triangulum

DEMONSTRATE·DISSEMINATE·REPLICATE

D2.5 Impact Report

January 2018

Project coordination:
Fraunhofer Institute IAO

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	
Project Title	**Triangulum: The Three Point Project / Demonstrate. Disseminate. Replicate**	
Project Coordinator	Damian Wagner (Damian.Wagner@iao.fraunhofer.de) Fraunhofer IAO	
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Contributing beneficiary(ies)	P11-TU/e, P17-UiS, all city partners	
DoA	Report capturing the impact of ongoing demonstration activities 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	Comments
08/12/2017	1	Kelly Watson	James Evans, Dujuan Yang, Trond Linjordet, Russell Gene Wolff	Updated structure
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Executive Summary

Triangulum proposes a novel form of smart district development that integrates energy, mobility and ICT to improve the efficiency of commerce and governance as well as reduce greenhouse gas emissions. The goals of Work Package 2 (WP2) 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 WP6 replication framework.

Deliverable 2.5: impact report presents the impacts and impact indicators that have been coproduced using an innovative methodology that works with teams leading implementation projects in each city. WP2 worked with WP6 to develop a holistic approach to smart city solutions that conceptualises projects as 'modules'. Modules provide the basis for monitoring and assessment, and underpin the use cases set out in D6.2 Smart City Framework as the units for replication.

Deliverable 2.3 Baseline Report, submitted in M12 and in updated version in M24, set out the impact indicators for each module and provided the first overview of the complete set of modules being implemented by the project. Due to delays in the implementation of modules Deliverable 2.5 provides updates to the baselines included in Deliverable 2.3 Baseline Report and where available an early indication of the impacts of the Triangulum project.

225 impact indicators have been finalised across the 29 modules being implemented in the Lighthouse Cities. A total of 16 modules have been fully implemented out of 29 (55%). 182 baselines have been set out of the 225 impact indicators required in total (78%). 125 impact indicators have had impact values calculated (57%). In terms of modules, 59% are now generating impacts and 72% have a complete set of baseline data. Specific privacy issues and third party issues have hampered the collection of data for certain modules. These will be a focus for the WP2 work between M36 and M48.

Although this deliverable is incomplete, its production is important for two reasons:

- *To provide partners with a snapshot of impacts so far where possible.* M36 represents the end of the implementation phase and start of the official monitoring phase so the reporting of impacts at this stage is intended to support early learning within the Lighthouse Cities.
- *To identify gaps in monitoring and the measures partners need to take to address them*. These measures will be undertaken between M36 and M48, when an updated version of this deliverable will be produced. At that stage any incomplete impact indicators relating to module changes or unavailable data will be expunged. This will provide a minimum of a one year monitoring period for all modules.

This report is organised into 7 sections. Section 1 provides an introduction to the report, setting it within the context of the broader Triangulum project and the goals of WP2. Section 2 summarises the impact assessment methodology that was set out and elaborated in deliverables 2.1 and 2.3. It adds new details concerning the final stages of impact assessment, and explains the structure used to report impacts in each city. Sections 3, 4 and 5 present the three Lighthouse city impact reports for Manchester, Eindhoven and Stavanger respectively. The structure of this report mirrors the structure of the overall Triangulum project, with city sections following work package numbering and addressing sectors in the order of energy, mobility and ICT. Each of these sections begins by providing an overview

of the districts and modules in that particular Lighthouse City and an overall summary of the progress and impacts so far. The sections give detailed breakdowns of module level impacts by sector, starting with energy, then mobility and finally ICT. For each module a detailed explanation is provided explaining why data or information is missing, what actions are being taken to secure it, and what the anticipated timeframe for acquiring it is.

Section 6 provides a brief synthesis of impacts and progress across the Lighthouse Cities. Highlights include:

- Manchester decreased greenhouse gas emissions by 2,600tCo2e through the deployment of 9 EVs and 4 cargo bikes. It has optimised building space for smart energy interventions of 23,000 m^2, and the Manchester-I platform now hosts 13 live data feeds.
- Eindhoven has decreased heating costs by 48% for residents in Eckart Vaartbroek, with 217 buildings retrofitted. 28 SMEs have been created and downloads from the city data platform have increased by over 1000%. 120 citizens were involved in project-planning.
- Stavanger has deployed 5 battery buses and installed 56 smart gateways in buildings.

Across all three cities:

- The main Energy sector impacts are reduced local energy use, reduced energy costs, and decreased greenhouse gas emissions.
- The main Mobility sector impacts are improvements in efficiency, and reduced greenhouse gas emissions (CO2, NOx, CO).
- The main ICT sector impacts are increases in the availability of open data, data downloads, and improvements to fibre optic networks.

Given current progress across the project WP2 predict approximately 70% of the modules will produce 24 months of monitoring data for reporting in M60. Approximately 20% of modules are predicted to produce between 12 and 24 months of monitoring data. Doubts exist over whether approximately 10% of the modules will be implemented in time to produce 12 months of data required to underpin meaningful monitoring.

Section 7 identifies risks and key tasks ahead, focusing on the timeline for acquiring missing data and information for modules up to M48 when an updated version of this impact report will be prepared.

1 Introduction

This introduction provides a concise summary of Triangulum and the role of WP2: Monitoring and Assessment. It outlines the tasks that this deliverable contributes to, and the methodology that has been used to develop the impact assessment.

1.1 Triangulum and the role of WP2: monitoring and assessment

The main goal of Triangulum is to demonstrate how 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 five year project is structured to have 3 years for implementation and then 2 years for monitoring and assessment. The goal of WP2 is to rigorously monitor and assess the impacts of the implementations to support the work of the lead city partners and learning between them.

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. It reviewed leading smart city frameworks and developed an innovative model of co-production to ensure that monitoring and assessment reflects best practice in terms of existing frameworks such as CityKeys and SCIS, while also capturing impacts that city partners are most interested in and able to monitor. Deliverable 2.2 produced a cloud data hub, hosted at the University of Stavanger, to collect and store relevant datasets. Deliverable 2.3 presented the baseline report based on the expected impacts and impacts indicators that modules foresee, including a detailed account of the methodology that was used to co-produce the monitoring framework with WP2 staff and partners in the Lighthouse cities. Deliverable 2.3 provided a first attempt to set the baseline for the module impact assessments, although this was not possible for modules that were not yet fully specified. Deliverable 2.4 presented the interim report which focused on the sustainability of data generation, collection and use in Triangulum. The deliverables are publicly available on the Research Gate website as outlined in the DoW as follows:

- Deliverable 2.1: Common monitoring and impact assessment framework (http://bit.ly/2GpeOm6)
- Deliverable 2.3: Baseline report (http://bit.ly/2novDov)
- Deliverable 2.4: Interim report (http://bit.ly/2rJN9cA)

This report, Deliverable 2.5, provides a full set of baseline data, and gives an early insight into the impacts that are being generated by the Triangulum modules. As outlined in Section 1.2 of D2.1, this fulfils a formative evaluation role in Triangulum, allowing partners to see impacts at an early stage of module development. An updated version of this deliverable will be prepared in M48 when all modules have been implemented. Deliverable 2.6: Final multi-level impact assessment and monitoring summary, due in M60, will provide a full account of the impact of the modules, including an assessment of the district and city-level impacts.

1.2 Modules and use cases: the relationship between monitoring and replication

WP2 monitors and assesses the impacts of the implementation projects in the Lighthouse Cities. Implementation projects are conceptualised as 'modules'. This is an innovative approach to smart city development that considers interventions as combinations of technology, interfaces, business cases, stakeholder structure, and policy. Section 3.1.2 of D6.2 Smart City Framework details the development of the 'module' concept as a way to capture the value of smart city projects in a more holistic way than has previously been managed. Modules provide the units of analysis for monitoring and assessment, and this informs D6.2 Smart City Framework technology approach. The modules also underpin the development of use cases as the units for replication in D6.2 Smart City Framework. Use cases build on the Triangulum implementations, but also go beyond them to focus on business models and the specific contexts in which they operate successfully. Some modules map onto single use cases, while others split into multiple use cases. For example, Module 444: Public space sensor network in Eindhoven supports numerous potential use cases related to smart lighting and safety. Use case nomenclature follows the WP2 module numbering system and simply adds a letter to the end to denote each separate use case. So Module 444 supports UC-444a, UC-444b, and so forth. For modules with multiple use cases, impact indicators that vary by use case (e.g. amount of energy used in the different types of building) have also been split. This is denoted by the addition of a letter to the impact indicator number. This means that data collected as part of WP2 can be linked to WP6 use cases in order to provide evidence for them where possible. In other instances, use cases emerged from WP6 city visits and are not directly linked to actual implementations, meaning that there is nothing to monitor and assess. For this reason, WP2 focuses on modules as the unit of analysis for monitoring and assessment, while WP6 adopts use cases as the unit of analysis for replication. Table 2.7 on page 16 of this report gives an overview of the modules included in this report and how they relate to WP6 use cases.

1.3 Contribution of this deliverable towards tasks outlined in the DoW

Deliverable 2.5 contributes to the following tasks:

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.

80% complete. Outstanding baseline data exists for modules that are still in the process of being fully specified and/or are in the process of implementation. All outstanding data is noted in the dataset tables provided for each module in Sections 3-5.

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.

80% complete. All data holders have been identified and contacted. Specific processes are being used to negotiate with third party data holders and data holders with privacy concerns, as outlined in the 'next steps' columns of the dataset tables for each module.

Maintain and populate Cloud Data Hub.

Relevant and appropriate data has been captured by the Cloud Data Hub as part of the process of collecting data. See Deliverable 2.2 Cloud Data Hub for further details, and section 2.3 of this report.

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

80% complete for baseline values, 54% complete for impact values. The common monitoring and assessment frameworks are being applied as part of this report, and will be completed as missing data is gathered up to M48.

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.

The framework described in this report is intended to be implemented in years 4 and 5 to inform the updated version of this deliverable in M48 and the final deliverable, Final multi-level impact assessment and monitoring summary report, in M60.

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 deliverable comprises the first reporting iteration and is 80% complete for baseline values and 54% complete for impact values. The reporting task will be completed for the baseline values as missing data is gathered up to M48, and for baseline and impact values up to the end of the project in M60.

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 very brief comparison of baselines across the three cities and summative data concerning key impacts. Given the stage of the impact assessment it is too early to provide a full synthesis report. This will be attempted in the M48 update to this deliverable in order to meet the objectives outlined above.

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.

The process of co-producing monitoring and impact reporting with partners has embedded data collection in their operations and a clear definition of the desired outcomes of the modules. Formative learning has thus been occurring throughout the project. The final version of this report has been circulated to partners and will be taken as an agenda item at city board meetings in Spring 2018.

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

The WP2 evidence base of impacts will inform new WP6 activities post-M36 that are waiting to be resourced, including the spin-out Babel platform.

1.4 Overview of progress: using this report

This report provides a snapshot of progress implementing modules and achieving expected impacts in the Triangulum city districts and must be read as such. It will be of use to key audiences in the following ways:

- WP2 researchers: the report clearly highlights gaps in data and the steps that are required to address them for the M48 update.
- Project partners: the report indicates progress in terms of implementation and some of the early expected impacts for specific modules. It also highlights the remaining gaps in data provision.
- City coordinators: the report indicates overall city progress in terms of implementation and some of the early expected impacts. It also highlights the remaining gaps in data provision.
- Project coordinator: the report indicates overall progress and comparative progress in terms of achieving expected impacts across the three Lighthouse Cities.
- Interested third parties: the report gives an insight into the different dimensions of impacts that are being achieved by each module, and the magnitude of each.
- Third party data holders: the report highlights the remaining gaps in data provision.

2 Approach to Impact Reporting

This section draws on the baseline and impact assessment methodology outlined in Deliverable 2.1, adding details about impact assessment that has been undertaken since the submission of Deliverable 2.3 in M24.

2.1 Baseline and Impact Assessment Methodology

The seven stage methodology adopted by WP2 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 in Figure 2.1 to aid interpretation of the impact report.

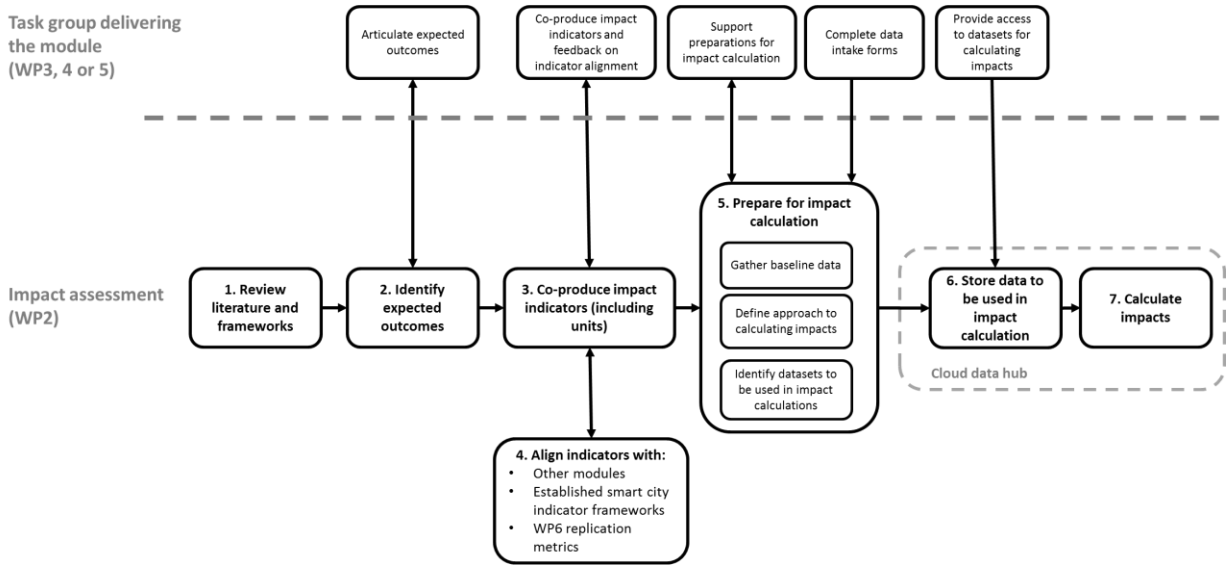

Figure 2.1: A Seven-Stage Methodology for Developing Indicators and Calculating Impacts

Explanation of Seven-Stage Methodology for Developing Indicators and Calculating Impacts:

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

2. **Identify and document expected outcomes**. WP2 engaged 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 was tasked with developing impact indicators and associated reports for the modules of the local partners. Engagement was aligned with the operation of the task group. Methods used included contributing to task group meetings, conducting workshops and semi-structured interviews, electronic consultation and opportunities to feedback on draft WP2 documents.

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

4. **Align and verify impacts, indicators and metrics.** The impact indicators for each module were 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 were verified with the task groups through electronic consultation.

5. **Prepare for impact calculation.** With support from task groups WP2 preparation for impact calculation included: 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 were 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 was used for more complex data sets that go beyond individual data points or simple spread sheets. Additional work facilitated documentation and transfer of data, but partners were not asked to perform additional work to generate the data.

6. **Store data to be used in impact calculation**. Based on the details provided by stakeholders and in the data intake form WP2 (Stavanger) has imported datasets for impact calculation into the cloud data hub. Where data is not in the appropriate format or does not warrant automation, datasets have either been manually collected by WP2 researchers in each city or specific data items have been requested from dataset holders.

7. **Calculate impacts**. Impacts have been calculated in three ways. The preferred option is to calculate impacts automatically in the Cloud Data Hub. This has only been possible for a limited number of impacts, reflecting the fact that not many datasets were available and / or appropriate for storage in the cloud data hub. Where this is not possible, WP2 researchers have requested the relevant data to make impact calculations. Where data has been unavailable for sharing, WP2 researchers have requested pre-calculated impacts from data holders.

Table 2.1 shows the timescales, key input required for each activity from partners, and the key instruments used at each stage.

Stage	Impact assessment activity (WP2)	Timescale	Input required from other WPs and partner organisations	Key methods used by WP2 staff

1.	Review of existing literature and frameworks	M1-M6	N/A	Desk study.
2.	Identify and document expected outcomes	M3-M9	Articulation of module scope and expected outcomes (WPs 3, 4 and 5)	Participation in task group meetings, email consultation on module outcomes.
3.	Co-produce and document impacts, indicators and datasets	M6-M12	Input to identify, review and validate indicators (WPs 3, 4, 5 and 6, and follower cities)	Semi-structured interviews, electronic consultation on module impact tables.
4.	Align and verify impacts, indicators and metrics	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	M33-36	Relevant formulae and additional data required from partners for some indicators	Electronic requests for data and meetings.

Table 2.1: Impact assessment methodology overview

2.2 Calculation of Impacts:

A number of complexities exist in relation to the specific calculation of impacts from data. This section considers three key challenges: units and formulae, extrapolated values, and calculation approaches.

Units and formulae

Where possible impact indicators have been aligned with the SCIS smart city indicator framework, as outlined in stage 4 of the impact methodology described above and available here: http://www.smartcities-infosystem.eu/sites/default/files/document/scis_kpi_guide.pdf. As a result D2.5 uses standard metric measures and units that are outlined in the SCIS framework. For indicators not aligned with SCIS consistent units are used across the three modules and cities.

Extrapolated values

Many modules have only recently been implemented, making it hard to assess impacts. To produce comparable impacts we have provided extrapolated values for impact indicators showing how the trend would look over a calendar year using simple linear extrapolation. It should be noted that extrapolated impacts that are based on relatively short implementation periods should be taken as indicative of general trends rather than as absolute figures. The validity of extrapolated values also varies by type of indicator. For example, absolute numbers of cargo-bikes deployed will not change over the duration of the rest of the project so are relatively time-independent. Changes in energy use meanwhile need to reflect seasonal variations, so require data covering at least a year. For any indicator which is subject to complex causal factors that vary over time, simple linear extrapolation is a major simplification[1].

The relative change and extrapolated rate per annum of relative change are both included to give some measure of scale for comparison between the impact indicator values. They are not intended to imply that changes will continue indefinitely with the values shown. For example, a value that increased 400% in 6 months, and therefore extrapolated to 800 % per year, is not expected to grow by 800 % every year.

Calculation approaches

Where possible, impacts have been calculated automatically in the cloud data hub. Where this is not possible, WP2 researchers have requested necessary data directly from data holders to make impact calculations. Where data has been unavailable for sharing, WP2 researchers have requested pre-calculated impacts from data holders in modules. Impact calculation options in order of preference are presented in Figure 2.2 below.

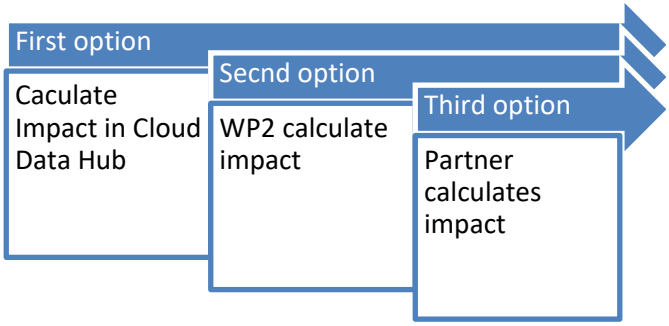

Figure 2.2: Impact calculation options in order of preference

For each module the section titled '*Factors limiting progress towards defining the approach to calculating impacts, identifying associated datasets, and establishing impact'* describes formulae

[1] Franklin, J. (2013) Arguments whose strength depends on continuous variation, *Journal of Informal Logic* 33, 33-56.

where relevant to enable third parties to understand exactly how impacts have been calculated. For some indicators these formulae are country specific. For example, CO2e calculations that reflect different national fuel mixes. Financial values for Manchester and Stavanger have been reported in Pounds and Norwegian Krona respectively *and* Euros, using the currency exchange rate at 29th January 2018.

2.3 Securing data required to monitor impacts, data sharing and the Cloud Data Hub

The Triangulum consortium has made every effort to supply the data required to monitor and assess the impacts of the modules to the Cloud Data Hub. A number of difficulties have been encountered that have limited the supply of data. Specific issues and their proposed resolutions are recorded in the dataset tables for each module, but general difficulties have related to:

1. Nature of 'small' data. Much of the data that WP2 requires to calculate impact indicators is static and / or does not constitute big data. For example, 'number of electric vehicles' is a single figure that is reported each year. Given the resource costs of making datasets available in the cloud data hub only large / real time datasets have been pursued. Similarly, the Cloud Data Hub is designed to receive data feeds from online databases. Where partners hold data offline it is impossible to automate the process of data collection. A key lesson here involves the need to conduct an audit of data management in partner organisations early in the project life-cycle to understand the parameters for automated data sharing and plan accordingly.

2. Privacy concerns. Data relating to modules deploying in residential settings contains personal information, and partners have been hesitant to share datasets with WP2. Particular concerns surround the uploading of data to the Could Data Hub and potential issues that this may cause in relation to the adoption of the GDPR in May 2018. WP2 have addressed these issues through the following steps:
   - Meeting between WP2 leader and Lighthouse City partners face-to-face to discuss concerns.
   - Liaising with city data platform managers.
   - Producing a bespoke agreement for partners supplying data to the cloud data hub outlining the data security and management principles.
   - Testing whether a Privacy Impact Assessment is required for sensitive datasets.
   - Obtaining the expert advice of data privacy experts working in the CityVerve IoT project.
   - Meeting with data experts from sister Lighthouse projects to share solutions (SCIS side-event, October 2017).

   Partners with privacy concerns are now considering how they can supply data before the M48 update of the D2.5 report. A key lesson here involves the need to help key partners understand the privacy implications of their specific data through in-depth liaison and a robust self-assessment process.

3. Technical capability of partners. UiS developed an online data intake form (found at https://goo.gl/forms/mIcsAIfMETwsDhxe2) to assist partners in providing the necessary

technical information concerning datasets in M24, but the form requires considerable technical expertise to complete. UiS provided live online support for partners, and key technical personnel in each Lighthouse City assisted where possible. A key lesson here has been to focus on data sets that have the most potential for use and analytic manipulation and work with existing data platforms in cities to streamline the process of automating data transfer through APIs.

4. Ownership of data. Some partners have outsourced data collection, storage and management to third parties. The possibility of gaining full access to these datasets is then dependent on the specific service contract that has been signed. Similarly, where data is owned by private individuals, the ability to share it is dependent on the specific contracts that were signed with those individuals. Often these contracts were developed prior to the start of the Triangulum project or independently of WP2 considerations. The key lesson here is to ensure that key data holders party to contracts signed before projects commence are included as full partners in smart city projects, and that any contracts signed after projects commence specify an adequate level of access and reporting responsibilities.

Summary of datasets held in the Cloud Data Hub

Currently, the cloud data platform holds the following module datasets.

- Module 332: m332-mcc-autotrip – updated manually every fortnight. This on-going data transfer is live
- Module 432: m432-vialistraffic – consistent, but stopped working on the 27th December 2017. Requires follow-up
- Module 522: m522-energisentralen-test – ongoing, but expected transfer on 27th December 2017 failed. This transfer should be automated and unaffected by holidays, so is currently being followed-up with the partner.

It also holds a dataset which is unrelated to any Triangulum modules and this will be renamed in future versions to x000 to indicate that the data source is external to the Triangulum project, albeit potentially interesting as a basis for comparison with Triangulum Module 432.

- m000_svg_parkering – ongoing, expected transfer on 27th of December also failed, so this may constitute a time where the surrounding network at UiS has affected the CDP operations.

2.4 Timeline and Considerations for D2.5: Impact Report

The plan for delivery and draft structure for the Deliverable 2.5: Impact Reports has been developed through intensive Skype meetings and consultation with partners and the project officer from INEA between M28 and M36. WP2 consulted with partners and the project officer to determine how best to handle the delayed implementation of modules. Two options were considered:

1. Delay submission of D2.5 impact report from M36 to M48
2. Submit an incomplete D2.5 in M36 and update it in M48

After widespread consultation it was decided to adopt the second approach, which would provide partners with an earlier indication of progress towards expected impacts, identify key gaps and plans to address them, and produce less inconsistency with the DoA.

The activities and agreed timescale for delivery is presented in Table 2.2 as follows:

Date	Agreed Action
26th June	Skype meeting with WP2 partners to develop delivery schedule for D2.5. Begin updating module descriptions and verifying impacts and indicators with partners. Agree to develop individual city impact reports as used in D2.3 Baseline Report.
12th July	Skype meeting to map links between WP2 and WP6 M36 deliverables.
15th August	Skype meeting to coordinate with WP6 and project coordinators.
18th September	Face-to-face meeting at INEA and consult project officer about plan to deliver incomplete D2.5 in M36 and refresh in M48.
20th September	Skype meeting with WP2 partners to set deadlines for data collection.
9th October	Skype meeting with WP2 partners to prepare for Leipzig General Assembly.
12th-13th October	Present plan for delivering D2.5 to project partners at the Leipzig General Assembly.
27th October	Skype meeting with WP2 partners to address partner feedback from Leipzig General Assembly.
3rd November	Research partners in Eindhoven, Manchester and Stavanger to share progress on city baseline reports to ensure the reporting approach is consistent.
16th November	Skype meeting with WP2 partners to address issues with impact calculations.
29th November	Skype meeting with WP2 partners to address missing module information and data.
1st December 2016	Research partners in Eindhoven, Manchester and Stavanger to share progress on city baseline reports to identify key gaps and actions to address them.
11th December	Skype meeting with WP2 partners to address progress completing section 3,4 and 5 (city impact reports), and discuss structure of sections 1,2, 6 and 7 of D2.5 Impact Report.
21st December	Research partners in Eindhoven, Manchester and Stavanger to submit finalised city baseline reports to WP2 coordinator.
22nd December	WP2 coordinator to circulate draft of D2.5 for comment to WP2 team.
2nd January	WP2 coordinator to provide feedback on city impact reports to research partners in Eindhoven, Manchester and Stavanger.
3rd January	Research partners in Eindhoven, Manchester and Stavanger to provide feedback on draft of D2.5 to WP2 coordinator.
9th January	Final Skype meeting between WP2 partners to agree report.
12th January	Submission to the Triangulum coordinator.

Table 2.2: timescale for delivering WP2.5: Impact Report

Between M24 and M36 we received and addressed the following feedback from partners and the project officer:

Feedback	Source	Response
The difficulties of completing the data intake form to push data into the Cloud Data Hub in time.	Municipal and corporate city partners	UiS developed instructions and offered online support for partners to complete the data intake form. Period for completing form extended by two months.
The need to be clear about procedures for reporting missing data and delayed modules.	Project officer	A typology of explanations has been developed to explain any omissions, and actions to rectify them have been reported in the redesigned impact tables (see section 2.6 below).
The need to explicitly determine the timeframe for different impacts, including the difficulties of reporting impacts over shorter timescales for certain types of modules such as energy.	Project officer	Partners implementing modules have been asked to supply details of exact implementation dates, and explanatory text has been added as required to contextualise any extrapolated impacts.

Table 2.3: Feedback on impact reporting process and WP2 response

2.5 Structure of report for each city

For each city the impact report (see sections 3-5) provides an overview and update of the Triangulum activity taking place and a summary of the results so far, followed by a detailed account of the Energy, Mobility and ICT modules with impact assessment indicator, data set and impact assessment tables for each module. The structure for each city report is as follows:

- *An executive summary:* A brief summary outlining the modules that have been or yet to be implemented within the city and the key findings emerging from the baseline and impact data.
- *Overview and initial assessment:* a synthesis of the current context of each module, an update on its progress since the submission of deliverable 2.3 updated baseline report, and an initial assessment of the baseline and impact assessment data.
- *The modules:* a description of the modules that have been or are to be implemented including objectives, partner organisations involved, technologies used, implementation dates, and the indicators that have been used for assessing the impacts and benefits. For each module baseline data is presented and, where available, impact data is also presented. This includes quantitative data gathered and text summarising the important features of the baseline and impact data.

Deliverable 2.3 gives details for each module concerning: Objective, Approach, Expected Impacts, Links with other modules, the Socio-technical configuration of the module, and the stakeholder structure of the module. These are not repeated here in Deliverable 2.5. This report considers three further elements for each module under the following headings.

- The implementation dates of the module, which outlines the dates of implementation.

- The indicators to be used for assessing the impacts and benefits and baseline conditions, which outlines the general approach.
- Factors limiting progress towards defining the approach to calculating impacts, identifying associated datasets, and establishing impact.

The section 'Factors limiting progress towards defining the approach to calculating impacts, identifying associated datasets, and establishing impact' records changes that have been made since Deliverable 2.3. These include:

- Missing modules. Where modules are missing an explanation for omission is given covering the main reason. These have been codified as: i) delay in implementation; ii) unavailability of data; iii) changes to proposed module, and iv) project amendment.
- Proposed WP2 actions. Where indicators remain unchanged (i.e. i or ii above) they will be included into M48 refresh of impact report, or if indicators are substantively changed (i.e. iii or iv above) they will be removed from the monitoring and assessment process).
- For modules that are simply being delayed (i) or for which data is simply not yet available (ii) and which are therefore being included in M48 refresh of impact report, impact assessment indicator, dataset and impact assessment calculation tables are included with updated comments in the WP2 next steps columns.
- New or altered impact indicators. Details concerning any updates to impact indicators that have arisen as a result of changes to the module design or data availability.

2.6 The structure of module impact indicator, dataset and impact calculation tables

For each module described in sections 3-5 below, impact indicators, datasets and impact assessment calculations are presented in detail in the form of tables. To aid interpretation of these tables their structures are outlined below (in Table 2.4, Table 2.5 and Table 2.6) including a description of the column headings, column content and approach to populating the column. This approach has been adopted with partners through regular meetings with WP2 researchers to link the co-produced monitoring framework to the available datasets in a clear and actionable way. They reflect the structure of module impact reporting outlined in D2.3 Baseline Report, but have added a table for the impacts which includes baseline data.

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.

Column headings (impact indicator tables)	**Description of column contents**	**Approach to populating the column**
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.
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.
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

Table 2.4: Indicator Tables - description of the structure of the tables which identify impact indicators for each module.

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.

Column headings (dataset tables)	**Description of column contents**	**Approach to populating the column**
Required for impact calc. for 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.
Dataset owner	Identify which organisation owns the dataset.	Text.
Dataset contact	Identify who WP2 can contact to access the dataset and gather the contextual information needed to understand and use the dataset.	Text. Name and email address.
Comments	Any additional information relating to the dataset and its availability. Where possible and appropriate, justify why dataset is currently unavailable.	Text.
WP2 next steps	Identify next action for WP2 relating to the dataset.	Text.

Table 2.5: Dataset Tables - description of the structure of the tables which identify datasets to potential be used in calculating impact indicators for each module.

Column headings (impact calculation 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 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.
Start value	The baseline value	The units specified in the Impact indicator table
Start value period	The time period that baseline data was collected, preferably for 12months until the month preceding implementation	Dates in the format MMM YYYY – MMM YYYY
End value	The calculated impact value	The units specified in the Impact indicator table
End value period	The time period that impact data was collected, preferably from month of implementation for 12 months	Dates in the format MMM YYYY – MMM YYYY
Absolute change	The difference between the baseline and the impact	Start value minus end value
Extrapolated rate of absolute change (p.a.)	The difference value over the course of one year, if not already reported in this format	Absolute change as a per annum figure
Relative change	The absolute change as a percentage of the start value	Absolute change divided by start value
Extrapolated rate of relative change (p.a.)	The relative change value over the course of one year, if not already reported in this format	Relative change as a per annum figure

Table 2.6: Impact Tables - description of the structure of the tables which show the impact assessment calculation for each module.

2.7 At a glance summary of modules

A summary of the modules and related sub-tasks from the DoW is presented in Table 2.7 to give an overview of the entire set of modules under consideration in this deliverable. The modules are listed by city, sector and related to the subtasks and deliverables in the DoW. Table 2.7 also shows how the Use Cases developed by WP6 relate to the impact assessment modules. The modules are colour-coded to indicate implementation progress at January 2018. Green indicates that a module has been fully implemented, orange indicates that a module has been partially or only just implemented, while red indicates that the module has not yet been implemented. The stage of implementation has a major bearing on the availability of data to use to calculate baseline and impact values for impact indicators, but is not the only factor causing delays in the gathering of data as outlined in Section 2.3

City	Sector	Module	Use Cases	Subtasks and Deliverables
Man	Energy	Module 321: Central energy controller (Subtasks 3.2.2-5)	Demand Side Response Control for Student Accommodation (UC-321a) Demand Side Response Control for Office Block (Academic Building) (UC-321b) Demand Side Response Control for Public building (UC-321c) Micro-grid management system (UC-321d) City Energy Controller (UC-321e)	Subtask 3.2.2 Construction and Installation Subtask 3.2.3 Hardware/IT integration Subtask 3.2.4 Testing and Resilience Subtask 3.2.5 Operation and Evaluation
		Module 322: Energy optimization in buildings (Subtasks 3.2.2-5)	Building Benchmark Assessment (UC-322a)	Subtask 3.2.2 Construction and Installation Subtask 3.2.3 Hardware/IT integration Subtask 3.2.4 Testing and Resilience Subtask 3.2.5 Operation and Evaluation
		Module 323: Low-carbon energy generating assets (Subtasks 3.2.2-5)	Energy Storage Assets (UC-323a) Photovoltaic Installation on post 2000 building (UC-323b)	Subtask 3.2.2 Construction and Installation Subtask 3.2.3 Hardware/IT integration Subtask 3.2.4 Testing and Resilience Subtask 3.2.5 Operation and Evaluation
	Mobility	Module 331: Electric vehicle procurement (Subtasks 3.3.2-4)	Corporate Electric car sharing for University (UC-331a) Leasing electric vans for estate management (UC-331b)	Subtask 3.3.2 Procurement and Implementation Subtask 3.3.3 Monitoring Subtask 3.3.4 Evaluation

		Module 332: Electric assist cargo bikes (Subtasks 3.3.2-4)	Electric Assist Cargo bikes (Pedelecs) for goods delivery (UC-332)	Subtask 3.3.2 Procurement and Implementation Subtask 3.3.3 Monitoring Subtask 3.3.4 Evaluation
	ICT	Module 341: Data curation service (D3.4.1)	Data Curation & 342a Data Visualization Platform (UC-341)	Subtask 3.4.1 Establish Open Data and Service Engine Subtask 3.4.2: Ongoing Running and Monitoring of Open Data and Service Engine D3.4.1 Open Data and Service Engine (ODSE)
		Module 342: Data visualization platform (D3.4.2)	Data Visualization Platform (UC-342)	Subtask 3.4.3: Establish Visualisation Platform and Incubation Structures Subtask 3.4.4: Support MCR-i and Open Application Marketplace D3.4.2 Full MCR-i platform
		Module 343: Data-enabled innovation challenges (D3.4.3)	Data-Enabled Innovation Challenges (UC-343a) App to train electric vehicle drivers (UC-343b) Behavioural change application for students (UC-343c) Vehicle charging Application (UC-343d)	Subtask 3.4.3: Establish Visualisation Platform and Incubation Structures D3.4.3 Suite of Open Market Apps
Eind	Energy	Module 421: Sustainable energy supply and soil sanitation (Subtask 4.2.1)	Sustainable Energy Supply by Soil Sanitation (UC-421)	Subtask 4.2.1 Sustainable energy supply and soil sanitation
		Module 422: Optimization of heat provision in existing buildings (Subtask 4.2.2)	Switching from steam based to water based heating systems powered by biomass (UC-422)	Subtask 4.2.2 Optimization of heat provision in existing buildings of Strijp-S
		Module 423: Smart energy for offices (Subtask 4.2.3)	Smart Control of individual rooms in existing buildings (UC-423a) Smart control of individual floors in existing buildings (UC-423b)	Subtask 4.2.3 Smart energy savings offices on Strijp-S
		Module 424: Renovation of	Renovation of Semi-attached homes of housing association	Subtask 4.2.4 Renovation of family homes Eckart-

		family homes and creation of participative society (Subtask 4.2.4)	using woonconnect tool (UC-424a) Renovation of Semi-attached homes of privately owned apartments using woonconnect tool (UC-424b) Renovation of Semi-attached homes of privately owned houses using woonconnect tool (UC-424c)	Vaartbroek & creation of participative society
		Module 425: Smart distribution of locally produced renewable energy (Subtask 4.2.5)	Solar Smart Grid for apartment buildings with private home owners (UC-425a) Wind energy for common areas of apartment building (UC-425b)	New module
	Mobility	Module 431: Smart charging of electric vehicles (Subtask 4.3.1)	Public Charging Infrastructure (UC-431a)	Subtask 4.3.1 Smart charging of electric vehicles on Strijp-S
		Module 432: Mobility management (Subtask 4.3.2)	Parking Management System (UC-432a) Station bound district car sharing (UC-432b) Single base bike sharing (UC-432c) Point-to-point station bound bike sharing (UC-432d)	Subtask 4.3.2. Mobility management
	ICT	Module 441: Smart distribution of local renewable energy (Subtask 4.4.1)		Subtask 4.2.5 Installation and smart distribution of locally produced renewable energy
		Module 441: Eindhoven smart city open data platform (Subtask 4.4.2)	Eindhoven Open Data Portal (UC-441a)	Subtask 4.4.1 Eindhoven facilitation smart city ICT open data platform
		Module 442: Interactive energy retrofit for dwellings	Public Sound Sensor Safety Project in Stratumseind (UC-442a)	Subtask 4.4.2 Interactive process for dwellings in Eckart-Vaartbroek Subtask 4.4.3 Eckart-

		(Subtasks 4.4.2-3)	Sensor based citizen initiative for environmental monitoring (UC-442b) Camera based crowd management in the Eindhoven city center (UC-442c)	Vaartbroek area: Stimulating private owners and other housing corporations in the area to follow
		Module 443: Smart environment fibre-optic infrastructure (Subtask 4.4.4)	Fibre Optic Infrastructure in Stijp S (UC-443a) Public Wi-Fi (UC-443b)	Subtask 4.4.4 Second phase of implementation and integration of the fibre-optic data infrastructure
		Module 444: Public space sensor network (Subtask 4.4.5)	Smart Lighting in Strijp-S (UC-444a) Public Sound Sensor Safety Project (UC-444b)	Subtask 4.4.5 Sensor network in the public space
		Module 445: Smart city innovation fund (Subtask 4.4.6)		Subtask 4.4.6 Stimulating the development of innovative services / applications
		Module 446: Smart streetlights for social interaction and health route (Subtask 4.4.7)	IOT Security Systems (UC-446a) High-End solar E-bike sharing system (UC-446b) Navigation device for visually impaired people in Smart Cities (UC-446c) Preference based work space finder for Flex buildings (UC-446d) Interactive neighborhood screen for development projects (UC-446e) Self-sufficient modular plant-panels (UC-446f) Smart City Data Platform of Platforms (UC-446g) Non-intrusive camera based vehicle recognition system (UC-446h) Sound Sensor for Vehicle operation safety (UC-446i) Smart Interactive floorlight for walking and running in Eckart (UC-446j) Unidirectional functional lighting in Eckart (UC-446k)	Subtask 4.4.7 Smart streetlights for a 1-KM social interaction and health route

Stav	Energy	Module 521: Smart gateways (Subtask 5.2.1)	Smart Gateway for Homes (UC-521a) Smart Gateway for nursing homes (UC-521b) Smart Gateway for Schools (UC-521c)	Subtask 5.2.1 Smart gateway introduction and energy management
		Module 522: Central energy plant (Subtask 5.2.2)	Sewage heat pump system (UC-522a)	Subtask 5.2.2 City goes zero – switching to renewables
	Mobility	Module 531: Electric battery bus demonstration (Subtask 5.3.1)	Public Transport with battery electric busses (UC-531a)	Subtask 5.3.1 Demo project of eBuses
		Module 532: Electric vehicle charging infrastructure upgrade (Subtask 5.3.2)	Electric vehicle private home charging infrastructure (UC-532b) Electric vehicle apartment building charging infrastructure (UC-532c)	Subtask 5.3.2 EV charging infrastructure, expanding the super charging hubs
	ICT	Module 541: Innovative video (Subtask 5.4.1)	Blink: Innovative video for distance health care (UC-541a) Blink: Innovative video for communication services (UC-541b)	Subtask 5.4.1 Innovative video
		Module 542: Data analytics toolkit (Subtask 5.4.2)	Data Analytics Toolkit (UC-542a)	D5.4.2: Design of tools for data analytics
		Module 543: Sustainable citizen service development (Subtask 5.4.3)	Multimodal decision support service (UC-543a)	Subtask 5.4.3 Sustainable citizens' service development
		Module 544: Cloud data platform (D2.2)	Cloud Data Platform for Stavanger (UC-544a) Computing Platform (UC-544b)	D2.2 : Cloud Data Hub

Table 2.7: Module, subtask and implementation progress overview

3 Manchester Impact

Executive Summary

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

Section 1 offers an initial evaluation of the module impacts followed by a high-level overview of the impact and assessment and monitoring activities to continue in Manchester during 2018. Section 2 describes the Energy modules in detail including objectives, socio-technical configurations and stakeholder structures. The indicators used for assessing the impacts and benefits of the module and the current understanding of impacts are then presented. Sections 3 and 4 provide module descriptions and impact indicators for the Mobility and ICT modules respectively.

3.1 Overview and initial assessment

This section briefly assesses the local modules and their impacts. The progress of the Manchester partnership in terms of module implementation and impact reporting is summarized in Table 3.1.

	#modules implemented	#baseline indicator values available	#impact indicator values available
Overall value	4/8	90/95	59/95
Energy	0/3	34/34	6/34
Mobility	2/2	40/40	37/40
ICT	2/3	16/21	16/21

Table 3.1: Implementation and impact reporting of Manchester modules

Due to delays in implementation, no impacts can yet be measured for Energy modules. However, all three Energy modules are due to be implemented by April 2018, and updated baselines and early impact calculations will be included in the M48 refresh and full impact calculations will be included in the M60 report. Some key impacts achieved in Manchester to date include lowered greenhouse gas emissions (Module 331 and 332) due to the Mobility modules, and enhanced digital infrastructure and increased user engagement (Module 341 and 342) due to the ICT modules implemented to date.

3.2 Energy Modules

The Energy task group in Manchester defined 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 have been revised over the course of the project as module scope was 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, has been submitted by the Manchester energy task group. The amendment was approved and the scope of this module has changed significantly. WP2 have updated the module description, impact indicator table and dataset table, and the impact calculation table has been presented accordingly.*

Table 3.2 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 3.2: Expected impacts of Manchester Energy modules

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

The implementation dates of the module

The module was implemented in MCC (the Town Hall Extension and the Central Library) in November 2017, and will be implemented in MMU (Birley Fields Energy Centre) and UNIMAN (Alan Gilbert and Alan Turing Buildings) in January 2018.

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

Below, Table 3.3 provides details of the impact indicators developed for this module, and Table 3.4 identifies datasets that have been used to calculate impacts.

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

- All impact indicators have updated baselines, and no impact calculations, due to delay to module implementation.
- **M34 (2017):** The energy controller technology has only been implemented at one site of three. Therefore, the baselines have been updated to coincide with the 12 months preceding implementation.
- Energy cost data was not available for MMU. Therefore, the average cost rate from MMC and UNIMAN was applied to the energy use at MMU.
- UK government Co2e factors have been used to calculate emissions, available from the Department of Energy and Climate Change [https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting]

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
321001	Reduced energy consumption	Change in annual primary energy use (MCC buildings)	kWh	Primary energy use data (MCC), CC operational data	Y
321002	Reduced energy consumption	Percentage change in annual primary energy use (MCC buildings)	Dimensionless decimal	Primary energy use data (MCC), CC operational data	Y
321003	Reduced energy consumption	Change in annual primary energy use (MMU buildings)	kWh	Primary energy use data (MMU), CC operational data	Y
321004	Reduced energy consumption	Percentage change in annual primary energy use (MMU buildings)	Dimensionless decimal	Primary energy use data (MMU), CC operational data	Y
321005	Reduced energy consumption	Change in annual primary energy use (UNIMAN buildings)	kWh	Primary energy use data (UNIMAN), CC operational data	Y
321006	Reduced energy consumption	Percentage change in annual primary energy use (UNIMAN buildings)	Dim. Int.	Primary energy use data (UNIMAN), CC operational data	Y
321007	Reduced energy consumption	Change in annual primary energy use (all buildings)	kWh	Primary energy use data (MCC, MMU & UNIMAN), CC operational data	Y
321008	Reduced energy consumption	Percentage change in annual primary energy use (all buildings)	Dim. Int.	Primary energy use data (MCC, MMU & UNIMAN), CC operational data	Y
321009	Reduced energy costs	Change in annual energy costs (MCC buildings)	€	Energy cost data (MCC), CC operational data	Y
321010	Reduced energy costs	Change in annual energy costs (MMU buildings)	€	Energy cost data (MMU), CC operational data	Y
321011	Reduced energy costs	Change in annual energy costs (UNIMAN buildings)	€	Energy cost data (UNIMAN), CC operational data	Y
321012	Reduced energy costs	Change in annual energy costs (all buildings)	€	Energy cost data (MCC, MMU & UNIMAN), CC operational data	Y

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
321013	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMC buildings)	tCO_2e	GHG emission data (MCC), CC operational data	Y
321014	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMU buildings)	tCO_2e	GHG emission data (MMU), CC operational data	Y
321015	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	GHG emission data (UNIMAN), CC operational data	Y
321016	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	GHG emission data (MCC, MMU & UNIMAN), CC operational data	Y

Table 3.3: Impact assessment indicators description for Module 321

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Primary energy use data (MCC)	Longitudinal dataset detailing primary energy use (heat and electricity) in specified MCC buildings	321001 321002 321007 321008	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
Energy cost data (MCC)	Longitudinal dataset detailing the costs arising from primary energy use in specified MCC buildings	321009 321012	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
GHG emission data (MCC)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MCC buildings	321013 321016	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
Primary energy use data (MMU)	Longitudinal dataset detailing primary energy use (heat and electricity) in specified MMU buildings	321003 321004 321007 321008	MMU	Callum Donnelly (C.Donnelly@mmu.ac.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
Energy cost data (MMU)	Longitudinal dataset detailing the costs arising from primary energy use in specified MMU buildings	321010 321012	MMU	n/a	Module implementation delayed. Therefore, baseline has been updated. Unavailable as data owner classifies as commercially sensitive. Average used, as outlined in module overview above.	Impact calculation will be included in M48 refresh.
GHG emission data (MMU)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MMU buildings	321014 321016	MMU	Callum Donnelly (C.Donnelly@mmu.ac.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Primary energy use data (UNIMAN)	Longitudinal dataset detailing primary energy use (heat and electricity) in specified UNIMAN buildings	321005 321006 321007 321008	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
Energy cost data (UNIMAN)	Longitudinal dataset detailing the costs arising from primary energy use in specified UNIMAN buildings	321011 321012	UNIMAN	n/a	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
GHG emission data (UNIMAN)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified UNIMAN buildings	321015 321016	UNIMAN	n/a	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
CC operational data	Data detailing the operations and impacts of the central controller.	All indicators from 321001 to 321016	Siemens	Andrew Smyth (Andrew.Smyth@siemens.com)	Format and frequency of data remains to be specified by WP3.	

Table 3.4: Datasets description for Module 321

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
321001	Change in annual primary energy use (MCC buildings)	kWh	10,414,692	Nov 2016 – Oct 2017						

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
321002	Percentage change in annual primary energy use (MCC buildings)	Dimensionless decimal	0	Nov 2016 – Oct 2017						
321003	Change in annual primary energy use (MMU buildings)	kWh	10,338,644	Jan 2017 – Dec 2017						
321004	Percentage change in annual primary energy use (MMU buildings)	Dimensionless decimal	0	Jan 2017 – Dec 2017						
321005	Change in annual primary energy use (UNIMAN buildings)	kWh	2,372,043	Jan 2017 – Dec 2017						
321006	Percentage change in annual primary energy use (UNIMAN buildings)	Dim. Int.	0	Jan 2017 – Dec 2017						
321007	Change in annual primary energy use (all buildings)	kWh	23,125,379	n/a (impacts not aligned)						
321008	Percentage change in annual primary energy use (all buildings)	Dim. Int.	0	n/a (impacts not aligned)						
321009	Change in annual energy costs (MCC buildings)	€	532,964 (£467,827)	Nov 2016 – Oct 2017						
321010	Change in annual energy costs (MMU buildings)	€	570,369 (£500,661)	Jan 2017 – Dec 2017						
321011	Change in annual energy costs (UNIMAN buildings)	€	142,463 (£125,052)	Jan 2017 – Dec 2017						
321012	Change in annual energy costs (all buildings)	€	1,245,797 £1,093,540)	n/a (baseline periods not aligned)						
321013	Change in annual greenhouse gas emissions (MMC buildings)	tCO_2e	4,291	Nov 2016 – Oct 2017						

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
321014	Change in annual greenhouse gas emissions (MMU buildings)	tCO_2e	3,635	Jan 2017 – Dec 2017						
321015	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	834	Jan 2017 – Dec 2017						
321016	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	8,760	n/a (baseline periods not aligned)						

Table 3.5: Impact assessment for Module 321

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

The implementation dates of the module

The module is being implemented and will be finalised in the MCC (Manchester Art Gallery) and UNIMAN estates (Ellen Wilkinson Building) in January 2018.

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

Below Table 3.6 provides details of the impact indicators developed for this module by the partners and Table 3.7 identifies datasets that have been used to calculate impacts.

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

- All impact indicators have updated baselines, due to delayed implementation.
- Baselines have been updated to the 12 month period preceding panned implementation.
- Data was not yet available for the full 12 months prior to implementation for MCC buildings. Therefore, this baseline period is set back by 3 months.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
322001	Optimised building energy management systems	Number of MCC buildings optimised	Dimensionless integer	WP3 self-reports on module implementation progress	N
322002	Optimised building energy management systems	Area of MCC building floor space optimised	m^2	WP3 self-reports on module implementation progress	N
322003	Optimised building energy management systems	Number of UNIMAN buildings optimised	Dimensionless integer	WP3 self-reports on module implementation progress	N
322004	Optimised building energy management systems	Area of UNIMAN building floor space optimised	m^2	WP3 self-reports on module implementation progress	N
322005	Optimised building energy management systems	Total number of buildings optimised	Dimensionless integer	WP3 self-reports on module implementation progress	N
322006	Optimised building energy management systems	Area of building floor space optimised (all buildings)	m^2	WP3 self-reports on module implementation progress	N
322007	Reduced energy consumption	Change in annual primary energy use (MCC buildings)	kWh	Primary energy use data (MCC), Optimisation operational data	Y
322008	Reduced energy consumption	Percentage change in annual primary energy use (MCC buildings)	Dimensionless decimal	Primary energy use data (MCC), Optimisation operational data	Y
322009	Reduced energy consumption	Change in annual primary energy use (UNIMAN buildings)	kWh	Primary energy use data (UNIMAN), Optimisation operational data	Y
322010	Reduced energy consumption	Percentage change in annual primary energy use (UNIMAN buildings)	Dim. Int.	Primary energy use data (UNIMAN), Optimisation operational data	Y
322011	Reduced energy consumption	Change in annual primary energy use (all buildings)	kWh	Primary energy use data (MCC & UNIMAN), Optimisation operational data	Y

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
322012	Reduced energy consumption	Percentage change in annual primary energy use (all buildings)	Dim. Int.	Primary energy use data (MCC & UNIMAN), Optimisation operational data	Y
322013	Reduced energy costs	Change in annual energy costs (MCC buildings)	€	Energy cost data (MCC), Optimisation operational data	Y
322014	Reduced energy costs	Change in annual energy costs (UNIMAN buildings)	€	Energy cost data (UNIMAN), Optimisation operational data	Y
322015	Reduced energy costs	Change in annual energy costs (all buildings)	€	Energy cost data (MCC & UNIMAN), Optimisation operational data	Y
322016	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMC buildings)	tCO_2e	GHG emission data (MCC), Optimisation operational data	Y
322017	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	GHG emission data (UNIMAN), Optimisation operational data	Y
322018	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	GHG emission data (MCC & UNIMAN), Optimisation operational data	Y

Table 3.6: Impact assessment indicators description for Module 322

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Primary energy use data (MCC)	Longitudinal dataset detailing primary energy use (electricity and heat) in specified MCC buildings	322007 322008 322011 322012	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh. Baseline will be further updated.
Energy cost data (MCC)	Longitudinal dataset detailing the costs arising from primary energy use in specified MCC buildings	322013 322015	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh. Baseline will be further updated.
GHG emission data (MCC)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MCC buildings	322016 322018	MCC	Sophie Sheil (s.sheil@manchester.gov.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh. Baseline will be further updated.
Primary energy use data (UNIMAN)	Longitudinal dataset detailing primary energy use (electricity and heat) in specified UNIMAN buildings	322009 322010 322011 322012	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
Energy cost data (UNIMAN)	Longitudinal dataset detailing the costs arising from primary energy use in specified UNIMAN buildings	322014 322015	UNIMAN	n/a	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
GHG emission data (UNIMAN)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified UNIMAN buildings	322017 322018	UNIMAN	n/a	Module implementation delayed. Therefore, baseline has been updated.	Impact calculation will be included in M48 refresh.
Optimisation operational data	Data detailing the operations and impacts of the optimisations.	All indicators from 322007 to 322018	Siemens	Andrew Smyth (Andrew.Smyth@siemens.com)	Format and frequency of data remains to be specified by WP3.	WP2 will continue to liaise with WP3 throughout 2018, in order to include data in M48 refresh.

Table 3.7: Datasets description for Module 322

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change (%)	Extrapolated rate of relative change (p.a.)
322001	Number of MCC buildings optimised	Dimensionless integer	0	Nov 2017	1	Jan 2018				
322002	Area of MCC building floor space optimised	m^2	0	Nov 2017	10,300	Jan 2018				
322003	Number of UNIMAN buildings optimised	Dimensionless integer	0	Nov 2017	1	Jan 2018				
322004	Area of UNIMAN building floor space optimised	m^2	0	Nov 2017	12,881	Jan 2018				
322005	Total number of buildings optimised	Dimensionless integer	0	Nov 2017	2	Jan 2018				
322006	Area of building floor space optimised (all buildings)	m^2	0	Nov 2017	23,181	Jan 2018				
322007	Change in annual primary energy use (MCC buildings)	kWh	3,347,177	Oct 2016 – Sept 2017						
322008	Percentage change in annual primary energy use (MCC buildings)	Dimensionless decimal	0	Oct 2016 – Sept 2017						
322009	Change in annual primary energy use (UNIMAN buildings)	kWh	481,574	Jan 2017 – Dec 2017						
322010	Percentage change in annual primary energy use (UNIMAN buildings)	Dim. Int.	0	Jan 2017 – Dec 2017						
322011	Change in annual primary energy use (all buildings)	kWh	3,833,870	n/a (baselines not aligned)						
322012	Percentage change in annual primary energy use (all buildings)	Dim. Int.	0	n/a (baselines not aligned)						
322013	Change in annual energy costs (MCC buildings)	€	236,752 (£207,817)	Oct 2016 – Sept 2017						
322014	Change in annual energy costs (UNIMAN buildings)	€	28,814 (£25,293)	Jan 2017 – Dec 2017						

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change (%)	Extrapolated rate of relative change (p.a.)
322015	Change in annual energy costs (all buildings)	€	265,566 (£233,110)	n/a (baselines not aligned)						
322016	Change in annual greenhouse gas emissions (MMC buildings)	tCO_2e	1379	Oct 2016 – Sept 2017						
322017	Change in annual greenhouse gas emissions (UNIMAN buildings)	tCO_2e	169	Jan 2017 – Dec 2017						
322018	Change in annual greenhouse gas emissions (all buildings)	tCO_2e	1548	n/a (baselines not consistent)						

Table 3.8: Impact assessment for Module 322

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

An amendment, related to this module, has been submitted by the Manchester energy task group. The amendment was approved and the scope of this module has changed significantly. WP2 has updated the module description, impact indicator table and dataset table, and the impact calculation table has been presented accordingly.

The implementation dates of the module

The module will be implemented in MMU (Birley Fields Building) estate in April 2018.

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

Below Table 3.9 provides details of the impact indicators developed for this module and Table 3.10 identifies datasets used to calculate impacts.

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

- **M35 (2017):** Amendment to the module, causing scope to be changed and module implementation to be delayed to April 2018.
- Module being implemented in MMU Birley Fields campus only, causing removal of impact indicators relating to UNIMAN: 323003-323006, 323008-323009, 323011-323012.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
323001	Increased use of low carbon energy sources	Energy delivered by the low carbon energy generation assets (MMU buildings)	kWh	Energy generation asset operational data	Y
323002	Increased use of low carbon energy sources	Change in share of primary energy demand met by onsite renewables (MMU buildings)	Dimensionless decimal	Energy generation asset operational data	Y
323007	Reduced energy costs	Change in annual energy costs (MMU buildings)	€	Energy cost data (MMU), Energy generation asset operational data	Y
323010	Reduced greenhouse gas emissions	Change in annual greenhouse gas emissions (MMU buildings)	tCO_2e	GHG emission data (MMU), Energy generation asset operational data	Y

Table 3.9: Impact assessment indicators description for Module 323

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Energy cost data (MMU)	Longitudinal dataset detailing the costs arising from primary energy use in specified MMU buildings	323007 323009	MMU	n/a	Unavailable as data owner classifies as commercially sensitive.	WP2 will use standard energy prices to calculate energy cost, once energy data is available. To be included in M48 refresh.
GHG emission data (MMU)	Longitudinal dataset detailing the GHG emissions arising from primary energy use in specified MMU buildings	323010 323012	MMU	Callum Donnelly (C.Donnelly@mmu.ac.uk)		GHG emissions data will be calculated once energy generation data is available. To be included in M48 refresh.
Energy generation asset operational data	Data detailing the operations and impacts of the low carbon energy generation assets.	All indicators 323001 to 323012	Siemens	Andrew Smyth (Andrew.Smyth@siemens.com)	Format and frequency of data remains to be specified by WP3.	WP2 will continue to liaise with WP3 throughout 2018, in order to include data in M48 refresh.

Table 3.10: Datasets description for Module 323

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
323001	Energy delivered by the low carbon energy generation assets (MMU buildings)	kWh	0	Apr 2017 – Mar 2018						
323002	Change in share of primary energy demand met by onsite renewables (MMU buildings)	Dimensionless decimal	0.00	Apr 2017 – Mar 2018						
323007	Change in annual energy costs (MMU buildings)	€	Not currently available (commercially sensitive)	Apr 2017 – Mar 2018						
323010	Change in annual greenhouse gas emissions (MMU buildings)	tCO_2e	0	Apr 2017 – Mar 2018						

Table 3.11: Impact assessment for Module 323

3.3 Mobility Modules

The Mobility task group has defined the scope of two modules (see below). Hence, the module descriptions and proposed impact indicators presented below have been revisited and revised over the course of the project as module scope was 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 owned 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 3.12 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 3.12: Expected impacts of the Manchester Mobility Modules

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

The implementation dates of the module

The module was implemented in the MMU fleet in August 2016, and the UNIMAN fleet in November 2016.

The indicators used for assessing the impacts and baseline data

Below Table 3.13 provides details of the impact indicators developed for this module and Table 3.14 identifies datasets used to calculate impacts.

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

- The Triangulum procured EVs are part of larger EV fleets at MMU and UNIMAN. Therefore, it was necessary to gather a wider set of data in relation to the fleets, EVs, and Triangulum EVs, in order to understand and calculate all required impacts.
- The following modules have been amended: 331001 into 331001a and 331001b; 331002 into 331002a, 331002b and 331002c; 331003 into 331003a and 331003b; 331004 into 331004a and 331004b; 331005 into 331005a, 331005b and 331005c; 331006 into 331006a and 331006b; 331007 into 331007a and 331007b; 331008 into 331008a, 331008b and 331008c; and 331009 into 331009a and 331009b.
- NOx and CO data was not collected. These impacts were calculated using Euro 6 emission standards for diesel vehicles, with 0.5g/km CO and 0.08g/km NOx criteria multiplied by the distance travelled by the electric vehicles. This represents the avoided emissions.
- No charging station was installed at UNIMAN. Two charging stations were installed at MMU.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
331001a	Reduced Greenhouse Gas Emissions	Number of electric vehicles within MMU vehicle fleets	Dimensionless integer	EV module impact data	Y
331001b	Reduced Greenhouse Gas Emissions	Number of Triangulum electric vehicles within MMU vehicle fleets	Dimensionless integer	EV module impact data	Y
331002a	Reduced Greenhouse Gas Emissions	Percentage of electric vehicles within MMU vehicle fleets	Dimensionless decimal	EV module impact data	Y
331002b	Reduced Greenhouse Gas Emissions	Percentage of Triangulum electric vehicles within MMU vehicle fleets	Dimensionless decimal	EV module impact data	Y
331002c	Reduced Greenhouse Gas Emissions	Percentage of Triangulum electric vehicles within MMU electric vehicle fleet	Dimensionless decimal	EV module impact data	Y
331003a	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions from MMU vehicle fleets	tCO_2e	MMU vehicle emission telematics data	Y
331003b	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions attributable to Triangulum electric vehicles in MMU vehicle fleets	tCO_2e	MMU vehicle emission telematics data	Y
331004a	Reduced Greenhouse Gas Emissions	Number of electric vehicles within UNIMAN vehicle fleet	Dimensionless integer	EV module impact data	Y
331004b	Reduced Greenhouse Gas Emissions	Number of Triangulum electric vehicles within UNIMAN vehicle fleet	Dimensionless integer	EV module impact data	Y
331005a	Reduced Greenhouse Gas Emissions	Percentage of electric vehicles within UNIMAN vehicle fleet	Dimensionless decimal	EV module impact data	Y
331005b	Reduced Greenhouse Gas Emissions	Percentage of Triangulum electric vehicles within UNIMAN vehicle fleet	Dimensionless decimal	EV module impact data	Y

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
331005c	Reduced Greenhouse Gas Emissions	Percentage of Triangulum electric vehicles within UNIMAN electric vehicle fleet	Dimensionless decimal	EV module impact data	Y
331006a	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions from UNIMAN vehicle fleet	tCO_2e	UNIMAN vehicle telematic data	Y
331006b	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions attributable to Triangulum electric vehicles in UNIMAN vehicle fleet	tCO_2e	UNIMAN vehicle telematic data	Y
331007a	Reduced Greenhouse Gas Emissions	Total number of electric vehicles within specified vehicle fleet	Dimensionless integer	EV module impact data	Y
331007b	Reduced Greenhouse Gas Emissions	Total number of Triangulum electric vehicles within specified vehicle fleet	Dimensionless integer	EV module impact data	Y
331008a	Reduced Greenhouse Gas Emissions	Percentage of electric vehicles within specified vehicle fleets	Dimensionless decimal	EV module impact data	Y
331008b	Reduced Greenhouse Gas Emissions	Percentage of Triangulum electric vehicles within specified vehicle fleets	Dimensionless decimal	EV module impact data	Y
331008c	Reduced Greenhouse Gas Emissions	Percentage of Triangulum electric vehicles within specified electric vehicle fleets	Dimensionless decimal	EV module impact data	Y
331009a	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions from specified vehicle fleets	tCO_2e	MMU vehicle telematic data UNIMAN vehicle telematics data	Y
331009b	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions attributable to Triangulum electric vehicles in specified vehicle fleets	tCO_2e	MMU vehicle telematic data UNIMAN vehicle telematics data	Y
331010	Reduced emissions of air quality pollutants	Reduction in NOx emissions from MMU vehicle fleet	g/vkm	MMU vehicle telematics data	Y

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
331011	Reduced emissions of air quality pollutants	Reduction in NOx emissions from UNIMAN vehicle fleet	g/vkm	UNIMAN vehicle emission and tracking data	Y
331012	Reduced emissions of air quality pollutants	Reduction in NOx emissions from specified vehicle fleets	g/vkm	MMU vehicle emission and tracking data UNIMAN vehicle emission and tracking data	Y
331013	Reduced emissions of air quality pollutants	Reduction in CO emissions from MMU vehicle fleet	g/vkm	MMU vehicle emission and tracking data	Y
331014	Reduced emissions of air quality pollutants	Reduction in CO emissions from UNIMAN vehicle fleet	g/vkm	UNIMAN vehicle emission and tracking data	Y
331015	Reduced emissions of air quality pollutants	Reduction in CO emissions from specified vehicle fleets	g/vkm	MMU vehicle emission and tracking data UNIMAN vehicle emission and tracking data	Y
331016	Evaluating new technologies	Number of electric vehicle charging stations installed	Dimensionless integer	EV charging station use data	Y
331017	Evaluating new technologies	Quantity of energy supplied by EV charging stations installed	kWh/yr	EV charging station use data	N
331018	Evaluating new technologies	Percentage of users satisfied with telematics	Dimensionless decimal	EV user satisfaction data	N
331019	Evaluating new technologies	Percentage of electric vehicles with telematics	Dimensionless decimal	MMU vehicle telematics data UNIMAN vehicle telematics data	N

Table 3.13: Impact assessment indicators description for Module 331

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
MMU vehicle telematics data	Telematics for Triangulum EVs within the MMU fleet	331003 331009 331010 331012 331013 331015 331019	MMU	Andrew Taylor – Travel Manager	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.	WP2 will liaise with partner to understand how this data can be harnessed ethically, and included in M48 refresh.
UNIMAN vehicle telematics data	Telematics Triangulum EVs within the UNIMAN fleet	331006 331009 331011 331012 331014 331015 331019	UNIMAN	Fleet Manager – Phil Lord and Sustainability Manager Julia Durkan.		
EV user satisfaction data	Data detailing user satisfaction with EV	331018	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	WP3 has yet to define approach to capturing user satisfaction data post M36.	WP2 is working with WP3 to help support an evaluation programme. This data will be included in M48 refresh.
EV charging station use data	Data detailing the use of EV charging stations installed as part of module implementation	331016 331017	Greater Manchester Electric Vehicle Scheme	Transport for Greater Manchester	Data is owned by the commercial organisation that installed the EV charging stations. WP3 are currently exploring if these data can be accessed.	WP2 will liaise with partner to understand whether this data can be included in M48 refresh.
EV module impact data	Data reporting module impacts including number of EVs procured by MMU and UNIMAN.	331001 331002 331004 331005 331007 331008	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)		This data will be updated and included in M48 refresh.

Table 3.14: Datasets description for Module 331

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
331001a	Number of electric vehicles within MMU vehicle fleets	Dimensionless integer	2	Aug 2015 – Jul 2016	12	Aug 2016 – Jul 2017	10	10	+500%	+500%
331001b	Number of Triangulum electric vehicles within MMU vehicle fleets	Dimensionless integer	0	Aug 2015 – Jul 2016	2	Aug 2016 – Jul 2017	2	2	n/a	n/a
331002a	Percentage of electric vehicles within MMU vehicle fleets	Dimensionless decimal	0.1	Aug 2015 – Jul 2016	0.48	Aug 2016 – Jul 2017	0.38	0.38	+380%	+380%
331002b	Percentage of Triangulum electric vehicles within MMU vehicle fleets	Dimensionless decimal	0	Aug 2015 – Jul 2016	0.08	Aug 2016 – Jul 2017	0.08	0.08	n/a	n/a
331002c	Percentage of Triangulum electric vehicles within MMU electric vehicle fleet	Dimensionless decimal	0	Aug 2015 – Jul 2016	0.17	Aug 2016 – Jul 2017	0.17	0.17	n/a	n/a
331003a	Reduction in greenhouse gas emissions from MMU vehicle fleets	tCO_2e	44.3	Aug 2015 – Jul 2016	30.1	Aug 2016 – Jul 2017	14.2	14.2	-32.1%	-32.1%
331003b	Reduction in greenhouse gas emissions attributable to Triangulum electric vehicles in MMU vehicle fleets	tCO_2e	0	Aug 2015 – Jul 2016	2.4	Aug 2016 – Jul 2017	2.4	2.4	n/a	n/a
331004a	Number of electric vehicles within UNIMAN vehicle fleet	Dimensionless integer	3	Nov 2015 – Oct 2016	13	Nov 2016 – Oct 2017	10	10	+333%	+333%
331004b	Number of Triangulum electric vehicles within UNIMAN vehicle fleet	Dimensionless integer	0	Nov 2015 – Oct 2016	7	Nov 2016 – Oct 2017	7	7	n/a	n/a
331005a	Percentage of electric vehicles within UNIMAN vehicle fleet	Dimensionless decimal	0.04	Nov 2015 – Oct 2016	0.15	Nov 2016 – Oct 2017	0.11	0.11	+275%	+275%
331005b	Percentage of Triangulum electric vehicles within UNIMAN vehicle fleet	Dimensionless decimal	0	Nov 2015 – Oct 2016	0.08	Nov 2016 – Oct 2017	0.08	0.08	n/a	n/a

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
331005c	Percentage of Triangulum electric vehicles within UNIMAN electric vehicle fleet	Dimensionless decimal	0	Nov 2015 – Oct 2016	0.54	Nov 2016 – Oct 2017	0.54	0.54	n/a	n/a
331006a	Reduction in greenhouse gas emissions from UNIMAN vehicle fleet	tCO_2e	164.1	Nov 2015 – Oct 2016	143.4	Nov 2016 – Oct 2017	20.7	20.7	-12.6%	-12.6%
331006b	Reduction in greenhouse gas emissions attributable to Triangulum electric vehicles in UNIMAN vehicle fleet	tCO_2e	0	Nov 2015 – Oct 2016	11.2	Nov 2016 – Oct 2017	11.2	11.2	n/a	n/a
331007a	Total number of electric vehicles within specified vehicle fleet	Dimensionless integer	5	2015-2016 (baselines not aligned)	25	2016-2017 (baselines not aligned)	20	20	+400%	+400%
331007b	Total number of Triangulum electric vehicles within specified vehicle fleet	Dimensionless integer	0	2015-2016 (baselines not aligned)	9	2016-2017 (baselines not aligned)	9	9	n/a	n/a
331008a	Percentage of electric vehicles within specified vehicle fleets	Dimensionless decimal	0.05	2015-2016 (baselines not aligned)	0.23	2016-2017 (baselines not aligned)	0.18	0. 18	+360%	+360%
331008b	Percentage of Triangulum electric vehicles within specified vehicle fleets	Dimensionless decimal	0	2015-2016 (baselines not aligned)	0.08	2016-2017 (baselines not aligned)	0.08	0.08	n/a	n/a
331008c	Percentage of Triangulum electric vehicles within specified electric vehicle fleets	Dimensionless decimal	0	2015-2016 (baselines not aligned)	0.36	2016-2017 (baselines not aligned)	0.36	0.36	n/a	n/a
331009a	Reduction in greenhouse gas emissions from specified vehicle fleets	tCO_2e	208.4	2015-2016 (baselines not aligned)	173.5	2016-2017 (baselines not aligned)	34.9	34.9	-16.7%	-16.7%
331009b	Reduction in greenhouse gas emissions attributable to Triangulum electric vehicles in specified vehicle fleets	tCO_2e	0	2015-2016 (baselines not aligned)	12.6	2016-2017 (baselines not aligned)	12.6	12.6	n/a	n/a

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
331010	Reduction in NOx emissions from MMU vehicle fleet	g/vkm	0	Aug 2015 – Jul 2016	-792.8	Aug 2016 – Jul 2017	-792.8	-792.8	n/a	n/a
331011	Reduction in NOx emissions from UNIMAN vehicle fleet	g/vkm	0	Nov 2015 – Oct 2016	-2,973.2	Nov 2016 – Oct 2017	-2,973.2	-2,973.2	n/a	n/a
331012	Reduction in NOx emissions from specified vehicle fleets	g/vkm	0	2015-2016 (baselines not aligned)	-3,766	2016-2017 (baselines not aligned)	-3,766	-3,766	n/a	n/a
331013	Reduction in CO emissions from MMU vehicle fleet	g/vkm	0	Aug 2015 – Jul 2016	-4,955	Aug 2016 – Jul 2017	-4,955	-4,955	n/a	n/a
331014	Reduction in CO emissions from UNIMAN vehicle fleet	g/vkm	0	Nov 2015 – Oct 2016	-18,582.5	Nov 2016 – Oct 2017	-18,582.5	-18,582.5	n/a	n/a
331015	Reduction in CO emissions from specified vehicle fleets	g/vkm	0	2015-2016 (baselines not aligned)	-23,537.5	2016-2017 (baselines not aligned)	-23,537.5	-23,537.5	n/a	n/a
331016	Number of electric vehicle charging stations installed	Dimensionless integer	0	n/a	2	Nov 2017	2	n/a	n/a	n/a
331017	Quantity of energy supplied by EV charging stations installed	kWh/yr	0	n/a	Not known	Nov 2017	n/a	n/a	n/a	n/a
331018	Percentage of users satisfied with telematics	Dimensionless decimal	0	n/a	WP3 monitoring post M36	n/a	n/a	n/a	n/a	n/a
331019	Percentage of electric vehicles with telematics	Dimensionless decimal	0	n/a	1.0	Nov 2017	n/a	n/a	n/a	n/a

Table 3.15: Impact assessment for Module 331

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

The implementation dates of the module

The module was implemented in the Corridor in June 2016.

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

Below Table 3.16 provides details of the impact indicators developed for this module and Table 3.17 identifies datasets used to calculate impacts.

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

- A total of four cargo bikes were procured through Triangulum, however the fleet is made up of 12 cargo bikes in total. It is not possible to separate the tracking data for the four Triangulum procured bikes, and so the data has been presented as totals and as a proportion of 4/12.
- M35: Due to teething issues with the telematics, the data is not available from deployment date of June 2016. There are also some gaps in the data available. Therefore, data is provided from March 2017 when full set of data was available, with Jan-Feb 2018 extrapolated.
- M35: The stakeholders do not collect or calculate GHG emission data. This impact indicator (332004) has been calculated as avoided Co2e based on the miles travelled by the cargo bikes, a standard fuel efficiency of 50 miles per gallon (MPG), and using UK government conversion factor for petrol.
  Take standard fuel efficiency at 50 MPG =
  6,239 mi = 124.8 gallons = 567.4 litres * 2.19697 (2016 petrol conversion factor) = 1,246.6 Co2e
- NOx and CO data was not collected. These impacts were calculated using Euro 6 emission standards for diesel vehicles, with 0.5g/km CO and 0.08g/km NOx criteria multiplied by the distance travelled.
- The following modules have been amended to provide improved data: 332002 has been split into 332002a (number of journeys) and 332002b (distance travelled); 332003 has been split into 332003a (hours in use in total) and 332003b (hours in use per cargo bike).

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
332001	Reduced Greenhouse Gas Emissions	Number of cargo bikes provided by the scheme	Dimensionless integer	Cargo bike impact data	N
332002	Reduced Greenhouse Gas Emissions	Number of journeys made by cargo bikes within the scheme	Dimensionless integer	Cargo bike use data	N
332003	Reduced Greenhouse Gas Emissions	Average time cargo bikes are in use per day	hh:mm	Cargo bike use data	N
332004	Reduced Greenhouse Gas Emissions	Reduction in greenhouse gas emissions as a result of module implementation	tCO_2e	Cargo bike use data	Y
332005	Reduced Air Quality Pollutant Emissions	Reduction in NO_x emissions	g/vkm	Cargo bike use data	Y
332006	Reduced Air Quality Pollutant Emissions	Reduction in CO emissions	g/vkm	Cargo bike use data	Y
332007	Reduced traffic congestion	Number of journeys by motorised vehicles replaced by cargo bike journeys	Dimensionless integer	Cargo bike use data	N
332008	Evaluation of new technologies	Percentage of users satisfied with cargo bikes	Dimensionless decimal	Cargo bike user satisfaction data	N
332009	Evaluation of new technologies	Percentage of cargo bikes with GPS tracking	Dimensionless decimal	Cargo bike impact data	N

Table 3.16: Impact assessment indicators description for Module 332

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Cargo bike use data	GPS tracking for cargo bikes within the scheme	332002 332003 332004 332005 332006 332007	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	Data collected by Autotrip tracker hardwired to the bike battery.	WP2 will liaise with partner to understand how this data can be included in M48 refresh.
Cargo bike user satisfaction data	Data detailing user satisfaction with the Cargo Bikes	332008	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)	WP3 has yet to define approach to capturing user satisfaction data	WP2 will liaise with partner to support evaluation programme and understand how this data can be included in M48 refresh.
Cargo bike impact data	Data detailing impacts of the module including number of cargo-bikes within the scheme	332001 332009	MCC	Martine Tommis (m.tommis1@manchester.gov.uk)		This data will be updated and included in the M48 refresh.

Table 3.17: Datasets description for Module 332

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
332001	Number of cargo bikes provided by the scheme	Dimensionless integer	0	Jun 15 – May 16	4	Mar 17 – Feb 18	4	4	n/a	n/a
332002a	Number of journeys made by cargo bikes within the scheme	Dimensionless integer	0	Jun 15 – May 16	1,989	Mar 17 – Feb 18	1,989	1,989	n/a	n/a

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
332002b	Distance travelled by cargo bikes within the scheme	km	0	Jun 15 – May 16	10,041	Mar 17 – Feb 18	10,041	10,041	n/a	n/a
332003a	Average time cargo bikes are in use per day	hh:mm	00:00	Jun 15 – May 16	07:40	Mar 17 – Feb 18	07:40	07:40	n/a	n/a
332003b	Average time each cargo bike is in use per day	hh:mm	00:00	Jun 15 – May 16	01:55	Mar 17 – Feb 18	01:55	01:55	n/a	n/a
332004	Reduction in greenhouse gas emissions as a result of module implementation	tCO_2e	0	Jun 15 – May 16	-1246.6	Mar 17 – Feb 18	-1246.6	-1246.6	n/a	n/a
332005	Reduction in NO_x emissions	g/vkm	0	Jun 15 – May 16	-803.3	Mar 17 – Feb 18	-803.3	-803.3	n/a	n/a
332006	Reduction in CO emissions	g/vkm	0	Jun 15 – May 16	-5,020.5	Mar 17 – Feb 18	-5,020.5	-5,020.5	n/a	n/a
332007	Number of journeys by motorised vehicles replaced by cargo bike journeys	Dimensionless integer	0	Jun 15 – May 16	1,989 (assumed 1:1)	Mar 17 – Feb 18	1,989	1,989	n/a	n/a
332008	Percentage of users satisfied with cargo bikes	Dimensionless decimal	0.00	Jun 15 – May 16	Post M36 monitoring as WP3.3	n/a	n/a	n/a	n/a	n/a
332009	Percentage of cargo bikes with GPS tracking	Dimensionless decimal	0.00	Jun 15 – May 16	1.00	Mar 17 – Feb 18	1.00	1.00	n/a	n/a

Table 3.18: Impact assessment for Module 332

3.4 ICT Modules

The Manchester ICT task group defined 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 have been revised as module scope was, and continues to be, refined and lessons 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 *data-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 3.19 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 3.19: Expected impacts of Manchester ICT modules

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

The implementation dates of the module

The module was implemented through the Manchester-i launch on 29th November 2017 [http://vm-pi-p03.ds.man.ac.uk/].

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

Below Table 3.20 provides details of the impact indicators developed for this module and Table 3.21 identifies datasets used to calculate impacts.

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

- Due to module implementation in November 2017, one months' worth of data for December 2017 has been used to extrapolate impact calculations for this deliverable. This will be updated for the M48 refresh.
- The quantity of data downloaded from the service is based on an estimate using WP3's experience, as no data is currently being collected.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
341001	Enhanced digital infrastructure	Total number of datasets openly accessible via the data curation service	Dimensionless integer	Data curation service metadata	N
341002	Enhanced digital infrastructure	Number of datasets relating to energy modules openly accessible via the data curation service	Dimensionless integer	Data curation service metadata	N
341003	Enhanced digital infrastructure	Number of datasets relating to mobility modules openly accessible via the data curation service	Dimensionless integer	Data curation service metadata	N
341004	Enhanced digital infrastructure	Number of real time[2] data feeds curated by the service	Dimensionless integer	Data curation service metadata	N
341005	Enhanced digital infrastructure	Quantity of data openly accessible via the data curation service	GB	Data curation service metadata	Y
341006	Increased engagement with data	Number of data downloads from the data curation service	Dimensionless integer	Data curation use data	N
341007	Increased engagement with data	Number of users downloading data from the data curation service	Dimensionless integer	Data curation use data	Y
341008	Increased engagement with data	Number of visualisation options offered for viewing and interacting with the data hosted by the curation service	Dimensionless integer	Data curation use data	N
341009	Increased engagement with data	Quantity of data downloaded by users of the curation service	GB	Data curation use data	Y

Table 3.20: Impact assessment indicators description for Module 341

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

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Data curation service metadata	Metadata detailing the form and quantity of data hosted by the service.	341001 341002 341003 341004 341005	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	Form and format of data to be provided by WP3 remains to be confirmed	WP2 will liaise with partner to understand whether this data can be included in the M48 refresh.
Data curation use data	Use data detailing number of users etc.	341006 341007 341008 341009	UNIMAN	Ettore Murabito (ettore.murabito@manchester.ac.uk)	Form and format of data to be provided by WP3 remains to be confirmed	WP2 will liaise with partner to understand whether this data can be included in the M48 refresh.

Table 3.21: Datasets description for Module 341

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
341001	Total number of datasets openly accessible via the data curation service	Dimensionless integer	0	Dec 16 – Nov 17	13	Dec 2017	13	n/a	n/a	n/a
341002	Number of datasets relating to energy modules openly accessible via the data curation service	Dimensionless integer	0	Dec 16 – Nov 17	3	Dec 2017	3	n/a	n/a	n/a
341003	Number of datasets relating to mobility modules openly accessible via the data curation service	Dimensionless integer	0	Dec 16 – Nov 17	6	Dec 2017	6	n/a	n/a	n/a

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
341004	Number of real time[3] data feeds curated by the service	Dimensionless integer	0	Dec 16 – Nov 17	13	Dec 2017	13	n/a	n/a	n/a
341005	Quantity of data openly accessible via the data curation service	GB	0	Dec 16 – Nov 17	0.22	Dec 2017	0.22	n/a	n/a	n/a
341006	Number of data downloads from the data curation service	Dimensionless integer	0	Dec 16 – Nov 17	33	Dec 2017	33	396	n/a	n/a
341007	Number of users downloading data from the data curation service	Dimensionless integer	0	Dec 16 – Nov 17	32	Dec 2017	32	384	n/a	n/a
341008	Number of visualisation options offered for viewing and interacting with the data hosted by the curation service	Dimensionless integer	0	Dec 16 – Nov 17	2	Dec 2017	2	n/a	n/a	n/a
341009	Quantity of data downloaded by users of the curation service	GB	0	Dec 16 – Nov 17	0.001	Dec 2017	0.01	n/a	n/a	n/a

Table 3.22: Impact assessment for Module 341

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

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

The implementation dates of the module

The module has been implemented in an *ad hoc* fashion throughout 2017, through a series of videos and VR technologies, and collated through the Manchester-i launch on 29th November 2017.

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

Below Table 3.23 provides details of the impact indicators developed for this module and Table 3.24 provides details of the impact indicators developed for this module.

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

- The *ad hoc* nature of this module implementation has meant some difficulties with collecting impact indicator data. Therefore, the Manchester-i launch has been used as the point of implementation to allow start and end periods to be set.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
342001	Enhanced digital infrastructure	Total number of visualisation services provided by the platform	Dimensionless integer	Visualisation platform metadata	N
342002	Enhanced digital infrastructure	Number of visualisation services provided by the platform which use data related to energy modules	Dimensionless integer	Visualisation platform metadata	N
342003	Enhanced digital infrastructure	Number of visualisation services provided by the platform which use data related to mobility modules	Dimensionless integer	Visualisation platform metadata	N
342004	Enhanced digital infrastructure	Total number of real time data feeds integrated into the visualisation platform	Dimensionless integer	Visualisation platform metadata	N
342005	Enhanced digital infrastructure	Number of real time data feeds related to energy modules and integrated into the visualisation platform	Dimensionless integer	Visualisation platform metadata	N
342006	Enhanced digital infrastructure	Number of real time data feeds related to mobility modules and integrated into the visualisation platform	Dimensionless integer	Visualisation platform metadata	N
342007	Increased engagement with data	Number of visualisation platform users	Dimensionless integer	Visualisation platform use data	Y

Table 3.23: Impact assessment indicators description Module 342

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Visualisation platform metadata	Metadata detailing the form and quantity of data hosted by the service.	342001 342002 342003 342004 342005 342006	C&L	Michael King (michael.king@clicksandlinks.com)	Form and format of data to be provided by WP3 remains to be confirmed	WP2 will liaise with partner to understand whether this data can be included in the M48 refresh.
Visualisation platform use data	Use data detailing number of users etc.	342007	C&L	Michael King (michael.king@clicksandlinks.com)	Form and format of data to be provided by WP3 remains to be confirmed	WP2 will liaise with partner to understand whether this data can be included in the M48 refresh.

Table 3.24: Datasets description for Module 342

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
342001	Total number of visualisation services provided by the platform	Dimensionless integer	0	Dec 16 – Nov 17	2	Dec 2017	2	n/a	n/a	n/a
342002	Number of visualisation services provided by the platform which use data related to energy modules	Dimensionless integer	0	Dec 16 – Nov 17	0	Dec 2017	0	n/a	n/a	n/a
342003	Number of visualisation services provided by the platform which use data related to mobility modules	Dimensionless integer	0	Dec 16 – Nov 17	2	Dec 2017	2	n/a	n/a	n/a
342004	Total number of real time data feeds integrated into the visualisation platform	Dimensionless integer	0	Dec 16 – Nov 17	13	Dec 2017	13	n/a	n/a	n/a

342005	Number of real time data feeds related to energy modules and integrated into the visualisation platform	Dimensionless integer	0	Dec 16 – Nov 17	3	Dec 2017	3	n/a	n/a	n/a
342006	Number of real time data feeds related to mobility modules and integrated into the visualisation platform	Dimensionless integer	0	Dec 16 – Nov 17	6	Dec 2017	6	n/a	n/a	n/a
342007	Number of visualisation platform users	Dimensionless integer	0	Dec 16 – Nov 17	32	Dec 2017	32	n/a	n/a	n/a

Table 3.25: Impact assessment for Module 342

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

The implementation dates of the module

The module will be implemented at the first innovation challenge in January 2018.

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

Below Table 3.26 provides details of the impact indicators developed for this module and Table 3.27 identifies datasets used to calculate impacts.

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

- This module is yet to be implemented until after January 2018, and therefore no data is available currently.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
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	Innovation challenge participation and impact data	Y
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	Innovation challenge participation and impact data	Y
343003	Increased engagement with data	Number of people participating in innovation challenges	Dimensionless integer	Innovation challenge participation and impact data	N
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	Innovation challenge participation and impact data	Y
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	Innovation challenge participation and impact data	Y

Table 3.26: Impact assessment indicators description for Module 343

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Innovation challenge participation and impact data	Data detailing the outcomes and impacts of the innovation challenge module.	343001 343002 343003 343004 343005	C&L	Michael King (michael.king@clicksandlinks.com)	Data likely to be manually collected (rather than sensor generated).	

Table 3.27: Datasets description for Module 343

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
343001	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	n/a	n/a	n/a	n/a	n/a	n/a
343002	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	n/a	n/a	n/a	n/a	n/a	n/a
343003	Number of people participating in innovation challenges	Dimensionless integer	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
343004	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	n/a	n/a	n/a	n/a	n/a	n/a
343005	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	n/a	n/a	n/a	n/a	n/a	n/a

Table 3.28: Impact assessment for Module 343

4 Eindhoven Impact

Executive Summary

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

Section 1 offers an initial evaluation of the module impacts followed by a high-level overview of the impact and assessment and monitoring activities to continue in Eindhoven during 2018. Sections 2-4 describe the Energy, Mobility and ICT 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 comparison between end conditions and baseline conditions, are presented with assessment tables.

4.1 Overview and initial assessment

This section briefly assesses the local modules and their impacts. The progress of the Eindhoven partnership in terms of module implementation and impact reporting is summarized in Table 4.1.

	#modules implemented	#baseline indicator values available	#impact indicator values available
Overall value	6/13	70/70	60/70
Energy	1/5	22/22	20/22
Mobility	1/2	12/12	11/12
ICT	4/6	36/36	29/36

Table 4.1: Overview assessment table

The Energy projects cover private/social house, office and public infrastructure upgrading. Based on the assessment, it is concluded that it is easier to reduce energy consumption by replacing existing infrastructures, such as implementing new technologies (building pipes to connect houses/offices with bio-mass factory; connecting energy pipes with SANERGY). For office buildings, the old structure of the building could create additional problems once it is merged with new technologies such as sensors. For private and social housing, the significant challenge is how to approach residents and persuade them to agree to house renovation. After renovation residents may not be willing to install smart metering due to privacy issues which means no real energy consumption data can be attained. Comparison cannot be done easily without sufficient samples of energy consumption data considering weather conditions and yearly difference.Transportation is an important contributor to energy consumption, and it is important to provide new technologies for improving traffic efficiency. Providing additional traffic tools and promoting Electric Vehicles (EV) by installing more charging stations could help. Without disaggregated level travel information, only limited conclusions can be drawn. Moreover, comparison is difficult to interpret unless valid data collected systematically before and after the implementation. However the information does show promise. With the streaming sensor data availability, such as the occupancy data of parking slots and EV charging data, more insight and understanding of people's travel behaviour can be captured.

ICT projects provide the backbone for energy and mobility projects. It can also improve citizens' quality of life by providing playful or fun facilities (such as 1km street light project).

4.1 Energy Modules

Eindhoven has developed five modules to demonstrate development of energy infrastructures in district/area level. Only one of the three modules of energy infrastructure has been implemented in Strijp-S district, Module 4.2.2. The modules are:

- *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.
- *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.
- *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.

Two modules of energy infrastructure are located in Eckart-Vaartborek district. Neither has been implemented. They 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 described in sections 3.1-3.5. Table 4.2 presents a summary of the expected impacts of these modules, and detailed module descriptions are provided below.

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.	*	*		*	*	
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 devices to increase renewable energy percentage at district level and reduce CO2 emission.	*	*				

Table 4.2: Expected impacts of the Eindhoven Energy Modules

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

The implementation dates of the module

The module will be implemented in Eindhoven Strip-S in March 2018, and completed in August 2018.

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

The project aim concerns 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 4.3 provides details of the indicators developed for this module.

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

- 421001 - This indicator has been removed since there is no influence on electricity energy bill
- 421002 - This indicator has been changed from energy price for gas to energy bill for gas per month since no price will be influenced by this project. Only energy consumption would come from different resource, which will reduce their energy cost in the end.
- 421005 – This indicator has been changed from “Total primary energy demand of connected buildings” to “Total primary energy demand of connected buildings per month”.
- 421007 - This indicator has been changed from “Reduction in greenhouse gas emissions as a result of implementing the Sanergy” to “Reduction in greenhouse gas emissions as a result of implementing the Sanergy per month”. The calculation is based on “The Netherlands: list of fuels and standard CO2 emission factors version of January 2017”. We assume the energy generated from Sanergy is CO2 free. The energy produced by Sanergy which has been used for buildings are 17512*37% = 6479.44GJ. Based on the report 2017, 56.6kg/GJ CO2 will be produced by using natural gas (dry). Therefore the reduction of CO2 emission is 6479.44*56.6 = 366736.304

Dataset Name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Energy price data	Energy price data from energy company	421001 421002 421005 421006	Eneco/ Enexis	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	All data is regarding SANERGY implemented since 2009. The extension will be implemented in 2018	Data will be updated after implementation of the extension part
Energy consumption data	Energy consumption data for each building in Strijp-S	421005 421006	Park Strijp Energy	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		
Soil sanitation	Ground energy utilisation and pollution reduction	421004 421007	Philips/Arcadis	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		

Table 4.3: Potential datasets that may be used to calculate quantifiable impacts for the indicators

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
421002	Reduce energy bills	Heating price for consumer	€/year	Energy price data; Energy consumption data	Y
421003	Reduce energy consumption/ increase renewable energy	Percentage increase in use of renewable energy (energy generated on-site)	%	Energy consumption data	Y
421004	Reduce energy consumption/ increase renewable energy	Soil Sanitation	Years	Soil sanitation	N
421005	Reduce energy consumption/ increase renewable energy	Total primary energy demand of connected buildings	GJ/month	Energy consumption data	Y
421006	Reduced carbon emissions	Share of other renewable energy in the grid (solar, wind, biomass)	%	Energy consumption data	Y
421007	Reduced carbon emissions	Reduction in greenhouse gas emissions as a result of implementing the Sanergy	kg/month	Energy consumption data	Y

Table 4.4: Impact assessment indicators description for Module 421

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Energy price data	Energy price data from energy company	421001 421002 421005 421006	Eneco/ Enexis	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	All data is regarding SANERGY implemented since 2009. The extension will be implemented in 2018	Data will be updated after implementation of the extension part
Energy consumption data	Energy consumption data for each building in Strijp-S	421005 421006	Park Strijp Energy	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Soil sanitation	Ground energy utilisation and pollution reduction	421004 421007	Philips/Arcadis	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		

Table 4.5: Datasets description for Module 421

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
421002	Heating price for consumer per month	€/yr	24808,67	2014Jan - 2014Dec	22421,30	2017Jan – 2017Oct	-2387,37	-795,79	-9,62%	-3,21%
421003	Percentage increase in use of renewable energy (energy generated on-site)	%	37	2014Jan - 2014Dec	11,38	2017Jan – 2017Oct	-25,62	-8,54	-69,24%	-23,08%
421004	Soil Sanitation	Years	+/- 30	2014Jan - 2014Dec	+/- 30	2017Jan – 2017Oct	3,00	1,00	10,00%	3,33%
421005	Total primary energy demand of connected buildings per month	GJ/yr	1459,33	2014Jan - 2014Dec	1318,90	2017Jan – 2017Oct	-140,43	-46,81	-9,62%	-3,21%
421006	Share of other renewable energy in the grid (solar, wind, biomass)	%	0	2014Jan - 2014Dec	88,62	2017Jan – 2017Oct	88,62	29,54	na	na
421007	Reduction in greenhouse gas emissions as a result of implementing the Sanergy per month	kg/yr	30561,36	2014Jan - 2014Dec	16449,95	2017Jan – 2017Oct	-14111,40	-4703,80	-46,17%	-15,39%

Table 4.6: Impact assessment for Module 421

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

The implementation dates of the module

The model was implemented by M14.

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

The project is expected to provide 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 4.7 below, provides details of the indicators developed for this module. Table 4.8 identifies potential datasets used to calculate quantifiable impacts for the indicators.

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

422002 – The indicator changed from Total primary heating energy demand of district to Total primary heating energy demand of district per month.

422003 – The indicator has been removed since electricity energy demand will not be influenced by this project.

422004 – The indicator changed from Net greenhouse gas emissions by steam/heating system to Net greenhouse gas emissions by steam/heating system per month. It is caculated based on "The Netherlands: list of fuels and standard CO2 emission factors version of January 2017", 56.6kg/GJ CO2 will be produced by using natural gas (dry). Therefore the CO2 emission caused by central heating is 67483 * 56.6 = 3819537.8kg. Since the energy served with Biomass pipe is differ from the buildings severed by SANERGY. Therefore the total gas consumption is different. The local green waste is being used to fire up the biomass central. Therefore after renovation, 'solid biomass' is going to use for generate heating. According to the CO2 report 2017, per unit of solid biomass will produce 109.6 kg CO2. In this case, CO2 reduction is not applicable. Changing heating provider will increase CO2 emission. Based on the Netherlands Energy efficiency report (2011), co2 emission per kWh generated (in gCO2/kWh) is 351. Therefore, net greenhouse gas emissions by electricity is 5546081*351/1000=1946674

422005 - The indicator has been removed since net greenhouse gas emissions by electricity will not be influenced by this project.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
422001	Reduce non- renewable energy consumption	Reliability of off-gas systems by biomass (energy generated on site）	%	Energy consumption data	N
422002	Reduce non- renewable energy consumption	Total primary heating energy demand of district	GJ/month	Energy consumption data	Y
422004	Reduced carbon emissions	Net greenhouse gas emissions by steam/heating system	kg/month	Energy consumption data	Y
422006	Reduced carbon emissions	Share of other renewable energy on the heating part (solar, wind, geothermal/SENERGY）	%	Energy consumption data	N/A

Table 4.7: Impact assessment indicators description for Module 422

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Energy consumption data	Energy consumption data for each building in Strijp-S	422001 422002 422003 422004 422005 422006	Park Strijp Energy	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Data will not be shared in CDH due to privacy issues surrounding personal data.	

Table 4.8: Datasets description for Module 422

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
422001	Reliability of off-gas systems by biomass (energy generated on site）	%	0	2014Jan - 2014Dec	100	2017Jan – 2017Oct	100,00	33,33	na	na
422002	Total primary heating energy demand of district per month	GJ/month	5623,58	2014Jan - 2014Dec	2788,83	2017Jan – 2017Oct	-2834,75	-944,92	-50,41%	-16,80%
422004	Net greenhouse gas emissions by steam/heating system per month	kg/month	318294,82	2014Jan - 2014Dec	291932,17	2017Jan – 2017Oct	-26362,64	-8787,55	-8,28%	-2,76%
422006	Share of other renewable energy on the heating part (solar, wind, geothermal/SENERGY）	%	0,0444	2014Jan - 2014Dec	0,0449	2017Jan – 2017Oct	0,00	0,00	1,13%	0,38%

Table 4.9: Impact assessment for Module 422

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

The implementation dates of the module

The roll out of the smart energy management system was ready in M16 and was originally planned to finish in M21. However due to a third party resigning from the project due to technical reasons, the implementation of this module was on hold until M30. The implementation has been postponed to 2018.

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

The smart energy office project aims improve energy efficiency and CO2 emission. Indicators will be developed in 2018.

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

After the amendment process, the indicators for this module need to be redeveloped. Implementation will be postponed to 2018, no end value can be monitored yet.

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

The implementation dates of the module

The module began implementation in Eindhoven Eckart-Vaartbroek area in June/July 2017, and will continue until all houses have been renovated.

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, whilst including local residents into the decision process to create a participative society. Due to legal issues, 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 4.10 below, provides details of the indicators developed for this module. Table 4.11 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

424003 - Use of local energy sources (electricity) instead of measure the energy consumption per year (KWH/yr), we are going to measure the energy consumption per square meters per year (KWH/yr/m2).

424004 - Use of local energy sources (gas) instead of measure the energy consumption per year (m3/yr), we are going to measure the energy consumption per square meters per year (m3/yr/m2).

424006 - Greenhouse gas emissions instead of measure the CO2 emission per year (kg/yr), we are going to measure the CO2 emission per square meters per year (kg/yr/m2).

424005 Reduce (non-renewable) energy consumption and CO2 reduction through material re-use (Nature step). This indicator is not applicable since no reuse of material related to CO2 reduction. It has been removed.

For impact indicator 424012 and 424013, the data collection is conducted in 2016 Jan till 2016 Apr. In total 250 dwellings have been approached and 199 dwellings were participated in the face to face interview. Each interview takes around 1.5 hours. The purpose of this interview is to understand how they are living in their current dwellings and how this can be improved. The satisfaction data for residence house is shown in Appendix-1. The satisfaction data for the neighbourhood is also shown in Appendix-1.

For 424012 (satisfaction of neighbourhood overall score), 12 perspectives are considered which are traffic, air quality, infrastructure, landscaping, atmosphere, buildings around, safety, neighbour, clearness, noise, layout and location. There are two variables which are traffic and noise do not apply for satisfaction score. We cannot interpret people's preference with the description provided in the survey. Therefore, to calculate the overall score, only 10 neighbourhood variables are used. The calculation method applied as below. Assume the score v_i (which is equal to1 to 5) represent very bad situation to very good situation. a_{ij} is the percentage of neighbourhood variable j on score i . The total score equal to:

$$\left(\sum_{j=1}^{10}\sum_{i=1}^{5} v_i a_{ij}\right)\Big/_{10}$$

Indicator 424013 is calculated based on the overall comfort value. It is equal to the average score. (1*3.02%+2*22.11%+3*43.72%+4*21.61%+5*0.5%) / (3.02%+22.11%+43.72%+21.61%+0.5%) = 2.94

The end value for modules 424012 and 424013 are not currently applicable, since only two houses have been renovated.

Impact indicator identifier	Impacts	Impact Indicator	Quant. Unit	Datasets to be used in impact calculation	Aligned with SCIS
424001	Reduce (non-renewable) energy consumption	Amount of buildings retrofitted / smartified	m2 /yr	Renovation choice set	N
424002	Reduce (non-renewable) energy consumption	Reduction in monthly energy bills	%	Renovation choice set	Y
424003	Reduce (non-renewable) energy consumption	Use of local energy sources (electricity)	KWH/yr/m2	Historical energy consumption data; Energy consumption data after renovation	Y
424004	Reduce (non-renewable) energy consumption	Use of local energy sources (gas)	m3/yr/m2	Historical energy consumption data; Energy consumption data after renovation	Y
424006	Reduced carbon emissions	Greenhouse gas emissions	Kg/yr/ m2	Historical energy consumption data; Energy consumption data after renovation	Y
424007	Reduced carbon emissions	Share of renewable energy on the grid (solar, wind, geothermal)	%	Installed renewable energy	Y
424008	Reduced carbon emissions	Smart meters installed and used	Dimensionless integer	Energy consumption data after renovation	N
424009	Fostering citizen engagement (co-creation)	Increase awareness of energy consumption by acceptance of renovation per year	Dimensionless integer	Renovation choice set	N
424010	Better quality of life	Affordable housing - increase in rent over cost of inflation	%	Renovation choice set	N
424011	Better quality of life	Payback periods for specific demonstration activities on average	Years	Renovation choice set	Y
424012	Better quality of life	Satisfaction of neighborhood – average score (1 lowest -5 highest)	Dimensionless integer	Dwelling conditions and satisfaction	N
424013	Better quality of life	Recorded satisfaction of residence houses - Average score (1 lowest -5 highest)	Dimensionless integer	Dwelling conditions and satisfaction	N

Table 4.10: Impact assessment indicators description for Module 424

Dataset name	Dataset description	Related impact indicators	Dataset owner	Dataset contact	Comments	WP2 next steps
Historical energy consumption data	Historical energy consumption data for household level (year based)	424003 424004 424006	TU/e, Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Due to privacy issue, no household level data will be available.	Only estimated energy consumption data can be used
Energy consumption data after renovation	Energy consumption data after renovation of dwellings in Eckart/Vaartbroek	424003 424004 424006 424008	Residents	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	77 residents are willing to share their data with TU/e.	Approach residents houses by houses together with Woonbedrijf after renovation
Dwelling conditions and satisfaction	Questionnaire data of current living condition and environment satisfaction	424012 424013	TU/e, Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Baseline is ready. After renovation, a new round data collection is needed.	Between M48 and M60, a new round data collection will be implemented.
Renovation choice set	Woonconnect data (including renovation choice option, energy reduction expectation, payback year etc..)	424001 424002 424009 424010 424011	Residents, Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		
Installed renewable energy	Renewable energy share for the whole Eckart/Vaartbroek district	424007	Woonbedrijf	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		

Table 4.11: Datasets description for Module 424

Impact indicator identifier	Impact Indicator	Quant. Unit	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
424001	Amount of buildings retrofitted / smartified	m2 /yr	0	2014Jan - 2014Dec	217	Till 2017 Oct	217,00	72,33	na	na
424002	Reduction in monthly energy bills	%	0	2014Jan - 2014Dec	48,9	Till 2017 Oct	48,90	16,30	na	na
424003	Use of local energy sources	KWH/yr* m2 (electricity)	8,75	2014Jan - 2014Dec	5,4	Till 2017 Oct	-3,35	-1,12	-38,29%	-12,76%
424004	Use of local energy sources	m3 (gas)/ m2	16,00	2014Jan - 2014Dec	9,4	Till 2017 Oct	-6,60	-2,20	-41,25%	-13,75%
424006	Greenhouse gas emissions	Kg/yr* m2.	33,43	2014Jan - 2014Dec	19,8	Till 2017 Oct	-13,63	-4,54	-40,77%	-13,59%
424007	Share of renewable energy on the grid (solar, wind, geothermal)	%	0	2014Jan - 2014Dec	0.15	Till 2017 Oct	0,15	0,05	na	na
424008	Smart meters installed and used	Dimensionless integer	0	2014Jan - 2014Dec	0	Till 2017 Oct	0,00	0,00	na	na
424009	Increase awareness of energy consumption by acceptance of renovation per year	Dimensionless integer	0	2014Jan - 2014Dec	2	Till 2017 Oct	2,00	0,67	na	na
424010	Affordable housing - increase in rent over cost of inflation	%	0	2014Jan - 2014Dec	2	Till 2017 Oct	2,00	0,67	na	na
424011	Payback periods for specific demonstration activities on average	Years	not applicable	2014Jan - 2014Dec	44.07	Till 2017 Oct	na	na	na	na
424012	Satisfaction of neighborhood – average score (1 lowest -5 highest)	Dimensionless integer	3.32	2014Jan - 2014Dec	Not applicable	Till 2017 Oct	na	na	na	na
424013	Recorded satisfaction of residence houses - Average score (1 lowest -5 highest)	Dimensionless integer	2.94	2014Jan - 2014Dec	Not applicable	Till 2017 Oct	na	na	na	na

Table 4.12: Impact assessment for Module 424

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

The implementation dates of the module

The module has not been implemented yet.

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

The project aims to refurbish the Eckart Vaartbroek district with the provision of local energy-production from renewable sources. However, as the project is under amendment, no indicators can be identified so far.

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

Indicators for this module will be developed in 2018 when a plan has been approved.

4.2 Mobility Modules

The Eindhoven mobility task group have developed two modules.

1. *Smart charging of electric vehicles (module 4.3.1):* an intelligent smart charging information service system developed through 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 has developed an ICT based tool for real time parking guidance system and a payment incentive for green alternatives and to stimulate car sharing.

Detailed information for each module is descripted in the sub-sections below. Table 4.13 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 4.13: Expected impacts of the Eindhoven Mobility Modules

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

The implementation dates of the module

The implementation of the new charging poles (20 connections) started in M18. In M23 the first 4 charging poles were installed and operational. The completed system which offers a dashboard for users and Mobility-S will be implemented in 2018.

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

The smart EV charging project aims to improve EV charging facility efficiency by developing an ICT supporting tool. Due to privacy issues, the three charging pools data is not currently available. Only one charging pool baseline data has been collected. Table 4.14 below, provides details of the indicators developed for this module. Table 4.15 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

Except charging station 1, no data was able to be collected before start of the project. Therefore, the indictors of 431005 – 431019 have been removed. For newly installed charging stations data are available. In order to compare the charging efficiency, two new impact indicator are generated which are 431021 and 431022.

Impact indicator identifier	Impacts	Impact Indicator	Quant. Units	Datasets to be used in impact calculation	Aligned with SCIS
431001	Developing a digital infrastructure – for EV charging pools	Nr. of EV/FC charging stations	Dimensionless integer	Charging transaction data	Y
431002	Developing a digital infrastructure – for EV charging pools	Reservation system - Possibility of making reservation of charging	Yes/No	Charging transaction data	N
431003	Developing a digital infrastructure – for EV charging pools	Switch charging modes (AC/DC) - Possibility of choosing charging speed	Yes/No	Charging transaction data	N
431020	Improvement of mobility	Improvement of parking efficiency by increasing number of EV parking reservation	Dimensionless integer	Charging transaction data	N
431021	Improvement of EV charging efficiency	Average transaction energy per pool	MWh/yr	Charging transaction data	N
431022	Improvement of EV charging efficiency	Average monitoring transaction nr per pool	Nr/yr	Charging transaction data	N

Table 4.14: Impact assessment indicators description for Module 431

Dataset name	Dataset description	Required for impact calc. for indicators	Dataset owner	Dataset contact	Comments	WP2 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	Charing company/ VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Data for new charging poles are available by request	EV parking reservation data will be collected after implementation of the technology

Table 4.15: Datasets description for Module 431

Impact indicator identifier	Impact Indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
431001	Nr. of EV/FC charging stations	Dimensionless integer	8	2014Jan - 2014Dec	12	2016Nov-2017Nov	4,00	1,33	50,00%	16,67%
431002	Reservation system - Possibility of making reservation of charging	Yes/No	No	2014Jan - 2014Dec	No	2016Nov-2017Nov				
431003	Switch charging modes (AC/DC) - Possibility of choosing charging speed	Yes/No	No	2014Jan - 2014Dec	No	2016Nov-2017Nov				
431020	Improvement of parking efficiency by increasing number of EV parking reservation	Dimensionless integer	0	2014Jan - 2014Dec	Not available	2016Nov-2017Nov				
431021	Average transaction energy per pool	MWh/yr	1237	2014Jan - 2014Dec	963,3433	2016Nov-2017Nov	-273,66	-91,22	-22,12%	-7,37%
431022	Average monitoring transaction nr per pool	Nr/yr	171	2014Jan - 2014Dec	186,4167	2016Nov-2017Nov	15,42	5,14	9,02%	3,01%

Table : Impact assessment for Module 431

*For baseline charging transaction data, only one old charging pole 1 has transaction data. For the other poles, there is no data available.

4.2.2 Module 432: Mobility management (Subtask 4.3.2)

The implementation dates of the module

The implementation started in M20 and is expected to be completed in M36.

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 4.16, below, provides details of the indicators developed for this module and part of the baseline data. Table 4.17 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

432002 - The baseline value (percentage) is calculated by taking the average of 5 samples within a week, over a period of a year. The end value is based on 11th – 17th Dec 2017. The average occupancy is calculated which is 26.547 %, with a standard deviation of 21.34 %. When the parking lots do not register, the data is not reported. In total, 66 out of 2058 unique timestamps have not been reported.

432003 – There were previously four (bus, train, bike, on foot) green mobility alternatives. After implementing bike sharing in Strijp-S, there are now five.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Datasets to be used in impact calculation	Aligned with SCIS (Y/N)	Auto. calc.
432001	Improving mobility	Improvement of mobility parking efficiency by reducing parking lots	Dimensionless integer	Parking information	N	N
432002	Improving mobility	Improvement of mobility parking efficiency by increasing average parking occupancy percentage	%	Parking information	N	Y
432003	Improving mobility	Improving mobility management by increasing green mobility alternatives	Dimensionless integer	Parking information	N	N
432004	Improving mobility	Improving mobility management by providing car-pooling program	Yes/no	Parking information	N	N
432005	Developing a digital infrastructure	Availability of Reservation system	yes/no	Parking information	N	N
432006		Availability of Real-time information of parking space	yes/no	Parking information	N	N

Table 4.16: Impact assessment indicators description for Module 432

Dataset name	Dataset description	Required for impact calc. for indicators	Dataset owner	Dataset contact	Comments	WP2 next steps
Parking information	Parking information about parking facilities Strijp-S	432001 432002 432003 432004 432005 432006	VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	The parking data is in CDH	

Table 4.17: Datasets potentially to be used in the calculation of impacts for Module 432

Impact indicator identifier	Impact Indicators	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
432001	Improvement of mobility parking efficiency by reducing parking lots	Dimensionless integer	1763	2014Dec	1532	2017Dec	-231,00	-77,00	-13,10%	-4,37%
432002	Improvement of mobility parking efficiency by increasing average parking occupancy percentage	%	40	2015Dec	26.54 (std.21.34)	2017Dec	-13,46	-4,49	-33,65%	-11,22%
432003	Improving mobility management by increasing green mobility alternatives	Dimensionless integer	4	2014Dec	5	2017Dec	1,00	0,33	25,00%	8,33%
432004	Improving mobility management by providing car-pooling program	Yes/no	No	2014Dec	Yes	2017Dec	1,00	na	na	na
432005	Availability of Reservation system	yes/no	No	2014Dec	Yes	2017Dec	0.00	na	na	na
432006	Availability of Real-time information of parking space	yes/no	No	2014Dec	Yes	2017Dec	0.00	# na	na	na

Table 4.18: Impact assessment for Module 432

4.3 ICT Modules

Eindhoven has developed 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 was conducted to understand inhabitants' needs. To improve the living environment, a smart sensor network was developed. 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 4.19 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			*	*		
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 4.19: Expected impacts of the Eindhoven ICT Modules

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

The implementation dates of the module

The module was implemented from M25 and will continue until the end of this project.

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

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

Table 4.19 below, provides details of the indicators developed for this module. Table 4.20 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

441001 - the indicator has been changed from “Smart apps developed using open data platform” to “Number of API calls of the top five data sets per month” The original impact indicator can no longer be measured, as the city has no way of telling who uses the data provided on the open data portal for what purpose. We can however see how many times the API’s that provide data are called upon.

441003 - After discussion with Eindhoven municipality, this indicator has been changed from “Active view times does not make sense” to “number of times actively downloaded” which we agree providing more meaningful value for this indicator.

441005 - The reason for reduction is data consolidation in larger datasets, and a clean-up of low-quality datasets has been implemented.

Impact indicator identifier	Impacts	Impact Indicators	Quant Unit	Datasets to be used in impact calculation	Aligned with SCIS
441001	Promoting commercial activities	Smart apps developed using open data platform.	Nr	Open data	Y
441002	Promoting commercial activities	Use of open data platform- Nr of viewed times (data.eindhoven.nl)	Nr	Open data	N
441003	Promoting commercial activities	Use of open data platform- Nr of active view times (data.eindhoven.nl)	Nr	Open data	N
441004	Developing a digital infrastructure	Nr of data base of portals	Nr	Open data	N
441005	Developing a digital infrastructure	Nr of data base of data files	Nr	Open data	N
441006	Developing a digital infrastructure	Platform functions(data.Eindhoven.nl)	Nr	Open data	N
441007	Developing a digital infrastructure	Data handling capability (Max)	Gb	Open data	N

Table: Impact assessment indicators description for Module 441

Dataset name	Dataset description	Required for impact calc. for indicators	Dataset owner	Dataset contact	Comments	WP2 next steps
Open data	Eindhoven open data platform data	441001 441002 441003 441004 441005 441006 441007	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Data is provided by Eindhoven open data platform record	

Table 4.20: Datasets potentially to be used in the calculation of impacts for Module 441

Impact indicator identifier	Impact Indicators	Quant.Unit	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
441001	Number of API calls of the top five data sets per month	Dimensionless decimal	508	2014Jan - 2014Dec	7167.2	2017Jan-2017Nov	6659,18	2219,73	1310,86%	436,95%
441002	Use of open data platform- Nr of viewed times per month (data.eindhoven.nl)	Dimensionless integer	21509.0	2014Jan - 2014Dec	23919.5	2017Feb-2017Nov	2410,63	803,54	11,21%	3,74%
441003	Nr of times actively downloaded per month (data.eindhoven.nl)	Dimensionless integer	8.3	2014Jan – 2015June	58.8	2017Feb-2017Nov	50,48	16,83	605,82%	201,94%
441004	Nr of data base of portals	Dimensionless integer	4	2014Jan - 2014Dec	7	2017Jan-2017Nov	3,00	1,00	75,00%	25,00%
441005	Nr of data base of data files	Dimensionless integer	93	2014Jan - 2014Dec	63	2017Jan-2017Nov	-30,00	-10,00	-32,26%	-10,75%
441006	Platform functions (data.eindhoven.nl)	Dimensionless integer	7	2014Jan - 2014Dec	4	2017Jan-2017Nov	-3,00	-1,00	-42,86%	-14,29%
441007	Data handling capability (Max)	Gb	5	2014Jan - 2014Dec	5	2017Jan-2017Nov	0,00	0,00	0,00%	0,00%

Table 4.21: Impact assessment for Module 441

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

The implementation dates of the module

Implementation of this module started in M08 in several steps. The communication plan for Eckart Vaartbroek was finished in M15-M16. In M22, a customer journey is offered to ensure that the experience of the tenants with this new tool has started. The implementation is ongoing and will continue till the end of this project.

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 quality of life. However due to privacy issues and concerns of over burdening with information from the company's perspective, there is a very limited access to residents. To distinguish this module from module 424, only private house owners were measured in this module. Finally we agreed that 3 private houses as volunteers will share their information with us. This data has been used as the baseline. Since no renovation project has been done so far for any private houses, no information can be filled in for the end value. Table 4.22 below, provides details of the indicators developed for this module. Table 4.23 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

To distinguish the impacts of Module 422 and Module 424, indicators of this module are focused on private houses renovation. After several rounds of discussion with Woonconnect, indicators have to be modified. There are mainly two reasons for these modification: 1) privacy issue raised by private owners, Woonconnect and KPN; 2) least indicators capturing as much impacts as possible. Considering the privacy issue, start value are based on volunteer samples which consists of three houses.

442003 - Wide scale deployment/ dissemination of project results by measuring reduction in monthly energy bills of electricity on average has been removed. Energy price will not be changed in the near future. The energy consumption of electricity can reflect this indicator as well.

442004 - Wide scale deployment/ dissemination of project results by measuring reduction in monthly energy bills of gas on average has been removed. Energy price will not be changed in the near future. The energy consumption of gas can reflect this indicator as well.

442005 - - Wide scale deployment/ dissemination of project results by measuring payback periods for specific demonstration activities (Average payback year) has been removed due to privacy issue.

442008 - Based on the Netherlands Energy efficiency report (2011), co2 emission per kWh generated (in gCO2/kWh) is 351, while 56.6kg/GJ CO2 will be produced by using natural gas (dry).

Impact indicator identifier	Impacts	Impact Indicators	Quant. unit	Datasets to be used in calculation	Aligned with SCIS
442001	Wide scale deployment/ dissemination of project results	Amount of buildings retrofitted / smartified from tenants	m2/yr	Woonconnect data private owners	N
442002	Wide scale deployment/ dissemination of project results	Amount of buildings retrofitted / smartified from private owners	Dimensionless integer	Woonconnect data private owners	N
442006	Reduced carbon emissions	Primary energy usage for electricity	KWH/yr/m2	Woonconnect data private owners	Y
442007	Reduced carbon emissions	Primary energy usage for gas	m3 /yr/m2	Woonconnect data private owners	Y
442008	Reduced carbon emissions	Greenhouse gas emissions	Kg/yr/m2	Woonconnect data private owners	Y
442009	Reduced carbon emissions	Share of renewable energy resource on grid	%	Woonconnect data private owners	Y
442010	Wide scale deployment/ dissemination of project results	Nr of private house owners have been approached	Dimensionless integer	Woonconnect data private owners	N
442011	Better quality of life	Overall satisfaction of their current houses (1-5)	Dimensionless integer	Woonconnect data private owners	N

Table 4.22: Impact assessment indicators for Module 422

Dataset name	**Dataset description**	**Required for impact calc. for indicators:**	**Dataset owner**	**Dataset contact**	**Comments**	**WP2 next steps**
Woonconnect data private owners	Woonconnect data from private house owners	442001 442002 442006 442007 442008 442009 442010 442011	KPN	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	With limited access to house owners, only start value could be measured based on 3 sample houses	Stay in contact with KPN to collect missing data

Table 4.23: Datasets description for Module 422

Impact indicator identifier	Impact Indicator	Quant. Unit	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
442001	Number of buildings converted per year	m2/yr	0	2014Jan - 2014Dec	0	Till 2017 Oct				
442002	Nr. of private owners willing to make renovation	Nr.	0	2014Jan - 2014Dec	0	Till 2017 Oct				
442006	Primary energy usage for electricity	KWH/yr/m 2	23,84	2017Jan - 2017Dec						
442007	Primary energy usage for gas	m3 /yr/m2	11,37	2017Jan - 2017Dec						
442008	Greenhouse gas emissions	Kg/yr/m2	9010,30	2017Jan - 2017Dec						
442009	Share of renewable energy resource on grid	%	44,65%	2017Jan - 2017Dec						
442010	Nr of private house owners have been approached	Dimension less integer	0	2017Jan - 2017Dec						
442011	Overall satisfaction of their current houses (1-5)	Dimension less integer	4,33	2017Jan - 2017Dec						

Table 4.24: Impact assessment for Module 422

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

The implementation dates of the module

The implementation includes two parts which are outdoor and indoor.

For outdoor implementation work, the preparation started in M22. A supplier was found in M23 and extension was ready around M26. The network was implemented in M27.

For indoor implementation work, the office-S network was finished in M24. The development of the Smart City Hub in the building Viedolab started in M21. It has been implemented from M28.

The indicators 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 4.25. Table 4.26 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

None

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Datasets to be used in impact calculation	Aligned with SCIS	Auto.calc.
443001	Developing a digital infrastructure	Fibre-optic network expanded by connecting homes	Dimensionless integer	Fibre-optic network data	Y	N
443002	Developing a digital infrastructure	Fibre-optic network expanded by connecting offices	M_2	Fibre-optic network data	Y	N
443003	Developing a digital infrastructure	Fibre-optic network expanded by connecting lamp pole	%	Fibre-optic network data	N	N
443004	Fostering citizen engagement (Co-creation)	Nr of types of data available on the platform	Dimensionless integer	Fibre-optic network data	N	N
443005	Fostering citizen engagement (Co-creation)	Nr of users of soft platform	Dimensionless integer	Fibre-optic network data	Y	N

Table 4.25: Impact assessment indicators description for Module 443

Dataset name	Dataset description	Required for impact calc. for indicators:	Data set in CDH	Dataset owner	Dataset contact	Comments	WP2 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)		

Table 4.26: Datasets description for Module 443

Impact indicator identifier	Impact Indicators	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
443001	Fibre-optic network expanded by connecting homes	Dimensionless integer	0	2014Jan - 2014Dec	1000	2017Jan - 2017Dec	1000	333,33	na	na
443002	Fibre-optic network expanded by connecting offices	M_2	200.000	2014Jan - 2014Dec	270.000	2017Jan - 2017Dec	70000	23333,33	35,00%	11,67%
443003	Fibre-optic network expanded by connecting lamp pole	%	0,445	2014Jan - 2014Dec	0,627	2017Jan - 2017Dec	0,182	0,06	40,77%	13,59%
443004	Nr of types of data available on the platform	Dimensionless integer	0	2014Jan - 2014Dec	9	2017Jan - 2017Dec	9	3,00	na	na
443005	Nr of users of soft platform	Dimensionless integer	0	2014Jan - 2014Dec	20	2017Jan - 2017Dec	20	6,67	na	na

Table 4.27: Impact assessment for Module 443

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

The implementation dates of the module

The implementation started in M16 and is expected to be completed by M36.

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 4.28. Table 4.29 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

444006 – Improvement of quality of life by recorded happiness of residents and workforce. There was a workshop and group interview organized by VW. However there is no well-organized document to record the interview data. This indicator has been removed.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Datasets to be used in impact calculation	Formula for impact calculation	Aligned with SCIS
444001	Fostering citizen engagement (Co-creation)	Nr. of citizens involved in project-planning	Dimensionless integer	Interview data	Counting	Y
444002	Developing a digital infrastructure	Improved public space by installing sound sensors	Dimensionless integer	Sensor & App data	Counting	N
444003	Developing a digital infrastructure	Improved public space by installing video sensors	Dimensionless integer	Sensor & App data	Counting	N
444004	Developing a digital infrastructure	Improved public space by installing water sensors	Dimensionless integer	Sensor & App data	Counting	N
444005	Developing a digital infrastructure	Improved public street lighting by promoting App used by citizens	Dimensionless integer	Sensor & App data	Counting	N

Table 4.28: Impact assessment indicators description for Module 444

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Sensor & App data*	Sensor data and App data from residents at Strijp-S	444002 444003 444004 444005	VW/ residents	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		

Table 4.29: Datasets description for Module 444

Impact indicator identifier	Impact Indicators	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
444001	Nr. of citizens involved in project-planning	Dimensionless integer	0	2014Jan - 2014Dec	20	2017Oct	20	6,67	na	na
444002	Improved public space by installing sound sensors	Dimensionless integer	0	2014Jan - 2014Dec	7	2017Oct	7	2,33	na	na
444003	Improved public space by installing video sensors	Dimensionless integer	0	2014Jan - 2014Dec	15	2017Oct	15	5,00	na	na
444004	Improved public space by installing water sensors	Dimensionless integer	0	2014Jan - 2014Dec	10	2017Oct	10	3,33	na	na
444005	Improved public street lighting by promoting App used by citizens	Dimensionless integer	0	2014Jan - 2014Dec	5	2017Oct	5	1,67	na	na

Table 4.30: Impact assessment for Module 444

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

The implementation dates of the module

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. Participants had to pitch their ideas in front of an independent jury that selected 19 participants that may enter into the second phase. 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 a jury. The 2nd iCity Tender Event was scheduled in M25.

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 4.31. Table 4.32 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators.

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

After discussion with project manager, the quantity unit of 445001 and 445004 have been changed from €m to €m/yr and € to €/yr to better capture the change before and after implementing the project.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Datasets to be used in impact calculation	Aligned with SCIS
445001	Promoting commercial activity	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr	Innovative services	Y
445002	Promoting commercial activity	SMEs stimulated	Dimensionless integer	Innovative services	N
445003	Promoting commercial activity	Jobs created (Full time equivalent)	Dimensionless integer	Innovative services	Y
445004	Wide scale deployment/ dissemination of project results	SMEs development Turnover	€/yr	Innovative services	Y
445005	Wide scale deployment/ dissemination of project results	Generate large-scale investment - Venture capital	€	Innovative services	Y
445006	Wide scale deployment/ dissemination of project results	Generate large-scale investment - Commercial value	€	Innovative services	Y
445007	Wide scale deployment/ dissemination of project results	Software and application development (Nr. of apps registered)	Dimensionless integer	Innovative services	Y

Table 4.31: Impact assessment indicators for Module 445

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Innovative services	Data on request - Stimulating the development of innovative services / applications	445001 445002 445003 445004 445005 445006 445007	VW	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)		

Table 4.32: Datasets description for Module 445

Impact indicator identifier	Impact Indicators	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
445001	Capital /operational expenditure of partners on energy, ICT and mobility	€m /yr	0	2016 Oct	50	2017 Oct	50,00	50,00	na	na
445002	SMEs stimulated	Dimensionless integer	0	2016 Oct	28	2017 Oct	28,00	28,00	na	na
445003	Jobs created (Full time equivalent)	Dimensionless integer	0	2016 Oct	28	2017 Oct	28,00	28,00	na	na
445004	SMEs development Turnover	€/yr	0	2016 Oct	230	2017 Oct	230,00	230,00	na	na
445005	Generate large-scale investment - Venture capital	€	0	2016 Oct	40000	2017 Oct	40000,00	40000,00	na	na
445006	Generate large-scale investment - Commercial value	€	0	2016 Oct	0	2017 Oct	0,00	0,00	na	na
445007	Software and application development (Nr. of apps registered)	Dimensionless integer	0	2016 Oct	5	2017 Oct	5,00	5,00	na	na

Table 4.33 Impact assessment for Module 445

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

The implementation dates of the module

The implementation started from M 16 with an internal session using the "design thinking" method. M17 observations by the pond, along the water had been carried out and interviews were organized with key-persons in the district from different groups of people. By end of M17, a co-creation evening was organized with people living in the area where the most important functionalities of the pond were discussed and the focus themes were decided about. In M23 the first developed design was presented to the residents of the district. Final version of the "design" was presented to the residents on M25. The project was completely implemented at the beginning of M34.

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 fostering citizen engagement (Co-creation) society and improving the quality of life. Table 4.34 provides details of the indicators developed for this module. Table 4.35 identifies potential datasets that may be used to calculate quantifiable impacts for the indicators

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

446001 -Besides the people signed in the signed list each time, based on rough estimation of Annemarie Totte (the project manager), during the house visits they spoke to 10 people and during the observations around 50 people are involved.

446003 - The indicator is calculated based on three observation periods. The observation document is attached in appendix 1. During May 2016, three random periods were selected to observe peoples' behaviour on this route. The observer stands at a certain point and counted the number of people in their sight range. Meanwhile, they interviewed random selected passers-by.

Impact indicator identifier	Impacts	Impact Indicators	Quant. Unit	Datasets to be used in impact calculation	Aligned with SCIS
446001	Fostering citizen engagement (Co-creation)	Adoption of co-creation procedure by involving citizens in the decision process	Nr.	Dialogue method	N
446002	Improving the quality of life	Improved public street lighting by installing lights pole	Nr	Sensor data	N
446003	Improving the quality of life	Improved public street lighting by sensing density of people on the route	Nr. per m2	Sensor data	N
446004	Improving the quality of life	Recorded well-being of residents	Recorded overall well-being 1-10 (low to high)	District monitor	N

Table 4.34: Impact assessment indicators for Module 446

Dataset name	Dataset description	Related impact indicators	Dataset owner	Dataset contact	Comments	WP2 next steps
Dialogue method	Interview data based on Dialogue method: Design thinking	446001	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Design thinking method was use to involve citizens: observations, interviews, house to house calls, and creative design events. Data is available.	
Sensor data	Sensor data from light poles	446002 446003	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	The data will be available in M37-M38	Follow up with Eindhoven municipality
District monitor	Excerpt from district monitor data collected by municipality on yearly basis ('Buurtmonitor')	446004	Eindhoven municipality	Dujuan Yang (D.Yang@tue.nl) & Niels Wiersma (n.wiersma@eindhoven.nl)	Data is available	

Table 4.35: Datasets description for Module 446

Impact indicator identifier	Impact Indicators	Quant. Unit	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
446001	Adoption of co-creation procedure by involving citizens in the decision process	Dimensionless integer	0	2014Dec	99	2017Oct	99,00	33,00	na	na
446002	Improved public street lighting by installing lights pole	Dimensionless integer	0	2014Jan - 2014Dec	31	2017 Oct	31,00	10,33	na	na
446003	Improved public street lighting by sensing density of people on the route Nr. Per min/Nr. per day	Dimensionless integer	0,217	2014Jan - 2014Dec		2017 Oct – 2017 Dec				
446004	Recorded well-being of residents	Recorded overall well-being 1-10 (low to high)	6,7	2014Jan - 2014Dec	6,85	2017 Jan – 2017 Dec	0,15	0,05	2,24%	0,75%

Table 4.36: Impact assessment for Module 446

5 Stavanger Impact

Executive Summary

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 data to assess the impacts of these modules. This report section is organised into four sections.

Section 1 provides a high-level description of the City of Stavanger, and highlights the smart city initiatives taking place which complement Triangulum. This section also identifies the potential of Triangulum modules to contribute to meeting city objectives. It offers an initial evaluation of the module impacts followed by a high-level overview of the impact assessment and monitoring activities to continue in Stavanger during 2018.

Section 2 describes the Energy modules in detail including objectives, socio-technical configurations and stakeholder structures. The indicators used for assessing the impacts and benefits of the module and the current understanding of impacts are then presented. Sections 3 and 4 provide module descriptions and impact indicators for the Mobility and ICT modules, respectively.

5.1 Overview and initial assessment

This section briefly assesses the local modules and their impacts. The progress of the Stavanger partnership in terms of module implementation and impact reporting is summarized in Table 5.1.

	#modules implemented	#baseline indicator values available	#impact indicator values available
Overall value	6/8	22/60	6/60
Energy	1/2	6/18	0/18
Mobility	2/2	2/17	0/17
ICT	3/4	14/25	6/25

Table 5.1: Implementation and impact reporting of Stavanger modules

Some key impacts achieved in Stavanger include the installation of Smart Gateways in 90 homes (Module 521), the increased reliance on renewable energy sources at municipal buildings (Module 522), and the ongoing collection of data from other modules to the cloud data platform (Module 544).

Please note, the Stavanger impact indicators were challenging to implement and evaluate due to a necessary emphasis and priority on data transfer to the cloud data platform.

5.2 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 in the next iteration of this report due in M48 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 enables 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 5.2 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 5.2: Expected impacts of Stavanger Energy modules

5.2.2 Module 521: Smart gateway (Subtask 5.2.1)

The implementation dates of the module

The module was implemented in January 2016 and has been operating in the private households since.

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

The module aims to have an impact of having smart gateways installed among the residences, to reduce energy consumption, and to flatten peak demand. The impact indicators are derived from the data generated by the smart gateways themselves, and from electric energy price data for the relevant time periods.

Table 5.3 below describes the indicators developed for this module. Table 5.4 describes datasets that are intended to be used to calculate impacts indicators for this module.

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 was possible.
- ***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.
- **M34 (2017)**: Wherever the column "Data set in CDP?" is marked with "N" in Table 5.3, the data transfer is on hold awaiting bilateral data processing agreement between Lyse and UiS, and/or resolution of due diligence with regards to the coming GDPR.
- **M35 (2017)**: Due diligence has been completed by reviewing the data model and schema with the help of Privacy Impact Assessment expertise organized by WP2. The data from this module may be considered as not personal data. However, establishing the ongoing data transfer to the cloud data platform must occur after M36 given the available time and resources. Collaboration is ongoing to establish programmatic calculation of impact indicators to provide results for *some* values in Table 5.5.
    - **While the process of establishing a bilateral agreement between Lyse and UiS is ongoing, Lyse has agreed to provide their own programmatic evaluation of impact indicators 521001 and 521002**. Lyse has given notice that these will not be available before the end of 2017.
- **M36 (2018):** Since data could not be transferred yet, and programmatic evaluations of impact indicators undertaken by UiS, Lyse has supported the impact reporting effort by themselves performing the programmatic calculation of two impact indicators in this module. This step is also helpful to support future discussions on impact indicator formulae and their

programmatic implementation, once an agreement is reached and Lyse data can be transferred to the UiS cloud data platform.

- Indicator 521001 is programmatically evaluated as the number of gateways where power consumption data has been stored by Lyse. This number (56) differs from the physically installed gateways (100). These values were evaluated and reported by Lyse to WP2 researchers at UiS.
- Indicator 521002 is programmatically evaluated as the mean of the annual consumption (in kWh) of all households where the total time period of the consumption data exceeds 6 months (38 households). The annual consumption is estimated by calculating the consumption per time for the time period where data is available and using this consumption rate for one year. This estimate will not be totally accurate, as the time period where data is available may not be representative of a full year (e.g. if the time period is in the winter season only, the annual consumption estimate will be too high), and it should be regarded as a first estimate before longer periods of consumption data is available. These values were evaluated and reported by Lyse to WP2 researchers at UiS.
- The remaining impact indicators could not be evaluated at the time of this report. See Comments column in Table 5.4.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
521001	Installation of smart gateways	Count of smart gateways installed	Dimensionless integer	Lyse smart gateway data set	N
521002	Reduced energy consumption. Buildings' consumption of electrical energy via smart gateway	Mean of annual energy consumption per residence	kWh	Lyse smart gateway data set	Y
521003		Variance of annual energy consumption per residence	MW^2h^2	Lyse smart gateway data set	N
521004		Mean of annual energy cost per residence	€ (NOK)	Lyse smart gateway data set + Energy price data	Y
521005		Variance of annual energy cost per residence	$€^2$ (NOK^2)	Lyse smart gateway data set + Energy price data	N
521006		Annual mean of electricity price per kWh	€ (NOK)	Lyse smart gateway data set + Energy price data	Y
521007		Annual variance of electricity price per kWh	$€^2$ (NOK^2)	Lyse smart gateway data set + Energy price data	N
521008	Flattening peak demand	Mean of intradiurnal mean of hourly energy consumption per residence	kWh	Lyse smart gateway data set	N
521009	Flattening peak demand	Mean of intradiurnal variance of hourly energy consumption per residence	M W^2h^2	Lyse smart gateway data set	N

Table 5.3: Impact assessment indicators description for Module 521

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Lyse smart gateway data set	Collection of sensor data from smart gateways installed.	521001 521002 521003 521004 521005 521006 521007 521008 521009	Lyse	Sindre Tøsse (Sindre.Tosse@lyse.no)	Data transfer was put on hold due to concerns over GDPR and awaited due diligence regarding appropriateness of Privacy impact assessment. Transfer to CDP may depend on extra resources to contract third-party data processor to undertake GDPR-compliant anonymization. Transfer to CDP has aggregation as prerequisite from Lyse and will be completed by February 1st. Also awaiting bilateral data agreement between UiS and Lyse.	UiS researchers follow up with UiS legal team and forward initial draft of agreement by M38. UiS researchers follow up availability of data set after M36, to generate a dedicated adaptor and commence ongoing data collection. Once data transfer from Lyse to CDP is established, UiS researchers will undertake a sanity check to ensure the same programmatic evaluations of 521001 and 521002 can be replicated at CDP, to in turn ensure common understanding with Lyse about the impact indicator definitions.
Lyse smart gateway data set (Continued)					After evaluation by an external data expert of the potential need for Privacy Impact Assessment, it was determined that this was not necessary given that data shared to UiS CDP does not provide a way to re-identify the homes where the smart gateways were installed. Furthermore, in M36 the values for impact indicators 521001 and 521002 were evaluated by Lyse and reported directly by module task group contact.	

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Energy price data (Lyse)	Longitudinal dataset detailing the price per kilowatt hour of energy of Lyse residential customers over months.	521004 521005 521006 521007	Lyse	Sindre Tøsse (Sindre.Tosse@lyse.no)	Lyse suggests to use historical spot market prices made available by Nord Pool. This data set was identified after the deadline for data intake for submissions leading up to the D2.5 report. However, this data set is open and as such not affected by privacy concerns.	Following up availability of data set after M36, UiS will collaborate with Lyse to clarify the relevant subset of available data and generate a dedicated adaptor and commence ongoing data collection.

Table 5.4: Datasets description for Module 521

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
521001	Count of smart gateways installed	Dimensionless integer	56	Jan 2017	N/A	Jan 2020 (expected)				
521002	Mean of annual energy consumption per residence	kWh	12102	Feb 2016	N/A	Jan 2020 (expected)				
521003	Variance of annual energy consumption per residence	MW^2h^2				Jan 2020 (expected)				
521004	Mean of annual energy cost per residence	€ (NOK)				Jan 2020 (expected)				
521005	Variance of annual energy cost per residence	$€^2$ (NOK^2)				Jan 2020 (expected)				

521006	Annual mean of electricity price per kWh	€ (NOK)				Jan 2020 (expected)				
521007	Annual variance of electricity price per kWh	$€^2$ (NOK^2)				Jan 2020 (expected)				
521008	Mean of intradiurnal mean of hourly energy consumption per residence	kWh				Jan 2020 (expected)				
521009	Mean of intradiurnal variance of hourly energy consumption per residence	M W^2h^2				Jan 2020 (expected)				

Table 5.5: Impact assessment for Module 521

5.2.3 Module 522: Central energy plant (Subtask 5.2.2)

The implementation dates of the module

The energy plant was completed for energy delivery to the administration buildings, OK23 and the City Hall, in June 2017. After a trial period of six months, the municipality of Stavanger has overtaken monitoring and control from the operating centre as of December 2017. Energy meters for all energy sources and delivery points (buildings) are installed to measure energy production.

The energy plant will supply heating and cooling to three municipal buildings. Since the rehabilitation of one of the three municipal buildings, OK19, is ongoing, the CEP module cannot deliver energy to the full planned extent before the rehabilitation of OK19 is completed in 2018/2019.

In summary, the module is partly finalized and partly being implemented, and will be fully finalized in January 2019.

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

The module is intended to have an impact of increasing the proportion of renewable energy used by municipal buildings. The impact indicators are intended to be derived from the data generated by the module itself, and from electric energy price data for the relevant time periods. Note that direct measurement carbon emissions measurement data does not exist, and could be estimated from electricity consumption according to the method used in the municipality. The coefficients used to estimate carbon emissions are given by *City of the Future*'s guidelines for emissions from buildings. See the Comments column in Table 5.7.

Table 5.6 below describes the indicators developed for this module. Table 5.7 describes datasets that are intended to be used to calculate impacts indicators for this module.

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.
- ***M30-M33 (2017)***: The module task group at Stavanger Kommune has made a Data intake form submission with technical specifications of the data generated. Subsequently, direct collaboration between Stavanger municipality technical personnel and UiS researchers made it possible to establish ongoing transfer of data from Module 522 to Module 544 Cloud data platform.
- ***M34-M36 (2017)***: Discussions on exact impact indicators and their formulae; working towards programmatic calculation. Note that the impact indicators had originally been projected as

aggregates over years of data, although the data transfer has been ongoing for a much shorter time period.

- ***522001 clarifications on what will be considered a renewable energy source***:
  - ***M36:*** **The Energisentralen task group uses the following definition***: All the energy sources used in the central energy plant module are considered renewable. Norwegian construction regulations define solar heating, biogas, and heat pump systems as renewable (including the electricity used to run the heat pumps). Fossil fuels and the use of direct electricity in heating systems are not considered renewable.*
  - In the old power plant installed in 1970, energy production was based on direct electricity and natural gas as energy sources. The energy production, (Calculated to 3.5 MWh per annum, and consequently emissions of 834 metric tonnes CO_2 per annum) was the same as purchased energy. The energy solution for the new CEP is a heat pump system based on the use of wastewater in the sewage tunnel as the primary source and biogas as a peak load. In the rehabilitation of OK19, the recycling of greywater and the use of solar energy will lead to a reduction in energy production from the new energy plan.
  - The need for energy production is reduced to 2.56 MWh per annum, and 101 metric tonnes CO_2 per annum. Here, the part of energy that must be purchased is reduced to only 1.15 MWh per annum. The difference between produced and purchased energy is considered to constitute the renewable portion. The difference between calculated greenhouse gas emissions in the old CEP and the new CEP is considered the new carbon footprint.
- ***522002 variants (a-d) are modified to reflect available data, i.e. energy consumption from energy provided by the module after module implementation. Total energy consumption is not available in the module dataset.***
- ***522003 was extended into variants (a)-(f) to more specifically reflect the energy consumption for either heating or cooling in each building. Note that***
  - ***522002b = 522003c, and***
  - ***522002d = 522003f.***
- ***522004 (Annual energy cost per building, was previously 522005) clarification and cost data identification:***
  - The municipality of Stavanger has entered into a new agreement for the purchase of energy in January 2018. Whether energy cost can be provided in an energy cost data set will be clarified and finalized in April 2018.
  - ***The previous 522004 ("The amount of energy consumed for heating by each building, each year") was rescinded as a proposed impact indicator due to the original impact indicator concept not reflecting the final design and implementation of Module 522.***
- ***522005 (Was 522006 "Estimated total CO_2 emission per year avoided by the use of CEP"):*** The current approach to this indicator about CO_2 is an estimate of the emitted from all electricity used, and all gas used, by the module. This does not follow the pattern of impact indicators for electric vehicles, where the obviated greenhouse gas emissions can be estimated as a function of the distance driven as if by a comparable fossil fuel vehicle.

- ***However, 522005 is currently an estimate of the carbon footprint of the module, based on the following coefficients:***
  - 132 g CO_2 equivalents per kWh of electricity.
  - 25 g CO_2 equivalents per kWh of biogas.
  - The documentation or references underlying these assumptions have not yet been determined.
  - *City of the Future* was a six-years national program where the largest cities cooperate on reducing greenhouse gas emissions. Stavanger municipality has used coefficients based on the final report from this project. Documentation is given here, see page 22: http://www2.stavanger.kommune.no/Documents/Natur%20og%20milj%c3%b8/Framtidens%20byer/FBprosjektavslutning_%c3%a5rsberetning2014_Stavanger.pdf. There is an ongoing discussion in Norway regarding which coefficients will be used to calculate CO_2 emissions from buildings and construction, which may affect the coefficients. Stavanger Kommune reports an expectation that a conclusive outcome to this discussion as it applies to this module will be forthcoming by June 2018.
- The challenge with this conception of the impact indicator lies in the fact that the basis for a before/after comparison would require historical data on the total energy consumption of the buildings before and after module implementation. This data may or may not be possible to acquire subsequently.

- New impact indicators were identified from the data generated by the module once implemented:
  - ***522006a and 522006b (“***Sum of energy produced for (a) heating and (b) cooling***”)***
  - ***522007a and 522007b (“***Total energy (a) purchased and consumed by, and (b) distributed by the module.***”)***
  - ***522008 with four variants (a-d) (“***Energy produced by each of the energy sources in the module: (a) electricity; (b) biogas; (c) solar; (d) greywater; …***”)***
  - ***522009 (“***Energy consumed to heat tap water.***”)***

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
522001	Increased proportion of renewable energy sources	Percentage of energy from renewable energy sources.	%	Stavanger Kommune Energisentralen m522 dataset. + A document is required to classify energy sources as renewable or not. + Static data for energy consumption prior to module implementation must be transferred separately.	Y
522002a-d		The total amount of energy supplied by the module and consumed by each building: (a) OK19 offices, heating and cooling; (b) OK19 swimming pool, heating; (c) OK23, heating and cooling; (d) City Hall, heating.	kWh	Stavanger Kommune Energisentralen m522 dataset. + Historical data from the overall Energioppfølgingssystemet (EOS) dataset.	Y
522003a-f		The amount of energy consumed for heating or cooling by each building: (a) heating OK19 offices; (b) cooling OK19 offices; (c) heating OK19 swimming pool; (d) heating OK23 offices; (e) cooling OK23 offices; (f) heating City Hall.	kWh	Stavanger Kommune Energisentralen m522 dataset.	Y
522004a-d		Annual energy cost per building: (a) OK19 offices; (b) OK19 swimming pool; (c) OK23; (d) City Hall.	€ (NOK)	Stavanger Kommune Energisentralen m522 dataset. + Price data.	Y
522005	CO_2 emission	Estimated total CO_2 emission per year produced by the module in operation.	Metric tonnes	Stavanger Kommune Energisentralen m522 dataset. + Emissions estimation reference publication.	Y
522006a 522006b	Increased proportion of renewable energy sources	The energy produced by the module for (a) heating and (b) cooling.	kWh (%)	Stavanger Kommune Energisentralen m522 dataset	Y
522007a 522007b	Increased proportion of renewable energy sources	Total energy (a) purchased and consumed by, and (b) distributed by the module.	kWh (%)	Stavanger Kommune Energisentralen m522 dataset	Y
522008a-d	Increased proportion of renewable energy sources	Total energy produced by each of the energy sources in the module: (a) electricity; (b) biogas; (c) solar; (d) greywater.	kWh (%)	Stavanger Kommune Energisentralen m522 dataset	Y

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
522009	Increased proportion of renewable energy sources	Energy produced by the module and consumed to heat tap water.	kWh (%)	Stavanger Kommune Energisentralen m522 dataset	Y

Table 5.6: Impact assessment indicators description for Module 522

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Stavanger Kommune Energisentralen m522 dataset, a subset of EOS (Stavanger Kommune)	Module 522-relevant subset of data: Energisentralen energy monitoring data subset of Energioppfølgingssystemet (EOS) operated by Stavanger Kommune.	522001 522002a-d 522003a-f 522004a-d 522005 522006a-b 522007a-b 522008a-d 522009	Stavanger Kommune	michael.taoushanis@stavanger.kommune.no espen.svendsen@stavanger.kommune.no)	The Energisentralen task group has been proactive in establishing local mechanisms that forward data to the Cloud Data Platform on an ongoing basis, despite challenging network configurations at both institutions. The Energisentralen task group have also been proactive in supporting the work of mapping the schema of the data source to the impact indicator calculations.	M36-M37: UiS researchers develop the dataset into impact indicators. Verify common understanding of impact indicators and their calculation with Energisentralen task group. Ongoing data transfer does require some troubleshooting and improvement, but the current lack of values for module 522 impact indicators is a result of UiS constraints rather than data being unavailable.
Energy price data (Stavanger Kommune)	Longitudinal dataset detailing the costs arising from primary energy use in specified municipal buildings	522005	Stavanger Kommune	michael.taoushanis@stavanger.kommune.no espen.svendsen@stavanger.kommune.no	These values may most appropriately be collected in an automated way if practical. Otherwise, the values may be reported directly by the module task group for specific time periods.	UiS researchers can follow up after April 2018, since whether energy cost can be provided in an energy cost data set will then be clarified and finalized.

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Emissions estimation reference publication.	Documentation as basis for coefficient to estimate CO2 emissions.	522005	Stavanger Kommune	michael.taoushanis@stavanger.kommune.no espen.svendsen@stavanger.kommune.no	The reference used is the final report (2014) of the project *Cities of the future* (Framtidens byer): http://www2.stavanger.kommune.no/Documents/Natur%20og%20milj%c3%b8/Framtidens%20byer/FBprosjektavslutning_%c3%a5rsberetning2014_Stavanger.pdf.	Reference and coefficients used to estimate CO2 equivalents emissions may be updated by June 2018. UiS researchers can contact Stavanger Kommune at that point about any updates.
Historical data from the overall Energioppfølgingssystemet (EOS) dataset.		522002a-d	Stavanger Kommune	michael.taoushanis@stavanger.kommune.no espen.svendsen@stavanger.kommune.no	These values were reported directly by the module task group.	These data are considered to have been captured for impact reporting purposes.

Table 5.7: Datasets description for Module 522

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
522001	Percentage of renewable energy from renewable energy sources	%		2013-2015		Jan 2020 (expected)				
522002a	The total amount of energy supplied by the module and consumed by each building: (a) OK19 offices, heating and cooling.	kWh	1149836	2013-2015		Jan 2020 (expected)				

522002b	The total amount of energy supplied by the module and consumed by each building: (b) OK19 swimming pool.	kWh	1904066	2013-2015		Jan 2020 (expected)				
522002c	The total amount of energy supplied by the module and consumed by each building: (c) OK23, heating and cooling.	kWh	983558	2013-2015		Jan 2020 (expected)				
522002d	The total amount of energy supplied by the module and consumed by each building: (d) City Hall, heating.	kWh	1281841	2013-2015		Jan 2020 (expected)				
522003a	The amount of energy consumed for heating or cooling by each building: (a) heating OK19 offices.	kWh				Jan 2020 (expected)				
522003b	The amount of energy consumed for heating or cooling by each building: (b) cooling OK19 offices.	kWh				Jan 2020 (expected)				
522003c	The amount of energy consumed for heating or cooling by each building: (c) heating OK19 swimming pool.	kWh				Jan 2020 (expected)				
522003d	The amount of energy consumed for heating or cooling by each building: (d) heating OK23 offices.	kWh				Jan 2020 (expected)				
522003e	The amount of energy consumed for heating or cooling by each building: (e) cooling OK23 offices.	kWh				Jan 2020 (expected)				
522003f	The amount of energy consumed for heating or cooling by each building: (f) heating City Hall.	kWh				Jan 2020 (expected)				
522004a	Annual energy cost per building: (a) OK19 offices.	€ (NOK)				Jan 2020 (expected)				
522004b	Annual energy cost per building: (b) OK19 swimming pool.	€ (NOK)				Jan 2020 (expected)				
522004c	Annual energy cost per building: (c) OK23.	€ (NOK)				Jan 2020 (expected)				
522004d	Annual energy cost per building: (d) City Hall.	€ (NOK)				Jan 2020 (expected)				

522005	Estimated total CO_2 emission per year produced by the module in operation.	Metric tonnes				Jan 2020 (expected)				
522006a	The energy produced by the module for (a) heating.	kWh				Jan 2020 (expected)				
522006b	The energy produced by the module for (b) cooling.	kWh				Jan 2020 (expected)				
522007a	Total energy (a) purchased and consumed by the module.	kWh				Jan 2020 (expected)				
522007b	Total energy (b) distributed by the module.	kWh				Jan 2020 (expected)				
522008a	Total energy produced by the various sources in the module: (a) electricity.	kWh				Jan 2020 (expected)				
522008b	Total energy produced by the various sources in the module: (b) biogas.	kWh				Jan 2020 (expected)				
522008c	Total energy produced by the various sources in the module: (c) solar.	kWh				Jan 2020 (expected)				
522008d	Total energy produced by the various sources in the module: (d) greywater.	kWh				Jan 2020 (expected)				
522009	Energy produced by the module and consumed to heat tap water.	kWh				Jan 2020 (expected)				

Table 5.8: Impact assessment for Module 522

5.3 Mobility Modules

The Stavanger Mobility task group has defined the scope of two modules (see below). Hence, the module descriptions and proposed impact indicators presented below have been revisited and revised over the course of the project as module scope was 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.* The Stavanger Region has a high density of electric vehicles. To meet increased demand for charging capacity for electrical vehicles (EVs), several measures are implemented independently of the Triangulum process. In the corresponding task, emphasis is concentrated on home-based charging in 10 pilot homes.

Table 5.9, 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		*	*	*	

Table 5.9: Expected impacts of the Stavanger Mobility modules

5.3.1 Module 531: Battery bus demonstration (Subtask 5.3.1)

The implementation dates of the module

The module was implemented in December 2016, in the sense that the electric battery busses were delivered, and these buses have been operating in the Nord-Jæren bus fleet since.

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

The module is intended to have an impact of providing and utilizing electric battery busses, and of reducing greenhouse gas emissions which would otherwise be cause by diesel busses. The greenhouse gas emissions thus avoided should be estimated based on the distance driven by the battery busses and a commissioned report by Asplan Vlak for Kolumbus that indicates 0.9 kg CO2 equivalents per km driven by a diesel bus.

The distance data can be calculated from the Kolumbus Vehicle Monitoring (VM) dataset in various ways, though the most reliable way to do so has yet to be determined.

Table 5.10 below describes the indicators developed for this module. Table 5.11 describes datasets that are intended to be used to calculate impacts indicators for this module.

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.
- ***M32:*** Detailed review of feasibility of impact indicators based on data being collected.
    - ***The relevant overall bus fleet that the battery busses are a part of, and therefore can be meaningfully compared to, is the "Norgesbuss på Nordjæren" fleet, which all have a VehicleRef value of the form 2xxx.***
    - Battery busses that are provisioned under the Triangulum project have VehicleRef values 2402, 2403, and 2404. These were delivered at the very end of 2016. Pre-existing battery busses are labelled 2400 and 2401, and were operational as of April 2015.
- ***M35:*** Follow-up after detailed review that identified additional data to take into account has not been possible due to operational/implementation priorities at Kolumbus.
    - While an important dataset (Vehicle Monitoring, or VM) on Kolumbus busses is being collected to CDP on an ongoing basis, the variable data quality/sparsity and underlying data model require more work by UiS researchers to extract reliable estimates of e.g. the distance travelled by each bus in a given time interval.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
531001	Provision of battery busses	Total number of buses in relevant fleet	Dimensionless integer	Kolumbus VM dataset + Kolumbus Drift	Y
531002		Number of battery busses in relevant fleet	Dimensionless integer	Kolumbus VM dataset + Kolumbus Drift	Y
531003a		Battery busses annual purchasing cost	€ (NOK)	Kolumbus Drift + Battery busses purchase cost	N
531003b	Provision of battery busses	Battery busses annual maintenance and repairs cost	€ (NOK)	Kolumbus Drift + Battery busses purchase cost	N
531004	Reduced greenhouse gas/pollution emissions Reduced greenhouse gas/pollution emissions	Annual fossil fuel consumption (litres of diesel) by normal diesel bus	Litres	Kolumbus Drift	Y
531005		Annual electrical load by battery busses	kWh	Kolumbus Drift	Y
531006a 531006b 531006c 531006d 531006e		Greenhouse gas/ pollution emissions spared annually by battery busses replacing diesel busses: (a) CO2; (b) CO; (c) NOx; (d) SOx; and (e) PM.	Metric tonnes	Emissions estimation reference publication – Asplan Vlak report ordered by Kolumbus. + Kolumbus Drift (odometer data) + Kolumbus VM dataset (possibly).	Y
531007	Utilization of battery busses compared to conventional buses	Mean of passengers per bus ride	Dimensionless decimal	APC (advanced passenger counting) system, being implemented during autumn 2017	Y
531008	Utilization of battery busses compared to conventional busses	Variance of passengers per bus ride	Dimensionless decimal	APC advanced passenger counting system, being implemented during autumn 2017	Y

Table 5.10: Impact assessment indicators description for Module 531

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Kolumbus Drift	Kolumbus internal operations data.	531001 531002 531003 531004 531005 531006a-e	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	Only select pieces of information can reasonably be shared from the company operations database to the CDP.	M37: UiS researchers follow up with Kolumbus data set contact about getting the select data points required for impact indicator calculations. Need to clarify whether this is the FRIDA data set mentioned in previous discussions.
Battery busses purchase cost data	Data set not fully identified.	531003a 531003b	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	Has been mentioned in discussions as necessary for the corresponding impact indicators.	UiS researchers follow up with Kolumbus and Rogaland Fylkeskommune to request data/document.
Emissions estimation reference publication – report ordered by Kolumbus.	Emissions estimation reference publication .	531006a 531006b 531006c 531006d 531006e	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	The document has been discussed and identified in meetings between UiS and Kolumbus. Asplan Vlak report ordered by Kolumbus. Coefficients to estimate greenhouse gas emissions spared will require a documented, evidence-based justification.	UiS researchers follow up with Kolumbus and Rogaland Fylkeskommune to request data/document.
Kolumbus VM	Kolumbus bus monitoring system providing open, real-time data.	531006a 531006b 531006c 531006d 531006e	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	This data set is being collected by the CDP, except temporary outages on the collection process and busses with tracking turned off – a significant proportion at any given time.	UiS researchers: Continue exploratory data analysis to identify best wat to estimate distances driven by busses, including rules on when to drop busses with inconsistent histories from evaluation.

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
APC advanced passenger counting system		531007 531008	Kolumbus	Odd Vinje (odd.vinje@kolumbus.no)	Please provide description of the status of this data set. Was under implementation during Autumn 2017.	UiS researchers follow up with Kolumbus and Rogaland Fylkeskommune to request data/document.

Table 5.11: Datasets description for Module 531

Impact indicator identifier		Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
531001	Total number of buses in relevant fleet	Dimensionless integer	186	N/A		Jan 2020 (expected)				
531002	Number of battery busses in relevant fleet	Dimensionless integer	2+3	2 from April 2015, 3 from December 2016.		Jan 2020 (expected)				
531003a	Battery busses annual purchasing cost	€ (NOK)								
531003b	Battery busses annual maintenance and repairs cost	€ (NOK)								
531004	Annual fossil fuel consumption (litres of diesel) by normal diesel bus	Litres								
531005	Annual electrical load by battery busses	kWh								
531006a	Greenhouse gas/ pollution emissions spared annually by	Metric tonnes								

	battery busses replacing diesel busses: (a) CO2.									
531006b	Greenhouse gas/ pollution emissions spared annually by battery busses replacing diesel busses: (b) CO.	Metric tonnes								
531006c	Greenhouse gas/ pollution emissions spared annually by battery busses replacing diesel busses: (c) NOx.	Metric tonnes								
531006d	Greenhouse gas/ pollution emissions spared annually by battery busses replacing diesel busses: (d) SOx.	Metric tonnes								
531006e	Greenhouse gas/ pollution emissions spared annually by battery busses replacing diesel busses: (e) PM.	Metric tonnes								
531007	Mean of passengers per bus ride	Dimensionless decimal								
531008	Variance of passengers per bus ride	Dimensionless decimal								

Table 5.12: Impact assessment for Module 531

5.3.2 Module 532: Electric vehicle charging (Subtask 5.3.2)

The implementation dates of the module

The module was implemented in August 2017 and has been operating at the 10 households since.

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

The module aims to support the use of electric vehicles in road traffic. This indirectly supports the reduction of greenhouse gas emissions, by removing the need for combustion engine vehicles. Thus, the energy provided via EV charging could be used to estimate obviated greenhouse gas emissions. However, the type of combustion engine vehicle that has been replaced by such an electric vehicle is not obvious, and hence determining a relevant coefficient for estimating obviated greenhouse gas emissions is not simple. Nevertheless, the energy provided to EVs represents an impact on more sustainable mobility in the smart city.

Table 5.13 below describes the indicators developed for this module. Table 5.14 describes datasets that are intended to be used to calculate impacts indicators for this module.

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

- ***M12:*** Fast charging network established, collecting data. First Internal deliverable made available in M09 (internal deliverable Subtask 5.3.4) reflecting Lyse company strategy reassessment.
- ***M24:*** Subtask 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.
- ***M34:*** Reviewed feasibility of impact indicators. The availability of this module's data was affected by the same due diligence concerns as for Module 521. However, the smaller number of private users may require a different approach (aggregation) to ensure no data is collected to the CDP that may represent any implicit personal information. The implementation of an ongoing data transfer to CDP may also depend on a bilateral agreement between UiS and Lyse on data.
    - Impact indicator 532006 from previous impact reports (e.g. D2.3, D2.4) is removed because it was a speculative impact indicator projected on the basis of planned implementations, where the plans have since changed.
    - Note that the originally projected variety of EV chargers has been abandoned in favour of a single type of EV chargers to be installed. Hence the variants (*a-d*) of impact indicators in previous impact reports have also been abandoned.

- ***M36:*** After further follow-up with Lyse, UiS is informed that for this module, only static data sets are available from the chargers.
    - Impact indicator 532005 ("Number of distinct vehicles in each year using the module EV chargers") seems to impinge on the privacy of the users and the indicator is recommended to be cancelled. This impact indicator was proposed at an earlier stage of the module's development, when the public highway use of the chargers was expected, which may have attenuated privacy concerns at the time.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
532001	Installation of charging capacity	Number of chargers installed.	Dimensionless integer	Lyse EV charger data set	Y
532002	Energy consumption via EV charger	Number of charging events per year	Dimensionless integer	Lyse EV charger data set	
532003	Energy consumption via EV charger	Mean of time per charging event	Minutes	Lyse EV charger data set	N
532004	Energy consumption via EV charger	Variance of time per charging event	$Minutes^2$	Lyse EV charger data set	N

Table 5.13: Impact assessment indicators description for Module 532

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Lyse EV charger data set	Collection of sensor data from EV chargers installed as part of module.	532001 532002 532003 532004	Lyse	Sindre Tøsse (Sindre.Tosse@lyse.no)	Transfer to CDP may depend on extra resources to contract third-party data processor to undertake GDPR-compliant anonymization. After evaluation by an external data expert of the potential need for Privacy Impact Assessment, it was determined that this was not necessary given that data shared to UiS CDP does not provide a way to re-identify the homes where the smart gateways were installed.	UiS researchers follow up with UiS legal team and forward initial draft of agreement by M38.

Table 5.14: Datasets description for Module 532

Impact indicator identifier	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
532001	Dimensionless integer								
532002	Dimensionless integer								
532003	Minutes								
532004	Minutes^2								

Table 5.15: Impact assessment for Module 532

5.4 ICT Modules

The ICT task group has developed four modules to demonstrate the potential of ICT as an enabler of innovation within Stavanger.

Hence, the module descriptions and proposed impact indicators presented below have been revisited and revised as the module scope was refined throughout the implementation period.

- *Module 541: Innovative video.* This module focuses on exploiting the optical fibre network to deploy Full HD video services in new sustainable, inclusive and smart contexts in residential buildings. Note that this module has been deferred beyond M36.

    a. Lyse confirms that almost the entire module is postponed and moved to WP6 allowing adjustments with new technology. Only 2 pilots were installed with old version, and they do not function as expected.

    b. The WP2 impact reporting perspective is that while delayed, and implementation limited to follower (fellow) cities Prague and Sabadell under WP6, the development from this module's original intention is worthwhile to observe and report alongside the modules that have required less extensive re-configurations.

- *Module 542: Data analytics toolkit.* This module focuses on using ICT and data to provide useful calculations and analytics. The module implementation has in effect been primarily in support of WP2 impact reporting, but the hope is to proceed 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 services 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 is developed to collect and maintain data from the Lighthouse cities in support of WP2 impact reporting. In the future, it is hoped to develop into providing computation capabilities to registered external users in the partnership.

Table 5.16 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 data analytics toolkit depends on the cloud data 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 5.16: Expected impacts of Stavanger ICT modules

5.4.1 Module 541: Innovative video (Subtask 5.4.1)

The implementation dates of the module

The module implementation has been re-allocated to WP6 under Amendment AMD-646578-38 and will continue in the context of follower cities beyond M36. Depending of outcome from initial tests of new Blink solution during M36, the first installations in follower cities can start in second half of 2018.

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

The module is intended to have an impact of supporting the use of video-calls by citizens. Secondary impacts may include reduced greenhouse gas emissions. Especially given the privacy issues relating to personal user data, data generated by the module implementation is likely not amenable to transfer to the cloud data platform before some processing, such as anonymization or aggregation, by Lyse, the data provider. Furthermore, all impact indicators are highly speculative for this module due to the delays in implementation, making all assertions about data which may exist in the future less reliable.

Table 5.23 below describes the indicators developed for this module. Table 5.24 describes datasets that are intended to be used to calculate impacts indicators for this module.

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.
- ***M35:*** Impact indicators cannot be quantified by M36 due to transfer of implementation of Module 541 to WP6, to be delivered after M36.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
541001	Installation of Innovative Video	Number of buildings with innovative video	Dimensionless integer	Currently unknown.	N
541002	CO_2 emissions reduction due to telecommuting	Number of eligible workers using innovative video to telecommute	Dimensionless integer	Currently unknown.	N
541003	CO_2 emissions reduction due to telecommuting	Total transport savings per year	km	Currently unknown.	N
541004	CO_2 emissions reduction due to telecommuting	Reduced CO_2 emissions per year (Estimates)	Tonnes	Currently unknown.	Y
541005	CO_2 emissions reduction due to telecommuting	Electrical energy consumed by innovative video	kWh	Currently unknown.	Y
541006	Utilization of innovative video	Mean of time used on video calls per household per year	Minutes	Currently unknown.	N
541007	Utilization of innovative video	Variance of time used on video calls per household per year	$Minutes^2$	Currently unknown.	N
541008	Utilization of innovative video	Most typical hour of the day for using innovative video	XX:00	Currently unknown.	N
541009	Utilization of innovative video	Number of video calls per year to same technology	Dimensionless integer	Currently unknown.	N
541010	Utilization of innovative video	Number of video calls per year via video bridge (Video bridge enables the innovative video solution to call other video call programs.)	Dimensionless integer	Currently unknown.	N
541011	Utilization of innovative video	Number of software installations on smart phones, tablets and PCs	Dimensionless integer	Currently unknown.	N

Table 5.17: Impact assessment indicators description for Module 541

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Blink data set	Innovative video (Blink) data set.	541001 541002 541003 541004 541005 541006 541007 541008 541009 541010 541011	Lyse	Currently unknown.	Transfer to CDP may depend on extra resources to contract third-party data processor to undertake GDPR-compliant anonymization. Transfer to CDP may also depend on appropriate aggregation and/or bilateral data agreement between UiS and Lyse. Depends additionally on compliance with regulations in Spain and The Czech Republic. This module is postponed and transferred to WP6, expecting data available during second half of 2018.	UiS researchers follow up with UiS legal team and forward initial draft of agreement by M38. M38: Lyse can identify and share with UiS researchers the data schema and data set name of the data that this module will generate.

Table 5.18: Datasets description for Module 541

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
541001	Number of buildings with innovative video	Dimensionless integer	Not yet available.	Not yet available.						
541002	Number of eligible workers using innovative video to telecommute	Dimensionless integer	Not yet available.	Not yet available.						
541003	Total transport savings per year	km	Not yet available.	Not yet available.						
541004	Reduced CO_2 emissions per year (Estimates)	Metric tonnes	Not yet available.	Not yet available.						

541005	Electrical energy consumed by innovative video	kWh	Not yet available.	Not yet available.						
541006	Mean of time used on video calls per household per year	Minutes	Not yet available.	Not yet available.						
541007	Variance of time used on video calls per household per year	$Minutes^2$	Not yet available.	Not yet available.						
541008	Most typical hour of the day for using innovative video	HH:00	Not yet available.	Not yet available.						
541009	Number of video calls per year to same technology	Dimensionless integer	Not yet available.	Not yet available.						
541010	Number of video calls per year via video bridge (Video bridge enables the innovative video solution to call other video call programs.)	Dimensionless integer	Not yet available.	Not yet available.						
541011	Number of software installations on smart phones, tablets and PCs	Dimensionless integer	Not yet available.	Not yet available.						

Table 5.19: Impact assessment for Module 541

5.4.2 Module 542: Data analytics toolkit (Subtask 5.4.2)

The implementation dates of the module

The module was designed and developed as far as possible in tandem with Module 544, on which Module 542 depends, from M09 through M32. Module 542 was implemented in M33 and is subsequently operating as a deployment on the CIPSI Computing Platform (CCP) at UiS, interfacing with the data collection framework in Module 544, also deployed on CCP.

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

The module aims to have an impact of supporting the WP2 impact reporting. The module also aims to have an impact of providing data analytics tools to researchers and registered users in the consortium. Finally, the module is intended to support the creation of analytics services that can improve the lives of local citizens.

Table 5.20 below describes the indicators developed for this module. Table 5.21 describes datasets that are intended to be used to calculate impacts indicators for this module.

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 (deployment of Module 544).
- ***M31:*** Module 542 initially deployed with access to data collected to module 544. Initial exploratory data analysis on data from Module 531 and simplified impact indicator calculation for Module 432 performed.
- ***M32-M36:*** Final, delayed deadline 20th October 2017 for submissions of the Triangulum Impact Data Intake Form. Focus at UiS on documenting Module 544 and Module 542 in reasonable detail for replication. Severe resource constraints across multiple Triangulum deliverables.
    - Analytics as a service is not developed yet, due to slower than expected data collection and development of the cloud data platform that supports the data analytics toolkit. Critically, network security challenges can be solved but require work past M36 to develop demo services that are accessible outside the UiS internal network while maintaining the security of the cloud data platform.
        - This means all external access for users is delayed, and hence all impact indicator and supporting data reflecting such external access.

- Module 544 was developed by M36 with self-monitoring capabilities, but this principle has not yet been extended to Module 542. Therefore, dynamic self-generated data for the data analytics toolkit is sparser.
- Implementation, documentation, and negotiation of other modules' impact indicators and data transfers have forced a lower priority on additional non-functional implementation details towards self-monitoring and WP2 impact indicators in Module 542.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
542001	Provision of analytics tools	Number of analytics tools	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542002	Utilization of analytics toolkit	Total number of registered users	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542003	Utilization of analytics toolkit	Number of external users	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542004	Utilization of analytics toolkit	Number of users for each demo service	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542005	Utilization of analytics toolkit	Number of apps for end users that involve the analytics toolkit	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542006	Utilization of analytics toolkit	Number of Triangulum modules that use the analytics toolkit	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542007	Utilization of analytics toolkit	Number of impact indicators calculated by data analytics toolkit for WP2 reporting.	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N
542008	Provision of analytics tools	Resources (e.g. number of vCPUs) supporting Module 542 on CCP.	Dimensionless integer	Value of impact indicator reported directly by module task group contact.	N

Table 5.20: Impact assessment indicators description for Module 542

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Value of impact indicator reported directly by module task group contact.	Value of impact indicator reported directly by module task group contact.	542001 542002 542003 542004 542005 542006 542007 542008	University of Stavanger	Trond Linjordet (trond.linjordet@uis.no)	Documented in this report after inspecting system manually. Does not exist as an organized dataset.	UiS researchers can organize a living document to update values and refine the impact indicators from current gross and static quantities.
Expected name: "Data processing framework self-monitoring"	The module is currently operating without self-monitoring of operationally relevant quantities.	None.	University of Stavanger	Trond Linjordet (trond.linjordet@uis.no)	Does not exist as an organized dataset. Some of the currently formulated impact indicators may be suitable for reporting via module self-monitoring data, but new impact indicators may be more valuable to develop along with self-monitoring.	UiS researchers can develop the module's self-monitoring capability to dynamically aggregate a dataset for operational and reporting purposes, and consequently produce programmatically calculated impact indicators.

Table 5.21: Datasets description for Module 542

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
542001	Number of analytics tools	Dimensionless integer	2	Jan 2018						
542002	Total number of registered users	Dimensionless integer	2	Jan 2018						
542003	Number of external users	Dimensionless integer	0	Jan 2018						

542004	Number of users for each demo service	Dimensionless integer	2	Jan 2018						
542005	Number of apps for end users that involve the analytics toolkit	Dimensionless integer	0	Jan 2018						
542006	Number of Triangulum modules that use the analytics toolkit	Dimensionless integer	0	Jan 2018						
542007	Number of impact indicators calculated by data analytics toolkit for WP2 reporting.	Dimensionless integer	1	Jan 2018						
542008	Resources (e.g. number of vCPUs) supporting Module 542 on CCP.	Dimensionless integer	6	Jan 2018						

Table 5.22: Impact assessment for Module 542

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

The implementation dates of the module

The module was implemented in January 2016 and has been operating in the households since.

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

The module aims to have an impact of providing services to citizens who have volunteered to participate in the module task. The planned services include personalized home display, push button, and decision support (for sustainable transport choices). The impact of the module can be documented as the number of installations of each service, but due to the personal nature of user data, the potential of inferring secondary impacts is limited.

Table 5.23 below describes the indicators developed for this module. Table 5.24 describes datasets that are intended to be used to calculate impacts indicators for this module.

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.
- ***M34:*** Reviewed feasibility of impact indicators for this module together with other Lyse modules. The overall bilateral agreement about data between UiS and Lyse, as well as concerns for GDPR affect this module as well, delaying the establishment of ongoing transfer of data until such time as these questions are resolved.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
543001	Utilization of module technology	Number of buildings with software installed	Dimensionless integer	Currently unknown.	N
543002	Utilization of module technology	Number of buildings with hardware installed	Dimensionless integer	Currently unknown.	N
543003	Utilization of module technology	Mean of number of times used per day	Dimensionless decimal	Currently unknown.	N
543004	Utilization of module technology	Variance of number of times used per day	Dimensionless decimal	Currently unknown.	N

Table 5.23: Impact assessment indicators description for Module 543

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
Home decision support	Lyse sustainable citizen service data set	543001 543002 543003 543004	Lyse	Sindre Tøsse (sindre.tosse@lyse.no)	Transfer to CDP may depend on extra resources to contract third-party data processor to undertake GDPR-compliant anonymization. Transfer to CDP may subject to appropriate aggregation and bilateral data agreement between UiS and Lyse.	UiS researchers follow up with UiS legal team and forward initial draft of agreement by M38. M37: Lyse can identify and inform UiS about the appropriate dataset for calculating this module's impact indicators.

Table 5.24: Datasets description for Module 543

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
543001	Number of buildings with software installed	Dimensionless integer		January 2015		February 2020				
543002	Number of buildings with hardware installed	Dimensionless integer		January 2015		February 2020				
543003	Mean of number of times used per day	Dimensionless decimal		January 2015		February 2020				
543004	Variance of number of times used per day	Dimensionless decimal		January 2015		February 2020				

Table 5.25: Impact assessment for Module 543

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

The implementation dates of the module

The module was designed and developed from M09. Implementation began in earnest in M25, and an operational proof-of-concept was deployed from M33 and has been operating since.

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

The module impacts the domain of ICT by providing resources to project partners and registered external users. The Cloud data platform provides on-demand access to a shared pool of storage, computational, and networking resources that constitute the CIPSI Computing Platform (CCP) at UiS. The module impact indicators are defined according to nominal capacities and actual utilization of these resources.

Note that impact indicators relating to actual utilization are not currently articulated or implemented computationally. For example, it may be useful in the future to establish more dynamic impact indicators such as the following:

The cloud data platform (including 3 instances (VMs) with 6 vCPUs allocated to the Module 542 data analytics toolkit) is currently allocated 19 VMs with 34 vCPUs.

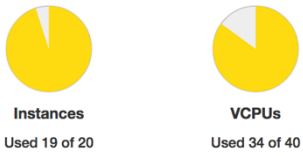

Table 5.26 below describes the indicators developed for this module. Table 5.27 describes datasets that are intended to be used to calculate impacts indicators for this module.

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.

- ***M30:*** Module 544 initially deployed in its current form. Ongoing data collection commenced, from e.g. Module 531.
- ***M33:*** Final deadline to register new data sources to connect to the cloud data platform before M36 elapsed.
- ***M34-M36:*** The priority is to adequately document Module 544 and Module 542 for replication, and to demonstrate the calculation of impact indicators.

Impact indicator identifier	Impact	Impact indicator	Quant. unit	Datasets to be used in impact calculation	Aligned with SCIS?
544001	Data storage capacity	Nominal hardware storage capacity, HDD	Terabytes	UiS Triangulum cloud data platform interface	N
544002	Data storage capacity	Nominal hardware storage capacity, SSD	Terabytes	UiS Triangulum cloud data platform interface	N
544003	Data storage utilization	Number of Triangulum partners providing data via DIF specifications	Dimensionless integer	UiS Triangulum cloud data platform interface	N
544004	Computational capacity /resources	Number of physical cores	Dimensionless integer	UiS Triangulum cloud data platform interface	N
544005	Computational capacity /resources	Estimated number of virtual machines (VMs) possible	Dimensionless integer	UiS Triangulum cloud data platform interface	N
544006	Network capacity	Full bisection bandwidth	Gigabits per second	UiS Triangulum cloud data platform interface	N

Table 5.26: Impact assessment indicators description for Module 544

Dataset name	Dataset description	Required for impact calc. for indicators:	Dataset owner	Dataset contact	Comments	WP2 next steps
UiS Triangulum cloud data platform interface	Value of impact indicator reported directly by module task group contact.	544003	University of Stavanger	Trond Linjordet (trond.linjordet@uis.no)	It may be possible but not necessarily useful to programmatically extract the number of unique indices stored at the CDP, but this number may not be guaranteed to reflect impact indicator 544003 as conceptualized without additional intervention or quality control.	UiS researchers can develop 544003 and additional impact indicators based on current self-monitoring data being collected. In addition, further self-monitoring may be developed if appropriate.
The module is currently operating without self-monitoring of operationally relevant quantities.	None.	University of Stavanger	Trond Linjordet (trond.linjordet@uis.no)	Speculative, does not exist as an organized dataset. Some of the currently formulated impact indicators may be suitable for reporting via module self-monitoring data, but new impact indicators may be more valuable to develop along with self-monitoring.	UiS researchers can develop the module's self-monitoring capability to dynamically aggregate a dataset for operational and reporting purposes, and consequently produce programmatically calculated impact indicators.	
Data centre requirements specification	Value of impact indicator reported directly by module task group contact.	544001-002 544004-006		Aryan TaheriMonfared (aryan.taherimonfared@uis.no)		

Table 5.27: Datasets description for Module 544

Impact indicator identifier	Impact indicator	Quant. Unit.	Start value	Start value period	End value	End value period	Absolute change	Extrapolated rate of absolute change (p.a.)	Relative change	Extrapolated rate of relative change (p.a.)
544001	Nominal hardware storage capacity, HDD	Terabytes	60.0	February 2017	60.0	January 2018	0.0	0.0	0.0	0.0
544002	Nominal hardware storage capacity, SSD	Terabytes	1.6	February 2017	1.6	January 2018	0.0	0.0	0.0	0.0
544003	Number of Triangulum partners providing data via DIF specifications	Dimensionless integer	1	February 2017	5	January 2018	4	4.0	4.0	4.0
544004	Number of physical cores	Dimensionless integer	20	February 2017	20	January 2018	0.0	0.0	0.0	0.0
544005	Estimated number of virtual machines (VMs) possible	Dimensionless integer	160	February 2017	160	January 2018	0.0	0.0	0.0	0.0
544006	Full bisection bandwidth	Gigabits per second	40.0	February 2017	40.0	January 2018	0.0	0.0	0.0	0.0

Table 5.28: Impact assessment for Module 544

6 Synthesis

This section offers a preliminary synthesis across the three cities drawing on the impact reports. Although the city reports are incomplete and monitoring has 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.

6.1 Preliminary assessment of overall impacts

Progress completing indicator values

225 impact indicators have been finalised across the 29 modules being implemented in the Lighthouse Cities. A total of 16 modules have been fully implemented out of 29 (55%). 182 baselines have been set out of the 225 impact indicators required in total (78%). 125 impact indicators have had impact values calculated (57%). In terms of modules, 59% are now generating impacts and 72% have a complete set of baseline data. Table 6.1 shows the overall progress in terms of implementing modules, setting baselines and securing impact values for the Lighthouse Cities and Triangulum project as a whole.

	#modules fully implemented	#baseline indicator values available	#impact indicator values available
MAN	4/8	90/95	59/95
EIN	6/13	70/70	60/70
STAV	6/8	22/60	6/60
Total	16/29	182/225	125/225

Table 6.1: Preliminary overview of baselines and impacts

Early impacts

M36 represents the end of the implementation phase and start of the official monitoring phase so the reporting of impacts at this stage is intended to support early learning within the Lighthouse Cities.

In Manchester: the main impacts achieved include:

- Optimised building space for smart energy interventions of 23,000 m^2
- Purchase of 9 EVs, increasing university share of fleets from 5% to 23%. Avoided greenhouse gas emissions of 1,400tCo2e, 4,600kg NOx, and 24,000kg CO through EVs. 4 cargo bikes made 1989 journeys and saved 1246 tCO_2e.
- Manchester-I data platform hosts 12 real time data feeds and has 32 users.

In Eindhoven: the main impacts include:

- In Strijp-S Sanergy has created savings of 2387 pa on energy bills for customers, increased share of renewables to 88% and saved 4704 KgC pa. 28 SMEs have been created and 50m additional investment has been secured from partners.
- In Eckart Vaartbroek 217 buildings have been renovated, reducing GHG emissions by 13% and monthly energy bills by 48%.
- In terms of public engagement the number of API calls of the top five data sets in the city data platform has increased from 508 per month in 2014 to over 7000 in 2017. 120 citizens were involved in project-planning for public sensor network and smart lighting, including 37 sensors and 31 smart lights, and 100 homes have been connected to super-fast fibre.

In Stavanger: the main impacts include:

- 5 battery buses have been deployed by the bus operator in the city.
- 56 smart gateways installed have been installed in buildings.
- Specific privacy issues and third party issues have hampered the collection of data. These will be a focus for the WP2 work between M36 and M48.

Across all three cities:

- The main Energy sector impacts are reduced local energy use, reduced energy costs, and decreased greenhouse gas emissions.
- The main Mobility sector impacts are improvements in efficiency, and reduced greenhouse gas emissions (CO2, NOx, CO).
- The main ICT sector impacts are increases in the availability of open data, data downloads, and improvements to fibre optic networks.

6.2 Overall assessment of missing data and plan for M48 and M60 reports

A total of 21 modules have a complete baseline set in this report, out of a total of 29 modules (72%), with 8 module baselines outstanding (one for Manchester, one for Eindhoven and six for Stavanger). 17 out of 29 modules have started to generate impacts (59%). All of the outstanding baselines are due to missing data, as a result of the modules not yet being implemented fully or privacy concerns. Delays have particularly affected energy modules in Manchester and Stavanger, while privacy issues have particularly affected energy modules in Stavanger. Progress has been held up in Stavanger by amendments, delays and the focus of WP2 partners UiS on populating the Cloud Data Hub.

For the M48 refresh and M60 report, these baselines will be updated once modules have been implemented, through liaison with the module leads and relevant partners.

7 Next steps

This section outlines the next steps for the final 24 months of the project.

a. Priorities

Four priorities have been identified that relate to each of the WP2 tasks.

1. **Further populating the Cloud Data Hub (Task 2.1 Developing Monitoring and Assessment Frameworks)**

Relevant and appropriate datasets will be uploaded to the cloud data hub between M36 and M48. Energy datasets concerning residential retrofit modules in Stavanger and Eindhoven are of particular value as they represent user behaviour and are relatively large in size and dynamic in offering analysis over time. Relevant partners are involved in privacy impact assessment processes that will determine whether data can be secured before M48 as detailed in the dataset tables under WP2 next steps.

2. **Completion of baseline and impacts (Task 2.2 Monitoring)**

The datasets that have been identified as necessary to monitor impacts need to be secured by the M48 update to this report. The section 'Factors limiting progress towards defining the approach to calculating impacts, identifying associated datasets, and establishing impact' and dataset tables for each module give specific next steps for WP2 in terms of securing datasets.

3. **District and city level monitoring (Task 2.2 Monitoring)**

District level monitoring will be undertaken by amalgamating impacts for modules within each district. This will be done in the final WP2 deliverable due in M60.

City level monitoring involves a separate process of developing an impact framework with city partners, informed by the CityKeys framework. This work has already started with a value-mapping exercise between M40 and M44, which captured key city-level impacts from partners in the Lighthouse Cities. These are being analysed to form the basis for a robust surveying process to capture city level impacts. This will be undertaken in M56.

4. **Reporting and Dissemination (Task 2.3 Reporting and Task 2.4 Learning)**

It is important that the impacts of the Triangulum project are fed back to partners to support their activities and the wider dissemination strategies of the Lighthouse Cities and project as a whole. This will be done in three ways:

- Through the updated version of this report planned for M48 and the final deliverable (Final multi-level impact assessment and monitoring summary report) due in M60.
- Through liaison with city coordinators (WP3, WP4, WP5) to identify opportunities to support city level dissemination and learning through supplying impact evidence. This will be initiated by bringing a summary city report to Lighthouse City board meetings to highlight impacts and data gaps (by M42).
- Through liaison with replication coordinators (WP6). WP6 is currently identifying post M36 activities and now that WP2 is generating impact data it is a priority to ensure that it is used

to support WP6 replication activities. A key priority involves scoping out the possibility of supplying data to the Babel spin-out replication tool. This will be done through periodic Skype meetings and dedicated sessions at SC meetings.

- Through liaison with WP7 responsible for overall dissemination to identify opportunities to support city and project level dissemination and learning through supplying impact evidence for the project newsletter, Twitter feed, and press releases. This will be done through relevant dissemination sessions at SC meetings.

b. Key Activities

Table 7.1 lists the key activities and timeline for addressing the priorities identified above.

Priority	Lead	Months	Key activities
Further populating the Cloud Data Hub	UiS	36-48	Continue working with partners to secure key datasets as outlined in the sections 'Factors limiting progress towards defining the approach to calculating impacts, identifying associated datasets, and establishing impact'.
Completion of baseline and impacts	UNIMAN, TuE and UiS	36-48	Request updates from partners as outlined in the WP2 next steps column in the dataset description tables for the production of the updated D2.5 Impact Report in M48.
District and city level monitoring	UNIMAN, TuE, FhG	48-60	Aggregate module impacts to produce district impacts (M58). Prepare and administer survey for all Lighthouse City partners for M56 to capture city level impacts.
Reporting and Dissemination	UNIMAN, TuE UiS, WP6 and WP7	36-60	Summarise city reports for city board meetings to highlight impacts and data gaps (M42). Survey Lighthouse City leads (M54) to identify best way to present district and city impacts in M60 deliverable. Meet with WP6 and WP7 teams at SC meeting in April to identify key data that could be used to support their activities.

Table 7.1: Key activities and timeline

Table 7.2 below maps the risks for each priority, including their probability and impact, and proposed response and risk owner.

Priority	Risk	Probability	Impact	Response	Owner
Further populating Cloud Data Hub	Privacy prevents sharing of data	Med	Low	Secure aggregated data to enable calculation of impacts.	UiS
Completion of baseline and impacts	Data is unavailable / inaccessible	Low	High	Maintain communication with key data owners and leverage support of city and project coordinators.	UNIMAN, TuE, UiS and FhG

District and city level monitoring	Aggregation problems, poor partner response	Low	Med	Use SC and GA meetings and project coordinator to ensure M56 survey is completed.	UNIMAN and FhG
Reporting and Dissemination	Lack of WP coordination	Med	Med	Use SC and GA meetings and project coordinator to ensure coordination.	UNIMAN and FhG

Table 7.2: Risk register for WP2 priorities and activities

8 Conclusion

The monitoring and assessment of smart city solutions has been identified by the European Commission as a priority to support the development of a functioning smart city market place in Europe. Triangulum has now entered the official monitoring period from M36 to M60 and offers a valuable and possibly unique opportunity to generate evidence and processes to address this need.

Although impacts are only starting to emerge across the project, there are already a number of strong achievements that indicate a substantial impact will be produced up to M60. 59% of modules are now generating impacts and 72% have a complete set of baseline data. Given progress so far at the project level we would expect approximately 75% of the modules to produce 24 months of monitoring data that will be available to report in M60. Approximately 15% of modules can reasonably be expected to produce between 12 and 24 months of monitoring data. Severe doubts exist over whether approximately 10% of the modules will be fully implemented in time to produce at least 12 months of data to enable any meaningful level of monitoring.

While the process of defining and specifying modules, impact indicators and datasets has been resource intensive and highly iterative, this has generated close relationships between WP2 researchers and specific partners and third party holders of relevant data. Dataset tables for each module have specific contact details for all datasets, and WP2 researchers will continue to attend city board meetings and meet bilaterally with key data holders to secure the necessary data to complete the monitoring tasks. Additionally the WP2 coordinator will continue to liaise with key partners to solve specific challenges surrounding privacy issues. These ongoing relationships provide a productive basis upon which to continue to secure data as required over the remaining 24 months of the project. Finally, the Triangulum coordinators are fully committed to the full completion and delivery of the WP2 tasks and will support requests for data as required.

The lack of progress around finalising the baseline values for specific modules has potentially serious implications for the validity of the impact evidence that is produced. Our recommendation is to bring this to the next SC meeting in Eindhoven (planned for either April or May 2018) as an agenda item to gain specific agreements from city coordinators concerning the actions they will take to help resolve these issues.