Evaluation plan

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1 Introduction

1.1 Background

GrowSmarter is a Lighthouse Project financed within the framework of EU's Horizon 2020. The purpose of the project is to demonstrate measures of decreasing energy use and CO_2 emissions in the urban environment. Another purpose is to increase the quality of life of citizens, and to create wealth by new job opportunities and new businesses. For this purpose, three cities, Stockholm, Cologne and Barcelona, will implement several such measures, related to Low Energy Districts, Integrated Infrastructure and Sustainable Urban Mobility. Some of the measures demonstrated and evaluated in these cities are going to be implemented also in other Follower Cities participating in the project, and hopefully also in other cities across Europe.

The following report is the first delivery of WP5 of the project, and outlines how the evaluation of the measures should be done to allow correct conclusions to be drawn concerning the feasibility of each measure and to determine if the expected goals in terms of energy savings, decrease in CO2 emissions etc. are met and what are the social costs incurred by implementing the measures. The evaluation plan is also of key importance for the replication of the measures in follower cities. The evaluation is primarily technical, but social factors are of course very important for the implementation of the measures, and guidelines to the evaluation of these factors are therefore also included. An extensive plan for the evaluation of the economic effects of the measures is being presented in the economic evaluation plan delivered in parallel by WP6.

A problem with a project like GrowSmarter, which includes refurbishment of a large number of multifamily buildings, is time. For natural reasons, the project cannot extend over a too long time period, but during this period, there must be time for correct handling of procurement, acceptance of the plans by the tenants, the actual reconstruction of the houses and a sufficiently long evaluation period (in this case 24 months) to allow conclusions to be drawn. To ensure that the evaluation is done in a correct way, it would be necessary to know each of the measures much more in detail than as described in the Grant Agreement (DoW). However, at the early stage of the project, some of this information is not yet well defined. For the evaluation of the measures, it is important to define a baseline, i.e. a state to which the performance after implementation is compared. This baseline needs to be determined by measurements. Also, the evaluation method must be well defined and agreed on at an early stage e.g. to ensure that the necessary sensors are installed and that the costs related to the evaluation are included in the procurements. Because of the time constraints, it has been necessary to speed up the development of the evaluation plan. According to the original plan it was scheduled to be delivered in M8, but the draft was delivered in the first days of M5, and the final version (now updated) was presented little more than three months from the kick-off meeting of GrowSmarter. Additional adjustments were however required and an adjusted version was finally accepted by the steering committee in M13. Even so, amendments to the Grant Agreement has required further adjustments.

The focus has been on describing how to determine the baseline and the methodologies to ensure that a proper evaluation of each measure is possible. Less focus is put e.g. on how the data will be made available to the partners within the project. In some cases it will be necessary to complement the instructions given here when the exact design of the measures is known.

Evaluation plans have been produced also within other EU-projects on Eco/Smart/Sustainable Cities. Particularly, the Concerto projects, financed within the 6th and 7th framework programs, have delivered extensive reports which can be seen as handbooks on evaluation of possible measures. The present evaluation plan has been set up based on some of the experiences from those reports. However, it should be noted that many measures are so specific that the evaluation methods have to be designed particularly for them.

Experiences from other projects in which the participants have participated, e.g. from Hållbara Järva, Royal Seaport and Hammarby Sjöstad will also be used in the evaluation and validation of the project.

It should be pointed out that the evaluation plan is developed within WP5. However, it will be implemented as a part of the actions of WP2, 3 and 4 where the evaluation of the measures will be performed. WP5 will validate the evaluations done within the other WPs. This is explained more in detail in Chapter 2.

1.2 Project goals

The financing of GrowSmarter can be seen as one mean to fulfill the climate change and energy targets of the EU, which is, by 2020, to decrease the greenhouse gas emissions by 20% (compared to 1990), to have 20% of the energy supply from renewables, and to increase the energy efficiency by 20%[1].

But the EU also has as a goal to improve the quality of life of the citizens. Measurable targets to this end is that 75% of the population in the age 20 to 64 should be employed, and that the number of people in risk of poverty and social exclusion should be decreased by 20 million to the year 2020[2].

The goals of GrowSmarter[3], as expressed in the Grant Agreement, are to a large extent reflecting the goals of the EU stated above. First, the quality of life of the European citizens should be improved by

1. "…better options for urban transport and better deliveries of goods with improved service towards citizens…"
2. "Cost efficient refurbishment … of existing residential and commercial buildings in cooperation with the tenants "
3. "Improvements in the street environment with smarter lighting and better communication facilities …."
4. "… better economy by both lower energy costs and increased economic growth and job-creation…"
5. "The project is expected, on the demonstration level … to create as much as 1500 jobs."

Second, the goal is to reduce the environmental impact and need of energy:

6. "The aim for reduction of energy is 60 % on the demonstration level compared to levels before the project was implemented."
7. "The reductions of Greenhouse-gases are slightly higher [than 60%] through the extensive use of waste heat and renewable energy sources."
8. "The project aims to reduce the emissions from transport by 60% in the chosen districts by smarter sustainable transport solutions."

Additionally, in the project summary[4], it is stated that

9. "GrowSmarter demonstrates the cost efficient renewal of 100.000 square meters of Nearly Zero or low energy districts reducing energy demand by 70-90%."

In the description of the Expected Impact[5] it is also stated that

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[1] http://ec.europa.eu/europe2020/targets/eu-targets/index_en.htm
[2] Ibid.
[3] Grant Agreement, GrowSmarter SEP-210138131, section 2.1.1
[4] Ibid., Annex 1, section 1.1
[5] Grant Agreement, GrowSmarter SEP-210138131, Annex 1, section 2.2.1

10. [the GrowSmarter project will] "Reduce the … local emissions from transport esp NOx by 60% of the chosen districts."

The third and final goal is to contribute to a sustainable economic development:

11. "… the project aims at saving energy with quantitative reductions in capital costs as well as reduced costs for energy and maintenance."
12. "The project aims at saving 60 % of the energy needs for the demonstrated smart solutions thus significantly reducing the cost of energy."
13. "The project aims to contribute to European economic growth by the integrated Smart Solutions demonstrated."

Apart from these clearly stated goals, other figures are mentioned e.g. as savings potential of different measures in the Description of Work[6]. However, these figures are considered here as indications only and are not seen as definite targets for the actions in the project.

As can be noted, a few of the goals are stated in terms of a qualitative change to the "better" (c.f. goal 1, 2, 3, 4, 11, 13). The remaining 7 are partly overlapping. In conclusion, the quantitative goals which can be evaluated are the following:

- Creation of 1500 jobs.
- Reduction of energy use by 60%
- Reduction of CO_2 emissions by more than 60%
- Reduction of emissions from local traffic, especially NOx by 60%
- Reduction of energy use in 100.000 m^2 of buildings by 70 – 90%.

In the second and third months of the project, meetings were arranged, one in each city, by WP5 with the partners, the WP leaders and the Assistant Coordinator. At these meetings, each Site discussed the goals of the project and specified the definition of them. Each partner was asked to specify which goals their specific measure contributed to fulfill. The result of this exercise is shown in Table 1. The list includes several goals which are not directly mentioned above, but which may be of high interest to evaluate. Many of these are social and relates to the quality of life of the citizens in the areas. These should be evaluated through questionnaires to the users of, or persons affected by, the implemented measures.

[6] Ibid., Annex 1.

Table 1: Summary of the goals identified by partners at the meetings in Stockholm, Cologne and Barcelona

At the end of the three meetings the following goals have been agreed upon:

1. Better quality of life

1.1. Better options and <u>access</u> for urban transport *(time saving, reliable, flexible, convenient, space saving, model-split, easy to plan, foreseeable, economically feasible from the maintenance and investment point of view)*
1.2. Better deliveries of goods *(time saving, reliable, flexible, convenient, space saving, less noise)*
1.3. Better waste handling *(time saving, reliable, flexible, convenient, space saving, less noise, quality of fractions, accessible, hygienic)*
1.4. Cost efficient refurbishment (100.000m2) *(economic, improve indoor quality, energy production, energy consumption, mobility, how to have an environmental behavior, comfort, change in the value of the building, value of the neighborhood)*
1.5. Improvement in street environment *(safety, less noise, reduce pollution, enjoyable, space saving, accessible, recreational, shift of users, more services and shops)*
1.6. Lower energy costs *(economic, better consciousness/ awareness, transport, refurbishment)*
1.7. Increased job creation (1500) *(economy, social benefit, #working on implementation, #new jobs in the future, #new businesses, new skills needed, long and short term, during and after the project)*
1.8. Citizens participation *(inclusion, resource efficiency, control of the planning, local expertise, ownership, innovation, speed up processes, cost efficient, measure to reach targets, transparency, information sharing, interaction level, participation and engagement)*

2. Environmental

2.1. Reducing the need of energy (60%) - in buildings by 70-90% *(transport, infrastructure, refurbishment cost efficient[PBT- 10 years?], LCC)*
2.2. Reducing the greenhouse gas emissions from energy use and increase use of renewable energy (60%)
2.3. Reducing the emissions of transports (60%)

3. Economical

3.1. Saving energy with reduction in capital and operational costs *(reducing cost for maintenance, investment, depreciation period, interest rate, subsidies, calculate the external benefits for health, third-party business creation, reduction of energy dependency)*
3.2. Increased economic growth *(impact on health)*

Goals\ Measures	1.1	2.1	3.1	4.1	4.2	5.1	5.2	5.3	6.1	6.2	6.3	7.1	7.2	7.3	8.1	8.2	8.3	8.4	9.1	9.2	10.1	10.3	10.4	10.5	11.1	11.2	11.3	11.4	11.5	11.6	12.1	12.2	12.3	12.4	12.5	12.6
Quality of Life																																				
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1.2		S														K	K	B	S B	B	B					B	B						K	K		
1.3.		S										S	S	S				B																		
1.4.	S K		B	K			K			B		S	S	S		K	K	B																		
1.5.	S B		B			S	B		S			S	S	S	K B	K	K	B		B	B	S	S			B	B	S		B	S	S	K	K	B	B
1.6.	S		S B K	S	B	S	B		S	B	B				K	K	K	B		B						B	B			B			K	K		
1.7.	B	S	S B		B				S	B				S	K B	K	K	B	S	B						B	B						K	K		
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Economical																																				
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S=Stockholm, K=Cologne, B=Barcelona

(Chart based on discussions and partners' evaluation of the goals of their measure. Subject to interpretation).

As noted, the goals of GrowSmarter are to be reached by implementing 12 Smart Solutions, each represented in the Description of Work by one or more defined and described Measures. Some of the Measures are implemented in all three Lighthouse cities, while others only in one or two. The main part of the present evaluation plan consists of instructions on how to evaluate these individual measures (see the following chapter).

2 About the evaluation plan

2.1 Purpose

This evaluation plan is intended to be a guideline for the evaluations being done as part of the work within WP 2, 3 and 4 by the partners in those work packages. The evaluations of the measures are done with the purpose of determining if the expected goals in terms of energy savings, decrease in CO2 emissions etc. are met and what are the social costs incurred by implementing the measures. The evaluation will thereby be a guideline for further implementation of the measures in follower cities and in cities and regions outside of the project.

It is to be understood that the results may be dependent on local conditions, e.g. climate, and that the results may not be directly applicable or transferable to another city or region. It is the ambition of WP5 to suggest methods on how the transfer of the results should be done in the cases where this is not obvious. A detailed analysis in this respect has not been possible within the timeframe allowed to develop this report. However, we believe that the information gathered by following the guidelines here will be sufficient for the transfer of the results later.

2.2 Scope

The report is focusing on defining the methods of evaluation for the measures described in the text concerning WP 2, 3 and 4 in the Grant Agreement's Description of Work. The main focus in the report is on the technical evaluation of the measures. However, questionnaires have been developed to be answered by the users and tenants. Many of the questions asked are part of the technical evaluation, but these questionnaires should include also questions concerning social issues, such as user friendliness, acceptance, perception, how the measures influence the social environment etc.

Based on the findings concerning the individual measures, upscaling will be done to district and city level to determine the effect of large scale implementation of the tested measures.

2.3 Basic Questions to be answered

Referring to the description of the goals in the previous chapter, the basic questions to be answered by the evaluations are the following:

- How does the measure influence the use of bought energy for achieving a certain task?
- How does the measure influence the release of CO_2 and other pollutants?
- Is an investment in the measure economically feasible? Under what conditions? (Will be treated by WP6)
- Is the measure acceptable for the users and the citizens? Does it have positive effects or is it causing any disturbances?

It should be noted that some measures are "enabling technologies", which may form the infrastructure for new business ideas and new ways of reducing energy use etc. In these cases it is very difficult to answer the questions above in a reasonably correct way.

2.4 Baseline

To determine the effect of the measures, a baseline must first be defined. In this evaluation plan, the general idea concerning the baseline is that this is the state before the measure was implemented. As an example, for the refurbishment of existing buildings, the baseline would be the amount of bought energy before the refurbishment. It has been assumed that measurements are available, or can be made available through new measurements, to establish the baseline. The measured values may have to be corrected e.g. for changes in weather between the years, for changes in the indoor temperature, for differences in use and other known differences between the state at the time of establishing the baseline and the evaluation of the implemented measure.

In some cases, the baseline may be difficult to establish. Comments on this are given for each individual measure. In questionable cases, WP5 team should be consulted for the definition.

2.5 Reporting Requirements

For the evaluation it is important that the data are comparable between the cities. This puts some constraints to how the data is collected, the format of the data etc. This is one of the reasons for having a common, general evaluation plan. Any deviations from the specifications given below for each measure must therefore be avoided. In doubtful cases WP5 team must be consulted.

In the Grant Agreement it is stated that the evaluation period should be 24 months. This applies to all measures and measurements described in the Evaluation Plan unless another time period is specifically stated.

For each set of data collected there should be a clear description of how the parameters are determined and a detailed definition of what the data represents.

Raw (primary) data should be made available for the partners in order to perform the evaluations.

2.6 Collection of data

It is expected that all data which is possible to collect automatically over a distance should be collected in this way. This data should be collected into a common data base and made accessible by the participants in the consortium. High time resolution of the data is in general preferred. (The meaning of this differs between the measures evaluated. As an example, for use of smart plugs for incentivizing the tenants to reduce energy use, changes in energy use need to be displayed instantaneously. For studying the willingness to shift energy use in time, one hour intervals may be sufficient. For determining the efficiency of collection of heat from ventilation air, monthly averages may be enough. See the evaluation templates for each measure below). At the time of preparation of the evaluation plan, the technical solution for collecting the data into a common database and giving access to the data is not defined. We believe however, that this is not a critical issue for the definition of the plan.

Sensitive information concerning individual users must be collected according to the regulations of each country. Typically, this means that the user must give a written consent to collecting data related to the private behavior. The data should be used in the evaluation in a format that does not allow identifying the exact source of the information.

For each city an ethics advisor has been given the responsibility to assure that the data collection is done in a way not violating the legislation in this respect. The following persons are taking this role:

- For Stockholm: Eva Debels (eva.debels@stockholm.se). (National legislation: Personuppgiftslagen, PUL)
- For Cologne: Herbert Powalka (herbert.powalka@stadt-koeln.de). (National legislation: Article 2, paragraph 1 of the German Constitution).
- For Barcelona: Lluis Sanz Marco (lsanz@bcn.cat) (National legislation: LOPD (Ley Organica de Protección de Datos. See Spanish Data Protection Agency official site: http://www.agpd.es/)

2.7 Roles and Responsibilities

The responsibilities for evaluation and validation are governed by the text in the Grant Agreement. The following are citations from this document, Annex 1, Part A:

- "The WP5 leader will provide instructions prior implementation on data gathering format and monitoring methods to be used at each site to achieve comparable data from the measures."
- "…all demonstration partners will set up special quality systems to make sure the implementation is made with all care and precision possible". [from WP2 description]
- "Gathered data will be used to evaluate innovation potential, theoretical vs practical energy savings, user acceptance and real investment costs, etc. The results will be [the] main input to WP5 where the data will be analyzed on a global project level and further validate…"
- According to the Grant Agreement, "The results from the monitoring and evaluation will be compiled into a deliverable from each measure (D2.4, D2.5). The WP 2 leader will coordinate this task in cooperation with the local Site Managers in each site that have implemented measures within the same smart solution." (Similar statements are found for WP3 and 4)

and further:

- "At the end of phase 1-3, leaders from WP2, WP3 and WP4 will develop conclusions with focus on up-scaling and replicability and to disseminate results external to the project.").

In the updated inception report, however, the procedure is changed. Instead of the evaluation reports on each measure being sent to the WP2, 3, 4 leaders, who compile the information into a comprehensive report and send it to the WP5 team for validation, the evaluation reports from each measure are now expected to be sent to the WP5 team for validation. No comprehensive report is now expected from any of the WPs.

- WP5 will "…Guide data collection and analysis to assess the implemented measure's impact"
- "During implementation stage, the WP [5]'s team will provide necessary guidance, quality control, eventual trouble shooting and other support to the local evaluation teams (D5.2)."

In short, WP5 is responsible for setting up the evaluation plan, supporting the evaluation teams in the other WPs and validating the results of the evaluations. However, the evaluations are to be done as part of WP2, 3 and 4 by the partners in these WPs. The partners in WP2, 3 and 4 are thus responsible for evaluating their measures according to the evaluation plan and for delivering their results to WP5. This must be done both for the respective measure and for the baseline/counterfactual/control group. The leader of WP 5 has the responsibility to receive the information and analyse it and aggregate it. WP 5 will also support the partners in their evaluation with questions/answers and other types of problem solving. Of course the site managers and other contact persons as a local team will also assist, but the main responsible is the WP 5 leader. The process is described graphically
in

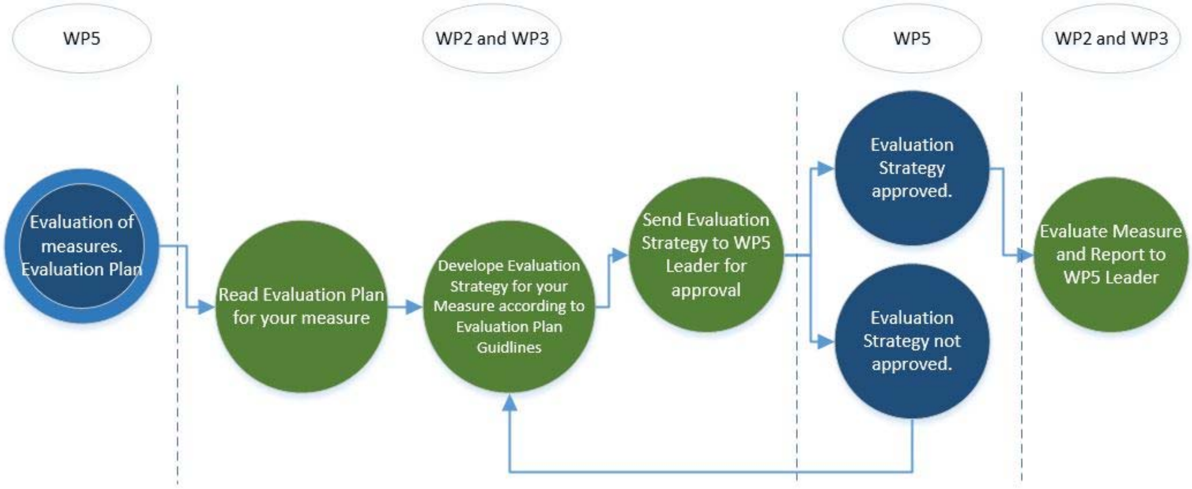


Figure 1. Finally, WP5 is responsible for the integrated evaluation report, D5.3.

According to the original Grant Agreement, WP5 was responsible for recommendations to policy makers and practitioners , report D5.4. However, according to the updated Inception report 2017, this responsibility is moved to WP1.

As for the questionnaires to the users, these will be designed by WP5, in cooperation with the other WPs, but the translation and distribution/collection of the questionnaires will be done by WP2, 3 and 4 by the partners in these WPs.

According to Amendment 2, it has been decided that all economic evaluation will be done within WP6. This is not according to the initial plans presented in the GA. The corresponding manmonths of IESE in WP5 will be moved to WP6. The leaders of WP5 and WP6 have the responsibility to ensure that the evaluations are done based on the same units of study, using the same baseline and performance data.

2.8 Time Schedule

The individual measures will be implemented at different times during the project. For WP 5 to be able to support the evaluation, it is important that a time plan is determined and communicated for each measure in each city. It is of outmost importance for the evaluation that the baseline is established early in the project before any measures are implemented. In some cases, the measures will have combination effects. To separate the effects of each measure it would be preferable to do the implementations in an order that allows measuring the effect of each measure. This is mentioned in the text below for some measures. When in doubt, WP5 team should be consulted.

The evaluation of the measures should be based on an assessment period of 24 months according to the Grant Agreement. After this period, there must be sufficient time for the evaluation and validation of the results. This should be kept in mind when discussing the time plan with WP5 team.

2.9 KPI - general

For each measure, at least one Key Performance Indicator (KPI) is to be determined. In general, a KPI should be a quantifiable measure of performance which can be monitored over time and thereby be used to determine the effect of changes that have been implemented. The KPIs should be connected to the goals which have been set up.

A listing of KPIs is presented in one of the reports of the Concerto Premium project[7]. Even though some of these may not be mentioned in the plan below, this does not exclude the calculation of these during the evaluation of the measures: The descriptions in this report of how the evaluations should be done will allow the determination of several other relevant KPIs than the ones suggested in the text.

Several international, EU and national standards have been defined for the evaluation of the energy performance of buildings. Relevant examples are EN 15603 and the International Performance Measurement and Verification Protocol, IPMVP. Even though none of these standards are explicitly referred to in the following text, the methodology suggested here is mainly in line with these.

The evaluation and the calculation of the KPIs (and generally analysis of the data) should be done continuously during the measurement period so that the quality of the data and the measurement system is constantly assured. Such continuous evaluation also allows confirmation that the measures are having the expected effect.

[7] Report from Concerto Premium, Evaluation of (Smart) Solutions – Guidebook for Assessment Part I – Methodology

3 Evaluation of individual measures

3.1 Introduction

In this chapter, evaluation templates are presented for the technical evaluation of each of the measures.

In the evaluation plan the measures are divided into three main categories depending on which work package the measure belongs to, and the type of measure. This approach leads to three different headings in the evaluation plan:

- Low Energy Districts
- Integrated Infrastructure
- Sustainable Urban Mobility

Each of the categories contain measures from different "Smart Solutions" described in the grant agreement. In the evaluation plan, a measure related to e.g. "Smart Solution 1" have a measure number that starts with the number 1 and so on.

The first category, "Low Energy District" is divided into two sub categories:

- Building Evaluation
- Local Evaluation

In the category "Building Evaluation" the total building energy performance is evaluated, before and after the measures have been implemented. The measure number for this category is 1.0 and is described under heading 3.2.1.1.

The category "Local Evaluation", describes the evaluation process for individual measures for each participating city. This category includes evaluation guidelines for several different "Smart Solutions". Heading 3.2.2 provides information on the measures that are associated to the city of Stockholm. Heading 3.2.3 describes the evaluation for the city of Barcelona and heading 3.2.4 describes the procedures for the city of Cologne.

The category "Integrated Infrastructure" describes the evaluation process in the same fashion. Measures are numbered according to the "Smart Solutions" in the GA and divided city wise.

The category "Sustainable Urban Mobility" describes the evaluation process in the same fashion. Measures are numbered according to the "Smart Solutions" in the GA and divided city wise.

The social evaluation is only treated in detail for some of the measures. Instead, a questionnaire is prepared and attached as Appendix 1 to this report. The intention is that questions concerning social acceptance and social effects of the measures will be posed there for all measures. The questionnaire constitutes a minimum of questions to be posed and could be complemented with additional, similar questions concerning the measures which are not explicitly referred to in the appendix. Particularly, it is of interest to understand the citizens' opinion on the measures and how they have changed the life in the areas. Questions should thus be related to satisfaction with the new technologies, and their social and economic impacts for the users, their sense of involvement and interaction, their sense of security etc.

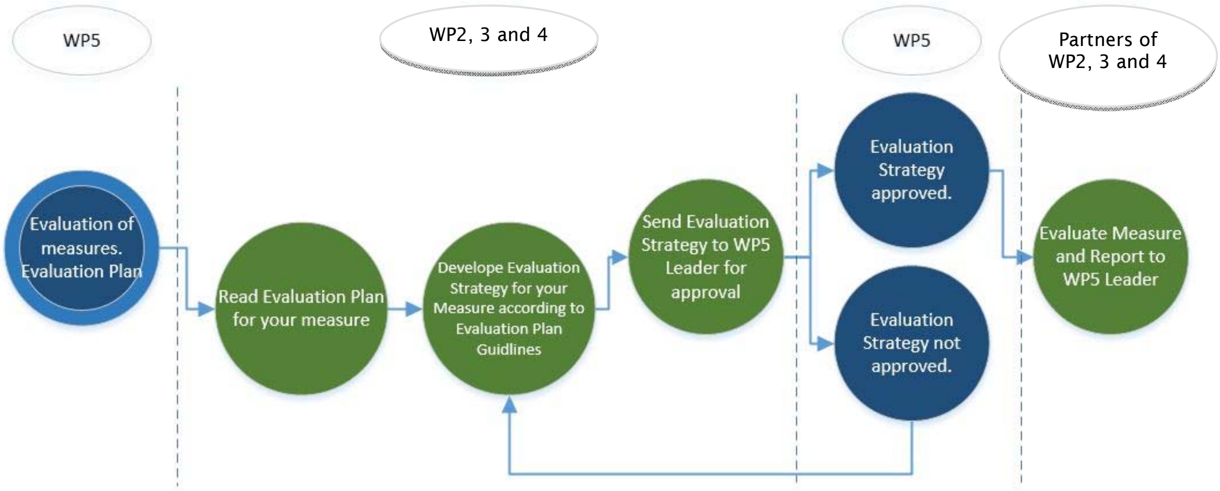


Figure 1- Flow chart of Evaluation Process

3.2 Technical evaluation of measures Low Energy Districts

3.2.1 Introduction, Evaluation of building energy use

The total building energy demand is evaluated with regards to the annual demand of the different energy carriers (kWh) and the heated/cooled area of the building (m^2). Energy demand shall be evaluated as final energy demand (bought energy). Primary energy demand should also be used for evaluation in addition to final energy demand, even though primary energy demand is not required according to information from the project management. For the evaluation of the primary energy demand, standard EN-15603:2008 should be used. In EN-15603:2008, Table E1 shall be used when establishing primary energy factors. The heated area of the building is defined as all areas that are heated or cooled with inside wall as boundary. When annual Heating- and Cooling demand is required to be normalized to climatic conditions, Heating- and Cooling degree day method as described in the EU Concerto "Evaluation of (Smart) Solutions - Guidebook for Assessment Part I – Methodology" shall be used. Also a list of all the measures implemented in the different buildings shall be attached to the evaluation. The evaluation procedure shall follow the work flow described by **Error! Reference source not found.**.

3.2.1.1 Building Evaluation

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.0	Evaluation of building energy use	Skanska/ Stockholmshem, Veolia, Gas Natural, Schneider, IREC, DEWOG	KTH-EGI,

Description of Measure

The building energy performance shall be obtained through measurements and evaluated based on the different energy carriers. All buildings where measures are implemented shall be evaluated in this fashion.

Intentions

1. To obtain energy performance of evaluated buildings (kWh/m²).

Definition of baseline and how it will be determined

1. The baseline will be determined based on performance before measures have been implemented.
2. Baseline for Heating, Cooling and Electric energy shall be obtained through measurement[9] of annual energy demand (kWh/m²) corrected for ambient conditions (heating- cooling degree day correction).
3. The annual performances are also to be displayed as energy signature, highlighting any difference between the two cases.
4. The emission data source shall be established from official authoraties and used throughout the evaluation period of baseline and evaluation of conducted measures.
5. The bought energy mix (per energy carrier) shall be established and used throughout the evaluation period of baseline and evaluation of conducted measures.

Specification of methodology for evaluation

1. Heating-, Cooling- and Electric energy demand shall be measured every hour over one year (12 consecutive months) and the climate corrected annual energy demand after implementation of measures should be compared to the baseline.[10]
2. The annual performance shall also to be evaluated using energy signature method, presented as monthly values (i.e. monthly average heating need kW versus monthly average outdoor temperature).

Specification of quantifiable parameters to be measured/ monitored

1. The annual heating energy supplied to the building (kWh/h), sampling interval is one hour.
2. The annual domestic hot water use (m³), sampling interval is one hour.
3. The annual energy need for domestic hot water (kWh/h), sampling interval is one hour.
4. The annual cooling energy supplied to the building (kWh/h), sampling interval is one hour.
5. The annual electric energy supplied to the building (kWh/h), sampling interval is one hour, divided into the main categories (e.g. property electricity and activity based electricity).
6. Indoor temperature (°C), sampling interval is one hour over evaluated year.
7. Climatic conditions, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas). Sampling interval is one hour over evaluated year.

Specification of Key Performance Indicators to be determined

1. Heat energy required (kWh) per year and month normalized for climatic conditions.
2. Cooling energy required (kWh) per year and month normalized for climatic conditions.
3. Electric energy required (kWh) per year and month.
4. CO_2 emissions due to heating energy demand (kt/year).
5. CO_2 emissions due to cooling energy demand (kt/year).
6. CO_2 emissions due to electric energy demand (kt/year).

[9] For buildings where the future intended purpose (e.g. apartments, after implementing measure) of the building is significant different from the original purpose of the building (e.g. storage facilities), the baseline shall be determined by building energy simulation according to standard ISO 13790.

[10] As stated in the introduction (section 2.6), all data collection must be done in accordance with national legislation. In case permission of the tenants is necessary, such permission should be sought.

3.2.1.2 Local evaluation

The evaluation of the individual measures related to energy use in buildings is carried out within work package 2 and 3. In this chapter a general description is given of what and how the different measures, related to energy use in Buildings, should be evaluated. The text under the headings "Description of Measure" are relayed according to the Grant Agreement. The reason for the absence of a more specific description of how the evaluation should be carried out, is that the detailed description of the different measures is yet to be decided by the different actors. Instead the actors should device their specific Evaluation Strategy for their measures according to the general guidelines given in this document and get the plan approved by the WP5 leader. See **Error! Reference source not found.** for guidance. It is important that the Evaluation Strategy includes a list of all other measures implemented in the same building as the specific measure that is to be evaluated. These other measures should be taken into account when devising the Evaluation Strategy, i.e. that the evaluation of the different measures is carried out in the correct order.

The environmental impact of the individual measure (as listed in subsequent paragraphs) shall be evaluated by first establish an environmental base line, as:

1. The emission data source shall be established from official authorities and used throughout the evaluation period of baseline and evaluation of conducted measures.
2. The bought energy mix (per energy carrier) shall be established and used throughout the evaluation period of baseline and evaluation of conducted measures.

The intended purpose is to decrease impact of external impact outside the control of the builing system. It is not reasonable to account for environmental benefits by changed energy mix of the supplier, as this has little bearing on the savings of the individual measures.

3.2.2 Measures of Stockholm

3.2.2.1 Low U-values of windows

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.1	Low U-values of windows	Skanska/ Stockholmshem	KTH-EGI,

Description of Measure

New windows with a U-value of 0.7 developed for easier mounting will be used when refurbishing existing buildings in Stockholm. The new concept window will not only be more energy efficient but also allow a more time efficient mounting procedure.

Another thing that has proved to be a problem with highly insulating windows is that cellphone reception in the house or apartment is affected negatively. Therefore a study on the effects and how to solve this problem will be conducted within the project.

Intentions

1. The intention is to simplify mounting of windows when refurbishing building.
2. Reduce space heating demand.
3. Increase comfort and quality of living.

Definition of baseline and how it will be determined

1. Air leakage testing with blower door
2. Window thermal status determination (such as transmission and solar gain coefficients)
3. Indoor environmental investigation
4. Installation effects (surroundings of the frame of window) by e.g. thermal imaging

Specification of methodology for evaluation

1. Air leakage testing with blower door
2. Thermal status (U-value) determination of windows(e.g. by measurement)
3. Indoor climate investigation
4. Thermal imaging

Specification of quantifiable parameters to be measured/ monitored

1. Instantaneous measurement of air leakage with blower door type measurement of 10 % of the apartments (reference apartments) in reference buildings (two different types should be selected)
2. Thermal status measurement of 5 randomly selected windows in each of the reference buildings (i.e. 10 windows in total)
3. Thermal indoor environmental investigation according to relevant standards (e.g. ISO 7730 ISO 7726), in the selected 10 % of the apartments of the building.
4. Measurements and investigations should be carried out before and after the measure have been implemented.

Specification of Key Performance Indicators to be determined

1. Air leakage in air changes per hour at 50 Pa (ACH_{50})
2. U Value of windows (incl. frame) in W/m2.K
3. Solar gain coefficient (%)
4. PPD of overall thermal environment evaluated at reference point of window)
5. PD of local thermal comfort (draught, radiant asymmetry, vertical air temperature difference)
6. Sensible air temperature of the reference apartments according to relevant standards (e.g. ISO 7726, 7730).

Measurements are to be done only at one occasion

3.2.2.2 Reducing hot water losses

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.2	Reducing hot water losses	Skanska/ Stockholmshem	KTH-EGI,

Description of Measure

Poor insulation of the pipes in the hot water circulation have been overlooked for a long time and recent studies have shown that the heat losses can be in the range of 6-20kWh/m2(heated area) annually. In this measure the losses will be cut by 50 %. A new type of pipe in pipe hot water circulation pipe system will be used.

Intentions

1. Reduce heat losses from hot water circulation by 50 %

Definition of baseline and how it will be determined

1. Measure heat losses in hot water circulation as average over one year (kWh/h)

Specification of methodology for evaluation

1. Installation of flow meter and temperature sensors to make continuous measurements over one year.

Specification of quantifiable parameters to be measured/ monitored

1. Flow rate of circulated water should the measured together with temperature of the hot water supply and return. The data should be logged over one year for two reference buildings. Data should be average over one hour. Losses should be presented as average loss over one year (kWh/ h)

Specification of Key Performance Indicators to be determined

1. Hot water circulation loss factor (kWh/h)
2. Annual hot water circulation loss (kWh/m^2) (heated area of building).

Measurements are to be done only once.

3.2.2.3 Recovering waste water heat from the drain

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.3	Recovering waste water heat from the drain	Skanska/ Stockholmshem	KTH-EGI,

Description of Measure

Recovering heat from the sewage system to preheat tap hot water is a new area for heat recovery with great potential. About 25 % of the energy for heating water will be saved.

Intentions

1. By installing waste heat recovery in the drain system 25% of the energy for heating domestic hot water (DHW) will be recovered.

Definition of baseline and how it will be determined

1. Measuring the heat used for DHW during one year, measuring heating energy required (kWh/ h).

Specification of methodology for evaluation

1. Installation of flow meter and temperature sensors to make continuous measurements over one year.
2. Installation of measurement equipment to determine heat recovered by the heat recovery unit.

Specification of quantifiable parameters to be monitored

1. Energy meter measuring water flow rate and temperature of the supply DHW leaving the heating unit, and the incoming cold water mains, sampling interval one hour
2. Energy meter measuring the amount of recovered heat using energy meters measuring water temperature before and after the heat recovery unit, and the corresponding flow rate, sampling interval one hour.
3. Temperature of supplied DHW to building and temperature of incoming water mains, sampling interval one hour.

Specification of Key Performance Indicators to be determined

1. DHW heating demand (kWh/h) during one year.
2. Temperatures (°C) of the delivered DHW.
3. Temperatures (°C) of the incoming water mains.

3.2.2.4 Energy classified DHW fixtures

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.4	Energy classified DHW fixtures	Skanska/ Stockholmshem	KTH-EGI

Description of Measure

By using energy classified hot water fixtures it is possible to save ca. 5 kWh/m^2 annually.

Intentions

1. Reduce the need of DHW while maintaining or increasing comfort and service as provided with older fixtures.

Definition of baseline and how it will be determined

1. Measurements of used DHW (m^3) over the period of one year week.

Specification of methodology for evaluation

1. Measurements of used energy for DHW (kWh/h) over the period of one year.

Specification of quantifiable parameters to be monitored

1. DHW (m^3) used, sampling interval one hour.
2. Temperature (°C) of water of incoming mains, sampling interval one hour.
3. Temperature (°C) of DHW supplied to building, sampling interval one hour.

Specification of Key Performance Indicators to be determined

1. Energy use for DHW (kWh/h).
2. Annual DHW use (m^3).
3. Energy use for DHW per person in building (kWh/person).
4. Energu use for DHW per square meter (kWh/m^2).

3.2.2.5 New efficient exhaust air heat pumps

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.5	New efficient exhaust air heat pumps	Skanska/ Stockholmshem	KTH-EGI

Description of Measure

Heat recovery connected to the ventilation system is unusual in old buildings. A new type of heat pump cools the exhaust air to -10 °C to -15 °C.

Intentions

1. Recover heat from the exhaust ventilation system to space heating and DHW, as no supply ventilation system will be used.
2. Enabling savings up to 50 kWh/m^2 annually.

Definition of baseline and how it will be determined

1. Establish ventilation heat losses before installation of equipment.

Specification of methodology for evaluation

1. Measure of ventilation losses after installation of equipment.

Specification of quantifiable parameters to be monitored

1. Measurements (on an hourly resolution basis for a reference week):
    a. Ventilation flow rate (m^3/s).
    b. Ventilation air temperature (°C) before the heat recovery unit.
    c. Exhaust air temperature (°C) of ventilation air leaving the building.
    d. Compressor work (kWh/h).
    e. Pump work (kWh/h).
    f. Fan power work (kWh/h).
    g. Pressure loss over recovery unit (Pa).

Specification of Key Performance Indicators to be determined

1. Heat recovery ratio (%).
2. Effectiveness of the heat recovery system (i.e. overall COP of the system)

3.2.2.6 New adaptive control technique for heating systems

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.6	New adaptive control and techniques for heating systems	Veolia	KTH-EGI

Description of Measure

Indoor temperature sensors will be used to feedback information to the heating/cooling and ventilation control system. It is a system that adapts to the individual building's dynamics and responds to weather conditions. Hence, it provides heating/ cooling more efficiently compared to traditional systems which only uses outdoor ambient temperature as sole parameter.

Intentions

1. Better control of the supplied heat and cooling to building potentially decrease overheating and undercooling the buildings. The savings potential is around 10 %.

Definition of baseline and how it will be determined

1. Establish energy consumption for heating and cooling (kWh/m^2) during one year, normalized to a typical climatic year, without the adaptive control algorithm engaged.
2. Climatic conditions, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m^2), global radiation on horizontal surface (W/m^2), diffuse radiation on horizontal surface (W/m^2), total cloud cover (Octas).

Specification of methodology for evaluation

1. Establish energy consumption for heating and cooling (kWh/m^2) during one year, normalized to a typical climatic year, with the adaptive control algorithm engaged.
   a. Both the baseline and the improved algorithm shall be evaluated by successive engaging and disengaging the algorithm, using period of two weeks for each. This is carried out for, at least, a duration of one year.
   b. The measured energy for each successive time period is to be measured and reported as kWh/h, using the sampling interval of one hour, for each two week period.
2. The annual performances are to be displayed as energy signature, highlighting any difference between the two control strategies.

Specification of quantifiable parameters to be monitored

1. The heating energy supplied to the building (kWh/h), sampling interval is one hour.
2. The cooling energy supplied to the building (kWh/h), sampling interval is one hour.

3. Indoor temperature (°C), sampling interval is one hour.
4. Climatic conditions, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas). Sampling interval is one hour.

Specification of Key Performance Indicators to be determined

1. Saving of heat energy required (kWh/year) normalized by energy required without the measure implemented.
2. Saving of cooling energy required (kWh/year) normalized by energy required without the measure implemented.

3.2.2.7 Energy quality assurance

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.7	Energy quality assurance	Veolia	KTH-EGI

Description of Measure

Using an energy supervisor for all parts influencing energy performance during the whole building construction phase is a new way of optimizing the building performance, usually referred to as Integral Design.

Intentions

1. By involve all key actors early in the design phase, evaluating all possible alternative, the most energy efficient can be identified.
2. The energy quality manager is responsible to ensure that changes from design are assessed from an energy efficiency point of view.
3. Experience indicated that the cost of a building does not have to be higher by implementing energy efficient technology and solutions, as the whole processes are initially well thought through.

Definition of baseline and how it will be determined

1. No validation procedure on a single building has been identified. The actor is however free to suggest evaluation method if one is available.

Specification of methodology for evaluation

1. None at this time.

Specification of quantifiable parameters to be monitored

1. No identifiable validation parameters have been found.

Specification of Key Performance Indicators to be determined

1. None found at this time.

3.2.2.8 Air tightness

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.8	Air tightness	Veolia	KTH-EGI

Description of Measure

Part of the buildings will be tested in order to secure the quality of measures according to the climate shield. This is not common practice to apply on large scale or in a renovation context but can be of great importance in a climate with a fairly long heating season.

Intentions

1. Reduce energy use for heating and cooling by reducing infiltration over the climate envelope.
2. Increase IEQ (Indoor Environmental Quality) by decrease risk of draught.

Definition of baseline and how it will be determined

1. Establish infiltration flow rate ($m^3/s{\cdot}m^2$ envelope area) at 50 Pa.

Specification of methodology for evaluation

1. Establish infiltration flow rate ($m^3/s{\cdot}m^2$ envelope area) at 50 Pa.
2. Establish infiltration losses (kWh/m^2).

Specification of quantifiable parameters to be monitored

1. Infiltration flow rate ($m^3/s{\cdot}m^2$ envelope area) at 50 Pa.

Specification of Key Performance Indicators to be determined

1. Infiltration flow rate ($m^3/s{\cdot}m^2$ envelope area) at 50 Pa.
2. Infiltration losses (cooling and heating) (kWh/m^2 floor area).
3. Reduction of energy use compared to baseline (kWh/m^2 floor area).

Measurements are to be done only once.

3.2.2.9 Efficient lighting

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.9	Efficient lighting	Skanska/ Stockholmshem	KTH-EGI

Description of Measure

By implementing different energy saving measures a significant amount of electric energy can be saved. The lighting in elevators will be controlled efficiently. These lights will, if they are on at all times, consume as much electricity as the elevator motor. The elevator motor will also be controlled efficiently. LED lighting will be used in common spaces and energy efficient appliances in common laundry rooms.

Intentions

1. Reduce electricity demand by implementing smart new systems for the property electrical system.

Definition of baseline and how it will be determined

1. Measure property electricity consumption (kWh/m^2) for a year.
2. Lighting intensity, illuminance (lx).

Specification of methodology for evaluation

1. Establish reference area for comparison measurement
2. Establish electrical need for improved system.

Specification of quantifiable parameters to be monitored

1. Measure property electricity consumption (kWh/m^2) for a year.
2. Lighting intensity, illuminance (lx).

Specification of Key Performance Indicators to be determined

1. Lighting intensity (lx)
2. Annual electric energy use (kWh/m^2).
3. Reduction of electrical consumption related to baseline.

3.2.2.10 Local production

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.1.1	Local electricity production	FORTUM Veolia and City of Stockholm	KTH-EGI

Description of Measure

Installation of photovoltaic's, mainly on rooftops and facades, storages (electricity) in combination with district heating and heat pumps..

Intentions

1. Decrease the need of externally supplied energy by local production units.
2. Increased amount of renewable share of energy consumption.

Definition of baseline and how it will be determined

1. Establish demand of externally supplied energy.
2. Establish the renewable share of the supplied energy.

Specification of methodology for evaluation

1. Measure the energy supplied by local production unit.
2. Determine the share of externally supplied energy.
3. Determine the share of renewable energy supplied, both locally and externally.

Specification of quantifiable parameters to be monitored

1. Energy supplied from local production unit (kWh/h) in the form of electricity and heat. The energy supply should be logged continuously.
2. Climatic conditions, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas).

Data is to be collected hourly.

Specification of Key Performance Indicators to be determined

Measured energy supplied by local production unit (kWh/year).

1. Measured energy supplied by local production unit (kWh/year).

2. Measured energy supplied by local production unit (kWh/h).
3. Share of external renewable energy supplied of total local demand (%).
4. Reduction of CO_2 emissions due to local production (%).

3.2.2.11 Metering and sensors

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.1.3	Metering and sensors	FORTUM	KTH-EGI

Description of Measure

Smart meters – to manage the grid and to incentivize the demand and supply, it is essential to install smart metering that can monitor the net electricity flow at each users inlet.

Intentions

1. Enable opportunity to decrease demand through incentivising the consumers.

Definition of baseline and how it will be determined

1. Measure will be evaluated under Smart Measure 3.1

Specification of methodology for evaluation

1. Measure will be evaluated under Smart Measure 3.1

Specification of quantifiable parameters to be monitored

1. No parameters to be monitored under this Measure. Parameters are determined in the evaluation under Measure 3.1.

Specification of Key Performance Indicators to be determined

1. No Key Performance Indicators developed under this measure, Measure is evaluated under Measure 3.1.

3.2.2.12 Smart Street lighting 1.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner

5.1.1	Sensor controlled LED lighting for pedestrian and bicycle paths	Trafikkontoret	KTH-EGI

Description of Measure

Sensor controlled LED lighting for pedestrian and bicycle paths to enable the lights to provide base lighting to satisfy the feeling of security at all times and increase the level of lighting when someone approaches.

Intentions

1. Reduce the demand of energy for lighting of pedestrian and bicycle paths by 40-50 %.

Definition of baseline and how it will be determined

1. Measure the electric energy demand during 6 selected months before measure is implemented (kWh/h).

Specification of methodology for evaluation

1. Measure electric energy demand during the same 6 months that was used for baseline after implementation of measure and compare outcome with baseline measurements.

Specification of quantifiable parameters to be monitored

1. Energy demand (kWh/h) using an energy measuring equipment. Data should be logged on an hourly basis.

Specification of Key Performance Indicators to be determined

1. Average energy demand over 6 months before implementation of measure (kWh/h).
2. Average energy demand over 6 months after implementation of measure (kWh/h).
3. Reduced CO_2 emissions due to reduced energy demand (kt/year).

In 1 and 2, data should be collected hourly.

3.2.2.13 Smart Street lighting 2.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
5.1.2	Self-controlled LED street lighting	Trafikkontoret	KTH-EGI

Description of Measure

Self-controlled LED street lighting with pre-set lighting schemes based on levels of traffic has the potential to saving energy compared to regular LED light.

Intentions

1. Reduce the demand of energy for LED street lighting by 20 %.

Definition of baseline and how it will be determined

1. Measure the electric energy demand of regular LED lighting installation during 6 selected months before measure is implemented (kWh/h).

Specification of methodology for evaluation

1. Measure electric energy demand during the same 6 months that was used for baseline after implementation of measure and compare outcome with baseline measurements.

Specification of quantifiable parameters to be monitored

1. Energy demand (kWh/h) using an energy measuring equipment. Data should be logged on an hourly basis.

Specification of Key Performance Indicators to be determined

1. Average energy demand over 6 months before implementation of measure (kWh/h).
2. Average energy demand over 6 months after implementation of measure (kWh/h).
3. Reduced CO_2 emissions due to reduced energy demand (kt/year).

In 1 and 2, data should be collected hourly.

3.2.2.14 Smart Street lighting 3.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
5.1.3	Remote controlled LED street lighting	Trafikkontoret	KTH-EGI

Description of Measure

Remote controlled LED Street lighting which can be controlled from a distance to provide sufficient lighting depending on the time of the day and the level of traffic that comes with it. The aim is to use advanced control system with standardized open protocol according to TALQ Consortium.

Intentions

1. Save 30-50 % energy compared to regular LED lighting.
2. Evaluate city benefit of measure, savings of 7-12 GWh can be achieved yearly in the entire city using local grid energy supply.

Definition of baseline and how it will be determined

1. Measure the electric energy demand of regular LED lighting installation during 6 selected months before measure is implemented (kWh/h).

Specification of methodology for evaluation

1. Measure electric energy demand during the same 6 months that was used for baseline after implementation of measure and compare outcome with baseline measurements.
2. Calculation of city benefit if the measure is implemented in the whole city.

Specification of quantifiable parameters to be monitored

1. Energy demand (kWh/h) using an energy measuring equipment. Data should be logged hourly.

Specification of Key Performance Indicators to be determined

1. Average energy demand over 6 months before implementation of measure (kWh/h).
2. Average energy demand over 6 months after implementation of measure (kWh/h).
3. City benefit if the measure is implemented for all street lights, savings should be presented (GWh/year).
4. Reduced CO_2 emissions due to reduced energy demand (kt/year).

In 1 and 2, data should be collected hourly.

3.2.2.15 Combined electrical charging and street lighting poles + Wifi-to-grid connection.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
5.2.1	Combined electrical charging and street lighting poles + Wifi-to-grid connection	IBM	KTH-EGI

Description of Measure

As traffic posts are evenly distributed across cities they posts a great opportunity to provide extra data coverage throughout the city, both Wi-Fi and mobile data (4G). In Stockholm a City Wi-Fi will provide the means for leveraging the 'Internet of Everything' potential in terms of connectivity and real-time monitoring and enabling services to support and/or manage all aspects of city life and operations. The City Wi-Fi would enable the connectivity and communication– IP based – over one common network infrastructure. This would enable Smarter City solutions in the areas of Traffic Management, Sustainable Mobility, Low Energy solutions for buildings, Video Surveillance and Incident Monitoring, Waste Management and Quality of Life.

Intentions

1. Enabling smart solutions through better possibility to connect devices.

Definition of baseline and how it will be determined

1. Measure the average energy needed to operate street lighting and traffic posts (kWh/h). Measurements should be carried over a representable week and for a relevant number of different posts.

Specification of methodology for evaluation

1. Measure average energy demand of smart street lighting and traffic posts over one representable week (kWh/h) and compare with baseline.

Specification of quantifiable parameters to be monitored

1. Energy demand of traditional street and traffic posts (kWh/h).
2. Energy demand of smart street and traffic posts (kWh/h).
3. Data traffic relayed over smart street and traffic posts (Mb/h).

Specification of Key Performance Indicators to be determined

1. Energy demand per hour of traditional street and traffic posts within the area (measured continuously for a test period of six months before the implementation of the Wifi-system.
2. Energy demand per hour of smart street and traffic posts within the area measured continuously for two years after implementation of the Wifi-system.
3. Average data traffic relayed over smart street and traffic posts (Mb) during two years.
4. Reduced CO_2 emissions due to reduced energy demand (kt/year).

3.2.2.16 Open district heating with feed in of waste heat 1.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
6.1.1	Waste heat from data centers	FORTUM	KTH-EGI

Description of Measure

Installation of heat recovery equipment in order to recover heat from the cooling process of a datacenter to the district heating/cooling system. The recovered heat is transferred to the district heating network and used to warm up apartments and offices. The recovered heat during one year from a 1 MW data center could in this way warm up approx. 800 standard apartments (including tap water).

Intentions

1. A typical datacenter of 1 MW generates annually approx. 12 GWh (based on 8760 hours of operation/year) of waste heat which is usually released into the atmosphere through cooling towers. With Open District Heating , roughly 50% of the generated heat is economically feasible to recover

Definition of baseline and how it will be determined

1. Determination of data center annual total energy demand broken down to electricity, and cooling (kWh).
2. Determination of carbon footprint of conventional cooling of the datacenter (kg/y)

Specification of methodology for evaluation

1. Measure the annual cooling demand of the datacenter (MWh/y)
2. Measure annual energy demand (electricity) of conventional cooling (cooling machine + cooling tower) of the datacenter adjusted to a representable metrological year (MWh).
3. Determine the COP of conventional cooling
4. Measure the hourly energy demand (electricity) of cooling the datacenter with a heat pump (including pumps and fans) and recovering the waste heat to the district heating system over one year.
5. Measure volume of recovered heat (MWh/y)
6. Calculate the COP of the heat recovery process
7. Determine yearly number of economically feasible hours of operation with heat recovery (h)
8. Calculate carbon footprint of cooling the datacenter with heat recovery taking into account that the recovered heat is used elsewhere in the city, thus reducing the city's need for energy via the district heating system from other fuels. (kg/y)
9. Compare the carbon foot prints of conventional and heat recovery cooling.
10. Measure average recovered heat (kWh/h).
11. Compare recovered heat with available heat in the system.
12. Calculate heat recovery ratio (%).
13. Determine hourly operating temperature levels for the heat pump system, i.e. the temperature of the supplied air (to the recovery system) and the leaving water temperature (from the heat pump system) to the district heating network.
14. Calculate the total system COP for the heat pump based heat recovery system.

Specification of quantifiable parameters to be monitored

1. Measurements (on an hourly resolution basis for a reference year):
    a. Data center electric energy demand (kWh/h).
    b. Electric energy demand for cooling with heat recovery, incl compressor and pump work (kWh/h).
    c. Data center cooling energy demand (kWh/h).
    d. Vacuum waste plant electric energy demand (kWh/h).
    e. Recovered heat from heat recovery system (kWh/h).
    f. Estimation of saving potential if heat recovery systems were installed in all data centers in Stockholm where it would be economically feasible.

Specification of Key Performance Indicators to be determined

1. Heat recovery ratio (%).
2. Effectiveness of the heat recovery system (i.e. overall COP of the system).
3. Total Carnot efficiency of the heat pump recovery system.
4. Reduced CO_2 emissions due to reduced net energy demand (kt/year).
5. Carbon footprint of cooling with heat recovery

3.2.2.17 Open district heating with feed in of waste heat 2.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
6.1.2	Waste heat from fridges and freezers in supermarkets	FORTUM	KTH-EGI

Description of Measure

Installation of heat recovery equipment in order to recover heat from the cooling process of a supermarket to the district heating/cooling system. The recovered heat is transferred to the district heating network and used to warm up apartment and offices. The recovered heat during one year from a 200 kW supermarket could in this way warm up approx. 160 standard apartments (including tap water).

Intentions

1. A larger supermarket with 200 kW cooling capacity generates annually approx. 2,5 GWh (based on 8760 hours of operation/year) of waste heat which is usually released into the atmosphere through cooling towers. With Open District Heating , roughly 50% of the generated heat is economically feasible to recover.

Definition of baseline and how it will be determined

1. Determination of all supermarkets annual total energy demand for cooling in Stockholm (kWh).
2. Determination of total annual cooling demand (kWh) of reference supermarkets.
3. Determination of annual cooling demand for the supermarkets with implemented measure (kWh).
4. Determine required driving energy (compressors, pumps, fans, etc.) to provide the annual cooling demand (kWh).
5. Determination of carbon footprint of conventional cooling of the supermarket (kg/y)

Specification of methodology for evaluation

1. Measure the yearly cooling demand of the supermarket (MWh/y)
2. Measure energy demand (electricity) of conventional cooling (cooling machine + cooling tower) of the supermarket over one representable year based on historical data (MWh).
3. Calculate the COP of conventional cooling
4. Measure, hourly, for one year, energy demand (electricity) of cooling the supermarket with a heat pump and recovering the waste heat to the district heating system (MWh/y).
5. Measure volume of recovered heat (MWh/y)
6. Calculate the COP of the heat recovery process
7. Determine yearly number of economically feasible hours of operation with heat recovery (h)
8. Calculate carbon footprint of cooling the supermarket with heat recovery taking into account that the recovered heat is used elsewhere in the city, thus reducing the city's need for energy via the district heating system from other fuels. (kg/y)
9. Compare the carbon foot prints of conventional and heat recovery cooling.
10. Compare recovered heat with available heat in the system.
11. Calculate heat recovery ratio (%).
12. Determine hourly operating temperature levels for the heat pump system, i.e. the temperature level as supplied by the heat source and temperature level as delivered by the heat pump recovery system to the heat sink (i.e. the district heating network).
13. Relate savings (kWh) to the additional driving energy (i.e. the COP of the heat recovery system) (kWh/kWh).

Specification of quantifiable parameters to be monitored

1. Measurements (on an hourly resolution basis for one year, normalized for typical climatic year):
    a. Supermarket energy demand for cooling with heat recovery, including pumps and fans (kWh/h).
    b. Supermarket electric energy demand (kWh/h).
    c. Supermarket cooling energy demand (kWh/h).
    d. Recovered heat from heat recovery system (kWh/h).

Specification of Key Performance Indicators to be determined

1. Heat recovery ratio (%).
2. Effectiveness of the heat recovery system (i.e. overall COP of the system).
3. Possible annual savings in Stockholm (kWh/year).
4. Reduced CO_2 emissions due to reduced net energy demand (kt/year).
5. Carbon footprint of cooling with heat recovery
6. Estimate of possible annual energy savings in Stockholm if recovery was installed in supermarkets where economically feasible.

3.2.3 Measures of Barcelona

3.2.3.1 New adaptive control technique for heating systems

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.6	New adaptive control and techniques for heating systems	IREC, Aj Barcelona	KTH-EGI

Description of Measure

In Ca l'Alier indoor temperature sensors will be used to feedback information to the heating/cooling and ventilation control system. It is a system that adapts to the individual building's dynamics and responds to weather conditions. Hence, it provides heating/ cooling more efficiently compared to traditional systems which only uses outdoor ambient temperature as sole parameter.

Intentions

1. Better control of the supplied heat and cooling to building potentially decrease overheating and undercooling the buildings. The savings potential is around 10 %.

Definition of baseline and how it will be determined

1. Establish energy consumption for heating and cooling (kWh/m²) during one year, normalized to a typical climatic year, without the adaptive control algorithm engaged. The effect shall be evaluated by engaging and disengaging the algorithm, using periods of sufficient time period (to mimimize inertia effects) for each. This is carried out for, at least, a representative annual climatic conditions.
2. Climatic conditions for the specific site, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas).

Specification of methodology for evaluation

Methodology for the energy savings will be done based on option D from the IPMVP. The model shall be calibrated experimentally by engaging and disengaging the algorithm, using periods of sufficient time period (to mimimize inertia effects) for each. This is carried out for, at least, representative annual climatic conditions.

Specification of quantifiable parameters to be monitored

1. The heating energy supplied to the building (kWh/h), sampling interval is one hour.
2. The cooling energy supplied to the building (kWh/h), sampling interval is one hour.
3. Indoor temperature (°C), sampling interval is one hour.
4. Climatic conditions, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas), if data is available. Sampling interval is one hour.

Specification of Key Performance Indicators to be determined

1. Saving of heat energy required (kWh/m²/period of interest) normalized by energy required without the measure implemented.
2. Saving of cooling energy required (kWh/m²/period of interest) normalized by energy required without the measure implemented.

3.2.3.2 Efficient lighting

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.9	Efficient lighting	Gas Natural, IREC	KTH-EGI

Description of Measure

By implementing different energy saving measures a significant amount of electric energy can be saved. The lighting in residential (common spaces) and tertiary buildings will be controlled efficiently.

Intentions

1. Reduce electricity demand by implementing smart new systems for the property electrical systems including high efficient lighting technologies and/or control systems to reduce the operation hours.

Definition of baseline and how it will be determined

1. Assess property electricity consumption (kWh/m²) for a year on the building level.

Annual energy demand for lighting may be evaluated through measurements of electric power for lamp ballast combinations for a representative sample (in accordance with IPMVP uncertainty and confidence level ranges). The representative sample has to include at least one measurement for each different kind of lamp ballast combination replaced, the result from the measurements shall be combined with measurements of operation hours of the lighting to extrapolate the annual electricity demand for lighting in the building (kWh).

Electricity consumption for lighting (kWh) will be calculated using the following formula:

$$\sum_{i=i}^{n} N \cdot P_i \cdot h_i$$

Where:

n= lamp ballast combination group

N= number of units

P= average measured electric power per unit for group n

h= average estimated operating hours per unit per group n

2. Measurements of lighting intensity, illuminance (lx) to be able to compare the installed lighting system.

Specification of methodology for evaluation

1. Establish reference area for comparison measurement
2. Establish electrical need for improved system.

Specification of quantifiable parameters to be monitored

1. Assess property electricity consumption (kWh/m²) for a year on the building level.
2. Measure electric power for lamp ballast combinations for a representative sample. The representative sample has to include at least one measurement for each different kind of lamp ballast combination replaced.
3. Measurement of number of operating hours for each of the lamp ballast combination group.
4. Lighting intensity, illuminance (lx).

Specification of Key Performance Indicators to be determined

1. Lighting intensity, illuminance (lx)
2. Annual electric energy use (kWh/m²) on the building level.
3. Reduction of electrical consumption related to baseline for lighting.
4. CO2 emissions reduction.

3.2.3.3 Efficient and smart climate shell and equipment's refurbishment

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.10	Efficient and smart climate shell and equipment's refurbishment	Gas Natural, , IREC, Aj Barcelona	KTH-EGI

General Description of Measure

This measure is very wide in scope and it has been subdivided into passive and active measures, i.e. 1.1.10.1 and 1.1.10.2, since the measures to be implemented are quite different. Both, residential and tertiary sector buildings (hotels, offices, sport center and schools) will be refurbished introducing passive and active measures.

As passive measures insulation improvement on facades and roof will be implemented, as well as, low-U values windows (window frame and glazing) and adding shading elements. As active measures, renovation facilities will be done.

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.10.1	Efficient and smart climate shell and equipments refurbishment for buildings	Gas Natural, IREC	KTH-EGI

Description of Measure

Passive measures will be different depending on the typology. It will consists of improvement of facades- and roof insulation, low-U values windows (window frame and glazing), and shading elements.

Intentions

1. Reduce space heating demand.
2. Reduce space cooling demand.
3. Increase comfort and quality of living.

Definition of baseline and how it will be determined

1. Aggregated gas consumption for the whole building. Information can be obtained from utility invoices (data from DSO metering), provided for each building. At least one year of data shall be gathered.
2. Aggregated electricity use for the whole building. Information can be obtained from utility invoices (data from DSO metering), provided by for building. At least one year of data shall be gathered. Electricity consumption for common space does not have to be considered, if no efficiency measures are applied.
3. For hotel and sportcenter, aggregated cooling use for the whole building. Information can be obtained from invoices provided by the utilityas well as separate submetering. At least an annual representative time period shall be used.
4. Energy Management Systems (HEMS or BEMS) may be used for sufficient time period to establish the baseline for GNF-buildings.
5. Independent variables that affect energy consumption, e.g., external and indoor temperatures, humidity and irradiation, shall be collected.
6. In residential (GNF) the baseline may be established by combination of above points, together with detailed building simulation. The building simulation shall compare the results with utility data, adjusted for user behavior from surveys. If the deviation between the simulated and utility data for each of the energy carrier is greater than 15%, then addition steps are required, as stupilated below:
    a. Air leakage testing with blower door to determine air tightness before refurbishment.
    b. Window thermal status determination (such as transmission and solar gain coefficients).
    c. Facade thermal status determination to establish U value of existing façade.
7. In hotels (GNF) the baseline may be established by combination of above points (1 – 5), together with detailed building model (with relevant user behavior). The building model shall compare the results with measured data. If the deviation between the modelled data and utility data for each of the energy carrier is greater than 15%, then addition steps are required, as stupilated below:
    a. Air leakage testing with blower door to determine air tightness before refurbishment.
    b. Window thermal status determination (such as transmission and solar gain coefficients).
    c. Facade thermal status determination to establish U value of existing façade.
8. In Big Blue, the thermal status of walls will be determined using thermal imaging.
9. Relevant indoor environmental parameters, such as temperature.

Specification of methodology for evaluation

1. Electricity, cooling and gas invoices collection and analysis.
2. Determine building energy consumption, electricity, cooling and heating demand (kWh/year).
3. In case of Big Blue: indoor thermal conditions (indoor temperature and relative humidity sensors) will be measured. As an independent variable: external temperature, humidity and radiation will be gathered as well. Temperature sensors will measure T_{out} from solar thermal, T_{in} to DHW and $T_{coldwater}$ from the water mains. From the water and gas meter, heating demand will be

determined.
4. Air leakage testing with blower door.
5. Thermal status determination (e.g. determination of U-values by measurement)
6. Indoor environmental investigation
7. Thermal imaging of façade and windows to investigate installation effects.
   Information before and after implementing measures shall be compared, using a climatic representative year.

Specification of quantifiable parameters to be measured/ monitored

1. Gas consumption. Information can be obtained from utility invoices (data from DSO metering). At least two year of data has to be gathered. In case of Big Blue, gas consumption will be gathered by a gas meter on an hourly basis.
2. Electricity use. Information can be obtained from utility invoices (data from DSO metering). At least two year data has to be gathered. In case of Big Blue, electricity consumption (aggregated by end-uses) will be gathered by an electricity meter at an hourly basis.
3. Cooling use for hotel and tertiary buildings. Information can be obtained from utility invoices or sub-metering. At least two years of data needs to be gathered.
4. Independent variables that affect energy consumption, e.g., internal and external temperature and relative humidity
5. Instantaneous measurement of air leakage with blower door type measurement of 10 % of the GNF apartments (in reference buildings) or hotels, at least one type of buildings should be selected as reference buildings in each category (residential, tertiary).
6. Thermal status measurement of representative sample of windows in each of the GNF reference buildings.
7. Thermal status measurement of facades in the selected reference buildings.
8. Relevant thermal indoor environmental investigation according to relevant standards (e.g. ISO 7730 ISO 7726), in the selected reference buildings.
9. Climatic conditions for the specific site, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m^2), global radiation on horizontal surface (W/m^2), diffuse radiation on horizontal surface (W/m^2), total cloud cover (Octas).

Specification of Key Performance Indicators to be determined

1. U Value of windows (incl. frame) in $W/m^2.K$
2. U Value of facades in $W/m^2.K$.
3. Relevant overall thermal environment evaluated at reference point.
4. If required (based user survey), PD of local thermal comfort (draught, radiant asymmetry, vertical air temperature difference).
5. Sensible air temperature of the reference buildings.
6. Energy demand and consumption by heating, cooling (if applicable), DHW other electricity uses (kWh/m^2) normalized for a typical climatic year, quantified by simulationor other equivalent procedure.
7. Energy savings, in final and primary energy terms.
8. CO2 emmisions reduction.

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.10.2	Equipment's refurbishment	Gas Natural, , IREC, Aj Barcelona	KTH-EGI

Description of Measure

As active measures, renovation of the facilities will be done, i.e. led lighting, photovoltaic power plant, reducing the heating, DHW and cooling consumptions. In addition, high-efficient lighting and pumps will be also installed to reduce electricity consumption. New heating radiator loops will be installed in apartments. In tertiary buildings, free-cooling and heat recovery will be implemented. LED Lighting will substitute the old lamps.

Intentions

1. Reduce space heating energy consumption.
2. Reduce space cooling energy consumption.
3. Increase share of RES in electricity supply
4. Reduce DHW energy consumption.
5. Reduce electric energy demand for lighting and other consumptions (if applicable).

Definition of baseline and how it will be determined

1. Heating, cooling and DHWsystem should be evaluated on a global building level. Gas, electricity and water consumptions will be gathered and will be used as a basis to determine energy demands.
2. Equipment performances. A measurement campaign for a representative perioed, covering annual climatic conditions, is needed to obtain information from some of the equipments that are going to be replaced:
    a. Boilers
    b. HVAC system
    c. Other equipment that is going to be refurbished.
3. Independent variables that affect energy consumption, e.g., external and indoor temperatures.
4. Free cooling baseline should be determined by measuring, if possible, the cooling demand of HVAC system before the measures have been implemented.
5. If available, driving energy for HVAC system for cooling for the duration of one year, normalized to typical climatic year.
6. If available, heat recovery in HVAC system should be determined by measuring the heating demand of HVAC system before implemented measures.
7. The change to LED lighting shall be determined as the electrical energy demand to lighting system, see measure 1.1.9 for details.
8. Illuminance level (lx), see measure 1.1.9 for details..

    For buildings where the intended purpose (e.g. apartments, after implementing measure) of the building is significant different from the original purpose of the building (e.g. storage facilities), the baseline shall be determined by building energy simulation according to standard ISO 13790 or equivalent procedure.

Specification of methodology for evaluation

1. Heating and DHW system should be evaluated on a global building level, therefore the evaluation of the impact of the installation of heating system is not carried out at the local level.
2. Cooling and heating energy requirement of the HVAC system shall be measured on an hourly basis (kWh/h) over for representative periods, covering annual climatic conditions. Meters should usually be a fixed installation, but may for small distributed units be done at measurement campaign. The normalized cooling energy demand shall be compared with the determined normalized demand before the measure was implemented.
3. If possible, driving energy for HVAC system for cooling shall be measured on an hourly basis (kWh/h) for the duration of one year, normalized to typical climatic year.
4. The HVAC heat recovery system shall be evaluated for representative annual climatic conditions by determining the heat recovery system heat recovery ratio (%) (i.e. recovered heat/available heat).
5. Lighting system energy performance is evaluated by determining the average demand during one representable week (kWh/h). The demand after the measure is implemented is compared with the demand before, see 1.1.9 for details.

Demands before and after implementing measures shall be compared. For heating and cooling, a climatic representative year is needed to compare results.

For buildings where the intended purpose (e.g. apartments, after implementing measure) of the building is significant different from the original purpose of the building (e.g. storage facilities), the baseline shall be determined by building energy simulation according to standard ISO 13790 or other equivalent procedure.

Specification of quantifiable parameters to be measured/ monitored

1. Instantaneous (hourly) measurement of HVAC cooling and heating demand (kWh/h) and system performance.
2. HVAC heat recovery system heat recovery ratio (%), average heat recovery rate (kW) on an hourly basis.
3. Annual HVAC heat recovery system COP (heat energy recoverd divided by driving energy).
4. If possible, driving energy for installed cooling equipment and components (kWh/h)
5. Electric energy demand of lighting system (kWh/h), sampling one hour, see 1.1.9 for details.
6. Illuminance level (lx), see 1.1.9 for details.
7. Climatic conditions for the specific site, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m^2), global radiation on horizontal surface (W/m^2), diffuse radiation on horizontal surface (W/m^2), total cloud cover (Octas).
8. DHW energy consunmptions (kWh/h).
9. Lighting consumption and other electricity uses consumption (kWh)

Specification of Key Performance Indicators to be determined

1. Heating, cooling, DHW and electricity demands (kWh/yr). HVAC heat recovery system efficiency, heat recovery ratio (%).
2. Equipment performances.
3. Average electric energy demand of lighting system and other electricity uses (kWh/yr). On-site electricity production (kWh/yr).
4. Energy savings in final and primary energy terms.
5. Share of RES in heating cooling and electricity supply.
6. CO2 emissions savings.

3.2.3.4 Pool measures

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.11	Pool measures	Gas Natural	KTH-EGI

Description of Measure

Swimming pools have special characteristics and are seldom built to be energy efficient. In Barcelona several specific pool measures will be implemented: heat pumps for dehumidification, heat recovery from shower waste water, pool insulation, night covers of the pool, heat pumps in ventilation system, condensing natural gas boilers, variable speed fans and pumps.

Intentions

1. Reduce swimming pool area energy demand.

Definition of baseline and how it will be determined

1. Determine the swimming pool average heating demand (kWh/yr) over one year. Yearly results can be extrapolated through measurements obtained from a representative measurement campaign.
2. Determine the hot water demand for showers (m^3) and the average heating energy demand of shower hot water over one representable period (kWh/h)
3. Determine the ventilation system average heating and cooling demand for the swimming pool area over one representable year (kWh/yr), from an annual representative measurement campaign.
4. Determine swimming pool total energy demand over one year (kWh/yr).

Specification of methodology for evaluation

1. Measured swimming pool average heating demand (kWh/h) before and after implemented measures shall be compared. Individual measures that influence the heating demand shall be carried out one by one and evaluated. Measurements shall be conducted on a representative time period.
2. Measured average recovered heat from showers shall be compared with the average energy demand for shower hot water. Measurements shall be representative time period using at least 1 day resolution.
3. Ventilation system heating and cooling demand (kWh) after the measure has been implemented shall be compared with the baseline case. The total swimming pool average energy demand (kWh) after all measures have been implemented shall be measured and compared with the baseline. Measurements shall be conducted on an hourly basis.

Specification of quantifiable parameters to be monitored

1. Water temperature in the pool(s).
2. Swimming pool average heating demand (kWh).
3. Average recovered heat from showers (kWh/h).
4. Average energy demand for shower hot water (kWh/h).
5. Ventilation system heating and cooling demand (kWh).
6. The total swimming pool average energy demand (kWh).

Specification of Key Performance Indicators to be determined

1. Decrease of heating demand due to heat pump for dehumidification compared to baseline total heating demand (%).
2. Decrease of heating demand due to pool insulation compared to baseline total heating demand (%).
3. Decrease of heating demand due to night covers of the pool compared to baseline total heating demand (%).
4. Heat recovery ratio of shower waste water heat recovery system (%) and heat recovery system annual total COP.
5. Decrease of heating demand of ventilation due to heat pumps in ventilation system compared to baseline ventilation heating demand (%).
6. Decrease of energy demand of swimming pool due to all measures compared to baseline case (%).

Determination of the KPI will be measured, if possible, otherwise estimated using models.

3.2.3.5 Metering and sensors

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.1.3	Metering and sensors	Aj. Barcelona	KTH-EGI

Description of Measure

Smart meters – to manage the grid and to incentivize the demand and supply, it is essential to install smart metering that can monitor the net electricity flow at each users inlet. In sunny climates the electricity use is closely connected to the weather conditions. Good forecasting is essential to plan for storage before demand rises

Intentions

1. Enable opportunity to decrease demand through incentivizing the consumers.

Definition of baseline and how it will be determined

1. No baseline will be needed, measure will be evaluated under Smart Measure 3.1

Specification of methodology for evaluation

1. Measure will be evaluated under Smart Measure 3.1

Specification of quantifiable parameters to be monitored

1. No parameters to be monitored under this Measure. Parameters are determined in the evaluation under Measure 3.1.

Specification of Key Performance Indicators to be determined

1. No Key Performance Indicators developed under this measure, Measure is evaluated under Measure 3.1.

3.2.3.6 Smart Energy and Self-Sufficient Block

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.2.1	Self-sufficient block: photovoltaic on-site production	IREC, Gas Natural, Schneider	KTH-EGI

Description of Measure

Control of energy systems in residential and tertiary buildings by means of Home Energy Management System and Building Energy Management System (BEMS) will allow better control and minimize consumption of fossil fuels and electricity. The local renewable energy production is mainly dependent on weather conditions. BEMS has the capacity of planning an optimal supply/demand of energy and ensuring a system balance at real time. BEMS is able to manage energy supply, demand and storage at real time:

- It is able to manage the monitored data from grid-connected systems;
- It is able to decide the optimal behavior of the system at real time based on final user's choice (e.g. cost minimization, environmental footprint, peak shaving, etc.)

In order to do that, BEMS inputs are: weather forecast affecting RES production, energy prices forecast and demand forecast in order to correctly balance the system at real time.

This information will be included in a control software integrating block's electrical energy demand, RES, and available energy storage systems that will balance permanently production and storage capacity versus consumption needs.

Intentions

1. Enable opportunity to increase renewable energy fraction in the local area.

Definition of baseline and how it will be determined

1. Determine the amount of electricity used on-site.

Specification of methodology for evaluation

1. Determine the amount of renewable energy with the BEMS and RES activated and compare with baseline.

Specification of quantifiable parameters to be monitored

1. Supplied renewable energy from local production (kWh).
2. Supplied total energy (renewable and non-renewable) from local production (kWh).
3. All measurements shall be done on an hourly basis. Climatic conditions for the specific site, for example,dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas).
4. Production shall be normalized with respect to a typical climatic year.

Specification of Key Performance Indicators to be determined

1. Increased fraction of renewable energy in local energy system (%).
2. Reduced CO_2 emissions due to reduced energy demand (kt/year).

3.2.3.7 Combined electrical charging and street lighting poles + Wifi-to-grid connection+ Smart Meter information analysis and actuators.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
5.2	Combined electrical charging and street lighting poles + Wifi-to-grid connection	ENDESA, RETEVISION	KTH-EGI
5.3	Smart Meters and Actuators	ENDESA	KTH-EGI

Description of Measure

5.2.- In order to save energy and rationalize public space, RETEVISION will deploy a "Smart Multifunctional Tower" in which lighting, environmental sensors and communications equipment will be integrated in a single lighting pole. Regarding the communications equipment, a Wi-Fi access point will be installed in the lighting pole. Furthermore, the overall performance of these "Smart Multifunctional Towers" will be monitored from the energy point of view through the Multi Service Concentrator" (MSC), developed in mesure 5.3 by Endesa. The MSC will also monitor from the energy point of view other public assets such as lighting, traffic lights and electrical vehicle recharging units through the GrowSmarter Platform.

5.3.- The smart meter information will be used to better assign priorities on the energy asset management. Smart Meter information of these public assets will be available through the GrowSmarter platform.

Intentions

1. Enabling smart solutions through better possibility to connect devices.

Definition of baseline and how it will be determined

1. Measure the average energy needed to operate traditional lighting and traffic lights and compare with the average energy needed to operate smart lighting and traffic lights. (kWh).
   Also, it will be measured average energy demanded for EV.
   Measurements should be carried over a representable week and for a relevant number of different equipment.

Specification of methodology for evaluation

1. Measure average energy demand of MSC over one representable week (kWh/h) and compare with baseline.

Specification of quantifiable parameters to be monitored

1. Energy demand of traditional services (kWh/h).
2. Energy demand of New Smart Services (traffic and lighting) (kWh/h).
3. Energy demand of EV (kWh/h)
4. Data traffic relayed over Smart Towers (Mb).

Specification of Key Performance Indicators to be determined

1. Average energy demand of traditional services (kWh/h) per week.
2. Average energy demand of New Smart Services (kWh/h) per week.
3. Average data traffic relayed over smart street and traffic posts (Mb) per week.
4. Reduced CO_2 emissions due to reduced energy demand (kt/year).
5. Reduced CO_2 emissions due to increase use of EV (kt/year).

3.2.3.8 District heating and cooling rings.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
6.2.1	Solar panels	Gas Natural, IREC	KTH-EGI
6.2.2	Heat pumps		
6.2.3	Micro CHP		

Description of Measure

The District heating and cooling network will be optimized and make use of local energy generation from solar panels, heat pumps (absorption) and micro CHPs connected to a new heating and cooling net. This will be integrated with the electricity production and managed by the Smart Energy and Self-Sufficient Block (measure 4.2) making a truly integration of all energy systems at block level. GNF will coordinate the work included in this measure and together with Aiguasol define the smart energy and self-sufficient blocks.

Intentions

1. Integrated control of heating, cooling and electricity enabling the operation of the self-sufficient block (Measure 4.2).

Definition of baseline and how it will be determined

1. The measure is enabling Measure 4.2 and is evaluated under Measure 4.2.1

Specification of methodology for evaluation

1. The measure is enabling Measure 4.2 and is evaluated under Measure 4.2.1

Specification of quantifiable parameters to be monitored

1. None at this time.

Specification of Key Performance Indicators to be determined

1. None at this time.

3.2.3.9 Smart local thermal districts.

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
6.3	Smart local thermal districts	Aj. Barcelona, IREC	KTH-EGI

Description of Measure

Smart local thermal district (offices, residential and social spaces) will demonstrate integration in existing district heating and cooling network including PV generation. The results will demonstrate the technical and social viability of this type of solution at higher scale and the total consumption from the grid will be nearly zero.

Intentions

1. By implementing smart integrated local energy generation, the local area will be close to self-sufficient when it comes to thermal energy.

Definition of baseline and how it will be determined

1. Determine the local area annual total energy demand (kWh), broken up into heating, cooling, electricity, and normalized to a typical climatic year.

For buildings where the intended purpose (e.g. apartments, after implementing measure) of the building is significant different from the original purpose of the building (e.g. storage facilities), the baseline shall be determined by building energy simulation according to standard ISO 13790 or equivivalent procedure.

Specification of methodology for evaluation

1. The local area annual energy demand for heating, cooling and electricity after the smart local thermal district have been implemented shall be compared to the baseline case.
2. Comparison shall be done for a typical climatic year.

Specification of quantifiable parameters to be monitored

1. Delivered locally generated heating energy (kWh/h) over one year.
2. Delivered locally generated cooling energy (kWh/h) over one year.
3. Delivered locally generated electric energy (kWh/h) over one year.
4. Delivered bought heating energy (kWh/h) over one year.
5. Delivered bought cooling energy (kWh/h) over one year.
6. Delivered bought electric energy (kWh/h) over one year.
7. Required climatic conditions for the specific site, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas), for the duration of one year. Sampling interval shall be one hour.

Specification of Key Performance Indicators to be determined

1. Fraction of locally generated heating energy compared to baseline case (%).
2. Fraction of locally generated cooling energy compared to baseline case (%).
3. Fraction of locally generated electric energy compared to baseline case (%).
4. Reduced CO_2 emissions due to reduced energy demand (kt/year).
5. Savings in final and primary energy.

3.2.4 Measures of Cologne

3.2.4.1 Efficient lighting

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
1.1.9	Efficient lighting	DEWOG	KTH-EGI

Description of Measure

By implementing different energy saving measures a significant amount of electric energy can be saved. The lighting in elevators will be controlled efficiently. These lights will, if they are on at all times, consumes as much electricity as the elevator motor. The elevator motor will also be controlled efficiently. LED lighting will be used in common spaces and energy efficient appliances in common laundry rooms.

Intentions

1. Reduce electricity demand by implementing smart new systems for the property electrical system.

Definition of baseline and how it will be determined

1. Measure property electricity consumption (kWh/m^2) for a year.
2. Lighting intensity, illuminance (lx).

Specification of methodology for evaluation

1. Establish reference area for comparison measurement
2. Establish electrical need for improved system.

Specification of quantifiable parameters to be monitored

1. Measure property electricity consumption (kWh/m^2) for a year.
2. Lighting intensity, illuminance (lx).

Specification of Key Performance Indicators to be determined

1. Lighting intensity (lx)
2. Annual electric energy use (kWh/m^2).
3. Reduction of electrical consumption related to baseline.

3.2.4.2 Local production

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.1.1	Local production	Rhein Energie	KTH-EGI

Description of Measure

Installation of photovoltaic's, mainly on rooftops and facades, and CHP.

Intentions

1. Decrease the need of externally supplied energy by local production units.
2. Increased amount of renewable share of energy consumption.

Definition of baseline and how it will be determined

1. Establish demand of externally supplied energy.
2. Establish the renewable share of the supplied energy.

Specification of methodology for evaluation

1. Measure the energy supplied by local production unit.
2. Determine the share of externally supplied energy.
3. Determine the share of renewable energy supplied, both locally and externally.

Specification of quantifiable parameters to be monitored

1. Energy supplied from local production unit (kWh/h). The energy supply should be logged continuously using an energy meter.
2. Bought energy delivered into the area of interest (kWh/h).
3. Climatic conditions, i.e. dry-bulb air temperature (°C), humidity (-), wind speed (m/s), wind directions (°), direct beam (normal) solar radiation (W/m²), global radiation on horizontal surface (W/m²), diffuse radiation on horizontal surface (W/m²), total cloud cover (Octas).[11]

Specification of Key Performance Indicators to be determined

1. Measured energy supplied by local production unit (kWh/year).
2. Measured energy supplied by local production unit (kWh/h).
3. Share of total renewable energy supplied of total local demand (%).
4. Share of external renewable energy supplied of total local demand (%).
5. Reduced CO_2 emissions due to reduced energy demand (kt/year).

[11] Data for any location in the Cologne area may be used.

3.2.4.3 Demand/Storage

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.1.2	Demand/Storage	Rhein Energie	KTH-EGI

Description of Measure

A number of actions are going to be implemented:

- Dynamic pricing for individual households and industry, reducing electricity usage during scarcity periods
- Decision to store/not store the cars be managed by the manager
- VPP (settlement managing system) managed Batteries,
- Charging of Electric Vehicles – a price model will allow for temporarily reduction of the electricity to charging stations. A driver in no hurry can utilize this cheaper price model
- Heat pumps for heat storage in heating system and hot tap water system for each building.

Intentions

1. Better load balancing through dynamic pricing and increased storing capacity will lead to better utilization of energy.

Definition of baseline and how it will be determined

1. Establish the electric grid and district heating 100 highest average peak loads during one year (kWh/h).

Specification of methodology for evaluation

1. Measure the average peak loads in the district heating network and the electric grid per building during one year after the implementation of the actions (kWh/h) and compare to baseline case.

Specification of quantifiable parameters to be monitored

1. Average peak loads in the heating network (if applicable) and the electric grid per building during one year after the implementation of the actions (kWh/h).

Specification of Key Performance Indicators to be determined

1. Magnitude of peak loads (kWh/h).
2. Number peak loads (-).
3. Reduced CO_2 emissions due to reduced energy demand (kt/year).

3.2.4.4 Metering and sensors

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
4.1.3	Metering and sensors	Rhein Energie	KTH-EGI

Description of Measure

Smart meters – to manage the grid and to incentivize the demand and supply, it is essential to install smart metering that can monitor the net electricity flow at each users inlet.

Intentions

1. Enable opportunity to decrease demand through incentivizing the consumers.

Definition of baseline and how it will be determined

1. No baseline will be needed, measure will be evaluated under Smart Measure 3.1

Specification of methodology for evaluation

1. Measure will be evaluated under Smart Measure 3.1

Specification of quantifiable parameters to be monitored

1. No parameters to be monitored under this Measure. Parameters are determined in the evaluation under Measure 3.1.

Specification of Key Performance Indicators to be determined

1. No Key Performance Indicators developed under this measure, Measure is evaluated under Measure 3.1.

3.3

3.3 Measures, Integrated Infrastructure

3.3.1 Smart energy saving tenants - Stockholm

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
3.1.1	Active house	Fortum	KTH IE

(3.1.5-3.1.10)

Description of Measure

Utilizing in-home and near real-time visualization on household energy* consumption and steering signals for behavioral changes.

* Defined as electricity and hot tap water

Intentions

1. Increase energy awareness and efficiency in households
2. Reduce climate impact from household energy consumption
3. Increase comfort and quality of living

Definition of baseline and how it will be determined

1. Measuring of electricity and hot tap water consumption on representative reference building during the test period (as collection of baseline data from test building pre implementation is impossible, due to no individual measuring on household level). In addition, the issue of metering for the reference building is owned by Stockholmshem and must be coordinated with Fortum and KTH. This means that Stockholmshem is responsible for supplying reference values.

2. Surveying residents on comfort life with regards to household energy consumption pre and post the test period

Specification of methodology for evaluation

1. Statistical data analysis on changes in household energy consumption patterns
   - Energy savings and peak load reduction as an effect of steering signals and energy visualization

2. Calculations on climate impact potential as an effect of changes in household energy consumption patterns

3. Qualitative evaluation on changes in household energy consumption

Specification of quantifiable parameters to be monitored

1. Measuring of household energy consumption
   - Hourly measuring of electricity and hot tap water consumption (kWh, liters)**

2. Tracking of visualized information and indoor temperature
   - Hourly tracking of steering signals and energy visualization
   - Hourly tracking of indoor temperature

3. Survey pre and post implementation and number of technical interruptions and incidents.

** With the prerequisite that the customers agree on sharing this information

Specification of Key Performance Indicators to be determined

- Electricity and hot tap water consumption (kWh and liters per household) and load shift level (%)

- Climate impact potential of changes in energy consumption

- Perceived change in household behavior and average system availability

3.3.2 Smart energy saving tenants - Cologne

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
3.1.2 (3.1.5-3.1.7)	Smart home system	Rheinenergie, AGT International	KTH IE

Description of Measure

Utilizing in-home real-time visualization on household energy consumption and dynamic steering signals for behavioral changes.

Intentions

1. Increase energy efficiency in households
2. Reduce climate impact from household energy consumption
3. Increase comfort and quality of living

Definition of baseline and how it will be determined

1. Measuring of household energy consumption pre implementation
   - Electricity consumption on a household level* during at least 3 months before implementation.

2. Measuring of household energy consumption on representative reference households** during the test period
   - Hourly electricity consumption on a household level.

3. Surveying residents on comfort life with regards to household energy consumption pre and post the test period.

* Hourly data on a household level is preferable, but if it cannot be obtained, data on building level is considered as the second best option.
** Baseline data from the actual apartments where the Home Energy Management System will be installed is preferable, but if it cannot be obtained, data from representative reference households is considered as the second best option.

Specification of methodology for evaluation

1. Statistical data analysis on changes in household energy consumption patterns
   - Energy savings and peak load reduction*** as an effect of dynamic price signals and energy visualization

2. Calculations on climate impact potential of changes in household energy consumption patterns
   - Changes in climate impact as an effect of energy savings and load shift***

3. Statistical survey evaluation on comfort life with regards to household energy consumption

*** With the prerequisite that customers has agreed on such a tariff

Specification of quantifiable parameters to be monitored

1. Measuring of household energy consumption
   - Hourly (if possible) measuring of electricity on a household level* during the test period.

2. Tracking of visualized information
   - Tracking of price signals and energy visualization

3. Survey pre and post implementation and number of technical interruptions and incidents (see Appendix 2)

* Data on a household level is preferable, but if it cannot be obtained, due to regulations regarding customer data confidentiality, data on building level is considered as the second best option.

Specification of Key Performance Indicators to be determined

1. Energy consumption
   - Per household (kWh/household)
   - Per household size (kWh/sqm.)
   - Per tenant (kWh/capita)
   - Energy savings per household (kWh/household, %/household)
   - Peak load reduction per household (kWh/household,%/household) ***

2. Emissions from energy consumption
   - Per household (CO_2/household)
   - Per household size (CO_2/sqm.)
   - Per tenant (CO_2/capita)
   - CO_2 reductions due to energy savings per household (CO_2/household, %/household)
   - CO_2 reductions due to peak load reduction per household (CO_2/household,%/household) ***

3. Average comfort rating, average system availability

*** If hourly data is available

3.3.3 Smart energy saving tenants - Barcelona

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
3.1.3 (3.1.6+3.1.7)	Home energy management system	GasNatural Fenosa	KTH IE

Description of Measure

Utilizing in-home real-time visualization on household energy consumption and dynamic steering signals for behavioral changes.

Intentions

1. Increase energy efficiency in households
2. Reduce climate impact from household energy consumption
3. Increased comfort and improved life quality.

Definition of baseline and how it will be determined

1. Measuring of household energy consumption pre implementation
    - Hourly electricity consumption and monthly gas consumption on a household level* during a annual representative time period.

2. Surveying residents on comfort life with regards to household energy consumption pre test period.

* Data on a household level is preferable, but if it cannot be obtained, due to regulations regarding customer data confidentiality, data on building level or dwelling typology level is considered as the second best option.
Baseline data from the actual apartments where the Home Energy Management System will be installed is preferable, but if it cannot be obtained, data from national reference profile is considered as the second best option.

Specification of methodology for evaluation

1. Statistical data analysis on changes in household energy consumption patterns
    - Energy savings and peak load reduction*** as an effect of dynamic price signals and energy visualization

2. Calculations on climate impact potential of changes in household energy consumption patterns
    - Changes in climate impact as an effect of energy savings and load shift***

3. Statistical survey evaluation on comfort life with regards to household energy consumption

*** With the prerequisite that customers has agreed on such a tariff and no legal constraints

Specification of quantifiable parameters to be monitored

1. Measuring of household energy consumption
    - Hourly measuring of electricity on a household level* during the test period.

2. Tracking of visualized information and indoor temperature
    - Hourly tracking of price signals and energy visualization

3. Survey pre and post implementation and number of technical interruptions and incidents (see Appendix 2)

* Data on a household level is preferable, but if it cannot be obtained, due to regulations regarding customer data confidentiality, data on building level or dwelling typology level is considered as the second best option.

Specification of Key Performance Indicators to be determined

1. Energy consumption
   - Per household (kWh/household)
   - Per household size (kWh/sqm.)
   - Per tenant (kWh/capita)
   - Energy savings per household (kWh/household, %/household)
   - Peak load reduction per household (kWh/household,%/household)

2. Emissions from energy consumption
   - Per household (CO_2/household)
   - Per household size (CO_2/sqm.)
   - Per tenant (CO_2/capita)
   - CO_2 reductions due to energy savings per household (CO_2/household, %/household)
   - CO_2 reductions due to peak load reduction per household (CO_2/household,%/household)

3.3.4 Evaluation Guideline Measure 5.2

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
5.2	Combined electrical charging and street lighting poles + Wifi-to-grid connection	Stockholm	Stokab	KTH IE ISIE

Description of Measure

By combining multiple functionalities within shared infrastructure such as street lighting poles, traffic lights, and traffic signs, the aim is to make walkable urban areas ubiquitously connected, and enable a shared sensing infrastructure in the open street spaces. By relying on the extensive fiber infrastructure prevalent around the city, new wifi connections will be made available for people and things such as a variety urban sensors that can be analyzed and fed back. Traffic signs will be made available for Telecommunication companies for installing 4G to increase local connectivity.

Intentions

1. To make walkable urban areas ubiquitously connected
2. To provide high-speed internet to people and things in the walkable street environment
3. To enable higher degrees of urban sensing
4. To generate insights from the walkable urban areas
5. To increase 4G connectivity by enabling telecommunication companies to install 4G masts on traffic signs

Definition of baseline and how it will be determined

1. Street level bandwidth from wifi or cellular connection before implementation
2. Number of urban walkable space services and sensors before implementation

Specification of methodology for evaluation

A quantitative metric of number of connections of end-users and things to the new infrastructure. If specific services are developed (based on the new infrastructure and sensors) that engage citizens, bikers, or provide feedback to the municipality, a survey will be designed to capture the feedback of their end-users.

Specification of quantifiable parameters to be monitored

1. Street level bandwidth from wifi or cellular connection
2. Number and type of connections per day
3. Data transfer per day (MB)

Specification of Key Performance Indicators to be determined

1. End-users (of data and services) per day

3.3.5 Evaluation Template Measure 7.1

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
7.1	Optical Sorting of Waste	Stockholm, Årsta, Valla torg	Envac	KTH IE ISIE

Description of Measure

Optically sort collected waste bags from 300+ households within an AWCS terminal into separate waste streams for further processing. The waste bags are entering the AWCS terminal through an underground pipe system transported by force of vacuum. The mixed waste stream consisting of differently coloured bags (no. of fractions TBD) will be optically identified, separated and moved and stored into a dedicated container for that specific waste stream.

Intentions

1. The intention is to simplify recycling and thereby increasing the recycling rates of residents.
2. Increase comfort and quality of living (Clean, convenient, accessible and efficient waste collection service)

Definition of baseline and how it will be determined

1. Garbage Analysis before and after measure to evaluate % recyclables in rest fraction
2. Surveying residents on comfort life with regards to waste management before and after the measure

Specification of methodology for evaluation

1. Life cycle energy and emission calculations on increased recycling rates
2. Statistical survey evaluation on comfort

Specification of quantifiable parameters to be monitored

1. % recyclables in rest waste fraction, kg of waste per fraction, kWh of electricity for vacuum system
2. Survey pre and post implementation, downtime (hours) of waste collection system, and number of incidents

Specification of Key Performance Indicators to be determined

1. Recycling Rate, Metric Tonnes GHGs/Capita, kWh Energy/Capita
2. Average comfort rating, average system availability

3.3.6 Evaluation Template Measure 7.2

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
7.2	Automated Waste Collection	Stockholm, Årsta, Valla torg	Envac	KTH IE ISIE

Description of Measure

Design and deliver/ install one automated waste collection system in an existing urban neighborhood. Households sort their waste and recyclables into different colored bag, each bag representing a fraction. Inlet points will be equipped with RFID-readers identifying the user who opens the inlet with the RFID-tag. A color sensor will recognize the color of the waste bag deposited thereby identifying type of waste. The inlet is equipped with a weight scale recording the weight of the deposition as well as with a compactor compacting the bags before pipe transport by air to a central waste terminal.

Intentions

1. The intention is to make local waste collection more efficient and enable a better local environment (local noise and pollution)

Definition of baseline and how it will be determined

1. Prior to implementation, a baseline of current vehicle trucks in the area is to be determined. The baseline period should cover at least one full month that does not occur during vacation intensive months (Jun-Aug and December).
2. Prior to implementation, a baseline, the weight of waste collected by existing trucks in the area
3. Prior to implementation, a baseline of noise levels should be captured during truck waste collection by a noise monitoring expert.

Specification of methodology for evaluation

1. Life cycle energy and emission comparison of the two different waste collection systems
2. Noise comparison of the two different waste collection systems

Specification of quantifiable parameters to be monitored

1. Net electricity use (kWh) for vacuum system, vehicle kilometers of waste collection trucks from Envac terminal
2. Weight of waste collected by trucks from Envac terminal
3. Noise levels (dB) when vacuum system of waste collection is activated

Specification of Key Performance Indicators to be determined

1. Metric Tonnes GHGs/kg collected waste, kWh Energy/ kg collected waste

3.3.7 Evaluation Template Measure 7.3

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
7.3	Automated Waste Collection	Stockholm, Årsta, Valla torg	Envac	KTH IE ISIE

Description of Measure

Recording of waste related statistics derived from individual deposition of sorted waste and recycable bags at inlet points of an AWCS. Inlet points in an AWCS serving upto 1000 households are equipped with RFID key readers identifying the user (household or buisiness) and furnished with colour sensors to recognise type of waste by the color of the bag. In addition inlets have a scale wheighing each bag. All the information is passed on to a central database where statistics can be retreived.

Statistics collected can be sorted per inlet, per individual household, per waste stream or at a certain given time. Statistics can be tied to an incentive system or to a charging system. Bonus features can be connected to promote certain behaviour.

Intentions

1. Household can be made aware of their waste behaviors and its impacts
2. The municipality can be provided with better data and promote more sustainable recycling practices
3. The recycling industry can get information on collected pre-sorted raw material to be delivered
4. Energy producers can get information on collected pre-sorted raw material to be delivered

Definition of baseline and how it will be determined

1. Household survey of existing awareness of their own recycling behaviors and their consequences
2. A baseline of one year of waste generation data without feedback or incentives

Specification of methodology for evaluation

1. Statistical household survey on awareness before and after implementation
2. One year of waste generation data with feedback and/or incentives
3. Summary report of new services or opportunities within municipality, recycling industry, or energy producers

Specification of quantifiable parameters to be monitored

1. Weight of fraction and time of generation by household
2. Household survey before and after feedback is implemented

Specification of Key Performance Indicators to be determined

1. % Recycling rates
2. Waste generation kg/capita
3. GHG/Capita
4. Relative awareness (survey based)

3.3.8 Evaluation Guideline Measure 8.1

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
8.1	Big consolidated open data platform	Stockholm, Barcelona, Cologne	IBM (S) Barcelona Supercomputing Center (B), AGT (C),	KTH IE ISIE

Enabling Measure

All measures in Section 8 are enabling measures, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of these measures.

Description of Measure

By consolidating, aggregating and using existing and new sensor data from infrastructure, traffic and users will generate a new base for innovation to support a new generation of management, control and policies. We will also be able to monitor the status and the impact of various measures in real time to a low cost. It will also be possible to simulate short and long term trips and transports in more detail in a dynamic way to improve the quality of decisions. By this we will manage environment and other impacts more efficiently but also open for new generations of policies as well as accelerate innovation of new services based on the open and available data. Finally this platform also will form a base for dialogue with citizens and the business community by a more transparent management.

In order to improve the energy efficiency on the public infrastructure, we will integrate information from City OS or other Service Provider System that manages data from assets. The platform will monitor the overall performance of lighting, traffic, bus shelters, environmental, and small EVSE from the energy point of view, assign priorities and command based on decision making algorithms via a "multi-functionality towers".

Intentions

1. Integrating asset data and monitoring performance
2. Enabling real-time measurement and verification of Grow Smarter measures
3. Making generated Grow Smarter data accessible for management, evaluation, and policies
4. Enabling smart city services
5. Enabling dialogue with citizens and business community
6. Enable insights of the urban spaces derived from those sensors.

Definition of baseline and how it will be determined

1. Performance baselines covered in enabled Grow Smarter measures

Specification of methodology for evaluation

1. Qualitative surveys
2. Quantitative evaluation of metrics that describe how well the outcomes correlate with the described intentions

Specification of quantifiable parameters to be monitored

1. Big Data: What is the size of data managed within the project (GB / Day and GB Total)
2. Big Data Integration: How many distinct data sources have been integrated due to the implementation of this measure?
3. Estimated electricity use in data centers for storage, access, and processing (kWh / Day)
4. What percent of intended grow smarter measures have been enabled for real-time evaluation? (%)
5. What percentage of policy makers, businesses, and researchers within the project has received satisfactory access to grow smarter data?
6. How many smart city services have been enabled due to the implementation of this measure? (Survey/Interview-based)
7. How many innovations, if any, have been enabled due to the implementation of this measure? (Survey/Interview –based)
8. How many insights that can lead to new policies and practices have been enabled or generated due to this measure? (Survey/Interview -based)
9. Numbers of end-users that have accessed generated data and services

Specification of Key Performance Indicators to be determined

1. Big Data Velocity and Volume
2. Big Data Variety
3. Big Data Energy Use
4. % Enabling Factor
5. Monitoring Accessibility
6. Number of enabled services
7. Number of enabled innovations
8. Type and number of customers that have accessed services
9. Number of insights

3.3.9 Evaluation Guideline Measure 8.2

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
8.2	Semantic Urban Model	Barcelona, Cologne	Barcelona Supercomputing Center (B), AGT (C),	KTH IE ISIE

Enabling Measure

All measures in Section 8 are enabling measures, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of these measures.

Description of Measure

Building a model that reflects the structure, processes, and events specific to urban environments for the three vertical domains of interest: mobility, energy and integrated infrastructures. It may contain other more general concepts such as geopositioning, time, and KPIs, which are required by the modules computing e.g. carbon footprint and pollution. This data integration platform will provide semantic access for any service that wants to access Barcelona's data (including the modeled domain-transversal data) - geo- positioned when available - either in raw form or in form of aggregated indicators.

Intentions

1. A digital semantic model representation of urban structure, processes, and events
2. Semantic access to data
3.

Definition of baseline and how it will be determined

1. Performance baselines covered in enabled Grow Smarter measures

Specification of methodology for evaluation

1. Qualitative surveys
2. Quantitative evaluation of metrics that describe how well the outcomes correlate with the described intentions

Specification of quantifiable parameters to be monitored

1. A summary report describing how much of the urban environment that have been modeled
2. Big Data Integration: How many distinct data sources have been integrated due to the implementation of this measure?
3. Estimated electricity use in data centers for storage, access, and processing (kWh / Day)
4. What percent of intended grow smarter measures have been enabled for real-time evaluation? (%)
5. How many smart city services have been enabled due to the implementation of this measure? (Survey/Interview-based)

Specification of Key Performance Indicators to be determined

1. Big Data Variety
2. Grow smarter measures enabled for monitoring %
3. Number of enabled services

3.3.10 Evaluation Guideline Measure 8.3

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
8.3	Semi-automatic instance mapping	Barcelona, Cologne	Barcelona Supercomputing Center (B), AGT (C),	KTH IE ISIE

Enabling Measure

All measures in Section 8 are enabling measures, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of these measures.

Description of Measure

The semantic urban model needs to be populated with actual data to take full advantage of the power of the approach. This step consists in the semantic mapping of the data to the concepts and is usually time consuming. Semi-automating this process is possible. We will use new technologies to semi-automatically map urban data to specific city. This problem is highly relevant when other want to populate the city model with their data. This requires finding correspondences between concepts and relationships embedded in the data, on one hand, and explicit in the ontology, on the other.

Intentions

1. Simplify (i.e. semi-automate) the process of introducing new and previously unmapped data

Definition of baseline and how it will be determined

1. Performance baselines covered in enabled Grow Smarter measures

Specification of methodology for evaluation

1. A summary report describing how much faster/easier it is to use the semi-automatic approach

Specification of quantifiable parameters to be monitored

N/A

Specification of Key Performance Indicators to be determined

N/A

3.3.11 Evaluation Guideline Measure 8.4

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
8.4	Integration of sensor data in standard data format	Barcelona	Barcelona RETEVISION (B)	KTH IE ISIE

Enabling Measure

All measures in Section 8 are enabling measures, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of these measures.

Description of Measure

We will provide a platform for integration of sensor data coming from different producers (e.g. deployed sensors, data from proprietary platforms, open data repositories, etc) and using different formats based on a uniform, standard-driven format. This platform will provide a set of APIs to access the sensor data from the open linked city model, and will publish the integrated data --- raw or aggregated. We will also be building a Web portal that can access and visualize raw and aggregated data from sensor infrastructures managed by the city of Barcelona and other trusted third parties, partners in this project.

Intentions

1. Facilitate new sensor deployment
2. Facilitate new sensor analytics/visualization

Definition of baseline and how it will be determined

1. Performance baselines covered in enabled Grow Smarter measures

Specification of methodology for evaluation

1. A quality satisfaction survey among sensor and data owners regarding the new platform
2. A quantitative assessment of the number of integrated sensors
3. A quantitative assessment of the number of end-users of the visualization interfaces and their affiliation (municipality, research institute, grow smarter project)

Specification of quantifiable parameters to be monitored

Number of integrated sensors and type

Number of end-users and affilitation

Specification of Key Performance Indicators to be determined

Quality satisfaction – Sensor integration platform

Sensor adaptation

End user adaptation

3.3.12 Evaluation Guideline Measure 8.5

Measure

Nr	Description	Location	Responsible Evaluation Partner	Responsible Validation Partner
8.5	Sustainable Connected lighting to enhance safety and mobility	Barcelona	RETEVISION (B)	KTH IE ISIE

Enabling Measure

All measures in Section 8 are enabling measures, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of these measures.

Description of Measure

To develop an API (Application Programming Interface) for smart lighting systems implemented by measure 5.2 able to communicate the lighting management system with other applications (e.g. traffic management, weather systems) and software platforms in order to exchange data between systems. The solution will demonstrate a lighting technology agnostic system which means all kinds of luminaires (also third party products and new future innovative light sources) can be connected to the management system by developing their own APIs. The lighting infrastructure will be managed by a system that will seamlessly connect to the GrowSmarter Platform or other SW platforms available in other cities using an API based on open standards. This means that lighting will be influenced not just by the decisions of the lighting system, but also by other systems managing other asset. The proposal seeks to motivate also a change of mind, realizing what the intelligent public lighting can do for cities when they become more interactive and create the base for novel services within the city.

Intentions

1. Facilitate integration of lighting management systems with other city services and infrastructures

Definition of baseline and how it will be determined

1. Performance baselines covered in enabled Grow Smarter measures

Specification of methodology for evaluation

1. A report detailing the development status, opportunities and barriers of the city lighting API
2. A quality satisfaction survey among invited city service providers, covering their satisfaction,

views, opinions regarding the API

Specification of quantifiable parameters to be monitored

City Lighting API satisfaction

Specification of Key Performance Indicators to be determined

Quality satisfaction – Sensor integration platform

API adaptation

3.4 Measures, Sustainable Urban Mobility

Definition of baseline parameters for transports (collectively reported by each defined site in Stockholm, Cologne and Barcelona)

In order to define a "quantitative" baseline for each site (Stockholm, Barcelona, Cologne) the parameters given in table 1 and 2 below need to be reported by each city. This enables an assessment of what is needed at a macro level in each site to reach the 60 % emission/energy reduction target, and how the respective measures assist target fulfillment. This also brings essential information in order to characterize the three city districts in GrowSmarter in relation to other city districts or cities when upscaling the results.

The aim is to evaluate all measures in section 3.4 according to the evaluation plan defined for each measure in separate sections throughout chapter 3.4. Each responsible partner has reviewed and got the opportunity to adjust and modify the evaluation plan according to local circumstances and availability of data. However, specific further modifications may become necessary due to unexpected restrictions of data accessibility or other unforeseen technical hitches.

Stockholm baseline parameters

Table 1a. Stockholm baseline parameters per travel mode per year

Site specific baseline parameters	Car (driver)	Car (passenger)	Car sharing	Park and Ride	Public Transport
Number of trips per travel mode					
Number of kilometers per travel mode					
Emissions per vehicle kilometer					
kWh per vehicle kilometer					
Emissions per person kilometer					
kWh per person kilometer					

Site specific baseline parameters	Train	Bus	MC/Moped	Bike	Walk
Number of trips per travel mode					
Number of kilometers per travel mode					
Emissions per vehicle kilometer					
kWh per vehicle kilometer					
Emissions per person kilometer					
kWh per person kilometer					

Table 2a. Stockhollm baseline parameters for heavy vehicles per year

Site specific baseline parameters	Heavy vehicles
Number of vehicles passing	
Number of vehicle kilometers	
Emissions per vehicle kilometer	
kWh per vehicle kilometer	
Average velocities during peak-hours	
Share of renewable fuels (% of energy)	

Barcelona baseline parameters

Table 1b. Barcelona baseline parameters per travel mode per year

Site specific baseline parameters	Car (driver)	Car (passenger)	Car sharing	Park and Ride	Public Transport
Number of trips per travel mode					
Number of kilometers per travel mode					
Emissions per vehicle kilometer					
kWh per vehicle kilometer					
Emissions per person kilometer					
kWh per person kilometer					

Site specific baseline parameters	Train	Bus	MC/Moped	Bike	Walk
Number of trips per travel mode					
Number of kilometers per travel mode					
Emissions per vehicle kilometer					
kWh per vehicle kilometer					
Emissions per person kilometer					
kWh per person kilometer					

Table 2b. Barcelona baseline parameters for heavy vehicles per year

Site specific baseline parameters	Heavy vehicles
Number of vehicles passing	
Number of vehicle kilometers	
Emissions per vehicle kilometer	
kWh per vehicle kilometer	
Average velocities during peak-hours	
Share of renewable fuels (% of energy)	

Cologne baseline parameters

Table 1c. Cologne baseline parameters per travel mode per year

Site specific baseline parameters	**Car (driver)**	**Car sharing**		**Bike**		**Bus**
		Electricl	**Conventional**	**Electrical**	**Conventional**	
Number of trips per travel mode						
Number of kilometers per travel mode						
Emissions per vehicle kilometer						
kWh/petrol per vehicle kilometer						
Emissions per person kilometer						
kWh per person kilometer						

Table 2c. Cologne baseline parameters regarding reservable parking lots

Site specific baseline parameters	**Reservable public and private parking lots**
Number of reservable municipality parking lots	
Number of parking bookings on reservable municipality parking lots	
Duration of parking bookings on reservable municipality parking lots	
Savings of CO2-Emissions	

3.4.1 Evaluation Guideline for Measure 2.1

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
2.1	Integrated multi-modal transport for construction materials/logistics center in Årsta (Stockholm)	Carrier, Info24	KTH IE IESE

Description of Measure

A center will be established in Årsta to handle the incoming construction materials. All deliveries under a set amount will deliver to the logistics center where it will be consolidated with other goods and then delivered to the site where it is needed, when it is needed. This will save time for delivery firms and at the building site as it avoids the need to handle all the smaller deliveries and manage on-site logistics and security. It will also save both time and money as the materials get delivered at the right time. This saves about two or three times of reshuffling the materials at the building sites which saves both time and reduces the damage caused on the goods. This very logistic centre will be located at a train station, which will provide opportunity to deliver some construction material by train, which is very unusual in the construction business.

Intentions: describe how evalutation could prove that measure contributes to one or more of the following efficiencies

A. Reducing traffic volumes
B. Transition to more energy/emission-efficient transport alternatives
C. Transition to renewable fuels
D. Improved traffic flows

Define the site

A. Number of kilometers street/road links where measure will be implemented

Definition of baseline parameters for transports (collectively reported by each defined site in Stockholm, Cologne and Barcelona)

A quantitative baseline need to be reported for each site based on the parameters given in table 1 and 2 below.

Table 1. Baseline parameters per travel mode per year

Site specific baseline parameters	Train
Number of trips per travel mode	
Number of kilometers per travel mode	
Emissions per vehicle kilometer	
kWh per vehicle kilometer	
Emissions per person kilometer	
kWh per person kilometer	

Table 2. Baseline parameters for heavy vehicles per year

Site specific baseline parameters	Heavy vehicles
Number of vehicles passing	
Number of vehicle kilometers	
Emissions per vehicle kilometer	
kWh per vehicle kilometer	
Average velocities during peak-hours	
Share of renewable fuels (% of energy)	

Specification of methodology for evaluation of measure 2.1
Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time
Quantifiable indicators needed for the evaluation are given in table 3 below:

Table 3. Impact from measure 2.1 on heavy vehicle traffic

Measure 2.1	Number of heavy vehicle kilometers in the area	Average emissions per heavy vehicle kilometer (Kg CO2/km)	Average energy use per heavy vehicle kilometer in the site (kWh/km)	Number of heavy vehicle kilometers shifting to renewable fuels due to measure 2.1 (km)	Number of heavy vehicle kilometers reduced due to measure 2.1 (km)
Key indicators baseline					
Key indicators 12 months					
Key indicators 24 months					
Key indicators 36 months					
Key indicators 48 months					
Key indicators 60 months					

Measure 2.1	Average emissions per heavy vehicle kilometer applying measure 2.1 (Kg CO2/km)	Average energy use per heavy vehicle kilometer applying measure 2.1 (kWh/km)	**Total estimated reduction of emissions (Kg CO2) due to measure 2.1 based on indicators**	**Total estimated reduction of energy use (% kWh) due to measure 2.1 based on indicators**	**Total estimated reduction of emissions (% CO2) compared to baseline**
Key indicators baseline			–	–	–
Key indicators 12 months			Kg CO2	% kWh	% CO2
Key indicators 24 months			Kg CO2	% kWh	% CO2
Key indicators 36 months			Kg CO2	% kWh	% CO2
Key indicators 48 months			Kg CO2	% kWh	% CO2
Key indicators 60 months			Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 2.1 will be based on interviews with drivers.

3.4.2 Evaluation Template for Measure 9.1

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
9.1	Integrated multi-mode transport for light goods	Stockholmshem, Carrier	KTH IE

Description of Measure

Service boxes will be placed in a central location among the refurbished residential properties, where tenants can receive a 24 h PIN code for home deliveries, which reduces the need to go far away to pick up packages and the need to stay home waiting for the delivery to come. Some boxes will be refridgerated to handle the very popular grocery delivery. To reduce traffic in the area, only bike deliveries will have access to the boxes.

Intentions: describe how evalutation could prove that measure contributes to one or more of the following efficiencies

A. Reducing traffic volumes
B. Transition to more energy/emission-efficient transport alternatives
C. Transition to renewable fuels
D. Improved traffic flows

Define the site

A. Number of people living in the site, potentially applying the measure
B. Number of kilometers street/road links where measure will be implemented

Definition of baseline parameters for transports (collectively reported by each defined site in Stockholm, Cologne and Barcelona)

A quantitative baseline need to be reported for each site based on the parameters given in table 1 and 2.

Specification of methodology for evaluation of measure 9.1

Describe methodology for evaluation using one or several of the following techniques:

E) Traffic flow measurements
F) GPS-technologies in vehicles or other data from transport actors
G) Simulation of traffic flows on specific road links
H) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 9.1 on heavy vehicle traffic

Measure 9.1	Number of heavy vehicle kilometers in the area	Average emissions per heavy vehicle kilometer (Kg CO2/km)	Average energy use per heavy vehicle kilometer in the site (kWh/km)	Number of heavy vehicle kilometers shifting to renewable fuels due to measure 9.1 (km)	Number of heavy vehicle kilometers reduced due to measure 9.1 (km)
Key indicators baseline					
Key indicators 12 months					
Key indicators 24 months					
Key indicators 36 months					
Key indicators 48 months					
Key indicators 60 months					

Measure 9.1	Average emissions per heavy vehicle kilometer applying measure 9.1 (Kg CO2/km)	Average energy use per heavy vehicle kilometer applying measure 9.1 (kWh/km)	**Total estimated reduction of emissions (Kg CO2) due to measure 9.1 based on indicators**	**Total estimated reduction of energy use (% kWh) due to measure 9.1 based on indicators**	**Total estimated reduction of emissions (% CO2) compared to baseline**
Key indicators baseline			Kg CO2	% kWh	% CO2
Key indicators 12 months			Kg CO2	% kWh	% CO2
Key indicators 24 months			Kg CO2	% kWh	% CO2
Key indicators 36 months			Kg CO2	% kWh	% CO2
Key indicators 48 months			Kg CO2	% kWh	% CO2
Key indicators 60 months			Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 9.1 will be based on travel survey to people utilizing the service.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 9.1

Please see document "Travel survey GrowSmarter".

3.4.3 Evaluation Template for Measure 9.2

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
9.2	Micro distribution of freight (Barcelona)	CENIT	KTH IE

Description of Measure

Demonstrate the use of micro platforms or micro Urban Consolidation Centres (mUCC) where transport operators can store their goods and transfer them to electric tricycles for the last mile distribution, covering a designated area. Provision of the mUCC and its related facilities, as well as the installation of the charging infrastructure for the electric tricycles an installed operation zone, which could also be available for citizens. Tricycles will be equipped with sensors to monitor relevant parameters of the service, as well as relevant city environmental parameters, and a dynamic routing algorithm will be implemented. Results will show the technical and social viability of the measure, reducing emissions and calming traffic in inner city streets. The work will be carried out by CENIT, I2CAT, and Barcelona city council together with a subcontracted micro carrier.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Specific KPI's evaluate the shift from conventional vehicles to electric-fuelled vehicles such as tricycles, hence giving evidence of the transition to renewable energy. The reduction of traffic congestion will be evaluated through the indicator: "Number of heavy vehicle kilometers reduced due to measure 9.2 (km)"

Define the site

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

The area that will be served by the last-mile goods distribution is the Sant Martí district, centered mainly in the Rambla del Poble Nou area. This zone has a high density of retail shops and requires an efficient and rapid distribution of goods. It also has some pedestrian streets that facilitate the introduction of such solution beacause tricycles can circulate in both streets and sidewalks. The urban consolidation center may me placed in a commercial mall located very close to the area. At this moment we are in conversations with the Glòries mall, which may provide us with a space in the parquing area. This will also entail new business oportunities for the last-mile operator, since all products bought in the shopping mall, both online or at the shop could be sent by this operator if the residence of the customer is within the range area.

Specification of methodology for evaluation of measure 9.2

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

The methodology used to evaluate the indicators will be to gather information from logistic operators during the monitoring period of the pilot. Also, GPS technology and WLAN scanning techniques will be used to infer the routes followed by the tricycles and track the vehicles (location or speed). Furthermore, the information provided by the motion-tacking sensors embedded in the vehicle (accelerometers, gyroscopes, magnetometers) will be used to infer the number of stops performed by the tricycle determine non-productive times, etc.

To evaluate the qualitative KPI's, surveys will be carried out mainly to the logistic operator employees and citizens close to the area of the consolidation center.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 9.2 on heavy vehicle traffic

Measure 9.2	Number of heavy vehicle kilometers in the area	Average emissions per heavy vehicle kilometer (Kg CO2/km)	Average energy use per heavy vehicle kilometer in the site (kWh/km)	Number of heavy vehicle kilometers shifting to renewable fuels due to measure 9.2 (km)	Number of heavy vehicle kilometers reduced due to measure 9.2 (km)
Key indicators baseline					
Key indicators					

12 months					
Key indicators 24 months					
Key indicators 36 months					
Key indicators 48 months					
Key indicators 60 months					

Measure 9.2	**Total estimated reduction of emissions (Kg CO2) due to measure 9.2 based on indicators**	**Total estimated reduction of energy use (% kWh) due to measure 9.2 based on indicators**	**Total estimated reduction of emissions (% CO2) compared to baseline**
Key indicators baseline	Kg CO2	% kWh	% CO2
Key indicators 12 months	Kg CO2	% kWh	% CO2
Key indicators 24 months	Kg CO2	% kWh	% CO2
Key indicators 36 months	Kg CO2	% kWh	% CO2
Key indicators 48 months	Kg CO2	% kWh	% CO2
Key indicators 60 months	Kg CO2	% kWh	% CO2

Measurable indicators concerning operational impact:

(These indicators will be measured throughout the pilot test to evaluate trends)

- Vehicle types used: Type of vehicle used according to vehicle categories, including any specific vehicle characteristics.
- Number of vehicles (per type): Number of vehicles used per type.
- Vehicle kilometres (per type): The number of vehicle kilometers per vehicle type. (KM/vehicle)
- Roundtrips: Number of roundtrips per vehicle (number)
- Time of roundtrip: average start time (at depot if applicable) and end time of the roundtrip (Time period)

- Deliveries and pick ups: Number of deliveries and pick ups made in a given time period (number)
- Deliveries (and pick-ups) per km: Number of deliveries per km (number/km)
- Volume (weight): Volume delivered and collected during roundtrips (kg, m3 or number)
- Volume (weight) per km: Volume delivered and collected during roundtrips (Kg/km, m3/km or number/km)
- Stops: Number of stops (can differ from the number of deliveries and pick-ups, in case of bundling)
- Time of delivery: Time of delivery is time of the day a delivery or pick up is made (Time period)
- Driving time: Driving time is defined as the average time a vehicle participates in traffic per day (minutes)
- Waiting time: Waiting time is defined as the average time a vehicle has to wait before (un)loading (minutes)
- Loading and unloading time: Loading and unloading time is defined as the average time required for loading and unloading activities.
- Idle time at depot: Idle time is defined as the average time (per day) that a vehicle is not utilized (minutes)
- Load factor: Load factor is defined as the ratio of the average load per vehicle when leaving a depot, divided by its maximum load capacity. The load can be expressed in either kg or m3 (%)
- Vehicle utilization: Vehicle utilisation is defined as the average number of hours a vehicle is used per day (%)
- Handling activities: A description of the handling activities.

Qualitative key performance indicators

Qualitative key performance indicators of measure 9.2 will be based in interviews with drivers and other employees of the third party logistics operator, citiziens and neighbours of the consolidation center**:**

Acceptance level: Acceptance level is defined as the degree to which people favourably receive or approve the measure.

- **Employee satisfaction:** Employee satisfaction is defined as the degree in which employees are satisfied with their work and any operational changes in the organisation.

- **Green reputation, green concern:** Reputation is defined as the degree to which people favour or approve an organisation in terms of their sustainable operations. Green concern is defined as the degree to which an organization is driven by green concerns

- **Spatial consumption:** Spatial consumption is defined as the amount of space (m2) that is assigned for logistic service operations in a given (i.e. demonstration area) area, for example the surface area used for logistics operations (e.g. transhipment, consolidation centres) and the specific use of this land in this area (i.e. industrial, commercial, residential, etc.).

- **Attractiveness public, attractiveness business:** Attractiveness public is defined as the perception of the attractiveness of demonstration area's direct surroundings. Attractiveness business is defined as the perception on the business climate by entrepreneurs; this can be defined as the number of companies established in a given area or by directly asking local entrepreneurs how they perceive the attractiveness of the (local) business climate.

- **Perceived visual and physical nuisance:** Perceived visual intrusion is defined as the degree to which people are troubled, annoyed, frightened or any other way of perceived nuisance due to the presence of freight vehicles and operations.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 9.2

Please see document "Travel survey GrowSmarter"

3.4.4 Evaluation Template for Measure 10.1

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
10.1	Traffic management through MFD	CENIT	KTH IE

Description of Measure

This measure will be carried out by CENIT and the Barcelona city council. Test the new theory on the existence of MFD (see Daganzo 2008) for the urban area (already proven by simulation in Barcelona) as a traffic management tool to assist traffic managers in making decisions on actions to avoid or alleviate congestion in dense urban areas by controlling the entry and evacuation flow rates. It allows the control of the street network performance and traffic state in a reasonable density domain, and the prevention of energy consumption and emissions. This measure includes a traffic management specification, the implementation of the MFD, the traffic information specification, the traffic and air quality visualization and the information delivery. Concurrently it also includes the normalization of signals and technologies in the urban space. This measure will be carried out by CENIT and the Barcelona city council.

Intentions: describe how the evaluation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels

D) Improved traffic flows

The evaluation of this measure will allow to demonstrate that traffic flows can be improved thus reducing congestion. This will be evaluated through simulation using real time data of the traffic flow and density in the Sant Martí district.

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

The site that will host the study is the Sant Martí district located in the north-east side of the city. The area is limited by Diagonal Avenue on one side, by the sea on the other forming a triangular-shaped quarter of the city. This area has a population of 70,000 inhabitants approximately and a density of 203.5 inhabitants/acre.

This urban area has an orthogonal layout of streets with traffic light regulation at each intersection. The aim is to validate that depending on densities and traffic flows within the district traffic lights will help to prevent further vehicles to enter the district during high congestion times.

Specification of methodology for evaluation of measure 10.1

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

To evaluate traffic densities and traffic flows different systems will be used:

- Inductive-loop traffic detectors owned by the municipality of Barcelona are already installed in this district. These systems can detect vehicles passing or arriving at a certain point hence registering the traffic flow in a certain lane.
- Taxi vehicles have a GPS system installed that track their movements within the city. This information can be used to output parameters such as traffic flows by using routes and times. It is estimated that 1,000 taxis will be monitored. That represents 7% of the taxi fleet (approximately 14,000 taxis).

This real-time information will be used to perform computer-based simulations to study how the active management of traffic lights at the edges of the studied area (Sant Martí district) can be used to alleviate traffic congestion.Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 10.1 on personal transports

Measure 10.1	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 10.1 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 10.1 (kWh/km)	**Total estimated reduction of emissions due to measure 10.1 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 10.1 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 10.1 compared to baseline (% CO2)**
Key indicators baseline				Kg CO2	% kWh	% CO2
Key indicators 12 months				Kg CO2	% kWh	% CO2
Key indicators 24 months				Kg CO2	% kWh	% CO2
Key indicators 36 months				Kg CO2	% kWh	% CO2
Key indicators 48 months				Kg CO2	% kWh	% CO2
Key indicators 60 months				Kg CO2	% kWh	% CO2

Measure 10.1	Increase in the average cruising speed for both inner and passing routes (km/h)	Average time savings for both inner and passing trips (aggregated time measurement)	Reduction in traffic density in the area of study(vehicle-kilometer)			
Key indicators baseline						
Key indicators 12 months						
Key indicators 24 months						

Key indicators 36 months						
Key indicators 48 months						
Key indicators 60 months						

Qualitative key performance indicators

Qualitative key performance indicators of measure 10.1 will be based in interviews with drivers.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 10.1

Please see document "Travel survey GrowSmarter".

3.4.5 Evaluation Template for Measure 10.3

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
10.3	Travel Demand management (Stockholm)	KTH, Info24	KTH IE

Description of Measure

A smart phone application (based on an existing application called CERO Challenge) will be developped to follow up changes in travel behaviour among residents living in the area of Årsta. The aim is to obtain a better real-time update of transport behaviour in comparison to traditional travel surveys. This will also function as a useful information channel regarding travel demand management measures, as well as an effective way of colleting data for the evaluation of transport measiers in the area during the whole project period.

Enabling Measure

This is an enabling measures, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of this measure.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

The application will stimulate alternative emission/energy efficient transport modes through the idea of "gamification". The application will also provide key performance indicators of the day-to-day changes in travel behavior due to implementation of specific GrowSmarter-measures of interest.

Define the site where measure will be implemented and tested

Number of people living in the site, potentially applying the measure

Qualitative key performance indicators

Qualitative key performance indicators of measure 10.3 will be based in interviews with users of the application and on user data such as:

-Daily number of users of the application in Årsta

-Daily number of commute trips logged in the application

-Daily number of trips logged in the application

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 10.3

Please see document "Travel survey GrowSmarter".

3.4.6 Evaluation Template for Measure 10.4

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
10.4	Traffic control system for passenger vehicles	Insero E-Mobility	KTH IE

Description of Measure

This measure will use open traffic information data to find the traffic rhythm and route to allow for a smooth ride with as few stops and queuing as possible, thus reducing. The equipment will be used on renewably fuelled cars/EVs to add an extra incentive for these cars.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Transition to more energy/emission-efficient transport alternatives
B) Transition to renewable fuels
C) Improved traffic flows

Define the site where the measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 10.4

Describe methodology for evaluation using one or several of the following techniques:

A) Simulations
B) GPS-technologies in vehicles or other data from transport actors
C) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Measure 10.4	Number of people living in the site *potentially* using measure	*Observed* number of users of Measure	Average emissions per person kilometer with current vehicles in the site (g/km)	Average emissions per person kilometer with green test vehicles applying measure (g/km)	Average energy use per person kilometer with current vehicles in the site (kWh/km)	Average energy use per person kilometer with green test vehicles applying measure (kWh/km)
Key indicators baseline (pre demo test), end of baseline test phase						
Key indicators demo test, end of demonstration test phase						

Qualitative key performance indicators

Qualitative key performance indicators of measure 10.4 will be based in interviews with drivers.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 10.4

Please see document "Travel survey GrowSmarter".

3.4.7 Evaluation Template for Measure 10.5

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
10.5	Traffic signals synchronized to prioritize certain vehicles movement of goods (Stockholm)	KTH (and partners)	KTH IE

Description of Measure

Traffic signals synchronized to prioritize certain vehicles movement of goods (Stockholm). Traffic signals in and around Årsta will be re-programmed and synchronized to prioritize the movement of goods distribution vehicles to minimize starts and stops, resulting in more effective goods movements with lower emissions, noise and improved junction safety. Researchers from the Royal Institute of Technology will assist in the monitoring of results. Methods for real time priority for certain types of heavy vehicles will be tested.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Define the site where the measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 10.5

The baseline and assessment of measure 10.5 will be determined in two ways:

1. Direct emission- and energy use from the particular heavy vehicles before and after the traffic prioritizing technologies are installed will be measured using traffic flow measurements and GPS- technologies.
2. The indirect effects on connecting road links in the local transport system in Årsta, other than the "heavy vehicle prioritization-link". For this it will be necessary to apply computer simulation of traffic flows on specific road links in order to assess system effects, potential congestions etc.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 10.5 on heavy vehicle traffic

Measure 10.5	Number of heavy vehicle kilometers in the area	Average emissions per heavy vehicle kilometer (Kg CO2/km)	Average energy use per heavy vehicle kilometer in the site (kWh/km)	Number of heavy vehicle kilometers shifting to renewable fuels due to measure 10.5 (km)	Number of heavy vehicle kilometers reduced due to measure 10.5 (km)
Key indicators baseline					
Key indicators 12 months					
Key indicators 24 months					
Key indicators 36 months					
Key indicators 48 months					
Key indicators 60 months					

Measure 10.5	Average emissions per heavy vehicle kilometer applying measure 10.5 (Kg CO2/km)	Average energy use per heavy vehicle kilometer applying measure 10.5 (kWh/km)	**Total estimated reduction of emissions (Kg CO2) due to measure 10.5 based on indicators**	**Total estimated reduction of energy use (% kWh) due to measure 10.5 based on indicators**	**Total estimated reduction of emissions (% CO2) compared to baseline**
Key indicators baseline			Kg CO2	% kWh	% CO2
Key indicators 12 months			Kg CO2	% kWh	% CO2
Key indicators 24 months			Kg CO2	% kWh	% CO2
Key indicators 36 months			Kg CO2	% kWh	% CO2
Key indicators 48 months			Kg CO2	% kWh	% CO2
Key indicators 60 months			Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 10.5 will be based in interviews with drivers.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 10.5

Please see document "Travel survey GrowSmarter".

3.4.8 Evaluation Template for Measure 11.1

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.1	Developing charging infrastructure (Barcelona)	ENDESA	KTH IE

Description of Measure

Measure 11.1 Developing charging infrastructure (Barcelona)

Barcelona, Stockholm and Cologne are setting up a network of charging terminals for electric vehicles at strategic locations in the city, designed to fit in the surroundings. Both fast charging and normal charging will be installed.

Charging infrastructure developed for the Barcelona case is presented in detail in Measures 11.2 and 11.3.

3.4.9 Evaluation Template for Measure 11.1 Cologne

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.1	Developing charging infrastructure (Cologne)	Industry partner is in general RheinEnergie. RheinEnergie will implement the station. The evaluation data are delivered by RheinEnergie, Cambio and KVB, the evaluation is done in cooperation with the city of Cologne	KTH IE

Description of Measure

Barcelona, Stockholm and Cologne are setting up a network of charging terminals for electric vehicles at strategic locations in the city, designed to fit in the surroundings. Both fast charging and normal charging will be installed. In Cologne, the charging infrastructure provides the relevant data for the integration of the vehicles in the energy management concept and integrates the vehicles in such a way that also a controlled energy back supply from the vehicles is possible. The car sharing system of measure 13 needs information about the available energy in the vehicle battery around with the vehicle reservation information to the desired distance to be able to consider. The vehicles in the E Mobility will also be able to be charged in peak time without additionally network load. They should also to be used as energy storage serving demands in the grid.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels

D) Improved traffic flows

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 11.1

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 11.1 on personal transports

Measure 11.1	Number of people living in the site *potentially* using measure 11.1	*Observed* number of users of measure 11.1	Average emissions per person kilometer with private vehicles in the site (Kg CO2/km)	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 11.1 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 11.1 (kWh/km)	Number of private vehicle kilometers shifting to cycling due to measure 11.1 (km)
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							
Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 11.1	Number of private vehicle kilometers shifting to public transport due to measure 11.1 (km)	Number of private vehicle kilometers shifting to car sharing due to measure 11.1 (km)	Number of private vehicle kilometers shifting to renewable fuels or electricity due to measure 11.1 (km)	Total number of private vehicle kilometers reduced due to measure 11.1 (km)	**Total estimated reduction of emissions due to measure 11.1 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 11.1 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 11.1 compared to baseline (% CO2)**
Key indicators baseline					Kg CO2	% kWh	% CO2
Key indicators 12 months					Kg CO2	% kWh	% CO2
Key indicators 24 months					Kg CO2	% kWh	% CO2
Key indicators 36 months					Kg CO2	% kWh	% CO2
Key indicators 48 months					Kg CO2	% kWh	% CO2
Key indicators 60 months					Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 11.1 will be based on interviews with users of the service.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 11.1

Please see document “Travel survey GrowSmarter”.

3.4.10 Evaluation Template for Measure 11.1 Stockholm

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.1	Developing charging infrastructure (Stockholm)	Info 24, Fortum	KTH IE

Description of Measure

Barcelona, Stockholm and Cologne are setting up a network of charging terminals for electric vehicles at strategic locations in the city, designed to fit in the surroundings. Both fast charging and normal charging will be installed. The ca 1600 electric vehicles in Stockholm are in good balance using private charging. Complementary there is 8 fast charging stations and about 80 public normal charging stations. The development of PHEVs is believed to increase the demand for public charging. Within the project, Fortum will together with City of Stockholm install, 5 -10 normal charging stations and 1 fast chargers and closely monitor the use of these to form a strategy for the further roll-out of chargers. The grid in Stockholm is very stable and redundant and also a large amount of EVs will not affect the grid.

Fortum’s task is to install charging stations for electric vehicles and for each station measure.

A. Energy use per charging occasion
B. Number of chargings
C. Number of unique users
D. Charging time per user

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 11.1

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 11.1 on personal transports

Measure 11.1	Number of people living in the site *potentially* using measure 11.1	*Observed* number of users of measure 11.1	Average emissions per person kilometer with private vehicles in the site (Kg CO2/km)	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 11.1 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 11.1 (kWh/km)	Number of private vehicle kilometers shifting to cycling due to measure 11.1 (km)
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							
Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 11.1	Number of private vehicle kilometers shifting to public transport due to measure 11.1 (km)	Number of private vehicle kilometers shifting to car sharing due to measure 11.1 (km)	Number of private vehicle kilometers shifting to renewable fuels or electricity due to measure 11.1 (km)	Total number of private vehicle kilometers reduced due to measure 11.1 (km)	**Total estimated reduction of emissions due to measure 11.1 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 11.1 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 11.1 compared to baseline (% CO2)**
Key indicators baseline					Kg CO2	% kWh	% CO2
Key indicators 12 months					Kg CO2	% kWh	% CO2
Key indicators 24 months					Kg CO2	% kWh	% CO2
Key indicators 36 months					Kg CO2	% kWh	% CO2
Key indicators 48 months					Kg CO2	% kWh	% CO2
Key indicators 60 months					Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 11.1 will be based on interviews with users of the service.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 11.1

Please see document “Travel survey GrowSmarter”.

3.4.11 Evaluation Template for Measure 11.1/ 11.2

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.1	Developing charging infrastructure (Barcelona)	ENDESA	KTH IE
11.2	e – Mobility Management System		

Description of Measures

Measure 11.1 Developing charging infrastructure (Barcelona)

In order to reduce the energy consumption and to promote low carbon mobility modes, Barcelona will implement charging stations for electric vehicles to give service to different transport systems. In this way, Barcelona will implement a fast charging infrastructure for taxi vehicles, as well as V2X charging infrastructure. These charging facilities will be deployed and installed at strategic points.

Endesa Energía will deploy a smart charging infrastructure for electric vehicles in Barcelona. This infrastructure for the customer use will be composed of fast charge for taxi vehicles and bidirectional charge. The strategic location of the different charging infrastructures will be studied and analysed.

Measure 11.2 e – Mobility Management System (Barcelona)

Endesa Energía will develop an e-mobility charging system in order to manage the charging infrastructure in Barcelona. Furthermore, the charging infrastructure will be monitored in order to study the impact on the grid of the different charging events. New functionalities and services for the customer will be studied, as well as, a plan for deployment of the charging infrastructure.

Management and impact on the grid of charging infrastructure related to:

• E-V2X charging/discharging station will be installed in a parking area. This infrastructure will be operated by an EMS of ENDESA. This e-parking will provide private and public e-mobility services to the EV user and also to the e-parking owner, including V2X functionalities acting as a storage system for the parking facility optimizing the use of energy for e-mobility services and/or other consumptions. E-parking facility inside the macroblock will be evaluated from the point of view of mobility and energy.

• E-Taxi demo: deploy and operation of the fast charging public infrastructure (5) to accelerate the e-taxi private part of the project in a multistandard approach. The main task will be based on the manufacturing, commisiong and operation of fast charge infrastructure for public recharging services. All EVSE will be managed by EMS of ENDESA acting as EVSE operator and integrated on the City Os for an overall management of the city council acting as EVSP.

ENDESA and Barcelona city council will all work together to install fast charging stations in strategic places.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Transition to more energy/emission-efficient transport alternatives
B) Reduction of the contamination of CO2 due to reduced fossil fuels
C) Increase energy efficiency via implementation of e-mobility in Public Transport
D) Provide new e-mobility services to EV customers
E) Improve the quality of life of the citizens and EV customers

Define the site where measure will be implemented and tested

Barcelona is the capital city of the autonomous community of Catalonia in Spain and Spain's second most populated city, with a population of 1.6 million within its administrative limits. It is the largest metropolis on the Mediterranean Sea, located on the coast between the mouths of the rivers Llobregat and Besòs, and bounded to the west by the Serra de Collserola mountain range, the tallest peak of which is 512 metres high.

Until now, three fast charge points have been installed in Barcelona. Their specific locations are the following:

- Passeig de Gràcia 5
- Provença 447 (Sagrada Familia)
- Av. Del Paral.lel 55

Two more fast charge points will be installed in the following months.

The location for the bidirectional charging infrastructure as well as its use case is being defined.

Definition of the baseline and how it will be determined

1. Number of EV users before the GrowSmarter Poject per year (units)
2. Number of charging points before the GrowSmarter Poject per year (units)
3. Number of charging events before the GrowSmarter Poject per year (units)

Specification of methodology for evaluation of measure 11.1/11.2

Describe methodology for evaluation using one or several of the following techniques:

1. Update of the number of the chargers of the current charging infrastructure
2. Communication of the charging infrastructure with the GrowSmarter e-mobility management system
3. GPS-technologies in the charge infrastructure
4. Monthly reports of the charging infrastructure

Specification of quantifiable key performance indicators to be monitored over time

Table 1. Impact from measure 11.1/11.2 on personal transports

Measure 11.2	Number of EV users per year (units)	Number of charging points per year (units)	Number of charging events per year (units)	Daily average charge per session of fast charge (kWh/session)	Daily average charge per session of bidirectional charge (kWh/session)	Daily average discharge per session of bidirectional charge (kWh/session)	Total charging time per day of fast charge (min)
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							
Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 11.2	Total charging time per day of bidirectional charge (min)	Total discharging time per day of bidirectional charge (min)	Daily electricity charged of fast charge (kWh/day)	Daily electricity charged of bidirectional charge (kWh/day)	**Daily electricity discharged of bidirectional charge (kWh/day)**	**Total estimated reduction of emissions due to measure 11.1/11.2 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 11.1/11.2 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 11.1/11.2 compared to baseline (% CO2)**
Key indicators baseline						Kg CO2	% kWh	% CO2
Key indicators 12 months						Kg CO2	% kWh	% CO2
Key indicators 24 months						Kg CO2	% kWh	% CO2
Key						Kg CO2	% kWh	% CO2

indicators 36 months								
Key indicators 48 months						Kg CO2	% kWh	% CO2
Key indicators 60 months						Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 11.2 will be based on interviews with users of the service.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 11.2

Please see document "Travel survey GrowSmarter".

3.4.12 Evaluation Template for Measure 11.3

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.3	Charging infrastructure for electric tricycles for micro distribution (Barcelona)	Barcelona city	KTH IE

Description of Measure

Installation of charging points (initially planned to be 3-5) for the electric tricycles of the micro distribution measure (9.2), making them adaptable to electric bicycles and motorbikes to also be available for citizens. These charging points will provide energy to those tricycles that would substitute diesel vans in the last mile distribution in the macroblock through a micro Urban Consolidation Center (mUCC). These charging points will also be managed to assess their impact on the grid. Barcelona city council will work probably together with a subcontractor to make this measure successful.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

The evaluation of this measure will allow to calculate the reduction in CO2 emission and other pollutants due to the shift to more sustainable modes of logistic transportation.

Define the site where measure will be implemented and tested

The site will be the same as in measure 9.2. The Glòries commercial mall in which this measure will probably be implemented will make it easier to install the electric charging points. Since electric tricycles charge at low speed, no upgrade in the installed power is foreseen.

Specification of methodology for evaluation of measure 11.3

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

By metering the charging points the indicators will be calculated.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 and 2 below:

Table 1. Specification of quantifiable key performance indicators for travel behaviour

Measure 11.3	Number of tricycles using the electric charging point	Number of heavy vehicle kilometers shifting to cycling due to measure 11.3 (km)	Number of heavy vehicle kilometers shifting to renewable fuels or electricity due to measure 11.3 (km)	**Total estimated reduction of emissions due to measure 11.3 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 11.3 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 11.3 compared to baseline (% CO2)**
Key indicators baseline				Kg CO2	% kWh	% CO2
Key indicators 12 months				Kg CO2	% kWh	% CO2
Key indicators 24 months				Kg CO2	% kWh	% CO2
Key indicators 36 months				Kg CO2	% kWh	% CO2
Key indicators 48 months				Kg CO2	% kWh	% CO2
Key indicators 60 months				Kg CO2	% kWh	% CO2

Table 2. Specification of quantifiable key performance indicators for heavy vehicle traffic

Measure 11.3	Number of heavy vehicle kilometers in the area	Average emissions per heavy vehicle kilometer (Kg CO2/km)	Number of heavy vehicle kilometers shifting to renewable fuels due to measure 11.3 (km)	Number of heavy vehicle kilometers reduced due to measure 11.3 (km)
Key indicators baseline				
Key indicators 12 months				
Key indicators 24 months				
Key indicators 36 months				

Key indicators 48 months				
Key indicators 60 months				

Measure 11.3	Average energy use per heavy vehicle kilometer in the site (kWh/km)	**Total estimated reduction of emissions (Kg CO2) due to measure 11.3 based on indicators**	**Total estimated reduction of energy use (% kWh) due to measure 11.3 based on indicators**	**Total estimated reduction of emissions (% CO2) compared to baseline**
Key indicators baseline		Kg CO2	% kWh	% CO2
Key indicators 12 months		Kg CO2	% kWh	% CO2
Key indicators 24 months		Kg CO2	% kWh	% CO2
Key indicators 36 months		Kg CO2	% kWh	% CO2
Key indicators 48 months		Kg CO2	% kWh	% CO2
Key indicators 60 months		Kg CO2	% kWh	% CO2

Some of these indicators are very similar to those calculated in measure 9.2.

Qualitative key performance indicators

Qualitative key performance indicators of measure 11.3 will be based on interviews with users of the service.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 11.3

Please see document "Travel survey GrowSmarter".

3.4.13 Evaluation Template for Measure 11.4

Measure

Nr Description Responsible Evaluation Responsible Validation

		Partner	Partner
11.4	Setting up refueling facilities for alternative heavy duty fuels fuel (Stockholm)	Stockholm municipality, Stockholm Gas AB	KTH IE

Description of Measure

While there are many fuel stations available for cars and light duty distribution vehicles, there are only very few stations for heavy duty distribution vehicles. Following the work started in the Life+ project CleanTruck, Stockholm will together with the distribution companies set up at least 10 new stations for ED95, LBG, or HVO, operate the logistic centre on these vehicles, require increased rates of renewable fuels in the city's procurements of transport, and encourage business to put the same requirement on their deliveries. This strategy has been very successful to introduce renewably fuelled cars. Industrial companies such as the different fuelling station companies i.e IDS and AGA togheter with Stockholm Gas ABwill be involved in the realization of this measure as associated partners to the project

Define the potential with this measure

A) Number of renewable fueled trucks in Stockholm at present
B) Potential number of renewable fueled trucks in Stockholm using these facilities
C) Number of liters renewable fuel sold in Stockholm at present
D) Potential number of liters renewable fuel sold at these stations

Specification of methodology for evaluation of measure 11.4

This measure will be evaluated quantitatively through estimates of number of liters renewable fuel sold at these facilities, and qualitatively through a survey to the companies running the stations and a survery to the drivers operating the vehicles.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below. These figures will be estimated from the volyme of fuels sold and the averabe fuel consumption of a truck.

Table 1. Impact from measure 11.4 on heavy vehicle traffic

Measure 11.4	Number of heavy vehicle kilometers in the area	Average emissions per heavy vehicle kilometer (Kg CO2/km)	Average energy use per heavy vehicle kilometer in the site (kWh/km)	Number of heavy vehicle kilometers shifting to renewable fuels due to measure 11.4 (km)	Number of heavy vehicle kilometers reduced due to measure 11.4 (km)

Key indicators baseline					
Key indicators 12 months					
Key indicators 24 months					
Key indicators 36 months					
Key indicators 48 months					
Key indicators 60 months					

Measure 11.4	Average emissions per heavy vehicle kilometer applying measure 11.4 (Kg CO2/km)	Average energy use per heavy vehicle kilometer applying measure 11.4 (kWh/km)	**Total estimated reduction of emissions (Kg CO2) due to measure 11.4 based on indicators**	**Total estimated reduction of energy use (% kWh) due to measure 11.4 based on indicators**	**Total estimated reduction of emissions (% CO2) compared to baseline**
Key indicators baseline			Kg CO2	% kWh	% CO2
Key indicators 12 months			Kg CO2	% kWh	% CO2
Key indicators 24 months			Kg CO2	% kWh	% CO2
Key indicators 36 months			Kg CO2	% kWh	% CO2
Key indicators 48 months			Kg CO2	% kWh	% CO2
Key indicators 60 months			Kg CO2	% kWh	% CO2

3.4.14 Evaluation Template for Measure 11.5

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.5	Smart guiding to alternative fuel stations and fast charging (Stockholm)	Info24	KTH IE

Description of Measure

To improve for the 36,000 cars and light duty transport vehicles operating on renewable fuels in Stockholm, a mobile application will be developed, containing e.g. updated information on where each alternative fuel can be filled up, together with most recent price. There is currently 45 E85-stations, 12 Biogas stations, 8 fast charging stations and about 80 public normal charging stations in Stockholm and especially the latter are growing fast. Industrial companies IDS and AGA will be involved in the realization of this measure as associated partners to the project.

Enabling Measure

This is an enabling measure, enabling services used in the other WP's. Therefore, this enabling functionality is the main scope of the evaluation of this measure.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

The application will stimulate alternative emission/energy efficient transport modes through the idea of "gamification". The application will also provide key performance indicators of the day-to-day changes in travel behavior due to implementation of specific GrowSmarter-measures of interest.

Define the site where measure will be implemented and tested

Number of people living in the site, potentially applying the measure

Qualitative key performance indicators

Qualitative key performance indicators of measure 10.3 will be based in interviews with users of the application and on user data such as:

-Daily number of users of the application in Årsta

-Interviews with users of the application

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 10.3

Please see document "Travel survey GrowSmarter".

3.4.15 Evaluation Template for Measure 11.6

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
11.6	Small distributed CNG grid (Barcelona)	GNF	KTH IE

Description of Measure

Setting of 1 small CNG filling station giving service to CNG vehicles, with the following equipment: a small compressor, 60 m3/h, storage tanks, filling hose and control and payment devices. This kind of small CNG charging infrastructure technology has not yet been proven for public use. All the equipment would be integrated into a technological module. -

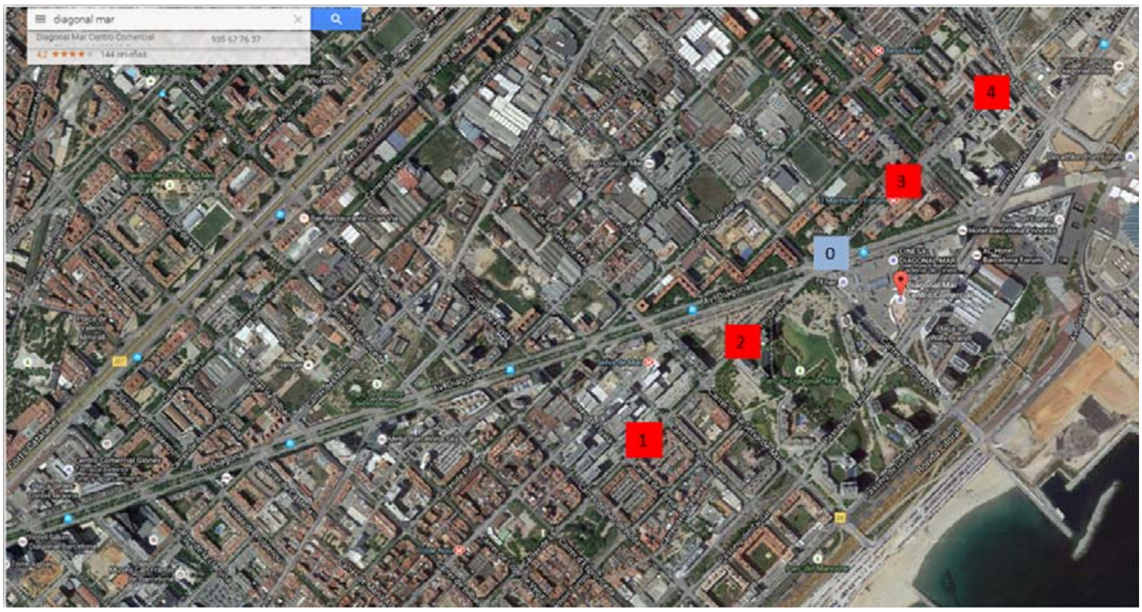
Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

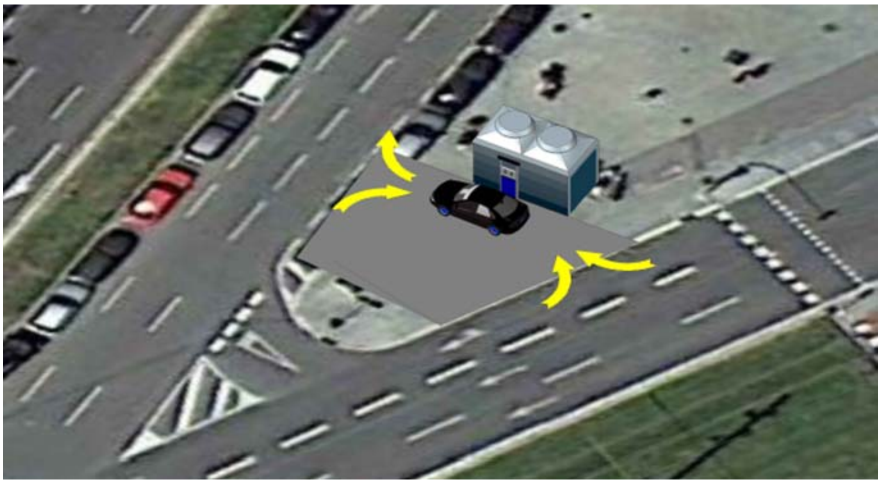
The application will stimulate all four points A-D above by improving information about alternative emission/energy efficient transport modes. The application will also provide key performance indicators of the day-to-day changes in travel behavior due to implementation of specific GrowSmarter-measures of interest according to table 1.

Define the site where measure will be implemented and tested

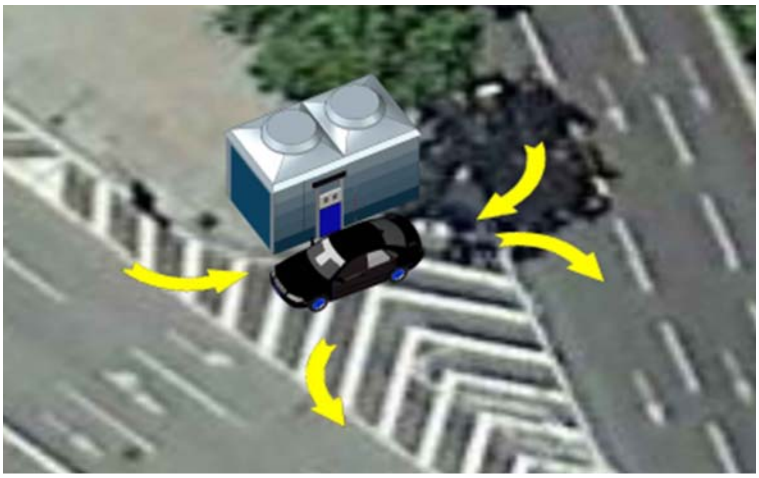
The CNG filling station will be installed in the Sant Martí district, along Llull street where a high pressure gas pipe is located. Currently, GNF is under discusion with Barcelona City Council in order to fix a final implementation for this measure, after several months of deliverations. During this period of time different locations have been proposed, for example, on the intersections with Josep Pla st., Provençals st., Diagonal Ave., Rambla de Prim or Sant Ramon de Penyafort st. If necessary, a small portion of parking surface will be destinated to the installation of this station. Next, three of the main locations proposed are presented:



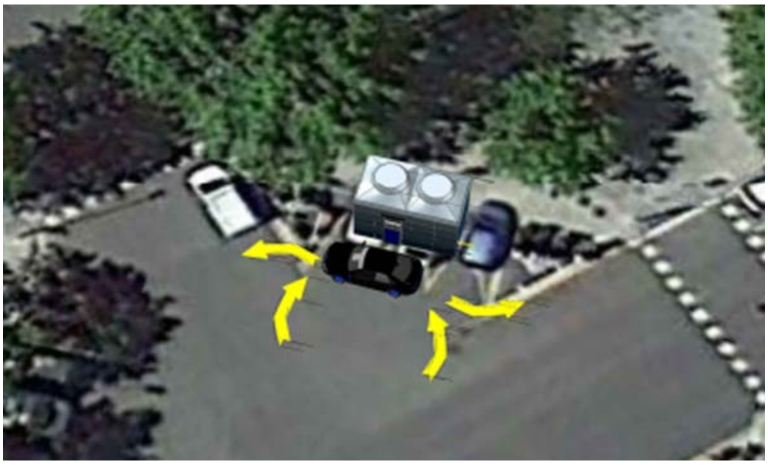
Proposed implementation locations for the CNG filling station along Llull street.



Representation of the CNG filling station in the intersection with Diagonal Ave.



Representation of the CNG filling station in the intersection with Josep Pla street.



Representation of the CNG filling station in the intersection with Provençals street.

Specification of methodology for evaluation of measure 11.6

The methodoly used to evaluate this measure will mainly be the monitoring of the CNG consumption in the refuelling station.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 11.6 on personal transports

Measure 11.6	*Observed* number of cars of measure 11.6	Average PM-10 emissions reduction (g/km or %)	Average NOx emissions reduction (g/km or %)	Average CO emissions reduction (g/km or %)	Average emissions per kilometer with private Baseline vehicles in the site(Kg CO2/km)	Average energy use per kilometer with private vehicles in the site (kWh/km)	Average emissions per kilometer with private vehicles applying measure 11.6 (Kg CO2/km)	Average energy use per kilometer with private vehicles applying measure 11.6 (kWh/km)	**Total estimated reduction of emissions due to measure 11.6 based on indicators (Kg CO2)**	**Total estimated reduction of emissions due to measure 11.6 compared to baseline (% CO2)**
Key indicators baseline										
Key indicators 12 months										
Key indicators 24 months										

Key indicators 36 months									
Key indicators 48 months									
Key indicators 60 months									

Qualitative key performance indicators

Qualitative key performance indicators of measure 11.6 will be based on interviews and travel survey of users of the service.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 11.6

Please see document "Travel survey GrowSmarter".

3.4.16 Evaluation Template for Measure 12.1

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
12.1	Green parking index in combination with car sharing pool with EV (Stockholm)	Stockholmshem, Info24, Fortum	KTH IE

Description of Measure

By offering membership in a car pool, property owners are able to reduce the number of parking spaces attached to the buildings (green parking index) drastically. By reducing the available number of parking spaces it gets less attractive to own a car which will act in favor of other modes of transportation such as public transport or bike and by offering a car pool it is easier for people to drop the car completely because they have the option to borrow a car when they really need to.

Fortum's task is to (according to 11.1) install charging stations for electric vehicles and for each station measure.

A. Energy use per charging occasion
B. Number of chargings
C. Number of unique users
D. Charging time per user

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 12.1

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 12.1 on personal transports

Measure 12.1	Number of people living in the site *potentially* using measure 12.1	*Observed* number of users of measure 12.1	Average emissions per person kilometer with private vehicles in the site (Kg CO2/km)	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 12.1 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 12.1 (kWh/km)	Number of private vehicle kilometers shifting to cycling due to measure 12.1 (km)
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							
Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 12.1	Number of private vehicle kilometers shifting to public transport due to measure 12.1 (km)	Number of private vehicle kilometers shifting to car sharing due to measure 12.1 (km)	Number of private vehicle kilometers shifting to renewable fuels or electricity due to measure 12.1 (km)	Total number of private vehicle kilometers reduced due to measure 12.1 (km)	**Total estimated reduction of emissions due to measure 12.1 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 12.1 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 12.1 compared to baseline (% CO2)**
Key indicators baseline					Kg CO2	% kWh	% CO2
Key indicators 12 months					Kg CO2	% kWh	% CO2
Key indicators 24 months					Kg CO2	% kWh	% CO2

Key indicators 36 months					Kg CO2	% kWh	% CO2
Key indicators 48 months					Kg CO2	% kWh	% CO2
Key indicators 60 months					Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 12.1 will be based on interviews with users of the service and on the travel survey.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 12.1

Please see document "Travel survey GrowSmarter".

3.4.17 Evaluation Template for Measure 12.2

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
12.2	Electrical and cargo bike pool (Stockholm)	Stockholmshem, Info24	KTH IE

Description of Measure

By offering membership in a car pool, property owners are able to reduce the number of parking spaces attached to the buildings (green parking index) drastically. By reducing the available number of parking spaces it gets less attractive to own a car which will act in favor of other modes of transportation such as public transport or bike and by offering a car pool it is easier for people to drop the car completely because they have the option to borrow a car when they really need to.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 12.2

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 12.2 on personal transports

Measure 12.2	Number of people living in the site *potentially* using measure 12.2	*Observed* number of users of measure 12.2	Average emissions per person kilometer with private vehicles in the site (Kg CO2/km)	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 12.2 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 12.2 (kWh/km)	Number of private vehicle kilometers shifting to cycling due to measure 12.2 (km)
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							

Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 12.2	Number of private vehicle kilometers shifting to public transport due to measure 12.2 (km)	Number of private vehicle kilometers shifting to car sharing due to measure 12.2 (km)	Number of private vehicle kilometers shifting to renewable fuels or electricity due to measure 12.2 (km)	Total number of private vehicle kilometers reduced due to measure 12.2 (km)	**Total estimated reduction of emissions due to measure 12.2 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 12.2 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 12.2 compared to baseline (% CO2)**
Key indicators baseline					Kg CO2	% kWh	% CO2
Key indicators 12 months					Kg CO2	% kWh	% CO2
Key indicators 24 months					Kg CO2	% kWh	% CO2
Key indicators 36 months					Kg CO2	% kWh	% CO2
Key indicators 48 months					Kg CO2	% kWh	% CO2
Key indicators 60 months					Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 12.2 will be based on interviews with users of the service and on the travel survey.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 12.2

Please see document "Travel survey GrowSmarter".

3.4.18 Evaluation Template for Measure 12.3

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
12.3	Mobility hub (Cologne)	Cambio, Ampido, KVB	KTH IE

Description of Measure

Cologne will establish three mobility hubs for up to 20 EV and 50 pedelecs including a larger number of electrical pedelecs, which will be available both as standard bikes or cargo bikes. Additionally public parking spaces can be reserved beforehand by car-drivers, combined with dynamic pricing according to traffic volume in order to reduce traffic and CO2-emissions. There will be installed several charging stations for EV as well as EP.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 12.3

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 12.3 on personal transports

Measure 12.3	Number of people living in the site *potentially* using measure 12.3	*Observed* number of users of measure 12.3	Average emissions per Euro-Emission Class	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 12.3 (Kg CO2/km)	Average energy use per customer kilometer with private vehicles applying measure 12.3 (kWh/km)	Number of private vehicle kilometers shifting to cycling due to measure 12.3
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							
Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 12.3	Number of private vehicle kilometers shifting to public transport due to measure 12.3 (km)	Number of private vehicle kilometers shifting to car sharing due to measure 12.3 (km)	Number of private vehicle kilometers shifting to renewable fuels or electricity due to measure 12.3 (km)	Total number of private vehicle kilometers reduced due to measure 12.3 (km)	**Total estimated reduction of emissions due to measure 12.3 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 12.3 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 12.3 compared to baseline (% CO2)**

Key indicators baseline					Kg CO2	% kWh	% CO2
Key indicators 12 months					Kg CO2	% kWh	% CO2
Key indicators 24 months					Kg CO2	% kWh	% CO2
Key indicators 36 months					Kg CO2	% kWh	% CO2
Key indicators 48 months					Kg CO2	% kWh	% CO2
Key indicators 60 months					Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 12.3 will be based on interviews with users of the service and on the travel survey.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 12.3

Please see document "Travel survey GrowSmarter".

3.4.19 Evaluation Template for Measure 12.4

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
12.4	Electrical and conventional car sharing (Cologne)	Cambio, KVB	KTH IE

Description of Measure

A car sharing service will be set up with a range of different cars to be able to cater to everybody's need in different situations. To completely be able to not owning your own car it is necessary that car pools can offer different car for your different needs. An electrical vehicle might be suitable for shorter trips in the city but when travelling longer distances w ith a big family an electric vehicle might not fit the needs and it is therefore important to offer alternatives. This offer will be put together by Cambio. Rentable e-bikes will be provided by KVB.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

Specification of methodology for evaluation of measure 12.4

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 12.4 on personal transports

Measure 12.4	Number of people living in the site *potentially* using measure 12.4	*Observed* number of users of measure 12.4	Average emissions per person kilometer with private vehicles in the site (Kg CO2/km)	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 12.4 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 12.4 (kWh/km)	Number of private vehicle kilometers shifting to cycling due to measure 12.4 (km)
Key indicators baseline							
Key indicators 12 months							
Key indicators 24 months							
Key indicators 36 months							
Key indicators 48 months							
Key indicators 60 months							

Measure 12.4	Number of private vehicle kilometers shifting to public transport due to measure 12.4 (km)	Number of private vehicle kilometers shifting to car sharing due to measure 12.4 (km)	Number of private vehicle kilometers shifting to renewable fuels or electricity due to measure 12.4 (km)	Total number of private vehicle kilometers reduced due to measure 12.4 (km)	**Total estimated reduction of emissions due to measure 12.4 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 12.4 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 12.4 compared to baseline (% CO2)**
Key indicators baseline					Kg CO2	% kWh	% CO2
Key indicators 12 months					Kg CO2	% kWh	% CO2
Key indicators 24					Kg CO2	% kWh	% CO2

months							
Key indicators 36 months					Kg CO2	% kWh	% CO2
Key indicators 48 months					Kg CO2	% kWh	% CO2
Key indicators 60 months					Kg CO2	% kWh	% CO2

Qualitative key performance indicators

Qualitative key performance indicators of measure 12.4 will be based on interviews with users of the service and on the travel survey.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 12.4

Please see document "Travel survey GrowSmarter".

3.4.20 Evaluation Template for Measure 12.5

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
12.5	Conventional/PHEV/CNG vehicle-sharing fleets (Barcelona)	CENIT	KTH IE

Description of Measure

Provision of vehicle sharing systems in the project area to enhance a more cooperative, flexible and sustainable transport service. This vehicle-sharing system is initially planned to be focused on cars (car-sharing, service provided by Avancar), but Barcelona also contemplates the possibility to incorporate motorbikes service (MotIt, e-Cooltra). The service will be mainly provided with EV/PHEV, but the possibility of including conventional and CNG vehicles is also considered (optional). These systems would benefit from the filling and charging infrastructures defined in other tasks of this project.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

The carsharing installed in the pilot site will be monitored in order to evaluate the number of trips made using this system. The use of carsharing system does not reduce traffic volumes but it can contribute to a more energy/emission-efficient transport system if vehicles used for carsharing are electric or use CNG. The evaluation proposed will give evidence of the intensity of use of the vehicles and will allow to calculate the reduction in emissions.

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure
B) Number of kilometers street/road links where measure will be implemented

The site that will host the study is the Sant Martí district located in a north-east side of the city. The area is limited by Diagonal Avenue on one side, by the sea on the other forming a triangular-shaped quarter of the city. This area has a population of 70,000 inhabitants approximately and a density of 203.5 inhabitants/acre.

The use of the carsharing will not be limited to this quarter as users will be able to drive to other areas of the city.

Specification of methodology for evaluation of measure 12.5

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

The methodology used to quantify the number of kilometers covered by carsharing will mainly be the surveys to the operator of vehicles. This operator will keep the record of all journeys made by vehicles as well as other data such as time consumed for each journey, daily number of trips, etc.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 12.5 on personal transports

Measure 12.5	Number of people living in the site *potentially* using measure 12.5	Number of users of measure 12.5	Average emissions per person kilometer with private vehicles in the site (Kg CO2/km)	Average energy use per person kilometer with private vehicles in the site (kWh/km)	Average emissions per person kilometer with private vehicles applying measure 12.5 (Kg CO2/km)	Average energy use per person kilometer with private vehicles applying measure 12.5 (kWh/km)
Key indicators baseline						
Key indicators 12 months						
Key indicators 24 months						
Key indicators 36 months						
Key indicators 48 months						
Key indicators 60 months						

Measure 12.5	Number of private vehicle kilometers shifting to car sharing due to measure 12.5 (km)	Total number of private vehicle kilometers reduced due to measure 12.5 (km)	**Total estimated reduction of emissions due to measure 12.5 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 12.5 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 12.5 compared to baseline (% CO2)**
Key indicators baseline			Kg CO2	% kWh	% CO2
Key indicators 12 months			Kg CO2	% kWh	% CO2
Key indicators 24 months			Kg CO2	% kWh	% CO2

Key indicators 36 months		Kg CO_2	% kWh	% CO_2
Key indicators 48 months		Kg CO_2	% kWh	% CO_2
Key indicators 60 months		Kg CO_2	% kWh	% CO_2

Productivity indicators:

- Average number of kilometers covered during a trip (km/trip)
- Daily number of kilometers covered by vehicles (km/veh)
- Ratio between in service hours and available hours of the service (%)
- Total number of trips made by all available vehicles (number of trips)

Qualitative key performance indicators

Qualitative key performance indicators of measure 12.5 will be based on interviews with users of the service and on the travel survey.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 12.5

Please see document "Travel survey GrowSmarter".

3.4.21 Evaluation Template for Measure 12.6

Measure

Nr	Description	Responsible Evaluation Partner	Responsible Validation Partner
12.6	Smart taxi stand system (Barcelona)	CENIT	KTH IE

Description of Measure

Taxis represent an important mobility agent in cities, providing fast and door-to-door services to users In this measure, users request for a taxi (accomplishing specific user's requirements) via mobile app or through a smart stand (included in the multipurpose information pole) in a designated location, and a taxi is assigned to satisfy this service. The main interest of the measure is that vacant taxis will be parked in a bigger feeder stand located outside crowded areas (i.e., in a municipal or mall parking area) reducing their cruising for clients, thus reducing the unproductive mileage in vacant and the consequent congestion, fuel costs, energy consumption and pollutant emissions.

The purpose of the measure is the efficient assignment of taxi services and the reduction of costs and externalities (energy consumption and pollution) related to vacant mileage of the taxi vehicles. Users will request for a taxi (accomplishing specific requirements) via mobile app or through a smart stand 81 (included in the multipurpose information pole), and a taxi parked in a bigger feeder stand located outside crowded areas (e.g., in a municipal or a mall parking) will be assigned.

Intentions: describe how the evalutation could prove that this measure contributes to one or more of the following efficiencies

A) Reducing traffic volumes
B) Transition to more energy/emission-efficient transport alternatives
C) Transition to renewable fuels
D) Improved traffic flows

The evaluation of this measure will allow to quantify the number of users of the mobile application. The app will be used both by taxi drivers and potential taxi clients and both will be benefited by this measure.

By reducing the cruising for clients, taxis will reduce fuel costs, unproductive mileage hence reducing traffic volumes and improving traffic flows.

Define the site where measure will be implemented and tested

A) Number of people living in the site, potentially applying the measure

Although the exact placement of the taxi stands are not defined yet, they will be located in the Sant Martí district, as most of the measures in this project. Around three taxi stands will be operating with this system with approximately four parking spots at each stand.

Specification of methodology for evaluation of measure 12.6

Describe methodology for evaluation using one or several of the following techniques:

A) Traffic flow measurements
B) GPS-technologies in vehicles or other data from transport actors
C) Simulation of traffic flows on specific road links
D) Travel surveys

The methodology will be to monitor the number of users of the app and the number of connections to the server. By monitoring the frequency of use we will be capable of evaluating the trend of the app utilization.

Specification of quantifiable key performance indicators to be monitored over time

Quantifiable indicators needed for the evaluation are given in table 1 below:

Table 1. Impact from measure 12.6 on personal transports

Measure 12.6	Total number of private vehicle kilometers reduced due to measure 12.6 (km)	**Total estimated reduction of emissions due to measure 12.6 based on indicators (Kg CO2)**	**Total estimated reduction of energy use due to measure 12.6 based on indicators (% kWh)**	**Total estimated reduction of emissions due to measure 12.6 compared to baseline (% CO2)**
Key indicators baseline		Kg CO2	% kWh	% CO2
Key indicators 12 months		Kg CO2	% kWh	% CO2
Key indicators 24 months		Kg CO2	% kWh	% CO2
Key indicators 36 months		Kg CO2	% kWh	% CO2
Key indicators 48 months		Kg CO2	% kWh	% CO2
Key indicators 60 months		Kg CO2	% kWh	% CO2

Indicators to be added:

- Number of connections to the app by taxi drivers
- Number of connections to the app by taxi clients
- Average waiting time at taxi stands (time between two taxi demands)
- Average taxi stand occupation (number of parking slots occupied on average)

Qualitative key performance indicators

Qualitative key performance indicators of measure 12.6 will be based on interviews with users of the service and on the travel survey.

Please state 1-3 additional questions required in the travel survey in order to evaluate measure 12.6

Please see document “Travel survey GrowSmarter”.

4 Aggregation of quantitative results

4.1 Introduction

As stated initially, the quantitative goals concerning energy use and CO2 reduction are stated on a global (project) level. Above, the methods for evaluating each of the measures to be implemented in GrowSmarter have been specified. The results of these evaluations must be aggregated to allow evaluation on a higher level. Several such levels could be identified: For the measures concerning the energy use in the buildings, the effect of the measures could be aggregated to apartment, building, block, district, city or the European level. Similar choices exist for the transport and mobility measures.

Several problems may be pointed out concerning the upscaling of the results:

- The effects of individual measures are often not independent which means that the results of the measures are not additive.
- Different assumptions may be made concerning the upscaling: Should the measures be assumed to be implemented at all possible locations or only assumed to penetrate to a specific degree?
- The effects of the measures may be higher when implemented in one area than in another neighboring area. Results will then be dependent on the choice of boundaries of the area investigated.
- The results may not be applicable to other regions because of differences in conditions, e.g. different climates, differences in legislation or taxation etc. Upscaling to the European or even national level therefore must be done with some caution. In some cases, it is possible to compensate for the differences by correcting the data. For the climate, as an example, the number of degree-days for heating and cooling may be used for this purpose. For other differences it may be more difficult to identify algorithms of correction.

In spite of the difficulties identified it is necessary to define goals and methods for the upscaling within GrowSmarter in order to determine if the quantitative targets concerning energy use and CO2 emissions have been met.

4.2 Comparison to the quantitative goals of GrowSmarter

As stated in the initial section of the report, there are five quantitative goals for GrowSmarter mentioned in the Grant Agreement. The interpretation of these goals shall be the following:

- Creation of 1500 jobs.
    - This could be jobs within new businesses initiated as a result of GrowSmarter, or jobs which are created to implement the measures within the project. Such jobs may be temporary, but as it can be assumed that many of the measures will prove successful, it can be anticipated that the jobs will remain as the same measures are implemented in other areas once they have proved successful.
    - Only jobs created within Europe should be counted.
- Reduction of energy use by 60%
    - This figure should be interpreted as referring to the measured bought energy used within the refurbished districts. The district should be defined as the refurbished buildings and the streets and parks immediately surrounding these buildings and thus not include non-refurbished buildings.

  - Additionally, and as a second indicator, the energy saving should be calculated assuming that all measures tested in the district were implemented in all buildings. (Transport and mobility measures are already assumed to be implemented in the whole district).
  - Electricity or heat generated from renewable energy within the area should not be considered in the calculation of the energy used. (Reduction in bought energy use should be neutral to the technology used for achieving the savings. Investments in thicker insulation, heat pumps or PV should be evaluated in the same way).
- Reduction of CO2 emissions by more than 60%.
  - This figure should relate to the measured bought energy within the district, defined as above. The reduction should primarily be calculated using the CO2 emission factors defined on the national level for each city according to IEA (*reference*).
  - Alternatively, and as a comparison, the calculations can additionally be done with other well motivated values for the emission factors.
  - The reduction should also be calculated assuming that all measures are implemented in all buildings in the area, as a separate indicator.
- Reduction of emissions from local traffic, especially NOx by 60%.
  - The reduction should be estimated for the local district, i.e. the area where the measures are implemented.
  - In case the measures are implemented over a larger area or the complete city, the estimate should be based on approximations of the effects if the measures were implemented broadly within the city. In this case, different levels of adoption should be compared and the reasons for selecting a most reasonable level given.
- Reduction of energy use in 100.000 m^2 of buildings by 70 – 90%.
  - This should be evaluated similarly as the reduction of energy use by 60%, but in this case only the reductions in the buildings should be included.
  - For the refurbished buildings the aggregated results of the implemented measures can be determined by monitoring the amount of energy supplied to the building in the form of electricity, fuel and heat. It is assumed that reasonably correct data for these energy flows will be available. In the case that certain tenants are not willing to share their electricity consumption (or other energy flows) it should be possible to estimate this from other measured data for other apartments in the building.
  - The energy consumption of the refurbished district can likewise be determined by summing up the energy use of the buildings in the area. After correction for differences in climate and population, this will give a direct measure of the changes in energy use due to the measures implemented within GrowSmarter.
  - In the case that certain measures are implemented only in some of the buildings in an area, e.g. that PV panels or heat pumps are installed in part of the buildings, then the decrease in energy use of these buildings will be used so as to define a possible decrease in bought energy if these measures were implemented in the whole area. This will give an actual and a possible level for the reduction of energy use in the district.

4.3 Upscaling

The upscaling of results from the evaluation of the individual measures to levels beyond the district is entirely a question of defining a calculation method for this purpose. The data collected from the implementation of the individual measures should be sufficient for performing these upscaling calculations. This means that the methods of the upscaling to the complete cities and to other cities can be developed during the cause of the project.

As the upscalings from any value beside the measured values are based on assumptions and estimates, the values should be given with some reasonable probability. Such a range was, in Concert, called plausibility corridors.

5 Appendices

5.1 Appendix 1, Preliminary Draft of Household Questionnaire, Demographics, Energy, and Social

This questionnaire has been drafted by WP5 to initiate a dialogue among the Grow Smarter partners, concerning the intentions, and depth of the household survey. It is predominantly based on experiences and questionnaires from the European Concerto project and the ELIH MED project. Together with the questionnaire on transport, these should provide a sufficient understanding of the state of the districts, before the implementing of the Grow Smarter measures. These questionnaires should be issued before, during, and after the refurbishment and construction process with some changes in the questions each timeThis questionnaire, is intended for the ”Before” state.
This questionnaire is divided in three parts:

1. Characteristics
2. Perceptions
3. Energy State

Questionnaire Grow Smarter
Part 1 – Characteristics

1 A. Demographics

When were your born? Please indicate the year of birth:	
Are you male or female? Please indicate your gender:	☐ male
What is the highest level of completed education? *Please adjust the name and description of the educational level to the terms used in your country.*	☐ ISCED Level 0-2* ☐ ISCED Level 3-4* ☐ ISCED Level 5-6* ☐ None
What is your nationality?	

How many people live in your household? *A differentiation of adults and children living in the household is also possible.*	☐ 1 ☐ 2 ☐ 3 ☐ 4

Are the people in your household…	☐ Seldom away ☐ Mostly away during daytime in weekdays ☐ Mostly away during
How high is the net monthly income of your household?	☐ <1,000 € ☐ 1,001 € - 1,500 € ☐ 1,501 € - 2,000 € ☐ 2,001 € - 2,500 €
Does your household receive housing subsidies/ financial aid	☐ yes

1 B. Home Characteristics

Thinking of the ownership of your present home – are you a …	☐ owner-occupier ☐ tenant
Who is your landlord, if applicable?	
For how many years have you been living in your present home?	☐ <1 year ☐ 1 - 3 years ☐ 4 - 6 years

What is the size of your home?	☐ < 50 m² GFA ☐ 51-70 m² GFA ☐ 71-90 m² GFA
How many bedrooms does your home have?	☐ 1 ☐ 2 ☐ 3 ☐ 4
What is the building type you are living or working in? *RESID 1-G3 and NRESID according to the EUROSTAT classification*	☐ single-family detached house (RESID1) ☐ semi-detached house (RESID2) ☐ 3 - or multi-family house (RESIDG3) ☐ non-residential building (NRESID)
In which period was the building you are living or working in built? *Construction year categories according to the EUROSTAT classification*	☐ <1919 ☐ 1919 - 1945 ☐ 1946 - 1960 ☐ 1961 - 1970
When was the last renovation of the building you are living or working in?	☐ 1961 - 1970 ☐ 1971 - 1980 ☐ 1981 - 1990

How high is the annual energy consumption in your household?		
Electricity:	....	kWh/a
Heating and DHW:		
Cooling:		kWh/a
How much are the annual energy costs in your household?		
Electricity:	....	€/a
Heating and DHW:		
Cooling:		€/

Questionnaire Grow Smarter
Part 2 - Perceptions

2 A. Environment

Q	Environmental perceptions	Strongly Agree (5)			Strongly Disagree (1)	
		5	4	3	2	1
1	I am concerned when I think about the environmental conditions that our children and grandchildren probably will face.					
2	Politicians are still doing too little for environmental protection.					
3	The major part of the population is still behaving little environmentally aware.					
4	If we go on acting as until today, we are facing an environmental disaster.					
5	When I read articles or watch television programs about environmental problems I am often shocked and become angry.					
6	There are limits to growth that the industrialized world already has exceeded or is going to exceed very soon.					
7	The consequences of the environmental problems are exaggerations by environmental protectors.					
8	Environmental protection measures should be implemented even if jobs are lost as a consequence.					
9	In favor for the environment we should all be willing to limit our actual living standard.					

Q	Environmental behaviors	Strongly Agree (5)			Strongly Disagree (1)	
		5	4	3	2	1
1	I only use the car if there is no other possibility e.g. for long distances, to get to work, for the transport of goods or persons					
2	For the average cleaning of the household I normally use environmentally friendly cleaner like neutral cleaning agent, vinegar					

	cleaner or potassium soap					
3	I pay attention to an environmentally friendly behavior in the education of my children					
4	I normally buy organic food (vegetables, fruits etc.)					
5	I normally take used batteries, paint etc. to a collection place for harmful substances					
6	I normally take glass waste to the bottle bank					
7	I separate the organic waste from other wastes					

2 B. Energy

Q	**Energy perceptions**	**Strongly Agree (5)**			**Strongly Disagree (1)**	
		5	**4**	**3**	**2**	**1**
1	I think using renewable energy is important					
2	My friends think that using renewable energy important					
3	I feel obliged for future generations to use renewable energy sources					
4	It is good to be less dependent of the energy companies					
5	When I use renewable energy, I am allowed to use more energy					
6	When I use renewable energy, this will benefit the environment					
7	Saving energy is important because it will benefit the environment					
6	Saving energy is important because it saves money					
8	Protecting the environment is an important reason for saving energy.					
9	Environmentalists strongly exaggerate the significance of environmental problems.					
10	Science and technology will solve a lot of environmental problems without us having to change our lifestyles.					
11	What is the more important motivation for energy saving?	To save money		To preserve the environment		

12	What are the reasons deterring you from energy saving?	Slothfulness	Lack of information	High investment for new appliances	No apparent reason

2 C. Indoor Environmental Quality

Q	**Indoor Environmental Quality**	**Strongly Agree (5)**			**Strongly Disagree (1)**	
		5	**4**	**3**	**2**	**1**
1	I am satisfied with the indoor environment (thermal comfort, air quality, ventilation, noise) of my home?					
2	I feel comfortable with the indoor temperature in my home in winter.					
3	I feel comfortable with the indoor temperature in my home in summer.					

2 D. Local Identity

Q	Local identity	Strongly Agree (5)			Strongly Disagree (1)	
		5	4	3	2	1
1	I feel connected to my neighborhood					
2	I feel proud to live in this neighborhood					
3	I feel I can trust my neighbors					
4	I think the perception and image of the neighborhood will positively change due to the Grow Smarter measures					

2 E. ICT Perceptions

Information Communication Technologies

Q	Local identity	Strongly Agree (5)			Strongly Disagree (1)	
		5	4	3	2	1
1	I use the internet on a daily basis for information and communication.					
2	I have the necessary devices to facilitate my information and communication needs (high speed internet, smart phones, tablets, laptop).					
3	I am comfortable with adapting new to smarter household devices (e.g. automated and wireless indoor light solutions)					
4	I get excited about adapting smarter household devices					

Questionnaire Grow Smarter
Part 3 – Energy State

3 A. Household Energy Characteristics

Lighting

Describe the number of light fixtures in your home:

Type of lamp	Quantity
Filament lamp	
Energy saving light bulbs	
Tubular fluorescent lamps	
Halogen lamps	
Other	

Use of household appliances

White goods

Quantity		Age of the appliance	Energy class (A++, A+, A, B, C, D, E, F, G)	Height (cm)	Volume (l)
Refrigerator					
Fridge with freezer					
Freezer					

Washing and drying machines

Quantity		**Age of the appliance**	**Energy class** (A++, A+, A, B, C, D, E, F, G)	**Average week use**	**Built – in timer** (yes/no)
Washing machine					
[6] Drying machine					
[6] Washer and dryer (combined)					
Dishwasher					

[6] ***Note:*** Indicate the average use during the winter and summer period.

Common washing and drying facilities within apartment building

Do you use washing and drying facilities within apartment building?	**Average weekly Use (number of times)**
Washing machine	
Drying machine	

TVs, computers, other entertainment electronics

Type and quantity			**Age of the appliance**	**Energy class (A++, A+, A, B, C, D, E, F, G)**	**Average use per day (h/day)**
TV	Cathode				
	LCD				
	Plasma				
Computer	Portable				
	Table				
Hi – Fi					
Other					

Heating – Cooling - Ventilation

Air - conditioning of dwellings

Type and quantity		Age of the appliance	Energy class (A++, A+, A, B, C, D, E, F, G)	9 Average use per day (h/day)	Built – in timer (yes/no)
8 No AC					
Air-condition					
Other					

[8] ***Note:*** Please continue with the next item in the survey.

[9] ***Note:*** Indicate the number of days and the average number of hours of use per day during the last 12 months.

Average room temperature in dwelling

Indoor temperatures sources for the local heating	Quantities
Average inside temperature during the hot season (°C)	
Average outside temperature during the hot season (°C)	
How many, months of the year are you feeling too cold in your home? (number of months per year: 0-12)	
How many, months of the year are you feeling too warm in your home? (number of months per year : 0-12)	
Do you use electrical furnaces to maintain indoor temperatures during cooling season? If yes, how many months of the year? (number of months per year: 0-12)	

Energy sources for local heating

The quantity of energy sources for the local heating	Hours per day during heating season?
14 Electric energy – el. Radiators, AC	
Firewood	
Wood pellets	
Wood briquettes	

Cooking

Cooking habits

	How many cooked meals per week on average have you prepared at home during the last 12 months?
Meals per week	

Cooking equipment and usage

What type of cooking stove do you use?		Have you used the oven during last 12 months?		Average monthly oven use (h/month)	Age of electric oven?	Average monthly microwave use (h/month).
Classic electric		Yes				
Glass - ceramic		No				
Induction panel						

5.2 Appendix 2: GrowSmarter Travel Survey

GrowSmarter Travel Survey

F1

How long *in total* do you travel between home and work during a typical week (preferably last week)?
State the number of days per week for the main forms of transportation you use and the kilometres travelled with each transport mode (NOTE! BOTH WAYS).

(Example: If you travel to work 5 days a week by car, write the number 5 in the row "Car". If you travel 2 days a week by car and 3 days a week with public transport, write 2 in the "Car" row and 3 in the "Public transport" row).

	# days	# km
Car (as driver)		
Car (as passenger)		
Car sharing		
Park-and-ride (car) and public transport		
Public transport		
Long-distance train (+ connection)		
Long-distance bus		
Motorcycle/moped full distance		
Cycle full distance		
Walk full distance		
Other		
Total		

[maximum 7 days per column – control must take place in the web programme.
Minimum 1 day per column –control must take place in the web programme.

F2

During last week, how many kilometres did you travel from home to other local destinations *except work commute*?
State the total number of kilometres for the main forms of transportation you used.

	# km
Car (as driver)	
Car (as passenger)	
Car sharing	
Park-and-ride (car) and public transport	
Public transport	
Long-distance train (+ connection)	
Long-distance bus	
Motorcycle/moped full distance	
Cycle full distance	
Walk full distance	
Other	
Total	

F3

Which type of fuel do you primarily use for your car*?*
[to be answered only by those driving cars]

- ☐ Petrol/gasoline
- ☐ Diesel
- ☐ Biogas
- ☐ Ethanol
- ☐ Electricity
- ☐ Other

F4

What would it take for you to choose another form of transportation, instead of bringing your car to work? (only one alternative can be chosen so choose the most important reason)

[to be answered only by those who drive cars to work]

- Improved car sharing facilities
- Better conditions for cycling (e.g. good cycle parking, improved cycle paths)
- More flexible working hours
- Better opportunity for bike-sharing
- Better charging facilities for electric vehicles
- Improved public transport (e.g. increased frequency, new routes)
- Other, namely...
- Nothing

F5

Other, specifically...

[Free text]

F6

What would it take for you to choose another form of transportation during evenings, weekends, leisure hours (only one alternative can be chosen so choose the most important reason)?

[to be answered only by those who drive cars to work]

- Improved car sharing facilities
- Better conditions for cycling (e.g. good cycle parking, improved cycle paths)
- More flexible working hours
- Better opportunity for bike-sharing
- Better charging facilities for electric vehicles
- Improved public transport (e.g. increased frequency, new routes)
- Other, namely...
- Nothing

F7

Other, specifically...

[Free text]

F8
What is the most important reason for your choice of transportation (only one response allowed)?

- Health reasons
- Exercise
- Environmental reasons
- Time savings
- Economic reasons
- Comfort
- Access to this form of transportation
- Flexibility
- Other

F9
Other, namely...

[Free text]

F10
On average, how much do you estimate your journeys to and from work cost you each month?

kr (max 4 figures)

F11
Are you...

- Man
- Woman

F12
Your age?

- Younger than 30
- 30-40
- 41-50
- 51-60
- 61 or older

F13 (open question)

Other comments
Here you can add any comments you have about the project.