy[44]

43 CityKeys, 2015 (no pagination)

44 CityKeys Workshop, 2015

The overall view of their approach and tasks allocated in each work package is illustrated in **Figure 9**.

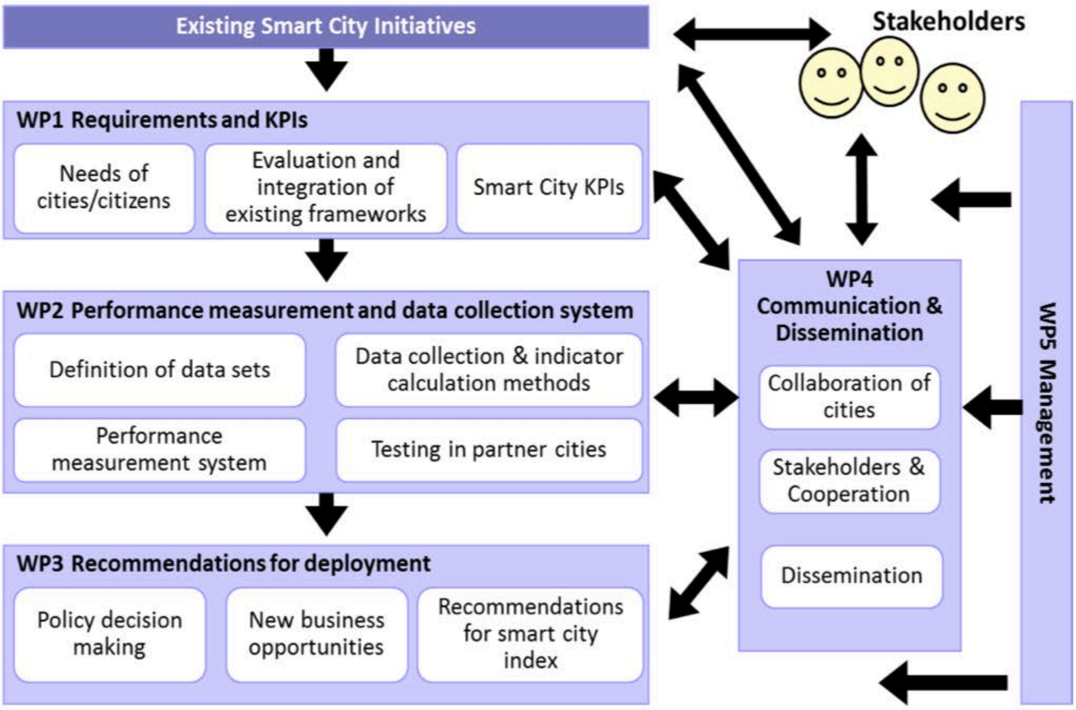


Figure 9 CityKeys approach and tasks allocation

The CityKeys project team reviewed many well-known frameworks, including ISO 37120, Civitas, European SCI, GDC, PLEEC, BREEAM, CASBEE 2012/2014, DGNB, Euro-District, Eurban Lab, LEED, and others to develop a database of indicators. These indicators address four impact domains: people, profit (or prosperity), planet, and governance. These four impact domains are supposed to contribute to the ultimate goal of a lower carbon society and higher quality of life. Propagation is a fifth domain under consideration that ensures that the projects or lessons from the projects at the very least are replicable.

The frameworks that currently exist are mostly based on the city level, while a few are designed on the project level. Many have thought about this contradiction, but previously efforts to merge city and project level assessments resulted in too many indicators. Through the surveys that they are gathering, the CityKeys team hopes to develop a coherent and agreeable definition as to what a smart city is and what the indicators to measure its performance would ideally be.

Citykeys have preliminary results of the needs of the cities and citizens. Two questionnaires were distributed among 100 cities across the EU and focused on smart city initiatives to determine what cities are currently measuring, what sort of information they wish they had, and what should be asked of cities to gauge their future performance. The relationship between this work and the overall structure is shown in

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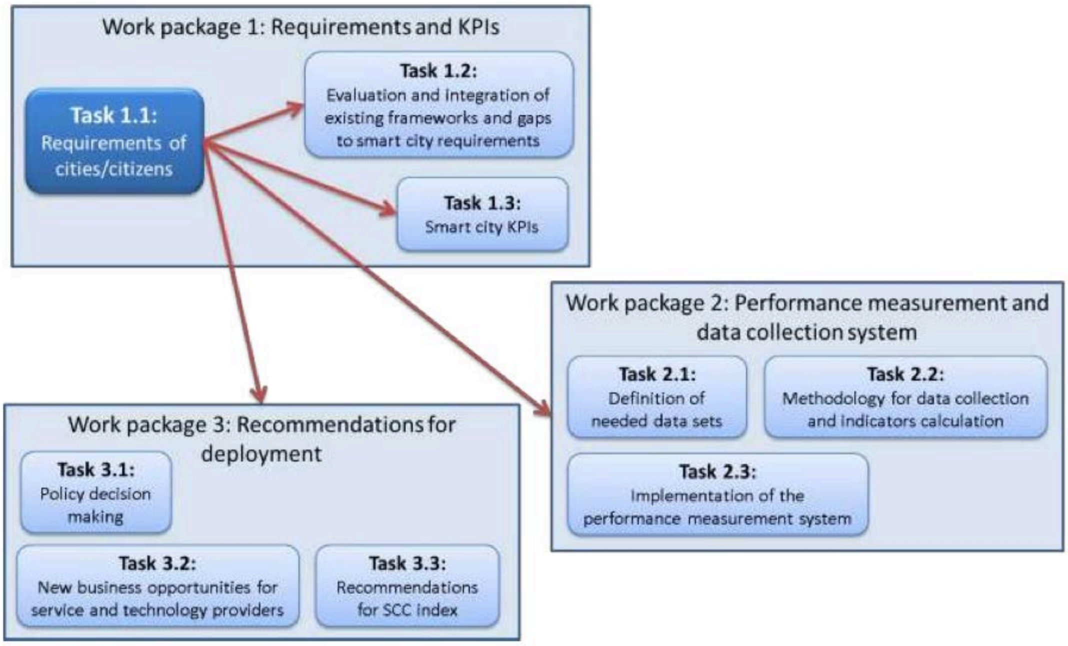

Figure 10 Relationship between requirements of cities/citizens and CityKeys project

The survey goes beyond the city level, looking at districts and projects to determine appropriate methodologies suitable to different levels of smart city initiatives. Preliminary findings are list as below:

- Three-quarters of cities said that the smart city is important to them
- When asked does your city measure smart city performance, less than 25% said yes, 50% said no, the rest measure some areas but not everything
- The majority said they wish to measure smart city performance to inform strategy for future smart city projects
- The top sectors currently measured by cities are greenhouse gases, quality of life, energy consumption/renewable energy, and mobility
- 17 out of 26 said they want to see better ways to measure how smart cities affect energy, GHG emissions, and technology, followed by competitiveness
- The majority said they wish to measure smart city project performance to evaluate smart city projects
- 15 out of 26 said they want to see better ways to measure GHG emissions and energy followed by transportation and digital infrastructure and e-service
- 40% citizens and stakeholders think their city is smart and 62% of them know there is smart city project implementing in their cities
- The top five important (desired) project results on behalf of citizens and stakeholders are: creation of innovation & knowledge, better public transportation, protection of the environment, better education & skills building and cleaner energy

The results show that some questions worked well in most cities, while, others need to be revised. Their revised survey will be distributed in August 2015 and 10-12 of the cities initially surveyed agreed to contribute to project in a more substantive way.

3.3 **Triangulum: Key Implications and Opportunities**

In general, the Lighthouse projects are intended to produce a standard to measure smart cities at the city, neighbourhood, and project scales. However, the project scale indicators are difficult to implement because there are no smart city projects involved in CityKeys. Thus, they may focus on city level indicators which could provide a general approach for more detailed project level indicators.

There are several opportunities for Triangulum with respect to the CityKeys project. CityKeys mainly focuses on city level or neighborhood level indicators and does not have any on-going smart city projects to provide in depth project level indictors and full project cycle indicators, Also, CityKeys does not have a data hub or open data platform to manage data collection. Without a data platform to handle dynamic sensor data, the performance measurement of CityKeys is more static rather than dynamic. This might also increase the difficulty of extension of current methodology with future smart city projects. Triangulum's unit of study is the project rather than the more broader city focus of CityKeys. Fuirthermore, Triangulum takes a bottom up approach from the project level to the city level, offering a distinctive way to deal with the multi-scalar challenge. The Triangulum indicators focus on various smart city projects in three different cities, based on usability for project sites and project manager themselves and also address project cycle process assessment. Finally, data collection is based on open data platform/data hub with dynamic evaluation and monitoring and the ability to apply the data format standards to other similar projects

Triangulum offers a distinct opportunity to previous smart city projects in that it is designed around real world experiments. The demonstration projects offers a range of interventions and an opportunity to measure impacts in the real world across the wider range of domains than has previously been done. This will be supported by a Cloud Data Hub that lends a degree of transparency and rigour to the monitoring process that is also unique, and is complemented by the detailed qualitative data collection included in WP06. Triangulum thus offers a broader and deeper approach to monitoring that will enable the development of a framework that effectively shows how smart city interventions can deliver the sustainable city goals required to address the key challenges of the 21st century.

3.4 **Capturing Social Impacts and Integration**

A key challenge highlighted by the review work involves the need to strengthen the citizen engagement and socioeconomic impacts of the demonstration projects, which were highlighted as desirable in the original proposal. The citizen engagement and socioeconomic impacts are the two impact domains most difficult to quantify. Fundamental to the definition of success laid out in the DoW is citizen involement in the creation and implmentation process for ICT, transport, and energy infrastructure that results in quality of life gains. Capturing individual response to and benefit from infrastructural developments presents complex methodological questions to ensure a representative sample and accurate surveying procedure. Certain past EU projects relied upon qualitative surveying to capture citizen satisfaction, however, the resources for such an intensive fact-finding process are not guaranteed in all of the Triangulum cities. Therefore, the review intended to determine both indicators and survey strategies that could capture a large volume of data on changes in citizen happiness as well as satisfaction with and indirect benefits stemming from project implementation. The socioeconomic and engagement goals of Triangulum projects originally outlined in the DoW emphasized job creation, replicability of projects, quality of life improvements, environmental and digital literacy, more effective and fair decision-making, more inclusive society, and engendering European identity all within the context of improving urban smartness and sustainability. While specific indicators to best monitor each of these areas were recommended in the draft framework, these were modifed and expanded as a result of the literature review. This included a review of the indicator and data gathering methodologies for citizen happiness used by the United Kingdom,[45] and numerous international indices for the evaluation of citizen well-being including the European Union Quality of Life Survey[46], European Social Survey[47], New Economics Foundation National Accounts of Well-Being[48], OECD Guidelines to Measuring Subjective Well-Being[49], and more broadly the EIU Liveability Ranking[50], and the Human Development Index.[51]

Within these frameworks, a vast range of indicators are employed, including scalar ranking of perceived levels of happiness and satisfaction with home, jobs, and neighbourhood, however, the majority of these survey tools focus on measuring the level of well-being within society based on an aggregate of indicators, emotional, financial, physical, and community health. While valuable to contextualize holistic definitions of well-being used by national and international agencies, the scope exceeds that needed for project level evaluation, as do the largely mail-in based, phone, and door-to-door survey strategies, which measure improvement in citizen happiness and well-being at a geographically larger scale. Concerns about survellience in the modern era must be taken into consideration, and many have raised alarm about the use of data that is aggreagated in open access platforms, such as the Cloud Data Hub, which can be commericalised for the benefits of individual entreprenuers or the city government without effectively addressing the needs of local residents from whom information is sourced. Given that citizen engagement is also a central component of evaluating the effectiveness of Triangulum, it is also neccesary to ensure that all systems of data monitoring are transparent and easily accessible to the public through the Cloud Data Hub. Systems of data gathering that operate after receiving participant consent also will be the most valuable to improving services as monitoring more appropriate to the project level will be based on transactional interactions through quality of experience (QoE) surveys presented at the end of a service provided.[52]

45 Office of National Statistics, 2014: 3

46 European Foundation for the Improvement of Living and Working Conditions, 2014

47 European Social Survey, 2014

48 Michaelson et al., 2009

49 OECD, 2013

50 EIU, 2014

51 UNDP, 2014

52 de Moor et al., 2010

An obvious approach to gather data is through an online interface. The advent of the internet was widely heralded as tool to increase participation and representativeness of local democratic decision-making. However, 25 years after its launch, while the number of users has increased, the rate of increase has slowed as society reaches a point of sturation. Regular use remains at 75% of the EU population and only 43% of the population uses the internet away from home or work (most often via a smart phone)[53], requiring other sampling methodologies that go beyond an online interface to achieve representative samples. The following section summarises some of the tools available for online data captureand then recommends other strategies for data collection.

Online strategies

Mobile apps: Tapping into the app economy is central to the ambitions of the Lighthouse cities and rightfully so as the sector is now worth more than €2.9 billion. However, growth is slowing as the sector matures, websites increasingly look towards mobile-friendly interfaces instead, and successful apps focus on service provision[54]. Apps can provide a valuable interface for city services that also enable data collection on who is using city services, who has problems with such services, and perceptions of the changes in urban infrasructure. The EU Commission project SUstainable and PERsuasive Human Users moBility in future cities (SUPERHUB) offers numerous recomendations for its industrial partners as to how services can be measured through mobile applications such as a gaming and an interactive journey planner.[55]

Mapping: Mapping applications can be used to understand how and where residents access different services in the city. Gathering data from online mapping applications, whether from a third party client such as Google or MapQuest or produced through a new, city-specific mapping applications can provide information on the mode and direction of travel. This is useful not only to plan routes for bicycles and pedestrians in the smart city, but also the placement of bus stops, transit hubs, electric vehicle chargining stations, and new business districts. Surveying, transport studies, and urban land use models are critical to the development of city services. However, gathering geographical metadata or introducing surveying into city-specific mapping applications can provide information about the flows of specific user groups, such as tourists, commuters, and youth to better allocate services[56].

Online User Surveys: While not as complex or interactive as an app, online surveys provide an important opportunity to poll those who may not use other wireless devices. However, making websites mobile responsive can also increase the likelihood that all users, whether they access the information through a wired or a wireless connection will fill out the surveys. Surveys are commonly used on government websites, including the Manchester City Council page.

[53] Coe et al., 2001; Digital Agenda Scoreboard, 2012

[54] Digital Agenda Scoreboard, 2015

[55] Muñoz et al., 2013

[56] Cottrill and Derrible, 2015; Crivello, 2014; Kourtit et al., 2012; Spiekermann and Wegener, 2004

Social Media Hits: There are numerous strategies to mine social media for data but these raise a range of ethical issues as well as technological difficulties for research teams.[57] However, at a basic level, social media hits via Twitter, Instagram, and Facebook are relatively simple to aggreagate, allowing cities to advertise Triangulum projects through specific hashtags and track knowledge about projects in local social media fora.

Offline strategies

Common strategies of data collection to track socioeconomic changes include questionnaires, surveys, interviews, focus groups, and observation. While these tools are able to provide a high-level of detail, more qualitative research methods are highly time-consuming and too clumsy to trace the impact of disaggregated, project-level impacts. Specific recommendations are listed under each impact domain heading. In general, the best system for tracking citizen engagement with new services is through surveys. For each of the various projects listed in which there is an element of community involvement, it is crucial to understand the motivation of participants. Surveys enable the city to better track populations that are not being served by smart city initiatives and also reform services to target those populations effectively. Surveys are easier to gather after a specific service has been provided, which may be invaluable to gather data on new entrepreneurs and users of the open data platform.

Media hubs where citizens can ask questions of librarians, programmers, business advisors, or interactive information screens in more remote locations such as bus stops, can serve as a point to answer questions about the new services activated in each city: What is the Cloud Data Hub? How can I access it? What does decarbonisation mean? What is a smart city? How can I get involved? One such hub is already active in the Central Library in Manchester and serves as a place where community members can share skills, use software that would otherwise be prohibitively expensive, and engage with others of similar interests. Increasing advertising of the media hub and establishing others throughout the city would multiply the beneficial effects already seen. Integrating new services into this platform, such as counselling for small and medium sized businesses, start-ups, and jobs seekers would also have an tangible financial benefit to the city that could be measured. Surveying first time users, subscribers, and participants in skills training workshops could then provide data to generate programming more specific to the needs of city residents or tailor advertising to attract different audiences.

Hubs act as a physical space for information, feedback, and engagement that corresponds to the digital infrastructure being implemented to support ICT integration of governance, energy, and transit systems. They have proven effective in numerous instances across the developed and developing world to bring together populations and disseminate information. Uniquely, from the perspective of data gathering, such hubs could also act as a point from which to survey users about their experiences with changes in the urban environment. The inspiration comes from transit-oriented development in Medellín, Colombia where the extension of the MetroCable system into peripheral, hilly areas of the city was able to create a community space around new metro stops. These not only helped to reduce violence, but also came to serve as a community gathering point to share information and advertise new enterprises.[58] Similar, multi-model transit hubs are common in urban and

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[57] Ben Abdesslem et al., 2013; Bohannon, 2013; Lomborg and Bechmann, 2014

[58] Bocarejo, 2014; Cerda et al., 2012

peri-urban areas across Europe and North America and act to improve the ease of travel for business and tourism. As an example of how hubs could be easily implemented to improve engagement with smart city projects, this model is easily transferable to the Manchester Corridor where smart city developments are based around public transit intergrated with improved bicycles and electric car facilities. Placing interactive screens at major bus stops could provide services as simple as the weather and bus arrival and departure times or a more extensive array of information, including access to the local government website, tourist information, and an opportunity to give feedback through short- and long-form questions. Such a system could improve the sense of security and safety for bus users who are able to register complaints through the interactive form. Additionally, the integration of digital infrastructure into transit improvements provides opportunities to monitor user experience with the new system as well as improve digital literacy by bringing technology to the street. While transit hubs are only one iteration to improve citizen engagement in the city, other common examples include public bicycle repair shops, "fab labs", and the UK Citizens Advice Bureau, which not only provides vital public services, but can also act as a gathering point to stitch together the diverse impacts of urban projects and to contribute to the development of smartness, sustainability, and a wider perception of smart city growth.

Eindhoven has already made substantial progress is this regard, having designed different survey tools to gather information on citizen well-being and engagement that will contribute to the analysis of current projects and the on-going development of various iniatives to improve quality of life in the housing and business districts under observation. Their smart city projects are designed around specific, geographical districts, researchers have already designed a toolkit to survey urban residents. An example of this toolkit that is currently under development can be found in **Appendix 2**.

Monitoring integration of projects

A final challenge central to Triangulum is the need to monitor integration across the projects. This can be done at three levels: by identifying impacts that are contributed to by multiple projects in one city; by the survey that will be adminsitered by WP02 to monitor the governance impacts of the demonstration projects; and through WP06 citylab visits, where specific questions can be inserted into the inteview proformas relating to this challenge.

4. Impact Mapping and Evaluation Framework

This section presents a review of expected impacts across the lead cities and identifies indicators and quantifiable units to capture key impacts of demonstration activities.

4.1 Impact and Data Mapping Methodology

The DoW outlined a preliminary series of expected impacts identified by the lead and follower cities, subdivided into the impact domains of energy, mobility, citizen engagement, socio-economic/financial and ICT deployment. These expected impacts also list multiple indicators by which the different dimensions of the impact might be measured (**Table 5)**. This deliverable seeks to elaborate on the expected impacts, to enable comparisons between cities and sectors, as well as underpinning the replication of successful smart city technologies.

Table 5 Original table of expected impacts and preliminary quantifiable indicators[59]

Impact Domain	Expected Impacts	Indicators Identified for Assessing Impacts	Quantifiable Units
Energy	Lower energy bills	Amount of buildings retrofitted / smartified	Number and type of buildings converted /yr, m2 converted /yr
	Increased energy efficiency	Generation and use of local energy sources	GWh/yr or MWh/yr
	Increased use of renewables	Total energy demand of district and per capita	GWh/yr and KWh/yr
	Reduced carbon emissions	Carbon emissions per building	tC
		Air quality	PM10 ppm
		Average electricity price for companies and consumers	€/KWh
		Share of renewable energy on the grid	% solar, wind, geothermal
		Smart meters installed and used	Number of meters, GWh/yr
		Organisations sharing energy use / monitoring	Number, GWh/yr
Mobility	More efficient transport	Air quality	PM10 ppm
	Lower carbon emissions	Electric vehicles	Number
	Testing of new technologies	Modal split	% for passengers and logistics
		EV/FC charging stations	Nr in district vs. city, MWh/yr
		Carbon emissions	tC/yr
		Average journey times	Min/km

[59] Triangulum, 2014: 41-42

		Average journey costs	€/km
		User satisfaction and engagement	%
		Use of Smart mobility apps	Number and %
		Use of e-bike / e-car rental schemes	Nr and % people
		Average delivery costs	€/km/Kg
		Nr. of daily deliveries	Number
Citizen engagement	More inclusive society	Smart apps developed using open data platform.	Nr, commercial value in €
	More effective and fair decision-making	Internet penetration rate, broadband subscriptions and 3G/4G mobile subscriptions	Per 1000 population
		E-participation	Nr of people and % of population for district vs. city using apps)
		E-governance	Nr of decisions using electronic consultation, nr of people % population engaging in e-consultation / e-petition
		Use of open data platform	Nr people / % of population for district vs. City
Socio-economic / financial	Generate large-scale investment,	Re-use and repurposing of physical infrastructures	€k/yr (deferred) investment
	Job creation	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr
	Better quality of life	Payback periods for specific demonstration activities	Years
	Testing of new technologies	Inward investment	€/ yr by different sectors
	Development of replicable solutions.	Jobs created	Nr and overall earnings in
	Wide scale deployment	Average earnings data in district	€/yr
		Skills and training delivered	Person / hrs
		SMEs created	Nr and turnover in €/yr
		Satisfaction of SMEs with business environment	%
		Technologies trialled in Lighthouse city adopted elsewhere	Nr / commercial value
		Innovation and commercialisation	Nr of patents/ commercial value
		Recorded happiness of residents and workforce	%

4.2 Impact and Data Mapping Tables

To enable comparison between cities and to facilitate a meaningful interpretation of their smart city progress, the researchers undertook a two-staged review of the expected impacts to produce an impact mapping table. In the first stage, the original expected impacts and indicators from **Table 5** were cross referenced with the lead city proposals, along with the Triangulum project as a whole, and marked as to whether they had: not indicated a use of the metric (1), implied the use of the metric (2), had obligated to use the metric (3), or that the metric was not applicable to the city and/or project (.). Each impact domain has also been color coded for clarity (see **Figure 11**). Additional indicators and metrics were also mined from the proposal to expand the impact mapping table. The resultant impact mapping table allows for areas where commitments are like to be identified. This identification enables cities and their achievements to be compared.

In the second stage, the impact mapping table was presented to the leadcities to validate whether the interpretations drawn from the individual project proposals were correct. It also provided an opportunity for cities to update their commitments since the submission of the proposal and in view of other cities' obligations. This resulted in numerous alterations to both preferred metrics and also their respective commitments. This second-stage validation then informed the iteration of the impact mapping that is presented in this deliverable. **Table 6** presents a summary of the results of this process for the three cities (please note: the full impact mapping and data tables for each individual city are available in **Appendix 1**).

Colour Coding of Impact Domains				
Energy	Transport	Citizen Engagement	Socioeconomic/financial	ICT
Commitment to Indicators				
3 (Obligated)	2 (Implied Use)	1 (Not indicated)	. (Not applicable)	

Figure 11 Impact domains color coding and use

60 Triangulum, 2014: 41

Table 6 Impact and Data Mapping Table for Lead Cities

Impact Domain	Expected Impacts	Indicators Identified for Assessing Impacts	Potentially Quantifiable Units	Eindhoven	Manchester	Stavanger
Energy	Lower Energy Bills	Amount of buildings retrofitted / smartified	Number and type of buildings converted /yr, m2 converted /yr	3	3	3
		Reduction in monthly energy bills	% decrease in energy bills for residential and commercial properties	3	3	3
	Increased Energy Efficiency	Generation and use of local energy sources	GWh/yr or MWh/yr	3	3	3
	Flatten Peak Demand	Thermal and electric battery storage units adopted	GWh or MWh of storage capacity	1	3	2
		Distribution of generation/storage assets	% change in GWh/hr or MWh/hr at peak demand times	1	3	3
		Change consumer behaviour	% decrease in individual energy use	3	1	2
	Increased Use of Renewables	Reliability of off-grid systems (page 78)	% energy generated on site	2	3	2
		Soil Sanitation	% of water treated	3	1	1
	Reduced Carbon Emissions	Carbon emissions per building	tC	2	3	3
		Air quality	PM10 ppm	1	1	1
		Average electricity price for companies and consumers	€/KWh	2	2	1
		Share of renewable energy on the grid	% solar, wind, geothermal, biogas	3	2	2
		Smart meters installed and used	Number of meters, GWh/yr	3	1	2
		Organisations sharing energy use / monitoring	Number, GWh/yr	1	1	1
		Reduction in Net Carbon Emissions	CO2. emissions per annum at project site	3	3	3
Transportation	More Efficient Transport	Air quality	O3, PM2.5, PM10 ppm	1	3	2

		Gridlock	Minutes of average commute time, % change	1	2	1
	Lower Carbon Emissions	Public transport use	# of passengers, % change in ridership	1	3	3
		Bicycle use	# of riders, # of citizens claiming tax credit, # of riders observed with sensors	1	3	1
		Electric vehicles	Number	1	3	1
		Reduction in fuel intensity of transport	CO2 per km	1	2	3
	Testing of New Technologies	Modal Split	% for passengers and logistics	1	2	1
		EV/FC charging stations	Nr in district vs. city, MWh/yr	3	3	3
		Average journey times	Min/km	1	3	1
		Average journey costs	€/km	1	2	2
		User satisfaction and engagement	% registered customer/passenger satisfaction	1	2	2
		Use of Smart mobility apps	Number and %	1	1	1
		Use of e-buses	Reliability of e-busses compared to standard diesel busses measured in maintenance costs and days out of service	1	1	3
		Use of e-bike / e-car rental schemes	Number available and average hours of daily use	1	3	1
		Assessment and reduction of parking spaces	% reduction, % change in unmet need for parking	3	1	1
		Average delivery costs	€/km/Kg	1	2	1
		Number of daily deliveries	Number	1	3	1
Citizen Engagement	More Inclusive Society	Diverse target population	Census information on targeted neighbourhoods	3	1	2
		Adoption of co-creation procedure	# of citizens involved in project-planning	3	2	2
	Commercialisation Opportunities	Smart apps developed using	Number of apps developed,	3	3	2

		open data platform.	commercial value in €			
	More Effective and Fair Decision-Making	Internet penetration rate, broadband subscriptions and 3G/4G mobile subscriptions	% in users per 1000 population	1	1	2
		E-participation	Number of people and % of population for district vs. city using apps	2	1	2
		E-governance	Number of decisions using electronic consultation, number of people % population engaging in e-consultation / e-petition	1	1	2
		Use of open data platform	Number of people/ % of population for district vs. City	3	3	1
	Environmental Awareness and Communication	Energy consumption awareness campaign	# of contacts, # of pledges	3	3	3
	Foster European Identity	Adoption of sustainability and smart city programs from Horizon 2020	# of new programs developed	2	2	2
		Heritage building preservation	# of listed buildings retro-fitted	1	3	1
Socioeconomic/ financial well-being	Generate Investment	Public-private partnerships generated through Triangulum	€k/yr invested in new partnerships	2	3	1
		Promote economic growth in district	% change in GVA	1	3	3
		Re-use and repurposing of physical infrastructures	€k/yr (deferred) investment	3	3	3
	Job Creation	Capital /operational expenditure of partners on energy, ICT and	€m /yr	3	3	2

		mobility				
	Better Quality of Life	Respect local ways of working	kilos of toxins reduced	1	1	1
		Improved public street lighting	# of lights installed, # of hours/streets illuminated, change in crime rate/frequency of complaints to public authority, sensor density of people on the street	3	1	1
		High quality public space	User surveys, # of social media comments on new space	3	1	2
		Affordable housing	% increase in rent over cost of inflation	3	1	1
		Payback periods for specific demonstration activities	Years	3	1	3
	Testing of New Technologies	Inward investment	€/ yr by different sectors	2	2	2
	Development of Replicable Solutions	Jobs created	Nr and overall earnings in	3	3	2
	Wide-scale Deployment and Disemmination of project results	Average earnings data in district	€/yr	1	3	2
		Skills and training delivered	Person / hrs	1	2	1
		SMEs created	Nr and turnover in €/yr	3	3	2
		Satisfaction of SMEs with business environment	% of businesses indicating satisfaction in annual surveys	2	2	2
		Technologies trialled in Lighthouse city adopted elsewhere	Nr / commercial value	1	1	3
		Software and application development	# of apps registered	3	3	2
		Innovation and commercialisation	Nr of patents/ commercial value	3	3	3
		Recorded happiness of residents and workforce	%	3	1	3
ICT	Improved Energy	Advanced controls	GWh or MWh	1	3	3

	Efficiency		wasted/lifecycle cost			
			% change in public lighting energy consumption at district level	1	1	1
		Consumer energy app implementation	% reduction in office energy use	3	2	1
		Automatic grid independence in district	GWh or MWh purchased	1	3	1
	Mobility Efficiency	GIS tracking of rental e-bikes and e-cars	% of vehicles enrolled	1	3	3
		GIS tracking of eBuses	% of buses monitored	1	3	3
		Monitoring use of EV/FC charging stations	% of time used, unmet demand	3	3	3
	ICT Deployment	High speed fibre network expanded	# of homes, # of businesses reached	1	1	3
		Data streams monitored	Nr and sector, nr of data points collected	3	3	3
		Use of data sharing platforms and open data	Nr and sector, nr of data points shared	3	3	3
		Real time data capability	Nr and sector, nr of data points collected, time lag in minutes for data processing	1	2	3
		Smart city integrated services	Nr of services using integrated ICT system	1	3	3
		Synergies between smart grids	Exchange in GW/yr	1	3	1
		Integration of building management into ICT platform	Nr (across different sectors), carbon footprint in tC	1	3	3
		Use of ICT in public transportation	Passengers/yr, passenger km/yr	1	2	3
		Data storage	bytes	1	1	3
		Data processing capacity		1	2	3

4.3 Summary of Expected Impacts and Data Mapping across the Three Cities

This section analyses where impact assessment between cities might be both comparative and distinct. This is structured by the five impact domains of energy, transport, citizen engagement, socio-economic/financial, and ICT. For each impact domain, a table was generated to show any indicator that was listed for at least implied use in all three cities. While the overall approach of Triangulum is to focus on monitoring the demonstration projects themselves, these tables are useful to highlight possible areas for comparison and learning between lead cities.

4.3.1 Energy

As Table 7 shows, indicators for the expected impacts of lower energy bills were common between all cities. This comprised of the retrofitting of buildings and a reduction in monthly energy bills which all three cities committed to measure. Increased energy efficiency, in terms of the generation and use of local energy sources, is also common between cities. However, Manchester will report this as a percentage of overall energy generation whilst Stavanger will report this in terms of KWh. It might be useful for Manchester to further report in KWh so as not to lose this raw data through interpretation.

In terms of the expected impact of flattening peak demand, Manchester makes no commitment to establishing a change in consumer behaviour. Similarly, Eindhoven does not commit to measuring thermal and energy units or the distribution of generation and storage assets. In the impact of reduced carbon emissions, none of the cities committed to measuring the indicator of air quality, despite being part of the Triangulum proposal. In terms of an increased use of renewables, all cities at least give implied use of the measurement of the reliability of off-grid systems. The expected impact of reduced carbon emissions is most thoroughly represented across three indicators. There are no common commitments to indicators pertaining to the expected impact of flattened peak demand.

Table 7 Common indicators across lighthouse cities for the domain of energy

Domain	Expected Impact	Indicator
Energy	Lower energy bills	Amount of buildings retrofitted / 'smart-ified'
		Reduction in monthly energy bills
	Increased energy efficiency	Generation and use of local energy sources
	Increased use of renewables	Reliability of off-grid systems
	Reduced carbon emissions	Carbon emissions per building
		Share of renewable energy on the grid
		Reduction in net carbon emissions.

4.3.2 Transport

As Table 8 shows, there is limited overlap of indicators for transport due to the disparate nature of project proposals in this domain, with only two common indicators across only two impacts. The effect of this is two-fold. Firstly the expected impact of lower carbon emissions is not represented with regard to transport. Secondly, individually common indicators must be supplemented with other, city-specific indicators in order to report meaningfully of their progress. For instance, all cities agree to measure air quality as an indicator of more efficient transport, though this should come amongst other indicators, specific to the respective cities. It is insufficient as an indicator on its own and therefore should not be used as a baseline to compare the impact. This is true for all domains but particularly important with regard to transport where indicators are particularly city-specific.

It is surprising that whilst all cities plan to measure EV/FC charging stations, only Manchester will measure the number of electric cars on the roads themselves. The lowering of carbon emissions aspect of the transport domain, of which this is one, is largely incongruous between the lead cities. Whilst a large part of this is due to the specificity of individual plans, some of these appear as potential oversights. Eindhoven will not measure increased public transport use, instead considering the parking place reduction in Strijp-S, which might signal positive change if it results in a decrease in car use. Within the expected impacts of the testing of new technologies, Eindhoven is alone in not considering user satisfaction and engagement and average journey costs. There are no common commitments to indicators pertaining to the expected impact of lower carbon emissions.

Table 8 Common indicators across lighthouse cities for the domain of transport

Domain	Expected Impact	Indicator
Transport	More efficient transport	Air quality
	Testing of new technologies	EV/FC charging stations

4.3.3 Citizen engagement

Manchester does not evidence a diverse target population on the basis of census information on targeted neighbourhood, this is perhaps a symptom of the project level of Manchester Corridor, and it being a 'knowledge hub' as their proposal describes.[61] Whilst this seems permissible, the transient nature of the wider population and the demographics of those that travel to the Corridor should be considered. Similarly they are alone in not considering Internet penetration; perhaps for the same reason is it in not largely a domestic area. By extension, Manchester also omits e-participation from its indicators. These omissions considered holistically might impede demonstrable citizen engagement in Manchester, despite being explainable given the overwhelmingly student and professional demographics of the project site.

[61] Triangulum, 2014

As Table 9 shows, all three cities see the development of apps based on their open data platform as an indicator of their commercialisation opportunities, yet Stavanger has not committed to measure the use of the open data platform beyond app creation which might diminish the evidence of the social value of the platform beyond economic applications. There are no common commitments to indicators pertaining to the expected impact of more effective and fair decision-making.

Table 9 Common indicators across lighthouse cities for the domain of citizen engagement

Domain	Expected Impact	Indicator
Citizen Engagement	More inclusive society	Adoption of co-creation procedure
	Commercialisation opportunities	Smart apps developed using the open data platform
	Environmental Awareness / Communication	Energy consumption awareness campaign
	Foster European Identity	Adoption of sustainability and smart city programs from Horizon 2020

4.3.4 Socio-economic / Financial and Well-being

As Table 10 shows, Stavanger is not measuring public-private partnerships as an indicator of generated investment, and similarly Eindhoven have chosen not to measure the percentage change in Gross Value Added (GVA) as a signifier of the same expected impact. Within the expected impact of a better quality of life, Manchester is not measuring the high quality of public space or the payback periods for specific demonstration activities. In the impact of wide scale deployment and dissemination of project results, Eindhoven is not measuring the amount of GVA generated from data and within the same expected impact Stavanger is not measuring the skills and training delivered. Manchester, similarly, is not measuring the lead cities trialled technologies being adopted elsewhere and the happiness of residents and the workforce within this expected impact. There are no common commitments to indicators pertaining to the expected impact of better quality of life.

Table 10 Common indicators across lighthouse cities for the domain of socio-economic financial

Domain	Expected Impact	Indicator
Socio-economic / Financial	Generate investment	Reuse and repurposing of physical infrastructures
	Job creation	Capital / operational expenditure of partners on energy / mobility / ICT
	Testing of new technologies	Inward investment

	Development of replicable solutions	Jobs created
	Wide scale deployment / dissemination of project results	SMEs created

4.3.5 ICT

Stavanger does not measure consumer energy app implementation in the impact of improved energy efficiency. Within the impact of mobility efficiency, Eindhoven is not measuring the GIS tracking of eBuses, the GIS tracking of rental e-bikes and e-cars, or the use of ICT in public transportation. Aside from mobility, they also make no commitment to measuring the integration of building management into the ICT platform. As Table 11 shows, there are common commitments to at least one indicator for each expected impact within this domain.

Table 11 Common indicators across lighthouse cities for the domain of ICT

Domain	**Expected Impact**	**Indicator**
ICT	Improved energy efficiency	Advanced controls
	Mobility efficiency	Satisfaction of SMEs with business environment
		Software and application development
		Innovation and comercialisation
		Monitoring of EV / FC charging stations
	ICT deployment	Use of data sharing platforms and open data
		Data streams monitored
		Real time data capacity
		Smart city integrated services
		Data processing capacity

4.4 Impact Mapping Review: Conclusions

The tables in Section 4.2 identify numerous different impacts that can serve as a skeletal quantitative framework for comparing assessment and progress between lead cities. However, this review has highlighted that common indicators alone cannot generate a coherent representation of impact domains and their associated expected impacts. Rather, they are more meaningfully represented by various different city-specific constellations of indicators that together say something meaningful. This is owing to the nature of the bottom-up approach taken within Triangulum and reflects the particular social, economic, and political circumstances of each lead city. The common indicators listed, therefore, should never be compared in absolute terms but supplemented with other indicators. The domain of transport in particular is highly project-specific.

Despite this, there are certain identified potential oversights in city indicator commitments. Although further notable cases are given within this section, two key themes appear to emerge. Manchester in particular appears to have a deficit in measuring the social component of their interventions, mostly within the domain of citizen engagement. Eindhoven similarly appears to have a deficit in indicators within the domain of ICT relating to mobility and buildings integration.

Analysing these expected impact commitments and associated indicators has revealed what cities already want to measure. An important task within WP02 is to better understand what cities can measure, and as the impacts of the demonstrations become apparent, what it is most important to measure. Through this, Triangulum offers a way to develop a bottom up understanding of the most feasible and important indicators for smart sustainable development that will complement other current initiatives, such as CityKeys.

A key task going forward is to re-map impacts, indicators, associated metrics, and corresponding datasets by demonstration project to support the work of WP06, which is identifying distributed benefits for each demonstration project or smart city solution module. The final section of the report addresses the next steps.

5. Next Steps

The first five months of the Triangulum project provided an opportunity to review the academic, industry, and public policy literature surrounding smart city implementaion and allowed the research team to develop a novel evaluation framework based on project-level monitoring and assessment. This extensive review provided a wealth of case studies and methodologies that are still being assessed for feasibility and possible implementation. A range of possible methdologies to capture data across the five impact domains of transportation, energy, citizen engagement, socioeconomic/financial, and ICT have been outlined and are offered to each of the cities as a recommendation for possible data collection. However, there is still siginificant work to be done in devising a rigorous and detailed set of monitoring and assessment procedures to inform the baseline reports due in month 12. The schema presented provides a framework within which specific survey strategies, timelines, goals and responsibilites will be inserted. The following section sets out the next steps for WP02.

5.1 Finalising Impact Indicators

The framework offered by the WP02 research team was sent to each city for review in May 2015. Comments on the recommended impact indicators were received with different cities citing their desire to measure slightly different aspects, some of which are more applicable to city, rather than project level impacts. The framework was amended to take the city comments into account. However, given the level of revisions received, the vetting process of each indicator is still on-going. The feasibility of various indicators have been assessed based on information uncovered in the literature review. However, these indicators must also take into consideration the data already being captured by the cities and the viability of collecting additional information. A new member of the Triangulum WP02 team will be starting in August 2015 and transitioning to a full-time position at the University of Manchester in September 2015. His first task will be matching each impact indicator indicated to the data streams that are already entering the Cloud Data Hub, where gaps exist, the indicator may be amended, or conversely, the city may be asked to gather an additional piece of data, depending on the cost, availability, and importance to assessing project impact. At the end of the process, each indicator will have been evaluated individually based on the relevance, availability of data, measurability, reliability, familiarity, non-redundancy, and independence. Additionally, for each impact domain, the indicators selected will be assessed according to completeness, effectively whether or not measuring each of the variables indicated provides an adequate and complete picture of the area impacts.

5.2 Developing Monitoring Procedures

The finalised set of indicators are necessary to determine the timeline and schedule for data gathering and reporting. Within this report, certain recommendations have been made for strategies to facilitate and improve data capture. The project evaluation discussion in Section 4 provided an extensive background as to how and why cities gather data on transport and energy. In addition, the suggested techniques for surveying residents, supplemented by the toolkit already developed by Eindhoven (see section 6.1.2) provides an example that Manchester and Stavanger might choose to follow as to how information on citizen statisfaction, concerns, engagement, and perceptions can effectively be gathered and quanitified. In addition to the data capture on smart buildings, energy savings, infrastructure improvements, and transit projects that are being collated in the Cloud Data Hub, implemetation of new hubs and online applications where citizens and business developers can request information or learn more about Triangulum will provide a platform from which to gather data on the second and third measures of success in the project evaluation criteria, namely meaningful citizen engagement, and positive movement towards broader socioeconomic impacts. The final monitoring framework will include a mixed methdology of sensor data collection, observation, and surveying. Each indicator will have a specific criteria for data collection appended to it, so that for all variables common to each city, data will be gathered in the same way, expanding opportunitites for comparison. Given the scale of the project, a focus on quantifiable units will allow the team to survey the diverse impacts of the various projects easily, create points of comparison between cities, and develop a more comprehensive data set on the impacts of demonstration projects. This will be supplemented if necessary by some interviews with local officials, planning officers, and project coordinators to offer advice for the follower cities. The combination of observation of the physical environment to monitor improvements in sustainability and surveying to measure changes in engagement, socioeconomic well-being, and smartness provides a comprehensive framework to evaluate project level impacts and understand progress towards the broader goal of creating a smart city.

5.3 Key Activities and Timeline

Table 12 lists the next steps between the period from the submission of the Common Monitoring and Impact Assessment Framework report in month 6 and the Baseline reports in month 12. It sets out what the key activities are and who will be responsible for them to progress WP02 from the monitoring and assessment framework to a set of specific monitoring procedures for each city that will generate the data for the baseline reports.

Table 12 Key activities and timeline to D2.3: baseline report

Lead partner	Activity	Month
UNIMAN - UiS	**1. Develop a comprehensive roadmap to D2.3** This involves setting out the key activities and responsibilities for them that are required to produce the baseline reports in month 12.	8
UiS	**2. Match up metrics to datasets identified by data audit** This involves ensuring that the datasets identified by the data audit correspond to the preferred metrics identified by the cities to monitor the indicators. This process will ensure that the Coud Data Hub provides a one-stop shop for monitoring and assessment data. The metadata associated with each data set will also be used to formulate monitoring procedures that specify who is responsible for providing data, when, and at what resolution.	10
FhG – UNIMAN	**3. Re-map expected impacts and metrics by projects with WP06** Currently the expected impacts and corresponding indicators and metrics are mapped according to city and domain. To support the smart city replication framework in WP06, these fields need to be remapped against specific demonstration projects, AKA smart city modules. WP06 have already identified the set of modules.	8
UNIMAN – TU/e	**4. Work with cities to fill key monitoring gaps** The expected impact mapping and smart city literature review have identified key gaps, especially around capturing socio-economic, wellbeing and engagement data. WP02 will work with cities to understand how to fill these gaps.	10
UNIMAN –	**5. Produce monitoring procedures for demonstration projects / cities**	10

TU/e	Specific monitoring procedures that specify who is responsible for providing data, when, and at what resolution will be provided to the cities, organised by the responsible data provider. This will avoid a single data provider being asked for a dataset multiple times in relation to different demonstration projects.	
UiS	**Ensure Cloud Data Hub works with city-level platforms** Much of the city level data will be held in local data platforms. A key task is to ensure that the correct procedures, technical interfaces and permissions are in place to enable that data to flow to the Cloud Data Hub. This timing will be adjusted based on the progress of the city-level platforms.	12

The key deadlines for each activity are to allow the circulation of materials ahead of project meetings to enable feedback from partners. These include Steering Committee and WP02/WP06 meetings in Stavanger on the 16-17 September (month 9) and Berlin on the 24-26 November (month 11).

5.4 Development of Smart City Framework (WP06)

This deliverable will inform the WP06 work to develop a Smart City Framework for transfer to the follower cities. The Smart City Framework will focus on applicability, functionality, and replicability, and will likely include the following components:

- ☐ Smart city indicators, ICT reference architecture, monitoring protocols and data hub for smart city impact assessment;
- ☐ Checklists and design principles for smart city development projects;
- ☐ A set of integrated Smart City Modules (Technologies, Interfaces, Business Models, Stakeholders, and Policies) that serve as building blocks for future development projects;
- ☐ A software based decision making tool that operationalizes the Smart City Framework into decision making processes, and;
- ☐ A guideline for using the tool.

6. Appendix 1: WP02 Engagement with the Lead Cities and Detailed Impact Mapping and Data Tables

As is to be expected in a large and complex project, each of the lead cities is at a different stage of implementation, has differing levels of monitoring capacity, and a different set of capabilities. This reflects geographical and political differences at the city level, but also large differences between the specific demonstration projects themselves, which vary in scope, scale, focus and complexity. This appendix offers a more detailed sumary of progress in each city with respect to WP02, including the detailed impact and data mapping tables that were prepared for each city. They have been reviewed by each city. However, changes are still being made as each city completes the data audit of information already collected and their capacity to collect additional information across various domains above and beyond what has already been done. While these are preliminary indicators, the final review of indicators will allow the researchers to determine appropriate monitoring frameworks for each city.

6.1 Eindhoven

Eindhoven are the most advanced city in terms of implementation. As a result, WP02 researchers have focused on aligning impact indicators with the projects and identifying and securing potential baseline data. Two rounds of project manager interviews have been conducted to understand the demonstration projects and their impact indicators. Managers provided their feedback regarding to applicability of indicators and accessibility of the data. Benchmark data has also been requested and received for five projects, which are listed as below:

- Sustainable energy supply and soil sanitation
- Optimization of heat provision in existing buildings
- Smart energy savings offices
- Second phase of implementation and integration of the fiber-optic data infrastructure
- Renovation homes and dwellings in Woonbedrijf

Table 13 shows the detailed data and impact mapping table for Eindhoven that includes indicators identified for assessing the impacts, the preferred metrics of the Eindhoven city partners, and where appropriate a stated target. The table uses the same colour coding in the left hand column and numbering in the right hand column as listed in **Figure 11**.

Table 13 Eindhoven detailed impact mapping and data table

Impact Domain	Expected Impacts	Indicators Identified for Assessing Impacts	Potentially Quantifiable Units	EIN Preferred Metrics	EIN Target	#
Energy	Lower Energy Bills	Amount of buildings retrofitted /	Number and type of buildings converted /yr, m2 converted	# of buildings retrofitted (p.92)	Renovate 200 dwellings with a totl area of	3

		smartified	/yr		20,000m^2 (p.91)	
		Reduction in monthly energy bills	% decrease in energy bills for residential and commercial properties		20% of tenants in Woonbedrijf will accept retrofits that will increase retrofit costs but decrease long-term energy bills (p.92)	1
	Increased Energy Efficiency	Generation and use of local energy sources	GWh/yr or MWh/yr		Maximize wind power, upgrade heat network to renewable biomass energy, 75% of remaining, building energy generation by renewable sources (p.47); refurbishment of Eckart Vaartbroek district photovoltaic techniques (PV) and 2 wind turbines on strategic buildings (p.92)	3
	Flatten Peak Demand	Thermal and electric battery storage units adopted	GWh or MWh of storage capacity			1
		Distribution of generation/storage assets	% change in GWh/hr or MWh/hr at peak demand times			1
		Change consumer behaviour	% decrease in individual energy use		Collaboration with SMEs such as the solar energy corporation to raise energy awareness (p.47)	3

	Increased Use of Renewables	Reliability of off-grid systems (page 78)	% energy generated on site			2
		Soil Sanitation	% of water treated		Trial energy management systems with integrated soil sanitation" (p.47)	3
	Reduced Carbon Emissions	Carbon emissions per building	tC			2
		Air quality	PM10 ppm			1
		Average electricity price for companies and consumers	€/KWh			2
		Share of renewable energy on the grid	% solar, wind, geothermal, biogas			3
		Smart meters installed and used	Number of meters, GWh/yr		Increase number of smart meters	3
		Organisations sharing energy use / monitoring	Number, GWh/yr			2
		Reduction in Net Carbon Emissions	CO2. emissions per annum at project site	Overall CO2 emissions (p.47)	Reduce building energy consumption by 80%, install sensors in office buildings (p.47); In renovated houses, CO2 savings of 3,120 tonnes/year or 1,482 tonnes per unit/year (p.97).	3
Transportation	More Efficient Transport	Air quality	O3, PM2.5, PM10 ppm			1
		Gridlock	Minutes of average commute time, % change	Time of journeys (p.47)	Improve journey times (p.47)	1
	Lower Carbon Emissions	Public transport use	# of passengers, % change in ridership			1
		Bicycle use	# of riders, # of			1

			citizens claiming tax credit, # of riders observed with sensors			
		Electric vehicles	Number		Increase number of electric cars (p.47)	1
		Reduction in fuel intensity of transport	CO2 per km			1
	Testing of New Technologies	Modal split	% for passengers and logistics			1
		EV/FC charging stations	Nr in district vs. city, MWh/yr		Increase number of charging stations (p.47)	3
		Average journey times	Min/km			1
		Average journey costs	€/km			1
		User satisfaction and engagement	% registered customer/passenger satisfaction			1
		Use of Smart mobility apps	Number and %			1
		Use of e-buses	Reliability of e-busses compared to standard diesel busses measured in maintenance costs and days out of service			1
		Use of e-bike / e-car rental schemes	Number available and average hours of daily use			1
		Assessment and reduction of parking spaces	% reduction, % change in unmet need for parking	% change in journey times (p.47)	Smart parking management system deployed (p.47); includes 1) Improved routing and signing, 2) use of an ICT based tool for guidance and payment 3) Incentives for green	3

					alternatives to car transport 4) Stimulation of car sharing (p.94)	
		Average delivery costs	€/km/Kg			1
		Number of daily deliveries	Number			1
Citizen Engagement	More Inclusive Society	Diverse target population	Census information on targeted neighbourhoods		Citizen engagement and e-inclusion of disadvantaged groups (p.75)	3
		Adoption of co-creation procedure	# of citizens involved in project-planning		Establishment of Local Energy Cooperative as a forum for continuous dialogue to discuss finances and logistics of local energy production with the citizens, the local energy distributor (Endinet) and the housing association Woonbedrijf (p.92); co-creation method to be used in schools and nursing home projects	3
	Commercialisation Opportunities	Smart apps developed using open data platform.	Number of apps developed, commercial value in €	# of apps developed	To stimulate and provoke the development of integrated new services and tools for energy, mobility and	3

					quadruple stakeholder involvement and to develop a dashboard of city performance in these fields (p.96).	
	More Effective and Fair Decision-Making	Internet penetration rate, broadband subscriptions and 3G/4G mobile subscriptions	% in users per 1000 population	Rate of social innovation and e-participation (p.47)		1
		E-participation	Number of people and % of population for district vs. city using apps			2
		E-governance	Number of decisions using electronic consultation, number of people % population engaging in e-consultation / e-petition			1
		Use of open data platform	Number of people/ % of population for district vs. City		To offer a platform where not only governmental organisations, but any party willing to offer its data according to agreed standards, can exchange their data and to analyse data to improve policy decisions (p.96)	3
	Environmental Awareness and Communication	Energy consumption awareness campaign	# of contacts, # of pledges			3
	Foster European Identity	Adoption of sustainability and	# of new programs developed			2

		smart city programs from Horizon 2020				
		Heritage building preservation	# of listed buildings retro-fitted			1
	Generate Investment	Public-private partnerships generated through Triangulum	€k/yr invested in new partnerships		Public-private partnerships to encourage retrofits and Local Energy Cooperatives (p.47)	2
		Promote economic growth in district	% change in GVA			1
		Re-use and repurposing of physical infrastructures	€k/yr (deferred) investment			3
	Job Creation	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr			3
	Better Quality of Life	Respect local ways of working	kilos of toxins reduced		Minimized use of chemicals in new construction through Natural Step methodology (p.92)).	3
		Improved public street lighting	# of lights installed, # of hours/streets illuminated, change in crime rate/frequency of complaints to public authority, sensor density of people on the street	Changes in crime reported, social interaction, and reduction in municipal energy bills (p.47)		3
		High quality public space	User surveys, # of social media comments on new space	Improvement in social cohesion (p.100)	1-KM social interaction and health route (p.100)	3
		Affordable housing	% increase in rent over cost of inflation			3
		Payback periods for specific demonstration	Years			3

		activities				
	Testing of New Technologies	Inward investment	€/ yr by different sectors			2
	Development of Replicable Solutions	Jobs created	Nr and overall earnings in			3
	Wide-scale Deployment and Disemmination of project results	Average earnings data in district	€/yr			1
		Skills and training delivered	Person / hrs			1
		SMEs created	Nr and turnover in €/yr		Collaboration with SMEs such as the solar energy corporation (p.47)	3
		Satisfaction of SMEs with business environment	% of businesses indicating satisfaction in annual surveys			3
		Technologies trialled in Lighthouse city adopted elsewhere	Nr / commercial value		To make sure the solutions (App's) that come out can be shared with the other countries (creating an API and just inserting the data) and are used in policy-making and for local business development (p.96).	2
		Software and application development	# of apps registered			3
		Innovation and commercialisation	Nr of patents/ commercial value			3
		Recorded happiness of residents and workforce	%			3
ICT	Improved Energy Efficiency	Advanced controls	GWh or MWh wasted/lifecycle cost			1
			% change in public lighting energy			1

			consumption at district level			
		Consumer energy app implementation	% reduction in office energy use	% reduction in home energy use	Estimated average of 15% reduction in office energy use (p.97).	3
		Automatic grid independence in district	GWh or MWh purchased			1
	Mobility Efficiency	GIS tracking of rental e-bikes and e-cars	% of vehicles enrolled			1
		GIS tracking of eBuses	% of buses monitored			1
		Monitoring use of EV/FC charging stations	% of time used, unmet demand			3
	ICT Deployment	High speed fibre network expanded	# of homes, # of businesses reached			1
		Data streams monitored	Nr and sector, nr of data points collected			3
		Use of data sharing platforms and open data	Nr and sector, nr of data points shared	# of app-based companies, SMEs, and creative industry start-up companies (p.47)	Apps can be shared with other countries, are used in policy-making, and promote local business development (p.96).	3
		Real time data capability	Nr and sector, nr of data points collected, time lag in minutes for data processing			1
		Smart city integrated services	Nr of services using integrated ICT system	Use of neighbourhood facilities and services (p.47)	Improve access to neighbourhood facilities and services (p.47); use of ICT in public lighting	3
		Synergies between smart grids	Exchange in GW/yr			1
		Integration of building	Nr (across different sectors), carbon			1

		management into ICT platform	footprint in tC			
		Use of ICT in public transportation	Passengers/yr, passenger km/yr		Provide real-time traffic management in the district and smart mobility cards that can be used in the district as well as the city (p.47)	1
		Data storage	bytes			1
		Data processing capacity				1

6.2 Manchester

WP02 members have been attending the Manchester steering group meetings and the meetings of the sub-groups for ICT, energy and mobiity. This has enabled two-way communication between WP02 and WP03 with monitoring considerations being fed directly into the WP03 sub-groups. The ICT actions in Manchester include developing a Triangulum-I local data platform that will store much of the data required for monitoring the demonstration projects in the city, and WP02 has aligned its data audit with this initiative.

Table 14 shows the detailed data and impact mapping table for Manchester that includes indicators identified for assessing the impacts, the preferred metrics of the Manchester city partners, and where appropriate a stated target. The table uses the same colour coding in the left hand column and numbering in the right hand column as listed in **Figure 11**.

Table 14 Manchester detailed impact mapping and data table

Impact Domain	Expected Impacts	Indicators Identified for Assessing Impacts	Potentially Quantifiable Units	Manchester Preferred Metrics	MAN Target	#
Energy	Lower Energy Bills	Amount of buildings retrofitted / smartified	Number and type of buildings converted /yr, m2 converted /yr			3
		Reduction in monthly energy bills	% decrease in energy bills for residential and commercial properties	% change in energy cost (p.43)		3
	Increased Energy Efficiency	Generation and use of local energy sources	GWh/yr or MWh/yr	Energy use, energy cost, % generated from renewable sources (p.43)	20-25% energy from on-site generation (p.43); 5x Combined Heat and Power assets (2 at 378 kwh, 2 at 230kwh and 1 at 1.4mwh); 2 x PV arrays at UNIMAN and MMU, ground source heat pumps within MMU; 1Mwh of combined micro biomass boilers (p.79)	3
	Flatten Peak Demand	Thermal and electric battery	GWh or MWh of storage capacity		400 kwh lithium ion battery is	3

		storage units adopted			also available for storage at MMU (p.79)	
		Distribution of generation/storage assets	% change in GWh/hr or MWh/hr at peak demand times			3
		Change consumer behaviour	% decrease in individual energy use			1
	Increased Use of Renewables	Reliability of off-grid systems (page 78)	% energy generated on site		Near 100% reliability for critical loads and ability to switch to off-grid generation (p.78)	3
		Soil Sanitation	% of water treated			1
	Reduced Carbon Emissions	Carbon emissions per building	tC			3
		Air quality	PM10 ppm			1
		Average electricity price for companies and consumers	€/KWh			2
		Share of renewable energy on the grid	% solar, wind, geothermal, biogas			2
		Smart meters installed and used	Number of meters, GWh/yr			1
		Organisations sharing energy use / monitoring	Number, GWh/yr			1
		Reduction in Net Carbon Emissions	CO2. emissions per annum at project site	CO2 emissions per annum, within the Corridor (p.43)	Reduce carbon emissions across city by 41% by 2020, based on 2005 levels where emissions were 3.25 m tonnes CO2" (p.43)	3
Transportation	More Efficient Transport	Air quality	O3, PM2.5, PM10 ppm			3
		Gridlock	Minutes of average commute time, % change	% reduction in journeys, changes in air quality, journey time (p.44)	10% reduction in congestion (p.44)	2
	Lower Carbon Emissions	Public transport use	# of passengers, % change in ridership			3
		Bicycle use	# of riders, # of			3

			citizens claiming tax credit, # of riders observed with sensors			
		Electric vehicles	Number			3
		Reduction in fuel intensity of transport	CO2 per km			2
	Testing of New Technologies	Modal split	% for passengers and logistics			2
		EV/FC charging stations	Nr in district vs. city, MWh/yr			3
		Average journey times	Min/km			3
		Average journey costs	€/km			2
		User satisfaction and engagement	% registered customer/passenger satisfaction			2
		Use of Smart mobility apps	Number and %			1
		Use of e-buses	Reliability of e-busses compared to standard diesel busses measured in maintenance costs and days out of service			1
		Use of e-bike / e-car rental schemes	Number available and average hours of daily use			3
		Assessment and reduction of parking spaces	% reduction, % change in unmet need for parking			1
		Average delivery costs	€/km/Kg			2
		Number of daily deliveries	Number	% reduction of journeys	20% reduction in deliveries across Corridor (p.44)	3
Citizen Engagement	More Inclusive Society	Diverse target population	Census information on targeted neighbourhoods			1
		Adoption of co-creation procedure	# of citizens involved in project-planning			2
	Commercialisation Opportunities	Smart apps developed using open data platform.	Number of apps developed, commercial value in €			3
	More Effective and	Internet	% in users per 1000			1

	Fair Decision-Making	penetration rate, broadband subscriptions and 3G/4G mobile subscriptions	population			
		E-participation	Number of people and % of population for district vs. city using apps			1
		E-governance	Number of decisions using electronic consultation, number of people % population engaging in e-consultation / e-petition			1
		Use of open data platform	Number of people/ % of population for district vs. City			3
	Environmental Awareness and Communication	Energy consumption awareness campaign	# of contacts, # of pledges			3
	Foster European Identity	Adoption of sustainability and smart city programs from Horizon 2020	# of new programs developed			2
		Heritage building preservation	# of listed buildings retro-fitted			3
	Generate Investment	Public-private partnerships generated through Triangulum	€k/yr invested in new partnerships			3
		Promote economic growth in district	% change in GVA	Amount of additional GVA generated (p.44)	€11.1m Gross Value Added to the economy each year (p.44)	3
		Re-use and repurposing of physical infrastructures	€k/yr (deferred) investment			3
	Job Creation	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr	# of jobs created	232 net additional jobs	3
	Better Quality of Life	Respect local ways of working	kilos of toxins reduced			1

		Improved public street lighting	# of lights installed, # of hours/streets illuminated, change in crime rate/frequency of complaints to public authority, sensor density of people on the street			1
		High quality public space	User surveys, # of social media comments on new space			1
		Affordable housing	% increase in rent over cost of inflation			1
		Payback periods for specific demonstration activities	Years			1
	Testing of New Technologies	Inward investment	€/ yr by different sectors			2
	Development of Replicable Solutions	Jobs created	Nr and overall earnings in			3
	Wide-scale Deployment and Disemmination of project results	Average earnings data in district	€/yr	Amount of additional GVA generated (p.44)		3
		Skills and training delivered	Person / hrs	Efficiency of doing business (p.44)		2
		SMEs created	Nr and turnover in €/yr			3
		Satisfaction of SMEs with business environment	% of businesses indicating satisfaction in annual surveys	Efficiency of doing business (p.44)		2
		Technologies trialled in Lighthouse city adopted elsewhere	Nr / commercial value			1
		Software and application development	# of apps registered			3
		Innovation and commercialisation	Nr of patents/ commercial value		'Innovation challenge' to encourage new innovative products to be brought to market,	3

					including 25% of energy demand provision by SME-based sub-contractors (p.80)	
		Recorded happiness of residents and workforce	%			1
ICT	Improved Energy Efficiency	Advanced controls	GWh or MWh wasted/lifecycle cost			3
			% change in public lighting energy consumption at district level			1
		Consumer energy app implementation	% reduction in office energy use			2
		Automatic grid independence in district	GWh or MWh purchased			3
	Mobility Efficiency	GIS tracking of rental e-bikes and e-cars	% of vehicles enrolled			3
		GIS tracking of eBuses	% of buses monitored			3
		Monitoring use of EV/FC charging stations	% of time used, unmet demand			3
	ICT Deployment	High speed fibre network expanded	# of homes, # of businesses reached			1
		Data streams monitored	Nr and sector, nr of data points collected			3
		Use of data sharing platforms and open data	Nr and sector, nr of data points shared			3
		Real time data capability	Nr and sector, nr of data points collected, time lag in minutes for data processing			2
		Smart city integrated services	Nr of services using integrated ICT system			3
		Synergies between smart grids	Exchange in GW/yr			3
		Integration of	Nr (across different			3

		building management into ICT platform	sectors), carbon footprint in tC			
		Use of ICT in public transportation	Passengers/yr, passenger km/yr			2
		Data storage	bytes			1
		Data processing capacity				2

6.3 Stavanger

WP02 researchers have been working closely with WP05 on the data audit, conducting the pilot data audit in Stavanger that ran from month 3 onwards. This has yielded a wealth of data and an approach that is now being rolled out in Manchester and Eindhoven. This has led to UiS taking the lead on identifying and securing datasets across the three cities, which has freed up research capacity from UNIMAN and TU/e to consult in more detail over the coming months with WP05 partners on the impact indicators and monitoring procedures.

Table 15 shows the detailed data and impact mapping table for Stavanger that includes indicators identified for assessing the impacts, the preferred metrics of the Stavanger city partners, and where appropriate a stated target. The table uses the same colour coding in the left hand column and numbering in the right hand column as listed in **Figure 11**.

Table 15 Stavager detailed impact mapping and data table

Impact Domain	Expected Impacts	Indicators Identified for Assessing Impacts	Potentially Quantifiable Units	Stavanger Preferred Metrics	STA Target	#
Energy	Lower Energy Bills	Amount of buildings retrofitted / smartified	Number and type of buildings converted /yr, m2 converted /yr		Retrofit a swimming pool and one administrative building (p.106); implementatin of the new energy plant (p.108)	3
		Reduction in monthly energy bills	% decrease in energy bills for residential and commercial properties		The energy plant will be fully automated, monitored and remotely controlled from the operations center in SK. Energy meters for all energy sources and delivery points	3

					(buildings) will be installed in order to read the amount of energy produced and its carbon inventory. (p. 108)	
	Increased Energy Efficiency	Generation and use of local energy sources	GWh/yr or MWh/yr	KW/h (p.111)	Development of new power plant in basement of central administrative building and in building called "sentrumskvartalet ". The energy plant will reduce energy use through geothermal pumps, air to water heat pump. Peak load will be supplied with wood pellets bolier. The project will look at solutions for use of solar water heating system to supply to the heating system(p.110).	3
	Flatten Peak Demand	Thermal and electric battery storage units adopted	GWh or MWh of storage capacity			2
		Distribution of generation/storage assets	% change in GWh/hr or MWh/hr at peak demand times			3
		Change consumer behaviour	% decrease in individual energy use		20% of more gains in energy efficiency through smart monitoring and sensors (p.52)	2
	Increased Use of Renewables	Reliability of off-grid systems (page 78)	% energy generated on site			2
		Soil Sanitation	% of water treated			1
	Reduced Carbon Emissions	Carbon emissions per building	tC	CO_2 emissions per building, % change in CO_2 emissions (p.52)	CO_2 emissions of the corresponding buildings will be brought down to zero through	3

					upgrading and building a new energy plant that runs on 100% renewable energies (p.52)	
		Air quality	PM10 ppm			1
		Average electricity price for companies and consumers	€/KWh			1
		Share of renewable energy on the grid	% solar, wind, geothermal, biogas			2
		Smart meters installed and used	Number of meters, GWh/yr		Automatic meter reading (p.108); Energy meters for all energy sources and delivery points will be installed to read the amount of energy produced and its carbon inventory. The implementation of different virtual network able to communicate with the meters is in progress.	2
		Organisations sharing energy use / monitoring	Number, GWh/yr			1
		Reduction in Net Carbon Emissions	CO2. emissions per annum at project site	Tons of CO2	Reduce direct greenhouse gas emissions by around 50% between now and 2025; eliminate 40,000 tons of emissions from stationary energy use and 50,000 tons of emissions from the transportation sector (of which 40,000 tons will come from transportation)	3

					(p.52); Reduction of 25,000 tons locally and 150,000 tons on a global level" (p.52)	
Transportation	More Efficient Transport	Air quality	O3, PM2.5, PM10 ppm			2
		Gridlock	Minutes of average commute time, % change		Improved vehicle technology, concentration of land development along axes of public transportation and in parts of the city, mobility efficiency improvement by improved logistics, intelligent transport systems and services (p.52)	1
	Lower Carbon Emissions	Public transport use	# of passengers, % change in ridership	Total emissions reduction in CO2 from transport	Transportation sector CO2 reduction of at least 50,000 tons by 2020 (p.52)	3
		Bicycle use	# of riders, # of citizens claiming tax credit, # of riders observed with sensors	Total emissions reduction in CO2 from transport		1
		Electric vehicles	Number	Total emissions reduction in CO2 from transport		1
		Reduction in fuel intensity of transport	CO2 per km	Emission (CO2) reduction per passenger-km (based on reduction in fossil fuel use)	Cut carbon emissions in transportation	3
	Testing of New Technologies	Modal split	% for passengers and logistics			1
		EV/FC charging stations	Nr in district vs. city, MWh/yr			3
		Average journey times	Min/km			1
		Average journey costs	€/km	Change in average journey costs per vehicle-km	Change in average journey costs	2
		User satisfaction and engagement	% registered customer/passenger satisfaction	Register customer/passenger satisfaction	More satisfied customers/passengers	2

		Use of Smart mobility apps	Number and %			1
		Use of e-buses	Reliability of e-busses compared to standard diesel busses measured in maintenance costs and days out of service	Reliability of e-busses compared to standard diesel busses	Deployment of 3 eBuses (p.112)	3
		Use of e-bike / e-car rental schemes	Number available and average hours of daily use			1
		Assessment and reduction of parking spaces	% reduction, % change in unmet need for parking			1
		Average delivery costs	€/km/Kg			1
		Number of daily deliveries	Number			1
Citizen Engagement	More Inclusive Society	Diverse target population	Census information on targeted neighbourhoods			2
		Adoption of co-creation procedure	# of citizens involved in project-planning			2
	Commercialisation Opportunities	Smart apps developed using open data platform.	Number of apps developed, commercial value in €			2
	More Effective and Fair Decision-Making	Internet penetration rate, broadband subscriptions and 3G/4G mobile subscriptions	% in users per 1000 population		Implement smart generic gateways in 100 homes and two public buildings including a school and nursing home (p.108)	2
		E-participation	Number of people and % of population for district vs. city using apps			2
		E-governance	Number of decisions using electronic consultation, number of people % population engaging in e-consultation / e-petition			2

		Use of open data platform	Number of people/ % of population for district vs. City			1
	Environmental Awareness and Communication	Energy consumption awareness campaign	# of contacts, # of pledges			3
	Foster European Identity	Adoption of sustainability and smart city programs from Horizon 2020	# of new programs developed			2
		Heritage building preservation	# of listed buildings retro-fitted			1
	Generate Investment	Public-private partnerships generated through Triangulum	€k/yr invested in new partnerships			1
		Promote economic growth in district	% change in GVA			3
		Re-use and repurposing of physical infrastructures	€k/yr (deferred) investment			3
	Job Creation	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr			2
	Better Quality of Life	Respect local ways of working	kilos of toxins reduced			1
		Improved public street lighting	# of lights installed, # of hours/streets illuminated, change in crime rate/frequency of complaints to public authority, sensor density of people on the street			1
		High quality public space	User surveys, # of social media comments on			2

			new space			
		Affordable housing	% increase in rent over cost of inflation			1
		Payback periods for specific demonstration activities	Years			3
	Testing of New Technologies	Inward investment	€/ yr by different sectors	market-value of ICT platforms/technologies (p.52)	Gateway installation, which is expected to have a mid-term market value of at least €150m, installation of advanced super charging solutions are expected as at least €20m" (p.52)	2
	Development of Replicable Solutions	Jobs created	Nr and overall earnings in			2
	Wide-scale Deployment and Disemmination of project results	Average earnings data in district	€/yr			2
		Skills and training delivered	Person / hrs			1
		SMEs created	Nr and turnover in €/yr			2
		Satisfaction of SMEs with business environment	% of businesses indicating satisfaction in annual surveys			2
		Technologies trialled in Lighthouse city adopted elsewhere	Nr / commercial value		Replication of data systems led by Stavanger in follower cities.	3
		Software and application development	# of apps registered			2
		Innovation and commercialisation	Nr of patents/ commercial value			3
		Recorded happiness of residents and workforce	%			3
ICT	Improved Energy Efficiency	Advanced controls	GWh or MWh wasted/lifecycle cost		20% or more gains in energy efficiency (p.52)	3

			% change in public lighting energy consumption at district level			1
		Consumer energy app implementation	% reduction in office energy use		20% or more gains in energy efficiency (p.52)	1
		Automatic grid independence in district	GWh or MWh purchased			1
	Mobility Efficiency	GIS tracking of rental e-bikes and e-cars	% of vehicles enrolled			3
		GIS tracking of eBuses	% of buses monitored		Study and tracking of eBikes, pilot of 3 eBuses, and study of charging station use will inform eBuses implementation (p.111-112)	3
		Monitoring use of EV/FC charging stations	% of time used, unmet demand			3
	ICT Deployment	High speed fibre network expanded	# of homes, # of businesses reached			3
		Data streams monitored	Nr and sector, nr of data points collected			3
		Use of data sharing platforms and open data	Nr and sector, nr of data points shared	Market-value of ICT technologies (p.52)		3
		Real time data capability	Nr and sector, nr of data points collected, time lag in minutes for data processing			3
		Smart city integrated services	Nr of services using integrated ICT system			3
		Synergies between smart grids	Exchange in GW/yr			1
		Integration of building management into ICT platform	Nr (across different sectors), carbon footprint in tC			3

		Use of ICT in public transportation	Passengers/yr, passenger km/yr			3
		Data storage	bytes			3
		Data processing capacity				3

7. Appendix 2: Example of Social Toolkit under development in Eindhoven

A questionnaire of quality of life in Eckart Vaatbroek is under development. The questionnaire will be implemented as the first step in Eckart Vaatbroek to measure the social effects of the current situation as a benchmark in September 2015. It will be connected with the WoonConnect system and implemented before renovation. The expected respondents are around 1300. It is reproduced below to enable other lead cities to assess whether elements of the approach could be used to enhance their planned socio-economic and well-being monitoring.

Questionnaire Eckart Vaatbroek

Basic assumptions:

- This concept is a first assembly of all questions that could be asked. Later in the process we will determine which questions should be excluded for the different target groups (for instance for tenants whose homes will not be renovated in the first years) or should be added.
- There are different types of questions:
  - Facts (to gather data)
  - Wishes
  - Complaints
  - Opinions (what do you think about….?)
  - Public support (would you support…….?)
  - Additional Reference point questions. To establish the 'as is' situation. (provided by Dujuan).
- There are different subjects for these questions:
  - The house
  - The environment
  - Energy consumption
  - Behaviour
  - Well being
  - Social situation
  - Health care
  - Volunteers work
  - Etc
- Questionnaires that WoonConnect made earlier in other project form the basis for this concept. These parts are illustrated, but are not always in the same look and feel. The added pages are plain text. Later in the process – when the list is final - we will make a proposal for the presentation and the artwork.
- The questionnaire is divided into 2 sections:
  - **Section 1**: **the 'normal' inquiry** of what people recognize as a useful contribution for the renovation of the house, energy reduction and improvement of the neighbourhood.
  - **Section 2**: **additional questions for scientific research**. If you mingle the 2, people will get 'itchy' and suspicious about the motives of the questionnaire. If you make a clear statement about the

reason of the extra questions and you also emphasize the privacy guarantees here, I think there's much more chance that they will be willing to provide these answers.

Some of the questions in section 2 can also be moved to section one.

General Notes:

- Some questions are asking about the personal situation (health care, talents, willingness to do volunteers work) of one person. If a household consists of more than one person we should probably add the possibility to fill in these questions for more than one member of the household.
- During filling in the questionnaire, the resident gets some direct feedback. This gives him the confidence that his answers have a purpose and it's fun to benchmark your situation to that of other people. This motivates him to proceed. This principle of direct feedback will have to be elaborated further. (for instance: When the first persons are filling in the questionnaire, there is no reference data yet about the street and the district).
- We should have a closer look at the sequence of the questions. What is the best sequence to keep them motivated to proceed?

Section 1: 'normal' inquiry

Question 1: contact data

Huurt u, of bent u eigenaar van de woning? ◉ huur ○ Eigen woning

Aanhef

○ Mevrouw ○ De heer

Voornaam
Tussenvoegsel
Achternaam
Geboortedatum dd-mm-jj
Geboorteland

Adres
Postcode
Woonplaats

Huurder sinds

Hoe kunnnen we contact met u opnemen?

Telefoonnummer
2e Telefoonnummer
E-mail

Heeft u een medebewoner?

○ Ja ○ Nee

Gegevens partner/huisgenoot (optioneel)

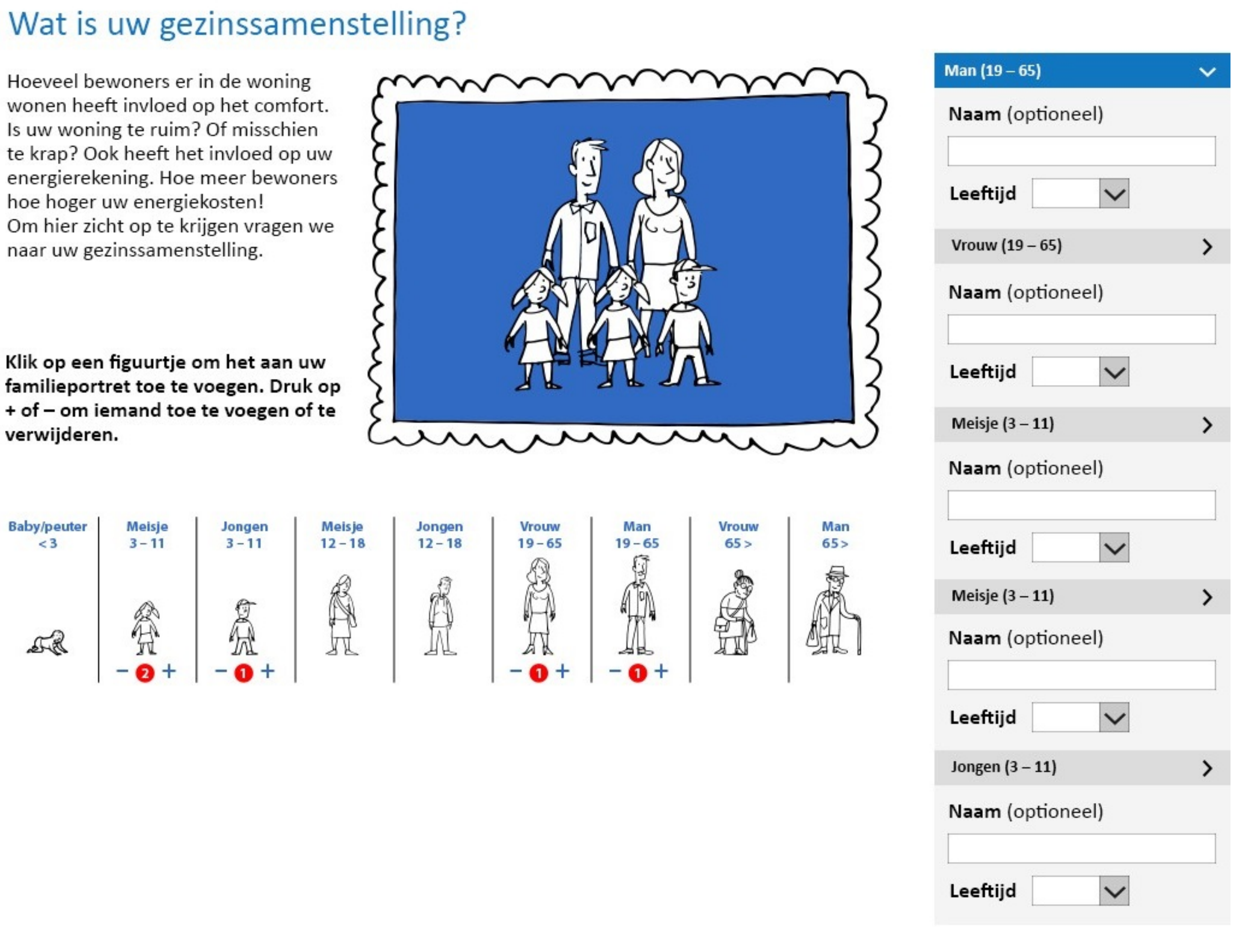
Aanhef

○ Mevrouw ○ De heer

Voornaam
Tussenvoegsel
Achternaam
Geboortedatum dd-mm-jj
Geboorteland

Telefoonnummer
2e Telefoonnummer
E-mail

Question 2: Composition of the household



Possible direct feedback:

• What is the average nr of people in a household	In the street/In the district/In the Netherland
• What is the average nr of adults in a household	In the street/In the district/In the Netherland
• What is the average nr of children in a household	In the street/In the district/In the Netherland
• How many adult women and man are there	In the street/In the district/In the Netherland

Question 3: positive aspects of the neighbourhood

Question 4: negative aspects of the neighbourhood

Question 5: additional questions about the facilities in the neighbourhood

Voldoen de voorzieningen dicht bij u in de buurt aan uw behoeften?

○ Ja ○ Nee

Zo nee, welke voorziening zou u bij u in de buurt moeten komen?

- ☐ Park
- ☐ Winkel
- ☐ Bioscoop
- ☐ Sportveld/hal
- ☐ Restaurant
- ☐ Café

Anders namelijk:

Hoe zou u het groen rondom de flat inrichten?

☐ Park

☐ Moestuin

☐ Speelplek

☐ Sportveld

☐ (Vis)vijver

☐ Ontmoetingsplek

Anders namelijk:

Question 6: Leisure

Waar bent u het liefst in uw vrije tijd?

- ☐ Lekker thuis
- ☐ Sporten
- ☐ Uit eten
- ☐ Vrienden bezoeken
- ☐ Winkelen/in de stad
- ☐ Op vakantie/dagje weg

Anders namelijk:

Waar geeft u het liefst uw geld aan uit?

- ☐ Vakantie
- ☐ Kleding
- ☐ Bioscoop
- ☐ Hobby
- ☐ (Uit)Eten
- ☐ Café

Anders namelijk:

Question 7: Profession, talents and hobbies

Wat is uw beroep?

☐ Fulltime ☐ Parttime ☐ Vrijwilliger ☐ Werkzoekend

Wat is het beroep van uw partner/huisgenoot? (optioneel)

☐ Fulltime ☐ Parttime ☐ Vrijwilliger ☐ Werkzoekend

Welke talenten en hobbies heeft u?

Administratief	Ervaring
Administratie	☆ ☆ ☆
(Belasting)formulier invullen	☆ ☆ ☆
Huishoudboekje maken	☆ ☆ ☆
Anders namelijk...	

Klussen	Ervaring
Tuinieren	☆ ☆ ☆
Schilderen	☆ ☆ ☆
Behangen	☆ ☆ ☆
Metselen	☆ ☆ ☆
Tuinieren	☆ ☆ ☆
Timmeren	☆ ☆ ☆
Kast in elkaar zetten	☆ ☆ ☆
Opruimen	☆ ☆ ☆
Anders namelijk...	

Sporten	Ervaring
Trimmen	☆ ☆ ☆
Fietsen	☆ ☆ ☆
Fitness	☆ ☆ ☆
Voetballen	☆ ☆ ☆
Anders namelijk...	

Organiseren	Ervaring
Buurtfeest	☆ ☆ ☆
Fietstocht	☆ ☆ ☆
(Buurt)voetbaltoernooi	☆ ☆ ☆
Barbecue	☆ ☆ ☆
Anders namelijk...	

Huishoudelijk	Ervaring
Boodschappen doen	☆ ☆ ☆
Koken	☆ ☆ ☆
Hond uitlaten	☆ ☆ ☆
Dieren voeren	☆ ☆ ☆
(Af)wassen	☆ ☆ ☆
Strijken	☆ ☆ ☆
Poetsen	☆ ☆ ☆
Knippen	☆ ☆ ☆
Anders namelijk...	

Creatief	Ervaring
Breien	☆ ☆ ☆
Tekenen en schilderen	☆ ☆ ☆
Knutselen	☆ ☆ ☆
Anders namelijk...	

Ontmoeten	Ervaring
Gezelschap	☆ ☆ ☆
Wandelen	☆ ☆ ☆
Kaarten	☆ ☆ ☆
Bingo	☆ ☆ ☆
Anders namelijk...	

Hobbies	Ervaring
Postzegels verzamelen	☆ ☆ ☆
Theezakjes verzamelen	☆ ☆ ☆
Modelbouw	☆ ☆ ☆
Trein	☆ ☆ ☆
Anders namelijk...	

Question 7a: Willingness to do voluntary work for the neighbourhood

Hoeveel tijd zou u uw talenten willen inzetten voor/met de buurt? ◉ ○

Ik zou kunnen op:

ma		di		wo		do		vr					
o	m	o	m	o	m	o	m	o	m	o	m	o	m

Op welke wijze zou u uw talenten willen inzetten? (meerdere antwoorden mogelijk)

Question 8a: Positive aspects of my house

Question 8b: Negative aspects of my house

Question 9: Mobility in and around the house, need for help

Kunt u zich zelfstandig in en om uw huis verplaatsen?

○ Ja ○ Nee

Zo nee, gebruikt u een of meer van de onderstaande hulpmiddelen?

☐ Krukken ☐ Wandelstok ☐ Rollator ☐ Rolstoel ☐ Scootmobiel

Welke van de onderstaande vervoersmiddelen heeft u?

☐ Fiets ☐ Scooter/brommer ☐ 45 km Auto ☐ Auto ☐ Motor

Krijgt u hulp/ondersteuning van instanties?

dagelijks wekelijks maandelijks nooit

Heeft u contact met uw buren en/of bewoners in uw woongebouw/buurt?

dagelijks wekelijks maandelijks nooit

Krijgt u hulp/ondersteuning van uw buren en/of bewoners in uw woongebouw/buurt?

dagelijks wekelijks maandelijks nooit

Welke hulp/ondersteuning heeft u (wel eens) nodig? Of heeft u behoefte aan?

☐ Geen

☐ Financieel ☐ Boodschappen ☐ Zorg voor huisdier(en)
☐ Afvallen ☐ Huishoudelijk ☐ Tuinieren
☐ Kinderoppas ☐ Klus in huis ☐ Vervoer
☐ Gezelschap ☐ Stoppen met roken

☐ Anders namelijk:

Question 10: About your flat

Denkt u dat uw woning, zoals deze nu is, over 10 jaar nog geschikt voor u is?

○ Ja ○ Nee

Zo nee, wat is de reden waarom u zou willen verhuizen?

☐ Moeite met traplopen ☐ Eigen tuin

☐ Gezinsuitbreiding ☐ Verhuizen naar een andere buurt/stad

Anders namelijk:

Staat u open voor verbouwingswerkzaamheden?

○ Ja ○ Nee

Zo ja, wat moet er volgens u aangepakt worden?

Gemeenschappelijk

☐ Gevel ☐ Berging

☐ Entree ☐ Groen rondom flat

☐ Trappenhuis

Woning

☐ Indeling woning

☐ Keuken en sanitair

☐ Balkon

Anders namelijk:

Maakt u gebruik van uw berging?

○ Ja ○ Nee

Wanneer we een nieuwe indeling voor de gemeenschappelijke ruimte voorstellen wat moet er dan volgens u zeker in komen?

☐ Fietsenstalling ☐ Werkplaats/atelier ☐ Ruimte om te huren

☐ Berghok ☐ Winkeltje ☐ Speelruimte

Anders namelijk:

Wat moet er veranderd worden aan het trappenhuis?

☐ Ruimere entree ☐ Andere kleur/schilderen ☐ Verlichting ☐ Trap

Anders namelijk:

Heeft u een satellietschotel / schotelantenne?

○ Ja ○ Nee

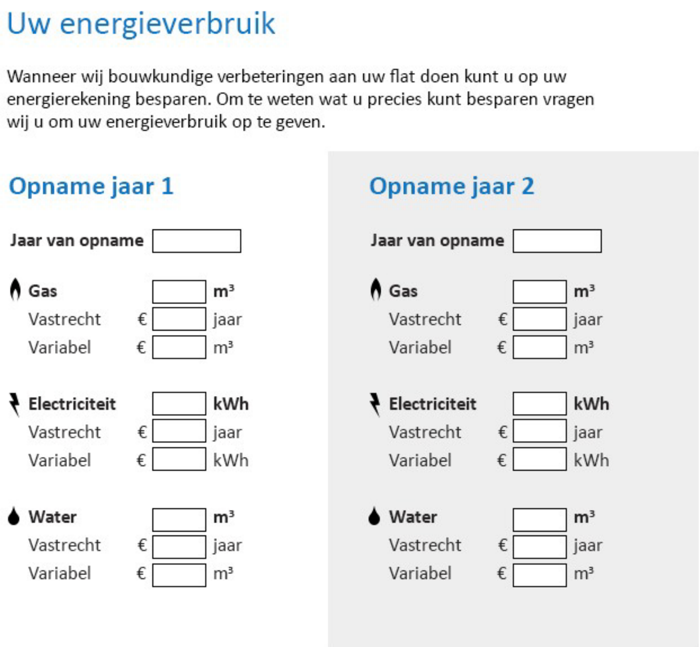
Zo ja, vindt u het belangrijk dat we voorzieningen treffen voor de schotel?

○ Ja ○ Nee

Wanneer wij uw woning en de flat verbeteren bent u dan bereid om meer huur te betalen?

○ Ja ○ Nee

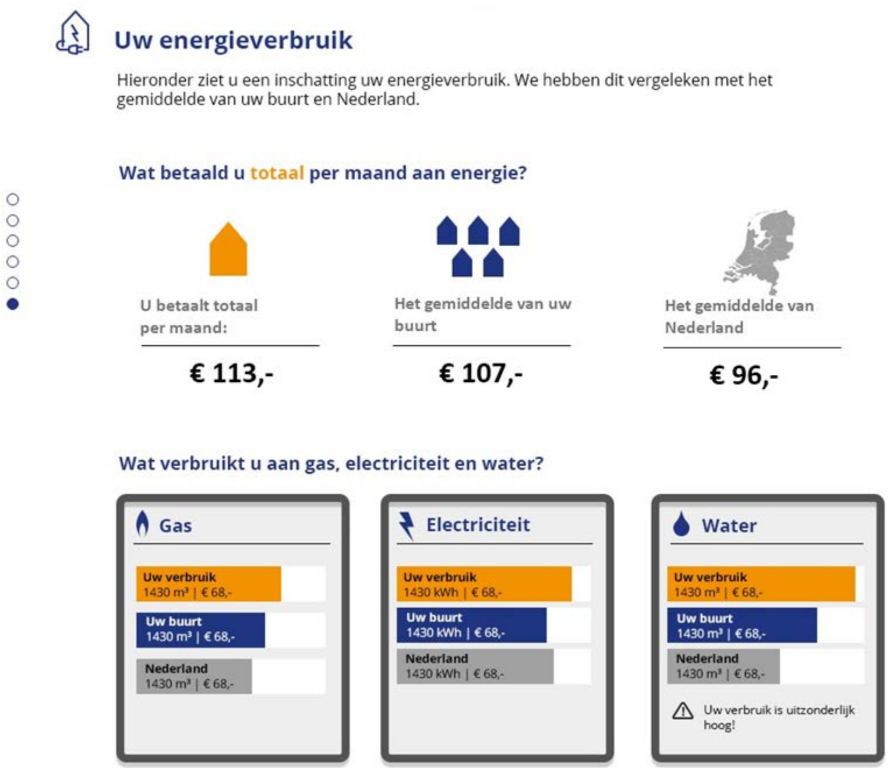
Question 11: Energy consumption



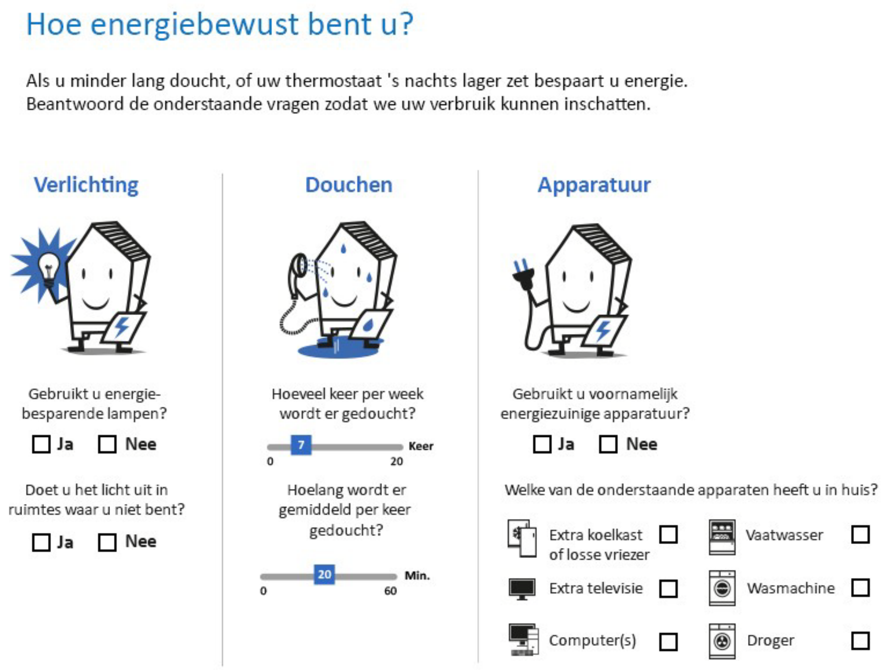
Note:

- We use these data not only as a reference point but also to check if our calculation of the energy consumption based on the energy consumption pattern and the actual condition of the house (and installations) is accurate (enough).

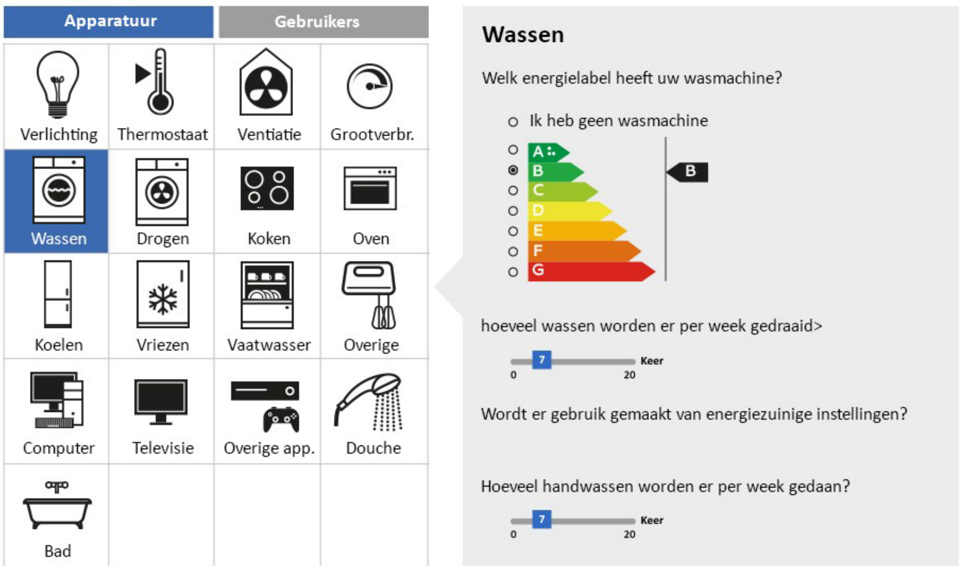
Direct feedback: benchmarking your energy consumption and first advice for reduction



Question 12a: Energy behaviour



Question 12a extended version:



Note:

- Every icon on the left side generates a detailed form on the right side where people can fill in the detailed information.

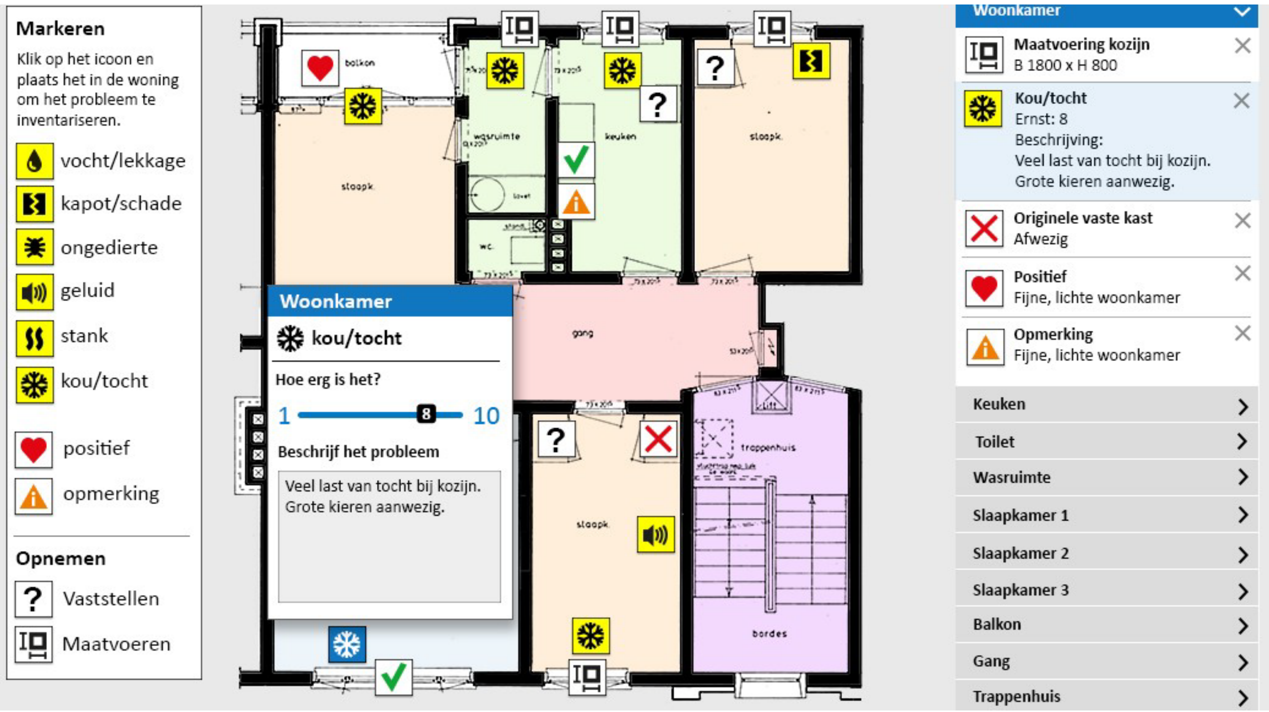
Question 12b: Occupancy of the house

Note:

- o This data is used to estimate the time the heating is on, electric lights is switched on, etc.

Direct feedback 12: now we know about your behaviour and equipment, we can give you some advice about energy reduction

Question 13: Complaints about the house



Notes:

- This is not the same as the technical recording of the house that is done by professionals, but an inventory of the complaints and remarks of the inhabitant.

Section 2: Additional questions for scientific research

Before asking these questions, participants will have to get a clear explanation about the scientific purpose and a clear guarantee that this data will be private an anonymized.

Question 2.1: demographics

What is uw opleidingsniveau?

- Weet niet \ wil niet zeggen
- Basisonderwijs
- MAVO \ eerste 3 jaar HAVO of VWO \ VMBO (theoretische en gemengde leerweg)
- LBO \ VBO \ VMBO (kader- en beroepsgerichte leerweg)
- HAVO en VWO bovenbouw \ WO en HBO propedeuse
- MBO
- HBO \ WO-bachelor of kandidaats
- WO-doctoraal of master

What is your household income level? (Choose one of them)

- Weet echt niet \ wil echt niet zeggen
- <12.500 Euro
- 12.500 - < 26.200
- 26.200 - < 38.800
- 38.800 - < 65.000
- 65.000 - < 77.500
- >= 77.500

Question 2.2 Sustainable contributions

Heeft uw huis zonnepanelen? Ja/nee

Zo ja, hoeveel energie produceren deze? Weet niet/ XXXX kwh/jr

Heeft uw huis een 'smart meter'? Ja/nee

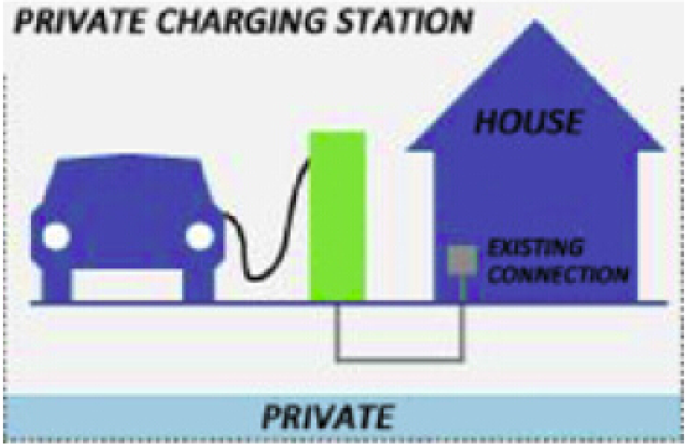
Zo ja, gebruikt u de gegevens daarvan om energiezuiniger te leven? Ja/nee

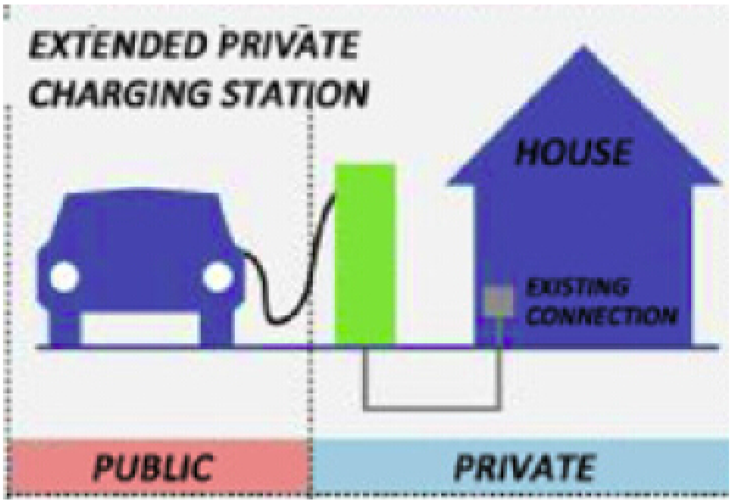
Heeft u een elektrische of hybride auto? Ja/nee

Zo ja, heeft u een eigen oplaadstation? Ja/nee

Zo ja, hoe vaak per week laadt u uw auto op? XXXX per week

Note:


PRIVATE CHARGING STATION
HOUSE
EXISTING CONNECTION
PRIVATE


EXTENDED PRIVATE CHARGING STATION
HOUSE
EXISTING CONNECTION
PUBLIC
PRIVATE

Question 2.4 Detailed perception of the neighbourhood

Geef aan welk antwoord uw mening het dichtste benadert

uw buurt		score				
		1	2	3	4	5
1	Wat vindt u van de verkeerssituatie?	Veel te druk	Te druk	Normaal	rustig	Zeer rustig
2	Wat vindt u van de luchtkwaliteit?	stank	Niet fris	Normaal	fris	Zeer fris
3	Wat vindt u van de inrichting en de faciliteiten in de buurt?	Saai	rustig	Normaal	afwisselend	Zeer afwisselend
4	Wat vindt u van de groen voorzieningen?	kaal	weinig	Normaal	groen	Zeer groen
5	Wat vind u van de sfeer in de buurt?	Ieder voor zich	Weinig buurt gevoel	Normaal	Vriendelijk/ samenhorig/ gezellig	Beklemmende sociale controle
6	Wat vindt u van de bebouwing?	afschuwelijk	Niet zo mooi	Normaal	Best aardig	mooi
7	Wat vind u van de veiligheid?	crimineel	Onveilig	Normaal	Redelijk veilig	Zeer veilig
8	Wat vindt u van de behulpzaamheid in de buurt?	Zeer slecht	slecht	Normaal	behulpzaam	Zeer behulpzaam
9	Hoe schoon vindt u de buurt?	vies	rommelig	Normaal	best netjes	Zeer schoon
10	Wat vindt u van het lawaai?	geluidsoverlast	lawaaiig	Normaal	rustig	Zeer rustig
11	Vindt u uw buurt overzichtelijk of rommelig?	rommelig	Gaar wel	Natural	redelijk	overzichtelijk
12	Wat denkt u van de ligging?	Te verveg van alles (hospital/school/doctor)	Ver weg van alles(hospital/school/doctor)	Natural	Redelijk dichtbij	Central ligging

Question 2.5 Perception of your house

Geef bij de volgende stellingen aan in welke mate u het ermee eens bent.

vraag		antwoorden				
		Zeer oneens	oneens	Weet niet	eens	Zeer eens
1	Ik woon in een comfortabel huis					
2	Het huis is ‘szomers niet te warm en ‘swinters niet te koud					
3	In het huis tocht het nergens					
4	Het huis is veilig tegen inbraken					
5	Het huis voldoet aan de behoeften van mijn gezin					
6	Het huis heeft een handige indeling					
7	Het huis is goed geventileerd					
8	Het huis krijg overal voldoende daglicht					
9	Het huis is gemakkelijk te onderhouden en schoon te maken					
10	De buitenkant van het huis (gevels en kozijnen) ziet er verzorgd uit					
11	De energierekening van het huis is betaalbaar					
12	De huur/hypotheek van het huis is betaalbaar					

Question		Score
1	**Insulation**	
2	**Soundproof**	
3	**Safety locks**	
4	**House space fit for your household need**	
5	**Room layout**	
6	**Ventilation and lighting**	
7	**Maintenance and clear**	

8	**Building exterior**	
9	**Energy consumption**	
10	**Affordable rental housing**	

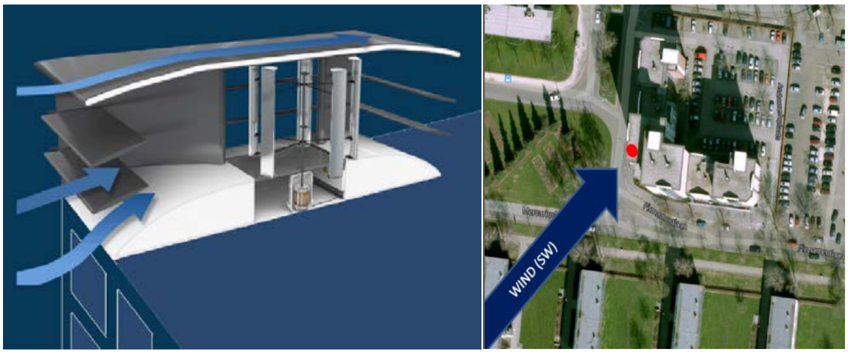
Question 2.6 Attitude towards wind turbine

Wat vindt u van de installatie van een wind turbine op het dak van een openbaar gebouw in uw omgeving?

- Ik ben er falikant tegen
- Ik ben er tegen
- maakt me niet uit - geen mening
- ik ben voor
- ik ben erg heel erg voor

What is your opinion about installing a wind turbine on public roof in your neighborhood?

- Strongly disagree
- Disagree
- Natural – no opinion
- Agree
- Strongly agree



- **Question 2.7 About the use of the pedestrian route**

Er is een voetgangers route van 1 km rond de vijver en door het park (with a map to indicate which route referred to). **Hoe vaak gebruikt u die? How often do you use it?**

- Nooit
- 1-2 keer per maand
- 3-5 keer per maand
- 6-15 keer per maand
- > 15 keer per maand

Wat zijn uw redenen om de voetgangersroute al dan niet te gebruiken?

The reasons of why you use/not use it? (The design could be similar to sample question 3&4) (kies nog maximaal 1 punt), Options would be:

Wel

- Dicht bij mijn huis
- Ik kan er mijn hond uitlaten
- Fris, schoon
- Groen
- Mooi
- Veilig
- Anders, nl……….

Niet

- Te ver van mijn huis
- Er worden honden uitgelaten; daar houdt ik niet van
- Vies, rommelig
- Stank
- Niet groen genoeg
- Lelijk
- Onveilig
- Anders, nl……….

Could you please give a score for each perspective regarding to your current experience of this road / (show a pic besides)

- 1 Ik ben er falikant tegen
- 2 Ik ben er tegen
- 3 maakt me niet uit - geen mening

- 4 ik ben voor
- 5 ik ben erg heel erg voor

Indicators	Score
Dicht bij mijn huis	
Ik kan er mijn hond uitlaten	
Fris, schoon	
Groen	
Mooi	
Veilig	
Sufficient lighting after sunset	

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