triangulum

DEMONSTRATE · DISSEMINATE · REPLICATE

D2.3 Impact Assessment and Monitoring Baseline Report

VERSION 2.0

WP 2, Task 3

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**

Project Acronym	TRIANGULUM	
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Project Coordinator	Damian Wagner (Damian.Wagner@iao.fraunhofer.de) Fraunhofer IAO	
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DoA	Report for Manchester capturing the baseline conditions before demonstration activities begin and a synthesis report comparing across cities and sectors to enable impacts to be clearly detected and measured. The report will make reference to the defined indicators on energy, mobility, citizen engagement, socioeconomic aspects and finances.	

Date	Version	Author	Contributors
01/11/2015	1	Chris Martin	James Evans, Dujuan Yang, Trond Linjordet, Bauke de Vries, Tomasz Wiktorski, Alanus von Radecki
03/12/2015	2	James Evans	Chris Martin, Dujuan Yang, Trond Linjordet plus WP partners
06/01/2016	3	James Evans	Chris Martin, Dujuan Yang, Trond Linjordet
13/01/2016	4	Chris Martin	James Evans, Andrew Karvonen, Krassimira Paskaleva
15/01/2016	5	James Evans	WP02 staff and other WP leaders
21/01/2016	6	Chris Martin	Andrew Karvonen, Krassimira Paskaleva, Trond Linjordet, Gerd Seehus, Dujuan Yang, Bauke de Vries
22/01/2016	7	James Evans	Alanus von Radecki, Alexander Schmidt

06/02/2017	9	Chris Martin	Bauke de Vries, Trond Linjordet
20/02/2017	10	James Evans	Chris Martin, Trond Linjordet, Katelien van den Berge, Per Fjeld
20/02/2017	11	Alexander Schmidt	Cross-check, IAO (WP6)
01/03/2017	12	Marielisa Padilla	Format check, UniS (WP1)
01/03/2017	13	Damian Wagner	Final check for submission

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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 D2.3 the Baseline Report as part of this process.

D2.3 the Baseline Report was originally submitted in M12 and sets out the baseline against which impacts can be calculated for each module. D2.3 has been extensively updated and revised to respond to the PO comments, and as part of a refresh process that was necessary due to the unavailability of data and details concerning some modules in M12. This was done through a second round of consultation with city partners contributing to each of the modules, followed by a final consultation with work package leaders.

The key updates include: providing further specification and new details concerning each module, impact, indicator and dataset; and aligning terminology across D2.1 and 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 D2.3

1. Extending and updating the tables of indicators for each module and adding tables identifying datasets potentially to be used in the calculation of impacts for each module (Manchester - see tables 7 to 24; Eindhoven – see tables 29 to 56; Stavanger – see tables 60 to 77). Updates to the indicator tables include:

   - Additional indicators providing a more detailed breakdown of expected impacts;
   - The addition of a unique identifier for each impact to assist clear communication especially between WP2 and WP6;
   - Additional baseline data (where available);
   - Justifications where baseline data remains unavailable;
   - The identification of formulas to be used in impact calculation (where available);
   - Justifications where the formulas remains unavailable;
   - A column showing whether it has been possible to align each indicator with and an indicator from the SCIS (Smart Cities Information System) indicator framework;
   - A column showing whether each indicator might be automatically calculated in the cloud data hub;
   - Details of the next steps WP2 will be taking to capture missing information / data for each indicator.

2. Adding a section explaining the structure of the impact indicator and dataset tables, to aid interpretation of them (page 26).
3. Updating the descriptions of modules including details of factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets (throughout sections 3, 4 and 5 of the report, pages 29-242).
4. Adding a summary of the impact assessment methodology employed in the process of developing the baseline reports (see page 21).
5. Updates to module names, and the inclusion of unique module identifiers, to ensure consistency across WP2 and WP6 above (Manchester - see tables 7 to 24; Eindhoven – see tables 29 to 56; Stavanger – see tables 60 to 77).

Details of revisions addressing PO comments during the review process

PO Comments	Details of revisions addressing comments
However, failing to quantify starting values on the KPIs and targets as well as final values will lower the impact and potential for replication.	Details are given concerning quantifiable start values for each indicator in the updated tables of indicators for each module : see tables 7 to 24 for Manchester (pages 46-102); tables 29 to 56 for Eindhoven (pages 123-191); and tables 60 to 77 for Stavanger (pages 201-241). These include: additional baseline data (where available); justifications where baseline data remains unavailable; the identification of formulas to be used in impact calculation (where available); justifications where the formulas remains unavailable.
The number of not required, not available or yet to be defined indicators is not sufficiently justified and will limit the contextualization of the results to be obtained	Details are given in the updated tables of indicators for each module that have yet to be defined elements to them as described in the box above: see tables 7 to 24 for Manchester (pages 46-102); tables 29 to 56 for Eindhoven (pages 123-191); and tables 60 to 77 for Stavanger (pages 201-241). These updated tables also include additional indicators that provide both a more detailed breakdown of expected impacts and captures a wider range of impacts to contextualise the results.
If indicators are not yet captured then additional information on planned methods and means to monitor and	The updated descriptions of modules includes details of factors limiting progress towards establishing the baseline, defining the approach to calculating impacts,

establish such baselines is needed.	and identifying associated datasets (see sections 3,4 and 5 of the report, or page 62 for a good example). Details are given in the updated tables of indicators for each missing piece of information of the next steps WP2 will be taking to capture missing information / data for each indicator: see tables 7 to 24 for Manchester (pages 46-102); tables 29 to 56 for Eindhoven (pages 123-191); and tables 60 to 77 for Stavanger (pages 201-241).
I know that there will be an updated version of D2.3, but please explain the context and the different linkages in the executive summary.	The executive summary has been updated to highlight the revisions made in version 2.

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 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 in Deliverable 2.1 provided the basis to assess the successes and challenges of the smart city modules developed within Triangulum. Deliverable 2.3 presents the baseline report based on the expected impacts and impacts indicators that modules foresee. Overall this report presents a detailed account of the work that has been co-produced between WP02 staff and partners in the Lighthouse cities. It is organised into five sections.

Section 1 summarises the role of WP02 within the broader context of the SCC (Smart Cities and Communities) funding programme and smart city agenda, emphasising the need to align smart cities with sustainability goals. This section recaps the monitoring and assessment approach outlined in Deliverable 2.1, which focuses on a bottom up approach to monitoring of the individual demonstration projects. It outlines the methodology that was used to construct this baseline report and provides a summary of progress of WP02 towards the tasks outlined in the DoW.

Section 2 summarises the approach to developing the baseline reports for each of the three Lighthouse cities Manchester, Eindhoven and Stavanger. There are considerable differences between each city and between individual modules within each city in terms of the stage of operationalisation. Datasets differ in terms of their availability and type and some are yet to be created. The process of identifying modules and impacts, indicators and datasets with project partners has required considerable resources and many details were not available in M12 when

version 1 of this deliverable was submitted. Version 2 has been extensively updated and revised to respond to comments made by the PO (Project Officer) as part of the 18 month review, and as part of a refresh process that was necessary due to the unavailability of data and details concerning some modules in M12. This was done through a second round of consultation with city partners contributing to each of the modules, followed by a final consultation with work package leaders. Version 2 has added a summary of the impact assessment methodology employed in the process of developing the baseline reports (page 21, see D2.1 for full description) and a section explaining the structure of the new impact indicator and dataset tables, to aid interpretation of them (page 26) to this section of the report.

Sections 3, 4 and 5 present the three Lighthouse city baseline reports. The baseline report for each city includes: an executive summary; a description of the city within which the Triangulum modules are being implemented; a brief description of how the modules and assessment of their impacts occur in multi-level governance settings; a description of the district (or districts) within which the Triangulum modules are being implemented; a description of the modules being implemented; baseline data (where available) including quantitative data gathered and text summarising the important features of the baseline data; a brief reflection on the process of developing the modules in each city and the experience of working with the stakeholders to identify impacts, indicators and secure data. Extensive updates and extensions have been made to this section in version 2 including: updating and further specifying new details concerning each module, impact, indicator and dataset; updating the descriptions of modules including details of factors limiting progress towards establishing the baseline and specific actions to address them, defining the approach to calculating impacts, and identifying associated datasets (throughout sections 3, 4 and 5 of the report). The updated tables also include updates to module names and the inclusion of unique module identifiers to support consistency across WP02 and WP6 (Manchester - see tables 7 to 24; Eindhoven – see tables 29 to 56; Stavanger – see tables 60 to 77).

Section 6 synthesises the findings across the three cities. It highlights similarities and differences in terms of expected impacts and monitoring approaches. 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 to support replication in the follower cities and complement initiatives such as SCIS and CityKeys. This section also comments on the process of developing the baseline reports for each city, which is a key contribution of WP02 to learning processes within the overall Triangulum project. Section 7 identifies key tasks ahead, which address the need for a shared framework that can reflect the specificity of each city and demonstration project, and securing data for the Cloud

Data Hub. This section has been updated in version two of this deliverable to reflect the progress made

1 Introduction

This introduction provides a concise summary of Triangulum and the role of WP02, monitoring and assessment, in the project. For a fuller account please see Deliverable 2.1: Common Framework for Monitoring and Assessment.

The main goal of Triangulum is to demonstrate that the integration of technologies from the energy, buildings, mobility and ICT sectors within one district leads to a significant reduction of energy demand and local GHG emissions whilst at by at the same time enhancing quality of life, delivering efficient and clean mobility to residents and local workers and providing the basis for economic growth and development. Cross-sectoral smart city modules are being demonstrated in Manchester, Eindhoven, and Stavanger to provide a test bed for new business models, technologies, and strategies of citizen engagement. The first goal of WP02 is to rigorously monitor and assess the impacts of the modules, to support the work of the lead city partners and learning between them.

But Triangulum's mission goes beyond demonstration to focus on replication. By utilising a widely tested research design developed by the Fraunhofer Society (Morgenstadt framework), Triangulum will through multi-sector partnerships demonstrate and deliver an adapted smart city framework and an ICT reference architecture that serves as a catalyst for replication in our follower cities and beyond. The framework for monitoring and evaluation presented in Deliverable 2.1 provides the basis for assessing the impacts of the projects, supporting the Triangulum replication model and the construction of a cohesive reference architecture through which smart city districts can be replicated in the follower cities of Prague, Sabadell, and Leipzig. Since presenting Deliverable 2.1, considerable effort has been expended to define the modules, including their impacts and indicators.

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:

- Monitor the impacts of the demonstration activities;

- Assess the level of success of the demonstration activities, and;
- Evaluate the sustainability of processes of data generation, monitoring, and usage in each city.

WP02 is led by the University of Manchester - The School of Environment, Education and Development together with the Alliance Manchester Business School - with coordinating assistance from university teams in each partner city. In addition to collaborating with their respective cities, the universities bring the following expertise to WP02:

- The University of Stavanger (UiS) brings ICT expertise;
- The Technical University of Eindhoven (TU/e) brings building science and mobility assessment expertise, and;
- The University of Manchester (UNIMAN) brings smart city, urban governance and 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 coordinated with WP06 to aid in the preparation of a reference architecture for replication in follower cities (see Figure 1).

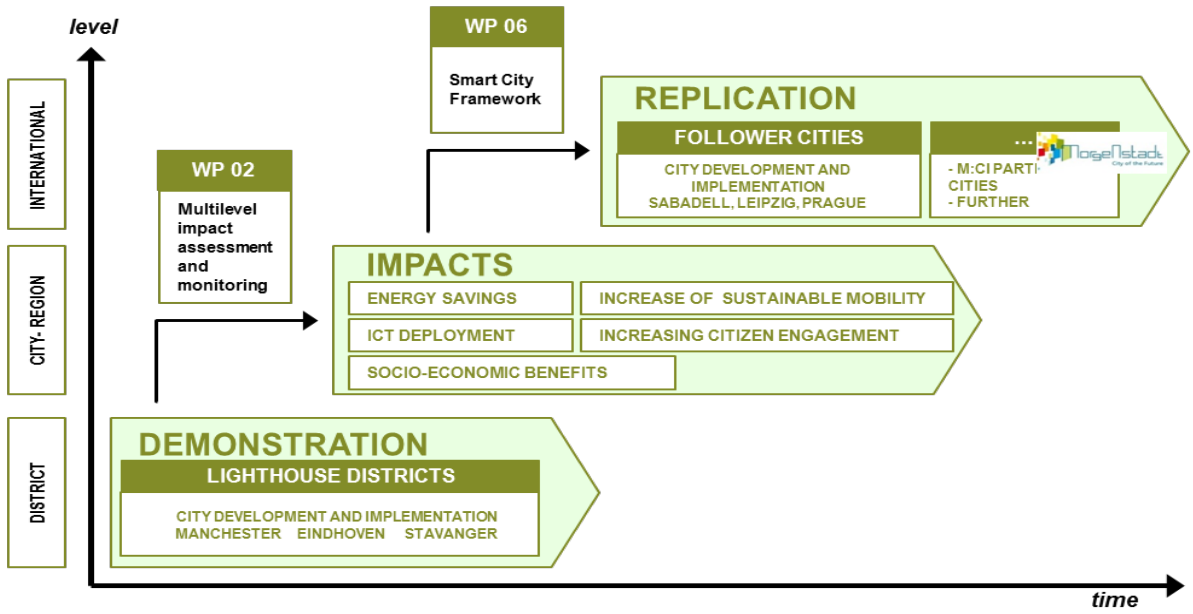

Figure 1: Scale, role, and timeline of WP02

In contrast to previous EU projects, Triangulum does not focus on a broader public policy agenda of smart city development, but rather works 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. Triangulum adopts a monitoring and assessment approach with a focus on the scale of demonstration project. WP02 aims to fulfil both a formative and a summative evaluation role in Triangulum[1], assessing both the impacts of demonstration projects in each city and the process through which they are identified and 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 amongst them about different monitoring solutions;
- Support the Triangulum replication model of WP06, and;

[1] Duignan, P. 2009. Evaluation Types: Formative/Developmental, Process, Impact/Outcome Evaluation. Outcomes Theory Knowledge Base Article No. 256. http://knol.google.com/k/paul-duignan-phd/-/2m7zd68aaz774/119 (accessed 6 June 2011).

- Support the follower cities by advising on appropriate impact indicators and feasible monitoring strategies.

Deliverable 2.1 (M6) outlined the overall approach to monitoring and assessment and presented the expected impacts and indicators that had been identified by Manchester, Eindhoven and Stavanger at the district level. Deliverable 2.3 builds on this report to outline the specific baseline conditions in each city before projects commence. This is done by developing a detailed understanding of each project and a corresponding set of expected impacts and indicators for each project. The bulk of this deliverable is devoted to presenting the baseline reports for each project. Before considering the baseline approach and results, the next section briefly summarises progress towards the commitments of Task 2.1 outlined in the DoW.

1.2 Progress towards Tasks Outlined in the DoW

The WP02 framework was developed based on the Fraunhofer assessment of impact domains initially 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.

Task 2.1 Developing monitoring and assessment frameworks. UNIMAN (Lead), MMU, UiS, TU/e and FhG

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.

Complete (see Deliverable 2.1).

Develop monitoring procedures[2] *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.*

This is the main purpose of this report.

[2] 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.

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

The data hub consists of a cloud platform that provides storage and computation. To design this solution, best practices and requirements are currently being analysed. In order to implement the appropriate infrastructure, a specific "stack" of hardware, operating system and other software (especially to support analytics) are being determined. In this process, comments to the ICT Reference Architecture document (WP6) will be provided. In particular, replicability in other circumstances is a priority in the design process.

Deploy the Cloud Data Hub in the smart city districts.

Through operation and management of the data hub, the themes of replicability and scalability will be explored in practice. Use will be initially confined to analytics (WP5). The analytics stack is being developed (WP5) in tandem with the data hub design (WP02). Exploration of alternative uses is deferred to future consideration.

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

The process of working with city partners has already yielded valuable insights into what kinds of monitoring cities are able to undertake. Reflections at the district level were offered in Section 4.4 of Deliverable 2.1. This understanding is developed to in greater detail in Sections 3-6 of this report, which considers the monitoring capacity at the level of the projects and the indicators that are used across the projects and cities.

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

WP02 seeks to evaluate the impact, indicators and data that are used to assess impacts over the next 3 years in terms of relevance to elucidating the project level impacts on smartness, sustainability, citizen engagement, citizen well-being, availability of data, measurability, reliability,

familiarity, non-redundancy, and independence. This will help to develop a long-term monitoring procedure for the Lighthouse cities.

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.

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 Lighthouse cities.

2.2 Monitoring. UNIMAN (Lead), MMU, UiS, TU/e.

Gather baseline data to capture conditions before the demonstrator projects begin to allow subsequent measurement of the success and impacts of demonstrator projects.

The research teams in each city have been working closely with the city partners to identify impacts and a set of indicators and data for each project. There are considerable differences in the status of each city in terms of operationalisation, and between individual modules within the cities. Similarly, not only do the datasets differ in terms of their availability and type, but many are yet to be created. Because of this, the process of discussing modules and identifying impacts, indicators and datasets with project partners was considerable and a significant amount of baseline data is not available yet. That said, this process has played a critical role in activating project partners as learners in the project and understanding the importance of monitoring and assessment to the Triangulum project.

Liaise with key city stakeholders and, where necessary, third party data providers who are not part of the project team to secure appropriate data in a timely and orderly fashion.

This has begun, and will form a key part of the WP02 work in each city over the coming 2 years.

Maintain and populate Cloud Data Hub.

Currently, the cloud platform is undergoing architectural redesign and re-implementation. The architecture will be documented and shared with other cities to improve reproducibility. In addition, one local partner (i.e. Kolumbus, the public transport administrator) is storing a subset of their real-time and historical data in the data hub. The University of Stavanger is also working with other partners (e.g. the Stavanger Municipality GIS Department) to collect and process relevant data and metadata and to address challenges around space.

Process and analyse data in accordance with the common monitoring and assessment frameworks identified in task 2.1.

This sub task has been started as part of the baseline reports.

Assist with the implementation of long-term monitoring protocols in smart city districts in the Lighthouse cities to cover years four and five of the project.

WP02 will seek to evaluate the impact indicators that are used to assess impacts over the next 2 years in terms of relevance to elucidating the project level impacts on smartness, sustainability, engagement or well-being, availability of data, measurability, reliability, familiarity, non-redundancy, and independence. This will help to develop a long-term monitoring procedure for the Lighthouse cities.

2.3 Reporting. UNIMAN (Lead), MMU, UiS, TU/e.

Produce assessment reports capturing the baseline conditions for each city and the subsequent impacts and success of demonstrator activities and improvements in data collection and monitoring capacity.

This is addressed in this deliverable.

Produce synthesis reports comparing baseline conditions and subsequent impacts between the cities and between sectors (energy, mobility, ICT, citizen engagement and socio-economic) to assess success of activities and enable identification of common challenges and opportunities and promote learning and replication.

Section 6 provides a synthesis report comparing baselines across the three cities and identifies common challenges and opportunities and promote learning and replication that will be addressed in the next 2 years.

2.4 Learning. UNIMAN (Lead), UiS, TU/e and FhG.

Disseminate baseline and impact reports to key city and project partners to enable formative learning.

Baseline reports have been developed in close consultation with the city partners and have already enable considerable learning to take place. The final version of this report will also be circulated.

Provide an evidence base of data and assessment for the on-site visits that form part of WP6.

WP02 and WP06 will continue to work closely to identify overlap and synergies between impact indicators (WP02) and the quantitative metrics which will enable module replication (WP06).

Assist follower cities with implementation of streamlined monitoring protocols.

The WP02 team will undertake an evaluation of the different strategies used in years 4 and 5 to make informed recommendations to the follower cities about how best to gather data based on the lessons learned from the first round of Lighthouse cities.

Produce final multi-level impact assessment and monitoring report for WP02 including summary of assessment and synthesis reports and long-term and streamlined monitoring protocols.

This will be included in deliverable 2.6.

2 Approach to Baseline Reporting

2.1 Overall approach

As outlined in Section 1.2 of D2.1, WP02 aims to fulfil both a formative and a summative evaluation role in Triangulum[3], 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.

Given the unique formulation of Triangulum, the first phase of WP02 has entailed the development of a novel yet pragmatic monitoring and assessment framework that is characterised by the following four priorities.

1. Focus on monitoring and assessment at the project level

This monitoring and assessment framework directly corresponds to the unique structure of the Triangulum projects. Building on the concept of Urban Living Labs, Triangulum provides a novel form of smart district development that frames the city as a series of modular units.[4] It is at the project level that impacts are generated and thus causal relations between interventions and resulting impacts can be established and verified. This focus is critical in relation to WP06, where we together identify benefits of the solutions and link them to indicators and metrics, thus creating individual project (module) based assessment opportunities.

The projects represent the building blocks of Triangulum. They are the scale at which corporate partners enact smart cities and the level at which replication can be achieved through procurement and decision-making processes. The project scale is also the most consistent scale for measurement and comparison because the districts differ widely in size and coherence across the three cities.

[3] Duignan, P. 2009. Evaluation Types: Formative/Developmental, Process, Impact/Outcome Evaluation. Outcomes Theory Knowledge Base Article No. 256. http://knol.google.com/k/paul-duignan-phd/-/2m7zd68aaz774/119 (accessed 6 June 2011).

[4] See WP06

2. Activate project stakeholders as learning partners

The expected impacts, impact indicators, preferred metrics and data sets have been determined by consulting extensively with city partners to identify changes to plans and to verify information from the original proposal. In a number of cases this process has played a substantial role in supporting city partners in project development. Taking a partnership approach to monitoring and assessment enables WP02 to better understand what the intended impacts are and to obtain more precise and appropriate data in a timely fashion.

Furthermore, this approach recognises that the understanding of impacts and available datasets will evolve over time as projects mature. Baseline dates are variable as because modules are implemented at different times and their impacts can extend beyond the Triangulum end date.

In addition to these utilitarian benefits, this approach has activated Triangulum organisations as learning partners in the project. This is significant, as monitoring and assessment is often not prioritised in smart city initiatives due to resource constraints, the complexity of partnerships and the relatively short timeframes of some projects. WP02 is encouraging partners to prioritise monitoring and assessment and assisting them in the development of more comprehensive forms of monitoring and evaluation. In addition, WP02 is synthesising the monitoring activities of city partners, which usually remain in organisational silos, to develop a holistic picture of the impacts of smart city projects.

3. Synergise data collection with WP06 replication

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. Through synergies with WP06, duplicate requests for information can be avoided, the evidence base for evaluating benefits can be expanded, and impacts can be linked more directly to the replication framework.

4. Adopt an organic, bottom up approach

Having real smart city projects to study and assess is a unique feature of Triangulum. Adopting a bottom up approach captures the experiences, capacities and needs of smart city partners in practice, which is critical in order to develop business models and monitoring approaches that are feasible and replicable in the Follower cities and a range of cities around the world.

2.2 Impact Assessment Methodology

The seven stage methodology adopted by WP02 for developing impact indictors and calculating impacts was presented in Deliverable 2.1 (the Common Monitoring and Impact Assessment Framework). The stages of the methodology are reiterated here and shown in Figure 2 to aid interpretation of the baseline reports. Table 1 shows the timescales, key input required for each activity from partners, and the key instruments used at each stage. This baseline report presents findings from stages 1 to 5 of the methodology, stages 4 and 5 remain in progress rather than complete.

1. **Review of existing literature and frameworks.** WP02 conducted a desk based review of the key literatures on sustainability and smart city indicator development and assessment. WP02 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.** WP02 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 WP02 documents.

3. **Co-produce and document impacts, indicators and datasets.** Based on the expected module outcomes and review of existing literature and frameworks WP02 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 WP02 and the task group through workshops and inviting comments electronically on draft WP02 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* (DIF) 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 WP02 (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 (WP02)	**Timescale**	**Input required from other WPs and partner organisations**	**Key methods used by WP02 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	M9-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	M9-36	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 1: Impact assessment methodology overview

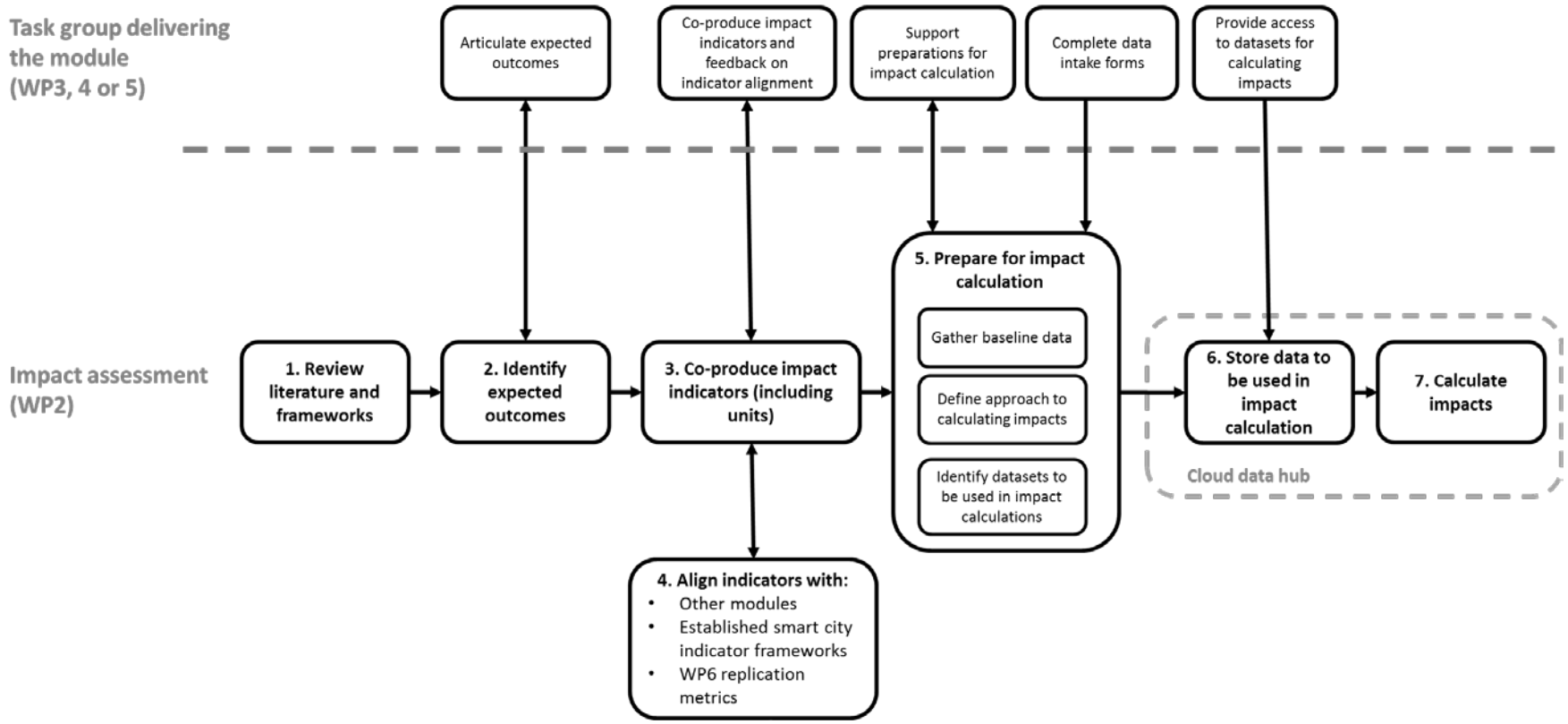

Figure 2: A Seven-Stage Methodology for Developing Indicators and Calculating Impacts

2.3 The structure of Deliverable 2.3: Baseline Reports

A draft structure for the Deliverable 2.3: Baseline Reports was discussed at a Skype meeting between WP02 partners on 11 November 2015. The partners agreed to develop individual city baseline reports that would enable each partner to begin working on the background and descriptive context for their respective cities immediately, rather than waiting until all the data was secured and the details of the projects were finalised. The timescale for delivery was agreed between WP02 partners as follows:

- **Tuesday 1 December 2015:** Research partners in Eindhoven, Manchester and Stavanger to share progress on city baseline reports to ensure the reporting approach is consistent.
- **Friday 8 January 2016:** Research partners to submit finalised city baseline reports to WP02 coordinator; who will then add a brief synthesis report which compares the baseline conditions across the cities, a reflection on the process so far, and outline the next steps for WP02, before submission to the Triangulum coordinator.

The draft structure was also presented to project partners at the Berlin General Assembly on 25 November 2015 and received the following feedback:

- The need to be consistent with language around indicators (KPIs, success indicators, impacts, etc.).
- The need to state the relationship between datasets and indicators (i.e. does the data need manipulating?)
- The need to explicitly determine the timeframe for different impacts.
- The importance to Follower cities of capturing the reliability and cost efficiency of different solutions.

The draft baseline reports for each city were then developed in close consultation with the project partners, according to the proposed structure and partner feedback. In order to ensure integration with WP06 shared spreadsheets were used for each project, including the WP06 information and the WP02 indicators and data for each project. Where possible, project templates were completed ahead of the WP06 city visits to each city. These took place in November in Eindhoven, December in Stavanger, and January in Manchester. Specific reflections on the process of developing the baseline templates for each project are included in the city baseline reports in Sections 3-5, while Section 6 synthesises the findings from all Lighthouse cities.

Baseline report structure: For each city the baseline report (see sections 3-5) provides details of the Triangulum activity taking place, the indicators used for assessing impacts and the baseline data gathered. The structure for each city report is as follows:

- *An executive summary:* A brief summary outlining the modules to be implemented within the city and the key findings emerging from the baseline data.
- *The urban context:* a description of the urban context within which the Triangulum modules are being implemented.
- *The district(s):* a description of the district (or districts) within which the Triangulum modules are being implemented. This section also includes a brief description of how the modules and assessment of their impacts occur in multi-level governance settings.
- *The modules:* a description of the modules being implemented including objectives, partner organisations involved, technologies used and the indicators to be used for assessing the impacts and benefits. For each module baseline data is also presented, where available, including quantitative data gathered and text summarising the important features of the baseline data.
- *Reflections on the process and next steps:* a brief reflection on the process of developing the modules in each city and the experience of working with the stakeholders to identify impacts, indicators and secure data. Next steps are also identified.

The following three sections present the baseline reports for the three Lighthouse cities.

2.4 The structure of impact indicator and dataset tables in the baseline report

For each module described in the baseline reports below, impact indicators and datasets to be used in calculating impacts are presented in detail in the form of tables. To aid interpretation of these tables their structures are outlined below (in Table 2 and Table 3) including a description of the column headings, column content and approach to populating the column.

Column headings (impact indicator tables)	**Description of column contents**	**Approach to populating the column**
Impact indicator identifier	Unique identifier for impact indicator	List impact indicator identifiers for all relevant rows in the indicator table. Impact indicator identifier format to be confirmed. Most likely a 6 digit number. For example, 311003 would be the third impact indicator for module 311.
Impact	A qualitative description of an impact that the module is expected to make.	Text. Noun phrase, preferably.
Impact indicator	Specific indicator that could be used to make quantitative measurements of a specific impact.	Text. Noun phrase, preferably.
Quant. Unit	Quantitative unit: Unit to be used in baseline measurements and the quantitative value calculated for the impact indicator.	SI Units Alternatively, use units with explicit reference to the standard to which they belong. If the quantity has no dimension, and hence no units, state “dimensionless integer”, or “dimensionless decimal”, or “percentage”, as appropriate.
Baseline value	An initial value for the indicator against which impact will be measured.	Integer or decimal numerical value as appropriate.
Baseline period	Identifies the time period the baseline value was measured.	Time period, e.g. Mar. 2015 – Feb. 2016.
Datasets to be used in impact calculation	Designates the names of the datasets that are expected to be used in the calculation of a quantitative value for the impact indicator. Further details of the datasets to be provided in the Dataset table for each module.	List dataset names corresponding to those in the Dataset table.

Column headings (impact indicator tables)	**Description of column contents**	**Approach to populating the column**
Formula for impact calculation	Identifies a formula that could be used to calculate a quantitative value for the indicator, in terms of variables from the schemas of the datasets identified in the table.	Mathematical expression in terms of variables. + : Addition - : Subtraction * : Multiplication / : Division ** : Exponentiation Parentheses can be used.
Aligned with SCIS?	Is this indicator aligned with an indicator in the SCIS (Smart Cities Information System) Key Performance Indicator Guide. *(Feedback from module delivery teams not required)*	Y : Yes N : No
Auto. calc.?:	Automated calculation: Is it feasible that a quantitative value for this indicator could be calculated automatically, using the datasets identified and a predefined formula?	Y : Yes N : No U : Uncertain.
WP02 next steps	Identify next action relating to this indicator. In particular, how missing baseline data will be collected.	Text. Operational brief description of task.

Table 2: Description of the structure of the tables which identify impact indicators

Column headings (dataset tables)	**Description of column contents**	**Approach to populating the column**
Dataset name	Unique name for the dataset	Text.
Dataset description	Brief description of the dataset, with some reference to how the data is generated.	Text.
Related impact indicators	Identify the impact indicators which this dataset will be used to calculate.	List impact indicator identifiers for all relevant rows in the indicator table. Impact indicator identifier format to be confirmed. Most likely a 6 digit number. For example, 311003 would be the third impact indicator for module 311.
Available in M24?	Determine if dataset is available in M24 to calculate values for impact indicators.	Y : Yes N : No
Dataset owner	Identify which organisation owns the dataset.	Text.
Dataset contact	Identify who WP02 can contact to access the dataset and gather the contextual information needed to understand and use the dataset.	Text. Name and email address.
To be collected beyond M60?	Determine if this dataset will likely be collected beyond the end of the Triangulum project, i.e. after M60.	Y : Yes N : No U : Uncertain
Comments	Any additional information relating to the dataset and its availability. Where possible and appropriate, justify why dataset is currently unavailable.	Text.
WP02 next steps	Identify next action for WP02 relating to the dataset.	Text.

Table 3: Description of the structure of the tables which identify datasets to potential be used in calculating impact indicators

3 Manchester Baseline

Executive Summary

The Manchester report presents a strategic overview of the on-going process of understanding the scope of the Triangulum modules being implemented in Manchester, and the development of a set of indicators and baseline data to assess the impacts of these modules. This report is organised into six sections.

Section 1 provides a high-level description of the City of Manchester, and highlights the diverse range of smart city initiatives taking place that complement Triangulum. Section 2 describes the Corridor, the district of Manchester which serves as the city's urban laboratory for developing and testing Triangulum's smart and sustainable urban solutions (i.e. modules). The key role of Corridor Manchester in governing the district, and smart city initiatives within it, is highlighted. Furthermore, the potential of Triangulum modules to contribute to meeting district-level objectives (e.g. reducing air quality pollution and carbon emissions, and fostering economic growth) is identified, and the approach to governing module development and implementation is outlined. Section 2 concludes with an outline of the WP02 approach to developing indicators for each of the Manchester modules.

Section 3 describes the Energy modules in detail including objectives, socio-technical configurations and stakeholder structures. The indicators to be used for assessing the impacts and benefits of the module and the current understanding of baseline conditions are then presented. Sections 4 and 5 provide module descriptions and impact indicators for the Mobility and ICT modules respectively.

Section 6 offers an initial evaluation of the process used to develop the impact indicators and aggregate baseline data followed by a high-level overview of the planned impact and assessment and monitoring activities in Manchester during 2016.

3.1 Smart city initiatives in the City of Manchester

Manchester lies at the heart of the Greater Manchester metropolitan region. With a regional population of 2.7 million, it comprises the second largest economy in the UK outside of London and generates 4% of national GDP. The city of Manchester has enjoyed rapid economic growth over the last decade, fuelled by unprecedented levels of investment, a skilled workforce and an entrepreneurial business sector. In the same period the population has grown by 19% making it the fastest growing city in the UK, with a population of approx. 520,000 generating €63 billion GVA annually.

Drawing on the expertise of Triangulum partners and a web-based study, it has been possible to identify a diverse range of smart city initiatives that are in progress or have been recently completed across Manchester. They fall into five groups:

1. Smart City initiatives led by Manchester city council including: refurbishing council buildings and installing smart building management systems; installing energy efficient intelligent street lighting; and, a Digital Demonstrator Hub which enables SMEs to learn about the potential of superfast broadband.
2. Smart city initiatives delivered by public-private partnerships including: CityVerve, a £10 million project which will demonstrate the potential of IoT (Internet of Things) technologies within the smart city; and, DIMMER, a FP7 project focussed on the role of information in creating more efficient district energy systems and catalysing changes in energy consumption behaviour.
3. Smart city research and innovation clusters including: Thinklab at the University of Salford; the Centre for Digital Innovation at Manchester Metropolitan University; and, The University Living Lab at the University of Manchester.
4. Smart city initiatives driven by grassroots and community organisations including: FabLab – a makerspace providing shared access to digital fabrication equipment; and, Eco Home Lab – a community group using open source hardware and software to increase the energy efficiency of their homes.
5. Innovation intermediates seeking to foster smart city activity across Manchester, including: FORWARDMcr – a hub for tech start-up companies; and, the Greater Manchester Hydrogen Partnership – a network of stakeholders promotig the use of hydrogen fuel cells in the city.

3.2 The Corridor District

The Corridor district (Figure 3) is central to Manchester's knowledge economy and home to numerous knowledge-intensive enterprises and organisations. These actors create value in sectors including education, health, digital innovation, low carbon technologies, advanced materials, finance and the creative industries. The Corridor itself is a "243 hectare area running south from St Peter's Square to Whitworth Park along Oxford Road"; 70,000 students and 60,000 workers are based within this area. Corridor Manchester was formed in 2007 to generate growth and investment within the area, and was the first partnership of its kind in the UK. It now brings together key stakeholders within the district including Manchester City Council (MCC), The University of Manchester, Manchester Metropolitan University (MMU), Central Manchester University Hospitals NHS Foundation Trust (CMFT), Bruntwood, Manchester Science Partnerships (MSP), ARUP and The Royal Northern College of Music (RNCM). Three members of Corridor Manchester - MCC, UNIMAN and MMU – are members of the Triangulum consortium; alongside industry partners Siemens and Clicks and Links.

The objective of Corridor Manchester is, by 2025, for the district to be become "Manchester's cosmopolitan hub and world-class innovation district, where talented people from the city and across the world learn, create, work, socialise, live and do business; contributing to the economic and social dynamism of one of Europe's leading cities.". Furthermore, smart city initiatives that increase the social and environmental sustainability of the Corridor (such as the Triangulum modules) are expected to play an important role in achieving this objective. For example, the transformation of a section of Oxford Road to limit general traffic (i.e. cars and delivery vehicles) will promote a modal shift to public transport, cycling and walking within the Corridor. Other major programmes in planning or delivery include:

- the redevelopment of Oxford Road rail station;
- the redevelopment of the UNIMAN Northern campus and the MMU campus (including the John Dalton Complex);
- the extension of the Manchester Science Partnerships campus and the development of Clusterlabs 2 and 3 (part of the Life Science Enterprise Zone);
- the development of a new hospital through a £50m partnership between Nuffield Health and Manchester Metropolitan University;
- the redevelopment of a form BBC (British Broadcasting Corporation) site and First Street;
- the development of the Graphene Engineering Innovation Centre and Sir Henry Royce Advanced Materials Institute.

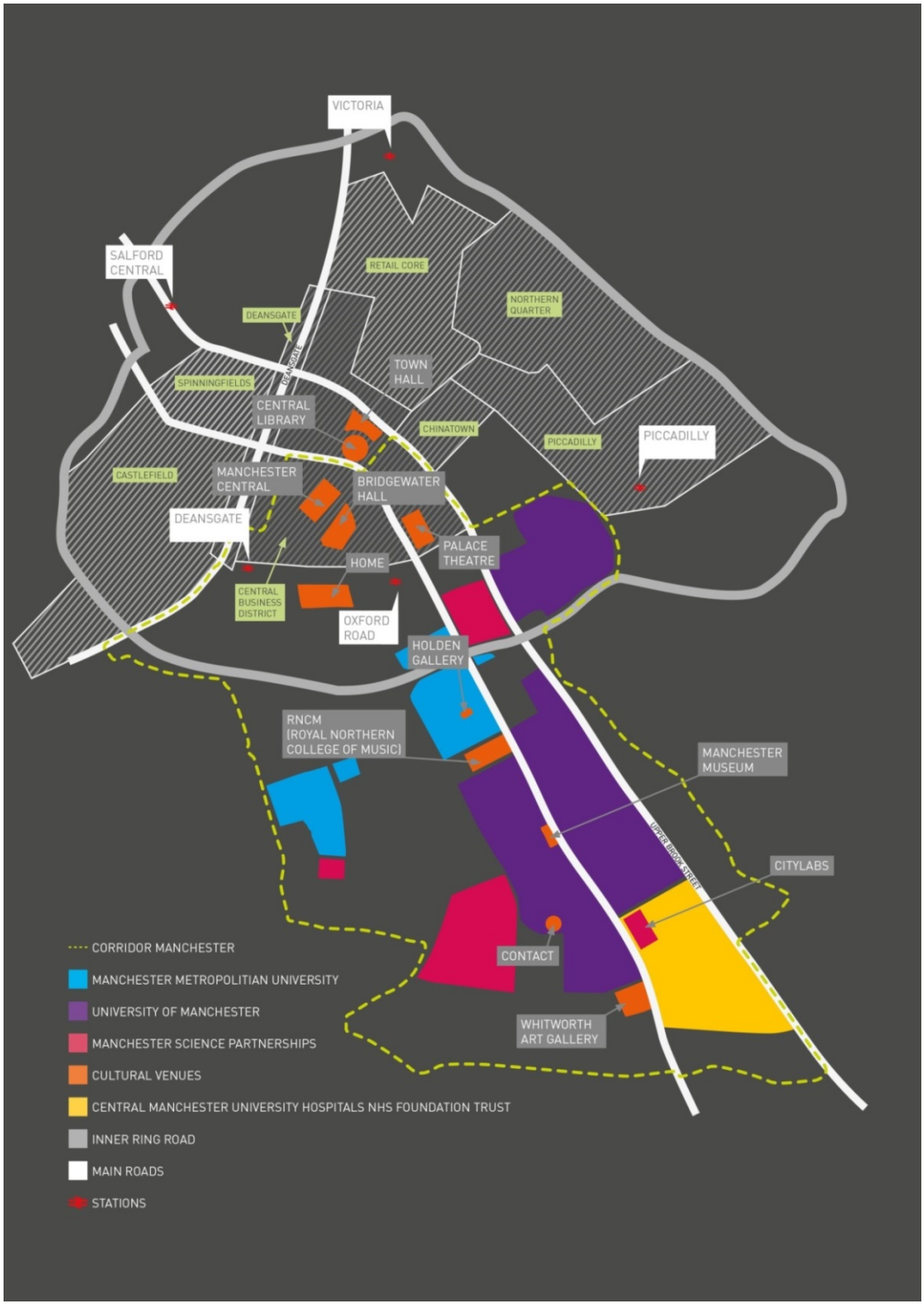

Figure 3: A map of the Corridor district

3.2.1 The role Triangulum modules in supporting district level objectives

We have identified 8 Triangulum modules that support Corridor Manchester objectives at the district scale. More, specifically the modules contribute to the wider efforts to achieve seven objectives: (1) reducing emissions of air quality pollutants; (2) reducing traffic congestion; (3) reducing carbon emissions; (4) reducing energy costs for partner organisations; (5) fostering economic growth; (6) developing a digital infrastructure; and, (7) fostering citizen engagement with digital infrastructure. Table 4 provides contextual data (where available) relating to each objective and Table 5 shows where Triangulum modules may contribute to efforts to achieve these objectives.

Objectives at corridor scale	**Contextual Data**		**Comments**
Reducing emissions of air quality pollutants	**Air Quality Measurements** NO: 55 µg/m^3 (hourly mean) NO_2: 57 µg/m^3 (hourly mean) PM10: 24 µg/m^3 (24 hour mean)		The current measurements of NO_2 are of most concern as currently over the 'safe' limit of 40ug/m^3 Data source: Air Quality England measurement station on Oxford Road
Reducing traffic congestion	**Road Traffic Entering City Centre 07:30-09:30** Car: 1,465 LGV: 74 OGV: 16 Bus: 253 Motorcycle: 24 Pedal cycle: 341 All Vehicles: 2,173	**Road Traffic Entering City Centre 10:00-12:00** Car: 687 LGV: 105 OGV: 16 Bus: 237 Motorcycle: 7 Pedal cycle: 85 All Vehicles: 1,137	Data Source: TfGM Highways Forecasting and Analytical Services Annual Transport Statistics Reports Data collected: Tuesday, 4 March 2014 (Oxford Road)
Reducing carbon emissions	**GHG emissions from vehicle fleets of Triangulum consortium members** MMU: approx. 55 (tonnes CO2e per year) UNIMAN: approx. 333 (tonnes CO2e per year)		Data source: MMU Environment Team Data source: UNIMAN Campus Carbon Calculator v3.1

Objectives at corridor scale	Contextual Data	Comments
	GHG emissions from energy consumption within buildings owned by Triangulum consortium members MMU: approx. 16,000 (tonnes CO2e per year) UNIMAN: approx. 66,000 (tonnes CO2e per year)	Data source: MMU Environment Team Data source: UNIMAN Campus Carbon Calculator v3.1
Reducing energy costs for partner organisations		Energy costs of Triangulum consortium members cannot be included as they are either unavailable or commercially sensitive information.
Fostering economic growth	£3 billion GVA (pa) generated by the Corridor district	Data source: the Corridor Manchester Strategy 2015.
Developing a digital infrastructure		Quantitative measures of the scale of the digital infrastructure within the Corridor are not feasible to collect at this stage of the project.
Fostering citizen engagement with digital infrastructure		Quantitative measures of engagement with the digital infrastructure within the Corridor are not feasible to collect at this stage of the project.

Table 4: Contextual data relating to district scale objectives

Task Group	Module	Contribution to district objectives						
		Reducing emissions of air quality pollutants	Reducing traffic congestion	Reducing carbon emissions	Reducing energy costs for partner organisations	Fostering economic growth	Developing a digital infrastructure	Fostering citizen engagement with digital infrastructure
Energy	321: Central energy controller			*	*			
	322: Energy optimisations in buildings			*	*			
	323: Additional energy resources			*	*			
Mobility	331: Electric vehicle procurement	*		*				
	332: Electric assist cargo bikes	*	*	*				
ICT	341: Data curation service					*	*	*
	342: Data visualisation platform					*	*	*
	343: Data-driven innovation challenges					*	*	*

Table 5: Contribution of Triangulum Manchester modules to achieving district scale of objectives

3.2.2 The Governance of the Triangulum modules

The governance structure for the development of the Triangulum modules is shown in Figure 4. The Corridor Manchester Board takes a strategic overview of Triangulum activity within Manchester. The Triangulum Manchester Board (Task Group 1) consists of representatives from each organisation within the consortium (MCC, MMU, UNIMAN, Siemens and Clicks and Links) and meets on a monthly basis to review progress across the energy, ICT and mobility sectors. The Triangulum Manchester Board meetings provide a forum for integrating activity and shared learning across the three sectors. The Triangulum Manchester project manager (Michelle Oddy, MCC) coordinates activity across the three sectors; monitoring and managing emerging risk and issues. The modules are being developed and implemented by three task groups: Energy (Task Group 2 - led by Heather Stapleton, Siemens); Mobility (Task Group 3 – led by Martine Tommis and Michelle Oddy, MCC); and ICT (Task Group 4 – led by Ian Cotton, UNIMAN). The impact assessment team (WP02 – UNIMAN) collate and integrate data generated by working closely with Task Groups 2, 3 and 4. Representatives from WP02 also attend board meetings to coordinate impact assessment activity across the energy, ICT and mobility sectors.

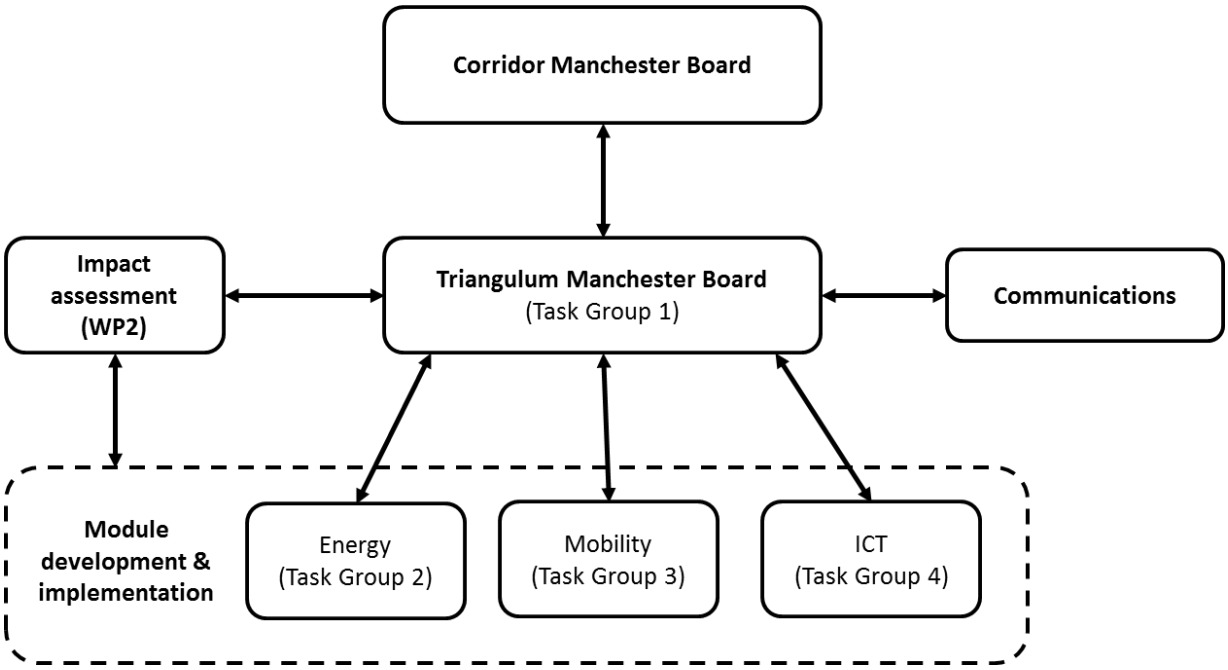

Figure 4: The governance of Triangulum modules in Manchester

3.2.3 The process of developing module specific indicators

The Triangulum DoW outlined a preliminary series of expected impacts and associated indicators identified by the Lighthouse and Follower cities. These indicators were further developed, based on in-depth analysis of bid documentation and feedback from the Lighthouse cities and presented in deliverable 2.1 (Common Monitoring and Impact Assessment Frameworks) in July 2015. Subsequently WP02 researchers have engaged extensively with the Manchester consortium partners over a 6-month period (August 2015 to January 2016) to document the evolving scope of the modules and develop module specific indicators. This engagement process is briefly outlined below.

1. Separate meetings were held with each task group to discuss the alignment of the indicators presented in Del. 2.1 with the evolving scope of the modules (September to October 2015). During these meetings the task group teams identified indicators where data collection would not be feasible and which were no longer aligned with the scope of the modules. Additional indicators were also identified, alongside potential sources of baseline data.
2. Drawing on the insight from these initial meetings, modules descriptions and module specific impact indicators were developed. This documentation was then shared with the three task groups and the Triangulum Manchester Board in November 2015. Based on feedback, further revisions and refinements were made. Meetings were also held with the Energy and Mobility task groups to discuss this feedback and finalise the impact indicators.
3. Baseline data, at both the district and module scales, was then collected by engaging with consortium partners (e.g. MMU and UNIMAN) and accessing relevant open data repositories (e.g. Transport for Greater Manchester and Air Quality England).
4. Finally, an initial draft of this report was circulated to consortium partners for feedback in December 2015, followed by revisions of the module descriptions and module specific indicators.
5. Between October 2016 and February 2017 WP02 staff engaged with the task groups to refresh of the Manchester baseline report. This refresh includes: updating module descriptions (to capture any changes in scope or additional details); updating impact indicators (including removing indicators that will not be feasible and adding new indicators); collecting the baseline data against which impacts will be assessed (where available); and, exploring which data sources might be used to calculate impacts.

3.3 Energy Modules

The Energy task group is in the process of defining the scope of three modules to demonstrate the potential of smart and low carbon energy technologies within the Corridor. Hence, the module descriptions and proposed impact indicators presented below will be revised over the course of the project as module scope is refined.

1. Trialling *a central energy controller:* delivering a Central Controller that connects to existing and new energy infrastructure across multiple buildings providing an extra mechanism for optimising energy generation, storage and consumption.
2. Implementing *building energy optimisations:* optimising the energy infrastructure within individual buildings by making recommendations to: (a) change current processes; (b) implement energy control devices; and, (c) encourage building occupants to make more efficient use of energy through the implementation of behaviour change campaigns.
3. Installing *additional energy resources:* including the design, approval, procurement, installation, commissioning and operation of additional assets throughout the corridor which demonstrates additional benefit of existing low carbon generation assets. *An amendment, related to this module, is being submitted by the Manchester energy task group. If the amendment is approved then the scope of this module will change significantly. WP02 will update the module description, impact indicator table and dataset table as needed once a decision on approval of the amendment has been reached (expected M26).*

Table 6 presents a summary of the expected impacts of each module.

Module	**Mechanism for creating impacts**	**Expected Impacts**				
		Reduced energy consumption	Reduced energy costs	Optimised building energy management systems	Increased use of low carbon energy sources	Reduced greenhouse gas emissions
321: Central energy controller	Optimising energy generation, storage and demand across multiple buildings	*	*			*
322: Building energy optimisations	Optimising the energy demand within individual buildings	*	*	*		*
323: Additional energy resources	Delivering low carbon energy generation flexibility with addition of energy resource				*	*

Table 6: Expected impacts of Manchester Energy modules

3.3.1 Module 321: Central energy controller (Subtasks 3.2.2-5)

Module Objective: To understand the impacts and benefits of implementing a central energy controller to optimise energy generation, storage, and consumption across multiple buildings.

Approach: This module will deliver a Central Energy Controller that connects to existing energy infrastructure, and any additional assets installed by modules 312 and 313, providing an extra mechanism to optimise energy generation, storage and consumption across multiple buildings. Buildings within the MCC (the Town Hall Extension and the Central Library), MMU (Birley Fields Energy Centre and the All Saints Building) and UNIMAN (Alan Gilbert and Alan Turing Buildings) estates are to be connected to the central controller. The controller will recommend optimisation by responding to simulated external signals with its capability of analysing market prices, tariffs, meteorological data and data on the distribution network.[5] The Central Energy Controller will then communicate its requirement to an Energy Intervention Component (EIC). This component will interpret the message and seek to amend the output of individual assets to reflect the initial request; either by interfacing with the Building Management System (BMS) which controls the asset or by interfacing with the asset directly.

Expected Impacts: By identifying opportunities to optimise energy generation, storage and demand this module is expected to make the following impacts: reduced energy consumption; reduced energy costs; and, reduced greenhouse gas emissions.

Links with other modules: The Central Energy Controller will interact with assets installed by Energy modules 322 and 323. Selected data generated by this module will be shared via the data curation service (ICT module 341). The whole module is a result of the studies carried out in the energy optimisation module.

Socio-technical configuration of the module

This module integrates three technologies: (1) the Central Energy Controller; (2) the energy intervention component (EIC); (3) the building management systems which the EIC interfaces with; and (4) the assets within buildings (including sensors, energy consuming technologies, and energy

[5] An illustrative scenario of how this module might operate is as follows. The Central Energy Controller receives a signal that peak demand on the national grid will occur in 2 hours time. To prevent exposure to that peak (when energy costs will increase) the output of heating systems will be temporarily increased by the central controller. Heating systems will then be turned off, or output will be reduced, during the peak time; as the residual heat (from previous heating) will be sufficient to maintain the thermal comfort of building occupants.

generation and storage technologies). The primary users of the module will be the building managers of the buildings that host assets connected to the central controller.

The stakeholder structure of the module

The module is being led by Siemens who will coordinate activity and implement and maintain the controller, and monitor its use. Building managers at MCC, MMU and UNIMAN will support the integration of the Central Energy Controller into existing energy infrastructure. UNIMAN will manage a pre-agreed trials programme locally due to the specifics of the agreed implementation.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below, Table 7 provides details of the impact indicators developed for this module, and Table 8 identifies datasets that could be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***December 2015:*** WP03 (task 3.2) had not specified which buildings and assets will be connected to central controller.
- ***October 2016:*** WP03 (task 3.2) has yet to confirm: Which assets will be connected to, or the format of data to be produced by, the Central Controller. Producing the module baseline relies on stakeholders outside Triangulum project collecting, archiving, and making available datasets. In some cases baseline data are not available. See Table 7 and Table 8 for further details.
- ***Next steps:***
    - Contact lead for task 3.2 monthly to ask if assets to be connected to the Central Controller, and format of data, have been confirmed.
    - Follow-up with MMU and UNIMAN regarding potential to calculate energy cost and greenhouse gas emission baselines. (M26-M30)
    - Distribute the Triangulum Impact Data Intake Form (DIF) to partners delivering task 3.2, and data owners outside the Triangulum consortium. (M26-M30)
    - Explore the feasibility of adapting further SCIS indicators to assess the impact of this module, including indicators for assessing energy savings per m^2 of building floorspace. (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
321001	Reduced energy consumption	Change in annual primary energy use (MCC buildings)	kWh	10,977,389	Oct 2015 – Sept 2016	Primary energy use data (MCC), CC operational data	Cannot yet be defined (as dataset formats yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321002	Reduced energy consumption	Percentage change in annual primary energy use (MCC buildings)	Dimensionless decimal	0.00	n/a	Primary energy use data (MCC), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321003	Reduced energy consumption	Change in annual primary energy use (MMU buildings)	kWh	16,588,516	Oct 2014 – Sept 2015	Primary energy use data (MMU), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321004	Reduced energy consumption	Percentage change in annual primary energy use (MMU buildings)	Dimensionless decimal	0.00	n/a	Primary energy use data (MMU), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
321005	Reduced energy consumption	Change in annual primary energy use (UNIMAN buildings)	kWh	49,158	Jan 2015 – Dec 2015	Primary energy use data (UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321006	Reduced energy consumption	Percentage change in annual primary energy use (UNIMAN buildings)	Dim. Int.	0.00	n/a	Primary energy use data (UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321007	Reduced energy consumption	Change in annual primary energy use (all buildings)	kWh	Not currently available (MCC, MMU & UNIMAN baselines misaligned)	n/a	Primary energy use data (MCC, MMU & UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Align baselines (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
321008	Reduced energy consumption	Percentage change in annual primary energy use (all buildings)	Dim. Int.	0.00	n/a	Primary energy use data (MCC, MMU & UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
321009	Reduced energy costs	Change in annual energy costs (MCC buildings)	€	550,000	Oct 2015 – Sept 2016	Energy cost data (MCC), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321010	Reduced energy costs	Change in annual energy costs (MMU buildings)	€	Not currently available (commercially sensitive)	n/a	Energy cost data (MMU), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
321011	Reduced energy costs	Change in annual energy costs (UNIMAN buildings)	€	Not currently available (not collected)	n/a	Energy cost data (UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
321012	Reduced energy costs	Change in annual energy costs (all buildings)	€	Not currently available (not collected)	n/a	Energy cost data (MCC, MMU & UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
321013	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMC buildings)	tCO_2e	25870	Oct 2015 – Sept 2016	GHG emission data (MCC), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
321014	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMU buildings)	tCO_2e	5056	Oct 2014 – Sept 2015	GHG emission data (MMU), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
321015	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	Not currently available (not collected)	n/a	GHG emission data (UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
321016	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	Not currently available (UNIMAN baseline not available)	n/a	GHG emission data (MCC, MMU & UNIMAN), CC operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Table 7: Impact assessment indicators and baseline data for Module 321

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Primary energy use data (MCC)	Longitudinal dataset detailing primary energy use (heat and electricity) in specified MCC buildings	321001 321002 321007 321008	Y	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Y		Provide DIF to data owner. (M26-M30)
Energy cost data (MCC)	Longitudinal dataset detailing the costs arising from primary energy use in specified MCC buildings	321009 321012	Y	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Y		Provide DIF to data owner. (M26-M30)
GHG emission data (MCC)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MCC buildings	321013 321016	Y	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Y		Provide DIF to data owner. (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Primary energy use data (MMU)	Longitudinal dataset detailing primary energy use (heat and electricity) in specified MMU buildings	321003 321004 321007 321008	Y	MMU	Callum Donnelly (C.Donnelly@mmu.ac.uk)	Y		Provide DIF to data owner. (M26-M30)
Energy cost data (MMU)	Longitudinal dataset detailing the costs arising from primary energy use in specified MMU buildings	321010 321012	N	MMU	n/a	Y	Unavailable as data owner classifies as commercially sensitive.	Explore the possibility of constructing this dataset based on *Primary energy use data (MMU).* (M26-M30)
GHG emission data (MMU)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MMU buildings	321014 321016	Y	MMU	Callum Donnelly (C.Donnelly@mmu.ac.uk)	Y		Provide DIF to data owner. (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Primary energy use data (UNIMAN)	Longitudinal dataset detailing primary energy use (heat and electricity) in specified UNIMAN buildings	321005 321006 321007 321008	Y	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	Y		Provide DIF to data owner. (M26-M30)
Energy cost data (UNIMAN)	Longitudinal dataset detailing the costs arising from primary energy use in specified UNIMAN buildings	321011 321012	N	UNIMAN	n/a	U	Unavailable as not currently collected by UNIMAN.	Explore the possibility of constructing this dataset based on *Primary energy use data (*UNIMAN*).* (M26-M30)
GHG emission data (UNIMAN)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified UNIMAN buildings	321015 321016	N	UNIMAN	n/a	U	Unavailable as not currently collected by UNIMAN.	Explore the possibility of constructing this dataset based on *Primary energy use data (*UNIMAN*).* (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
CC operational data	Data detailing the operations and impacts of the central controller.	All indicators from 321001 to 321016	N	Siemens	Andrew Smyth (Andrew.Smyth @siemens.com)	U	Format and frequency of data remains to be specified by WP03.	Each month (M26-M36), contact lead for task 3.2 to ask if he can advise which assets will be connected to the Central Controller.

Table 8: Datasets potentially to be used in the calculation of impacts for Module 321

3.3.2 Module 322: Energy optimization in buildings (Subtasks 3.2.2-5)

Module Objective: to understand the impacts and benefits of optimising the energy infrastructure within individual buildings by making recommendations to: a) change current processes; b) implement energy control devices; and, c) encourage building occupants to make more efficient use of energy through the development and implementation of behaviour change campaigns.

Approach: This module identified buildings where energy optimisations can be implemented through a series of site assessments. Analysis of the output from the site assessments identified buildings on the MCC (Manchester Art Gallery) and UNIMAN estates (Ellen Wilkinson Building), where optimisations can be implemented including improvements to operational practices and/or through the installation of energy control devices. The planning, preparation and implementation of any agreed optimisation will be realised as part of this module. Additionally, the module will develop and run campaigns targeted at building occupants to encourage changes in consumption behaviour, which in turn could lead to more efficient use of energy.

Expected Impacts: By optimising the energy infrastructure within individual buildings and running energy campaigns designed to encourage the efficient use of energy, this module is expected to make the following impacts: optimised building energy management systems; reduced energy consumption; reduced energy costs; and, reduced greenhouse gas emissions.

Links with other modules: Selected data generated by this module will be shared via the data curation service (ICT module 341).

Socio-technical configuration of the module

This module integrates two technologies: (1) energy control devices (including sensors) which gather data to inform BMS optimisations; and, (2) building management systems. The primary module users will be the managers of the buildings selected for optimisation.

The stakeholder structure of the module

The module is being led by Siemens, who will coordinate activity; identify and recommend optimisations; and, monitor impacts. Building managers at MCC and UNIMAN will support the module by implementing improvements to operational practices and enabling the installation of energy control devices.

Siemens will also coordinate, design, and implement energy campaigns. Energy managers and other stakeholders at MMU, UNIMAN and MCC will support the promotion of the campaigns. The occupants of selected buildings managed by these organisations will take part in the campaigns.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below Table 9 provides details of the impact indicators developed for this module and Table 10 identifies datasets that may be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.2) had not specified which buildings and assets would be optimised.
- ***October 2016:*** WP03 (task 3.2) had not yet to confirmed: what form the optimisations will take, or the format of data to be produced in the process of conducting the optimisations. Producing the module baseline relies on stakeholders outside Triangulum project collecting, archiving and making available datasets. In some case baseline data is not available, see Table 9 and Table 10 for further details.
- ***Next steps:***
    - Contact lead for task 3.2 monthly to check if the technical details of optimisation, and format of data, have been confirmed (M26-M30).
    - Follow-up with MMU and UNIMAN regarding potential to calculate energy cost and greenhouse gas emission baselines. (M26-M30)
    - Distribute the Triangulum Impact Data Intake Form (DIF) to partners delivering task 3.2, and data owners outside the Triangulum consortium. (M26-M30)
    - Explore the feasibility of adapting further SCIS indicators to assess the impact of this module including indicators for assessing energy savings on per m^2 of building space (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
322001	Optimised building energy management systems	Number of MCC buildings optimised	Dimensionless integer	0	Dec 2016	WP3 self-reports on module implementation progress	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).
322002	Optimised building energy management systems	Area of MCC building floor space optimised	m^2	0.00	Dec 2016	WP3 self-reports on module implementation progress	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).
322003	Optimised building energy management systems	Number of UNIMAN buildings optimised	Dimensionless integer	0	Dec 2016	WP3 self-reports on module implementation progress	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).
322004	Optimised building energy management systems	Area of UNIMAN building floor space optimised	m^2	0.00	Dec 2016	WP3 self-reports on module implementation progress	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
322005	Optimised building energy management systems	Total number of buildings optimised	Dimensionless integer	0	Dec 2016	WP3 self-reports on module implementation progress	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).
322006	Optimised building energy management systems	Area of building floor space optimised (all buildings)	m^2	0.00	Dec 2016	WP3 self-reports on module implementation progress	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).
322007	Reduced energy consumption	Change in annual primary energy use (MCC buildings)	kWh	3,097,163	Oct 2015 – Sept 2016	Primary energy use data (MCC), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
322008	Reduced energy consumption	Percentage change in annual primary energy use (MCC buildings)	Dimensionless decimal	0.00	n/a	Primary energy use data (MCC), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
322009	Reduced energy consumption	Change in annual primary energy use (UNIMAN buildings)	kWh	10,500	Jan 2015 – Dec 2015	Primary energy use data (UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
322010	Reduced energy consumption	Percentage change in annual primary energy use (UNIMAN buildings)	Dim. Int.	0.00	n/a	Primary energy use data (UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
322011	Reduced energy consumption	Change in annual primary energy use (all buildings)	kWh	Not currently available (MCC & UNIMAN baselines misaligned)	n/a	Primary energy use data (MCC & UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Align baselines (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
322012	Reduced energy consumption	Percentage change in annual primary energy use (all buildings)	Dim. Int.	0.00	n/a	Primary energy use data (MCC & UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
322013	Reduced energy costs	Change in annual energy costs (MCC buildings)	€	29,400	Oct 2015 – Sept 2016	Energy cost data (MCC), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
322014	Reduced energy costs	Change in annual energy costs (UNIMAN buildings)	€	Not currently available (not collected)	n/a	Energy cost data (UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
322015	Reduced energy costs	Change in annual energy costs (all buildings)	€	Not currently available (not collected for UNIMAN)	n/a	Energy cost data (MCC & UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
322016	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMC buildings)	tCO_2e	9562	Oct 2015 – Sept 2016	GHG emission data (MCC), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
322017	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	Not currently available (not collected)	n/a	GHG emission data (UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
322018	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	Not currently available (UNIMAN baseline not available)	n/a	GHG emission data (MCC & UNIMAN), Optimisation operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Table 9: Impact assessment indicators and baseline data for Module 322

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Primary energy use data (MCC)	Longitudinal dataset detailing primary energy use (electricity and heat) in specified MCC buildings	322007 322008 322011 322012	Y	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Y		Provide DIF to data owner. (M26-M30)
Energy cost data (MCC)	Longitudinal dataset detailing the costs arising from primary energy use in specified MCC buildings	322013 322015	Y	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Y		Provide DIF to data owner. (M26-M30)
GHG emission data (MCC)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MCC buildings	322016 322018	Y	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Y		Provide DIF to data owner. (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Primary energy use data (UNIMAN)	Longitudinal dataset detailing primary energy use (electricity and heat) in specified UNIMAN buildings	322009 322010 322011 322012	Y	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	Y		Provide DIF to data owner. (M26-M30)
Energy cost data (UNIMAN)	Longitudinal dataset detailing the costs arising from primary energy use in specified UNIMAN buildings	322014 322015	N	UNIMAN	n/a	U	Unavailable as not currently collected by UNIMAN.	Explore the possibility of constructing this dataset based on *Primary energy use data (*UNIMAN*).* (M26-M30)
GHG emission data (UNIMAN)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified UNIMAN buildings	322017 322018	N	UNIMAN	n/a	U	Unavailable as not currently collected by UNIMAN.	Explore the possibility of constructing this dataset based on *Primary energy use data (*UNIMAN*).* (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Optimisation operational data	Data detailing the operations and impacts of the optimisations.	All indicators from 322007 to 322018	N	Siemens	Andrew Smyth (Andrew.Smyth @siemens.com)	U	Format and frequency of data remains to be specified by WP03.	Each month (M26-M36), contact lead for task 3.2 to ask if he can advise on the details of optimisation being implemented.

Table 10: Datasets potentially to be used in the calculation of impacts for Module 322

3.3.3 Module 323: Additional energy resources (Subtasks 3.2.2-5)

An amendment, related to this module, is being submitted by the Manchester energy task group. If the amendment is approved then the scope of this module will change significantly. WP02 will update the module description, impact indicator table and dataset table as needed once a decision on approval of the amendment has been reached (expected M26).

Module Objective: to understand the impacts and benefits of installing low carbon energy generation assets within buildings in the Corridor.

Approach: This module is designed to ensure the procurement, installation and operation of assets to generate a target of 1500MWh of low carbon energy over the course of the Triangulum project. The assets will be installed in buildings within the MCC, MMU (Birley Fields Building) and UNIMAN (building tbc) estates. The initial stages of module development involved technical evaluation of low carbon energy generation technologies at MCC, MMU and UNIMAN sites.

Expected Impacts: By delivering additional low carbon energy generation capacity this module is expected to make the following impacts: increased use of low carbon energy sources, reduced energy costs; and, reduced greenhouse gas emissions.

Links with other modules: Once installed the additional generation assets may be connected to the Central Controller (module 321). Selected data generated by this module will be shared via the data curation service (module 341).

Socio-technical configuration of the module

The low carbon energy generation assets to be implemented are yet to be specified, but are likely to include: micro-CHP (combined heat and power) plants, and micro biomass (i.e. generators which burn biomass). The primary module users will be the managers of the buildings selected for asset installation.

The stakeholder structure of the module

The module is led by Siemens who will coordinate activity and procure the low carbon energy generation assets and monitor their use. Building managers at MMU will support the installation of assets. Low carbon energy technology vendors (to be specified) will supply the assets.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below Table 11 provides details of the impact indicators developed for this module and Table 12 identifies datasets that may be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.2) had not specified which low carbon energy generation assets will be installed (i.e. which technologies) or which building they will be installed in.
- ***October 2016:*** WP03 (task 3.2) is yet to confirm: which low carbon energy generation assets will be installed (i.e. which technologies), or the format of data to be produced by these assets. Producing the module baseline relies on stakeholders outside Triangulum project collecting, archiving and making available datasets. In some case baseline data is not available, see Table 11 and Table 12 for further details.
- ***Next steps:***
    - Contact lead for task 3.2 monthly to check if the technical details of the assets to be installed, and format of data, have been confirmed. (M26-M30)
    - Follow-up with MMU and UNIMAN regarding potential to calculate energy cost and greenhouse gas emission baselines. (M26-M30)
    - Distribute the Triangulum Impact Data Intake Form (DIF) to partners delivering task 3.2, and data owners outside the Triangulum consortium. (M26-M30)
    - Explore the feasibility of adapting further SCIS indicators to assess the impact of this module including indicators for assessing energy savings on per m^2 of building space.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
323001	Increased use of low carbon energy sources	Energy delivered by the low carbon energy generation assets (MMU buildings)	kWh	0	n/a	Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
323002	Increased use of low carbon energy sources	Change in share of primary energy demand met by onsite renewables (MMU buildings)	Dimensionless decimal	0.00	n/a	Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
323003	Increased use of low carbon energy sources	Energy delivered by the low carbon energy generation assets (UNIMAN buildings)	kWh	0	n/a	Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
323004	Increased use of low carbon energy sources	Change in share of primary energy demand met by onsite renewables (UNIMAN buildings)	Dimensionless decimal	0.00	n/a	Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
323005	Increased use of low carbon energy sources	Energy delivered by the low carbon energy generation assets (all buildings)	kWh	0	n/a	Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
323006	Increased use of low carbon energy sources	Change in share of primary energy demand met by onsite renewables (all buildings)	Dimensionless decimal	0.00	n/a	Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
323007	Reduced energy costs	Change in annual energy costs (MMU buildings)	€	Not currently available (commercially sensitive)	n/a	Energy cost data (MMU), Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
323008	Reduced energy costs	Change in annual energy costs (UNIMAN buildings)	€	Not currently available (not collected)	n/a	Energy cost data (UNIMAN), Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
323009	Reduced energy costs	Change in annual energy costs (all buildings)	€	Not currently available (not collected)	n/a	Energy cost data (MCC, MMU & UNIMAN), Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
323010	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMU buildings)	tCO_2e	3,672	Oct 2014 – Sept 2015	GHG emission data (MMU), Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
323011	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	Not currently available (not collected)	n/a	GHG emission data (UNIMAN), Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
323012	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	Not currently available (UNIMAN baseline not available)	n/a	GHG emission data (MMU & UNIMAN), Energy generation asset operational data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Table 11: Impact assessment indicators and baseline data for Module 323

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Energy cost data (MMU)	Longitudinal dataset detailing the costs arising from primary energy use in specified MMU buildings	323007 323009	N	MMU	n/a	Y	Unavailable as data owner classifies as commercially sensitive.	Explore the possibility of constructing this dataset based on *Primary energy use data (MMU).* (M26-M30)
GHG emission data (MMU)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MMU buildings	323010 323012	Y	MMU	Callum Donnelly (C.Donnelly@mmu.ac.uk)	Y		Provide DIF to data owner. (M26-M30)
Energy cost data (UNIMAN)	Longitudinal dataset detailing the costs arising from primary energy use in specified UNIMAN buildings	323008 323009	N	UNIMAN	n/a	U	Unavailable as not currently collected by UNIMAN.	Explore the possibility of constructing this dataset based on *Primary energy use data (*UNIMAN*).* (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
GHG emission data (UNIMAN)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified UNIMAN buildings	323011 323012	N	UNIMAN	n/a	U	Unavailable as not currently collected by UNIMAN.	Explore the possibility of constructing this dataset based on *Primary energy use data (*UNIMAN*).* (M26-M30)
Energy generation asset operational data	Data detailing the operations and impacts of the low carbon energy generation assets.	All indicators 323001 to 323012	N	Siemens	Andrew Smyth (Andrew.Smyth @siemens.com)	U	Format and frequency of data remains to be specified by WP03.	Contact lead for task 3.2 monthly to if assets to be connect to the Central Controller, and format of data, have been confirmed.

Table 12: Datasets potentially to be used in the calculation of impacts for Module 323

3.4 Mobility Modules

The Mobility task group is in the process of defining the scope of two modules (see below). Hence, the module descriptions and proposed impact indicators presented below will be revisited and revised over the course of the project as module scope is refined.

1. Support for *electric vehicle procurement:* enabling the additional costs of purchasing or leasing electric vehicles (relative to conventional vehicle costs) to be met, with the objective of reducing the CO_2 and air quality pollutant emissions of the vehicle fleets own by partner organisations.
2. A trial of an e*lectric assist cargo bike* sharing scheme: making cargo bikes more accessible to organisations and citizens, with the objective of increasing the number deliveries made by low emission vehicles and hence reducing the CO_2 and air quality pollutant emissions within the Corridor.

Table 13 presents a summary of the expected impacts of the two modules.

Modules	**Mechanism for creating impacts**	**Expected impacts**			
		Reduced Greenhouse Gas Emissions	Reduced emissions of air quality pollutants	Reduced traffic congestion	Evaluation of new technologies
331: Electric vehicle procurement	Replacing conventional vehicle journeys with low emission vehicle journeys (i.e. EVs)	*	*		*
332: Electric assist cargo bikes	Replacing conventional vehicle journeys with low emission vehicle journeys (i.e. Cargo Bikes)	*	*	*	*

Table 13: Expected impacts of the Manchester Mobility Modules

3.4.1 Module 331: Electric vehicle procurement (Subtasks 3.3.2-4)

Module Objective: To increase the use of electric vehicles (EVs) within the fleets of key organisations based within the Corridor.

Approach: The Triangulum project will provide funding to organisations based within the Corridor (UNIMAN and MMU) enabling them to purchase or lease electric vehicles. The funding provides will cover the additional cost of purchase or leasing a small number of electric vehicles, facilitating the business case for purchasing or leasing conventional vehicles. The use of existing and newly purchased/leased electric vehicles within the fleets will be monitored to identify cost and environmental benefit. In turn, this learning will be shared to promote further uptake of EVs within the Corridor. Four additional charging networks will be installed in the Corridor.

Expected Impacts: By replacing conventional vehicle journeys with low emission EV journeys, the module is expected to: reduce greenhouse gas emissions from the fleets; reduce emissions of air quality pollutants from the fleets; and, evaluate the viability of new technologies within the Corridor.

Links with other modules: Selected data collected about the use of EVs will be shared via the data curation service (Module 341).

Socio-technical configuration of the module

This module integrates three *technologies*: (1) the small electric vehicles purchased or leased (vehicle specifications to be defined); (2) telematics for monitoring vehicle use; and, (3) the new and existing network of electric vehicle charging points within the Corridor.

The *users* of this module will include: officers responsible for the developing sustainability issues; fleet managers; the staff who use the utility vehicles and pool cars within the UNIMAN and MMU fleets. Feedback and input from modules users may be captured through interviews addressing topics such as: perceptions of vehicle tracking; and, satisfaction with EVs compared to conventional vehicles.

The stakeholder structure of the module

The module is being led by MCC, who will coordinate activity. Financial support to UNIMAN and MMU is direct from their own project budgets. UNIMAN will collect, analyse and report the data gathered on EV use. Both UNIMAN and MMU will procure and maintain EVs and maintain an existing network of vehicle charging points. Cycle Waggle will manage the cargo bike resource.

The module also engages stakeholders beyond the Triangulum consortium. MMU use a commercial service (Enterprise) to manage their two pool cars; UNIMAN will manage their own fleet internally. .

Arup (a for-profit consultancy) were commissioned by MCC to conduct the research to inform the design of this module.

The indicators to be used for assessing the impacts and baseline data

Below Table 14 provides details of the impact indicators developed for this module and Table 15 identifies datasets that may be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.3) had not made key design decision including: what form of data will be created by the module and available for use in impact assessment.
- ***November 2016:*** WP03 (task 3.3) have yet not confirmed the form of data to be created by the module and available for use in impact assessment. Producing the module baseline relies on stakeholders outside Triangulum project collecting, archiving and making available datasets. In some case baseline data is not available, see Table 14 and Table 15 for further details.
- ***Next steps:*** Contact lead for task 3.3 monthly to check if the form of data available for use in impact assessment has been confirmed.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
331001	Reduced Greenhouse Gas Emissions	Number of electric vehicles within MMU vehicle fleets	Dimensionless integer	2	Dec 2015	EV module impact data	WP3 self-reports based on module implementation progress	Y	N	
331002	Reduced Greenhouse Gas Emissions	Percentage of electric vehicles within MMU vehicle fleets	Dimensionless decimal	10	Dec 2015	EV module impact data	WP3 self-reports based on module implementation progress	Y	N	
331003	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions from MMU vehicle fleets	tCO_2e	55.8	Aug 2014 – July 2015	MMU vehicle emission telematics data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
331004	Reduced Greenhouse Gas Emissions	Number of electric vehicles within UNIMAN vehicle fleet	Dimensionless integer	2	December 2015	EV module impact data	WP3 self-reports based on module implementation progress	Y	N	
331005	Reduced Greenhouse Gas Emissions	Percentage of electric vehicles within UNIMAN vehicle fleet	Dimensionless decimal	2	Dec 2015	EV module impact data	WP3 self-reports based on module implementation progress	Y	N	
331006	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions from UNIMAN vehicle fleet	tCO_2e	172	Sept 2015 – Aug 2016	UNIMAN vehicle telematic data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
331007	Reduced Greenhouse Gas Emissions	Total number of electric vehicles within specified vehicle fleet	Dimensionless integer	4	Dec 2015	EV module impact data	WP3 self-reports based on module implementation progress	Y	N	

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
331008	Reduced Greenhouse Gas Emissions	Percentage of electric vehicles within specified vehicle fleets	Dimensionless decimal	3.33	Dec 2015	EV module impact data	WP3 self-reports based on module implementation progress	Y	N	
331009	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions from specified vehicle fleets	tCO_2e	Currently unavailable (MMU and UNIMAN baselines not aligned)	n/a	MMU vehicle telematic data UNIMAN vehicle telematics data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
331010	Reduced emissions of air quality pollutants	Reduction in NOx emissions from MMU vehicle fleet	g/vkm	Currently unavailable (not collected)	n/a	MMU vehicle telematics data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
331011	Reduced emissions of air quality pollutants	Reduction in NOx emissions from UNIMAN vehicle fleet	g/vkm	Currently unavailable (not collected)	n/a	UNIMAN vehicle emission and tracking data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
331012	Reduced emissions of air quality pollutants	Reduction in NOx emissions from specified vehicle fleets	g/vkm	Currently unavailable (not collected)	n/a	MMU vehicle emission and tracking data UNIMAN vehicle emission and tracking data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
331013	Reduced emissions of air quality pollutants	Reduction in CO emissions from MMU vehicle fleet	g/vkm	Currently unavailable (not collected)	n/a	MMU vehicle emission and tracking data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
331014	Reduced emissions of air quality pollutants	Reduction in CO emissions from UNIMAN vehicle fleet	g/vkm	Currently unavailable (not collected)	n/a	UNIMAN vehicle emission and tracking data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
331015	Reduced emissions of air quality pollutants	Reduction in CO emissions from specified vehicle fleets	g/vkm	Currently unavailable (not collected)	n/a	MMU vehicle emission and tracking data UNIMAN vehicle emission and tracking data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Explore the feasibility of constructing baseline (M26-M30). Collaborate with WP3 to define 'Formula' (M26-M30).
331016	Evaluating new technologies	Number of electric vehicle charging stations installed	Dimensionless integer	0	n/a	EV charging station use data	WP3 self-reports based on module implementation progress	Y	N	

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
331017	Evaluating new technologies	Quantity of energy supplied by EV charging stations installed	kWh/yr	0	n/a	EV charging station use data	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	Collaborate with WP3 to define 'Formula' (M26-M30).
331018	Evaluating new technologies	Percentage of users satisfied with telematics	Dimensionless decimal	0	n/a	EV user satisfaction data	WP3 self-reports based on module implementation progress	N	N	
331019	Evaluating new technologies	Percentage of electric vehicles with telematics	Dimensionless decimal	0	n/a	MMU vehicle telematics data UNIMAN vehicle telematics data	WP3 self-reports based on module implementation progress	N	N	

Table 14: Impact assessment indicators and baseline data for Module 331

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
MMU vehicle telematics data	Telematics for Triangulum EVs within the MMU fleet	331003 331009 331010 331012 331013 331015 331019	N	MMU	Andrew Taylor – Travel Manager	U	Telematics data is available via Nissan's CarWings system pre-installed within EVs. However, an API is not provided. Ethical issues have been raised, and are being explored, regarding further use of telematics.	Provide DIF to data owner. (M26-M30)
UNIMAN vehicle telematics data	Telematics Triangulum EVs within the UNIMAN fleet	331006 331009 331011 331012 331014 331015 331019	N	UNIMAN	Fleet Manager – Phil Lord and Sustainability Manager Julia Durkan.	U		Provide DIF to data owner. (M26-M30)
EV user satisfaction data	Data detailing user satisfaction with EV	331018	N	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	U	WP3 has yet to define approach to capturing user satisfaction data.	Provide DIF to data owner. (M26-M30)

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
EV charging station use data	Data detailing the use of EV charging stations installed as part of module implementation	331016 331017	N	Greater Manchester Electric Vehicle Scheme	Transport for Greater Manchester	U	Data is owned by the commercial organisation that installed the EV charging stations. WP3 are currently exploring if these data can be accessed.	Confirm dataset contact. (M26)
EV module impact data	Data reporting module impacts including number of EVs procured by MMU and UNIMAN.	331001 331002 331004 331005 331007 331008	N	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	U		Provide DIF to data owner. (M26-M30)

Table 15: Datasets potentially to be used in the calculation of impacts for Module 331

3.4.2 Module 332: Electric assist cargo bikes (Subtasks 3.3.2-4)

Module Objective: To increase the use of electric assist cargo bikes by key organisations within the Corridor.

Approach: A trial electric assist cargo bike sharing scheme will be established within the Corridor; providing key organisations with the opportunity to use bikes rather than conventional vehicles to make deliveries within the Corridor. The use of cargo bikes will be monitored to identify environmental benefits. In turn, this learning will be shared to promote further uptake of cargo bikes within the Corridor.

Expected Impacts: By replacing conventional vehicle journeys with low emission vehicle journeys (i.e. cargo bike journeys) the module is expected to: reduce greenhouse gas emissions; reduce emissions of air quality pollutants; reduce traffic congestion; and, evaluate the viability of new technologies within the Corridor.

Links with other modules: Selected data collected about the use of electric assist cargo bikes will be shared via the data curation service (Module 341).

Socio-technical configuration of the module:

This module integrates two *technologies*: (1) the electric cargo bikes deployed within the trial scheme (specifications remain to be defined); and, (2) the GPS units installed on the bikes for monitoring use.

The *users* of this module will include: members of staff within the UNIMAN, MMU and SMEs (Small and Medium sized Enterprises) who make use of the cargo bikes.

The stakeholder structure of the module

The module is being led by MCC who will coordinate activity define the trial specification, and commission a service provider to run the trial scheme. UNIMAN will collect, analyse and report the GPS data gathered on cargo bike use. CycleWaggle, a small enterprise, will run the trial scheme: maintain the bikes; promote the service to organisations within the corridor; and, store and charge the bikes.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below Table 16 provides details of the impact indicators developed for this module and Table 17 identifies datasets that may be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.3) had not made key design decision including: what form of data will be created by the module and available for use in impact assessment.
- ***November 2016:*** WP03 (task 3.3) have yet not confirmed the form of data to be created by the module and available for use in impact assessment.
- ***Next steps:*** Contact lead for task 3.3 monthly to check if the form of data available for use in impact assessment has been confirmed.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
332001	Reduced Greenhouse Gas Emissions	Number of cargo bikes provided by the scheme	Dimensionless integer	0	n/a	Cargo bike impact data	WP3 self-reports based on module implementation progress	N	N	
332002	Reduced Greenhouse Gas Emissions	Number of journeys made by cargo bikes within the scheme	Dimensionless integer	0	n/a	Cargo bike use data	Cannot yet be defined (as dataset formats have yet to be defined)	N	Y	
332003	Reduced Greenhouse Gas Emissions	Average time cargo bikes are in use per day	hh:mm	00:00	n/a	Cargo bike use data	Cannot yet be defined (as dataset formats have yet to be defined)	N	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
332004	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions as a result of module implementation	tCO_2e	0	n/a	Cargo bike use data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
332005	Reduced Air Quality Pollutant Emissions	Reduction in NO_x emissions	g/vkm	0	n/a	Cargo bike use data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
332006	Reduced Air Quality Pollutant Emissions	Reduction in CO emissions	g/vkm	0	n/a	Cargo bike use data	Cannot yet be defined (as dataset formats have yet to be defined)	Y	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
332007	Reduced traffic congestion	Number of journeys by motorised vehicles replaced by cargo bike journeys	Dimensionless integer	0	n/a	Cargo bike use data	Cannot yet be defined (as dataset formats have yet to be defined)	N	Y	Collaborate with WP3 to define 'Formula' (M26-M30).
332008	Evaluation of new technologies	Percentage of users satisfied with cargo bikes	Dimensionless decimal	0.00	n/a	Cargo bike user satisfaction data	WP3 self-reports based on module implementation progress	N	N	

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
332009	Evaluation of new technologies	Percentage of cargo bikes with GPS tracking	Dimensionless decimal	0.00	n/a	Cargo bike impact data	WP3 self-reports based on module implementation progress	N	N	

Table 16: Impact assessment indicators and baseline data for Module 332

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Cargo bike use data	GPS tracking for cargo bikes within the scheme	332002 332003 332004 332005 332006 332007	N	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	U	Data collected by Autotrip tracker hardwired to the bike battery.	
Cargo bike user satisfaction data	Data detailing user satisfaction with the Cargo Bikes	332008	N	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	U	WP3 has yet to define approach to capturing user satisfaction data	
Cargo bike impact data	Data detailing impacts of the module including number of cargo-bikes within the scheme	332001 332009	N	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	U		

Table 17: Datasets potentially to be used in the calculation of impacts for Module 332

3.5 ICT Modules

The ICT task group are in the process of defining the scope of three modules to demonstrate the potential of ICTs as an enabler of innovation in the Corridor. The module descriptions and proposed impact indicators presented below will be revised as module scope is refined and lessons are learnt.

1. Trialling a *data curation service:* This module recognises the increasing value of city data as an asset to be actively managed. It trials an active data curation process to provide access to city data from multiple sources. This module will investigate how this active curation process might operate in Manchester and trial it to demonstrate the concept within the limits of the Triangulum project. The trial will investigate the associated curation and governance processes and the technical architecture. Data curated within the trial will be hosted on the platform that UNIMAN is using for data generated by the Triangulum mobility and energy projects (OSisoft), and other data platforms.

2. Developing a *data visualisation platform:* This module focuses on developing a visualisation platform which will make city data (hosted on OSisoft and other data platforms) more accessible to non-specialists and demonstrate the potential for innovative application development.

3. Facilitating d*ata-enabled innovation challenges:* This module focuses on using ICT and data to support and foster innovative data-enabled solutions to address issues and opportunities on the Corridor. In addition to data collected in Energy and Mobility a process is to be developed to capture "experience data" from stakeholders in the Corridor. The nature of this experience data is to be designed, but could include negative experiences (reporting a pothole, feeling unsafe at a location etc.), or positive experiences (perhaps captured through a satisfaction scale). The experience data and other data sources will be made available to organisations and citizens through the Visualisation Platform to encourage innovative data-enabled solutions.

Table 18 presents a summary of the expected impacts of each module.

Module	**Mechanism for creating impacts**	**Expected Impacts**			
		Enhanced digital infrastructure	Increased commercial activity	Increased engagement with data	Increased environmental awareness and behaviour change
341: Data curation service	Providing access to data which can be used by citizens, businesses and government to create economic, social and environmental value.	*		*	
342: Data visualisation platform	Reducing the barriers to citizens, businesses and government using data in visual and experiential manner to create economic, social and environmental value.	*		*	
343: Data-enabled innovation challenges	Promoting use of the data curation service and visualisation platform to solve real-world issues.		*	*	*

Table 18: Expected impacts of Manchester ICT modules

3.5.1 Module 341: Data curation service (D3.4.1)

Module Objective: The objective of the Data Curation Service module is to manage Triangulum project data make this data available for the benefit of the city and its citizens. From this insights will be gained to understand the issues of managing City Data as an active curation process.

Approach: A data curation service will be trialled, offering access to data generated by the Manchester mobility and energy modules (hosted on the OSIsoft platform) and other related datasets. This service will enable for-profit organisations, ICT developers, community groups, students and other actors within the Corridor to create economic, social and environmental value from Triangulum project data, citizen experience data (captured using the CommonPlace platform) and offer additional datasets for curation. At a technical level, the Data Curation Service will consider the integration of data and how data is stored and accessed as a resource. At a process level, the Data Curation Service will consider various other aspects, such as data quality, privacy, licensing and the ongoing business model for those providing and using the data. The trial will identify and clarify the components of the module.

Expected Impacts: this module is expected to make the following impacts: enhanced digital infrastructure; and, increased engagement with data.

Links with other modules: Some of the data curated will be drawn from the energy and mobility workstreams and associated Manchester modules. ICT module 342 builds upon this data curation service by enabling visualisations of the data curated. ICT module 343 uses the data to support data-enabled solutions and innovations.

Socio-technical configuration of the module

This module primarily is about the technological integration of data from multiple data sources. Hence, the technologies involved will be platforms which host data including OSIsoft (which will host Triangulum project data in Manchester).

As the data curation service will be open for anyone to use, it is difficult to anticipate specific module users. Users might include for-profit organisations, ICT developers, community groups, University students and staff, and other actors within and beyond the Corridor.

The stakeholder structure of the module

The module is being led by UNIMAN, who will coordinate activity to define and trial the Data Curation Service, define and acquire the data to be hosted on the OSISoft data platform, and

maintain the service and monitor use. Clicks and Links will also play a key role in defining and trailing the service. The Mobility (MCC) and Energy (Siemens) task groups will support UNIMAN in defining and acquiring data to be hosted on the platform. Other data providers (yet to be identified) will potentially provide complementary datasets. OSIsoft will support the software that underpins the Triangulum data platform.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below Table 19 provides details of the impact indicators developed for this module and Table 20 identifies datasets that may be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.4) had not made key design decision including: which datasets will be stored by the curation service; and, what form of data to be created by the module and available for use in impact assessment.
- ***November 2016:*** WP03 (task 3.4) have not confirmed the form of data to be created by the module and available for use in impact assessment.
- ***Next steps:*** Contact lead for task 3.4 monthly to check if the form of data available for use in impact assessment has been confirmed.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
341001	Enhanced digital infrastructure	Total number of datasets openly accessible via the data curation service	Dimensionless integer	0	n/a	Data curation service metadata	Cannot yet be defined (as dataset formats have yet to be defined)	N	N	
341002	Enhanced digital infrastructure	Number of datasets relating to energy modules openly accessible via the data curation service	Dimensionless integer	0	n/a	Data curation service metadata	WP3 self-reports on module implementation progress	N	N	
341003	Enhanced digital infrastructure	Number of datasets relating to mobility modules openly accessible via the data curation service	Dimensionless integer	0	n/a	Data curation service metadata	WP3 self-reports on module implementation progress	N	N	
341004	Enhanced digital infrastructure	Number of real time[6] data feeds curated by the service	Dimensionless integer	0	n/a	Data curation service metadata	WP3 self-reports on module implementation progress	N	N	

[6] Data feeds which are updated hourly or more frequently

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
324005	Enhanced digital infrastructure	Quantity of data openly accessible via the data curation service	GB	0	n/a	Data curation service metadata	WP3 self-reports on module implementation progress	Y	N	
324006	Increased engagement with data	Number of data downloads from the data curation service	Dimensionless integer	0	n/a	Data curation use data	WP3 self-reports on module implementation progress	N	N	
324007	Increased engagement with data	Number of users downloading data from the data curation service	Dimensionless integer	0	n/a	Data curation use data	WP3 self-reports on module implementation progress	Y	N	
324008	Increased engagement with data	Number of visualisation options offered for viewing and interacting with the data hosted by the curation service	Dimensionless integer	0	n/a	Data curation use data	WP3 self-reports on module implementation progress	N	N	
324009	Increased engagement with data	Quantity of data downloaded by users of the curation service	GB	0	n/a	Data curation use data	WP3 self-reports on module implementation progress	Y	N	

Table 19: Impact assessment indicators and baseline data for Module 341

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Data curation service metadata	Metadata detailing the form and quantity of data hosted by the service.	341001 341002 341003 341004 341005	N	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	U	Form and format of data to be provided by WP3 remains to be confirmed	Provide DIF to data owner. (M26-M30)
Data curation use data	Use data detailing number of users etc.	341006 341007 341008 341009	N	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	U	Form and format of data to be provided by WP3 remains to be confirmed	Provide DIF to data owner. (M26-M30)

Table 20: Datasets potentially to be used in the calculation of impacts for Module 341

3.5.2 Module 342: Data visualization platform (D3.4.2)

Module Objective: To provide a visual means for interacting with data generated by smart city initiatives.

Approach: A visualisation platform will be developed and trialled, offering supporting tools to enable visualisations of data generated by the Manchester mobility and energy modules and other related datasets. This platform will make data provided by the data curation service (ICT module 321) more accessible to actors on the Corridor and demonstrate the potential for visualisation to support data driven application development. Hence, this module (similarly to module 321 and 323) will enable for-profit organisations, ICT developers, community groups, students and other actors within the Corridor to create economic, social and environmental value from Triangulum project data, using the latest visualisation and experiential approaches.

Expected Impacts: this module is expected to make the following impacts: enhanced digital infrastructure; and, increased engagement with data.

Links with other modules: this module is linked to the data curation service (module 341)

Socio-technical configuration of the module:

This module uses *technologies* including: (1) a data visualisation platform; and (2) the data curation service developed in ICT module 321.

The platform is open for anyone, but the early focus is SMEs with technical skills. Other users might include for-profit organisations, ICT developers, community groups, University students and staff, and other actors within and beyond the Corridor.

The stakeholder structure of the module

The module is being led by Clicks and Links who will coordinate activity, define how the data is to be visualised on the platform, develop and maintain the platform and monitor use, and promote use of the platform. UNIMAN will support this module by providing access to a data curation service (ICT module 321) which includes data from the mobility and energy task groups. The mobility (MCC) and energy (Siemens) task groups will support Clicks and Links in defining data to be visualised on the platform. Other data providers (to be identified) will potential provide complementary datasets.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below Table 21 provides details of the impact indicators developed for this module and Table 22 provides details of the impact indicators developed for this module.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.4) had not made key design decision including: which what services the visualisation platform will provide; and, what form of data will be created by the module and available for use in impact assessment.
- ***November 2016:*** WP03 (task 3.4) remained in the process of defining the services the platform will provide, and have not confirmed the form of data to be created by the module and available for use in impact assessment.
- ***Next steps:*** Contact lead for task 3.4 monthly to check if: services have been defined; and the form of data available for use in impact assessment has been confirmed.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
342001	Enhanced digital infrastructure	Total number of visualisation services provided by the platform	Dimensionless integer	0	n/a	Visualisation platform metadata	WP3 self-reports on module implementation progress	N	N	
342002	Enhanced digital infrastructure	Number of visualisation services provided by the platform which use data related to energy modules	Dimensionless integer	0	n/a	Visualisation platform metadata	WP3 self-reports on module implementation progress	N	N	
342003	Enhanced digital infrastructure	Number of visualisation services provided by the platform which use data related to mobility modules	Dimensionless integer	0	n/a	Visualisation platform metadata	WP3 self-reports on module implementation progress	N	N	
342004	Enhanced digital infrastructure	Total number of real time data feeds integrated into the visualisation platform	Dimensionless integer	0	n/a	Visualisation platform metadata	WP3 self-reports on module implementation progress	N	N	

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
342005	Enhanced digital infrastructure	Number of real time data feeds related to energy modules and integrated into the visualisation platform	Dimensionless integer	0	n/a	Visualisation platform metadata	WP3 self-reports on module implementation progress	N	N	
342006	Enhanced digital infrastructure	Number of real time data feeds related to mobility modules and integrated into the visualisation platform	Dimensionless integer	0	n/a	Visualisation platform metadata	WP3 self-reports on module implementation progress	N	N	
342007	Increased engagement with data	Number of visualisation platform users	Dimensionless integer	0	n/a	Visualisation platform use data	WP3 self-reports on module implementation progress	Y	N	

Table 21: Impact assessment indicators and baseline data for Module 342

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Visualisation platform metadata	Metadata detailing the form and quantity of data hosted by the service.	342001 342002 342003 342004 342005 342006	N	C&L	Michael King (michael.king@clicksandlinks.com)	U	Form and format of data to be provided by WP3 remains to be confirmed	Provide DIF to data owner. (M26-M30)
Visualisation platform use data	Use data detailing number of users etc.	342007	N	C&L	Michael King (michael.king@clicksandlinks.com)	U	Form and format of data to be provided by WP3 remains to be confirmed	Provide DIF to data owner. (M26-M30)

Table 22: Datasets potentially to be used in the calculation of impacts for Module 342

3.5.3 Module 343: Data-enabled innovation challenges (D3.4.3)

Module Objective: To promote the building of applications that use data to solve real world issues in the Corridor.

Approach: Data-sets hosted by the curation service, and presented on visualisation platform (ICT module 322), will be made available in the form of an 'innovation challenge'. To help to focus innovation efforts upon real city issues, an experience gathering process will be developed to capture issues and opportunities within the Corridor (likely to be using the CommonPlace platform). This experiential data-set will be captured in the Data Curation Service (ICT Module 321) as an additional data source. The challenge will present organisations and citizens with the opportunity to create innovative solutions using all data-sets. Hence, this module will promote use of the data curation service and visualisation platform.

Expected Impacts: This module is expected to make the following impact: increased commercial activity; increased engagement with data; and, increased environmental awareness and behaviour change.

Links with other modules: this module builds upon the data curation service and visualisation platform.

Socio-technical configuration of the module

This module is about encouraging data-enabled innovation. The exact nature of this is still in consultation but could range from taking in Twitter feeds through to bespoke apps to capture people's current experience as they pass through pre-defined geo-tagged locations. Specific modules users also remain to be identified. This module uses technologies to capture experiences (issues and opportunities) within the Corridor.

The stakeholder structure of the module

The module is being led by Clicks and Link who will coordinate activity, define the scope of and deliver the innovation challenges, and monitor participation in and outcomes of the module. The ICT (UNIMAN), Mobility (MCC) and Energy (Siemens) task groups will support Clicks and Links in defining the scope of the challenges.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Below Table 23 provides details of the impact indicators developed for this module and Table 24 identifies datasets that could be used to calculate impacts.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts and identifying associated datasets

- ***December 2015:*** WP03 (task 3.4) had not made key design decisions for this module including: what form the innovation challenges will take; and, what form of data will be created by the module and available for use in impact assessment.
- ***November 2016:*** WP03 (task 3.4) had not made key design decisions for this module including: what form the innovation challenges will take; and, what form of data will be created by the module and available for use in impact assessment.
- ***Next steps:*** Contact lead for task 3.4 monthly to check if the scope of the module, and the form of data available for use in impact assessment, has been confirmed.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
343001	Increased commercial activity	Number of apps developed by for-profit organisations in response to innovation challenges which use the data curation service and/or the visualisation platform.	Dimensionless integer	0	n/a	Innovation challenge participation and impact data	WP3 self-reports based on module implementation progress	Y	N	
343002	Increased commercial activity	Number of apps developed in response to innovation challenges which use the data curation service and/or the visualisation platform, and provide services to for- profit organisations.	Dimensionless integer	0	n/a	Innovation challenge participation and impact data	WP3 self-reports based on module implementation progress	Y	N	
343003	Increased engagement with data	Number of people participating in innovation challenges	Dimensionless integer	0	n/a	Innovation challenge participation and impact data	WP3 self-reports based on module implementation progress	N	N	

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
343004	Increased engagement with data	Number of apps developed in response to innovation challenges which use the data curation service and/or the visualisation platform, and provide services to citizens.	Dimensionless integer	0	n/a	Innovation challenge participation and impact data	WP3 self-reports based on module implementation progress	Y	N	
343005	Increased environmental awareness and behaviour change	Number of apps developed in response to innovation challenges which use the data curation service and/or the visualisation platform, and seek to change user behaviour.	Dimensionless integer	0	n/a	Innovation challenge participation and impact data	WP3 self-reports based on module implementation progress	Y	N	

Table 23: Impact assessment indicators and baseline data for Module 343

Dataset name	Dataset description	Required for impact calc. for indicators:	Available at M24 for baselining & impact calc?	Dataset owner	Dataset contact	To be collected beyond M60?	Comments	WP02 next steps
Innovation challenge participation and impact data	Data detailing the outcomes and impacts of the innovation challenge module.	343001 343002 343003 343004 343005	N	C&L	Michael King (michael.king@clicksandlinks.com)	U	Data likely to be manually collected (rather than sensor generated).	Provide DIF to data owner. (M26-M30)

Table 24: Datasets potentially to be used in the calculation of impacts for Module 343

3.6 An initial evaluation of the process used to develop the indicators and next steps

Working with task groups as the modules were designed offered the opportunity to embed considerations of impact assessment and data collection from the outset. During this process several challenges emerged. First, the concept of the module was not immediately understandable to members of the task groups, and a slightly confusing mix of overlapping terminology has been used by members of the consortium (including tasks, projects, initiatives and modules). Secondly, the quantitative approach employed by WP02 requires the scope of the modules to be tightly defined prior to developing impact indicators and aggregating baseline data. Hence, as the defining the scope of modules was part of Manchester's planned Year 1 activity, WP02 progress has not been as rapid was hoped. Thirdly, there was initial uncertainty on the part of some members of the task groups about the nature of the impact assessment approach. In particular, there were initial concerns that WP02 would identify and implement a one-size fits all impact assessment framework across the three cities. Furthermore, the relationship between impact indicators at the module scale and broader objectives at the district scale remains unclear and in need of further exploration. Finally, the lack of clarity around the relationship between Manchester based Triangulum data curation service (WP03 - Module 1) and Stavanger based open data platform (WP02) has also created some confusion around the approach to data aggregation.

During 2016, WP02 activity will focus on gather data and producing the interim WP02 report. Additional activities will explore the potential to capture the governance and social impacts of the Triangulum modules. A brief overview of proposed WP02 2016 activity in Manchester is shown in Table 25.

	Primary focus of WP02 activity in Manchester	**Additional WP02 activities**
Jan-Mar 2016	In collaboration with Mobility and ICT Task Group refining module descriptions and impact indicators and identifying sources of baseline data.	Research focussed on capturing the: • governance impacts of Triangulum in Manchester, possibly by using an electronically administered survey to partners and analysing the interview data from WP06 city visits; • social impacts of Triangulum in Manchester, through complementary social science research projects.
Apr-Jun 2016	In collaboration with Energy Task Group refining module descriptions and impact indicators and identifying sources of baseline data.	
Jul-Sept 2016	Research focused on the experiences of the energy, ICT and mobility task groups of the process of defining modules, impacts, indicators and baseline data.	
Oct- Dec 2016	Producing the WP02 interim report (Deliverable 2.4).	

Table 25: high-level overview of planned impact assessment and monitoring activities in Manchester

4 Eindhoven Baseline

Executive Summary

The Eindhoven report is organised into six sections.

Section 1 provides a description of the City of Eindhoven, and highlights Eindhoven smart city ambitions and initiatives including development of roadmaps in Eindhoven.

Section 2 describes two living labs districts in Eindhoven, Strjip-S and Eckart-Vaartbork. It includes information on the historical development, current situation and existing challenges. Moreover, the key roles of each partner are defined along with and smart city initiatives within it. Furthermore, the Triangulum modules are identified to contribute to the district-level objectives of reducing energy consumption and carbon emissions, and fostering economic growth. Section 2 concludes with an outline of the WP02 approach to developing indicators for each of the Eindhoven modules.

Section 3 describes the Energy modules in detail including objectives, socio-technical configurations, stakeholder structures and impact indicators with baseline data. The indicators to assess the impacts and benefits of the module and the current understanding of baseline conditions are presented with existed reference point data.

Sections 4 and 5 provide similar descriptions for Mobility and ICT modules respectively.

Section 6 provides an initial evaluation of the process used to develop the indicators and aggregate baseline data, followed by a high-level overview of the planned impact and assessment and monitoring activities in Eindhoven during 2016.

4.1 Smart city initiatives in the City of Eindhoven

Description of the city: Eindhoven is a municipality and a city located in the province of North Brabant in the south of the Netherlands, originally at the confluence of the Dommel and Gender waterways. In January 2015, the city has a population of 223,220 and the metropolitan region had a population of 337,487, making it the fifth-largest city in the Netherlands and the largest in North Brabant. Eindhoven is also the heart of Brainport – an innovative high-tech region. Together with Amsterdam Airport and Rotterdam Seaport, Brainport is a cornerstone of the Dutch economy. As an innovative high-tech region, Eindhoven generates €4 billion in GDP and €55 billion in exports, which equates to a quarter of the Dutch total. It absorbs 36% of all private Dutch research and development spending and is home to globally recognized companies including Philips, the healthcare, lighting and consumer product business. Eindhoven boosts economic growth and helps make society more sustainable, healthy and safe by delivering solutions related to renewable energy, safe mobility and smart remote healthcare.

Smart city initiatives: Eindhoven has the ambition to be energy neutral by 2045 to contribute to a drastic reduction of the overall CO_2 emissions and to sustain human life in the city. With this target, Eindhoven engaged all stakeholders in its policy and decision-making processes at the centre of its policy processes. This is reflected in the city-wide commitment to follow the 'Natural Step' principles. On the road to a sustainable Eindhoven, these activities are guided by the 4 principles of the Natural Step, which are:

1) To use renewable materials, and reuse and recycling materials;
2) To use or produce no chemicals with negative effects on human health and the environment;
3) To protect nature and biodiversity, since they provide us with clean air, food, water, energy and medication;
4) To care for our citizens so they can lead secure, free and healthy lives, irrespective of their identity, beliefs, sex and background and make sure our activities do not harm others in the rest of the world.

Eindhoven's political commitment to offer its urban space as a living lab for innovative, co-created, solutions strongly supports this Smart City process. To date, Eindhoven has implemented a series of smart city initiatives based on the quadruple Helix Model (Figure 5). These initiatives include development of thematic roadmaps for Energy, Lighting, the Sustainable Urban Mobility Plan ('Eindhoven Op Weg!') and the ICT-Kompas. These roadmaps set out the overall vision and strategic goals, as well as the expected timeline and means necessary to achieve these goals. The on-going projects include:

1. An open data platform, which is the core of the smart Eindhoven approach. It is focused on the roll out of a robust data platform including a processing unit and dashboard.
2. Smart City Studio - The city of Eindhoven introduces the concept of 'testing grounds' as a means to open the city to anyone who can add to the development of the city. The idea behind it is that not only the municipality 'makes' the city, but its citizens, its entrepreneurs and its higher education; this requires an 'open' city that could facilitate initiatives and that leaves the leading role in the improvement of an area or neighbourhood to anyone who fits that role the best.
3. Smart city lighting - The consortium of Philips Nederland B.V./Heijmans Wegen B.V. is the proposed contractual partner to use Eindhoven as a pilot area in coming years to develop intelligent lighting applications in the public realm. The tendering procedure was based on the 'Vision and Roadmap Urban Lighting Eindhoven 2030'. The municipality has a clear goal:

to use lighting in the public space in such an innovative way that it contributes to improving the quality of life in the city.

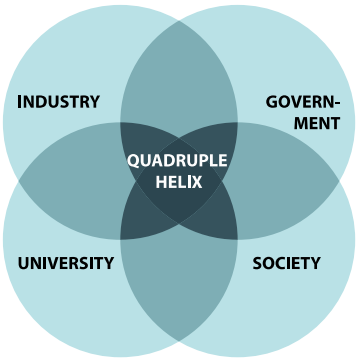

Figure 5: Quadruple Helix Model

4.2 The Districts

4.2.1 Strijp-S

Stijp-S (Figure 6) lies inside the ring road close to the city centre and Eindhoven Strijp-S station. Strijp-S comprises 27 hectares and is recognizable by 150,000 m^2 of industrial heritage. The core of Strijp-S is formed by a sixty-meter wide urban iconic axis through the complex called 'Torenallee'. It has many trees, public spaces, with characteristic street lighting and furniture, ornamental kiosks, and two sculptural buildings. Parallel to the Torenallee are two urban boulevards with wide profiles and many trees which serve as high quality addresses for the new estates. Alongside one of the boulevards is an intimate square with various restaurants and bars and a multi-purpose field. It used to be a closed industrial site within the city, where Philips conducted R&D and produced consumer goods. The history of Strijp-S is closely intertwined with the growth of Philips and the local and regional economy.

The revitalization of the Philips Company's former industrial and business complex transformed the area into a new urban quarter to live, work, and play. The redevelopment of the area started in 2000 when Philips suspended its operations. Philips sold Strijp-S to Park Strijp Beheer in 2004. The buildings that were still in use by Philips were hired back. Since 2006, the redevelopment of Strijp-S has been ongoing. Existing buildings were demolished and new activities were introduced, notably the creative industries and the annual Dutch Design Week. A strong characteristic of the new neighbourhood is the combination of existing buildings with new buildings. In 2013, Strijp-S was honoured with the Dutch Gulden Feniks (Golden Phoenix) award in the 'Area Transformation' category. From 2010 to 2020, 15 building construction projects are planned in Strijp-S.

The development of Strijp-S is segmented into several phases. A visualization of the phases can be found at: http://www.strijp-s.nl/nl/ontwikkeling. Strijp-S will eventually include 285,000 m^2 of residental áreas including studio, apartments, city dwellings, lofts; 90,000 m^2 of offices; 30,000 m^2 of comercial/leisure; and 30,000m^2 of additional space. Temporary use is one of the characteristics which makes Strijp-S unique. It prevents decay and makes sure the complete area stays alive while it is being developed. Therefore Strijp-S has to be seen as one big organization, which is going to be upgraded in 4 phases. Original Schedule - Phase 1: 2010-2015; Phase 2: 2011-2016; Phase 3: 2013-2018; and Phase 4: 2020-2030.

The most essential part of the Strijp-S Masterplan is the area called 'De Driehoek' (the triangle). This area houses the catalysts from Strijp-S and is currently under development. The planned developments in 'De Driehoek' include:

- 2010: Klokgebouw (mixture of offices, studios, event locations, and a hotel)
- 2011: Apparatenfabriek (commercial functions on the lower level, a mix of offices and studios on the upper levels)
- 2011: Ketelhuis (restaurant, studio, exposition)
- 2012: Machinekamer (restaurant)
- 2013: Anton & Gerard (commercial functions on the lower level, mixture of dwelling, studio's and offices on the upper levels)
- 2013: Leidingstraat (urban boulevard)
- 2015: Veemgebouw (food market, restaurants and parking)
- 2016: Kashba (small buildings with commercial activities on the lower level and apartments on the upper level)
- 2018: Angle (commercial functions on the lower level, apartments on the upper levels)
- 2018: City (commercial functions on the lower level, apartments on the upper levels)

- 2018: Condo (commercial functions on the lower level, apartments on the upper levels)
- 2020: Einstein (commercial functions on the lower level, student apartments on the upper levels)
- 2020: The Box / Transferium (parking garage with several commercial functions on the lower level)
- 2020: Tower (city icon, about100m tall, apartments and lofts with commercial functions on the main floor)
- 2020: Village (small buildings which combine commercial activities on the lower level and apartments on the upper level)

In the final Masterplan, 'De Driehoek' will house both 'giants' and 'dwarfs'. The 'giants' will impress passengers and citizens, and function like icons which serve the collective memory of Eindhoven, while the 'dwarfs' provide room for a more humanistic scale.

Park Strijp Beheer (a joint venture between VolkerWessels (VW) and Eindhoven Municipality), Spoorzone bv (joint venture between Volker Wessels and ING), Trudo, Woonbedrijf and de Koning Beleggingen bv are jointly working on the development of Strijp-S. The objective of the partnership is to realise a vibrant, multifunctional, open and creative urban environment that can serve as a European Smart City Lighthouse District (Figure 6). In addition, the location of the area in the city requires an approach focusing on the reuse of existing infrastructures for an optimal support to create a mixed use area of citizens, SMEs and creative start-ups and entertainment serving the new economy. The economy will be sustainable in terms of energy consumption and mobility. Based on open innovation and co-creation work on the development and implementation of new energy service concepts, Strijp-S will be developed into an innovative Smart Energy Business City with an international reputation.

Figure 6: Development of Strjip-S (2015 -2030)

4.2.1.1 The role of Triangulum modules in supporting Strijp-S objectives

We have identified 9 Triangulum modules (described below) to support the Strijp-S Partnership objectives at the district scale. The modules contribute to the wider efforts to achieve seven objectives: (1) reduce energy consumption; (2) reduce carbon emissions; (3) develop a digital infrastructure; (4) improve mobility; (5) foster citizen engagement (co-creation); (6) improve quality of life; and (7) foster a sustainable economy. Table 26 provides a summary of how the modules contribute to efforts to achieve these objectives.

4.2.1.2 Governance of the Triangulum modules – Strijp-S

The governance structure for the Triangulum modules is shown in Figure 7. The Strijp-S coordinator (VW) takes lead of Strijp-S activity within Eindhoven. The Triangulum Eindhoven Board (Task Group 1) consists of representatives from each organisation within the consortium (Eindhoven municipality, Woonbedrijf, TU/e, VW and KPN) and meets on a monthly basis to review project progress across the energy, ICT and mobility sectors. Each project manager takes control of their project progress and communicates with VW on a monthly basis. VW takes the lead of monitoring and managing emerging risks and issues. The impact assessment team (WP02 – TU/e) collates and integrates data generated by working closely with project managers and VW. Representatives from WP02 also attend board meetings to coordinate impact assessment activity across the Triangulum Lighthouse cities.

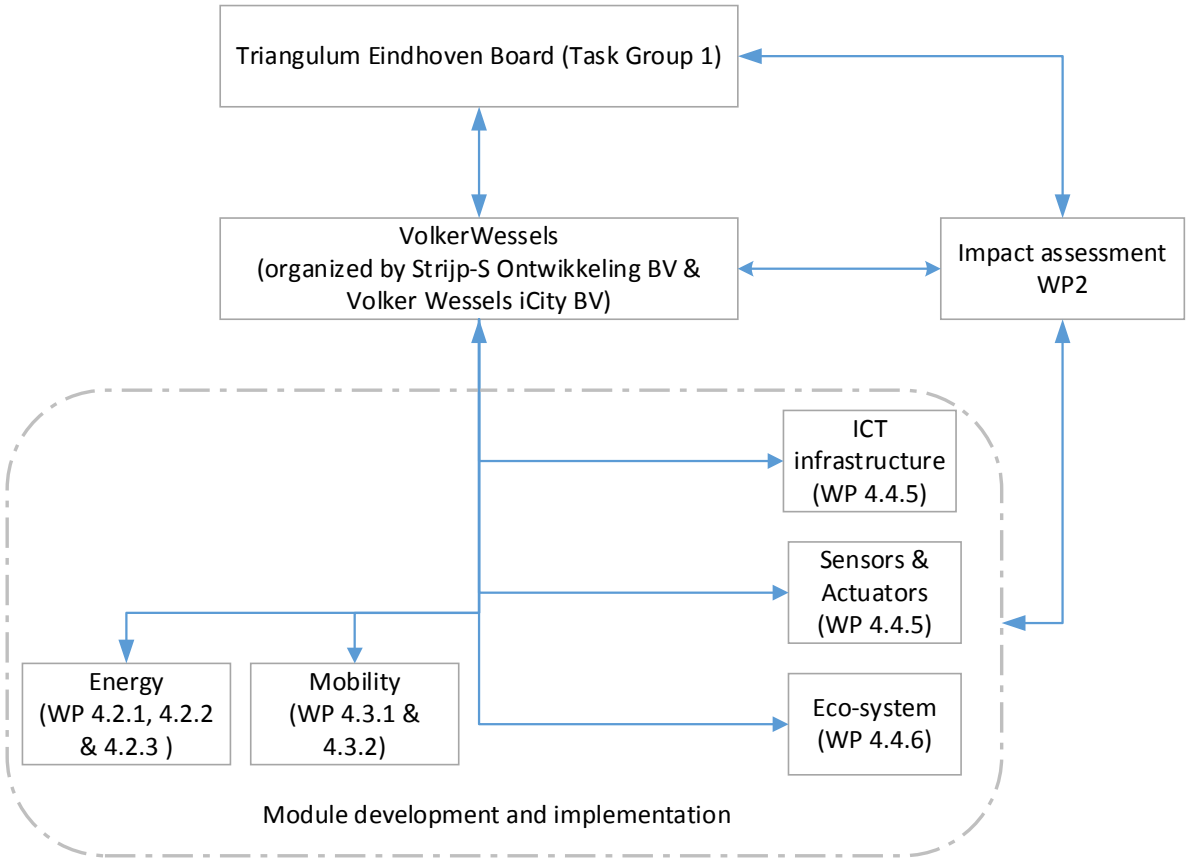

Figure 7: The governance of Triangulum modules in Eindhoven Strijp-S

Task group	**Module** *(task number: module name)*	**Contribution to district objectives**						
		Reducing energy consumption	Reducing carbon emissions	Developing a digital infrastructure	Improving mobility	Fostering citizen engagement (Co-creation)	Improving the quality of life	Sustainable economy
Energy	4.2.1: Sustainable energy supply and soil remediation	*	*					
	4.2.2: Optimization heat provision existing build (Module	*	*					
	4.2.3: Smart energy savings offices	*	*			*	*	
Mobility	4.3.1: Smart charging of electric vehicles			*	*		*	
	4.3.2: Mobility management		*?	*	*		*	
ICT	4.4.1: EHV facilitation smart city open data platform			*		*	*	
	4.4.4: Second phase of implementation and integration of the fiber-optic data infrastructure			*		*	*	
	4.4.5: Sensor network in the public space			*		*	*	
	4.4.6: Stimulating development of innovative services/apps							*

Table 26: Modules relating to Strijp-S objectives

Task group	**Module** *(task number: module name)*	**Contribution to district objectives**					
		Reducing energy consumption	Reducing carbon emissions	Developing a digital infrastructure	Fostering citizen engagement (Co-creation)	Improving the quality of life	Fostering sustainable economy
Energy	4.2.4: Renovation of family homes Eckart - Vaartbroek & creation of participative society	*	*		*	*	
	Module 4.2.5: Install. & smart distribution of Locally produced renewable energy	*	*				
ICT	Module 4.4.1: EHV facilitation smart city open data platform			*	*	*	*
	Module 4.4.2: Interactive process for dwellings in Eckart-Vaartbroek				*	*	
	Module 4.4.3: Stimulating private owners and other housing corporations in the area to follow				*	*	
	Module 4.4.7: Smart streetlights social interaction & health route			*	*	*	

Table 27: Modules relating to Eckart-Vaartbroek objectives

4.2.2 Eckart-Vaartbroek

This area is a more traditional district, with thousands of single-family houses, many of which fall under social housing, constructed in the late 1960s and 1970s (Figure 8). In that period, Eindhoven and the rest of the Netherlands experienced rapid economic and population growth. Eckart-Vaartbroek is a good example of modern urban development characterized by a strict hierarchy in street layout, segregation of duties and the application of building templates. The district has its own amenities including schools, community centres, churches and shopping centres. Today, the district has a total of 4,553 houses in the selected area, 1.900 of which are owned and managed by the housing corporation Woonbedrijf, one of the partners in the Eindhoven consortium. The other houses, including 2653 apartments, are owned privately or by other housing organisations. The owner-occupied houses are located mainly on the outer edges of the district. The rented houses/apartments are located in the heart of the area around Almond Park.

Various social issues and problems exist in the neighbourhood. The significant issue for the district is that the family as the fundamental unit of society is now outdated. In Vaartbroek-Eckart this is noticeable problem. The housing, services, public space and social atmosphere do not fit well with the current mix of the population. The original inhabitants, many of whom are senior citizens, contrasts with the new groups of residents, young middle class families, often from other cultural backgrounds – request a quality upgrade of public space and social environment. Households now also have a different household composition in this area than when the neighbourhood was built. Traditionally the household consisted of a husband, wife and 2-4 children. Now the area includes many single-parent families, cohabiting couples and singles. Another problem involves security. The number of burglaries in the area is relatively high. This is partly due to the spatial design of the area, which has difficulty for community watching (the visibility in and around the parks is not good). Districts such as Eckart-Vaartbroek are numerous in Eindhoven as well as in other Dutch and European cities and are currently in transition. With an ageing and less wealthy population and an influx of residents with different ethnic backgrounds, this district is almost the opposite of Strijp-S.

The partners in Eckart-Vaartbroek include the municipality, Basisschool de Bijenkorf, Spilcentrum Mirabel, Woman Fight Club, Gezondheidscentrum Airborne, Lumensgroep, Parochie Woensel-Oost, Politie Woensel-Noord, Stadsdeelteam Woensel-Noord, Steunpunt 55+, Stichting wijkactiviteit Vaartbroek, Stichting zesde kolonne, Wijkraad Vaartbroek, Heesterakker & Bokt, Woonbedrijf, Wooninc., and De Cabine. The objective of the partnership is to improve the quality of life of residents in Eckart-Vaartbroek. To achieve this goal, the integration of citizens, urban planners, social groups and social housing providers are jointly developing the area. Woonbedrijf is one of the partners in Eckart-Vaarbroek and is also in the Eindhoven Triangulum consortium. Woonbedrijf are leading on the upgrade of around 200 to 250 houses in the area from energy label E and F to B (or higher). Eindhoven municipality will also cooperate closely with Woonbedrijf to improve public spaces and install renewable energy facilities.

Figure 8: Map of Eckart-Vaartbroek (2015)

4.2.2.1 The role Triangulum modules in supporting district level objectives

The Triangulum modules described below support Eckart-Vaartbroek objectives at the district scale. Moreover, the modules contribute to the wider efforts to achieve seven objectives: (1) reducing energy consumption; (2) reducing carbon emissions; (3) developing a digital infrastructure; (4) improving mobility; (5) fostering citizen engagement (co-creation); (6) improving quality of life; and (7) fostering a sustainable economy. Table 27 summarises how the modules contribute to efforts to achieve these objectives.

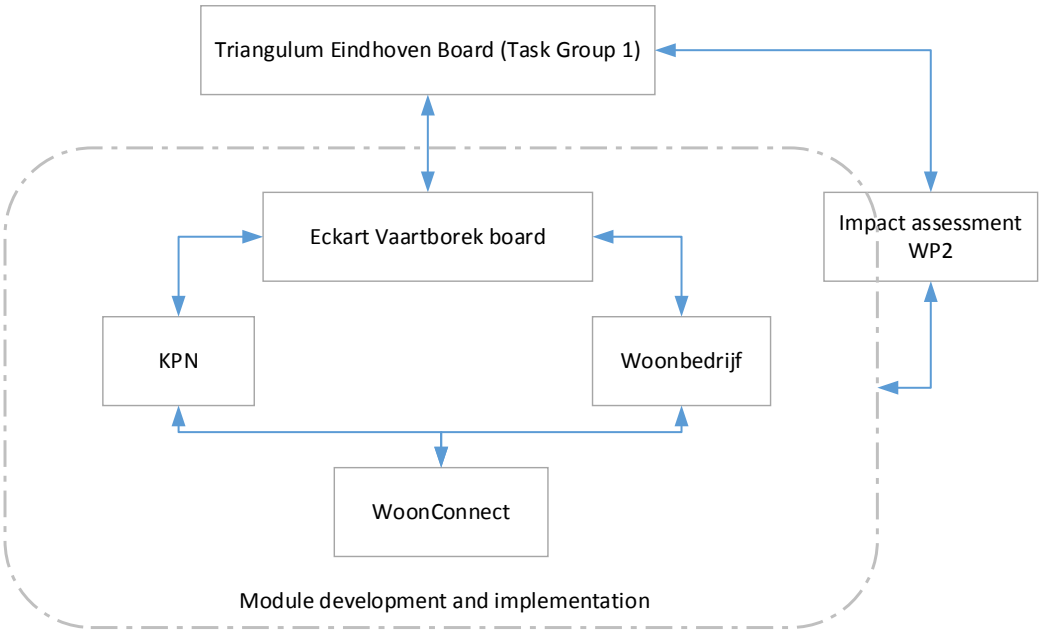

Figure 9: The governance of Triangulum modules of Eckart-Vaartbroek in Eindhoven

4.2.2.2 Governance of the Triangulum modules –Eckart-Vaartbroek

The governance structures for the Eckart-Vaartbroek modules are shown in Figure 9. Woonbedrijf and KPN (Subcontractor - Woonconnect) are leading on housing renovation activities in the Eckart-Vaartbroek district. The Eckart-Vaartbroek board and Woonbedrijf work closely with other projects in Eckart-Vaartbroek. The Triangulum Eindhoven Board (Task Group 1) consists of representatives from each organisation within the consortium and meets on a monthly basis to review module progress. The impact assessment team (WP02 – TU/e) is collating and integrating data generated by working closely with Woonbedrijf and Eckart Vaartborek board (Municipality). Representatives from WP02 also attend board meetings to coordinate impact assessment activities across the modules.

4.2.3 The process of developing module specific indicators for Eindhoven modules

The Triangulum DoW outlined a preliminary series of expected impacts, and associated indicators, identified by the Lighthouse and Follower cities. These indicators were further developed, based on in-depth analysis of bid documentation and feedback from the Lighthouse cities, and presented in deliverable 2.1 (Common Monitoring and Impact Assessment Frameworks) in July 2015.

WP02 researchers have engaged extensively with Eindhoven partners over the last year to understand the project aims and develop impact indicators with the partners to document the scopes of each module and specific indicators. The process includes four steps:

Step 1: Separate meeting were held with three main leading member of the consortium (municipality, VW and WB) and each project manager to align the indicators presented in Del. 2.1 with the evolving scope of the modules developed by WP02 and WP06. The non-feasible indicators and non-identified indicators, which were no longer aligned with the modules and project progress, were removed. New indicators were also identified during the discussion based on the project development.

Step 2: Drawing on the insights from these initial meetings, modules descriptions and module specific impact indicators were developed. This documentation was then shared with the Eindhoven consortium (September on-site assessment meeting) and the feedback was used for further revisions and refinements.

Step 3: Baseline data at module scales was collected in follow-up meetings, by engaging with project managers and consortium partners.

Step 4: Finally, an initial draft of this report was circulated to consortium partners for feedback in mid-December followed by revisions of the module descriptions and module specific indicators.

4.3 Energy Modules

Eindhoven is developing five modules to demonstrate development of energy infrastructures in district/area level. There are three modules of energy infrastructure are in Strijp-S district, which are:

1. *Sustainable energy supply and soil sanitation (module 4.2.1):* VolkerWessels is implementing the technology called SANERGY, which is a combination approach of sustainable energy production and soil sanitation in Strijp-S. It will accelerate natural decomposition of pollutants and bringing the accelerate water into deeper layers of soil. Meanwhile, warmth – cold heat exchange will enable cooling in the summer and heating in the winter. This sustainable energy production will be used in the new apartment buildings as a sustainable energy source.
2. *Optimization heat provision in existing buildings (module 4.2.2):* To replace the traditional heating system with renewable energy, VolkerWessels is building pipes to connect the buildings of Strijp-S to the new build biomass facility. It can provide renewable heating energy to an overall amount of 68,000 m2 within the strijp-S area, replacing a total of 13,3 Mio KWh of conventional heating.
3. *Smart energy for offices (module 4.2.3):* Y-Con and OpenRemote are developing an office heating remote control system. VolkerWessels implements the system in Strijp-S. The purpose is to reduce energy consumption in office building and increase people's environment awareness at the same time.

Three modules of energy infrastructure are in Eckart-Vaartborek district, which are:

1. *Renovation of family homes & creation of participative society (module 4.2.4):* Woonbedrijf cooperated with KPN and WoonConnect are working on renovation around 200 houses with a total area of 20,000 m² in Eckart-Vaartbroek area. The purpose is to fulfil regulatory requirement, reduce CO2 emission and improve residents' quality of life.
2. *Smart distribution of locally produced renewable energy (module 4.2.5):* Local energy-production from renewable energy source will be placed in Eckart-Vaartbroek district by a co-creation process. The purpose of the module is to increase renewable energy percentage at district level and reduce CO_2 emission.

The detailed information for each module is descripted in sections 3.1-3.5. Table 28 presents a summary of the expected impacts of these modules, and below detailed module descriptions are provided.

Modules	**Mechanism for creating impacts**	**Expected impacts**					
		Reducing (non-renewable) energy consumption	Reducing carbon emissions	Reducing energy bills	Fostering citizen engagement (Co-creation)	Developing a digital infrastructure	Improving the quality of life
Sustainable energy supply and soil Sanitation (Module 4.2.1)	The module will accelerate natural decomposition of pollutants and bringing the accelerate water into deeper layers of soil. This sustainable energy production will be used in the new apartment buildings as a sustainable energy source.	*	*	*	*		
Optimization heat provision existing build (Module 4.2.2)	The module will connect the buildings of Strijp-S to the new build biomass facility for providing renewable heating energy in Strijp-S area.	*	*				
Smart Energy for offices (Module 4.2.3)	A smart energy system for reducing energy consumption in office building and increase people's environment awareness at the same time.	*	*		*	*	

Modules	**Mechanism for creating impacts**	**Expected impacts**					
		Reducing (non-renewable) energy consumption	Reducing carbon emissions	Reducing energy bills	Fostering citizen engagement (Co-creation)	Developing a digital infrastructure	Improving the quality of life
Renovation of family homes & creation of participative society (Module 4.2.4)	The module is working on renovation around 200 houses with a total area of 20,000 m² in Eckart-Vaartbroek area for improve the energy lable from F to B (or above) using co-creation method.	*	*		*		*
Smart distribution of Locally produced renewable energy (Module 4.2.5)	The module will install renewable energy production divices to increase renewable energy percentage at district level and reduce CO2 emission.	*	*				

Table 28: Expected impacts of the Eindhoven Energy Modules

4.3.1 Module 421: Sustainable energy supply and soil sanitation (Subtask 4.2.1)

Module Objective: to understand the impacts and benefits of SANERGY on sustainable ground energy utilisation and pollution reduction (soil sanitation) based on ground water circulation.

Approach: At Strijp-S, the use of heat pumps (using the warmth and cold water energy of the deeper soil layers) is not allowed under Dutch law, as long as the water is polluted. The soil needs to be cleaned first before construction can start. Sanergy gives a solution for this problem. The system will be implemented and provide an innovative combination approach of sustainable energy production and soil sanitation. The combined approach of sustainable energy production and soil sanitation leads to cost reductions of 25.000€ / year only in the energy provision, not calculating the benefit of soil sanitation. Based on ground water circulation rather than storage, SANERGY accelerates natural decomposition of pollutants. It effectively eliminates spreading of the pollution by smart design of infiltration and extraction wells while heat or cold can be extracted from the water.

First year progress: On Strijp-S the natural ground water flow is away from Strijp-S. It was spreading the pollution in the groundwater over a larger area than just Strijp-S. To redirect the natural flow of the polluted groundwater a kind of isolation of the groundwater (an island) is created at Strijp-S. Within this area groundwater can be used for sustainable energy purposes (as shown in Figure 10). The circulation of groundwater speeds up the natural breakdown of pollution. The engineering of finding wells locations started in 2015. However due to many wells has been placed nearby Strijp-S in 2015, the water moves differently now. The wells location engineering needs to be re-measured. The work is planed to be finish at the beginning of 2016.

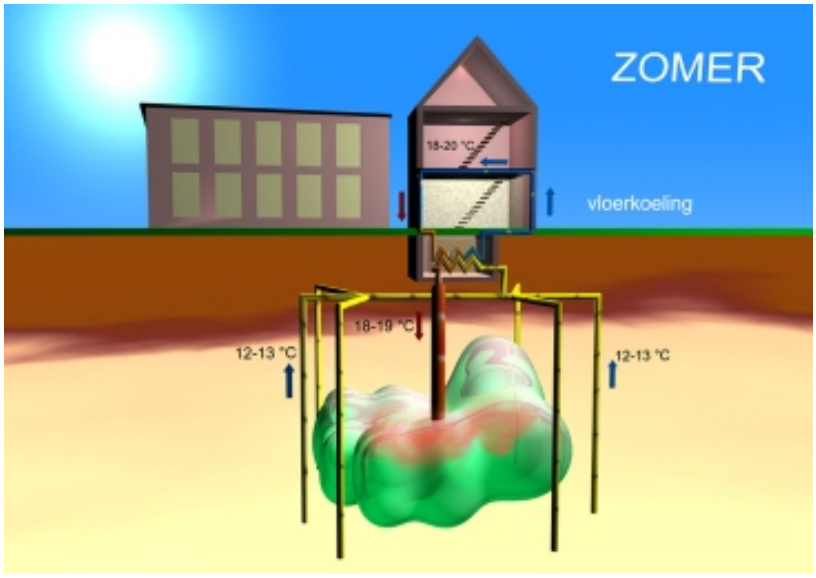

Figure 10: Concept of SANEGY

Links with other modules: none

Socio-technical configuration of the module

SANERGY

The stakeholder structure of the module

Park Strijp Energy, the public-private partnership between the Eindhoven municipality and VolkerWessels, is the current energy production company and main stakeholder in this project, they will use the system to sell energy to the companies and houses located at Strijp-S.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The project is aim on sustainable ground energy utilisation and pollution reduction (soil sanitation) based on ground water circulation without increasing the energy bill. The baseline data for assessing impacts is collected based on historical energy consumption data in Strijp-S. Table 29 below, provides details of the indicators developed for this module. Table 30 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
421001	Reduce energy bills	Average electricity price for companies / consumers	€/KWh	0.05631 (peak price); 0.04185 (off-peak price)	2014Jan - 2014Dec	Energy price data	N/A	Y	N/A	
421002	Reduce energy bills	Average heating price for consumer	€/GJ	17	2014Jan - 2014Dec	Energy price data	N/A	Y	N/A	
421003	Reduce energy consumption/ increase renewable energy	Percentage increase in use of renewable energy (energy generated on-site)	Dimensionless integer	37%	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
421004	Reduce energy consumption/ increase renewable energy	Soil Sanitation	Years	+/- 30	2014Jan - 2014Dec	Soil sanitation	Measurement is done by Philips/Arcadus (advise company)	N	U	

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
421005	Reduce energy consumption/ increase renewable energy	Total primary energy demand of connected buildings	GJ/yr	17512	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
421006	Reduced carbon emissions	Share of other renewable energy in the grid (solar, wind, biomass)	%	0	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
421007	Reduced carbon emissions	Reduction in greenhouse gas emissions as a result of implementing the SaDunergy	kg/yr	Not yet available, because base line calculation method undecided.	2014Jan - 2014Dec	Soil sanitation	To be calculated based on energy consumption data using an appropriate conversion factor.	Y	U	Contact data provider and figure out a reasonable method to calculate reduction in carbon emissions. CO2 reduction might be based on a comparison between normative emission numbers (M27-M32)

Table 29: Impact assessment indicators and baseline data for Module 421

Dataset name	Data description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Energy price data	Energy price data from energy company	421001 421002	Y	Eneco/ Enexis	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Ready and open	
Energy consumption data	Energy consumption data for each building in Strijp-S	421005 421006	Y	Park Strijp Energy	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Dataset is ready; not discussed yet with data owner about privacy or commercial sensitivity yet.	
Soil sanitation	Ground energy utilisation and pollution reduction	421004 421007	Y	Philips/Arcadis	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Dataset for 421004 is ready; not discussed yet with data owner about privacy or commercial sensitivity yet.	Dataset for calculation of 421007 will be decided together with data owner (M27-M32).

Table 30: Datasets potentially to be used in the calculation of impacts for Module 421

4.3.2 Module 422: Optimization of heat provision in existing buildings (Subtask 4.2.2)

Module Objective: To understand the environment and economic impacts and benefits of transforming the existing heat supply (steam based, from a gas fired CHP utility) to a biomass based supply for the complete office and industrial building stock on Strijp-S.

Approach: Supported by the national government of the Netherlands, with 25 Mio euro investment, a new biomass based CHP plant nearby the area of Strijp-S. It can provide renewable heating energy to an overall amount of 68,000 m2 within the strijp-S area, replacing a total of 13,3 Mio KWh of convential heating. This solution provides a nearly CO2 neutral heat supply and is the preferred approach to achieve significant energy savings, above extensive and expensive refurbishment of the industrial building stock. Within Triangulum VolkerWessels will provide in-building installations and pipelines for connecting the buildings to the CHP plant.

First year progress: The piping from the buildings previously connected to the gasfired production unit on the edge of Strijp-S, has been changed and reconnected to the new build combined heat power production facility that uses biomass. The pipes placement has been implemented in Sep. 2015. It is ready to transform the existing heat supply (steam based, from a gas fired CHP utility) for the complete office and industrial building stock on Strijp-S to a modern heat supply based on renewable energy (notably biomass) in a CHP configuration.

Links with other modules: None

Socio-technical configuration of the module

There are two main modules in this project, which are utility modernization and ground installations.

The stakeholder structure of the module

Park Strijp Energy, the public private partnership (PPP) between the Eindhoven municipality and VolkerWessels, is the current energy company and main stakeholder in this project.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The project is expected to provides a nearly CO2 neutral heat supply on Strijp-S. The baseline data for assessing impacts is collected based on historical energy consumption data in Strijp-S. Table 31 below, provides details of the indicators developed for this module. Table 32 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators Identified for Assessing Impacts	Quant. Unit	Baseline value	Baseline period	Datasets to be used for impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. rel.	WP02 next steps
422001	Reduce non-renewable energy consumption	Reliability of off-gas systems by biomass (energy generated on site）	%	0	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	N	U	
422002	Reduce non-renewable energy consumption	Total primary energy demand of district	GJ/yr	67483	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
422003	Reduce non-renewable energy consumption	Total primary energy demand of district	KWh/yr	5546081	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
422004	Reduced carbon emissions	Net greenhouse gas emissions by steam/heating system	kg/yr	Not yet available	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	Contact data provider and figure out a reasonable method (M27-M30).

Impact indicator identifier	Impacts	Impact Indicators Identified for Assessing Impacts	Quant. Unit	Baseline value	Baseline period	Datasets to be used for impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. rel.	WP02 next steps
422005	Reduced carbon emissions	Net greenhouse gas emissions by electricity	kg /yr	699792.6	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
422006	Reduced carbon emissions	Share of other renewable energy on the heating part (solar, wind, geothermal/SENERGY）	%	0.0444	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	N/A	U	

Table 31: Impact assessment indicators and baseline data for Module 422

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Energy consumption data	Energy consumption data for each building in Strijp-S	422001 422002 422003 422004 422005 422006	Y	Park Strijp Energy	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Dataset for 422001, 422002, 422003, 422005 and 422006 are ready; not discussed yet with data owner about privacy or commercial sensitivity yet.	Heat supply is 100% changed from gas to biomass. CO2 reduction can be based on a comparison between normative emission numbers. Contact data provider and figure out a reasonable method to calculate reduction in carbon emissions in 422004. (M27-M30)

Table 32: Datasets potentially to be used in the calculation of impacts for Module 422

4.3.3 Module 423: Smart energy for offices (Subtask 4.2.3)

Module Objective: To understand the environment and social impacts and benefits of providing smart energy saving systems and application in office buildings on Strijp-S.

Approach: The system aim to reduce the energy consumption of the Strijp-S office buildings through measures that induce behavioural change of the tenants. The system includes the three elements: (1) the individual control of working space by occupants; (2) self-learning capabilities of the control algorithm; and (3) dynamic working hours prediction. Over time the system combines sensor data and participates better and better on a set of criteria that it takes into consideration. Patterns of office space presence and behavior, weather conditions, sun up and down, will lead to a system that anticipates better and better and will outsmart human steering of the energy use.

First year progress: In the 6th floor of the office building VideoLab at Strijp-S, the try out version of smart energy management system has been installed by VolkerWessels - 13 offices. In every office room, 4 sensors were installed to measure (1) the presence, telling if anyone is in that room; (2) Thermostat, measuring room temperature; (3) Window opening, telling if a window is open or closed; (4) and an intelligent radiator controller, which can be remotely and digitally set. Based on the trial of 13 offices, Y-con (subcontractor) estimated the benefits of hypothetically 100 offices role out in 2016. Without any incentives of promoting energy conservation behaviour change, for 100 offices, the investment of 1130 euro will be paid back within 3.7 years. During the trial period, a problem is detected which is an obstacle for triggering consumers' intention to use smart office App. The temperature of main pipe, which pass rooms and open spaces of VideoLab, is relatively high. The temperature of small office rooms is around 22 degree during the daytime in winter without turning on radiator heating. Therefore, the first step was to find out how to control the main pipe temperature and decrease the heating temperature. The problem is under control by the end of November 2015. In December 2015, VolkerWessels is going to investigate the trail results and propose a further investment proposal for 2016. Based on the proposal, the start time of roll out and number of offices will be installed the smart office infrastructures will be decided at the beginning of 2017.

Links with other modules: Selected data collected from smart office sensor may be shared on the Eindhoven open data platform, however no discussion conducted yet. The module also links with module "Second phase of implementation and integration of the fibre-optic data infrastructure".

Socio-technical configuration of the module

This module integrates two *technologies*, which are sensor network with central controller and cloud-based control algorithm.

The stakeholder structure of the module

The main stakeholders in this module is VW. The smart office system and application is developed in cooperation with the local start-up company "OpenRemote" and Y-Con. Y-Con takes charge of building the control system and OpenRemote developed the application.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The smart energy office project is aim of improving energy efficiency and CO2 emission. Meanwhile, the project targets to get office users environment awareness by using the APP. There is no smart meter installed in separate office room. The baseline data for assessing impacts is collected based on historical building energy consumption data in Strijp-S. Table 33 below, provides details of the indicators developed for this module. Table 34 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicator	Quant. Units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
423001	Reduce (non-renewable) energy consumption	Primary energy consumption of VideoLab (gas)	GJ/yr	6358	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
423002	Reduce (non-renewable) energy consumption	Primary energy consumption of VideoLab (electricity)	KWh	1817432.063	2014Jan - 2014Dec	Energy consumption data	Calculated based on monthly billing information from provider	Y	U	
423003	Reduce (non-renewable) energy consumption	Average occupants percentage	%	0.5823	2014Jan - 2014Dec	Office occupation data	Calculated based on office occupation information from VideoLab	N	N	

Impact indicator identifier	Impacts	Impact Indicator	Quant. Units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
423004	Reduce (non-renewable) energy consumption	Flatten Peak gas Demand -Highest gas consumption month during a year - (normalized with average temperature in the month)	GJ	1330	Dec. 2014	Energy consumption data	Calculated based on monthly billing information from provider	N	U	
423005	Reduced carbon emissions	Greenhouse gas emissions	Kg/yr	0	2014Jan - 2014Dec	Energy consumption data	To be calculated based on energy consumption data using an appropriate conversion factor.	Y	U	
423006	Fostering citizen engagement (Co-creation)	Nr. of involvement users	Nr	0	2014Jan - 2014Dec	User engagement data	N/A	N	N/A	
423007	Fostering citizen engagement (Co-creation)	Nr. of involvement offices	Nr	0	2014Jan - 2014Dec	User engagement data	N/A	N	N/A	

Impact indicator identifier	Impacts	Impact Indicator	Quant. Units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
423008	Fostering citizen engagement (Co-creation)	Nr of pledges	Nr	0	2014Jan - 2014Dec	User engagement data	N/A	N	N/A	
423009	Fostering citizen engagement (Co-creation)	Recorded environment awareness of office users - 1-5 (low to high awareness)	Dim. Int.	Baseline cannot be set until questionnaire is concluded	2014Jan - 2014Dec	Users awareness	Statistics	N	U	Statistical analyses is concluded in M27-M30.
423010	Developing a digital infrastructure	Data streams monitored	Nr	0	2014Jan - 2014Dec	Sensor data	To be calculated from smart office installation.	N	U	
423011	Developing a digital infrastructure	Data streams monitored of data points	Nr.	0	2014Jan - 2014Dec	Sensor data	To be calculated from smart office installation.	N	U	

Table 33: Impact assessment indicators and baseline data for Module 423

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Energy consumption data	Energy consumption data for building Video-lab	423001 423002 423004 423005	Y	Park Strijp Energy	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Dataset is ready; not discussed yet with data owner about privacy or commercial sensitivity yet.	
Office occupation data	Office occupation data for building Video-lab	423003	Y	Park Strijp Beheer	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Dataset is ready; not discussed yet with data owner about privacy or commercial sensitivity yet.	
User engagement data	User engagement data for district Strijp-S	423006 423007 423008	Not currently available because it is waiting for further project roll-out	Park Strijp Beheer	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	Depend on the roll out scale in Strijp-S	Data is collected through workshops (M25-M48)

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Users awareness	Potential smart office users' environment awareness	423009	Not yet available, because data further processing is needed.	TU/e	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	Data is collected through an online questionnaire.	Organize the online questionnaire data and calculate the environment awareness value regarding potential users.
Sensor data	Data collected from sensors in smart offices	423010 423011	Not currently available because it is waiting for further project roll-out	VW and OpenRemote	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Depend on the roll out scale in Strijp-S. Not yet confirmed which offices will be installed the smart office system and which company will provide the sensors.	Data will be available after implementing the smart office installation. Decision need to be made regarding data ownership, privacy and commercial sensitivity.

Table 34: Datasets potentially to be used in the calculation of impacts for Module 423

4.3.4 Module 424: Renovation of family homes & creation of participative society (Subtask 4.2.4)

Module Objective: To understand impacts and benefits of residential house renovation with a toolkit.

Approach: To fulfil regulatory requirement, houses in Eckart-Vaartbroek from Woonbedrijf needs to be renewed. Within the renovation sites that contain 1,300 dwellings in total, 200 dwellings with a total area of 20,000m² will be refurbished during the project. The partners aim to reduce 800 tonnes of CO_2 per year by renovation. To achieve their goal, individual tenants will be given the opportunity to choose tailor made packages offering extra energy saving measures and/or renewable energy concepts. The partners aim to achieve that at least 20% of the tenants will opt for a further upgrade that, although it will increase rent, it will, at the same time, lower the energy bill, due to additional investments. This will be achieved through the co-creation process (WoonConnect) leading to increased awareness and ownership of the challenge. In addition, the general way of working of Woonbedrijf will be respected. This methodology, the Natural Step, pays particular attention to limitation of the use of harmful chemicals, the efficient use of resources and the human factor in all their operations.

First year progress: To make sure of completing the task of renovating 200 dwellings, Woonbedrijf initially assigned an area of 250 dwellings. Through the co-creation process people have the opportunity to participate. During 2015, Woonbedrijf cooperated with its partners completed the following tasks: (1) Preparation of the internal investment decision; (2) preparation of test homes for the implementation of a new renovation concept, which can energetically improve (isolate, produce energy sustainably) an individual dwelling or a component of this dwelling. This way the tenant has the opportunity to take ownership of his own house; (3) research (asbestos and nature laws) in preparation of building permits; (4) designed a web-based questionnaire to communicate with the tenants of the first area to collect the knowledge on how they live in their home and how this can be improved; (5) The questionnaire has been lunched with test and feedbacks during Nov. and Dec., 2015.

Two potential problems are recognized during the first year implementation. First, it appears that the dwellings in reality are larger than estimated numbers in BEST table, which is estimated based on average square meters per home. Therefore, the energy consumption and CO2 emission will be higher than estimation in BEST table. Second, we planned to collect household level energy consumption data from Endinet (local energy distribution company) for evaluating the project. However, due to legal issue, there is no individual data can be shared with Endinet, even with the agreement with residents. It will increase the difficulty of project evaluation.

Links with other modules: it is linked with module “interactive process for dwellings in Eckart-Vaartbroek” and “Stimulating private owners and other housing corporations in Eckart-Vaartbroek area to follow”

Socio-technical configuration of the module

It includes insulation of roofs, cavity walls and floor (depending on the situation), improving glazing, and sophisticated installations. Besides, a toolkit is in development to provide inhabitants about

their energy use as results of their daily behaviour. They will be advised on how they can save money and/or increase comfort and will be presented real-time with the costs involved.

The stakeholder structure of the module

The stakeholder in this module is Woonbedrijf

The indicators to be used for assessing the impacts and benefits and baseline conditions

The project aims to improve residents living conditions and reduce CO_2 emission. Meanwhile, the project wants to include local residents into the decision process to create a participative society. Due to legal issue, we might have difficulty to collect household level energy consumption data. Therefore, for this project, the baseline data for assessing impacts is collected based on historical district energy consumption data from Eckart-Vaartbroek. Table 35 below, provides details of the indicators developed for this module. Table 36 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
424001	Reduce (non-renewable) energy consumption	Amount of buildings retrofitted / smartified	m2 /yr	0	2014Jan - 2014Dec	Renovation choice set	To be calculated based on woonconnect data	N	U	
424002	Reduce (non-renewable) energy consumption	Reduction in monthly energy bills	%	0	2014Jan - 2014Dec	Renovation choice set	To be calculated based on woonconnect data	Y	U	
424003	Reduce (non-renewable) energy consumption	Use of local energy sources	KWH/yr (electricity)	489017.09	2014Jan - 2014Dec	Historical energy consumption data; Energy consumption data after renovation	Calculated based on energy consumption data	Y	U	
424004	Reduce (non-renewable) energy consumption	Use of local energy sources	m3 (gas)	958717.68	2014Jan - 2014Dec	Historical energy consumption data; Energy consumption data after renovation	Calculated based on energy consumption data	Y	U	

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
424005	Reduce (non-renewable) energy consumption	CO2 reduction through material re-use (Nature step)	kg	0	2014Jan - 2014Dec	Renovation choice set	Depend on availability of renovation data and find an appropriate calculation method	N	U	Review calculation method (M27-30)
424006	Reduced carbon emissions	Greenhouse gas emissions	Kg/yr.	1983301.28	2014Jan - 2014Dec	Historical energy consumption data; Energy consumption data after renovation	Calculated based on energy consumption data	Y	U	
424007	Reduced carbon emissions	Share of renewable energy on the grid (solar, wind, geothermal)	%	0	2014Jan - 2014Dec	Installed renewable energy	Calculated after renovation	Y	N	
424008	Reduced carbon emissions	Smart meters installed and used	Nr	0	2014Jan - 2014Dec	Energy consumption data after renovation	Counted after renovation	N	N	

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
424009	Fostering citizen engagement (co-creation)	Increase awareness of energy consumption by acceptance of renovation per year	Nr.	0	2014Jan - 2014Dec	Renovation choice set	Counted after renovation	N	N	
424010	Better quality of life	Affordable housing - increase in rent over cost of inflation	%	0	2014Jan - 2014Dec	Renovation choice set	Depend on availability of house price data from Woonbedrijf	N	U	
424011	Better quality of life	Payback periods for specific demonstration activities on average	Years	Not yet available	2014Jan - 2014Dec	Renovation choice set	To be calculated based on woonconnect data	Y	U	Collaborate with Woonbedrijf to define Formula (M37-M60)

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
424012	Better quality of life	Satisfaction of neighborhood – average score (1 lowest -5 highest)	Dim.int.	Not yet available	2014Jan - 2014Dec	Dwelling conditions and satisfaction	To be calculated based on questionnaire data	N	U	Collaborate with Woonbedrijf to define Formula (M27-M36)
424013	Better quality of life	Recorded satisfaction of residence houses - Average score (1 lowest -5 highest)	Dim.int	Not yet available	2014Jan - 2014Dec	Dwelling conditions and satisfaction	To be calculated based on questionnaire data	N	U	Collaborate with Woonbedrijf to define Formula (M27-M36)

Table 35: Impact assessment indicators and baseline data for Module 424

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Historical energy consumption data	Historical energy consumption data for household level (year based)	424003 424004 424006	Y	TU/e, Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Old system stays in place for non-renovated dwellings. Agreement needed from residents renovated dwellings.	
Energy consumption data after renovation	Energy consumption data after renovation of dwellings in Eckart/Vaartbroek	424003 424004 424006 424008	Not yet available, because renovation has not yet started.	Residents	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	77 residents are willing to share their data with TU/e.	Approach residents after renovation (M37-M48)
Dwelling conditions and satisfaction	Questionnaire data of current living condition and environment satisfaction	424012 424013	Y	TU/e, Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	Going to be updated in second year report	Baseline data of satisfaction of neighbourhood and residence houses will be calculated based on questionnaire data

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Renovation choice set	Woonconnect data (including renovation choice option, energy reduction expectation, payback year etc..)	424001 424002 424005 424009 424010 424011	Not yet available, because choice set entry by tenants starts in 2017	Residents, Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	U	More discussion is needed to figure out the data availability and privacy issue.	Collect data after each renovation round (M37-M48).
Installed renewable energy	Renewable energy share for the whole Eckart/Vaartbroek district	424007	Not yet available; waiting for further project roll-out	Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	Depend on availability of total energy consumption data in the area	Collect data about all installed renewable energy technologies (M37-M48)

Table 36: Datasets potentially to be used in the calculation of impacts for Module 424

4.3.5 Module 425: Smart distribution of locally produced renewable energy (Subtask 4.2.5)

Module Objective: To understand impacts and benefits of local energy-production from renewable sources in Eckart-Vaartbroek district.

Approach: The refurbishment of the Eckart Vaartbroek district will go along with the provision of local energy-production from renewable sources by the placement of renewable energy facilities. The process should be a co-creation process. In the co-creation process, a continuous dialogue with the citizens, the local energy distributor (Endinet) and the housing association Woonbedrijf, who finances the local production investments and upon whose premises the sustainable energy is produced, decisions will be taken about what the role of the citizens will be in this cooperation, and how / for what the locally generated energy will be used.

First year progress: During 2015, a feasibility study has been conducted to test the suitability of installation wind turbines on the public roof in Eckart-Vaartbroek district. Two potential locations were tested. Based on the estimation results, one building is not feasible to install the wind turbine considering the investment payback period (which is longer than the lifetime of the wind turbine). Woonbedrijf made the decision of install one wind turbine instead of two on public roof. The feasibility study is conducted by the wind turbine company called – IBIS power. After investigation it was decided not to continue with this process. Currently other possible technologies options mentioned in the original proposal, such as, PV, a virtual grid, a local micro smart grid and renewable energy storage are investigated. The decision process of selecting possible technologies is not finalized. A closely investigation is needed to understand options and possible impacts.

Links with other modules: None

Socio-technical configuration of the module

Wind turbines.

The stakeholder structure of the module

The proposed stakeholders for this module include Woonbedrijf and Eindhoven municipality.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The project aims to refurbishment of the Eckart Vaartbroek district with the provision of local energy-production from renewable sources. Table 37 below, provides details of indicators developed for this module according to their original plan and first year progress. Table 38 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
425001	Reduce (non-renewable) energy consumption	Energy generated on site	kwh/yr	0	2014Jan - 2014Dec	Energy consumption/ production data	Calculated based on yearly data per household	Y	U	
425002	Reduced carbon emissions	Share of renewable energy on the grid	% solar	0	2014Jan - 2014Dec	Energy consumption/ production data	Calculated based on yearly data per household	Y	U	
425003	Reduced carbon emissions	Share of renewable energy on the grid	% wind	0	2014Jan - 2014Dec	Energy consumption/ production data	Calculated based on yearly data per household	Y	U	
425004	Reduced carbon emissions	Share of renewable energy on the grid	% geothermal	0	2014Jan - 2014Dec	Energy consumption/ production data	Calculated based on yearly data per household	Y	U	

Table 37: Impact assessment indicators and baseline data for Module 425

Dataset id and name	Brief description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Energy consumption/ production data	Energy consumption/ production data in Eckart Vaartbroek district	425001 425002 425003 425004	N	Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Dependent on availability of energy data (consumption & production) in Eckart Vaartbroek district.	Contact Woonbedrijf to check if available (M26-M30)

Table 38: Datasets potentially to be used in the calculation of impacts for Module 425

4.4 Mobility Modules

The mobility task group are planning to develop two modules.

1. *Smart charging of electric vehicles (module 4.3.1):* an intelligent smart charging information service system will be developed with the implementation of smart charging facilities. The objective is to improve the EV charging facilities efficiency and EV parking management.
2. *Mobility management (module 4.3.2)*: To improving the mobility sustainability in Stijp-S. The project will develop an ICT based tool for real time parking guidance system and develop a payment Incentives for green alternatives and to stimulate car sharing.

The detailed information for each module is descripted in the sub-sections below. Table 39 presents a summary of the expected impacts of these two modules, and below detailed module descriptions are provided.

Modules	**Mechanism for creating impacts**	**Expected impacts**		
		Improvement of mobility	Developing a digital infrastructure	Improvement of EV charging efficiency
Smart Charging of electric vehicles (Module 4.3.1)	Replacing conventional electrical vehicle charging facilities with smart charging and parking management facilities and increasing the number of EV charging pools	*	*	*
Mobility Management (Module 4.3.2)	To improving the mobility sustainability in Stijp-S by developing smart parking guidance system and green alternative incentive system	*	*	

Table 39: Expected impacts of the Eindhoven Mobility Modules

4.4.1 Module 431: Smart charging of electric vehicles (Subtask 4.3.1)

Module Objective: to understand the impacts and benefits of improving smart charging facilities for EV users on Strijp-S.

Approach: This task involves smart charging of electric vehicles and improving parking management. To be more specific, to improve the EV charging facilities efficiency, the project will develop a smart charging information service. The service is dependent on the MPLS (see also subtask 4.4.5. for a detailed explanation of MPLS) service. The task will involve the purchase of several intelligent charging stations, an effective communication application system (through an app) with the user of the infrastructure, allowing a more efficient use of the infrastructure by more EV users.

First year progress: To solve replacement issue of Strijp-S Ontwikkeling by VolkerWessels iCity, there is a 3 months delay. As a consequence of the delay, the project started from Sep./Oct. 2015.

The location of current EV charging facilities is presented in Figure 11. Four EV charging pools are facilitated in Strijp-S with 2 connections on each charging pool. The supplier of Nr 1 charging pool is Eonnecomfort. Rest charging pools belong to Elaad. Now it is for free to use the EV charging pools in Strijp-S. Now the concept of smart charging facility and information service system has been developed. It should include four functions, which are:

1) Making reservation of the charging pool;
2) Receiving signal/message from APP of reminder of moving car when the car is fully charged;
3) One bill for parking and charging fee with specification (for on street parking, should be combined with park mobile to combine the cost);
4) Able to choose charging modes (fast charging/slow charging) - combination of AC/DC charging with different price scheme

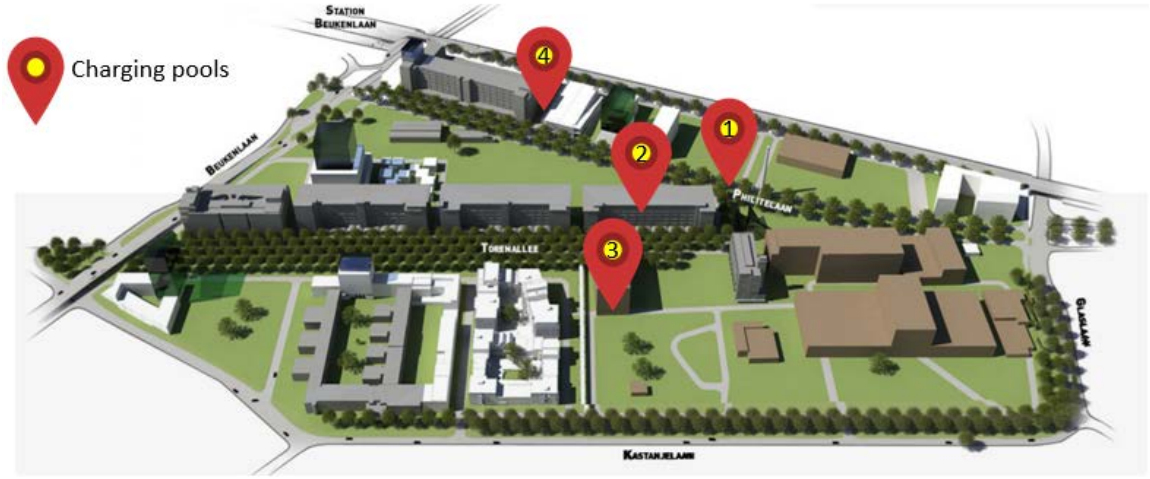

Figure 11: Four current charging pools in Strijp-S

It is expected to charge fees from EV customers when using the infrastructure. Moreover, 5-6 smart charging pools with 2 connectors each are expected to be implemented within Triangulum project

period with one supplier. It is expected that the increasing of EV charging facility and improvement of EV charging infrastructure efficiency will promote more EV users. The following steps include: 1) collecting charging infrastructure data from current supplier; 2) a deal will be made by the end of 2015 with current supplier (date and how much per KWh) - Eonnecomfort/BEcharged to bill costumers charging fee in Strijp-S; 3) discussing with potential suppliers about the smart charging facility and service. There are five possible suppliers are under negotiation now, which are Eonnecomfort/BEcharged, EcoTap/Mecro, Eneco, EVBox, and Vitae Mobility. The planning meeting has been lunched by the end of Nov., 2015. The investigation of supplier and choosing the best supplier will be implemented within 2 months (Feb. 2016). The first new charging pool will be launched in March/April, 2016.

Links with other modules: This module is linked with mobility management module - subtask 4.3.2 and Sensor network in the public space module - subtask 4.4.5.

Socio-technical configuration of the module

EV charging infrastructure and an intelligent communication application system (App)

The stakeholder structure of the module

VolkerWessels iCity is going to invest in the hardware and software of EV infrastructure. The future facility supplier will take charge of maintenance of infrastructure. Mobility-S (Mobility-S is a PPP collaboration between VolkerWessels and the municipality of Eindhoven. They are responsible for mobility on Strijp-S, and they are developing smart and integral solutions) will take charge of the business part to promote and provide the infrastructure to costumers in Strijp-S.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The smart EV charging project is aim of improving EV charging facility efficiency by developing an ICT supporting tool. Due to privacy issue, three charging pools data is not available now. Only one charging pool baseline data is collected. Table 40 below, provides details of the indicators developed for this module. Table 41 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
431001	Developing a digital infrastructure – for EV charging pools	Nr. of EV/FC charging stations	Nr.	8	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Counting	Y	N	
431002	Developing a digital infrastructure – for EV charging pools	Reservation system - Possibility of making reservation of charging	Yes/No	No	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Counting	N	N	
431003	Developing a digital infrastructure – for EV charging pools	Switch charging modes (AC/DC) - Possibility of choosing charging speed	Yes/No	No	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Counting	N	N	

Impact indicator identifier	Impacts	Impact Indicators	Quant. units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
431004	Improvement of EV charging efficiency	Transaction energy – Pool 1	MWh	2474	30th July 2015 – 24th Oct. 2015 - 17 weeks	tion data	Calculated based on weekly charging transaction data	N	U	
431005	Improvement of EV charging efficiency	Transaction energy – Pool 2	MWh	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431006	Improvement of EV charging efficiency	Transaction energy – Pool 3	MWh	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431007	Improvement of EV charging efficiency	Transaction energy – Pool 4	MWh	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	

Impact indicator identifier	Impacts	Impact Indicators	Quant. units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
431008	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool1_connection1	Nr.	161	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431009	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool1_connection2	Nr.	181	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431010	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool2_connection1	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431011	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool2_connection2	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	

Impact indicator identifier	Impacts	Impact Indicators	Quant. units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
431012	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool3_connection1	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431013	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool3_connection2	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431014	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool4_connection1	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431015	Improvement of EV charging efficiency	Monitoring transaction Nr of Pool4_connection4	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	

Impact indicator identifier	Impacts	Impact Indicators	Quant. units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
431016	Improvement of EV charging efficiency	Monitoring use of EV/FC charging by number of customers – Pool1	Nr.	37	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431017	Improvement of EV charging efficiency	Monitoring use of EV/FC charging by number of customers – Pool2	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431018	Improvement of EV charging efficiency	Monitoring use of EV/FC charging by number of customers – Pool3	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	
431019	Improvement of EV charging efficiency	Monitoring use of EV/FC charging by number of customers – Pool4	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	

Impact indicator identifier	Impacts	Impact Indicators	Quant. units	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
431020	Improvement of mobility	Improvement of parking efficiency by increasing number of EV parking reservation	Nr.	0	30th July 2015 – 24th Oct. 2015 - 17 weeks	Charging transaction data	Calculated based on weekly charging transaction data	N	U	

Table 40: Impact assessment indicators and baseline data for Module 431

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Charging transaction data	Charging transaction data from charging stations at Strijp-S collected through fibre-optic backbone and data platform	431001 431002 431003 431004 431005 431006 431007 431008 431009 431010 431011 431012 431013 431014 431015 431016 431017 431018 431019 431020	N	Charing company/ VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Except one existing charging station no data was collected before start the project. For newly installed charging stations data availability is unclear., because the charging company is not known yet. Data availability also depends on the agreement between VW and charging company.	Contact VMW about status of charging company (M27-M30)

Table 41: Datasets potentially to be used in the calculation of impacts for Module 431

4.4.2 Module 432: Mobility management (Subtask 4.3.2)

Module Objective: To understand the impacts and benefits of ICT guidance and payment tool for improving the mobility sustainability in Strijp-S.

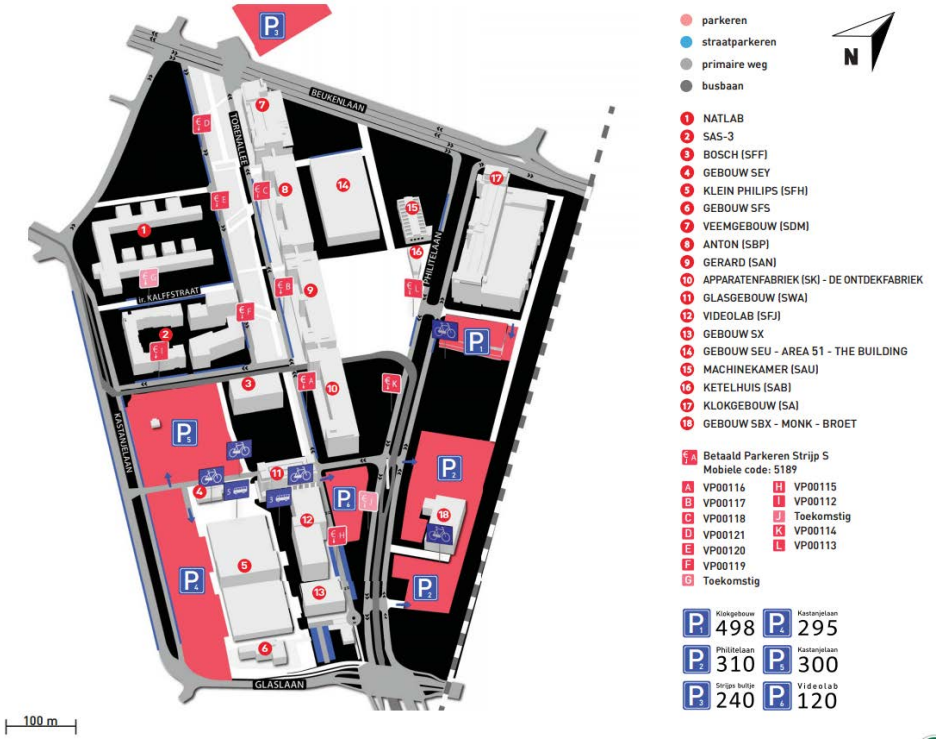

Figure 12: Parking places in Stijp-S

Approach: The project planned to develop an ICT based tool for real time parking guidance system and develop a payment Incentives for green alternatives and to stimulate car sharing. The transformation will be based on a business model that generates funds for mobility sustainability enhancements.

First year progress: The project has been delayed for around 3 months due to uncertainty of bringing Volker Wessels iCity within position. There are six parking spaces with 1763 parking slots in Strijp-S as shown in the Figure 12. To improve the mobility sustainability, an improved parking facility system will be implemented in Strijp-S. The aim is to develop a real time parking guide system, which integrated with navigation system. It should be able to make parking reservation by considering final destination and car size. The hardware is available now, however the software development needs further investigation. To get a better insight of mobility needs in Strijp-S, a real parking needs (24/7) has been monitored. An ICT management service has been developed and is implementing since September 2015. The system provides an important foundation for further developments of mobility management in Strijp-S. The ICT management service is also connected to the general ICT data platform of Strijp-S.

Links with other modules: Selected data collected from mobility will be shared on the Eindhoven open data platform.

Socio-technical configuration of the module

ICT management service system

The stakeholder structure of the module

Three main parties are involved in the stakeholder structure. Volker Wessels iCity is the investor of developing the intelligent software, which will be developed in cooperation with Ominess (SME). Mobility-S will get lease contract to use the software by monthly payback to Volker Wessels iCity . Mobility-S takes charge of promoting and providing service to customers.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The mobility management project is aim of improving mobility management in Strijp-S. Table 42, below, provides details of the indicators developed for this module and part of the baseline data. Table 43 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS (Y/N)	Auto. calc.	WP02 next steps
432001	Improving mobility	Improvement of mobility parking efficiency by reducing parking lots	Nr.	1763	2014Jan - 2014Dec	Parking information	Counting	N	N	
432002	Improving mobility	Improvement of mobility parking efficiency by increasing average parking occupancy percentage	%	Not yet available due to lack of data	2014Jan - 2014Dec	Parking information	Calculating Nr. Of parking occupied/ total nr. of parking slots	N	N	Contact VW for determining baseline value (M27-M30)
432003	Improving mobility	Improving mobility management by increasing green mobility alternatives	Nr.	4 – bus, train, bike, on foot	2014Jan - 2014Dec	Parking information	Counting	N	N	
432004	Improving mobility	Improving mobility management by providing car-pooling program	Yes/no	No	2014Jan - 2014Dec	Parking information	N/A	N	N	
432005	Developing a digital infrastructure	Availability of Reservation system	yes/no	No	2014Jan - 2014Dec	Parking information	N/A	N	N	
432006		Availability of Real-time information of parking space	yes/no	No	2014Jan - 2014Dec	Parking information	N/A	N	N	

Table 42: Impact assessment indicators and baseline data for Module 432

Dataset name	Dataset description	Available at M24	Related impact indicators	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Parking information	Parking information about parking facilities Strijp-S	N	432001 432002 432003 432004 432005 432006	VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	The data is unclear yet when it will be available and whether it will be available publicly or privately.	Collaborate with VW for access to parking information data (M27-M48) Historic data is being collected and will be available between M27-M30.

Table 43: Datasets potentially to be used in the calculation of impacts for Module 432

4.5 ICT Modules

Eindhoven is developing six modules to demonstrate development of ICT infrastructures in Eindhoven city level and district/area levels.

On Eindhoven city level, there are two modules:

- *Eindhoven smart city ICT open data platform (module 4.4.1):* Eindhoven municipality is continuing to develop an open data platform (based on Socrata platform) for hosting data generated by the Triangulum projects, and other related datasets. The aim of developing open data platform is to offer a platform where not only governmental organizations, but any party willing to offer its data according to agreed standards, can exchange data.
- *Smart city innovation fund (module 4.4.5):* TUE - Innovation Lab (IL) together with VW / EIN, and supported by "BrightMove", will stimulate fund for SME's in Eindhoven and stimulate entrepreneurs to develop services. It focuses on stimulating pro-active consortia, on achieving impact from societal research and on developing activities in the field of entrepreneurship for students, research support and business development.

In Eckart-Vaartbroek district, there are two modules:

- *Interactive energy retrofit for dwellings (module 4.4.2):* the module is to develop a 3D-ICT tool to facilitate an interactive refurbishment process by allowing the tenants to manage their energy consumption.
- *Smart streetlights for a social interaction and health route (module 4.4.6):* To develop a 1-km social interaction and health pedestrian route around the pond through a park in the middle of Eckart-Vaartbroek neighbourhood, Eindhoven municipality cooperated with KPN and Woonbedrijf. In order to create an ultimate integrated safety and quality public space, the route will be equipped with LED lighting and other additional functions such as WIFI and sensor to enable the use of smart connections with surrounding facilities and visitors,

In Strijp-S area, there are two modules:

- *Smart environment fibre-optic data infrastructure (module 4.4.3):* VW iCity and partners aim to develop the second phase of Backbone in Strijp-S to provide strong fibre-optic data infrastructure to enable a smart environment. The Backbone provides high-quality urban environment with possible service to all users in the area.
- *Public space sensor network (module 4.4.4):* In this task, a bottom up dialogue approach will be conducted to understand inhabitants' needs. To improve the living environment, a smart sensor network is needed. The sensor network allows for the meaningful development of additional and innovative services. The aim of the project is to improve the citizen's quality of life.

Table 44 presents a summary of the expected impacts of each module, and below detailed module descriptions are provided.

Module	Mechanism for creating impacts	Expected Impacts					
		Fostering citizen engagement (Co-creation)	Developing a digital infrastructure	Promoting commercial activity	Wide scale deployment/ dissemination of project results	Improving the quality of life	Reducing carbon emissions
EHV facilitation smart city open data platform (Module 441)	Providing access to data which can be used by citizens, businesses and government to create economic, social and environmental value.	*	*				
Interactive process for dwellings in Eckart-Vaartbroek (Module 442)	The module 4.4.2 will provide the 3D ICT tool.	*			*	*	*
Second phase of implementation and integration of the fiber-optic data infrastructure (Module 443)	The module will develop the second phase of Backbone in Strijp-S		*				
Sensor network in the public space (Module 444)	The module will develop a smart sensor network to improve citizen's quality of life		*			*	
Stimulating development of innovative services/app's (Module 445)	It will stimulate fund for SME's in Eindhoven and stimulate entrepreneurs to develop services			*	*		

Module	Mechanism for creating impacts	Expected Impacts					
		Fostering citizen engagement (Co-creation)	Developing a digital infrastructure	Promoting commercial activity	Wide scale deployment/ dissemination of project results	Improving the quality of life	Reducing carbon emissions
Smart streetlights social interaction & health route (Module 446)	The module will develop a 1-km social interaction and health pedestrian route around the pond through a park in the middle of Eckart-Vaartbroek neighbourhood					*	

Table 44: Expected impacts of the Eindhoven ICT Modules

4.5.1 Module 441: Eindhoven smart city ICT open data platform (subtask 4.4.1)

Module Objective: to understand the impacts and benefits of Eindhoven open data platform by smart city initiatives.

Approach: Eindhoven has installed the Socrata platform and made available governmental data (Geofundament, Police). Socrata contains around 40 datasets. It processes this data and presents it on a 2D-platform and through other formats (csv, kml, kmz, json, etc.). This creates openness and transparency and enables first steps for citizen participation and the further development of an app-ecosystem. Currently the app-ecosystem involves several large Eindhoven enterprises (Philips), Brainport Development, App developers (mostly small sized SME's), educational institutions such as TU/e and Fontys, higher education and several secondary schools, and the local sensor industry. https://data.eindhoven.nl/. During the Triangulum project, Eindhoven open data platform is continuously developing. It will extend the use for smart city developments and offer open access to data generated by Eindhoven mobility and energy modules and other related datasets. The objectives are: (1)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; (2)To analyse data to improve policy decisions; (3)To stimulate and provoke the development of integrated new services and tools for energy, mobility and quadruple stakeholder involvement; (4)To develop a dashboard of city performance in these fields; and (5)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).

Links with other modules: the data hosted by the platform will be drawn from the other Eindhoven modules.

Socio-technical configuration of the module

This module integrates three technologies: (1) an open data platform (developed on Socrata platform); (2) App ecosystem and (3) city dashboard.

The stakeholder structure of the module

The module is being led and implemented by Eindhoven municipality, who will: coordinate activity; define and acquire the data to be hosted on the platform; maintain the platform and monitor use; and, promote use of the platform through open data challenges.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The expected impacts of this module include mainly two perspectives, which are more inclusive society and ICT development for smart city.

Table 45, below, provides details of the indicators developed for this module. Table 46 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
441001	Promoting commercial activities	Smart apps developed using open data platform.	Nr	7	2014Jan - 2014Dec	Open data	Counted	Y	N	
441002	Promoting commercial activities	Use of open data platform-Nr of viewed times (data.eindhoven.nl)	Nr	514016	2014Jan - 2014Dec	Open data	Calculated based on data platform analytics	N	U	
441003	Promoting commercial activities	Use of open data platform-Nr of active view times(data.eindhoven.nl)	Nr	100	2014Jan - 2014Dec	Open data	Calculated based on data platform analytics	N	U	
441004	Developing a digital infrastructure	Nr of data base of portals	Nr	4	2014Jan - 2014Dec	Open data	Calculated based on data platform specs	N	U	
441005	Developing a digital infrastructure	Nr of data base of data files	Nr	93	2014Jan - 2014Dec	Open data	Calculated based on data platform specs	N	U	
441006	Developing a digital infrastructure	Platform functions(data.eindhoven.nl)	Nr	7	2014Jan - 2014Dec	Open data	Calculated based on data platform specs	N	N	

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
441007	Developing a digital infrastructure	Data handling capability (Max)	Gb	5	2014Jan - 2014Dec	Open data	Counted	N	N	

Table 45: Impact assessment indicators and baseline data for Module 441

Dataset name	Dataset description	Related impact factors	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Open data	Eindhoven open data platform data	441001 441002 441003 441004 441005 441006 441007	Y	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Data is provided by Eindhoven open data platform record	

Table 46: Datasets potentially to be used in the calculation of impacts for Module 441

4.5.2 Module 422: Interactive energy retrofit for dwellings (Subtask 4.4.2 + Subtask 4.4.3)

Module Objective: To understand impacts and benefits of WoonConnect tool and citizen dialogue on tenants and private houses owners

Approach: the module is to develop a 3D-ICT tool to facilitate an interactive refurbishment process by allowing the tenants to manage their energy consumption. The tool could visualize chosen measures and presents the cost effects in terms of rent/costs. It also enables tenants to compose the combination of measures and plan the moment of realisation energy costs simultaneously. Meanwhile, it creates a database of possible solutions and measures matching to a specific type of housing and creates a live 3D BIM archive of housing stock to be used for future maintenance. Moreover, It supports the process by registering decisions and generating all necessary documents.

The refurbishment will be executed individually (the series-of-one) and will be executed in a way that makes it possible for the tenants to stay in their homes during the retrofitting activities. In addition, the same tool, with the necessary adaptations depending on the situation will be made available to the 3,253 houses in the area that are in private ownership or belong to other corporations, on the basis of the individual characteristics of every dwelling.

The module is going to stimulate tenants and private house owners to renovate their homes using WoonConnect tool and citizen dialogue, which are developed by WoonConnect and Woonbedrijf. The objective of the module is to reduce household energy consumption and CO_2 emission in the whole Eckart-Vaartbroek area.

First year progress. There are three main activities have been implemented in the first year. First, 1300 dwellings are implemented in WoonConnect on level 1 (virtual 3D-model of the dwellings based on the original drawings). Second, the web-based survey design has been implemented. This survey was designed in collaboration with subtask 4.4.3. 'Eckart-Vaartbroek area: Stimulating private owners and other housing corporations in the area to follow'. Third, the process to upgrade Woonconnect to level 2 (an accurate digital 3D-version of reality) for the first 200 dwellings has been initiated.

To understanding resident opinion about their living environment (neighbourhood and own houses), a web-based questionnaire has been prepared for collecting household data of socio-demographic, environmental opinion, in-home energy consumption behaviour, energy consumption, satisfaction with neighbourhood, satisfaction with personal living environment etc..

Links with other modules: the module is linked with "Renovation of family homes Eckart-Vaartbroek & creation of participative society module (Subtask 4.2.4)".

Socio-technical configuration of the module

The 3D-ICT tool called WoonConnect that has been developed by KPN.

The stakeholder structure of the module

Woonbedrijf is the main stakeholder of this module for the tenants. KPN is the main stakeholder of this module for the private house owners. Woonconnect is the subcontractor in this module, who will provide the 3D-ICT tool.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The module aims to produce an interactive refurbishment process, allowing the tenants to manage their energy consumption through the use of innovative ICT applications. Our focus of this module is to measure the replication progress, improvement of energy efficiency and improvements to the quality of life. Table 47 below, provides details of the indicators developed for this module. Table 48 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. unit	Baseline value	Baseline period	Datasets to be used in calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
442001	Wide scale deployment/ dissemination of project results	Amount of buildings retrofitted / smartified from tenants	Number of buildings converted /yr, m2 converted /yr	0	2014Jan - 2014Dec	Woonconnect data tenants	To be calculated based on woonconnect data and agreement with residents	N	N	
442002	Wide scale deployment/ dissemination of project results	Amount of buildings retrofitted / smartified from private owners	Nr. of private owners willing to make renovation	0	2014Jan - 2014Dec	Woonconnect data private owners	To be calculated based on woonconnect data and agreement with residents	N	N	
442003	Wide scale deployment/ dissemination of project results	Reduction in monthly energy bills on average	% gas	Not yet available until renovation completed	2014Jan - 2014Dec	Woonconnect data tenants Woonconnect data private owners Public energy data	To be calculated based on woonconnect data and public energy data	Y	U	Stay in contact with Woonbedrijf & KPN (M37-M48)

Impact indicator identifier	Impacts	Impact Indicators	Quant. unit	Baseline value	Baseline period	Datasets to be used in calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
442004	Wide scale deployment/ dissemination of project results	Reduction in monthly energy bills on average	% electricity	Not yet available until renovation completed	2014Jan - 2014Dec	Woonconnect data tenants Woonconnect data private owners Public energy data	To be calculated based on woonconnect data and public energy data	Y	U	Stay in contact with Woonbedrijf & KPN (M37-M48)
442005	Wide scale deployment/ dissemination of project results	Payback periods for specific demonstration activities (Average payback year)	Years	Not yet available until renovation completed	2014Jan - 2014Dec	Woonconnect data tenants Woonconnect data private owners	To be calculated based on woonconnect data	Y	U	Stay in contact with Woonbedrijf & KPN (M37-M48)
442006	Reduce CO2 emission	Primary energy usage for electricity	KWH/yr	Not yet available until renovation completed	2014Jan - 2014Dec	Woonconnect data tenants Woonconnect data private owners Public energy data	To be calculated based on energy information from Woonconnect and public energy data	Y	U	Stay in contact with Woonbedrijf & KPN (M37-M48)

Impact indicator identifier	Impacts	Impact Indicators	Quant. unit	Baseline value	Baseline period	Datasets to be used in calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
442007	Reduce CO2 emission	Primary energy usage for gas	m3 /yr	Not yet available until renovation completed	2014Jan - 2014Dec	Woonconnect data tenants Woonconnect data private owners Public energy data	To be calculated based on energy information from Woonconnect and public energy data	Y	U	Stay in contact with Woonbedrijf & KPN (M37-M48)
442008	Reduce CO2 emission	Greenhouse gas emissions	Kg/yr	Not yet available until renovation completed	2014Jan - 2014Dec	Woonconnect data tenants Woonconnect data private owners Public energy data	To be calculated based on energy information from Woonconnect and public energy data	Y	U	Stay in contact with Woonbedrijf & KPN (M37-M48)

Table 47: Impact assessment indicators and baseline data for Module 422

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Woonconnect data tenants	Woonconnect data from tenants	442001 442003 442004 442005 442006 442007 442008	N	Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	U	Privacy issue of this dataset is unclear.	Discuss privacy issues with Woonbedrijf (M27-M36) Stay in contact with Woonbedrijf to collect data after renovations. (M37-M48)
Woonconnect data private owners	Woonconnect data from private house owners	442002 442003 442004 442005 442006 442007 442008	N	KPN	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	U	Privacy issue of this dataset is unclear.	Discuss privacy issues with KPN (M27-M36) Stay in contact with KPN to collect data after renovations (M37-M48)
Public energy data	Data for the Eckart-Vaartbroek district collected from national open data platforms 'Nationale energieatlas' and 'Energie in beeld'	442003 442004 442006 442007 442008	Y	Dutch government	N/A	Y	These datasets are NOT part of the Triangulum project but used as a reference	Discuss with Woonbedrijf and KNP how to aggregate public and private datasets for impact calculation

Table 48: Datasets potentially to be used in the calculation of impacts for Module 422

4.5.3 Module 443: Smart environment fibre-optic data infrastructure (Subtask 4.4.4)

Module Objective: To understand the impacts and benefits of backbone infrastructure development of fibre-optic.

Approach: the project is to develop the second phase of Backbone, which is a strong fibre-optic data infrastructure includes the hardware and software. The second phrase will extend the control and monitoring possibilities of Backbone to include other systems such as parking, in-building (domotica) and urban media information or entertainment applications. Moreover, the second phrase will extend the Backbone for the entire Strijp-S area throng the addition of a new generation innovation middleware. It targets to provide high-quality urban environment with highest possible service level to all users of the area. Furthermore, during the project period, a Multi-Protocol Label Switching (MPLS) will be implemented which enables the communication between different information/data. The Backbone, which consists of a passive (fibre-optic cable) and an active layer, follows the grid of public lighting points. This enables connections to a fine grid of 1 GB bandwidth. The MPLS approach connects the Backbone with a fibre-optic structure coupled to dwellings and buildings. This includes the data networks of Mobility-S and Office-S. The result is a "Smart Environment" that enables the environment to respond to "triggers" like weather, public events, and emergencies and communicates with the inhabitants as well. The partners will also deploy an integrated ICT system to manage the smart environment.

First year progress: During the first year, several main activities have been conducted. At the beginning of 2015 a first integration of traditionally different ICT networks was successfully implemented at Strijp-S by integrating the on-street parking facilities of Mobility-S on the Backbone. The project has two phrases, which are indoor phrase and outdoor phrase. For the indoor phrase, the engineering MPLS network started around April, 2015. The implementation of the MPLS network started in July, 2015. The upgrade of the office-S started in November 2015. The Office-S network is designed in such a way that it can be connected to the Backbone as soon as the Backbone is totally ready. By doing this the ICT network of up to 300 companies that are located at Strijp-S (in the buildings SX and VideoLab) will share the same Strijp-S network as for example the lighting system and mobility facilities. The development of the houses that also will be integrated on the Backbone is progressing well. 200 apartments will be built in 2016. There is a plan to connect their commercial network from KPN with fibre-optic network. It is under the decision making progress of how to make the connection. The decision (whether to build a para-network or connect KPN network to the backbone) and implementation will be made during 2016.
For the outdoor phrase, there are two work streams.

1) **Building a soft layer on top of the fibre-optic infrastructure which is used as a secured information sharing platform above the sensors/devices network layer which supports multiple users to process information with special devices/sensors with different security requirements (such as municipality, traffic controller, policy officer etc.):** The platform architecture engineering has been started since February 2015. After intensive discussions and negotiations, two systems showed capability of handling the multiple users requirements with different security levels. These systemsare the IBOR system (from CGI) and the Smart Society Service (from Alliander). The biggest obstacle of the progress is to get an estimated price and requirements list. This takes much longer than expected. The decision is going to be made around March 2016. Implementation will take place from upon April 2016.

2) **Extend and improve the fibre-optic infrastructure:** The old fibre-optic infrastructure used the standard of multimodal. To be consistent with the future standards, the second phrases will follow the single modal and place single fibre-optic cables. The tube network has been constructed in 2013. To make the network capable of coping the new standards, the re-engineering is conducted in 2015. To satisfy different future needs (security issues) from various parties, every lamp pole will house 8 or more fibre to increase the durability and the functionality of the system. The preparation of the new fibre-optic engineering plan has been finished in 2015. The engineering plan has been presented in December 2015. The plan will be reviewed to build a RFQ (Request for Qualification) to get a subcontractor for construction. The implementation is planned in Q1 of 2016. The new fibre-optic infrastructure will have a Multi-Protocol Label Switch (MPLS). The engineering of this MPLS feature started in January 2016 and will be ready in Q4 of 2016.
3) **Add wireless connectivity to the network:** The fibre-optic infrastructure creates a phsycial connection. A wireless and public wifi network will be added to this infrastructure to make sure the backbone can also be used by locals and professionals with mobile phones and tablets. The public wifi network will make use of small cells. The engineering of the network will be finished in March 2016. The network is scheduled to be delivered in January 2017.

The progress started later than scheduled due to uncertainty of VolkerWessels iCity involvement.

Links with other modules: it is the backbone module in Strijp-S. It supports other modules in Strijp-S, such as “Smart energy saving offices on Strijp-S”, “Smart charging of electric vehicles on Strijp-S”, “Mobility management on Strijp-S” and “Sensor network in the public space”.

Socio-technical configuration of the module

Technologies: MPLS network; single-modal and multimodal system; protocol layer for ALIS (open potocal it is a uniform protocol – for the software layer – it should be uniform prove via the ALIS portcol 2016)

The stakeholder structure of the module

The main stakeholder is VW iCity.

The indicators to be used for assessing the impacts and benefits and baseline conditions

According to the discussion with project manager, the key success indicators have been identified and mainly focus on three perspectives, which are building an enabling data infrastructure, promoting engagement with data and building smart environment as shown in Table 49. Table 50 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
443001	Developing a digital infrastructure	Fibre-optic network expanded by connecting homes	Nr.	0	2014Jan - 2014Dec	Fibre-optic network data	Counting	Y	N	
443002	Developing a digital infrastructure	Fibre-optic network expanded by connecting offices	M_2	23.000	2014Jan - 2014Dec	Fibre-optic network data	Counting	Y	N	
443003	Developing a digital infrastructure	Fibre-optic network expanded by connecting lamp pole	%	30	2014Jan - 2014Dec	Fibre-optic network data	Counting	N	N	
443004	Fostering citizen engagement (Co-creation)	r of types of data available on the platform	Nr	0	2014Jan - 2014Dec	Fibre-optic network data	Counting	N	N	

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
443005	Fostering citizen engagement (Co-creation)	Nr of users of soft platform	Nr	0	2014Jan - 2014Dec	Fibre-optic network data	Counting	Y	N	

Table 49: Impact assessment indicators and baseline data for Module 443

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Fibre-optic network data	Fibre-optic network data from MPLS network	443001 443002 443003 443004 443005	N	VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	The data should be available after building platforms.	Further data collection request need to be send out to get the baseline data (M27-M30)

Table 50: Datasets potentially to be used in the calculation of impacts for Module 443

4.5.4 Module 444: Public space sensor network (Subtask 4.4.5)

Module Objective: To understand the impacts and benefits of improving the public space by installation of sensors.

Approach: The existing advanced public lighting system, developed through the Light-S programme, is capable of 16 million colours and light intensities to 1.5 times the Dutch regulations. To adapt the lighting to the actual circumstances within the environment, a sensory field is needed. Sensor systems can include IR detection, but also Bluetooth or RF-ID. The sensor network allows for the meaningful development of additional and innovative services. In this task, a bottom up dialogue approach will be conducted to understand inhabitants' needs. According to their needs, services will be developed, such as open WIFI. The installation of sensors in the public space will generate all kind of new data, such as people density, traffic, weather, sound, and pollution. This data will be connected to the existing platform of the municipality of Eindhoven.

First year progress: A bottom up dialogue approach has been conducted during March to May in Strijp-S to understand the social needs in Strijp-S. Based on the results of this study, safety issue has been identified as one of hottest issues in Strijp-S. During the last 10 years, Philips workers gradually left the area when office buildings were closes. With the re-generation of this area, almost 1000 inhabitants are living in Strijp-S now. However, unsafe feeling is spreading with weak social control and a few accidents happened. To improve the quality of life, sensor project is going to be implemented in the area together with the smart lighting system and the Backbone. The sensor network engineering started in July, 2015. A first pilot network of sound sensor has been implemented within the smart lighting system and the backbone in January 2016 but was extended with other sensor networks in 2016.

Sound sensor network

- A bottom up dialogue approach was conducted during M2 - M4 in Strijp-S, to understand the social needs in Strijp-S. Based on the results of this study, safety issues were identified as one of the hottest issues in Strijp-S. To improve the quality of life, the sound sensor project is going to be implemented in the area together with the smart lighting system. Both will be connected to the Backbone.
- The sound sensor network engineering started in M6. A first pilot of sound sensors has been implemented within the smart lighting system and the backbone in M11. The purpose of the system is to detect safety issues within the public spaces based on sound reorganization algorithms. For instance people shouting, loud noises can be detected and will be alerted for further uptake of action.
- The iOS App caused some delay because it took a couple of months to be approved by Apple.
- The pilot with the inhabitants of Strijp-S is planned in M25. Afterwards the system will be evaluated.
- If the system performs well, the sound sensor system will be extended to other areas of Strijp-S.

Video sensor network

- The video sensor project which started in M16 will be attached on the existing sound sensor project to explore the possibilities of a combination between sound analytics and video analytics. It will be fully implemented in the sound sensor case if the results are positive. The

camera's will also be used by the mobility program. For instance to detect accidents, cars, bicycles, pedestrians and license plates.

Sound sensor network

- The indoor air quality project was started in M17 to make people aware of the quality of their living environment. Currently feedback is being collected to explore the potentials of the system. The final goal is to implement the system outside as well. This will also create possible crossovers. Besides being used by the current smart office management system, air quality data can also be used by parking garages or at public event locations.

Water sensor network

- To enable monitoring and smart maintenance to the sewer of Strijp-S a water sensor network is being prepared. This sensor network will be connected to the Backbone. The preparation of the network started in M20 and will be ready in M26.
- The roll out of the sensors in the sewer of Strijp-S will be ready in M36.

Links with other modules: Selected data collected from smart office sensor may be shared on the Eindhoven open data platform, however no discussion conducted yet. The module also links with module "Second phase of implementation and integration of the fibre-optic data infrastructure".

Socio-technical configuration of the module

There are three main technologies: sound sensor, video sensor, sewer sensor and remote control App called "Strijp-S App".

The stakeholder structure of the module

VW iCity is the main stakeholder. Besides VW iCity, Sorama is an important stakeholder. Sorama is a SME which is housed in Strijp-S.

The indicators to be used for assessing the impacts and benefits and baseline conditions

According to the discussion with project manager, the key success indicators have been identified and mainly focus on three perspectives, which are building an enabling data infrastructure, promoting engagement with data and improvement of quality of life as shown in Table 51. Table 52 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
444001	Fostering citizen engagement (Co-creation)	Nr. of citizens involved in project-planning	Nr.	20	2014Jan - 2014Dec	Interview data	Counting	Y	N	
444002	Developing a digital infrastructure	Improved public space by install sound sensors	Nr	0	2014Jan - 2014Dec	Sensor & App data	Counting	N	U	
444003	Developing a digital infrastructure	Improved public space by install video sensors	Nr.	0	2014Jan - 2014Dec	Sensor & App data	Counting	N	U	
444004	Developing a digital infrastructure	Improved public space by install water sensors	Nr.	0	2014Jan - 2014Dec	Sensor & App data	Counting	N	U	
444005	Developing a digital infrastructure	Improved public street lighting by promoting App used by citizens	Nr.	0	2014Jan - 2014Dec	Sensor & App data	Counting	N	U	
444006	Improvement of quality of life	Recorded happiness of residents and workforce (safety)	Descriptive data	Available, but not quantifiable	2014Jan - 2014Dec	Interview data	Descriptive analytics from interviews	N	N	

Table 51: Impact assessment indicators and baseline data for Module 444

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Interview data	Interview report (An interview has been conducted in Strijp-S with focus group to understand their needs)	444001 444006	Y	VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	The data is unclear yet whether it is available publicly or privately.	Contact VW to decide publicity (M27-M30)
Sensor & App data	Sensor data and App data from residents at Strijp-S	444002 444003 444004 444005	N	VW/ residents	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	The data is unclear yet whether it is available publicly or privately.	Contact VW to check if Sensor & App data is available (M27-M36)

Table 52: Datasets potentially to be used in the calculation of impacts for Module 444

4.5.5 Module 445: Smart city innovation fund (Subtask 4.4.6)

Module Objective: to understand the impacts and benefits of stimulating the development of innovative services and applications

Approach: Within this task start-ups and SME's will be asked to develop innovative products and/or services within the themes safety and comfort, energy and mobility, fun and entertainment. The requirements of the products and/or services will match the Triangulum goals and add extra value to the current work packages. This will make sure solutions are scalable and replicable. This will also make sure solutions will add extra value to the project.

First year progress: This task was originally a Stimulus/revolving fund. In M13, it was discovered that the funding scheme was not eligible under H2020 and the current EU work program. The Stimulus fund was transformed into the 'iCity Tender'. This change was the main reason for the second amendment of the GA: AMD-646578-29. The amendment letter together with the revised DoA was sent to INEA in M17 for internal revision and was officially accepted on 19th July 2016 (M18).

In M15 the design of the iCity tender was created by TU/e's Innovation Lab and VolkerWessels iCity in collaboration with the municipality of Eindhoven. In M17, the website of the iCity tender and the planning was prepared: http://strijps.nl/nl/icity-tender. In total 63 proposals were collected from which 42 were filled in correctly. The 20 best proposals were selected in M20.

In M21 the first iCity Tender Event took place. During this event participants had to pitch their ideas in front of an independent jury. At the end 19 participants continued in the process. In M24 the output from the first phase will be presented to the iCity Tender Committee. The best participants will be asked to present their progress during the 2nd iCity Tender Event in front of an jury. The 2nd iCity Tender Event is scheduled in M25. The final products/services will be presented in M33.

Links with other modules: start-ups and SME's will make use of the infrastructure of Strijp-S (WP4.2, 4.3 and 4.4)

Socio-technical configuration of the module

The iCity Tender consists of two phases. During the first phase, a maximum of 20 start-ups and SMEs will receive a maximum budget of €5K ex. VAT to develop their proposal into a concept. During the second phase, the best start-ups and SMEs will have the opportunity to receive a budget of maximum € 20K ex. VAT to develop their concept into a proof of concept or prototype.

Products and/or services must:

- Be innovative (factor: 10%)

This means that new products and/or services must be new. This does not mean that the techniques which are used have to be completely new.

- Improve the quality of life (factor: 20%)

We are not aiming for technological gimmicks. Therefore new products and/or services have to add extra value to the end-user. This value can be added directly (e.g. products/services which can be used directly by end-users), but also indirectly (e.g. improvement of the quality of the environment in which the end-user lives)

- Be developed within the described Smart City layers (factor: 10%)

Our smart city consists of three layers. The 'cloud layer' houses all data and online traffic. Analysis, communication and content development all take place in this layer. Next is the 'liveable layer': the tangible part of the city. The streets we walk in and the doorknobs in our hands. Finally, there is the 'infrastructure layer': roads, railways, pipes and optical fibre cables. The interaction between these layers makes the city smart. New products and/or services need to be developed within these layers. They also need to stimulate crossovers between these layers.

- Have an influence on the public space (factor: 5%)

It is important that everybody can benefit from the services and/or products. Therefore products and/or services need to be developed within the public domain.

- Be generic and replicable (factor: 20%)

To make sure products and/or services can be used by other cities as well it is important that products and/or services are generic. This means that solutions are not Strijp-S specific. It should be easy to adjust and replicate the proposed products and/or services.

- Be scalable (factor: 10%)

This means that the market in which the products and/or services will be developed has a high potential for growth.

- Increase employment within the area Strijp-S (factor: 5%)

New products and/or services need to increase employment within the area in which they will be developed. Therefore it is important that locals are involved in the process. Not only during the development in Strijp-S, but also during the development process in other cities.

- Have a solid and transparent business model which is based on competitive prices (factor: 20%)

It is important that the proposed solutions have a solid and transparent business model. We are not aiming to stimulate businesses which can only exist with the financial help of third parties. We are aiming to stimulate future proof businesses. It is important that proposed costs are based on competitive prices.

The stakeholder structure of the module

TU/e - Innovation Lab (IL) and VolkerWessels (VW) are the coordinators of the module. The municipality of Eindhoven (EIN) is responsible for the budget.

The indicators to be used for assessing the impacts and benefits and baseline conditions

According to the discussion with the coordinators, the key success indicators have been modified and mainly focus on two perspectives, which are job creation and Wide scale deployment/

dissemination of project results as seen in Table 53. Table 54 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
445001	Promoting commercial activity	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr	0	2015	Innovative services	N/A	Y	N	
445002	Promoting commercial activity	SMEs created	Nr	0	2015	Innovative services	N/A	N	N	
445003	Promoting commercial activity	Jobs created (Full time equivalent)	Nr	0	2015	Innovative services	N/A	Y	N	
445004	Wide scale deployment/ dissemination of project results	SMEs development Turnover	€/yr	0	2015	Innovative services	N/A	Y	N	
445005	Wide scale deployment/ dissemination of project results	Generate large-scale investment - Venture capital	€	0	2015	Innovative services	N/A	Y	N	
445006	Wide scale deployment/ dissemination of project results	Generate large-scale investment - Commercial value	€	0	2015	Innovative services	N/A	Y	N	

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
445007	Wide scale deployment/ dissemination of project results	Software and application development (Nr. of apps registered)	Nr.	0	2015	Innovative services	N/A	Y	N	

Table 53: Impact assessment indicators and baseline data for Module 445

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	To be collected beyond M60	Comments	WP02 next steps
Innovative services	Data on request - Stimulating the development of innovative services / applications	445001 445002 445003 445004 445005 445006 445007	Y	VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	These indicators are generated after discussion with the TUE - Innovation Lab (IL). The data will be collected by request. No specific dataset will be used for calculating the impacts.	Data will be provided by request. (M27-M48)

Table 54: Datasets potentially to be used in the calculation of impacts for Module 445

4.5.6 Module 446: Smart streetlights for social interaction and health route (Subtask 4.4.7)

Module Objective: To understand the impacts and benefits of upgrading a 1-km pedestrian route into a social interaction and health route for diverse groups of neighbourhood.

Approach: Centred in the middle of the Eckart-Vaartbroek district, a 1-km unlit pedestrian route is not frequently used. The project targets on upgrading the route into a social interaction and health route by lit with extremely energy efficient LED lighting. It is self-sufficiently fed by PV produced energy and equipped with battery storage. It will also carry extra functions such as WIFI and sensors, which will enable and provoke the use of smart connections with surrounding facilities and users/visitors. It aims to create an ultimate integration of a safety and quality impulse of public space through ICT. One of the important components in this project is co-creation. It will involve citizens in the decision process.

First year progress: According to the mid-term progress report, Eindhoven municipality has cooperated with industrial design of the Eindhoven University of Technology to design social interaction in the neighbourhood. Three case studies were delivered. One of these studies in particular gives insights how to approach and connect people in the smart streetlights project. In the spring of 2015 the area coordinator EV (gebiedscoördinator) began exploring the potential of the smart street lights project for the neighbourhood and how to optimize a participating role of the inhabitants in this project. In Nov. 2015, a project manager is employed and started communication plan.

Links with other modules: The dialogue method is the basis for the communication plan of Eckart-Vaartbroek related modules which include “Renovation of family homes Ecart-Vaartbroek & creation of participative society”, “Installation and smart distribution of locally produced renewable energy”, “Interactive process for dwellings in Eckart-Vaartbroek” and “Stimulating private owners and other housing corporations in the Eckart-Vaartbroek area to follow”. In all these modules, dialogue with the inhabitants living in Eckart-Vaartbroek is a key element that connects the various tasks.

Socio-technical configuration of the module

Dialogue method

The stakeholder structure of the module

Eindhoven municipality is the main stakeholder of this module. With the communication plan, the cooperating partners include VW, Woonbedrijf and KPN. The implementation partners are under investigation. The stakeholder structure will be decided in the beginning of 2016.

Table 55, below, provides details of the indicators developed for this module. Table 56 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
446001	Fostering citizen engagement (Co-creation)	Adoption of co-creation procedure by involving citizens in the decision process	Nr.	0	2014Jan - 2014Dec	Dialogue method	Counting	N	N	
446002	Improving the quality of life	Improved public street lighting by installing lights pole	Nr	Not yet available because waiting for new street lighting	2014Jan - 2014Dec	Sensor data	To be calculated based on sensor data	N	U	Stay in contact with Eindhoven municipality (M30-M36)
446003	Improving the quality of life	Improved public street lighting by sensing density of people in the street	Nr. per m2	Not yet available because waiting for new street lighting	2014Jan - 2014Dec	Sensor data	To be calculated based on sensor data	N	U	Stay in contact with Eindhoven municipality (M30-M36

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS	Auto. calc.	WP02 next steps
446004	Improving the quality of life	Recorded well-being of residents	Recorded overall well-being 1-5 (low to high awareness	Not yet available	2014Jan - 2014Dec	District monitor	To be calculated based on various indices from district monitor.	N	U	Collaborate with municipality to define overall well-being (M27-M30)

Table 55: Impact assessment indicators and baseline data for Module 446

Dataset name	Dataset description	Related impact indicators	Available at M24	Dataset owner	Dataset contact	Tobe collected beyond M60	Comments	WP02 next steps
Dialogue method	Interview data based on Dialogue method: Design thinking	446001	Y	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	N	Design thinking method was use to involve citizens: observations, interviews, house to house calls, creative design events.	
Sensor data	Sensor data from light poles	446002 446003	N	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	The sensor data might be open for public	Contact municipality to check if available (M27-M36)
District monitor	Excerpt from district monitor data collected by municipality on yearly basis ('Buurtmonitor')	446004	Y	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Y	Data is available	

Table 56: Datasets potentially to be used in the calculation of impacts for Module 446

4.6 Schedule of 2016

During 2016, WP02 activity will focus on data gathering and deliver of the interim impact report. Additional activities will explore the potential to capture the governance and social impacts of the Triangulum modules. A brief overview of proposed WP02 2016 activity in Eindhoven is shown in Table 19.

	Primary focus of WP02 activity in Eindhoven	**Additional WP02 activities**
Jan-Mar 2016	In collaboration with Eckart-Vaartbroek partners, develop impact indicators of measure co-creation/resident participation and identify sources of baseline data for these indicators.	Research focussed on capturing the: • governance impacts of Triangulum in Eindhoven, possibly by using an electronically administered survey to partners and analysing the interview data from WP06 city visits; • social impacts of Triangulum in Eindhoven through complementary social science research projects.
Apr-Jun 2016	In collaboration with Strijp-S partners, develop method to measure the impact on resident behaviour and identifying sources of baseline data.	
Jul-Sept 2016	Research focused on developing a systematic method to compare and analyse impacts of indicators and data.	
Oct- Dec 2016	Gathering data for, and producing, the WP02 interim report (Deliverable 2.4)	

Table 57: High-level overview of planned impact assessment and monitoring activities in Eindhoven

5 Stavanger Baseline

The Stavanger report presents a strategic overview of the on-going process of understanding the scope of the Triangulum modules being implemented in Stavanger, and the development of a set of indicators and baseline data to assess the impacts of these modules. This report is organised into seven sections.

Section 1 provides a high-level description of the City of Stavanger, and highlights the smart city initiatives taking place which complement Triangulum. Section 2 identifies the potential of Triangulum modules to contribute to meeting city objectives. The section concludes with an outline of the WP02 approach to developing indicators for each of the Stavanger modules.

Section 3 describes the Energy modules in detail, including objectives, socio-technical configurations and stakeholder structures. The indicators to be used for assessing the impacts and benefits of the module and the current understanding of baseline conditions are then presented. Sections 4, 5, and 6 provide module descriptions and impact indicators for the ICT, Mobility, and Citizen Engagement modules, respectively.

Section 7 offers an initial evaluation of the process used to develop the impact indicators and aggregate baseline data; followed by a high-level overview of the planned impact and assessment and monitoring activities in Stavanger during 2016.

5.1 Smart city initiatives in the City of Stavanger

Stavanger holds the status as the European capital of Energy. The city aims at becoming one of Europe's foremost sustainable cities by integrating ICT, energy and mobility. The city of Stavanger has a long tradition of citizen involvement, which is crucial for developing smart, integrated solutions.

Stavanger has a well-developed ICT business cluster. The experience from deliveries to offshore industry combined with high speed fibre optics have led the region ahead to service development based on existing infrastructure in an innovative way. As the region expects a population growth of approximately 30% by 2030, integrated solutions will be the key to develop smart and sustainable solutions for citizens. The energy system is almost totally based on renewable sources (hydroelectric), hence energy storage is established through the fjord, lakes and falls connected to the production system. Smart grid components include load management, surveillance and data analysis.

In some relevant parts of the city, 60% of houses already have high-speed fibre solutions installed. The next step of transformation is integration by installing the smart generic gateway in public buildings and private homes. Stavanger holds the highest density of electrical cars in Europe, and the charging challenge for electrical vehicles is already a pressing issue. Through a variety of energy and mobility demos which build on the existing high speed ICT infrastructure, Stavanger aims at integrating energy and mobility solutions in an innovative and smart way. Citizens and replication are at the centre of the integration aim

In addition to Triangulum, Stavanger is the site of smart city initiatives including

1. Smart City initiative led by the municipality to heat commercial buildings as well as municipal buildings in the city centre.
2. Nordic Edge Expo, an annual conference to promote knowledge exchange between businesses and other actors in the field of smart homes and smart cities.
3. Local start-up culture focusing on smart homes and smart cities, with events such as the Startupbootcamp Smart City & Living program.
4. Open data project in the city, including cooperation with Stavanger Hackathon.
5. VOF, an app where citizens can give information about errors in the municipal infrastructure.
6. Some parts of the city have installed waste containers with automatic sensors providing information about the amount of waste in the containers, and whether there is a need for waste collection.

5.2 The City of Stavanger modules overview

5.2.1 The role of Triangulum modules in supporting city-level objectives

We have identified that the 8 Triangulum modules (described below in sections 3, 4, and 5) support Stavanger objectives: (1) reducing energy consumption of buildings; (2) increasing utilisation of electric vehicles; (3) holistic residential solutions; (4) increase energy efficiency; and (5) fostering citizen engagement with digital infrastructure. **Table 58** shows where Triangulum modules may contribute to efforts to achieve these objectives.

Task Group	Module	Contributing to efforts to achieve objectives				
		Reduce energy consumption of buildings	Increase utilisation of electric vehicles	Holistic residential solutions	Increase energy efficiency	Fostering citizen engagement with digital infrastructure
Energy	Module 521: Smart gateway	*			*	
	Module 522: Central energy plant	*			*	
Mobility	Module 531: E-bus demonstration		*		*	
	Module 532: Electric vehicle charging infrastructure upgrade		*		*	
ICT	Module 541: Innovative video			*	*	*
	Module 542: Data analytics toolkit					*
	Module 543: Sustainable citizen service development	*		*		*
	Module 544: Cloud data platform					*

Table 58: Contribution of Triangulum Stavanger modules to achieving objectives

5.2.2 The process of developing module specific indicators

The Triangulum DoA outlined a preliminary series of expected impacts, and associated indicators, identified by the lead and follower cities. These indicators were further developed, based on in-depth analysis of bid documentation and feedback from the lead cities, and presented in deliverable 2.1 (Common Monitoring and Impact Assessment Frameworks) in July 2015. Subsequently a researcher has engaged extensively with the Stavanger consortium partners over a 5-month period (Sep 2015 - Jan 2015) to document the evolving scope of the modules and develop module-specific indicators. This engagement process is briefly outlined below.

1. Separate meetings were held with each local partner (task group) as well as researchers in Manchester and Eindhoven to develop the idea of the success or impact indicators in light of the partner's objectives in implementing the module. During these meetings the researcher and partner representatives identified indicators where data collection may be feasible or which were no longer aligned with the scope of the modules. Additional indicators were also identified, alongside potential sources of baseline data.
2. In some cases, there were several meetings throughout the engagement process with particular partners while the concept and process were elucidated.
3. In other cases, a single in-person meeting was held to define indicators for which data did, definitely would, or might plausibly exist and be available.

5.3 Energy Modules

The Energy task group is in the process of defining the scope of three modules to demonstrate the potential of smart and low carbon energy technologies. Hence, the module descriptions and proposed impact indicators presented below will be revisited and revised over the course of the project as module scope is refined.

- *Module 521: Smart gateway.* Installation of smart gateways enabling automated metering, which provide opportunities for end users to manage lighting, heating and cooling in a way that can meet both individual and community-level energy goals. Additionally, this will enable the energy provider to more precisely manage and plan the load variation
- *Module 522: Central energy plant.* Reducing energy consumption of buildings by delivering a more efficient and less CO_2-emitting heating system for multiple buildings within the Stavanger municipality.

Table 59 presents a summary of the expected impacts of each energy module and below detailed module descriptions are provided.

Task Group	**Module**	**Expected impacts**				
		Reduce energy consumption of buildings	Increase utilisation of electric vehicles	Holistic residential solutions	Increase energy efficiency	Fostering citizen engagement with digital infrastructure
Energy	Module 521: Smart gateway	*			*	
	Module 522: Central energy plant.	*			*	

Table 59: Expected impacts of Stavanger Energy modules

5.3.1 Module 521: Smart gateway (Subtask 5.2.1)

Module Objective: By increasing awareness among residents about their day-to-day energy consumption, more sustainable behaviours may emerge. The main benefit of this system is enabling the other services such as remote control of lights and doors. In addition, a significant range of end customer options for energy efficiency, heat and light control, safety, are enabled by this module. Finally, the installation of the smart gateway will enable the energy provider to more precisely manage and plan the load variation.

Approach: Within the Triangulum project, Lyse will install smart gateways (automatic measurement systems - AMS) in 100 residential and two public buildings, specifically a school and a nursing home. Existing fibre infrastructure facilitates the development of smart gateway capabilities.

Expected Impacts: The primary impact domain of the module is energy. In addition to energy savings for individual households, a flattening of peak demand on the electrical grid is expected.

Links with other modules: The smart gateway shares infrastructure and testing grounds with other modules led by Lyse, and exploring possible interactions between these modules may provide value in and of itself.

Socio-technical configuration of the module

The user types for the smart gateway module are implied by the Approach description: School, nursing home, households with an electrical car, and households without an electrical car. Given the scope and nature of the demo, further precision may not be possible. Unless otherwise noted, this means the smart gateway will measure activity based on the decisions of several persons in each building.

The stakeholder structure of the module

Lyse leads this module. The privacy rights of individuals may be more of a concern regarding data in this module than in modules that primarily involve public buildings/spaces or are otherwise less sensitive. This module corresponds to “Subtask 5.2.1 Smart gateway introduction and energy management” in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 60, below, provides details of the indicators developed for this module. Note that carbon emissions measurement data does not exist, and could be estimated from electricity consumption

according to the method used in the municipality, but this would require further consideration and discussion.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M14 (2016):*** Data collection was automated to Lyse internal database, but privacy concerns regarding home owners were not fully resolved. Hence limited transfer of data to UiS servers.
- ***M20 (2016):*** UiS working on automating a scalable system of data collection integrated with the automated assessment of impact indicators. The challenge for UiS is to accommodate a variety of specific data storage solutions at module task groups while capturing adequate metadata for Triangulum reporting.
- ***Next steps:***
    - Work with Lyse data contact to develop the process of initiating automated data collection with information from the Triangulum Impact Data Intake Form (DIF).
    - Implement stop-gap measure to collect data at UiS by provisioning virtual cluster to Lyse data contact.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
521001	Installation of smart gateways	Count of smart gateways installed	Dimension less integer	2	Jan 2015	Lyse smart gateway data set	Count of unique sensor identifiers.	N	Y	Collaborate formula from Lyse via DIF (M26-M30)
521002	Reduced energy consumption. Buildings' consumption of electrical energy via smart gateway	Mean of annual energy consumption per residence	kWh	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
521003		Variance of annual energy consumption per residence	MW^2h^2	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
521004		Mean of annual energy cost per residence	NOK	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
521005	Reduced energy consumption. Buildings' consumption of electrical energy via smart	Variance of annual energy cost per residence	NOK^2	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
521006	gateway	Annual mean of electricity price per kWh	NOK	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
521007		Annual variance of electricity price per kWh	NOK^2	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
521008	Flattening peak demand Flattening peak demand	Mean of intradiurnal mean of hourly energy consumption per residence	kWh	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
521009	Flattening peak demand Flattening peak demand	Mean of intradiurnal variance of hourly energy consumption per residence	$M\ W^2h^2$	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Table 60: Impact assessment indicators and baseline data for Module 521

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Lyse smart gateway data set	Azure DocumentDB/MongoDB aggregation of sensor data from smart gateways installed. { triangulum.lyse_events }	521001 – 521009	Y	Lyse	Pål Evensen (paal.evenson@lyse.no)	N	U		Provide DIF to data owner. (M26-M30)

Table 61: Datasets potentially to be used in the calculation of impacts for Module 521

5.3.2 Module 522: Central energy plant (Subtask 5.2.2)

Module Objective: Stavanger municipality will develop a more sustainable heating system for multiple buildings. This system is called the *Central Energy Plant* (Energisentralen) and will heat select administration buildings using at least 75 % of energy from renewable sources. The Central Energy Plant is centred in a central administrative building at Olav Kyrres gate 19 (OK19).

Approach: The specific approach to implementing the Central Energy Plant is still under deliberation. However, the initial concepts of a geothermal well park and pellet-burning heaters have been found to be impossible in the context of local constraints. A recent review has recommended a new approach, the adoption of which will be decided later in January 2016.

Expected Impacts: The primary impact domain of the module is energy. The Central Energy Plant will reduce CO_2 emissions through efficient heating systems based on renewable energy sources. Note that the estimations of CO_2 emissions are based on coefficients for each type of heating, developed by the Research Centre on Zero Emission Buildings.

Links with other modules: Depending on the form of the final implementation, the Central Energy Plant will produce high-resolution time-series data on several aspects of operations, which together with existing data of overall energy and heating energy consumption going back several years. These data are coordinated by the municipality's *Energioppfølgingssystemet* (EOS) and will be collected in the Cloud data platform (D2.2) and will provide a basis for a possible analysis of energy use and the impact on heating efficiency, using D5.4.2.

Socio-technical configuration of the module

The module will primarily heat administrative buildings and employees working within.

The stakeholder structure of the module

Municipality of Stavanger leads the Central Energy Plant module. This module corresponds to "Subtask 5.2.2 City goes zero – switching to renewables" in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 62, below, provides details of the indicators developed for this module. Note that carbon emissions measurement data does not exist, and could be estimated from electricity consumption according to the method used in the municipality, but this would require further consideration and discussion.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M12 2015:*** Module design was not yet determined.
- ***M24 2016:*** Module task group from Stavanger Municipality attended data technical workshop at UiS. The schema of energy data was not yet determined.
- ***Next steps:***
    - Request data contact from module task group leader and establish contact.
    - Discuss Triangulum Impact Data Intake Form (DIF) and begin process of filling in the necessary information, including necessary metadata.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
522001	Increased proportion of renewable energy sources	Percentage of renewable energy from renewable energy sources (Endres: %-vis endring energi/CO2 energisentral- før og etter rehabilitering)	Percentage	The time-scale is critical: With a target of 75 % renewable, both the cumulative percentage within a year and within a moving time-window on the order of a week should be monitored. However, a single percentage per year is likely best for reporting purposes.	Average 2013-2015.	Dataset to be determined together with Stavanger Municipality.	Formula to be determined.	N	Y	Request data set and formula from Stavanger Municipality via DIF (M27).
522002	Increased proportion of renewable energy sources	The total amount of energy consumed by each building, each year	kWh	Administration building - 1 149 836 Swimming area (public indoor pool) - 1 904 066 City hall: 983558 Administration Building - 1 281 841	Average 2013-2015	Dataset to be determined together with Stavanger Municipality.	Formula to be determined.	N	Y	Request data set and formula from Stavanger Municipality via DIF (M27).
522003	Increased proportion of renewable energy sources	The amount of energy consumed for heating by each building, each year	kWh	Baselines cannot yet be established	NO	Dataset to be determined together with Stavanger Municipality.	Formula to be determined.	N	Y	Request data set and formula from Stavanger Municipality via DIF (M27/2019).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
522004	Increased proportion of renewable energy sources	The amount of energy consumed for heating by each building, each year, from each energy source	kWh	The list of energy sources will be determined once the module approach has been decided	Average 2013-2015	Dataset to be determined together with Stavanger Municipality.	Formula to be determined.	N	Y	Request data set and formula from Stavanger Municipality via DIF (M27).
522005	Increased proportion of renewable energy sources	Variance of annual energy cost per residence	NOK^2	Baselines cannot yet be established	n/a	Dataset to be determined together with Stavanger Municipality.	Formula to be determined.	N	Y	Request data set and formula from Stavanger Municipality via DIF (M30).
522006	CO_2 emission reduction	Estimated total CO_2 emission per year. From energy sources of CEP	Tonnes	Baselines cannot yet be established	Average 2013-2015	Dataset to be determined together with Stavanger Municipality.	Formula to be determined.	N	Y	Request data set and formula from Stavanger Municipality via DIF (M30).

Table 62: Impact assessment indicators and baseline data for Module 522

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Stavanger Municipality EOS?	tbc	522001 – 522006	Expected to be available M27-M30	Stavanger Kommune -- Energioppfølgingssystemet (EOS). ?	michael.taoushanis@stavanger.kommune.no espen.svendsen@stavanger.kommune.no	Y	U		Provide DIF to data owner. (M27)

Table 63: Datasets potentially to be used in the calculation of impacts for Module 522

5.4 Mobility Modules

The Mobility task group is in the process of defining the scope of two modules (see below). Hence, the module descriptions and proposed impact indicators presented below will be revisited and revised over the course of the project as module scope is refined.

- *Module 531: Battery-bus demonstration.* Rogaland County Council will run a demo-project on battery busses. Lessons about using battery busses in the public transportation system will be documented, such as installing charging stations or differences in maintenance procedures from diesel buses.

- *Module 532: Electric vehicle charging infrastructure upgrade.* The Stavanger Region has a high density of electric vehicles. To meet increased demand for charging capacity for electrical vehicles (EVs), three stations were fitted with additional combined chargers for both Chardemo and CCS (Combined Charging System). Usage will be assessed, and further expansion is being considered.

Table 64, below, presents a summary of the expected impacts of the mobility modules, and below detailed module descriptions are provided.

Task Group	**Module**	**Expected impacts**				
		Reduce energy consumption of buildings	Increase utilisation of electric vehicles	Holistic residential solutions	Increase energy efficiency	Fostering citizen engagement with digital infrastructure
Mobility	Module 531: Battery bus demonstration		*		*	
	Module 532: Electric vehicle charging infrastructure upgrade		*		*	

Table 64: Expected impacts of the Stavanger Mobility modules

5.4.1 Module 531: Battery bus demonstration (Subtask 5.3.1)

Module Objective: To demonstrate the feasibility of reducing the use of fossil fuels through a changeover from buses based on combustion motors to busses based on electric motors (battery busses).

Approach: In cooperation with regional administrator of public transport, Kolumbus, Rogaland County Council will run a demo-project on battery busses. Any particular considerations about using battery busses in the public transportation system will be documented. Such lessons include to what extent the current system must be adjusted to make the best use of battery busses, for example installing charging stations. Another consideration may be differences in maintenance procedures from diesel buses.

Expected Impacts: The primary impact domain of the module is mobility. However, since Triangulum's initial impact mapping table categorized reductions of CO_2 emissions as falling within the impact domain of energy, certainly this module falls within that impact domain as well.

Links with other modules: This module may provide useful data to the Cloud data platform (D2.2) along with other data sources, about traffic patterns in the city of Stavanger. In addition, it will be possible to monitor the performance of battery busses compared to conventional diesel buses over time.

Socio-technical configuration of the module:

The users will primarily consist of the employees and customers of Kolumbus.

The stakeholder structure of the module

Rogaland County Council leads this module, in cooperation with regional administrator of public transport, Kolumbus, which Rogaland County Council will run a demo-project on electric busses. This module corresponds to "Subtask 5.3.1 Demo project of eBuses" in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 65, below, provides details of the indicators developed for this module. Note that the annual emissions of the total fleet of buses will not necessarily be reduced by the addition of battery busses, unless these are replacing some particular diesel buses. Estimating these emissions are at any rate challenging since actual and nominal emissions may differ, and the buses have no sensors recording the exhaust content throughout the operational lifetime of the conventional diesel buses.

Of course, this is a very important indicator for this module's expected impact of reduced CO_2 emissions. The most meaningful indicator for CO_2 reduction may be to consider the nominal emissions a diesel bus would make instead of the battery bus. Again, the carbon footprint of the electricity needed to charge the bus would also need to be accounted for.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M12:*** Battery busses that are part of the actual demonstration project have not arrived.
- ***M23:*** Battery busses have arrived.
- ***Next steps:***
    - Find out the vehicle identifiers of the Triangulum-funded battery busses in the Kolumbus dataset.
    - Distribute the Triangulum Impact Data Intake Form (DIF) – currently in draft version – to partners delivering modules and data owners outside the Triangulum consortium. (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
531001	Provision of battery busses	Total number of buses in fleet	Dimension less integer	**186** This is the number of buses for operator Norgesbuss in Nordjæren region which is the comparable dataset for battery buses. The larger fleet includes more than 400 buses.	July 2016	Kolumbus public API data, especially from the Vehicle Monitoring service.	Count of unique sensor identifiers.	N	Y	Request formula from Lyse via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
531002	Provision of battery busses	Number of battery busses	Dimension less integer	Currently there are two battery busses in the Kolumbus fleet. On the 1st of July 201, three more battery busses will be operational.	April 2015	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
531003	Provision of battery busses	Annual costs of purchasing, maintaining and repairing battery busses (These will be available for the battery busses, but not the conventional buses.)	NOK	Baselines cannot yet be established	tbc	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Kolumbus via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
531004	Reduced CO_2 emissions	Annual fossil fuel consumption (litres of diesel) **[SPEC]**	Dimension less integer	This data will likely be available via the FRIDA system from the 1st of July 2016.	tbc	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Kolumbus via DIF (M26-M30)
531005	Reduced CO_2 emissions	Annual electrical load by battery busses	kWh	Baselines cannot yet be established	tbc	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Kolumbus via DIF (M26-M30)
531006	Reduced CO_2 emissions	Annual CO_2 emissions **[SPEC]**	Tonnes	Baselines cannot yet be established	tbc	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Kolumbus via DIF (M26-M30)
531007	Utilization of battery busses compared to conventional buses	Mean of passengers per bus ride	Dimension less decimal	This and the preceding indicator will have data available on the 1st of July 2016	tbc	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Kolumbus via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
531008	Utilization of e-buses compared to conventional buses	Variance of passengers per bus ride	Dimension less decimal	This and the preceding indicator will have data available on the 1st of July 2016	tbc	Kolumbus public API data, especially from the Vehicle Monitoring service.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Kolumbus via DIF (M26-M30)

Table 65: Impact assessment indicators and baseline data for Module 531

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Kolumbus public API data, especially from the Vehicle Monitoring service.	Pulled from VM service.	511001 – 531008	U	Lyse	Odd Vinje (odd.vinje@kolumbus.no)	N	U		Provide DIF to data owner. (M26-M30)
FARA ticketing and ticket app sales	Passenger numbers		U	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	U	U		Waiting for input
Kolumbus Drift	Estimated CO2 emissions and energy consumption		U	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	U	U		Waiting for input

Table 66: Datasets potentially to be used in the calculation of impacts for Module 531

5.4.2 Module 532: Electric vehicle charging infrastructure upgrade (Subtask 5.3.2)

Module Objective: To meet increased demand for charging capacity for electrical vehicles (EVs) with the strongest emphasis on home charging followed by fast road based charging. *Approach:* 10 of the 100 demo homes under Module 521 are fitted with smart home charging installations for EV charging. In addition, a network of 8 road based fast chargers are delivering data.

Expected Impacts: The primary impact domain of the module is mobility. The expected impact of this module includes meeting the increased demand, mapping and analysing customer behaviour and unveiling impact on grid load capacity.. Arguably, the impact domain of energy is as relevant to this module as mobility.

Links with other modules: The availability of EV chargers is highly relevant for all EV owners, including those known from Module 521 “Smart gateway” bearing in mind D5.2.4, to be delivered in M36.

Socio-technical configuration of the module

Norway is the country in Europe with the highest density of electrical cars, which necessitates the provision of electricity along with a charging infrastructure for any demand.

The stakeholder structure of the module

Lyse leads this module, which is relevant for the private consumer, the private home, and the business environment. This module corresponds to “Subtask 5.3.2 EV charging infrastructure, expanding the super charging hubs” in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 67, below, provides details of the indicators developed for this module. Note that carbon emissions measurement data does not exist, and could be estimated from electricity consumption according to the method used in the municipality, but this would require further consideration and discussion.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M12 2016:*** Fast charging network established, collecting data. First Internal deliverable made available in M09 (iD 5.3.4) reflecting Lyse company strategy reassessment.
- ***M24 2016:*** iD 5.3.5 was submitted in M15 focusing on ICT solutions and preparing for effect based energy tariffs. Following government-supported involvement in the fast charging market, the focus shifted to home charging, enabling a stronger effort in module 521. A deviation requirement was submitted and a change request describing the shift of focus submitted in M24.
- ***Next steps:***
    - Make contact monthly with Module 532 task group leader, to ask whether the format of data has been confirmed.
    - Distribute the Triangulum Impact Data Intake Form (DIF) – currently in draft version – to partners delivering modules and data owners outside the Triangulum consortium. (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
532001	Installation of charging capacity	Number of charging stations installed, for each of the types: 43 kW AC / Chardemo / CCS / any home type	Dimension less integer	Baselines cannot yet be established	tbc	Dataset not yet designated.	Count of unique device identifiers.	N	Y	Request formula from Lyse via DIF (M26-M30)
532002	Energy consumption via EV charging infrastructure	Number of charging events per year, for each of the types: 43 kW AC / Chardemo / CCS / any home type	Dimension less integer	Baselines cannot yet be established	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
532003	Energy consumption via EV charging infrastructure	Mean of time per charging event, for each of the types: 43 kW AC / Chardemo / CCS / any home type	Minutes	Baselines cannot yet be established	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
532004	Energy consumption via EV charging infrastructure	Variance of time per charging event, for each of the types: 43 kW AC / Chardemo / CCS / any home type	$Minutes^2$	Baselines cannot yet be established	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
532005	Energy consumption via EV charging infrastructure	Number of distinct vehicles in each year using charger, for each of the types: 43 kW AC / Chardemo / CCS / any home type	Dimension less integer	Baselines cannot yet be established	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
532006	Energy consumption via EV charging infrastructure	Different categories of battery capacity among EVs may be inferable from charging power curve. **[SPEC]** (Note that the charging curve may contain interesting information that may or may not be meaningfully reducible to single numbers about the charging event or the EV.)	Dimension less integer / histogram	Baselines cannot yet be established	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Table 67: Impact assessment indicators and baseline data for Module 532

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps

Lyse charging infrastructure dataset?	?
	Azure DocumentDB/MongoDB aggregation of sensor data from smart gateways installed.
	{
	triangulum.ev_chargers
	}
		532001 – 532006	Y	Lyse	To be confirmed	Y	N?		Provide DIF to data owner. (M26-M30)

Table 68: Datasets potentially to be used in the calculation of impacts for Module 532

5.5 ICT Modules

The ICT task group are in the process of defining the scope of two modules (see below) to demonstrate the potential of ICTs as an enabler of innovation within Stavanger. Hence, the module descriptions and proposed impact indicators presented below will be revisited and revised as the module scope is refined.

- *Module 541: Innovative video.* This module focuses on exploiting the optical fibre network to deploy Full HDvideo services in new sustainable, inclusive and smart contexts both in residential and public buildings.
- *Module 542: Data analytics toolkit.* This module focuses on using ICT and data to support and foster innovative data-enabled solutions which demonstrate the potential for innovative decision support apps for citizens. This module is expected to impact citizens and businesses through the development of external services/apps as enabled by the analytics toolkit.
- *Module 543: Sustainable citizen service development.* Offering citizens decision support based on open data, via household display and/or apps. Providing truly personalized decision support would depend on the app interacting with correctly identified specific users over time.
- *Module 544: Cloud data platform.* This module (the "data hub") will be developed to collect and maintain data from the Lighthouse cities, and provide storage and computation capabilities to partners and external users. To design this solution, best practices and requirements are being analysed.

Table 69 presents a summary of the expected impacts of each module, and below detailed module descriptions are provided. Note that the analytics toolkit is expected to enable impacts in all city objectives, but the realization of this indirect impact may depend on external users exploiting the analytics toolkit. Since the analytics toolkit depends on the cloud platform, this module will also have a tertiary indirect effect to the extent that the potential of the analytics toolkit is tapped.

Task Group	Module	Expected impacts				
		Reduce energy consumption of buildings	Increase utilisation of electric vehicles	Holistic residential solutions	Increase energy efficiency	Fostering citizen engagement with digital infrastructure
ICT	Module 541: Innovative video.					*
	Module 542: Data analytics toolkit.					*
	Module 543: Sustainable citizen service development					*
	Module 544: Cloud data platform.					*

Table 69: Expected impacts of Stavanger ICT modules

5.5.1 Module 541: Innovative video (Subtask 5.4.1)

Module Objective: In this task, we will exploit the optical fibre network to deploy Full HD video services in new sustainable, inclusive and smart contexts both in residential and public buildings.

Approach: Existing infrastructure will be used to provide a new user-friendly video-call service via television screen. Innovative video is planned to be in production in May 2017.

Expected Impacts: The primary impact domain of the module may be citizen engagement or socioeconomic, to the extent that the innovative video improves society inclusiveness and quality of life for people with limitations on movement outside their residence. In addition, increased telecommuting may lead to reduced traffic, and hence less energy use and time spent in traffic. Thus, the impact of innovative video would also fall within the realm of energy and mobility. Unobtrusively quantifying the impacts in these domains remains an unsolved challenge.

Links with other modules: Deployment of the innovative video module will overlap with Module 511 Smart gateway deployment in the context of the Triangulum project.

Socio-technical configuration of the module:

The Stavanger region has one of Europe's most comprehensive FTTH deployments. User types may include people who have limited options of movements outside the home, for example among the elderly. In addition, telecommuters, schools, and businesses may make up a significant user type.

The stakeholder structure of the module

Lyse leads this module. Similar data privacy concerns pertain to this module as to smart gateways (D5.2.1). This module corresponds to "Subtask 5.4.1 Innovative video" in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 70, below, provides details of the indicators developed for this module. Note that carbon emissions measurement data does not exist, and could be estimated from electricity consumption according to the method used in the municipality, but this would require further consideration and discussion.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M12:*** State of progress unknown.
- ***M24:*** Technical challenges identified: Testing revealed production challenges. Some of the findings based on the tests have been very valuable in securing the necessary quality ahead of the work to be done in subtask 5.4.1. In parallel, Norsk Telemedisin and some other industrial actors have faced technical challenges that were not foreseen at the outset of the project. The implementation was therefore postponed to Nov. 2016 (M22), when the first installation was finished in one of the demo homes.
- ***Next steps:***
    - Distribute the Triangulum Impact Data Intake Form (DIF) – currently in draft version – to partners delivering modules and data owners outside the Triangulum consortium. (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
541001	Installation of Innovative Video	Number of buildings with innovative video	Dimension less integer	5	tbc	Lyse smart gateway data set	Count of unique sensor identifiers.	N	Y	Request formula from Lyse via DIF (M26-M30)
541002	CO_2 emissions reduction due to telecommuting [**SPEC**]	Number of eligible workers using innovative video to telecommute **[SPEC]**	Dimension less integer	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541003		Total transport savings per year **[SPEC]**	km	Estimates based on known commute distances for the eligible workers	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541004		Reduced CO_2 emissions per year **[SPEC]** (Estimates)	Tonnes	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
541005	CO_2 emissions reduction due to telecommuting [**SPEC**]	Electrical energy consumed by innovative video **[SPEC]**	kWh	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541006	Utilization of innovative video	Mean of time used on video calls per household per year	Minutes	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541007		Variance of time used on video calls per household per year	$Minutes^2$	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541008	Utilization of innovative video	Most typical hour of the day for using innovative video	XX:00	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
541009		Number of video calls per year to same technology **[SPEC]**	Dimension less integer	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541010	Utilization of innovative video	Number of video calls per year via video bridge **[SPEC]** (Video bridge enables the innovative video solution to call other video call programs.)	Dimension less integer	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
541011		Number of software installations on smart phones, tablets and PCs **[SPEC]**	Dimension less integer	0	tbc	Lyse smart gateway data set	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Table 70: Impact assessment indicators and baseline data for Module 541

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Lyse innovative video dataset?	tbc	541001 – 541013	Y	Lyse	gunnar.crawford@lyse.no	N	N		Provide DIF to data owner. (M26-M30)

Table 71: Datasets potentially to be used in the calculation of impacts for Module 541

5.5.2 Module 542: Data analytics toolkit (Subtask 5.4.2)

Module Objective: To provide a machine learning and statistical analysis toolkit. Based on the capabilities and design of the Cloud data platform, the data analysed can be of high volume and velocity. To showcase the capabilities thereof by applying the analytics to some of the various data sources connected to the Module 544: Cloud data platform (D2.2). To enable the development of external services, e.g. decision support apps for citizens.

Approach: To design this solution, best practices and requirements are being analysed. The analytics toolkit will use machine learning APIs that reflect the distributed nature of the Cloud data platform (D2.2), e.g. Apache Spark.

Expected Impacts: The primary impact domain of the module is ICT. D5.4.2 Big data analytics is expected to impact citizens and businesses through the development of external services/apps as enabled by the analytics toolkit. The ideal outcome is that improvements in all impact domains can be supported by the analytics toolkit, as reflected in the number of other Triangulum modules utilizing the analytics toolkit.

Links with other modules: D5.4.2 is developed in tandem with and based on the Data hub (D2.2). Other Triangulum modules will be able to use the analytics toolkit.

Socio-technical configuration of the module:

Users are expected to fall within user types categories as discussed in the previous section with regards to the Cloud data platform. Other categories of user types may be added as needed.

The stakeholder structure of the module

The analytics toolkit is provided on top of the Cloud data platform, and UiS leads both modules. Partners and external users will be able to utilize the analytics toolkit. This module corresponds to "D5.4.2: Design of tools for data analytics" in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 72, below, provides details of the indicators developed for this module. Note that carbon emissions measurement data does not exist, and could be estimated from electricity consumption according to the method used in the municipality, but this would require further consideration and discussion.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M9:*** Acquisition of data to analyse has been prioritized over analytics toolkit development, since the latter ultimately depends on the former.
- ***M25:*** Module 542 progress is still awaiting datasets and data collection framework.
- ***Next steps:***
    - Distribute the Triangulum Impact Data Intake Form (DIF) – currently in draft version – to partners delivering modules and data owners outside the Triangulum consortium. (M26-M30)
    - Develop skeleton Module 544 enough to begin meaningful work on Module 542.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
542001	Provision of analytics tools	Number of analytics demo services	Dimensionless integer	0	Jan 2015 – Month? 2015	Triangulum metadata database?	Not currently fully determined i.t.o. designated data set.	N	Y	Implement and develop DIF (M26-M30)
542002	Utilization of analytics toolkit	Total number of users	Dimensionless integer	0	Jan 2015 – Month? 2015	Triangulum metadata database?	Not currently fully determined i.t.o. designated data set.	N	Y	Implement and develop DIF (M26-M30)
542003		Number of users by type	Dimensionless integer	0	Jan 2015 – Month? 2015	Triangulum metadata database?	Not currently fully determined i.t.o. designated data set.	N	Y	Implement and develop DIF (M26-M30)
542004		Number of users for each demo service	Dimensionless integer	0	Jan 2015 – Month? 2015	Triangulum metadata database?	Not currently fully determined i.t.o. designated data set.	N	Y	Implement and develop DIF (M26-M30)
542005		Number of apps for end users that involve the analytics toolkit	Dimensionless integer	0	Jan 2015 – Month? 2015	Triangulum metadata database?	Not currently fully determined i.t.o. designated data set.	N	Y	Implement and develop DIF (M26-M30)
542006	Utilization of analytics toolkit	Number of Triangulum modules that use the analytics toolkit	Dimensionless integer	0	Jan 2015 – Month? 2015	Triangulum metadata database?	Not currently fully determined i.t.o. designated data set.	N	Y	Implement and develop DIF (M26-M30)

Table 72: Impact assessment indicators and baseline data for Module 542

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Expected name: "Data processing framework self-monitoring"	Tbc	542001 – 542006	N	Respective Triangulum partners	trond.linjordet@uis.no	U (Depends on requirements and funding.)	N		Provide DIF to data owner. (M26-M30)

Table 73: Datasets potentially to be used in the calculation of impacts for Module 542

5.5.3 Module 543: Sustainable citizen service development (Subtask 5.4.3)

Module Objective: To develop services to promote sustainable choices by citizens through decision support.

Approach: To offer citizens decision support based on open data, via household display and/or app. Providing truly personalized decision support depends on the app interacting with correctly identified specific users over time.

The module will involve specific technologies such as a *personalized home display* and/or a smart phone app as a personalized extension of the household's home display. This app or home display acts as an interface between the user and home technologies such as innovative video or smart gateway.

Another technology in this module consists of simple and conspicuous *push button*, such as having a green, physical push button which anyone in the household can simply push once to activate an energy saving mode for the whole household. Other modes activated by other push buttons may include "night" and "away".

A third technology will consist of *decision support* in the form of a prompt, feedback, or push notification. The latter would be used sparingly, for alarms and similar urgent messages.

Expected Impacts: The primary impact domain of the module is energy. A close second would be mobility, since decision support will also concern itself with transport choices. Specifically, expected impacts include increased energy awareness, increased transportation awareness, reduced use of transportation generally, and an increased proportion of transportation that is in some way environment-friendly.

Links with other modules: Innovative video (D5.4.1) is an alternative to physical transportation, and is closely connected with sustainable citizen service development. The smart gateway (D5.2.1) will be crucial to enable and document the sustainable citizen service development.

Socio-technical configuration of the module

Currently, there are two trial installations, and hardware components have been decided. The aim is to install sustainable citizen service in 100 residential buildings by April 2016.

The stakeholder structure of the module

Lyse leads this module. This module corresponds to "Subtask 5.4.3 Sustainable citizens' service development" in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

Table 74, below, provides details of the indicators developed for this module. For each of the following technologies – personalized home display, push button, and decision support:

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***2016:*** The core concept was formulated and initial implementation begun.
- ***Next steps:***
    - Request data contact from module task group leader and establish contact.
    - Discuss Triangulum Impact Data Intake Form (DIF) and begin process of filling in the necessary information, including necessary metadata.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
543001	Utilization of module technology	Number of buildings with software installed	Dimension less integer	0	tbc	Dataset not yet designated.	Count of unique identifiers for active clients.	N	Y	Request formula from Lyse via DIF (M26-M30)
543002	Utilization of module technology	Number of buildings with hardware installed	Dimension less integer	0	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
543003	Utilization of module technology	Mean of number of times used per day	Dimension less decimal	0	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)
543004	Utilization of module technology	Variance of number of times used per day	Dimension less decismal	Baselines cannot yet be established	tbc	Dataset not yet designated.	Not currently fully determined i.t.o. designated data set.	N	Y	Request formula from Lyse via DIF (M26-M30)

Table 74: Impact assessment indicators and baseline data for Module 543

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Lyse sustainable citizen service dataset	tbc	543001 – 543004	U	Lyse	tbc	Y	N		Provide DIF to data owner. (M26-M30)

Table 75: Datasets potentially to be used in the calculation of impacts for Module 543

5.5.4 Module 544: Cloud data platform (D2.2)

Module Objective: A Cloud data platform ("data hub") will be developed that collects and stores data from the Lighthouse cities. Additionally, the Cloud data platform will provide storage and computation capabilities to partners and external users.

Approach: To design this solution, best practices and requirements are being analysed. In order to implement the appropriate infrastructure, a specific "stack" of hardware, operating system and other software (especially to support analytics) are being decided upon.

Expected Impacts: The primary impact domain of the module is ICT. The cloud data platform will enable the collection, processing, storage, and visualization of data. In addition, the raw data collected, the metadata, and the processed data can be made accessible to citizens, researchers, city officials, and start-ups. The Cloud data platform will also enable the analytics toolkit (Module 522, "Subtask 5.4.2 Big data analytics"). Finally, this platform can also host services that use the collected data and the Data analytics toolkit. These services can be created and used by citizens, researchers, city officials, and start-ups.

Links with other modules: Module 544 Cloud data platform will be integral to the implementation of Module 522. The data collected in Module 544 will primarily be the data generated in the implementation of Triangulum modules, where the Big Data approach to handling data is appropriate. Therefore, Module 544 is linked with every Triangulum module that produces data at scale.

Socio-technical configuration of the module

Users are expected to fall within certain user types: Private individuals, start-ups, established business (3+ years), students, city officials, and academics. Additional categories of user types may be added as needed.

The stakeholder structure of the module

University of Stavanger leads the module and gives guidelines and provides the utilities for partners and external users to make their data (Including interfaces and protocols, schema, data model, data access policy, impact indicator formulae) accessible to the Cloud data platform's data collection framework. Likewise, UiS provides guidelines and utilities to access the data and services hosted on the Cloud data platform. This module corresponds to "D2.2: Cloud Data Hub" in the Triangulum Grant Agreement.

The indicators to be used for assessing the impacts and benefits and baseline conditions

The module impacts the domain of ICT by providing resources to project partners and external users. The Cloud data platform provides on-demand access to a shared pool of storage, computational and networking resources. The impact indicators are defined according to nominal capacities and actual utilization of these resources.

The module is under development and has not yet been deployed. Therefore, data from external modules have yet to be collected in the data collection framework. However, prototype use cases are being pursued with specific partners, such as Lyse and Kolumbus. The baseline values for the impact indicators reflect this situation. Services to be provided in the Cloud data platform include data collection framework, data processing framework, and self-service portal.

Factors limiting progress towards establishing the baseline, defining the approach to calculating impacts, and identifying associated datasets

- ***M1-M24 and ongoing:*** Delays in purchasing, and in subcontracted hardware and software developments.
- ***M16-M24 and ongoing:*** Unexpected sick leave, personnel turnover and associated human resource shortfall.
- ***M15-M24 2016:*** Since Module 544 is highly dependent on data from other modules in order to demonstrate its usefulness and fulfil its purpose within Triangulum, the development and adoption of the Triangulum Impact Data Intake Form (DIF) is critical. Several meetings and workshops have been organized to establish a common terminology and working relationships with data contacts from Triangulum partners with module task groups.
- ***Next steps:***
    - Distribute the Triangulum Impact Data Intake Form (DIF) – currently in draft version – to partners delivering modules.
    - Further develop DIF based on partner input, including a calibration of the technical challenges imposed.
    - Work on turning internal self-monitoring processes of Cloud data platform into
    - Continue development of data collection framework.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
544001	Data storage capacity	Nominal hardware storage capacity, HDD	Terabytes	60.0	February 2017	Data centre requirements specification	Number of machines installed multiplied by single-machine nominal value	N	Y	Implement and develop DIF (M26-M30)
544002		Nominal hardware storage capacity, SSD	Terabytes	1.6	February 2017	Data centre requirements specification	Number of machines installed multiplied by single-machine nominal value	N	Y	Implement and develop DIF (M26-M30)
544003	Data storage utilization	Number of Triangulum partners providing data via DIF specifications	Dimensionless integer	0.0	February 2017	Triangulum metadata database	Not currently fully determined.	N	Y	Implement and develop DIF (M26-M30)
544004	Computational capacity /resources	Number of physical cores	Dimensionless integer	20	February 2017	Data centre requirements specification	Number of machines installed multiplied by single-machine nominal value	N	Y	Implement and develop DIF (M26-M30)

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Baseline value	Baseline period	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS?	Auto. calc.	WP02 next steps
544005		Estimated number of virtual machines (VMs) possible	Dimensionless integer	160	February 2017	Data centre requirements specification	Number of machines installed multiplied by single-machine nominal value	N	Y	Implement and develop DIF (M26-M30)
544006	Network capacity	Full bisection bandwidth	Gigabits per second	40.0	February 2017	Data centre requirements specification	Number of machines installed multiplied by single-machine nominal value	N	Y	Implement and develop DIF (M26-M30)

Table 76: Impact assessment indicators and baseline data for Module 544

Dataset name	Dataset description	Related impact indicators:	Available in M24?	Dataset owner	Dataset contact	To be collected beyond M60?	To be stored on city data platform?	Comments	WP02 next steps
Data centre requirements specification	Tbc	544001-002 544004-006	N	Tbc	Aryan.taherimonfared@uis.no	N	N		Provide DIF to data owner. (M26-M30)
Triangulum modules metadata database ?	To be captured by DIF.	544003	N	Tbc	trond.linjordet@uis.no	N	N		Provide DIF to data owner. (M26-M30)

Table 77: Datasets potentially to be used in the calculation of impacts for Module 544

5.6 An initial evaluation of the process used to develop the indicators and next steps

Some data already exists, typically simple counts, such as how many buildings currently have the Smart Gateway installed, or how many battery busses are currently in operation. In a few cases, extensive time series have already been recorded, such as the energy consumption of municipal administrative buildings.

The process of developing the impact indicators has been useful so far, both in concretizing quantitative dimensions in which the partners expect to see the impact of their module, as well as directing attention towards the need for data to quantify said impacts. Note that several modules espouse a vision of supporting additional services. Here a shared challenge is to quantify how much different services are adopted by residents, citizens, or other user groups. Different services are hard to compare, since some may be functioning optimally when the user interacts minimally with the user interface, whereas others may meet their purpose best when users are inspired to interact intensively. For example, it is not obvious if a resident is enjoying the best benefits from the smart gateway installed at their household if they are actively engaging with the gateway interface, or if zero interaction reflects the highest level of satisfaction.

The simplest solution to this problem may be to count the number of users for each specific service supported by a given module. However, defining these impact indicators exactly depends on having a comprehensive list of the services supported by a module, and the compilation of these lists has barely begun at this stage of the project. Impact indicators of this kind cannot be rigorously defined until at least the number of distinct services has been determined for each module.

The data available has been further clarified, as well as the contact persons and owners of the different data sources. Through discussions of impact indicators and data sources to quantify these, perspectives on possible interactions between modules not lead by UiS and the data analytics module have repeatedly come up. It seems likely that some of the modules' impact indicators that are meaningful in the context of reporting may only become apparent after exploratory data analysis and trialling different predictive models. The process has also brought up challenges of quantifying user satisfaction in a non-obtrusive manner. Some modules may execute use cases or surveys that could elucidate some relevant and practical impact indicators.

Next steps will include deeper involvement with the data sources, which may provide additional insight into relevant impact indicators. The D2.3 report will hopefully also spur thought among researchers and non-academic partners about the relationships between modules' objectives, data generated, and desirable quantifications of successful implementation.

6 Synthesis

This section offers a preliminary synthesis across the three cities drawing on the baseline reports. Although there the city reports have been available for an insufficient amount of time to conduct any detailed analysis, a preliminary comparison is useful to help understand the activities, approaches and progress in each city relative to the overall goals and scope of the Triangulum project. It highlights similarities and differences in terms of expected impacts and monitoring approaches, and comments on some of the key lessons that have emerged from WP02 activity so far and potential challenges. With this in mind, the first sub-section below comments on the process of developing the baseline reports for each city, which is a key contribution of WP02 to learning processes within the overall Triangulum project.

6.1 The process of developing module specific impact indicators

Across the three cities WP02 activities are in progress, seeking to understand the scope of modules and their expected impacts, to develop associated indicators and to gather baseline data. For almost all modules, descriptions of scope, expected impacts and indicators have been presented in the city baseline reports above. These reports represent a snapshot of the current understanding of the WP02 team. In many cases the expected impacts and indicators will need to be revisited as the modules themselves are further developed and refined. Such an iterative process is necessary given that consortium partners are engaging in an on-going process of working together to learn how specific smart city technologies can be deployed in novel socio-technical configurations (i.e. modules) in specific local contexts. As a result, at this stage in the learning process, it is not feasible to gather baseline data against which impacts can be assessed (this is particularly the case for modules being deployed in Manchester and Stavanger).

The processes of defining modules and impact indicators have progressed in parallel over the first year of Triangulum. WP02 researchers played a key role supporting city partners in the modules definition work. For example, this has involved explaining the concepts of socio-technical modules and module replication to city partners, and working to refine module definitions. Hence, the role of WP02 researchers has been extended, as they have engaged in module design activities in addition to impact monitoring and assessment activities. Extending the WP02 researcher role in this way has both benefits and drawbacks. The main benefit has been raising the profile of impact assessment and monitoring activities with city partners, embedding these activities at the outset of module development, and forging extremely strong and close relationships between the academic project partners and the city partners. However, realising these benefits has required a significant unanticipated investment of time by WP02 researchers, creating some resource management and work-flow challenges for the work package partners.

6.2 Expected impacts and impact indicators

We observe a number of similarities and differences between the expected impacts and the impact indicators across the three cities. We outline these below, beginning by summarising the expected impacts in each city.

- In Eindhoven there is a strong emphasis on measuring the following impacts: reducing carbon emissions; fostering citizen engagement (Co-creation); developing a digital infrastructure; reducing (non-renewable) energy consumption; and, improving the quality of life.
- In Manchester there is a strong emphasis on measuring the following impacts: reducing carbon emissions; creating efficiency savings within the energy and mobility infrastructures; and, developing, and promoting engagement with, digital and data infrastructures.
- In Stavanger there is a strong emphasis on measuring the following impacts: reducing (non-renewable) energy consumption; and, developing and promoting engagement with digital infrastructures.

The overarching objective of Triangulum, as stated at the outset of this report, is to develop "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**". Specifically all parties involved in Triangulum are committed to the following main objectives:

Goal 1: Reduce energy consumption of buildings (a total of 107,390 m² floor area) on this project by factor 3 or higher (>65%) leading to a total reduction of over 14 Mio KWh/a.

Goal 2: Provide at least 75% of the remaining energy demand (electricity, heating, cooling) with renewable energies.

Goal 3: Increase utilisation levels of electric vehicles and charging infrastructure (e-cars, e-bikes, battery busses) in the districts significantly. (By 100% in Eindhoven and Manchester with reference to status quo 2014).

Goal 4: Integrate intelligent energy management technologies for approximating coverage of local energy demand and renewable energy provision.

Goal 5: Integrate buildings energy use, users mobility demand, alternative fuels like electric energy for EV's and smart appliances into an adaptive and dynamic ICT data hub that allows for a broad range of value added services and smart city appliances.

Goal 6: Maximize co-creation and a bottom up approach involving citizens – as users, inhabitants and tenants of the district – in the process of designing, implementing and participating in the smart city districts.

Based on the expected module impacts for each city, detailed above, it is possible to gain some sense of how the modules are seeking to meet this objective. First, we observe that reducing greenhouse gas emissions is an expected impact for many of the modules across the three cities. Secondly, we observe that a relatively small number of modules are expected to create quantifiable impacts relating to promoting commercial activity (1 in Eindhoven; 1 in Manchester; 0 in Stavanger) and improving local governance (0 in Eindhoven; 0 in Manchester; 0 in Stavanger). This suggests that it is challenging for city partners to: measure these indirect economic and governance impacts; and/or, develop modules which make these indirect impacts. Hence, over the course of Triangulum project it may be challenging to quantitatively demonstrate impacts relating to the efficiency of commerce and governance; whilst, impacts relating to greenhouse gas emissions may be more readily demonstrated.

We also observe a stronger emphasis in Eindhoven than in Manchester or Stavanger on creating, quantifying and measuring impacts around citizen engagement and quality of life. The may be a result of the differing characteristics of the districts which modules are being implemented in. For example, in Eindhoven some modules are being implemented within a residential district (Eckart-Vaartbroek), while in Manchester all modules are being implement within a commercial and University district (The Corridor). Hence, in Manchester there may be fewer opportunities for directly engaging citizens within the modules and impacts on citizens might be more diffuse and difficult to quantify. Furthermore, differences in expected impacts and associated indicators may have arisen as a result of the cities addressing different challenges. For example, in each city the mobility modules focus on a different aspect of the transport system: in Manchester the focus is on freight transport and deliveries; in Stavanger on public transport (electric Buses); and, in Eindhoven on private transport (more efficient parking and car-sharing). We also note that there is great diversity in the specificity of expected impacts; ranging from the easy to quantify (e.g. improve EV charging efficiency) to the challenging to quantify (Quality of Life).

We now turn to the similarities and differences across the cities at the indicator-level. The indicators for assessing impacts such as reducing energy consumption and greenhouse gas emission and generating energy from low carbon energy sources are relatively similar across the cities. However, the indicators for similar modules being developed in different cities (e.g. the data platform modules being developed in each city) show some significant differences. For example, impact indicators for the data platform module in Stavanger focus on measuring data storage and computational resources, while the indicators for a similar module in Manchester also seek to measure the impact on ICT skills of the data platform users. Such differences in indicators raise the questions of whether there are opportunities for harmonising indicators across cities and modules, or if the differences in indicators necessarily reflects local cultural and practical differences in module implementation.

Finally, there are still details concerning the science behind some of the CO2-estimates. Aside from building-specific electrical energy totals, many baseline indicators are estimated rather than measured. For example, the Stavanger Municipality and CEP have based their CO2 estimates on

coefficients from Research Centre of Zero Emission Buildings. The Triangulum project needs to be aware of how CO2 emissions from different energy sources are estimated across cities, although this probably does not mean to use the same models/coefficients. Aside from total energy use, many of the energy indicators are systematic estimates based on directly measured energy consumption. However, the method of estimation for each will be discussed further with local partners and Triangulum to ensure that indicators are as scientifically validated and as comparable as practically possible. Similarly, what counts as a renewable energy source and what does not should be more fully clarified as the projects in each city develop.

6.3 Key lessons from WP02 activity to date

Finally, we conclude by summarising the key learning emerging from WP02 activity to date.

- *Learning related to the delivery of WP02:* modules development is progressing at differing rates within, and across, the Lighthouse cities. Hence, progress with developing impact indicators and gathering baseline data, documented above, is also uneven. Working to refine impact indicators, and gather associated baseline data, will continue in parallel with the development of modules (as detailed in the following section).
- *Learning related to the WP02 – WP06 interface:* the indicators for measuring module impacts (WP02) and the metrics for supporting module replication (WP06) are complementary and overlap to a limited extent. Further work integrating WP02 and WP06 activity has been identified as beneficial (detailed in the following section).
- *Learning related to module development and replication:* the modules described above seek to implement novel smart city technologies in specific local contexts. Challenges have been faced by city partners in specifying how these modules can integrate into physical infrastructure and multi-level urban governance systems. Hence, we suggest that there would be value in WP06 exploring these challenges and the strategies and tactics employed to overcome them. This learning might then be shared to support replication of the modules in follower cities.
- *Learning related to the further development of the framework developed in D2.1*: a key shift in focus between D2.1 and D2.3 has been the shift from a primary focus from the district to the city level. This reflects the structuring of the Triangulum project around the projects as a primary unit of action and hence unit of analysis. A key challenge for WP02 over the next 24 months will be exploring the degree to which it is possible to link different types and magnitudes of project impact to district and city level impacts. In terms of the overall process of engagement with city partners and WP06 set out in D2.1, the approach has been time-consuming but has produced detailed understandings of impacts and the feasibility of measuring them.

7 Next Steps

7.1 Priorities

The following section sets out the next steps for WP02 and how they relate to the WP02 tasks. A series of priorities have been identified.

1. **Further indicator analysis (Task 2.1)**

The detailed understanding of modules and indicators that this report contains provides the opportunity to look across the indicators for similar projects in different cities and identify opportunities for harmonising indicators across cities.

2. **Develop methods to capture wider processes of learning (Task 2.1)**

Process factors relating to the working dynamics between the city partners and the sustainability of the process will be captured through the interviews performed as part of the WP06 CityLab visits to each city, which focus on stakeholder experiences and perceptions of the governance process to coincide with the production of the baseline and interim reports. An electronically administered survey will also be used to evaluate the sustainability of processes of data generation, monitoring and usage in each city.

3. **Further refinement of baseline (Tasks 2.1 and 2.2)**

As noted in the impact tables there are key next steps for WP02 in terms of securing datasets, setting baseline assessment periods, and working with partners to identify common formulae for calculating technical impacts for example around carbon emissions. some the datasets that have been identified as necessary to monitor impacts are not yet available.

4. **Integration of WP02 and WP06 (Task 2.4)**

The integration of WP02 and WP06 requires the robust analysis of the data fields for each project template to identify further redundancies and complementarities. For example, the WP06 city visit interviews have been identified as addressing governance impacts, while the WP02 carbon metrics for energy projects can be used to quantify project benefits for WP06. This can be done once the city visits are completed in M12 as all data fields for the two WPs will be present.

5. **Further develop the Cloud Data Hub (Task 2.1, Del. 2.2)**

A key next step involves designing a common architecture for the cloud platform, using cutting-edge technologies and industry best practices. The architecture should be reproducible and based on commodity hardware and software. The platform will provide not only storage services, but also computational resources to facility the introduction of new services and businesses. An important aspect of the platform is its openness and resistance to future data lock-in. Therefore, reliable APIs are crucial. A key next step involves the identification, development and deployment of Standard and Open APIs.

A reliable storage platform should provide various storage services such as Object storage, Block storage, and file-system. Understanding these service types and their use-cases is crucial for a sustainable design and capacity planning. Storage without computation may have little value in a cloud platform. Thus, analytics services will be studied to identify requirements for a robust compute platform.

6. Developing feasible and replicable monitoring and assessment frameworks for follower cities and Lighthouse cities in years 4 and 5 (Task 2.2, Del. 2.4)

In order to develop feasible and replicable monitoring and assessment for Follower cities and Lighthouse cities in years 4 and 5, a survey evaluating the processes of data collection and availability of data in the Lighthouse cities has been conducted. This will be used to identify key challenges and recommendations for monitoring and assessment frameworks for follower cities and Lighthouse cities in years 4 and **5**.

7. Dissemination (Task 2.4)

A literature has begun to emerge developing critical insights into the smart cities agenda[7,8]. Within this literature, there have been a number of calls for empirical research comparing how the smart cities agenda is implemented in different urban contexts[9]. There is a timely opportunity to draw on the content of the baseline report to develop a journal publication which analyses and compares the Triangulum projects across the three cities. This would build upon the interest generated through

[7] Hollands R G, 2008, "Will the real smart city please stand up?" *City 12*(3) 303–320

[8] Viitanen J, Kingston R, 2014, "Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector" *Environment and Planning A 46*(4) 803–819

[9] Kitchin R, 2014, "Making sense of smart cities: addressing present shortcomings" *Cambridge Journal of Regions, Economy and Society 8*(1) 131–136

numerous presentations by WP02 staff to academic and policy audiences in 2015, as well as building collaboration between the three university teams and Fraunhofer.

7.2 Key Activities and Timeline

Table 78 lists the next steps between the period from the submission of this Baseline Report in month 12 and deliverable 2.4, the Interim report in month 24. The interim report will set out the monitoring protocols for the three cities that can be sustained over the final two years of the project and beyond to underpin long-term smart urban sustainable management. It sets out what the key activities are and who will be responsible for them to progress WP02 from the baseline reports to the interim reports.

Lead partner	**Activity**	**Months**
UNIMAN - TU/e - UiS	Align and verify impacts, indicators and metrics (stage 4 of the methodology detailed in Section 2.2)	13-24
UNIMAN - TU/e - UiS	Preparation for impact calculation including further refinement of project indicators (stage 5 of the methodology detailed in Section 2.2)	13-36
FhG - UNIMAN	Further integrate WP02 and WP06	13-20
UiS	Further develop the Cloud Data Hub in preparation for the calculation of impacts	13-36
UNIMAN – UiS - TU/e	Developing monitoring and assessment frameworks for follower cities and Lighthouse cities in years 4 and 5	13-36
UNIMAN - TU/e - UiS - FhG	Dissemination	13-36

Table 78: Key activities and timeline to D2.4: interim report

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 Sabadell in month 21. WP02 members will be meeting virtually in Month 13 to discuss the implementation of these activities and how to better predict and manage workload.