IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

Project Acronym:	IRIS
Project Full Name:	Integrated and Replicable Solutions for Co-Creation in Sustainable Cities
Grant Agreement:	No 774199
Project Duration:	5 years (starting 1 October 2017)

Deliverable 5.3

Launch of T.T. #1 Activities on Smart renewables and near zero energy district

Work Package:	WP5: Utrecht Lighthouse City demonstration activities
Task:	T5.3 Demonstrating Transition Track #1: Smart renewables and near zero energy district
Lead Beneficiary:	BOEX
Due Date:	31 December 2019 (M27)
Submission Date:	31 December 2019
Deliverable Status:	Final
Deliverable Style:	R
Dissemination Level:	PU
File Name:	D5.3_Launch_of_T.T.1_activities_on_Smart_renewables_and_near_zero_energy_district_Utrecht

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 774199

Authors

Surname	First Name	Beneficiary
Broekman	Martijn	Bo-Ex
Klink	Arthur	Municipality of Utrecht
Peekel	Arno	Utrecht University / Utrecht Sustainability Institute

In case you want any additional information or you want to consult with the authors of this document, please send your inquiries to: irissmartcities@gmail.com.

Reviewers

Surname	First Name	Beneficiary
Kok	Matthijs	Municipality of Utrecht (internal review)
Malm	Rickard	HSB Gotheborg (external review)
Panagiotis	Tsarchopoulos	CERTH

Version History

Version	Date	Modifications made by
0.8 (ready for internal review)	October 2019	Martijn Broekman
0.9 (ready for external review)	November 2019	Martijn Broekman
1.0 (ready to submit)	December 2019	Arno Peekel

Disclaimer

Executive Summary

The ambitions of this Transition Track #1 'Smart renewables and closed-loop energy positive districts' consists of: contributing to Near Zero Energy districts by integrating (1) a high share of locally produced and consumed renewable energy at district scale, (2) energy savings at building level, and (3) energy savings at district level.

To achieve these objectives, seven measures will be developed and implemented in the demonstration area 'Kanaleneiland-Zuid' in Utrecht measures are:

- Measure 1: District wide PV
- Measure 2: LT district heating
- Measure 3: HEMS TOON
- Measure 4: NZEB refurbishment
- Measure 5: Smart (hybrid) e-heating systems
- Measure 6: AC/DC home switchboxes
- Measure 7: Smart DC Street Lighting

For this transition track, this deliverable describes the scope, how the work is organized, the involved parties, the elaborated measures, link to other transition tracks and work packages, monitoring and KPIs.

After 24 months, a lot of work has been done to execute and monitor the activities in the coming years of the IRIS project and beyond.

Behind track due to exhaustive collaboration with tenants

We are slightly behind planning with the planned activities. The main reason is that the planned refurbishment of the twelve apartment buildings have been delayed due to exhaustive participation with tenants to prepare plans for their apartment building. Tough discussions about other topics than the IRIS measures such as an elevator or a bigger kitchen for the tenants have not contributed to a smooth process of participation and caused a delay. For the IRIS apartment buildings we try to increase the level of participation with tenants to involve them frequently in the preparation phase.

The first apartment building Columbuslaan III should have been the first refurbished IRIS apartment building, but unfortunately the amount of support amongst tenants was a little too low to execute works.

Lessons learned

From the other activities, the following lessons have been learned and are taken into account considering activities in the (near) future:

1. It is not easy to come into contact with our target group, because of language barriers, people have bigger problems to worry about and a natural distrust within a large part of the target group towards institutions such as the municipality and housing corporation.
2. The distrust in housing corporation Bo-Ex amongst tenants is high and it is hard to find reasonable solutions. The distrust is strengthened by the plans of other housing corporations in

the district who act in the same area and offer their tenants more value for money according to the tenants of Bo-Ex.

Drivers and barriers

The main drivers of this transition track are still actual, the solutions which have been suggested are still applicable and increase the energy efficiency within the district of Kanaleneiland-Zuid.

The main barriers are primarily the involvement and support of tenants. Tenants in this district often have other problems to process such as obtaining enough income to feed my household, criminality, rats, traffic safety and parking problems. A sustainable house is not on top of their mind.

Involvement and support of citizens is a key factor in the IRIS project. This is even more relevant for the activities in Utrecht, since all integrated solutions are planned to be implemented in the same challenging district. Citizens have other problems on their minds than sustainability, problems that concern primary necessities of life, such as sufficient income to live on a monthly basis, criminality, nuisance caused by waste, insecurity caused by traffic situations.

Demonstrator	In a nutshell
#1 District wide PV	Brief summary: a high share of locally produced and consumed renewable power at district scale making PV profitable without subsidies.
	Expected impact: 1. Energy savings for the tenants, 2. CO_2 emission reduction and 3. Reduced energy costs for tenants
#2 LT district heating	Brief summary: a lower temperature district heating network to supply the apartment houses with heat.
	Expected impact: 1. Energy savings for the tenants, 2. CO_2 emission reduction and 3. Reduced energy costs for tenants
#3 HEMS Eneco Toon	Brief summary: a device for every household providing feedback on energy consumption, the PV-system (and hybrid E/G heating and ventilation).
	Expected impact: 1. Energy savings for the tenants, 2. CO_2 emission reduction and 3. Reduced energy costs for tenants, 4. Increased awareness of energy usage.
#4 NZEB refurbishment	Brief summary: refurbishment of twelve apartment buildings in the district of Kanaleneiland-Zuid, including maintenance as well renovation works.
	Expected impact: 1. Energy savings for the tenants, 2. CO_2 emission reduction and 3. Reduced energy costs for tenants
#5 Smart (hybrid) e-heating systems	Brief summary: a smart hybrid heat pump in four apartment buildings, connected with the existing gas heating device, to provide heat and hot tap water.

Demonstrator	In a nutshell
	Expected impact: 1. Energy savings for the tenants, 2. CO_2 emission reduction and 3. Reduced energy costs for tenants
#6 AC/DC home switchboxes	Brief summary: a small scale pilot of eight apartment dwellings where a partly direct current network in the dwellings is realized.
	Expected impact: 1. Energy savings for the tenants, 2. CO_2 emission reduction and 3. Reduced energy costs for tenants
#7 Smart DC Street Lighting	Brief summary: 50 lamp posts powered by renewable energy, providing district WiFi, dynamic and energy efficient lighting, powered by renewable energy.
	Expected impact: Reduction in annual final energy consumption by street lighting and additional functionalities which contribute to the demands amongst citizens in the district.

Table 1 Summary of measures: progress and impact

Table of Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

Abbreviation	Definition
AC	Alternating current
CIP	City Innovation Platform
DC	Direct Current
DH(N)	District Heating (Network)
DoA	Description of Action
EMS	Energy Management System
EU	European Union
FC	Follower City
HEMS	Home Energy Management Systems
IS	IRIS Solution
KPI	Key Performance Indicator
LH	Lighthouse
LHCSM	Lighthouse City Site Manager
LT	Low Temperature
MaaS	Mobility as a Service
NZEB	Near Zero Energy Building
PoR	Programme of Specification
PV	Photovoltaic
RES	Renewable Energy Sources
SoA	State Of the Art
TT	Transition Track(s)
WP	Work Package

1 Introduction

1.1 Scope, objectives and expected impact

Objective of this deliverable is to provide a detailed overview of the activities for Transition Track #1 within the Utrecht demonstration. This deliverable is relevant for other organizations, since the subject of research consists of apartment buildings which have been built in many places in the after-war period. Since the challenges with tenants who are faced with low-income, language barriers and other social problems are widespread in The Netherlands as well abroad. Finally, the need for replicable and scalable solutions regarding the energy transition for apartment buildings, is quite a big issue.

1.2 Contributions of partners

The activities within TT#1 are discussed and prepared by housing corporation Bo-Ex, electricity grid owner Stedin, district heating and HEMS Eneco Toon owner Eneco, owner of public areas and involved in all kind of matters in the district of Kanaleneiland-Zuid the Municipality of Utrecht, Luminext as service provider for smart street lighting and Utrecht Sustainability Institute (USI) as overall coordinator and linking pin with other work packages and initiatives.

Chapter 4 describes the involved parties and their roles and responsibilities.

1.3 Relation to other activities

The following figure shows the relation between the activities in TT#1 as described in the deliverable and the activities within other transition tracks and other work packages.

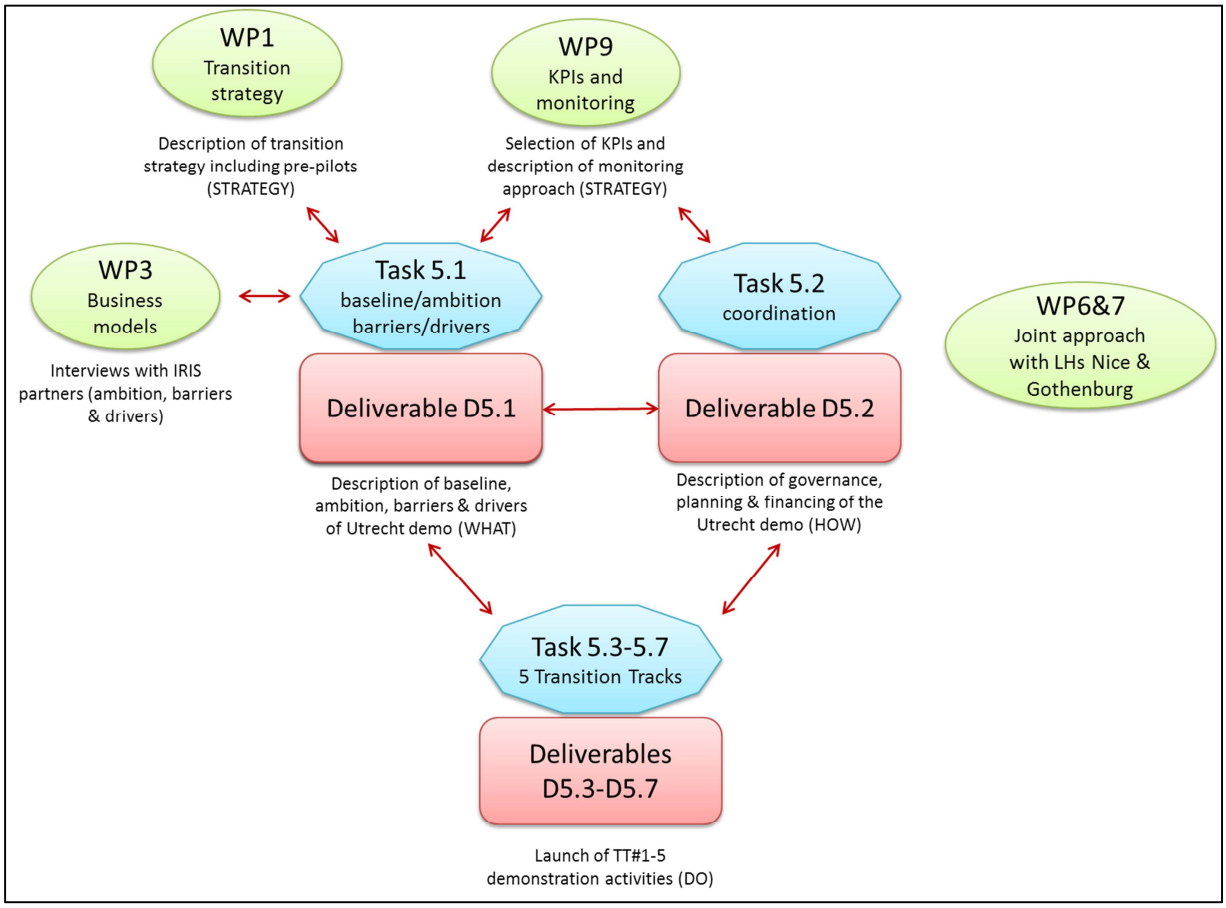


Figure 1. Relation of this deliverable with other deliverables and work packages

1.4 Structure of the deliverable

This document contains the overall starting points for TT#1 activities, which consists of a description of the demonstration in a nutshell, the baseline for TT#1 and the organisation of work.

Chapter 4 describes the organization of work.

From chapter 5, the seven Measures within TT#1 are explained and the achieved results reported.

Chapter 12 contains the KPI's and chapter 13 ethical requirements we've to deal with, when rolling out the activities and monitoring.

The last two chapters contains the output to the other Work Packages as well as a conclusion and next steps.

2 Demonstration in a nutshell

2.1 Ambitions for TT#1

The *DoA states* that Utrecht's ambition is to contribute to Near Zero Energy districts by integrating:

- A high share of locally produced and consumed renewable energy at district scale;
- Energy savings at building level;
- Energy savings at district level.

The applied measures concern integrating (1) a high share of locally produced and consumed renewable power at district scale making PV profitable without subsidies, (2) RES and low temperatures for the district heating system partly serving the district, (3) innovative home EMS TOON, (4) energy savings thanks to refurbishing towards near energy zero building, (5) smart (hybrid) electric heat pumps for heating and hot water, (6) energy savings thanks to smart AC/DC power grid in apartments and (7) smart DC street lighting at district level.

Measures 1, 3 and 4 will be integrated and deployed in 12 five-storey apartment buildings adding up to 644 apartments (locations still to be determined). Measure 2 and 5 will be integrated and deployed in 4 five-storey apartment buildings adding up to 192 apartments each. Measure number 6 will be demonstrated in 8 apartment houses.

2.2 Demonstration area

The demonstration area for *all five transition tracks* is situated in the district of Kanaleneiland-Zuid in the city of Utrecht and the neighbouring area Westraven, as showed in the next figure. This is a residential area of 64 hectares situated in the Utrecht Centre-West area, just southwest of the historic city centre and the Utrecht Central Station. The district is surrounded by two large canals (hence 'canal island'), one of which is used intensively for freight transport (Amsterdam-Rhine Canal).

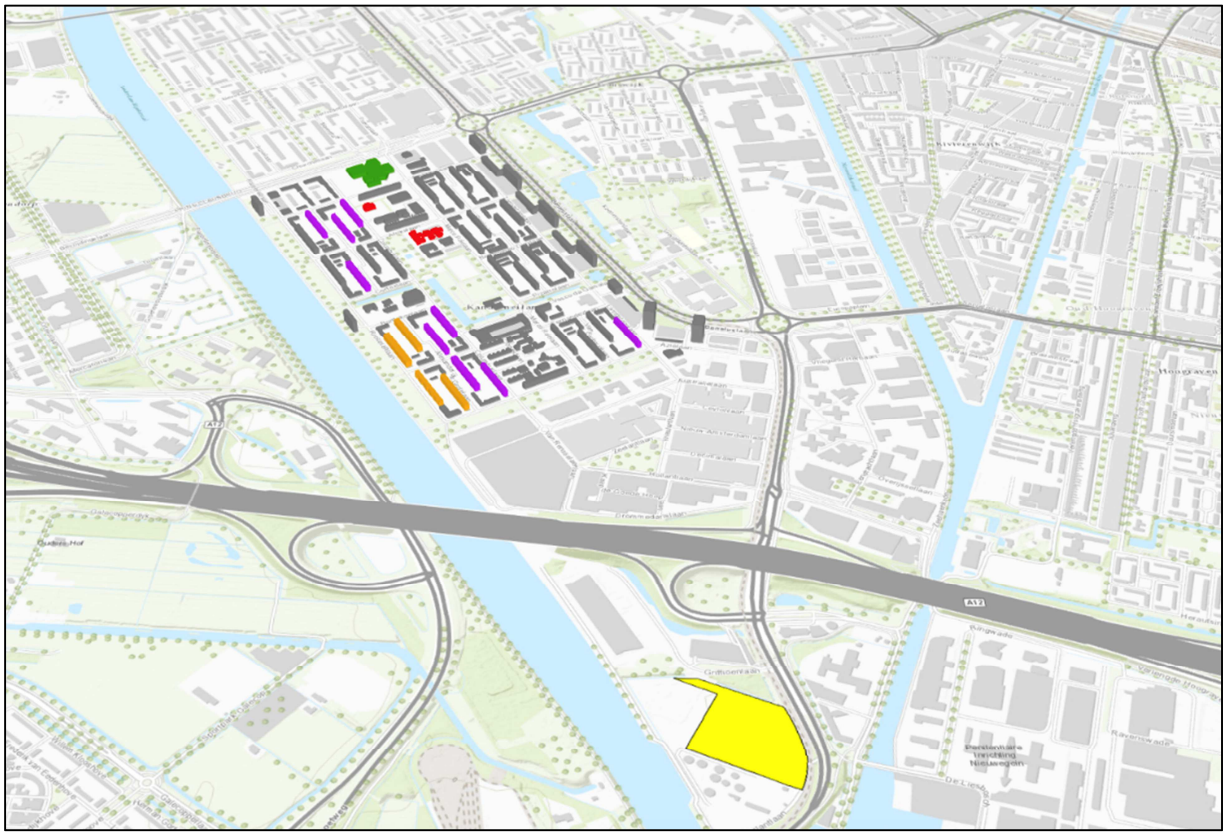


Figure 2. Location of the demonstration district Kanaleneiland Zuid and Westraven (yellow hatched).

Source: Utrecht op de Kaart http://kaartenutrecht-gemu.opendata.arcgis.com/

2.3 Integrated Solutions in TT#1

The demonstration activities of TT#1 on Smart renewables and near zero energy district in LH Utrecht comprise of the integration of a set of solutions integrated and deployed in 12 four-storey apartment buildings of social housing corporation Bo-Ex (8 buildings with gas-infra; 4 with DH-infra, 644 apartments in total). In particular:

- District-scale integrated PV-system installed on 12 apartment buildings, leading to a high share of locally produced and consumed renewable power at district scale making PV profitable without subsidies.
- RES and LT district heating, to be demonstrated in 4 apartment buildings.
- Energy savings towards NZEB by refurbishment of 12 apartment buildings from energy label E/F to A.
- Installation of innovative HEMS (home EMS TOON) in all 644 apartments, providing feedback on energy consumption, the PV-system, hybrid E/G heating and ventilation and facilitating citizen engagement.
- a smart hybrid heat pump in four apartment buildings, connected with the existing gas heating device, to provide heat and hot tap water.

- Energy savings thanks to a small scale pilot of eight apartment dwellings where a partly DC network in the dwellings is realized.
- Medium-scale demonstration of smart street lighting, providing district WiFi, dynamic and energy efficient lighting, powered by renewable energy.
- Installing performance testing and measurement equipment.

Figure 3 shows the links between the measures of TT#1 and the other measures within WP5. The figure reveals that many of the activities within TT#1 are an integral part of the Utrecht demonstration.

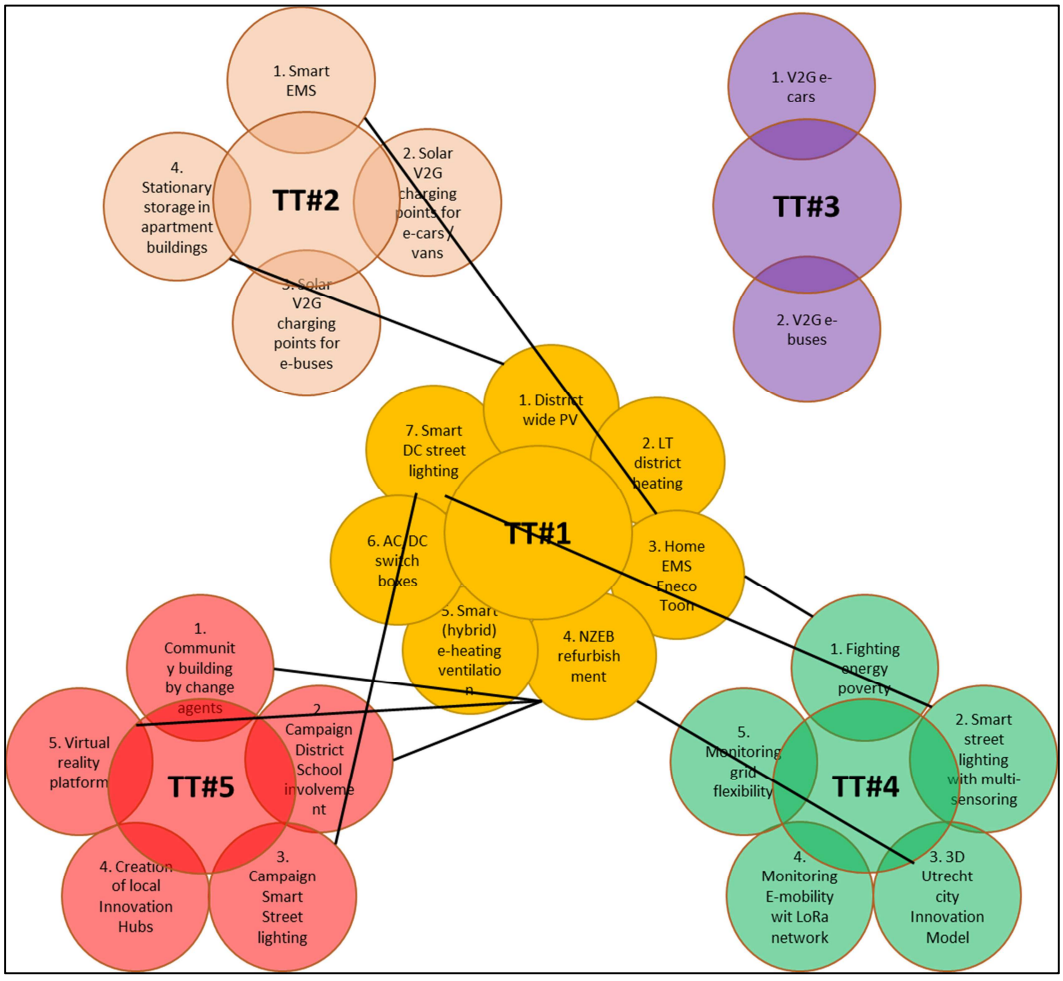


Figure 3 Position of TT#1 within WP5

2.4 Integration of Demonstrators

All measures, except for the smart street lighting, will be implemented by means of the refurbishment activities of Bo-Ex at the 12 apartment buildings. The current connection to the gas network or the DHN determines whether measure 2 and 5 can be applied to a building (see chapter 5 to 10).

All measures will be applied within the same district 'Kanaleneiland-Zuid'. The refurbished buildings and RES will be connected to the existing energy networks in the district, leading to a new district energy system, which will be monitored in close cooperation with the TT#2 and TT#3 of WP5.

2.5 Deviations according to the Grant Agreement

Deviations to the Grant Agreement in terms of other involved parties and/or other activities have not been taken place. We are still on track for most of the measures. But, some of the activities have been elaborated differently than the original thought. For example, the plan of approach for implementing the Home EMS Eneco Toon has been changed due to new insights and the schedule of the District wide PV and NZEB refurbishment has been changed due to external influences.

The following table shows the deviations of this transition track at this moment:

Type of deviation	Measure	Deviation
Specification of the demonstrator	M#7 Smart street lighting	Progressive insights have led to the conclusion that connecting street lighting to DC distribution is not an option that shortly will be replicated on a large scale in the city of Utrecht. Assessments show that energy efficiency gains do not outweigh additional investments. Lamp posts will be equipped with LED armatures financed from the regular public lighting budget of the city of Utrecht. Within IRIS, a concept for application of smart street lighting - "Smart pedestrian crossing" – that was co-created together with citizens in TT#5 will be implemented. The lamp post will also include a multifunctional column that will be equipped with multiple sensors to measure e.g. noise levels, air pollution and traffic intensity and in which data will be collected and assessed through open ICT system.
Ambitions of the demonstrator	M#1 / M#4 / M#5	Delay of the schedule: the proposed sequence and planning of the refurbishment of the apartment buildings has been delayed due to less support of the tenants. We now expect to complete all twelve apartment buildings before end of 2022, but that means that nothing may go wrong from now.
	M#1 PV panels on the roofs of the apartment buildings	The PV-panels on the roof of the schools are depending on the cooperation and investment possibilities of the involved schools and technical possibilities. At this moment, none of the three schools have plans to place PV-panels that can be connected to a district energy system.
KPI targets of the demonstrator	M#1 PV panels on the roofs of the apartment buildings	A detailed positioning plan of the PV-panels on the roofs of the 12 apartment buildings shows that the maximum amount of PV-panels is less than indicated originally.

Table 2 List of deviations to the GA

Further explanation of these deviations can be found in the chapters of the mentioned measures.

3 Baseline / Drivers and Barriers

3.1 Baseline

The demonstration area has a poor energy profile. Most buildings were built in the period 1950-1970, an era marked by the absence of energy regulations. The apartments are poorly insulated and have a typical energy label E-F. the next figure provides an overview of the current status of the energy labels for the buildings in Kanaleneiland-Zuid.

Figure 4. Current Energy labels in the demonstration district Kanaleneiland Zuid (red rectangle = demonstration area)
Source: Utrecht op de Kaart http://kaartenutrecht-gemu.opendata.arcgis.com/

The demonstrations area in Kanaleneiland Zuid includes 12 four-storey apartment buildings of social housing corporation BOEX, adding up to 644 apartments. Of these apartment buildings 8 are of the Intervam type (5 storey high apartment building with 48 apartments) and 4 of the Bredero type (5 storey high apartment building with 65 apartments). Intervam and Bredero are the names of the construction type of the buildings.

Figure 5 Typical 5 storey high Intervam apartment building

Intervam is a system that was introduced to the market by a company called intervam in the ’50 of the 20th century. The VAM system is a mounting construction method. In the factory all necessary elements are prefabricated and on the construction site they are combined into a residential block. This provided the opportunity to significantly speed up the building process in an era with a huge housing shortage after the Second

World War. Bredero was a project developer and building company that also offered standardized houses using a mounting method.

Next, 3 school buildings (Kaleidoscoop, Schatkamer, MBO Utrecht) and the local innovation hub Krachtstation are part of the demonstration area (see Figure 6).

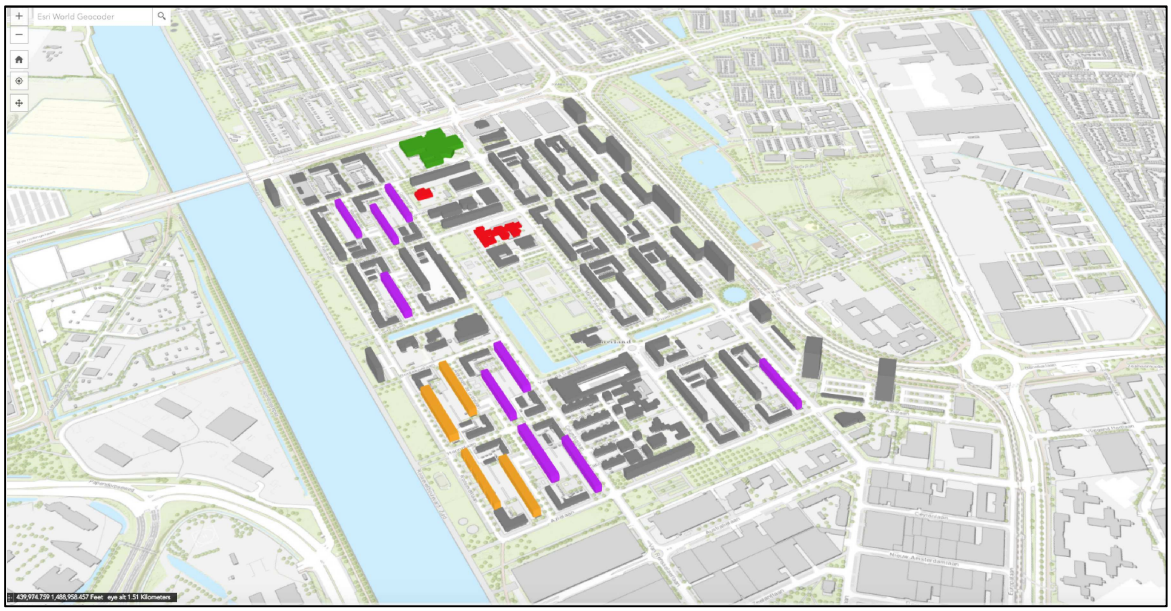


Figure 6. Map of the demonstration district Kanaleneiland Zuid.
Source: Municipality of Utrecht http://www.utrecht.nl

In the map of the demonstration above, the following objects are visualized: apartment blocks that will be renovated (marked yellow and purple), involved schools (marked red) and the local innovations hub Krachtstation (marked green).

The demonstration area is characterized by a mixed energy infrastructure. Of the apartment buildings that will be renovated 8 are currently heated with gas boilers and 4 are heated through the district-heating network (see Figure 7).

Figure 7. Overview of the apartment building that will be renovated

Table 1 provides an overview of the average annual electricity and natural gas consumption for households in the apartment buildings that will be renovated. Households in the apartment buildings heated by natural gas boilers consume between ~ 1000 and ~1200 m3 natural gas per year. Households in the apartment buildings connected to the district heating network only use natural gas for cooking, and as a result consume lower levels of natural gas. Average electricity consumption for households ranges from ~2000 to ~ 1500 kWh per year. It must be noted that:

- These consumptions are reached at often-low thermal comfort performance (f.i. heating in winter limited to one room only).
- Variations in energy consumption between households in one apartment building can be very large, which has consequences for financial gains that can be achieved through the implementation of the measures within the IRIS project.

Apartment building	Electricity use 2017 in kWh	Natural Gas use 2017 m3
Alexander de Grotelaan II	1819	1043
Alexander de Grotelaan III	1835	994
Alexander de Grotelaan I	1606	1137
Alexander de Grotelaan IV	1589	1226
Columbuslaan I *)	1348	332
Columbuslaan II	1492	1067
Columbuslaan III	1639	1072
Magelhaenlaan I*)	1769	384
Magelhaenlaan II*)	2036	368

Apartment building	Electricity use 2017 in kWh	Natural Gas use 2017 m3
Magelhaenlaan III*)	1696	376
Rooseveltlaan I	1694	1067
Rooseveltlaan II	1636	1030

Table 3. Average electricity and natural gas use per household in 2017 for each of the apartment buildings in the demonstration area. Source: Stedin
*) Natural gas for cooking only. Heating through the district heating systems

The use of district heating in the four apartment buildings in 2017 varies between 976 till 1.124 GJ for one apartment building (consisting of 48 apartments).

Hardly any renewables are being exploited in Kanaleneiland-Zuid; only a few PV-panels are installed so far. Kanaleneiland-Zuid furthermore applies conventional street lighting, i.e. lampposts are connected to the AC grid and not equipped with smart devices. Current location of lamppost in the area is mapped in Figure 8.

Figure 8. Current location of lamp posts in Kanaleneiland Zuid (red dots).
Source: Utrecht op de Kaart http://kaartenutrecht-gemu.opendata.arcgis.com/

3.2 Drivers and Barriers

The main drivers and barriers consist of citizen engagement, which is needed for successful co-creation processes. For that reason, any solutions proposed can be deployed in real-life and economy terms, only if the underlying multidisciplinary expertise of cities, citizens, industrial partners, city decision makers and knowledge centres get extensively integrated as well. The diversity in stakeholders and the crucial role of citizens as enablers require co-creation of attractive and inclusive services that support people in their own motivations to engage, express ownership, and change behavior.

4 Organisation of work

4.1 Standard procedure of approach

Bo-Ex as owner of the apartment buildings, and as TT#1-lead, organizes the retrofit of the apartment buildings. Every apartment building goes through a cycle of activities, part of the standard procedure that Bo-Ex is uses in retrofitting:

The figure on the right side visualizes the standard process from start decision till handover of the project.

- Investigation and research: Every building is inspected and investigated in order to get a clear picture of the current state of the building and the necessary activities;
- Engineering: producing technical descriptions and blue prints, obtaining permits;
- Preparations, purchase of materials and planning of retrofit.

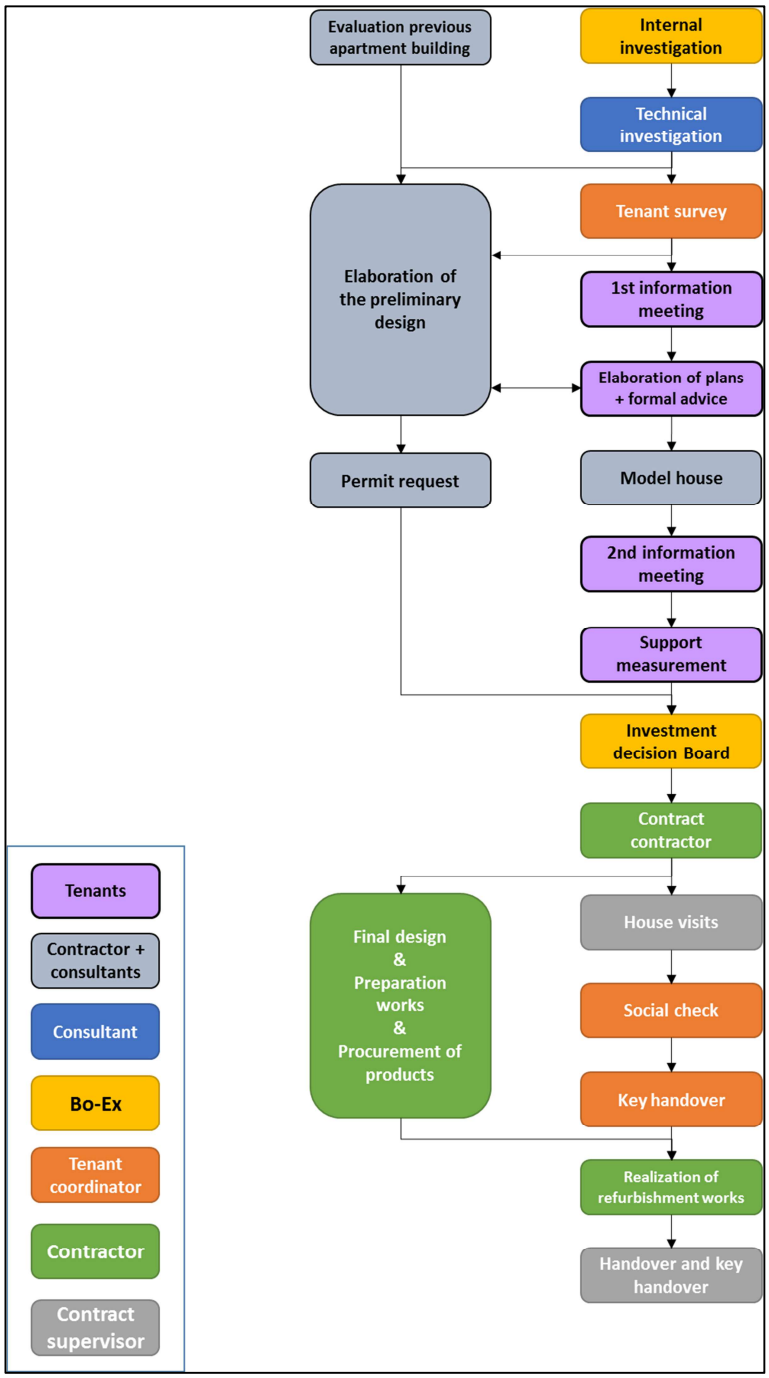


Figure 9 Standard list of activities for the retrofit of an apartment building

4.2 Partners within Utrecht

The measures that will be executed as part of the WP5 demonstration activities are detailed in close consultation with IRIS partners from the Utrecht ecosystem and are recorded in program of requirements for every measure. Key partners in TT#1 are:

Organization	Task and responsibility
Bo-Ex	Landlord/owner of the apartment buildings and coordinator of TT#1.
Stedin	Owner of the electricity grid and individual grid connections.
Eneco	Owner of the district heating infrastructure and connections, supplier of the Toon (HEMS).
Municipality of Utrecht	Responsible of public street lighting and WP5-leader.
Utrecht Sustainability Institute	Lighthouse City coordinator and Work package coordinator.

Table 4 overview of involved parties in TT#1

In order to elaborate and prepare the activities, the transition track leaders of WP5 Demonstration area Utrecht have bi-weekly meetings. In this meeting, so called coordination team meeting, the leaders together with the WP5 coordinator from USI discuss the schedule, progress and challenges. Furthermore, six times a year, a project group meeting is organized with all WP5 involved parties as well as the involved parties within other work packages come together. In this meeting we discuss the progress on a higher level and lift out a topic which is relevant for all parties e.g. AC/DC switch boxes and LT district heating.

5 M#1: PV panels on the roofs of the apartment buildings

5.1 Specifications

The roofs of the apartment buildings in the district will be equipped with PV-panels. In the DoA states that also the schools in the demonstration area are equipped with PV-panels, but this is not in the plans anymore because of technical and financial problems within the schools.

The number of PV-panels that will be placed on the roofs depends on:

(1) available and appropriate roof surface,
(2) efficiency of the PV-panels (i.e. electricity production), and
(3) energy usage of the tenants. The PV-panels produce energy and deliver this directly to the tenants.

When more PV-energy is generated than used on a specific moment, energy is delivered back to the grid provider. Currently, new regulations are under preparation by the Dutch government regarding the amount of energy delivery and the tariffs for delivering energy to the grid. Bo-Ex and Stedin work closely together to detail and plan the necessary modifications to the electricity grid and connections to host renewable energy production of the PV-panels. Figure 10 and Figure 11provide an overview of the current (upper), and envisioned (below) integrated energy systems for individual apartment buildings.

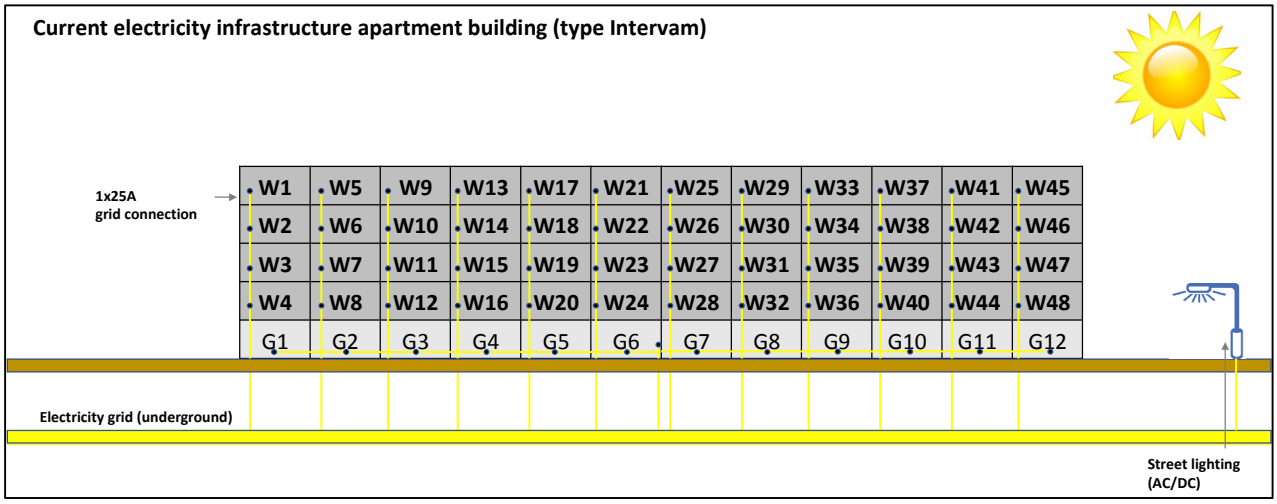


Figure 10 Overview of the current energy system

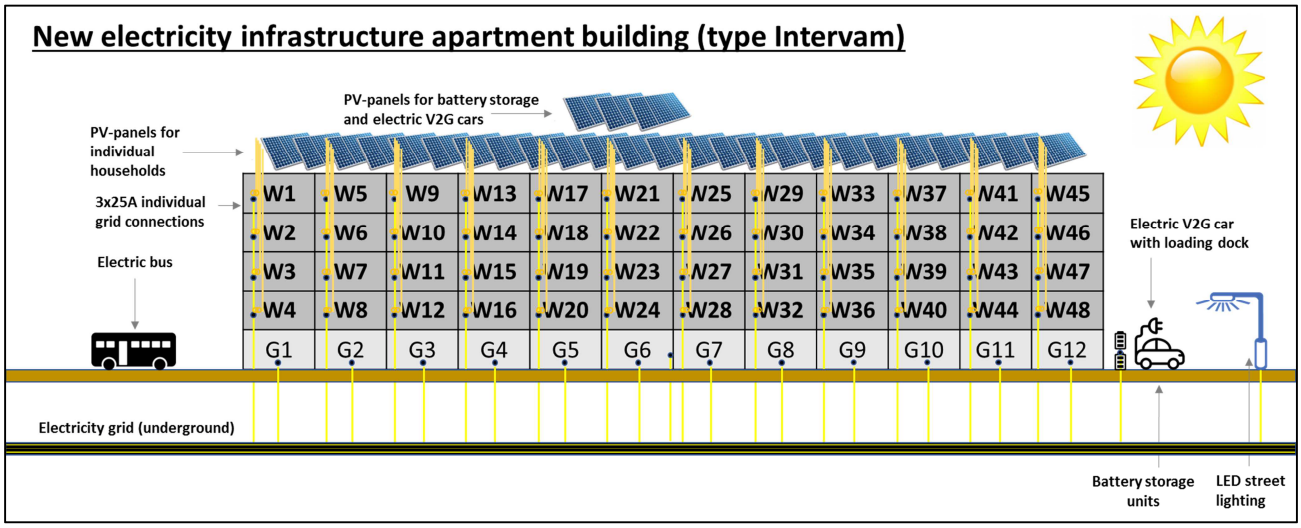


Figure 11 Overview of the envisioned energy system for an apartment building

5.1.1 Hardware: specifications

The main parts of this Measure are the PV-panels, the smart meter and software. The brand of the PV-panels is not yet known and depends on the actual market prices and availability.

The technical specifications of the PV-panels are:

- PV-panel should at least have a peak capacity of 300 Wp.
- PV-panel to degradate max. 25% over 25 years.
- PV-panels to be connected to the HEMS Toon.
- PV-panels are from the glass-glass type, not glass-foil type.

The dimensional/situational specifications of the PV-panels are:

- PV-panels to be installed on the roof of the apartment blocks / schools.
- PV-panel should have dimensions of approx. 1,600mm by 1,000mm.
- Individual connections to the individual tenants for the apartment buildings.
- A minimum of 4 and a maximum of 6 PV-panels should be connected to the apartments directly.
- A minimum of 30 PV-panels should be connected to a car charging point and the battery storage (see deliverable D5.5).
- Possibility to exchange power between tenants in the future.

In the meter cabinet (the cabinet where also the smart meter is positioned), a smart meter accessory from Qubino is installed.

The technical details of this accessory can be find on: https://qubino.com/products/smart-meter/smart-meter-techold/

5.1.2 Software: specifications

For the apartment houses, the PV-panels are linked with the HEMS Eneco Toon and provides actual data of the energy as provided by solar energy. This accessory connect wireless to the Eneco Toon and is installed in the fuse box. The software, hardware and connectivity of the HEMS Eneco Toon is described in chapter M#3 in this deliverable. The development of data services based on the HEMS Toon installation are described in deliverable D5.6. This is the most integrated solution because of the less impact and high connectivity with the HEMS Eneco Toon within each apartment house.

For the schools, the PV-panels are linked to an independent software solution which is unclear at this moment and depends on the availability of solutions and the wishes of the schools.

5.1.3 Procurement of equipment and/or services

For the apartment houses, the procurement of the PV-panels is done by housing corporation Bo-Ex. Since this product is not subject to subsidiary, Bo-Ex follows their own procurement procedure and budgeting.

In 2018, Bo-Ex selected one installation contractor for the supply and installation of PV-panels for over 1,000 households. The apartment buildings within IRIS are part of this scope.

Lessons learned from Bo-Ex is that every household shall have the same rights within their apartment building and that this programme shall also be accessible for tenants in the future. Therefore, we always start with a technical investigation of the available roof space to create a layout map of all possible PV-panels. Based on this outcome, we can divide the total amount of PV-panels to the tenants.

Important to know is that in The Netherlands, housing corporations may not build an industrial PV-installation with one (industrial) transformer and divide the total amount of generated PV-energy to the tenants. We may provide PV-panels for our tenants, but each tenant shall have its own physical connection and transformer.

5.2 Societal, user and business aspects

5.2.1 Citizen engagement

This Measure is positioned on the second step of the ladder of engagement (‘Citizen storytelling’), which means that for this Measure the scope is determined by housing corporation Bo-Ex. This implies that the challenge is to inform and involve the tenants well about the activities, the conditions and the benefits.

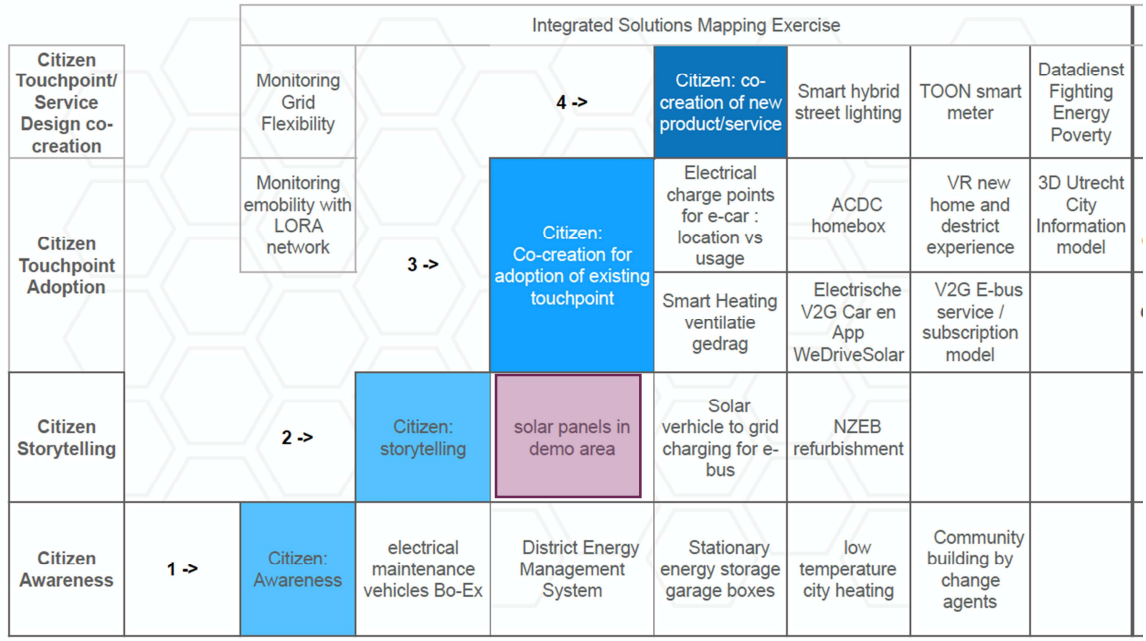


Figure 12 positioning of this Measure on the ladder of engagement

5.2.2 Business model

A business model will be set up for each of the 644 households, with their own set of PV-panels (collectively placed on the building roofs by Bo-Ex), to exchange solar power. This business model has been set up by Bo-Ex and consists of the following principles:

1. Bo-Ex invests in the PV-panels for a tenant;
2. A tenant pays 50% of the expected generated energy to Bo-Ex every month by a service cost fee:
    a. Bo-Ex purchases for example 4 PV-panels for a tenants: investment of € 1.830,- for 4 panels (€ 1,50 / WP);
    b. The expected generated energy on a yearly basis is approximately 1.000 kWh;
    c. The expected value of the generated energy on a yearly basis is approximately (€ 0,21 * 1.000 =) € 210, per year based on the current average electricity price per kWh;
    d. 50% of the expected value is paid back by the tenants on a monthly basis: ((50% * € (210/12 months) = € 8,75 per month; The other 50% of the expected value is the profit for the tenant.
3. With the service cost fee model, payback period for the investment of Bo-Ex is within 20 years. In the Total Cost of Ownership, the installation works is included, as well as the replacement of the transformer, the yearly cleaning of the PV-panels as well as the loan of interest and costs for monitoring and repairing failures.

This business model should motivate the households to participate in the IRIS project since no investment beforehand is required by the tenants.

5.2.3 Governance

For this measurement, the role of the grid operator Stedin is important to mention. The impact of PV-panels on the existing electricity grid is big. The capacity of the existing electricity grid has been based on the expected amount of used energy within the district. The PV-panels generate a lot of electricity at daytime which is delivered back to the electricity grid. This may cause peak load capacity problems. Without interventions, the electricity grid may blackout due to a high amount of generated electricity. Grid owner and operator Stedin is partner within the IRIS project and has taken precautions to minimize the chance of a blackout by implementing three additional medium voltage stations in the demonstration district (see deliverables D5.4 for more information about peak load reduction and congestion management and deliverable D5.6 for data service development on grid flexibility).

5.3 Impact Assessment

5.3.1 Expected impact

The impact of this Measure contributes to increasing the renewable energy and the reduction of CO_2, overall goals of the IRIS project. Table 5 shows the contribution of this Measure to the common objectives of IRIS:

Table 5 overview of the contribution of this Measure to the IRIS objectives

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: PV-panels are smart renewables.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	N/A
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.	N/A
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	N/A
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	N/A
6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	Yes: the business model regarding this Measure may be replicable abroad.
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size,	N/A

geography, climatic zones and economical situations.	
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

5.3.2 KPIs

The relevant Key Performance Indicators for this Measure consists of:

KPI	Why?	Definition	Baseline	Target
1. Degree of local renewable energy production	Lower environmental impact	Ratio of locally produced energy from renewable production.	n/a	60%
2. Degree of energetic self-supply by RES	Effectiveness of PV-panels	Ratio of locally produced energy used from RES and the energy consumption.	n/a	30%
3. CO_2 emission reduction	Lower environmental impact	Reduction of emissions of carbon dioxide related to measure.	n/a	600 ton CO_2 reduction / year
4. Amount of renewable energy	Lower environmental impact	Reduction of emissions of carbon dioxide related to measure.	n/a	0,8MWP / year

Table 6 KPI's of this Measure

5.3.3 Monitoring plan

To monitor the performance of the PV-panels and to obtain relevant data for the KPI's, the following steps are taken into account:

- With the use of the HEMS Eneco Toon, we're able to collect data on an aggregated level without the permission of the tenants to share data. This data consists of:
  - generated solar energy per every minute/hour/day/year
  - used energy per every minute/hour/day/year
  - balance of generated and used energy per every minute/hour/day/year
- This data is collected by Quby (part of Eneco), the company that develops the HEMS Eneco Toon and collects and shares data from the end users.
- For the objectives of this project, mentioned data shall be aggregated per hour and at building level to meet the required information.

5.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process

steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Bo-Ex • Energy consultant	• Initiation and coordination of works • Draw PoR
	Set up preliminary design	• Bo-Ex • Energy consultant • Installation contractor	• Coordination and input • Draw design • Assess the design
2 Engineering	Elaboration of the design	• Bo-Ex • Installation contractor • Energy consultant	• Input for design • Draw the design • Assess the design
	Structural calculations	• Bo-Ex • Structural designer	• Input for the calculation • Draw the design
	Revenue calculations	• Energy consultant • Installation contractor	• Set up calculation • Validate and approve
	Construction costs calculations	• Cost consultant • Installation contractor • Bo-Ex	• Construction costs calculations • Assess the calculations • Approve the calculations
3 Contracting	Contracting works	• Bo-Ex • Installation contractor	• Set up and sign contract • Sign contract
4 Realization	Preparation of the roof	• Installation contractor	• Make a clean roof
	Mount frames and PV-panels on the roof	• Installation contractor	• Install the installation on the roof
	Connect invertor tot fuse box	• Installation contractor	• Installation the installation in the houses
	Connect PV-panels to invertor	• Installation contractor	• Connect all items
5 Testing	Test the electricity generated by the PV-panels	• Installation contractor • Energy consultant	• Test and report the generated power • Assess the report
	Test the electricity inverted by invertor	• Installation contractor	• Test and report the generated power • Assess the report
	Test the electricity shown on the kWh-meter	• Installation contractor	• Test and report the generated power • Assess the report

6 Completion	Accept the executed works	• Installation contractor • Energy consultant • Bo-Ex	• Handover the installation • Assess the executed works and as-built documents • Accept the installation

Table 7 Commissioning Plan for this Measure

5.5 Implementation Plan

5.5.1 Planning of activities

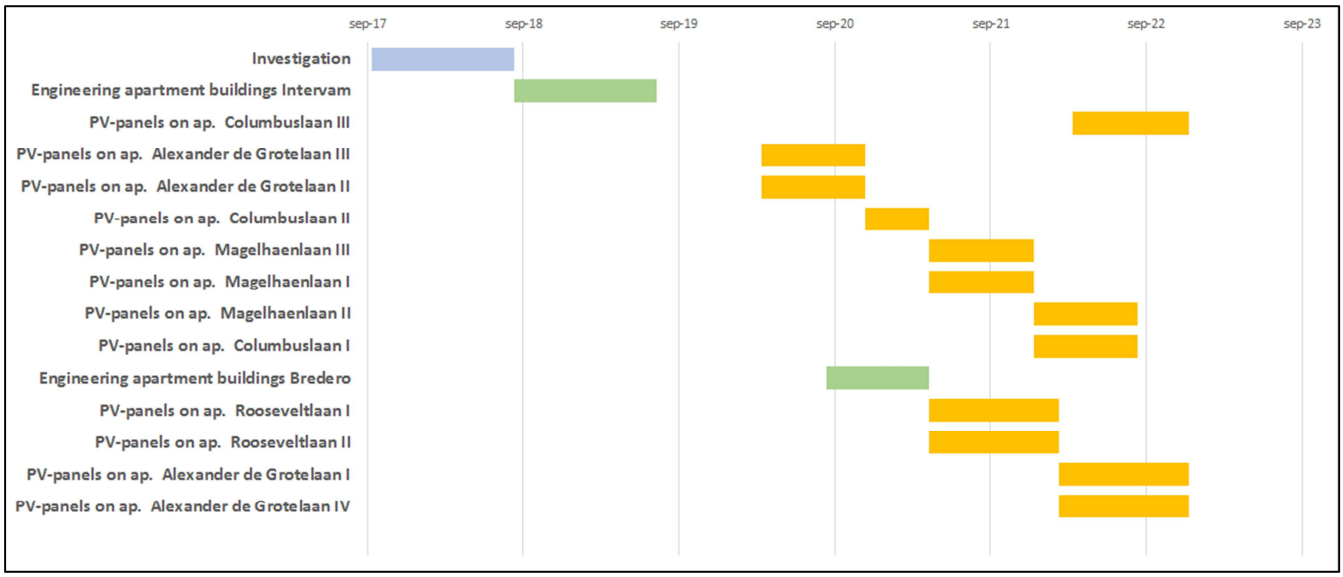


Figure 13. Timing of activities installation of PV-panels

5.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The main order for the contractor is assigned after the support of the tenants has been achieved.
- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

5.5.3 Risk management

The main risks regarding the PV panels are:

- Social: no support of the tenants for the installation of the PV-panels:
  Mitigation measure: early involvement of the tenants in the planning phase, individual house visits to tenants to explain the plan and the impact on their situation (including actions to be

undertaken by the tenant), set up a clear information booklet with the Measure, the impact and practicalities.

- Social: resistance of the tenants for PV-panels on the roof, due to fire risks or emissions of radiation:
  Mitigation measure: explain the system and technical impact, answer questions beforehand related to this topic, refer to other apartment buildings where this has been realized.
- Technical: not sufficient space on the roof of the apartment buildings to place the panels:
  Mitigation measure: start with creating a lay-out map of the roof to determine the available roof space for PV-panels. Divide the available roof space to all households, to determine the maximum number of PV-panels for one household.
- Technical: on the roof asbestos is found before the works are executed:
  Mitigation measure: research the possible presence of asbestos beforehand and mitigate this risk by cleaning the asbestos beforehand.

5.5.4 Progress achieved up to M24

For all the apartment buildings:

- Structural calculations have been made;
- Various plans of the configuration of the PV-panels on the roof, to calculate the amount of PV-panels on the roof without major adjustments of the roof.

For the first apartment building Columbuslaan III:

- Inventory of asbestos has been made for the coming apartment building;
- Unfortunately, support of the plan amongst the tenants, including 4 PV-panels per household, has been too less. 67% of the tenants voted YES, while a minimum of 70% voting YES is legally required. Reconsideration period of a few weeks did not change the consent rate. Due to lack of enough tenant support, PV-panels have not been installed. Due to this lack of sufficient support of the tenants, the whole process of engaging tenants has been evaluated. This has led to improvement areas that will be taken into account in preparation phases of next buildings (see deliverable D5.7 for more information).

5.6 Conclusions

Regarding this Measure, a lot of preparation work has been done. We know the starting points, social and technical approach. The biggest challenge is to obtain enough support amongst the tenants for the whole plan of refurbishment including the PV-panels.

6 M#2: LT district heating

6.1 Specifications

Currently, 4 out of 12 apartment buildings are connected to the district heating network (the other eight are connected to the gas infrastructure). This DHN provides hot water for space heating. The current supply temperature of the DH is 90°C. With the implementation of a low temperature DHN the supply temperature will be lowered to ≈40°C. Low Temperature district heating ('LT district heating') leads to lower energy losses in the apartment building and in the DHN.

Basically, there are two variants of the 644 apartments regarding grid connections and utilities. At this moment 8 apartment buildings have a central gas-heating boiler, and 4 have district heating. Regarding the other utilities, the apartments are almost similar:

- All apartments contain a grid connection to provide in electricity for domestic devices;
- All apartments contain a grid connection to provide in gas for the kitchen (cooking);
- All apartments contain a gas-heating boiler for hot tap water.

Figure 14 shows the current utility facilities and the envisioned facilities for apartment building currently connected to the district-heating grid.

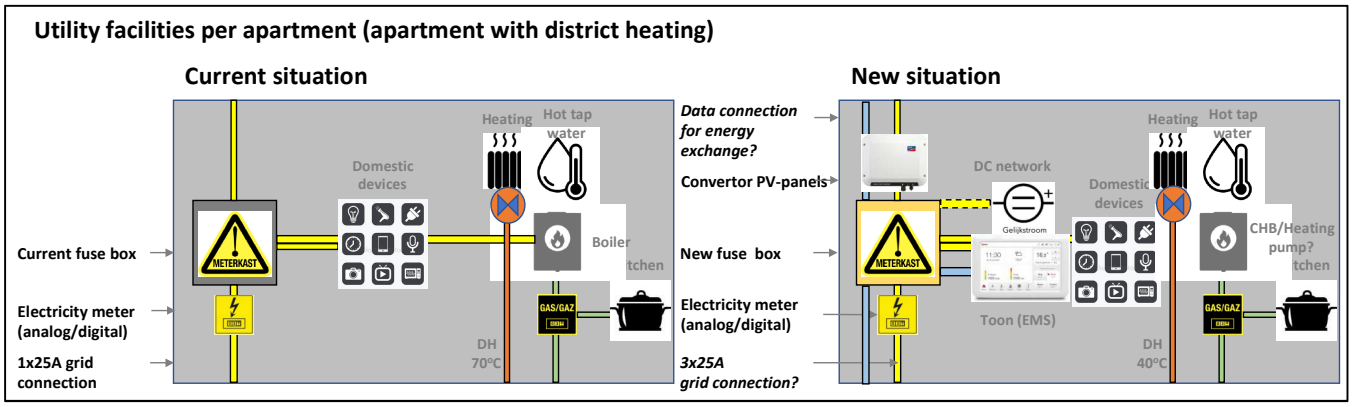


Figure 14. Envisioned sustainable heating system for apartment building on district heating network

6.1.1 Hardware

In the current situation, each apartment house has an evaporation meter from the supplier ISTA. This meter is positioned on the main radiator near the heat riser. Each apartment building consists of one central main GJ-meter of Eneco.

In the new situation the central main GJ-meter of Eneco still exists, while every apartment house has his own individual GJ-meter. This meter is positioned in the central heating cabinet in each apartment. This cabinet is situated near the kitchen, bathroom, toilet and technical shaft.

6.1.2 Software

In the current situation ISTA collects the usage data and invoices each tenant on behalf of Bo-Ex making use of a distribution code and the overview of Eneco provided for the main usage.

In the new situation the same collection and registration of data is applicable. Besides, the HEMS Eneco Toon collects data from the individual GJ-meters, so the tenants can record their energy usage for heating (and hot tap water).

6.1.3 Procurement of equipment and/or services

The procurement of the new individual GJ-meters from ISTA is done by housing corporation Bo-Ex. Since this product is not subject to subsidiary, Bo-Ex follows their own procurement procedure and budgeting.

The procurement of the adjustments of the central main GJ meter and feeds, is done by Eneco as owner of these assets. For the adjustments of the central meter, Eneco shall contract their preferred contractor.

6.2 Societal, user and business aspects

6.2.1 Citizen engagement

This Measure is positioned on the first step of the ladder of engagement ('Citizen awareness'), which means that for this Measure the scope is determined by housing corporation Bo-Ex. This implies that the challenge is to inform and involve the tenants well about the activities, the conditions and the benefits.

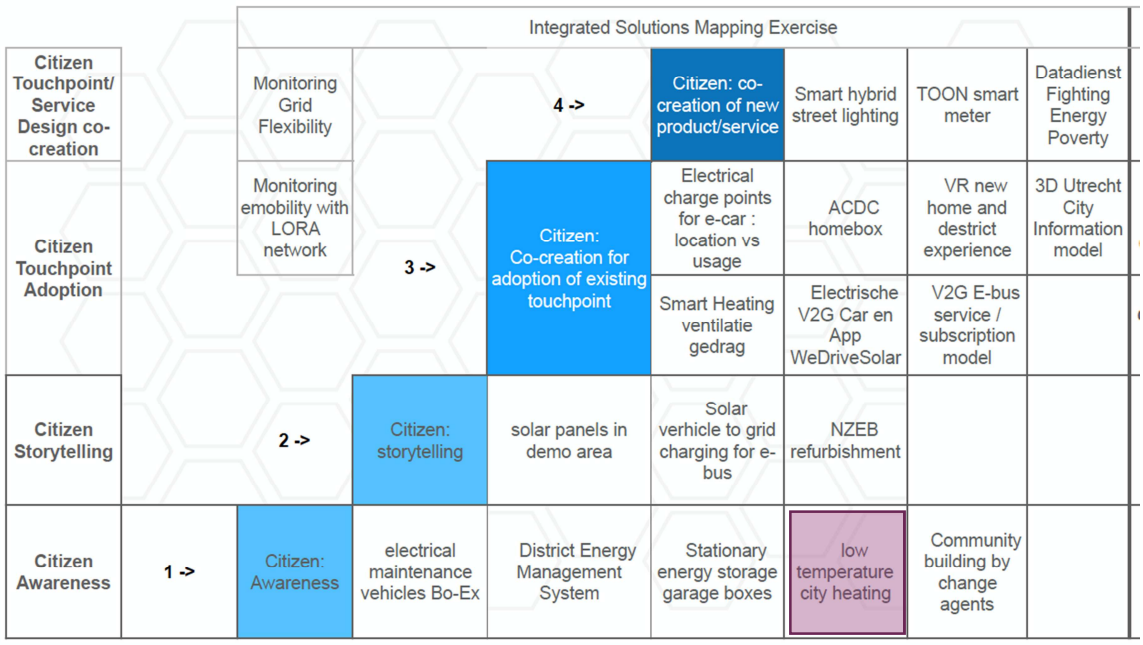


Figure 15 positioning of this Measure on the ladder of engagement

6.2.2 Business model

The business model for this Measure consists of necessary maintenance of the system (infrastructure from the central connection of Eneco to the radiators in every apartment house). These maintenance costs are earned back by the monthly rent from the tenants in the coming 40 years. No rent increase is and may be asked by the tenants due to the policy of Bo-Ex and constitutional law.

The internal infrastructure (from central connection to the radiators in the apartment houses) are owned and maintained by Bo-Ex. Since the technical lifetime of this internal infrastructure has ended, Bo-Ex has planned to replace the internal infrastructure during the refurbishment. With the replacement of the internal infrastructure, another internal routing is considered. The current routing consists of risers (heat piping) next to the façade. The current solution has a lot of disadvantages (unfair because of heat losses, the evaporation meters are not that reliable, sound nuisance from apartment house to apartment house and the presence of asbestos in the floor holes). With replacing the internal infrastructure to the central point of every apartment and lead the risers through the technical shafts, these disadvantages are taken away. This alternative internal infrastructure will benefit the tenants, which is also of value for Bo-Ex.

6.2.3 Governance

In this Measure, the main stakeholders are Bo-Ex, the tenants, the district heating owner and the municipality of Utrecht. These stakeholders are equal to almost all the other Measures within TT#1.

For this Measure, the role of Eneco is important to mention. The possibility of lowering the temperature depends on the city-wide heating network including the use of renewable energy for district heating. Since the four apartment buildings are located next to private housing, it is not easy to adjust a part of the DHN without involving plans for these private houses.

6.3 Impact Assessment

6.3.1 Expected impact

The impact of this Measure contributes to the reduction of CO2. the overall goal of this IRIS project. The following table shows the contribution of this Measure to the common objectives of IRIS:

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: LT-district heating contributes to energy positive districts.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	N/A
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for	N/A

collective mobility and lead to a decreased environmental impact.	
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	N/A
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	N/A
6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	Yes: the business model for as well Bo-Ex as well Eneco is replicable.
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.	N/A
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

Table 8 overview of the contribution of this Measure to the IRIS objectives

6.3.2 KPIs

There are no specific relevant Key Performance Indicators for this Measure, but this Measure contributes to the overall Key Performance Indicators of TT#1. The reason for aggregating the performance indicators to a higher level is that the specific impact of this Measure is difficult to abstract. With the refurbishment of the apartment building, not only this Measure contributes to energy savings and CO_2 reduction. The KPI's on the aggregated level of TT#1 are:

KPI	Why?	Definition	Baseline	Target
1. Energy savings for the tenants	Lower energy consumption for tenants	The reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the energy consumption from the reference period.	Current energy consumption	-/- 50%
2. CO_2 emission reduction	Lower environmental impact	Reduction of emissions of carbon dioxide related to the measure.	Current CO_2 emission	-/- 80%
3. Reduced energy costs for tenants	Lower energy costs for tenants	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	Current energy cost	-/- 50%
4. CO_2 reduction cost efficiency	Benchmarking	Costs in Euro's per ton of CO_2 saved per year.	n/a	*To determine*

Table 9 KPI's for this Measure

6.3.3 Monitoring plan

To monitor the energy usage and to obtain relevant data for the KPI's, the following steps are taken into account:

- Before refurbishment, we conduct a survey of the tenants regarding the current comfort experiences of the system.
- With the use of the HEMS Eneco Toon, we're able to collect data on an aggregated level without having the permission of the tenants to share data. This data consists of:
  - used energy per every minute/hour/day/year

  This data is collected by Qubie, the company who develops the HEMS Eneco Toon and collects and shares data from the end users.

  For the objectives of this project, mentioned data shall be aggregated per hour and at building level to meet the required information.
- After refurbishment, we conduct a survey of the tenants regarding the new comfort experiences of the system.

6.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Bo-Ex • Energy consultant • Eneco	• Initiation and coordination of works • Draw PoR of the infrastructure • Draw PoR of the feed in
	Set up preliminary design	• Bo-Ex • Energy consultant • Installation contractor Bo-Ex • Eneco	• Coordination and input • Draw design • Assess the design • Asses the design and draw the design of the feed in
2 Engineering	Elaboration of the design	• Bo-Ex • Installation contractor Bo-Ex • Energy consultant	• Input for design • Draw the design • Assess the design
	Construction costs calculations	• Cost consultant • Installation contractor Bo-Ex • Bo-Ex	• Construction costs calculations • Assess the calculations • Approve the calculations

3 Contracting	Contracting works infrastructure	• Bo-Ex • Installation contractor Bo-Ex	• Set up and sign contract • Sign contract
	Contracting works central station and feed in	• Eneco • Installation contractor Eneco	• Set up and sign contract • Sign contract
4 Realization	Remove the old and install the new infrastructure	• Installation contractor Bo-Ex	• Remove the current infrastructure • Installation of the new infrastructure
	Install the new GJ-meter of ISTA and connect to the HEMS	• Installation contractor Bo-Ex	• Installation of the meters in the houses • Connect the meters to the individual HEMS Eneco Toon
	Adjust the feed in and central station	• Installation contractor Eneco	• Adjust the incoming temperatures in the central station
5 Testing	Test the GJ-flow and -meters in every apartment house	• Installation contractor Bo-Ex • Energy consultant	• Test and report the energy flow • Assess the report
	Test the connectivity of the GJ-meters with the HEMS Eneco Toon	• Installation contractor Bo-Ex	• Test and report the connectivity
	Test the GJ-flow and -meters in the central station	• Installation contractor Eneco	• Test and report the generated power • Assess the report
6 Completion	Accept the executed works from the central station to each apartment house	• Installation contractor Bo-Ex • Energy consultant Bo-Ex • Bo-Ex	• Handover the installation • Assess the executed works and as-built documents • Accept the installation
	Accept the executed works of the central station and feed in	• Installation contractor Eneco • Energy consultant Eneco • Eneco	• Handover the installation • Assess the executed works and as-built documents • Accept the installation

Table 10 Commissioning Plan for this Measure

6.5 Implementation of the measure: planning and progress

6.5.1 Planning of activities

Currently, little experience exists with LT district heating in the Netherlands. Eneco will be involved in the design and research process of the low temperature district heating system. Together with an external advisor and a contractor, the design of the low temperature heating will be researched and designed in several scenarios. The most feasible scenario will be detailed and engineered. Figure 16 shows the programme for the scheduled activities for this measure:

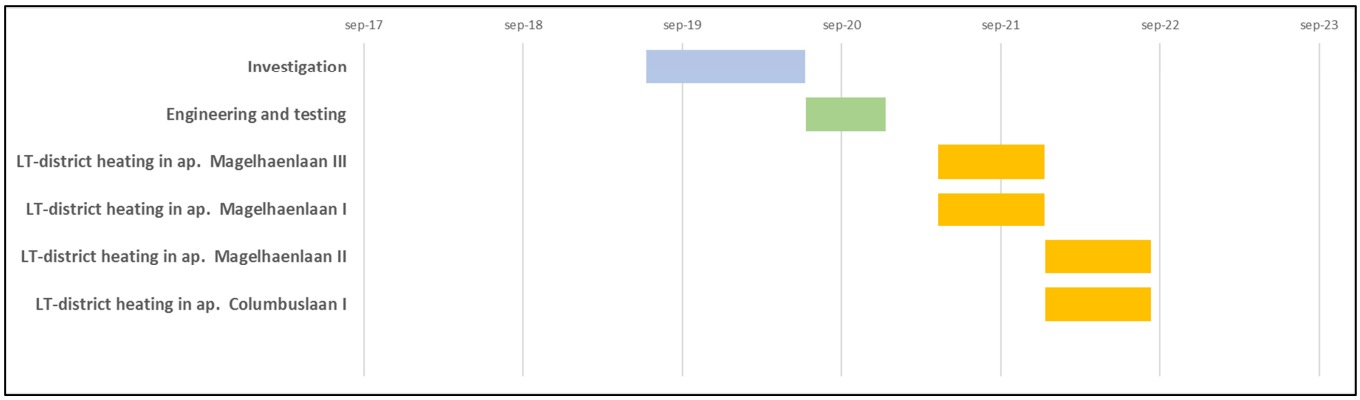


Figure 16. Timing of activities LT-district heating

6.5.2 Planning of costs and (equipment) investments

- The main order for the contractor is assigned after the support of the tenants has been achieved.
- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

6.5.3 Risk management

The main risks regarding the LT district heating are:

- Social: no support of the tenants for the new heating grid and temperatures;
  Mitigation measure: explain the system and technical impact, answer questions beforehand related to this topic, refer to other apartment buildings where this have been realized. Possibly involve tenants in the engineering phase of a scenario.
- Technical: the low temperature heating can't provide enough energy to heat up an apartment during cold days;
  Mitigation measure: set up temperature loss calculations in combination with comfort analysis and realize radiators which are appropriate for low temperature heating. Involve tenants and teach them different heating behaviour appropriate for low temperature heating.

6.5.4 Progress achieved up to M24

Since the four apartment buildings which are equipped with district heating are planned to be executed in 2020-2022, no concrete activities in these buildings and with the tenants have been done yet. But prior to the first apartment building Columbuslaan III, the apartment building Livingstonelaan III has been refurbished. This building consists of district heating in the same configuration of the four apartment buildings as mentioned. Although LT-heating is not implemented in this apartment building, the experience of refurbishing this building will benefit the further detailing and engineering of LT-heating scenarios.

6.6 Conclusions

Regarding this Measure, the preparation works have to be done in the coming year (2020). We know the starting points, social and technical approach. The biggest challenge is to obtain enough support amongst the tenants for the whole plan of refurbishment including the LT-temperature heating system.

7 M#3: Home Energy Management Systems (HEMS) TOON

7.1 Specifications

The Eneco Toon® (hereafter Toon) is an existing device (7`` display) with proven technology. The main objective of the Toon is to provide information about the energy usage of a household. Since a couple of years, the Toon is already installed in many houses and apartments in The Netherlands, for clients and non-clients of Eneco (approximately 300.000). The user interface and hardware of the Toon have been adjusted frequently. Other functionalities were added, such as:

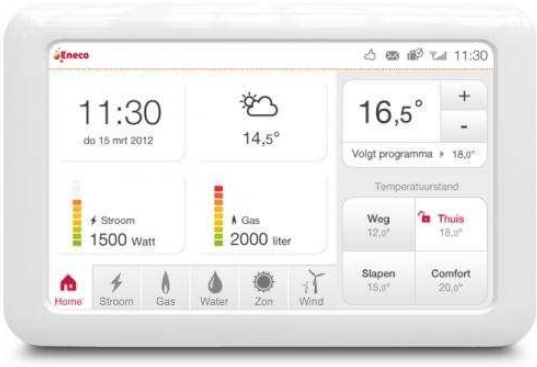


Figure 17 HEMS Eneco Toon display
Source: http://www.eneco.nl

- Amount of energy produced by PV panels;
- Insights into Daily/Weekly/Monthly energy usage and costs;
- Spoilage checker;
- Weather forecast.

The following figure shows the position of the HEMS Eneco Toon in every apartment (living room).

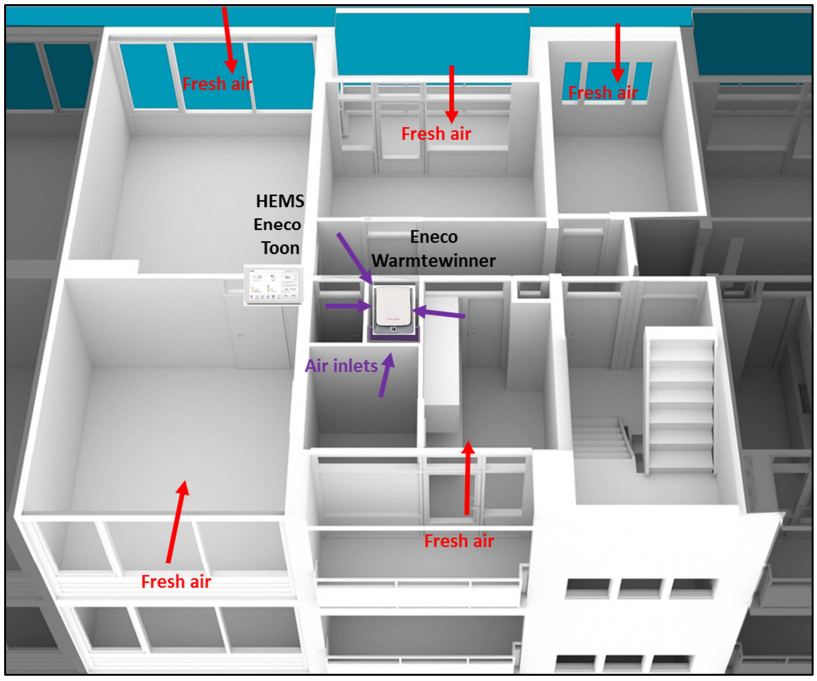


Figure 18 Schematic map of an apartment house with the position of the HEMS Eneco Toon

7.1.1 Hardware

The dimensions and weight of the Toon are:

- Outside dimensions: 190 x 120 x 30 mm.
- Weight: approx. 400 gram.
- Material of the enclosure: PC/ABS
- Display: 7” resistive touch screen, resolution 800x480
- External ports: 1x USB, 1x Ethernet.

The included components of the Toon are:

- Module for the central heating device
- Adapter
- Meter adapter
- Meter sensors

The electrical specifications are:

- Power connection: 24V
- Electricy usage: approx. 50 kWh per year (normal usage)

The control marks of the Toon are:

- CE-mark
- OpenTherm® certified
- Z-Wave certified

7.1.2 Software

Module: U-Boot 2010.09

- License Type: GNU General Public
- License (GPL) version 2
- Copyright Holder: DENX Software
- Engineering
- Date: 2000-2010

Module: Linux 2.6.36

- License Type: GNU General Public
- License (GPL) version 2
- Copyright Holder: Linus Torvalds
- Date: 2010

7.1.3 Procurement of equipment and/or services

The procurement of the Eneco Toon is done by Eneco since they are the developer, patent holder and sales representative of Eneco Toon. Eneco is going to install and test the Eneco Toon in each apartment house. The costs of the Toon and yearly subscriptions are covered by IRIS and Eneco till end of 2022.

7.2 Societal, user and business aspects

7.2.1 Citizen engagement

After the unfortunate event of not reaching enough consent among the tenants for the refurbishment of the first apartment building (Columbuslaan III), the whole process has been evaluated and materialised in an adjusted approach of the retrofit activities and the communication with tenants. It also led to an adjustment of citizen engagement strategy. Regarding the implementation of TOON, which was originally planned as part of the refurbishment activities, it was decided to decouple its implementation from the refurbishment activities.

Implementation of Eneco Toon will be performed between November 2019 and December 2020 in all twelve apartment buildings. An implementation plan is set up with LHC, Bo-Ex, Eneco and HKU, including citizen engagement. Instead of engaging citizens in a 'pull'-approach (get them interested to come to an event), a 'push'-approach will be applied, consisting of paying house visits and gain trust in the benefits of the Eneco Toon (see deliverable D5.7 for more detailed information). Currently available materials, like smartphone apps and manuals, will be used and evaluated with tenants and feedback will be given to Eneco, aimed at adjusting these materials to better fit the needs of the target group in the demonstration area. The implementation starts with a pilot in apartment building Columbuslaan II to test the new citizen engagement approach.

Furthermore, it is not possible to adjust the Eneco Toon hardware or its user interface. Instead a data service aimed at energy poverty will be co-created with citizens to get citizens to use the Eneco Toon and learn to deduct relevant energy usage information from it. This will be done in TT#4. More information is available in deliverable D5.6.

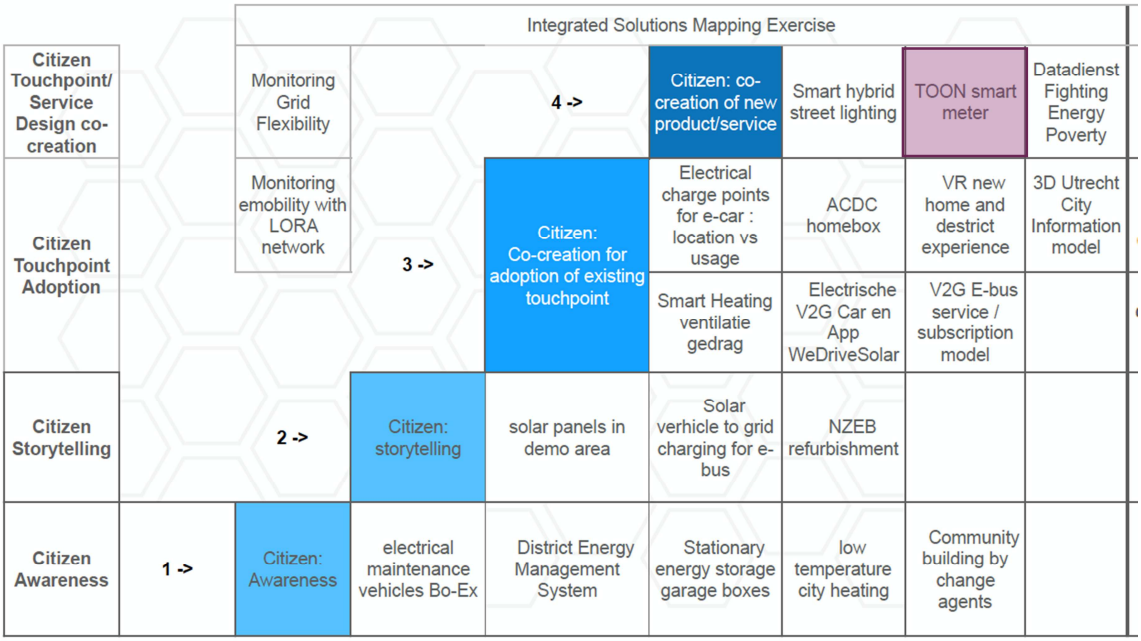


Figure 19 positioning of this Measure on the ladder of engagement

7.2.2 Business model

Usually the Eneco Toon is sold to users through purchase channels. With these earnings, the costs for developing and producing the Eneco Toon are covered. IRIS sponsors the purchase of the Toon including installation works which is worth about € 325 per household.

Besides, the (optional) subscriptions from clients and relevant information obtained from the users to develop (new) products and improve existing products e.g. Warmtewinner, compatible software applications and/or other concepts Eneco wants to develop in the future.

7.2.3 Governance

In this Measure, the main stakeholders are Bo-Ex, the tenants and Eneco. These stakeholders are equal to almost all the other Measures within TT#1.

For this Measure, the role of Eneco is important to mention. Eneco is the product developer and owner of Toon. Eneco also provides energy to residents. People who get energy from Eneco and use a Toon, will benefit from this combination since the Toon can make use of actual energy prices and the monthly prepayment of a resident. It's not obligated for a tenant to switch from energy provider, Toon also functions when a tenant makes use of another energy provider than Eneco.

7.3 Impact Assessment

7.3.1 Expected impact

The impact of this Measure contributes to the reduction of CO_2. the overall goal of this IRIS project. The following table shows the contribution of this Measure to the common objectives of IRIS:

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: Toon contributes to smart homes.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	Yes: data generated by Toon is relevant for the smart energy system of the district.
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.	N/A
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	Yes: data from Toon on an aggregated level will be used for the CIP.
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	Yes: the installation of Toon is subject of engagement.
6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	N/A
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.	N/A
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

Table 11 overview of the contribution of this Measure to the IRIS objectives

7.3.2 KPIs

There are no specific relevant Key Performance Indicators for this Measure, but this Measure contributes to the overall Key Performance Indicators of TT#1:

KPI	Why?	Definition	Baseline	Target
1. Increased awareness of energy usage	Awareness within tenants	The extent to which the project has used opportunities for increasing awareness of energy	n/a	4 on a scale of 1-5

		use.		

Table 12 KPI's for this Measure

7.3.3 Monitoring plan

To monitor the user-friendliness and comfort experiences, the following steps are taken into account:

- Short after installation in every household, we help the tenants to know how the device works and what the reasons of this initiative are. We also conduct a short survey amongst the tenants regarding the user and comfort experiences.
- A couple of weeks after installation, we visit the tenants again on an individual basis and help them to use the Toon (again) and tell them what the possible benefits can be.
- After a year, we measure the saved energy of our tenants on an aggregated level. This metric is easy to monitor when the refurbishment has not been executed yet because of the same comfort situation. When measuring the saved energy after refurbishment, the comfort situation is different to the situation before and therefore harder to measure.

7.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Tenants of Bo-Ex • HKU • Eneco and Quby	• Test and feedback • Facilitate the workshops • Set up possible solutions
2 Engineering	Elaboration of the design	• Eneco and Quby • Tenants of Bo-Ex	• Draw the design and create several options for the tenants • Assess the design (and make a choice)
3 Contracting	Contracting works	• Eneco and Quby	• Sign contract
4 Realization	Implement the design	• Eneco and Quby	• Implementation of the new set up / product
	Install the Eneco Toon	• Eneco	• Remove the current thermostat • Installation of the Eneco Toon
5 Testing	Test the Eneco Toon	• Eneco	• Test and report the output and connectivity

6 Completion	Accept the executed works	• Eneco • Tenants of Bo-Ex	• Handover the installation • Accept the device

Table 13 Commissioning Plan for this Measure

7.5 Implementation of the measure: planning and progress

7.5.1 Planning of activities

Eneco will be involved in the PoR stage and design process for the apartment buildings. The PoR of the Toon and linked applications depend on the possibilities to adjust the software of the Toon and/or linked applications. Eneco will therefore also be partner in the citizen engagement activities in TT#5. Eneco will install the Toon in every apartment and provide instructions to the tenants. Figure 20 shows the programme for the scheduled activities for this measure:

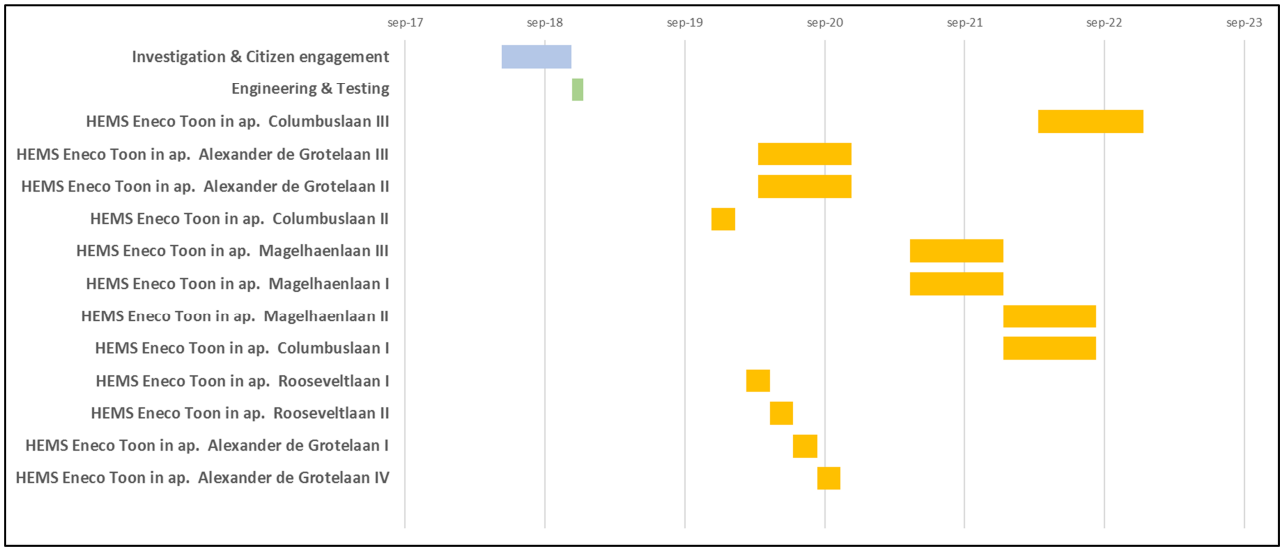


Figure 20. Timing of activities HEMS Eneco Toon

7.5.2 Planning of costs and (equipment) investments

- The main order for the Eneco Toon hardware (devices) has already been assigned including a free subscription.

7.5.3 Risk management

- Social: the tenants do not want an Eneco Toon in their house (privacy issues), they distrust the initiative;
  Mitigation measure: explain the system, technical impact and advantages and the GDPR statements which describe that individual data can only be used after the implicit approval of a tenant and for the IRIS project no individual data will be abstracted and used.

Secondly, an opt-out possibility is provided, so tenants are able to let the Eneco Toon be removed and replaced by the old thermostat.

- Social: the tenants are convinced that the Eneco Toon requires a contract with Eneco and therefore they do not want this device in their house;
  Mitigation measure: explain the system and the conditions (it's not obligated to switch to Eneco as energy provider even after the IRIS project period).
- Technical: no connectivity with the existing central heat devices.
  Mitigation measure: try to find connectible hardware (metering) for the district heating delivery system in every apartment house.

7.5.4 Progress achieved up to M24

In the past 24 months we have done the following activities:

- Meetings with Eneco and Quby to get an understanding about the Eneco Toon device and possibilities to co-create with the tenants.
- Meetings with Eneco and Quby about the privacy legislation and the level of data we can and want to obtain from the end-users (tenants).
- In the show house of apartment building Columbuslaan III we have installed an Eneco Toon to show to the tenants of that building.
- In the plan of the refurbishment of apartment building Columbuslaan III, the Eneco Toon was incorporated and part of the total package.
- Decouple the implementation of Eneco Toon from the refurbishment activities after the unfortunate event of too low consent rate for the refurbishment activities of Columbuslaan III.
- Draw up an implementation plan for Eneco Toon in the period November 2019-December 2020, starting with a pilot in Columbuslaan II. Lessons learned will be incorporated in the implementation of Eneco Toon in the other apartment buildings.

7.6 Conclusions

Initially we've planned to implement the Eneco Toon parallel to the refurbishment activities of the apartment buildings by Bo-Ex. Since Bo-Ex didn't obtain enough support for the plan among the tenants of the first apartment building (Columbuslaan III) and the refurbishment plans of the other apartment buildings are delayed, the coordination team made the decision to implement the Eneco Toon independently of the refurbishment of the 12 apartment buildings. A pilot with a different citizen engagement approach in Columbuslaan II, consisting of individual house visits and voluntarily installation of Eneco Toon will be performed in December 2019. Lessons learned from this pilot will be used in the implementation of Eneco Toon in the other apartment buildings. The benefit of this choice is that tenants can already take advantage from the IRIS activities and that the effect of energy efficiency caused by the Eneco Toon is abstracted more easily (the comfort of the apartment houses remains the same till the refurbishment takes place).

8 M#4: Energy savings as a result of refurbishing towards near energy zero building

8.1 Specifications

Currently the apartment buildings experience high heat losses due to poor insulation. As part of the refurbishment activities to increase energy efficiency the following measures will be implemented:

- New window frames and glazing (double or triple glazing)
- Insulation of outer walls and the ground floor ceiling
- Improvement of chinks (especially at the connection of the façade with the window frames)
- Mechanical ventilation (with natural or mechanical supply)

Figure 21 shows the parts which will be renewed or added in every apartment.

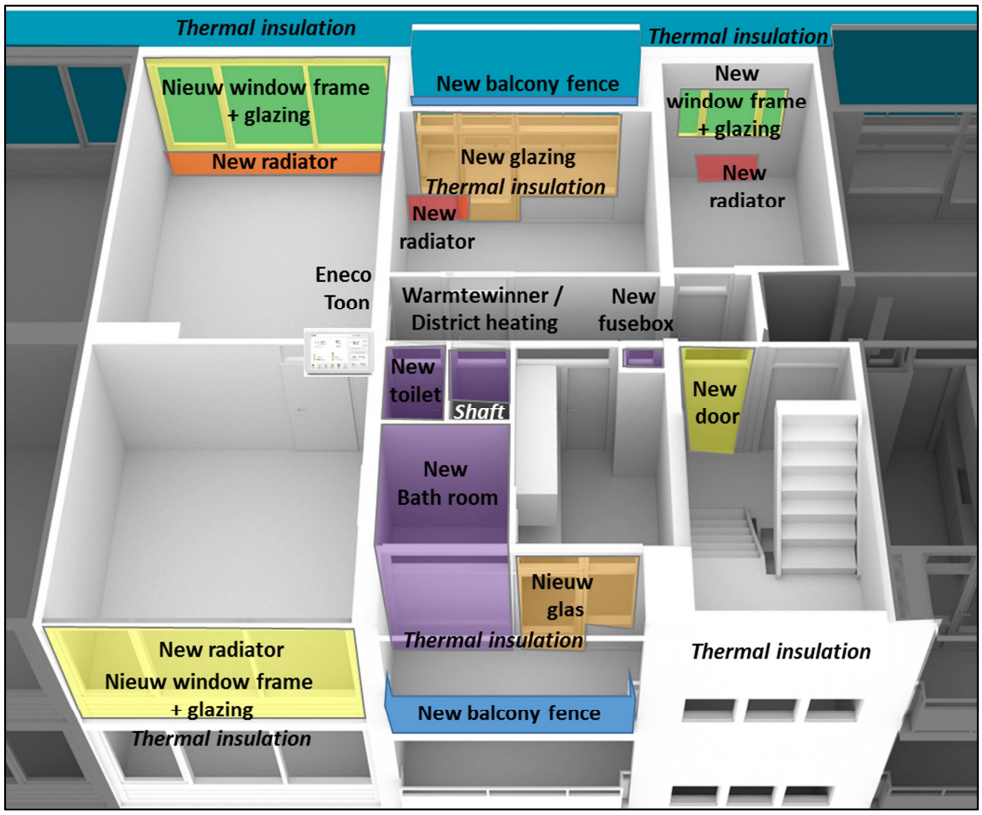


Figure 21 Schematic view of the measures in every apartment house

8.1.1 Hardware

The specifications related to this measure consists of material specifications. For the first apartment building Columbuslaan III, the following materials have been designed:

- Glazing of the outside windows:
  SGG Climaplus Ultran 90% Argon / 90% Krypton: U-value (heat continuity coefficient) of 1,2 W/(m²*K)
- Ventilation grills within the new and existing windows:
  Aralco MultiCoust EPC 14: Qv-value of 14 $dm^3/(s*m)$.
- Insulation in the outside panels:
  Eternite with mineral wool 50mm
- Insulation on the facade:
  Prefabricated EPS panels 50mm
- Insulation beneath the first floor:
  PUR foam 100mm on site sprayed

8.1.2 Software

No software is related to the NZEB or used for the Measures.

8.1.3 Procurement of equipment and/or services

The procurement of the NZEB Measures is done by housing corporation Bo-Ex. Since this product is not subject to subsidiary, Bo-Ex follows their own procurement procedure and budgeting.

In 2017, Bo-Ex selected one contractor for the role of main contractor for all the eight Intervam type apartment buildings in Kanaleneiland-Zuid. In case of good performed works, this contractor gets the first right to do an offer for the following apartment building.

For the other four Bredero type apartment buildings, a tender will be put into the market in 2020.

In general, the procurement steps are the following:

- The main order for the contractor is assigned after the support of the tenants has been achieved.
- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

8.2 Societal, user and business aspects

8.2.1 Citizen engagement

This Measure is positioned on the second step of the ladder of engagement (‘Citizen Storytelling’). This implies that the challenge is to inform and involve the tenants well about the activities, the conditions and the benefits.

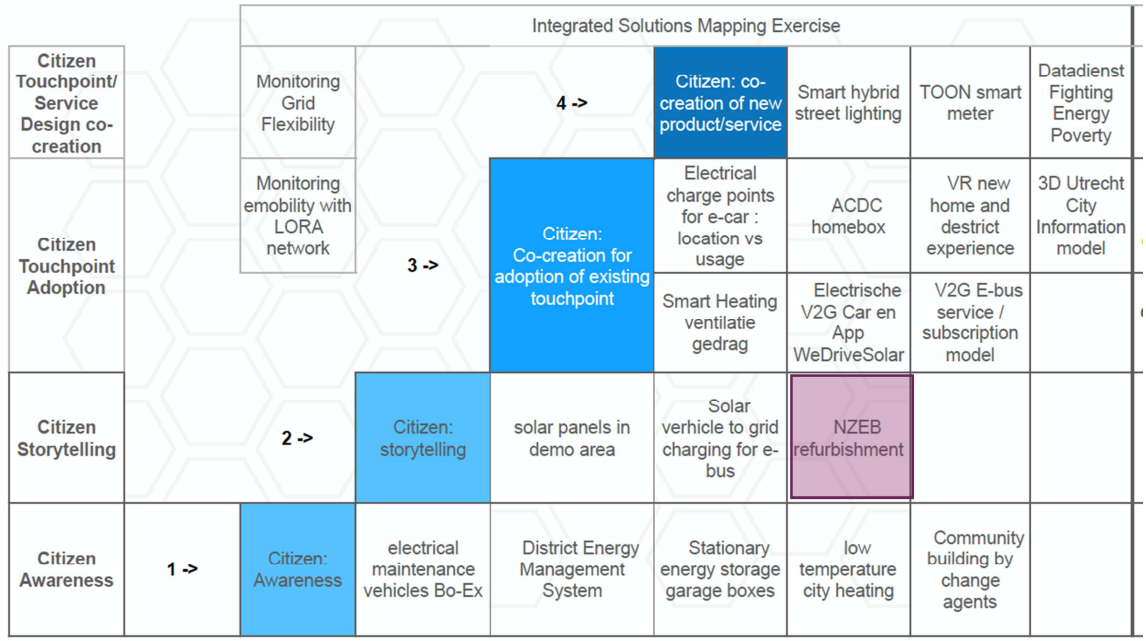


Figure 22 positioning of this Measure on the ladder of engagement

8.2.2 Business model

The business model consists of earning back the investment by monthly rents within the coming 40 years. In case of obtaining a higher grade of energy performance than budgeted, Bo-Ex will ask their tenants to pay monthly a higher rent to earn back the (additional) investments in increasing the energy performance.

8.2.3 Governance

In this Measure, the main stakeholders are Bo-Ex, the tenants and the Municipality of Utrecht. These stakeholders are equal to almost all the other Measures within TT#1.

For this Measure, the role of the Municipality of Utrecht is important to mention. The Municipality of Utrecht grants permission for the refurbishment works. They access the esthetical proposition and can encourage to undertake additional Measures regarding energy efficiency and circularity.

8.3 Impact Assessment

8.3.1 Expected impact

The impact of this Measure contributes to the reduction of CO_2. the overall goal of this IRIS project. The following table shows the contribution of this Measure to the common objectives of IRIS:

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: NZEB contributes to closed-loop energy positive districts.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	N/A
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.	N/A
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	N/A
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	Yes: the NZEB activities are subject of engagement.
6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	Yes, the business model is replicable.
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.	N/A
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

Table 14 overview of the contribution of this Measure to the IRIS objectives

8.3.2 KPI's

There are no specific relevant Key Performance Indicators for this Measure, but this Measure contributes to the overall Key Performance Indicators of TT#1. The reason for aggregating the performance indicators to a higher level is that the specific impact of this Measure is hard to abstract. With the refurbishment of the apartment building, not only this Measure contributes to energy savings and CO_2 reduction. The KPI's on the aggregated level of TT#1 are:

KPI	Why?	Definition	Baseline	Target
1. Energy savings for the tenants	Lower energy consumption for tenants	The reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the energy consumption from the reference period.	Current energy consumption	-/- 50%

2. CO_2 emission reduction	Lower environmental impact	Reduction of emissions of carbon dioxide related to the measure.	Current CO_2 emission	-/- 80%
3. Reduced energy costs for tenants	Lower energy costs for tenants	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	Current energy cost	-/- 50%
4. CO_2 reduction cost efficiency	Benchmarking	Costs in Euro's per ton of CO_2 saved per year.	n/a	*To determine*

Table 15 KPI's for this Measure

8.3.3 Monitoring plan

Monitoring the amount of refurbished apartments is quite easy. It's just a matter of counting how many apartment buildings we're able to refurbish within the scope timeline of IRIS.

Monitoring the energy performance is currently done by measuring the energy performance meters before and after the refurbishment. With this information, the old and new energy performance and energy label can be determined easily. Besides that, we make use of the data coming from the HEMS Eneco Toon on an aggregated level. With these two meters we're able to obtain relevant and reliable data.

Monitoring the impact on the energy usage is a quite difficult story. It's difficult because of two reasons:

- Within the refurbishment, the comfort of the apartment houses will increase: better refreshment of air (better air quality inside), active mechanical ventilation, a better insulated house, more heating heaters inside to provide heat. Actually, the energy usage could increase instead of decrease despite all the Measures.
- And because of the implementation of Measure 1 (PV-panels), the energy usage is also influenced. This is why we focus on the total amount of generated and used energy of the apartment houses, not only what's influenced by this Measure.

8.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Bo-Ex • Consultants / advisors • Main contractor	• Initiation and coordination of works • Draw PoR of the refurbishment • Asses the PoR
	Set up preliminary design	• Bo-Ex • Consultants / advisors • Main contractor	• Coordination and input • Draw design • Assess the design
2 Engineering	Elaboration of the design	• Bo-Ex • Consultants / advisors • Main contractor	• Input for design • Draw the design • Assess the design
	Construction costs calculations	• Main contractor • Consultants / advisors • Bo-Ex	• Construction costs calculations • Assess the calculations • Approve the calculations
3 Contracting	Contracting works infrastructure	• Bo-Ex • Main contractor	• Set up and sign contract • Sign contract
4 Realization	Realize the refurbishment Measures	• Main contractor	• Remove of parts • Installation of new parts and infrastructure
5 Testing	Test the performance of the energy performance Measures	• Main contractor • Energy consultant	• Test and report the energy flow • Assess the report
6 Completion	Accept the executed works	• Main contractor • Consultants / advisors • Main contractor	• Handover the installation • Assess the executed works and as-built documents • Accept the apartment building

Table 16 Commissioning Plan for this Measure

8.5 Implementation of the measure: planning and progress

8.5.1 Planning of activities

The following figure shows the programme for the scheduled activities for this measure:

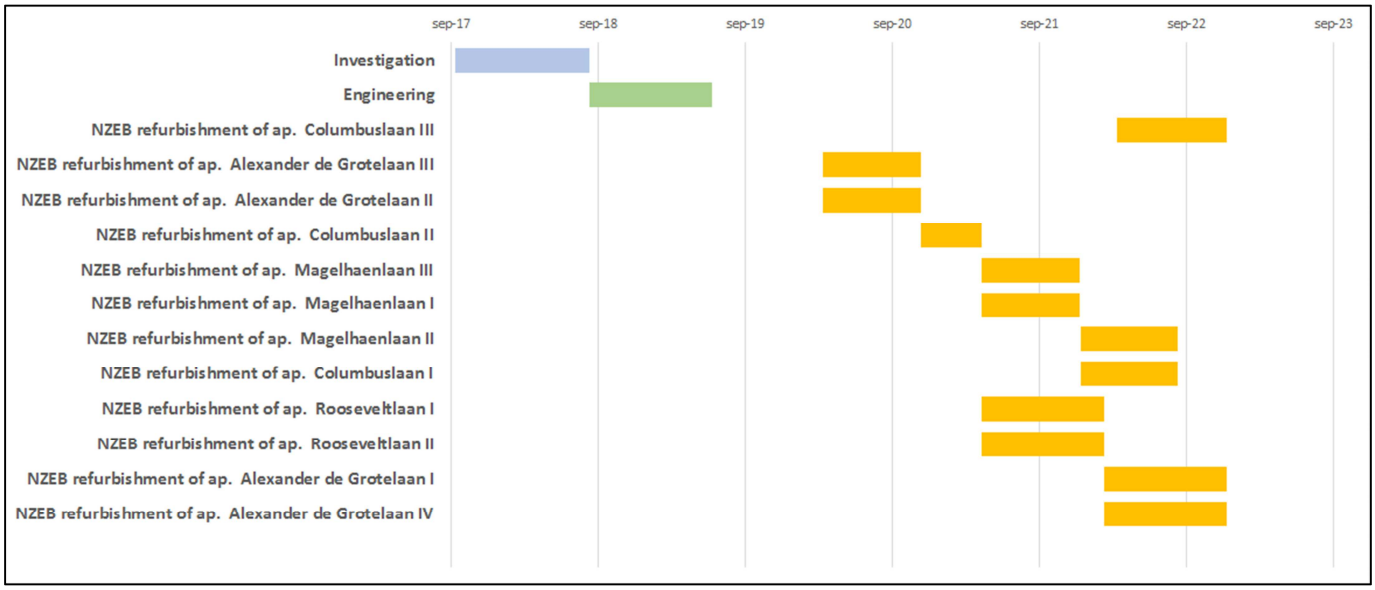


Figure 23. Timing of activities NZEB refurbishment

8.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The main order for the contractor is assigned after the support of the tenants has been achieved.
- The purchase order from the contractor to their suppliers is assigned shortly after the main order to the contractor.

8.5.3 Risk management

The main risks regarding the NZEB refurbishment are:

- Social: no support of the tenants for the refurbishment (improvement works); Mitigation measure: explain the system and impact, answer questions beforehand related to this topic, refer to other apartment buildings where this have been realized.
  Furthermore, the pilot with the implementation of Eneco Toon (measure 3) is used to get in contact with individual tenants and receive input and information about their wishes, needs, worries etc. That valuable information will be used to take a different approach in the tenant involvement in the different phases of the refurbishment activities.
- Financial: the cost of the refurbishment is becoming too high due to (market) cost raisings. Mitigation measure: make choices within the scope of works.

8.5.4 Progress achieved up to M24

For all the apartment buildings:

- Design and rough calculations have been made;

- Create a model house in Columbuslaan III showcasing an apartment house after refurbishment. Creating this model house consisted of all measures mentioned in Figure 21. This created the possibility to test the practicalities and (im)possibilities of the engineered refurbishment activities. It also provided the possibility to gain experience with the hybrid heat pump 'Warmtewinner' (measure 5) and HEMS Eneco TOON (measure 3), and a physical experience for the tenants to see what their house will look and feel like after refurbishment.

For the first apartment building Columbuslaan III:

- Inventory of asbestos has been made for the coming apartment building;
- The support of the plan amongst the tenants has been too less unfortunately. 67% of the tenants voted YES, while a minimum of 70% voting YES is required. A reconsideration period of a few weeks did not change the consent rate.
- The model house was used regularly to inform the tenants about the planned refurbishment activities and show them different colors of tiling in kitchen and bathroom. This was done by providing them a brochure with all the activities and explanatory notes at several locations in the model house.

8.6 Conclusions

Regarding this Measure, a lot of preparation work has been done. Getting experienced with and learn from refurbishment activities and the implementation of the hybrid heat pump 'Warmtewinner' (measure 5) and HEMS Eneco Toon (measure 3). We know the starting points, social and technical approach. The biggest challenge is to obtain enough support amongst the tenants for the whole plan of refurbishment, for which a different citizen engagement approach has been developed by LHC, Bo-Ex and HKU. The proposed sequence and planning of the refurbishment of the apartment buildings has been delayed due to too low support of the tenants. Mitigation measure for this unfortunate delay consist of clustering the next two apartment buildings, so these profit of a joint preparation process and efficient retrofit process, aiming to start retrofit activities in March 2020. We now expect to complete all twelve apartment buildings before end of 2022, but that means that nothing may go wrong from now.

9 M#5: Smart (hybrid) electric heat pumps

9.1 Specifications

The smart hybrid e-heating systems consists of devices which will provide heat and hot tap water for the tenants, in 8 of the 12 apartment buildings. The concept of the smart system consists of a central gas-heating device in combination with a ventilation heat pump. The ventilation heat pump uses the heated ventilation air in an apartment to provide heat for space heating. The ventilation air comes from outside or inside, depending on the choice of the ventilation principle applied. This is a hybrid system, since it's combines electrical and gas fed devices.

The smartness of this system consists of the ability to switch between gas and electrical heat. In principle baseload demand for space heating is supplied by the electrical system, whereas peak load in supplied by the gas fed part of the system. Furthermore, the hybrid heat pump can provide flexibility in for the electricity grid, by switching to gas-mode in times of high demand for electricity in the area and potential grid stress.

The heat pump either will be installed as an individual solution or as a centralized solution. Eventually every apartment will be equipped with heat pumps combined with a central gas-heating device. But, it's possible – and worth a research – to find out whether we can make use of centralized heat pumps instead of individual heat pumps. A centralized solution is much more efficient but requires also an administrative solution to let tenants pay for the individual consumption of the heat pumps. During the design and engineering of every apartment building, both options will be examined.

The following figure shows the current situation regarding utility facilities for the apartment buildings heated with natural gas, and the possible utility facilities after the renovation.

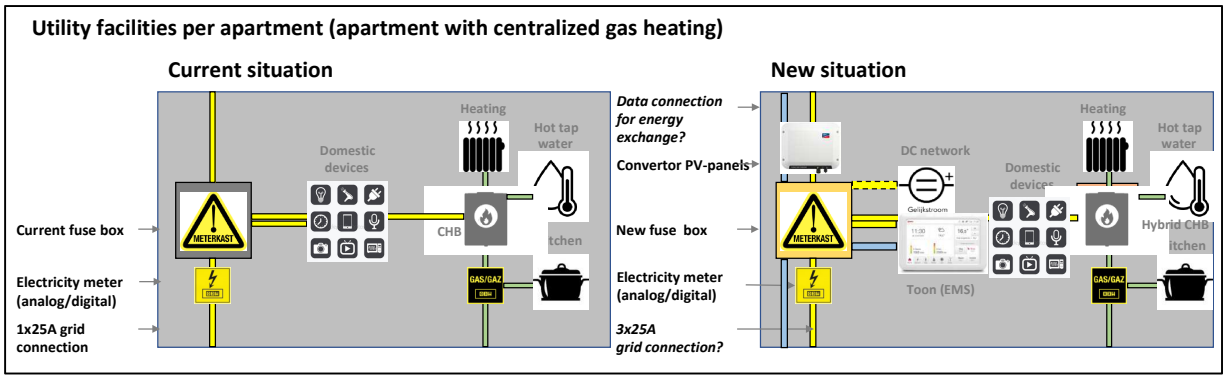


Figure 24. Current situation and potential situation after installation of a smart hybrid heat pump for apartment building currently equipped with centralized gas heating systems.

The following figure shows the position of the Eneco Warmtewinner in every apartment (heating cabinet next to the toilet, kitchen and bathroom) including the air inlets.

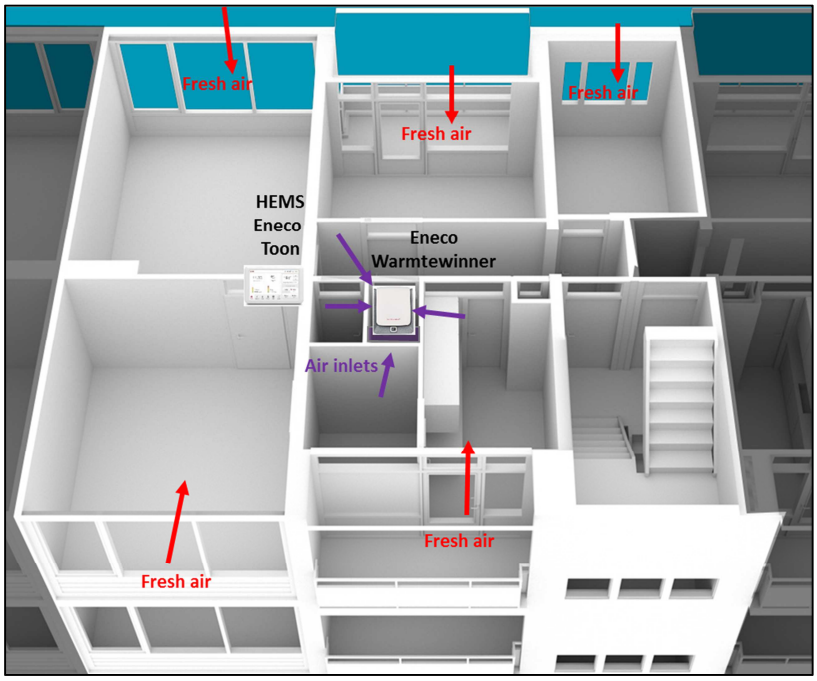


Figure 25 Schematic map of an apartment with the position of the HEMS Eneco Toon

9.1.1 Hardware

In the first four apartment buildings, we aim to provide every apartment with a product from Eneco called Eneco WarmteWinner®. This product is a ventilation heat pump, positioned in the technical cabinet in each apartment.

This ventilation heat pump uses the heated air coming from outside the apartment and exhausted mechanically inside the apartment. With the heated exhausted air, this electrical driven heat pump warms up the water filled pipes which feeds the radiators in the several rooms.

The heat pump runs parallel to the existing central-heating boiler (which uses gas for heating up water). In the occasion of a high demand of heated water (e.g. during winter conditions or when the tenants use hot tap water), both the devices run parallel. With this device, a household saves a lot of gas on a yearly basis, but uses more electrical energy to run the heat pump.

Dimensions:

- 570mm (height) * 500mm (width) * 500mm (depth)
- Weight: 45kg

Performances and specifications:

- Maximum electrical power: 620 watt
- Average electrical power: 300 watt
- Delivered thermal energy: 1,5kWh
- COP (20ºC- 45ºC) 4,2
- Noise level: <47 dBA
- Maximum supply temperature 60°C
- Ventilation volume (heat delvering): 100-250 m3/h

9.1.2 Software

The WarmteWinner is connected to the HEMS Eneco Toon. Besides, every apartment is equipped with a RF-switch with four buttons (1, 2, 3 and timer). With this switch, the tenants can adjust the ventilation volume manually.

9.1.3 Procurement of equipment and/or services

The procurement of the NZEB Measures is done by housing corporation Bo-Ex. Since this product is not subject to subsidiary, Bo-Ex follows their own procurement procedure and budgeting.

9.2 Societal, user and business aspects

9.2.1 Citizen engagement

This Measure is placed on the third step of the ladder of engagement ('Citizen Touchpoint Adoption'). This means that for this Measure, co-creation for adoption smart ventilation amongst tenants is planned.

At least we shall provide a clear instruction of installation to every tenant with contact details in case of questions. Besides, we'll organize workshops with tenants to get them more acquainted with this device.

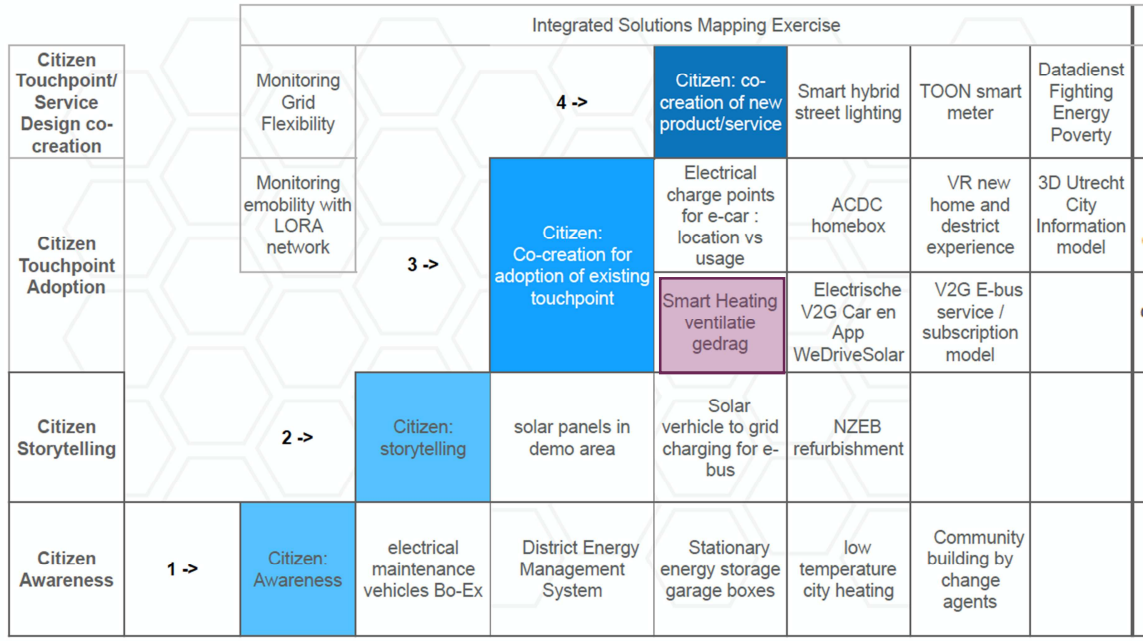


Figure 26 positioning of this Measure on the ladder of engagement

9.2.2 Business model

Initially no business model has been launched for this Measure. This Measure is part of the total refurbishment of the apartment building. Bo-Ex invests in the WarmteWinner, the tenants benefit of the energy cost reduction. Due to the fact that costs are raising, Bo-Ex considers to ask tenants to pay monthly a higher rent to obtain this ventilation heat pump in the future. This higher rent shall be determined as 50% of the average expected cost reduction for the tenant. In the elaboration of this option a break even period is considered of 10-15 years.

The costs for the Warmtewinner including all necessary activities (e.g. preparation works, sound insulating works, adjustments of existing piping) are about € 4.000,- per household. In The Netherlands, a subsidy is available when purchasing energy efficient heat pumps. For the Warmtewinner a subsidy of € 1.500,- per heat pump is available. So the net costs are about € 2.500,- per household.

9.2.3 Governance

In this Measure, the main stakeholders are Bo-Ex, the tenants and Eneco. These stakeholders are equal to almost all the other Measures within TT#1.

For this Measure, the role of Eneco is important to mention. Eneco is the product developer and owner of Warmtewinner. Their benefit of this initiative is that they can collect data of the use and effect of the Warmtewinner within this specific target group.

9.3 Impact Assessment

9.3.1 Expected impact

The impact of this Measure contributes to the reduction of CO_2. the overall goal of this IRIS project. The following table shows the contribution of this Measure to the common objectives of IRIS:

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: smart hybrid electric heating and ventilation contributes to closed-loop energy positive districts.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	N/A
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.	N/A
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	N/A
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	Yes: smart hybrid electric heating and ventilation is subject of engagement.
6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	Yes: the business model regarding this Measure may be replicable abroad.
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.	N/A
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

Table 17 overview of the contribution of this Measure to the IRIS objectives

9.3.2 KPIs

There are no specific relevant Key Performance Indicators for this Measure, but this Measure contributes to the overall Key Performance Indicators of TT#1. The reason for aggregating the performance indicators to a higher level is that the specific impact of this Measure is hard to abstract.

With the refurbishment of the apartment building, not only this Measure contributes to energy savings and CO_2 reduction. The KPI's on the aggregated level of TT#1 are:

KPI	Why?	Definition	Baseline	Target
1. Energy savings for the tenants	Lower energy consumption for tenants	The reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the energy consumption from the reference period.	Current energy consumption	-/- 50%
2. CO_2 emission reduction	Lower environmental impact	Reduction of emissions of carbon dioxide related to the measure.	Current CO_2 emission	-/- 80%
3. Reduced energy costs for tenants	Lower energy costs for tenants	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	Current energy cost	-/- 50%
4. CO_2 reduction cost efficiency	Benchmarking	Costs in Euro's per ton of CO_2 saved per year.	n/a	*To determine*

Table 18 KPI's for this Measure

9.3.3 Monitoring plan

To monitor the performance of the WarmteWinner and to obtain relevant data for the KPI's, the following steps are taken into account:

- With the use of the HEMS Eneco Toon, we're able to collect data on an aggregated level without having the permission of the tenants to share data. This data consists of:
  - used gas and electricity per every day/year
  - saved gas usage and additional electricity usage per every day/year
- This data is collected by Quby, the company who develops the HEMS Eneco Toon and collects and shares data from the end users.
- For the objectives of this project, mentioned data shall be available at most per hour to meet the required information.

9.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Bo-Ex • Energy consultant	• Initiation and coordination of works • Draw PoR
	Set up preliminary design	• Bo-Ex • Energy consultant • Installation contractor	• Coordination and input • Draw design • Assess the design
2 Engineering	Elaboration of the design	• Bo-Ex • Installation contractor • Energy consultant	• Input for design • Draw the design • Assess the design
	Construction costs calculations	• Cost consultant • Installation contractor • Bo-Ex	• Construction costs calculations • Assess the calculations • Approve the calculations
3 Contracting	Contracting works	• Bo-Ex • Installation contractor	• Set up and sign contract • Sign contract
4 Realization	Install the WarmteWinner	• Installation contractor	• Make a clean roof
	Connect WarmteWinner to HEMS Eneco Toon	• Installation contractor	• Connect the WarmteWinner with an IR-link
5 Testing	Test the working of the WarmteWinner	• Installation contractor • Energy consultant	• Test and report the generated power • Assess the report
	Test the connectivity of the WarmteWinner	• Installation contractor • Energy consultant	• Test and report the generated power • Assess the report
6 Completion	Accept the executed works	• Installation contractor • Energy consultant • Bo-Ex	• Handover the installation • Assess the executed works and as-built documents • Accept the installation

Table 19 Commissioning Plan for this Measure

9.5 Implementation of the measure: planning and progress

9.5.1 Planning of activities

Figure 27 shows the programme for the scheduled activities for this measure:

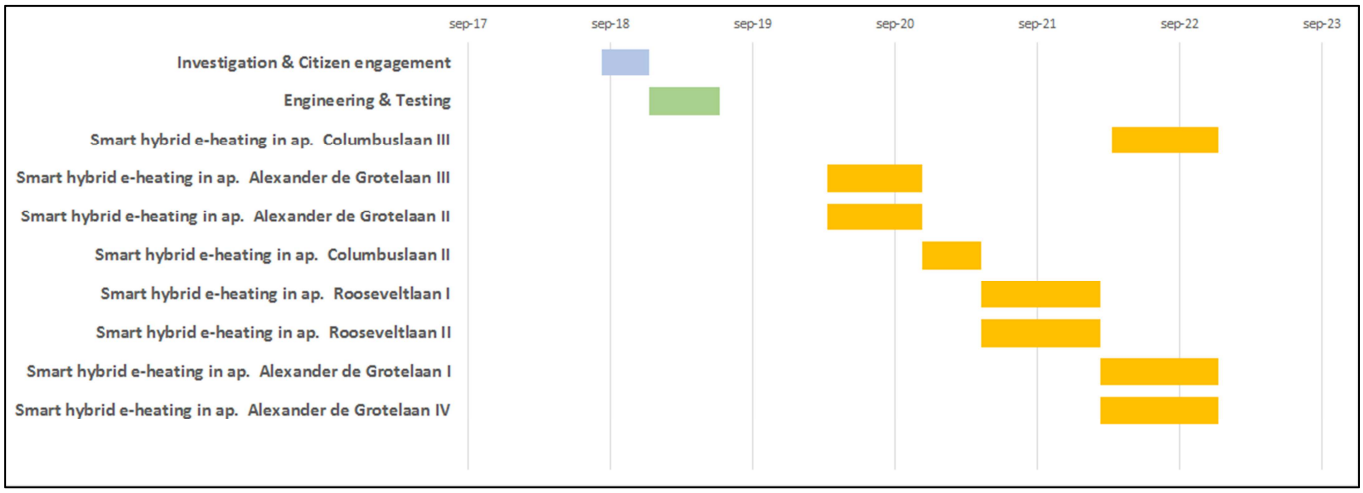


Figure 27. Timing of activities smart hybrid e-heating

9.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The main order for the contractor is assigned after the support of the tenants has been achieved.
- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

9.5.3 Risk management

The main risks regarding the WarmteWinner are:

- Social: no support of the tenants for the installation of the WarmteWinner;
  Mitigation measure: explain the system and technical impact, answer questions beforehand related to this topic, refer to other apartment buildings where this have been realized.
- Social: resistance of the tenants for the WarmteWinner because of the generated sound, vibrations (despite Measures taken out) and the less storage space tenants have after installation of the WarmteWinner;
  Mitigation measure: create a model house where people can see and experience the Warmtewinner.
- Technical: no sufficient space in the apartment house to install and maintain the WarmteWinner properly.
  Mitigation measure: explain the system and advantages and be honest about the disadvantages (the Warmtewinner uses some space in the cabinet).

9.5.4 Progress achieved up to M24

For all the apartment buildings:

- Technical and costs calculations have been made;

For the first apartment building Columbuslaan III:

- In the show house, the WarmteWinner has been installed and tested with the construction team;
- Tenants were able to visit the show house and give their feedback on the WarmteWinner: people are interested in this device though some don't like the amount of space given up for this device since the amount of storage space in an apartment house is quite less already;
- The support of the plan amongst the tenants, including a WarmteWinner per household, has been too less unfortunately. 67% of the tenants voted YES, while a minimum of 70% voting YES is required. The installation of the WarmteWinner have not been the reason for this result.

9.6 Conclusions

Regarding this Measure, a lot of preparation work have been done. We know the starting points, social and technical approach. The big challenge is to obtain enough support amongst the tenants for the whole plan of refurbishment including the WarmteWinner.

10 M#6: Energy savings as a result of smart AC/DC power grid in apartments

10.1 Specifications

Energy savings will also be realised through a direct current (DC) network in a small-scale pilot of 8 houses. Direct current electricity produced with the PV panels on the roof will be directly used in the homes. Usually, generated DC electrify is transformed by a transformer into 230 Volt alternating current (AC). This transformation causes energy losses and by directly using DC these losses are avoided.

Because of the fact that many domestic devices operate on low voltage AC/DC, the question is whether it's interesting to implement a (parallel running) DC network in a house to provide energy for a certain number of devices.

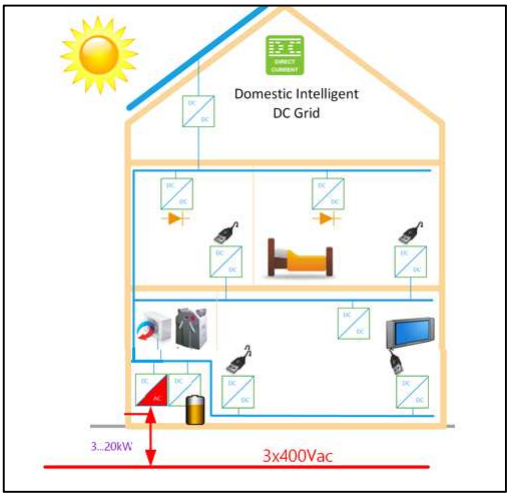


Figure 28 Possible direct current network in a house
Source: http://www.directcurrent.nl

A research project on this Measure, done by students of Utrecht University in the first half of 2018, shows that there are technical and financial possibilities to make a direct current network in an apartment. Basically, there are two options that are interesting for the tenants:

- A full direct current network within an apartment building instead of the existing alternating current network;
- A partially direct current network within an apartment building, parallel to the existing alternating current network.

The research concluded that a full DC network delivers more energy savings but is more expensive and more complex to incorporate in the existing apartments. Since the pilot will be done in existing apartment with existing tenants, the choice of a partially direct current network looks most sensible. The success of a partially direct current mainly depends on the attitude of residents.

To implement a DC network, it's necessary to have insight in the domestic devices of a (generic) household: which devices can be connected to a DC network directly and what is the impact for the user? To answer these questions, it's necessary to have insight in the tenant's kind and usage of devices.

With this information we can investigate the possibilities for implementing a DC network and guiding our tenants.

This solution will be implemented in 8 individual homes, because the technology is still very innovative and results from practical experiences are very limited. Part of this engagement activity is to find 8 volunteers who provide the ability to implement a DC network in their house.

10.1.1 Hardware

This application is subject of research. Obviously in the 8 apartment houses a partly direct current network will be created by implementing a DC transformer and a battery to store generated solar energy.

10.1.2 Software

This application is subject of research. A connection to the HEMS Eneco Toon is desirable, but at this moment there's no link between a transformer and the Eneco HEMS Toon.

To monitor the energy usage impact, we'll try to find an application which is suitable for this configuration.

10.1.3 Procurement of equipment and/or services

For the procurement of equipment and services Bo-Ex will give an order to an installation contractor who will be responsible for the procurement of hardware and software and will be responsible for the installation of parts. The budget which is available will cover all necessary hardware, software and services.

10.2 Societal, user and business aspects

10.2.1 Citizen engagement

This Measure is placed on the third step of the ladder of engagement ('Citizen Touchpoint Adoption'). This means that for this Measure, co-creation for direct current applications amongst tenants is planned. Because of the small scale pilot, Bo-Ex will ask tenants to submit on a voluntary basis. Those tenants who wants to join this pilot, will be involved in the developing process.

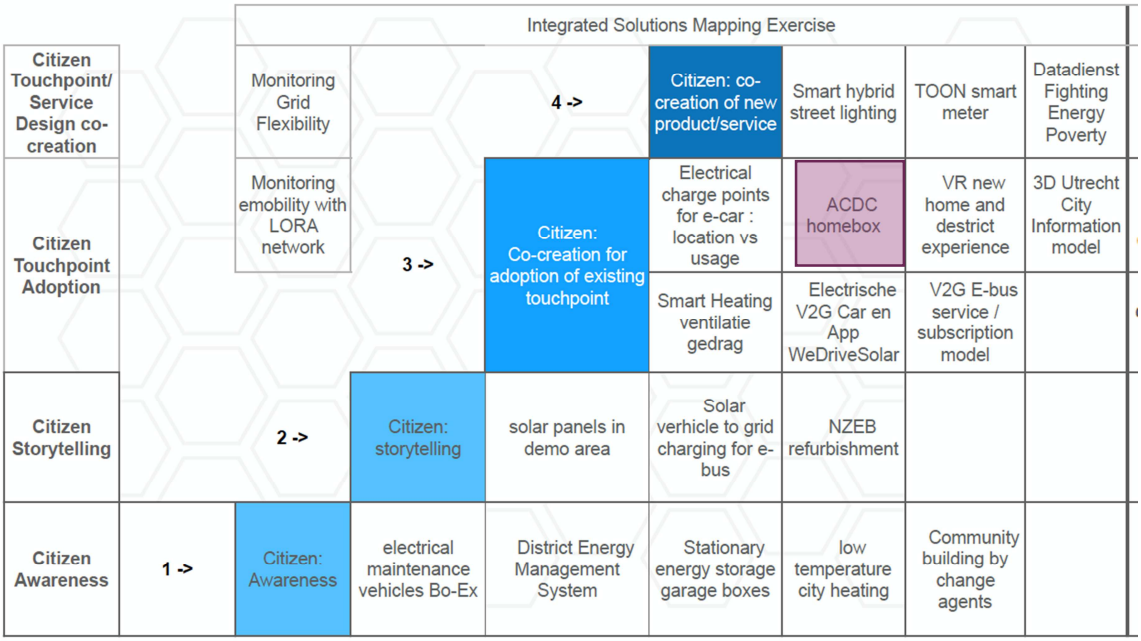


Figure 29 positioning of this Measure on the ladder of engagement

10.2.2 Business model

The business model of this Measure consists of the cost savings caused by a (partly) direct current network. Since it is still innovative and costly, savings and payback periods will be determined after implementing this pilot.

10.2.3 Governance

In this Measure, the main stakeholders are Bo-Ex and the tenants. These stakeholders are equal to almost all the other Measures within TT#1. The tenants who participate in this pilot commit on a voluntary basis.

10.3 Impact Assessment

10.3.1Expected impact

The impact of this Measure contributes to the reduction of CO_2. the overall goal of this IRIS project. The following table shows the contribution of this Measure to the common objectives of IRIS:

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: Direct Current network contributes to closed-loop energy

	positive districts.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	N/A
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.	N/A
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	N/A
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	Yes: DC networks are subject of engagement.
6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	Yes: the business model regarding this Measure may be replicable abroad.
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.	N/A
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

Table 20 overview of the contribution of this Measure to the IRIS objectives

10.3.2 KPIs

The relevant Key Performance Indicators for this Measure consists of:

KPI	Why?	Definition	Baseline	Target
1. Energy savings for the tenants	Lower energy consumption for tenants	The reduction of the energy use compared to a situation without the switchbox.	Current energy consumption	-/-10%
2. CO_2 emission reduction	Lower environmental impact	Reduction of emissions of carbon dioxide related to measure.	n/a	-/-10%

Table 21 KPI's for this Measure

10.3.3 Monitoring plan

To monitor the performance of the Direct Current network and to obtain relevant data for the KPI's, the following steps are taken into account:

- The monitoring of DC-energy usage data depends on the connectivity of the hardware with (existing) software applications.
- In case there's no application available for this objective, we can make use of existing monitoring data generated by the smart meter, with the permission of the tenants. With this permission we're able to measure the difference between an alternate current and direct current network and linked hardware.

10.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Bo-Ex • Energy consultant	• Initiation and coordination of works • Draw PoR
	Set up preliminary design	• Bo-Ex • Energy consultant • Installation contractor	• Coordination and input • Draw design • Assess the design
2 Engineering	Elaboration of the design	• Bo-Ex • Installation contractor • Energy consultant	• Input for design • Draw the design • Assess the design
	Construction costs calculations	• Cost consultant • Installation contractor • Bo-Ex	• Construction costs calculations • Assess the calculations • Approve the calculations
3 Contracting	Contracting works	• Bo-Ex • Installation contractor	• Set up and sign contract • Sign contract
4 Realization	Install the DC-network and devices	• Installation contractor	• Make a clean roof
5 Testing	Test the working of the DC-network and devices	• Installation contractor • Energy consultant	• Test and report the generated power • Assess the report
	Test the connectivity of the DC-network	• Installation contractor • Energy consultant	• Test and report the generated power • Assess the report
6 Completion	Accept the executed works	• Installation contractor • Energy consultant • Bo-Ex	• Handover the installation • Assess the executed works and as-built

	documents • Accept the installation

Table 22 Commissioning Plan for this Measure

10.5 Implementation of the measure: planning and progress

10.5.1 Planning of activities

Direct Current is currently the only specialized company in direct current applications. Direct Current will be involved in the PoR stage and design process of the apartment buildings. Direct Current will also be partner in the citizen engagement activities of TT#5. Figure 30 shows the programme for the scheduled activities for this measure.

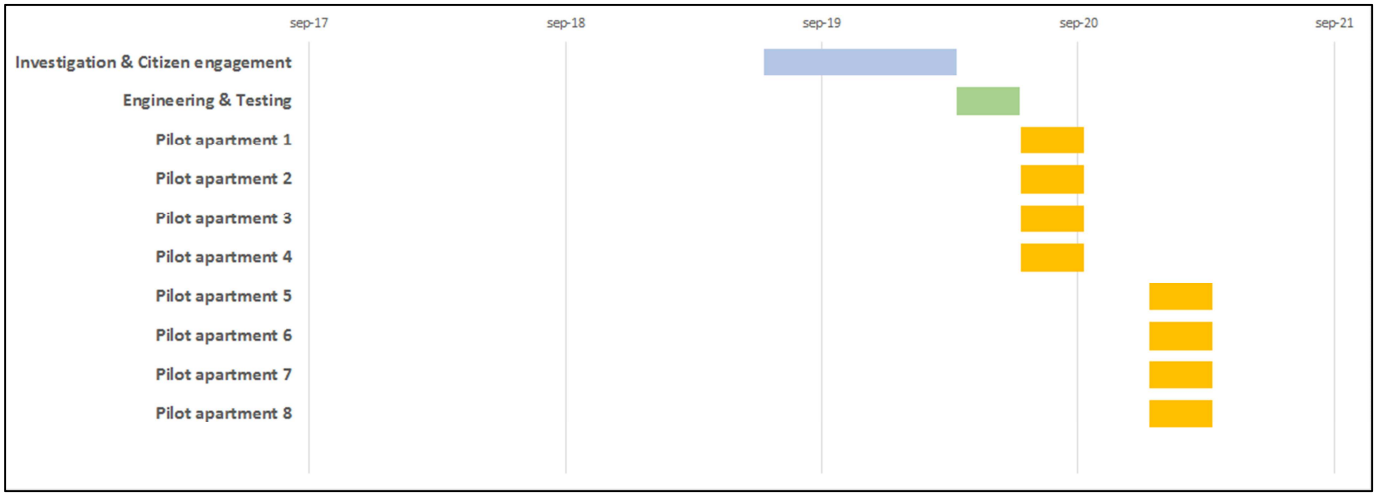


Figure 30. Timing of activities DC pilot 8 apartment dwellings

10.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The main order for the contractor is assigned after the support of the selected voluntary tenants has been achieved.
- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

10.5.3 Risk management

The main risks regarding the Direct Current network are:

- Social: not enough voluntary tenants to do this pilot with;
  Mitigation measure: create an appealing plan to find volunteers and make use of the people who are early adaptors.

- Financial/Technical: too many adjustments in hardware required to apply this pilot.
  Mitigation measure: make choices within the scope and divide the pilot into two shifts of four houses to learn from and if necessary adjust plans.

10.5.4 Progress achieved up to M24

This Measure is not that common within refurbishments. As far as we know, this is the first pilot with a DC-network within The Netherlands within refurbished houses. This means that we tried to find information and partners in the past months to make up our mind and find affordable solutions.

In the past months, we've contacted market participants such as Direct Current B.V. to get more information on the pros and cons of direct current and the possible applications.

Besides, we've asked students from University of Utrecht, to research possible solutions for direct current within the course innovation studies. This resulted in three reports of which one is a pragmatic and on first sight feasible guidance of possibilities.

10.6 Conclusions

Regarding this Measure, research has been done to create more knowledge on this topic. The next steps consist of making plans with a consultant and installation contractor and to select voluntary tenants who are prepared for a direct current application in their house.

11 M#7: Smart DC street lighting at district level

11.1 Specifications

This measure compromises energy efficient smart street lighting powered by renewables. Not only the energy efficiency of the Smart street lighting increases by using LED lighting bulbs and direct current (DC). Two poles will be equipped with other functionalities such as a lighted zebra crossing and smart tele management. These additional functionalities are investigated together with citizens of the district. In total 50 existing street lighting poles in the district will be replaced by the smart street lighting and two smart street poles will be installed.

11.1.1 Hardware

Regarding the energy efficient street lighting:

- Osram Streetlight mini led high power luminous flux 3060 lm. Warm/white colour temperature. Control gear power reduction and digital communication interface. Power consumption over average lifetime 23 W.

Figure 31 Osram street light

Regarding the smart street lighting with other functionalities:

- An interactive lighted pedestrian road crossing with two dynamic signalling poles with sensors for measuring speed, air quality and environment sound. The two smart lighting poles (brand Korner) are provided with PV cells and communication interfaces. It contains a lighted zebra crossing with ledstripes 4000x500 mm at both sides of the street. The height of these poles is 5 meters. The manufacturer is Eclatec.

Figure 32 Eclatec smart lighting pole

11.1.2 Software

Regarding the energy efficient street lighting:

- Programmable Logic Controller (PLC) lineswitch 100/50, Luminext Luminizer tele management system: https://www.luminext.eu/en/connect-control/.

Regarding the smart street lighting with other functionalities:

- Dali control, with a 4G/5G data connection, Luminext Luminizer tele management system: https://www.luminext.eu/en/connect-control/.

11.1.3 Procurement of equipment and/or services

For the procurement of equipment and services the Municipality of Utrecht will give an order to an installation contractor who will be responsible for the procurement of hardware and software and will be responsible for the installation of parts. The budget which is available will cover all necessary hardware, software and services.

Municipality of Utrecht has a framework contract with certain parties. This order will be placed at one of the pre-selected contractors.

The investment costs are:

- Energy efficient street lighting: € 24,000 including VAT
- Smart street lighting: € 75,000 including VAT

11.2 Societal, user and business aspects:

11.2.1 Citizen engagement

The Measure of the smart street lighting is placed on the fourth step of the ladder of engagement ('Citizen Touchpoint Service'). For this Measure, we've organized a co-creation project with citizens and others who are involved in the district of Kanaleneiland-Zuid. Deliverable D5.6 elaborates on these aspects.

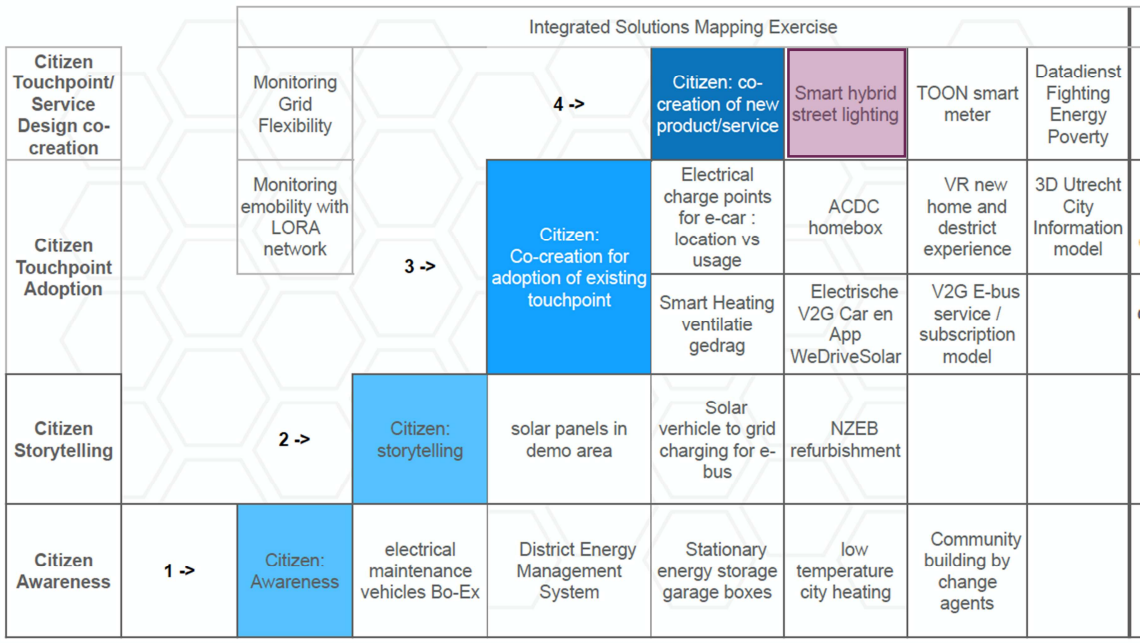


Figure 33 positioning of this Measure on the ladder of engagement

11.2.2 Business model

Municipality of Utrecht finances the energy efficient street lighting out-of-pocket. This money comes from the maintenance budget (the 50 lighting poles are ready for replacement). The energy efficient street lighting will decrease the energy usage in the coming years, but the investment will not be paid back within 20 years after installation.

For the smart street lighting, the budget from IRIS will be used. There's no business model regarding this investment. But, the information gathered from the smart street poles can be sold to other departments of Municipality of Utrecht or other companies. In TT#4 data services will be researched and developed which will provide possible business cases (see deliverable D5.6).

11.2.3 Governance

In this Measure, the main stakeholders are Municipality of Utrecht, Luminext and citizens of the district of Kanaleneiland-Zuid. Also other persons concerned were invited to join the co-creation sessions, such as policemen who work in this district and people from other departments of the Municipality of Utrecht.

11.3 Impact Assessment

11.3.1 Expected impact

The impact of this Measure contributes to the reduction of CO_2. the overall goal of this IRIS project. The following table shows the contribution of this Measure to the common objectives of IRIS:

IRIS objective	Contribution of this Measure?
1. Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.	Yes: smart DC street lighting contributes to closed-loop energy positive districts.
2. Demonstrate smart energy management and storage solutions targeting Grid flexibility.	N/A
3. Demonstrate integrated urban mobility solutions increasing the use of environmentally-friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.	N/A
4. Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services	N/A
5. Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.	Yes: smart street lighting is subject of engagement.

6. Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.	Yes: the business model regarding this Measure may be replicable abroad.
7. Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.	N/A
8. Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.	N/A

Table 23 overview of the contribution of this Measure to the IRIS objectives

11.3.2 KPIs

The relevant Key Performance Indicators for this Measure consists of:

KPI	Why?	Definition	Baseline	Target
1. Reduction in annual final energy consumption by street lighting	Lower environmental impact	The reduction of the energy consumption for street lighting.	0	-/-70%
2. CO_2 emission reduction	Lower environmental impact	Reduction of emissions of carbon dioxide related to the measure.	n/a	-/-70%

Table 24 KPI's for this Measure

11.3.3 Monitoring plan

For the monitoring and control of the street lighting, Luminext Luminizer telemanagement is used. This system gives insight in the energy usage and the information coming from the other functionalities.

11.4 Commissioning Plan

The purpose of commissioning is to verify and record that equipment and/or systems comply with the design specification and that construction is done accordingly. This process considers all the process steps from design till completion. The next table shows the high level commissioning plan for mentioned measure.

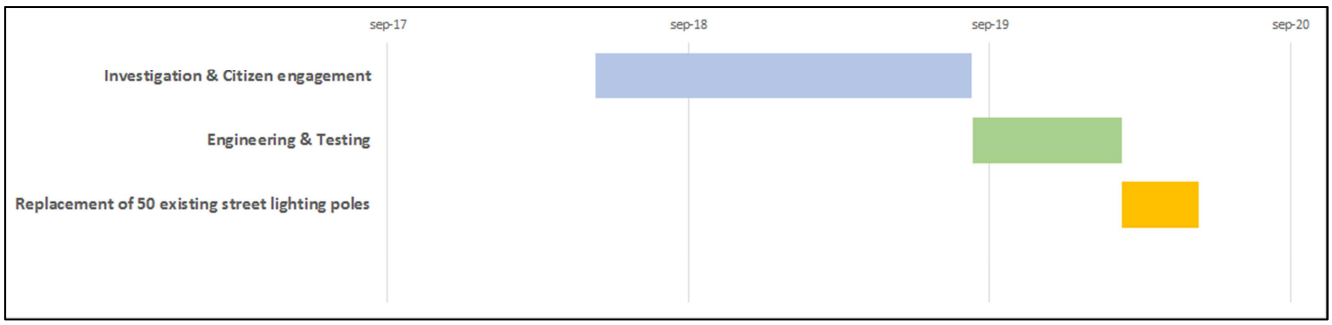
Phase	Activity	Parties involved	Responsibility
1 Design	Set up Programme of Requirements	• Municipality of Utrecht	• Initiation and coordination of works • Draw PoR
	Set up preliminary design	• Municipality of Utrecht • Luminext	• Coordination and input • Draw design

			• Installation contractor	• Assess the design
2	Engineering	Elaboration of the design	• Luminext • Installation contractor	• Input for design • Draw the design • Assess the design
3	Contracting	Contracting works	• Municipality of Utrecht • Installation contractor	• Set up and sign contract • Sign contract
4	Realization	Install the (smart) street lighting	• Installation contractor	• Replace and put in new street lighting poles
5	Testing	Test the working of the smart street lighting	• Installation contractor • Municipality of Utrecht	• Test and report the lighting • Assess the report
		Test the connectivity of the data network	• Luminext • Installation contractor • Municipality of Utrecht	• Test and report the generated power • Assess the report
6	Completion	Accept the executed works	• Installation contractor • Energy consultant • Municipality of Utrecht	• Handover the installation • Assess the executed works and as-built documents • Accept the installation

Table 25 Commissioning Plan for this Measure

11.5 Implementation plan

11.5.1 Planning of activities



11.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The main order for the contractor is assigned after complete engineering and calculating works of the installation contractor. We expect that the assignment will take place in December 2019.

- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor. We expect that the assignment will take place in January 2020.

11.5.3 Risk management

The main risks regarding the Direct Current network are:

- Technical: the smart street lighting does not function well:
  Mitigation measure: testing the street lighting beforehand.
- Social: resistance of the citizens for these poles (people think that these poles watch behaviour):
  Mitigation measure: inform the citizens well about the functionalities and data collection beforehand.

11.5.4 Progress achieved up to M24

For this Measure, the process of co-creation has been done, the technical programme of requirements has been written and products have been selected.

11.6 Conclusion

Regarding this Measure, a lot of preparation work have been done. We know the starting points and technical approach. The next step is to finalize the design and assign the orders and realize the street lighting in the first half year of 2020.

12 Summary on monitoring of KPIs

With reference to the chapters about the seven Measures, there are KPI's related to a specific measure and KPI's related to a combination of Measures within TT#1. The reason for aggregating the performance indicators to a higher level is that the specific impact of this Measure is hard to abstract. In this chapter these aggregated KPI's are mentioned

12.1 Expected impact

The expected impact of the measures of TT#1 are:

- CO_2 emission reduction
- Energy savings for the tenants
- Reduced energy costs for tenants
- A higher degree of local renewable energy production and energetic self-supply by RES
- Increased awareness of energy usage amongst tenants

12.2 Aggregation of KPIs for each LH city

Each LH city has its own set of KPIs that can be related to the IRIS KPI house; the top level of the house containing the IRIS level KPIs (IL) is however the same for all cities. On solution level (STT1-5), the KPIs may vary between the cities since different solutions are implemented in each city and the cities have different objectives, but in many cases the same KPIs can be found in all cities, thus allowing comparison between the Transition Tracks of the cities. For some Transition Tracks the evaluation of integrated solutions cannot be separated and the KPIs are hence calculated at Transition Track level (TT1-5). The KPIs for each transition track and possibilities to aggregate them are presented in Table 26.

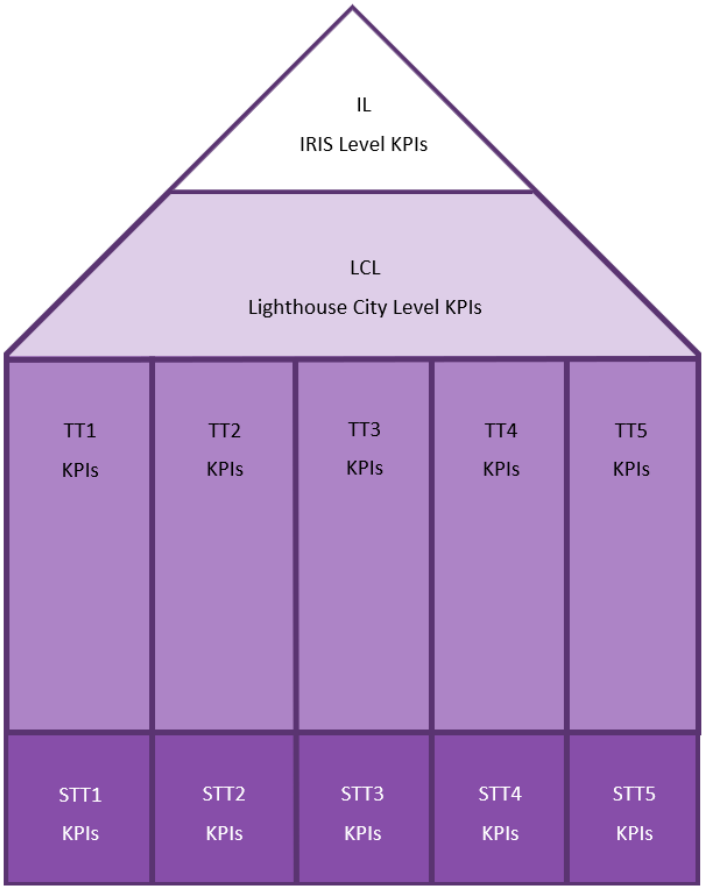


Figure 34 IRIS KPI-house. The KPIs presented in Tables 4-6 are, if possible, aggregated to transition track level (TT1-5) or higher.

The following table shows the KPI's of this transition track and their position in the IRIS-KPI-House.

KPIs	Solution	Position IRIS KPI-house
1. Energy savings for the tenants	Transition track 1: Smart renewables and near zero energy district	TT1
2. CO_2 emission reduction	Transition track 1: Smart renewables and near zero energy district	TT1
3. Reduced energy costs for tenants	Transition track 1: Smart renewables and near zero energy district	TT1
4. CO_2 reduction cost efficiency	Transition track 1: Smart renewables and near zero energy district	TT1
1. Degree of local renewable energy production	1.1. District-scale integrated PV	STT1
2. Degree of energetic self-supply by RES	1.1. District-scale integrated PV	STT1
3. CO_2 emission reduction	1.1. District-scale integrated PV	STT1
1. Increased awareness of energy usage	1.4 Installation of innovative HEMS (Eneco Toon)	STT1
1. Energy savings for the tenants	1.6 Small-scale demonstration of hybrid AC/DC switchbox	STT1
2. CO_2 emission reduction	1.6 Small-scale demonstration of hybrid AC/DC switchbox	STT1

1. Reduction in annual final energy consumption by street lighting	1.7 Smart DC street lighting	STT1
2. CO_2 emission reduction	1.7 Smart DC street lighting	STT1

Table 26. Relation and possible aggregation of KPIs to solutions and the IRIS KPI-house in Figure 34.

13 Ethics requirements

The scope of this deliverable is to show how the IRIS consortium will address the ethical, data protection, confidentiality and privacy aspects related to the processing of personal data collected by IRIS consortium partners for the purpose of executing the project tasks.

13.1 GDPR compliance

The overall Data Protection officer (DPO) is mr. Henk Kerlien from Stichting Bo-Ex '91. Henk Kerlien is involved in the IRIS project in the role of Project Legal Signatory.

The following table shows the GDPR elements per Measure of TT#1.

Demonstrator	Element and description	
#1 District Wide PV	Data controller:	Stichting Bo-Ex '91
	Personal Data:	Yes: name, address (of existing tenants)
	High risk involved:	No, because Bo-Ex uses the personal data on the same (existing) way it uses now.
	DPIA:	No DPIA required
	Informed Consent Procedure	Not applicable
#2 LT district heating	Data controller:	Stichting Bo-Ex '91
	Personal Data:	Yes: name, address (of existing tenants)
	High risk involved:	No, since the current way of collecting data is GDPR proof (ISTA on behalf of Bo-Ex collects the usage data from the tenants and processes the administrative payments).
	DPIA:	No DPIA required
	Informed Consent Procedure	Yes
#3 HEMS Eneco Toon	Data controller:	Eneco Consumenten B.V.
	Personal Data:	Yes: name, address, e-mail, phone number
	High risk involved:	No, since the permission of processing data on an individual level (the level of households) is depending on the explicit cooperation of the tenant. The collected data by Eneco is protected well and will not be distributed, only the data on an

Demonstrator	Element and description	
		aggregated level (without reference to individual households) is collected and shared with the IRIS partners.
	DPIA:	No DPIA required
	Informed Consent Procedure	Not applicable
#4 NZEB refurbishment	Data controller:	Stichting Bo-Ex '91
	Personal Data:	Yes: name, address (of existing tenants), relevant medical information
	High risk involved:	Yes, because relevant medical information is asked (to take into account during the activities)
	DPIA:	Yes, DPIA is required
	Informed Consent Procedure	Yes
#5 Smart (hybrid) e-heating system	Data controller:	Stichting Bo-Ex '91
	Personal Data:	Yes: name, address (of existing tenants)
	High risk involved:	No, because Bo-Ex uses the personal data on the same (existing) way it uses now.
	DPIA:	No DPIA required
	Informed Consent Procedure	Not applicable
#6 AC/DC home switchboxes	Data controller:	Stichting Bo-Ex '91
	Personal Data:	Yes: name, address, e-mail, phone number
	High risk involved:	No, since the requirement for tenants who wants to join this pilot, consists of the fact that data is collected by the Data Controller during the lead time of the IRIS project.
	DPIA:	Not applicable
	Informed Consent Procedure	Not applicable
#7 Smart DC street lighting	Data controller:	Gemeente Utrecht
	Personal Data:	No
	High risk involved:	Not applicable

Demonstrator	Element and description	
	DPIA:	Not applicable
	Informed Consent Procedure	Not applicable

Table 27 table of GDPR topics per measure

13.2 Ethical aspects

Almost all activities regarding this transition track are done together with tenants of housing corporation Bo-Ex. The activities are done with respect to the tenants and their rights (according to Dutch constitution law). Besides, the experiments within this transition track are only possible and feasible with the explicit allowance of the involved tenant(s). We know that the relation between tenants and Bo-Ex and citizens and the Municipality of Utrecht in this district is quite delicate. Therefore, one of our missions regarding this transition track is to launch experimental activities in a save way. So, the experiments we do, may not fear people, increase distrust or lead to other negative outcomes.

Besides, the main principles we use are:

- we don't exclude anyone
- we make direct contact with the tenants by an individual letter, house visit or phone call
- tenants are not being pressurized to support the plan and IRIS initiatives

14 Links to other work packages

Being a coordinating work package, WP5 has interdependencies with most of the other WPs.

WP3 supports the two expected impacts: Put in practice bankable solutions of IRIS cities' transitions tracks; Reduce the technical and financial risks in order to give confidence to investors for investing in large-scale replication. This transition track within WP5 gives opportunities to bankable solutions. For example the street lighting solution.

WP4 aims at "offering an open, reusable and reliable platform for sharing data, speeding-up innovation, standardization and implementation of smart application." The relevant data from the activities within this transition track contribute to the availability and connectability of data from the houses. With this data, other data solutions and tools can be developed.

WP9 aims to provide quantitative impact analysis for the LHs, which have implemented different SoA IRIS solutions, such as infrastructure, citizen engagement, ICT, energy saving and e-mobility, in order to determine the KPI's as defined in collaboration with the LHs. With the help of the people involved in this work package, the qualitative and quantitative key performance indicators of each Measure have been set up and reviewed.

At last, the results coming from this transition rack are shared with the people involved in WP10. For example, the reports from students of UU regarding direct current solutions, have been publishes on the Dutch IRIS website (with explicit permission of the involved students).

15 Conclusions and next steps

After 24 months, a lot of activities and initiatives have taken place already but further steps are required.

Behind track due to exhaustive collaboration with tenants

We're slightly behind track with the planned activities. The main reason is that the planned refurbishment of the twelve apartment buildings have been delayed due to exhausting participation with tenants to prepare plans for their apartment building. Tough discussions about other topics than the IRIS Measures such as an elevator or a bigger kitchen for the tenants have not contributed to a smooth process of participation and caused a delay. For the IRIS apartment buildings, we try to increase the level of participation with tenants to involve them frequently in the preparation phase. The first apartment building Columbuslaan III should have been the first IRIS apartment building, but unfortunately the amount of support amongst tenants was a little too low to execute works.

Lessons learned

From the other activities, the following lessons have been learned and are taken into account considering activities in the (near) future:

1. It's not easy to come into contact with our target group, because of language barriers, people have bigger problems to worry about and a natural distrust within a large part of the target group towards institutions such as the municipality and housing corporation.
2. The distrust in housing corporation Bo-Ex amongst tenants is high and it's hard to find reasonable solutions. The distrust is strengthened by the plans of the other housing corporation who act in the same area and offer their tenants more value for money according the tenants of Bo-Ex.

Drivers and barriers

The main drivers of this transition track are still actual, the solutions which have been suggested are still applicable and increases the energy efficiency within the district of Kanaleneiland-Zuid.

The main barriers are primarily the involvement and support of tenants. Tenants in this district often do have other problems to process such as obtaining enough income to feed my household, criminality, rats, traffic safety and parking problems. A sustainable house is not top of their mind.

Without involvement and support, the desired outcomes of this project seem to disappoint. Especially in TT#5 we focus on the citizen engagement and try increase the amount of involvement and support amongst tenants.

Next steps

Considering the lessons learned and results we've achieved, the next steps for this transition track are:

- Elaborate the plans for the low temperature district heating and direct current facilities;
- Focus on the target group and their reasons to support the plan of refurbishment (of the apartment buildings of Bo-Ex).

16 References

- Grant Agreement nr. 774199 — Integrated and Replicable Solutions for Co-Creation in Sustainable Cities (IRIS) Amendment, Reference No AMD-774199-24
- Deliverable D5.1 Baseline, ambition, activities, and barriers & drivers for Utrecht lighthouse interventions, 30 September 2018
- Deliverable D5.2 - Coordination of Utrecht integration and demonstration activities, 30 September 2018
- Deliverable D5.4 - Launch of T.T.#2 activities on Smart energy management and storage for flexibility (UTR)
- Deliverable D5.5 - Launch of T.T.#3 activities on Smart e-mobility (UTR)
- Deliverable D5.6 - Launch of T.T. #4 activities on CIP and information services
- Deliverable D5.7 - Launch of T.T. #5 Activities on Citizen Engagement and motivating feedback
- Utrecht op de Kaart http://kaartenutrecht-gemu.opendata.arcgis.com/
- Municipality of Utrecht http://www.utrecht.nl
- Utrecht op de Kaart http://kaartenutrecht-gemu.opendata.arcgis.com/
- Eneco http://www.eneco.nl
- Direct current http://www.directcurrent.nl

17 Annex 1

For the KPI's for this Transition Track, the main data parameters consist of energy usage data at apartment building level. As part of IRIS, Civity has made a data connection in the CIP aggregated data from Eneco Toon. The data from Eneco Toon will primarily be used to report on the different KPI's.

Table 28 Description of Energy usage data for KPI's in TT#1.

No	Parameter	Value
1	Data Variable Name *i.e. Thermal energy consumption, locally produced electrical energy, etc.*	Energy usage data
2	Measure Number *As it is stated in the measure tracker*	KPIs at TT#1 level Measures 1-6
3	KPI Number *KPI('s) that are related to the data*	5, 13, 34
4	Units of measurement *i.e. kWh, Euro, etc.*	kWh / m^2 GFA m^3 gas / m^2 GFA GJ / m^2 GFA
5	Baseline (of data variable) *e.g. relating to BaU or previous performance data*	Current energy consumption
6	Meter *i.e. smart meter, survey, energy bill, etc.*	Electricity: Eneco Toon and central meter Gas: Eneco Toon and central meter DH: central meter
7	Location of measurement *Where the measurements take place*	Apartment building
8	Data accuracy *How accurate is the measurement*	Standard required accuracy of meters
9	Collection interval *How often the data is recorded*	15 minutes, but aggregated to hourly data for Eneco Toon data
10	Start of measurements	Eneco Toon: after installation Central meters: already started before IRIS

	i.e. 1-1-2019, 0:00CET	
11	End of measurements *i.e. 31-12-2020, 24:00CET*	Measurements will continue after the project.
12	Expected availability *i.e. open data, public, confidential, no data available*	Confidential; Eneco Toon data are gathered by Eneco and provided to the CIP as aggregated data (hourly and at building level). Stedin and Eneco can supply aggregated data of the central meters.
13	Expected accessibility *i.e. 1) online without access constraints, 2) online, but requires authentication, and, 3) offline*	Online, but requires authentication
14	Data format *i.e. csv file, json…*	Data link between Eneco and CIP.
15	Data owner *i.e. the name of the company that will give access to data*	Eneco and Stedin
16	Comments *Further info*	

Table 29 Description of Construction costs for TT#1

No	Parameter	Value
1	Data Variable Name *i.e. Thermal energy consumption, locally produced electrical energy, etc.*	Construction costs
2	Measure Number *As it is stated in the measure tracker*	KPI at TT#1 level
3	KPI Number *KPI('s) that are related to the data*	7
4	Units of measurement *i.e. kWh, Euro, etc.*	Euro
5	Baseline (of data variable) *e.g. relating to BaU or previous performance data*	n/a
6	Meter *i.e. smart meter, survey, energy bill, etc.*	n/a
7	Location of measurement *Where the measurements take place*	n/a
8	Data accuracy *How accurate is the measurement*	n/a
9	Collection interval *How often the data is recorded*	Yearly
10	Start of measurements *i.e. 1-1-2019, 0:00CET*	Start of refurbishment of apartment building
11	End of measurements *i.e. 31-12-2020, 24:00CET*	After refurbishment of apartment building
12	Expected	Confidential

	availability *i.e. open data, public, confidential, no data available*	
13	Expected accessibility *i.e. 1) online without access constraints, 2) online, but requires authentication, and, 3) offline*	Offline
14	Data format *i.e. csv file, json…*	Excel
15	Data owner *i.e. the name of the company that will give access to data*	Bo-Ex
16	Comments *Further info*	

Table 30 Description of Electricity generated by PV-panels for measure 1

No	Parameter	Value
1	Data Variable Name *i.e. Thermal energy consumption, locally produced electrical energy, etc.*	Electricity generated by PV-panels
2	Measure Number *As it is stated in the measure tracker*	1
3	KPI Number *KPI('s) that are related to the data*	10, 20 (Degree of local renewable energy production)
4	Units of measurement *i.e. kWh, Euro, etc.*	kWh
5	Baseline (of data variable) *e.g. relating to BaU or previous performance data*	0
6	Meter *i.e. smart meter, survey, energy bill, etc.*	Eneco Toon
7	Location of measurement *Where the measurements take place*	Apartment building
8	Data accuracy *How accurate is the measurement*	Standard required accuracy of meters
9	Collection interval *How often the data is recorded*	15 minutes, but aggregated to hourly data
10	Start of measurements *i.e. 1-1-2019, 0:00CET*	After installation PV-panels
11	End of measurements *i.e. 31-12-2020, 24:00CET*	Measurements will continue after the project.
12	Expected	Confidential

	availability *i.e. open data, public, confidential, no data available*	
13	Expected accessibility *i.e. 1) online without access constraints, 2) online, but requires authentication, and, 3) offline*	Online, but requires authentication
14	Data format *i.e. csv file, json…*	Data link between Eneco and CIP.
15	Data owner *i.e. the name of the company that will give access to data*	Eneco
16	Comments *Further info*	

Table 31 Description of Opinion of tenants for measure 4

No	Parameter	Value
1	Data Variable Name *i.e. Thermal energy consumption, locally produced electrical energy, etc.*	Opinion of tenants
2	Measure Number *As it is stated in the measure tracker*	4
3	KPI Number *KPI('s) that are related to the data*	17
4	Units of measurement *i.e. kWh, Euro, etc.*	Likert scale
5	Baseline (of data variable) *e.g. relating to BaU or previous performance data*	n/a
6	Meter *i.e. smart meter, survey, energy bill, etc.*	Questionnaire
7	Location of measurement *Where the measurements take place*	Apartment building
8	Data accuracy *How accurate is the measurement*	n/a
9	Collection interval *How often the data is recorded*	Once
10	Start of measurements *i.e. 1-1-2019, 0:00CET*	After refurbishment of apartment building
11	End of measurements *i.e. 31-12-2020, 24:00CET*	After refurbishment of apartment building
12	Expected	Confidential

	availability *i.e. open data, public, confidential, no data available*	
13	Expected accessibility *i.e. 1) online without access constraints, 2) online, but requires authentication, and, 3) offline*	Offline
14	Data format *i.e. csv file, json…*	Excel with anonymized results
15	Data owner *i.e. the name of the company that will give access to data*	Bo-Ex
16	Comments *Further info*	

Table 32 Description of Electricity consumption for measure 7

No	Parameter	Value
1	Data Variable Name *i.e. Thermal energy consumption, locally produced electrical energy, etc.*	Electricity consumption
2	Measure Number *As it is stated in the measure tracker*	7
3	KPI Number *KPI('s) that are related to the data*	37
4	Units of measurement *i.e. kWh, Euro, etc.*	kWh
5	Baseline (of data variable) *e.g. relating to BaU or previous performance data*	Current electricity consumption street lighting
6	Meter *i.e. smart meter, survey, energy bill, etc.*	Electricity meter
7	Location of measurement *Where the measurements take place*	District
8	Data accuracy *How accurate is the measurement*	Standard required accuracy of meters
9	Collection interval *How often the data is recorded*	Daily
10	Start of measurements *i.e. 1-1-2019, 0:00CET*	Already started before IRIS
11	End of measurements *i.e. 31-12-2020, 24:00CET*	Measurement continue after IRIS
12	Expected	Confidential

	availability *i.e. open data, public, confidential, no data available*	
13	Expected accessibility *i.e. 1) online without access constraints, 2) online, but requires authentication, and, 3) offline*	Online, but requires authentication
14	Data format *i.e. csv file, json…*	TBD
15	Data owner *i.e. the name of the company that will give access to data*	Municipality of Utrecht
16	Comments *Further info*	