IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

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Executive Summary

The objective of this deliverable is to provide a detailed overview of the results of the Utrecht demonstration. This deliverable is intended for the following audiences:

- Stakeholders in the Utrecht ecosystem as it should provide a detailed overview of the solutions that are implemented by each of the partners;
- Stakeholders in the demonstration districts as it should provide them with an overview of the solutions and on how local stakeholders are involved;
- Project partners in the other lighthouse and follower cities;
- Broader public, which is interested in the details of the demonstration.

This deliverable will facilitate the common understanding of the demonstration activities and the results. It will allow the Steering Committee of the project to assess the status and compare with what is stated in the DoA of the IRIS project.

The IRIS project has worked with 5 interdependent Transition Tracks (TTs) enabling the transition towards reduced energy demand and increased shares of renewables and e-mobility in the urban energy and mobility systems. These TTs have served as a guiding structure in the project activities in the Utrecht demonstration. The 5 TTs will be used as chapters in this deliverable and are:

- Transition Track #1: Smart renewables and closed-loop energy positive districts
- Transition Track #2: Smart Energy Management and Storage for Grid Flexibility
- Transition Track #3: Smart e-Mobility Sector
- Transition Track #4: City Innovation Platform (CIP)
- Transition Track #5: Citizen engagement and Co-Creation

After the first three difficult years, where several activities in TT#1 faced delays besides good progress on other activities, we managed to reverse the negative flow and were able to start with the NZEB refurbishment in the district Kanaleneiland-Zuid in 2020, along with implementing PV-panels and smart hybrid heat pumps. In this district, four apartment buildings have been refurbished, counting almost 200 dwellings. We have also installed over 300 HEMS Eneco TOON (Home Energy Management System device from energy supplier Eneco, called 'TOON') in dwellings and successfully launched the DC-pilot by installing DC-equipment in a pilot dwelling. Furthermore, the PEB refurbishment of a high-rise building in the district Overvecht has been successfully finished, and the monitoring of the energy performance confirms that the building is actually a PEB, with all the energy production on the building itself; this is actually the first PEB retrofitted high-rise apartment building in Europe. In the district Lombok, the NZEB refurbishment has been completed, 354 dwellings have been refurbished over the last three years despite the corona pandemic.

Smart street lighting with 50 lampposts and a smart pedestrian crossing, creating a safer traffic situation, have been implemented. The results are taken into account for the city-wide street lighting program of 60,000 lamp posts.

In TT#2 and 3, the development and demonstration of the smart charging system for electric cars and the installation of a large stationary battery in the Kanaleneiland-Zuid demonstration district have enabled the rapid evolvement and growth of an energy management system at city level with currently about 600

bidirectional charging stations and thousands more to come. This has made Utrecht a world-wide pioneer in bidirectional charging. IRIS has sped up that development and the focus now is to speed up further demonstration, expansion, and replication. Interest from various parties in the Netherlands and the EU is rapidly increasing, with implementation of bidirectional charging points taking place in several Dutch cities like Amsterdam and Rotterdam.

As part of TT#2 and 3, 68 e-buses are in operation in Utrecht with two large charging plazas just outside the city and several fast chargers along the route. As part of IRIS, bus company Qbuzz has fitted the buses with detailed monitoring and logging devices that are providing valuable data on battery behaviour, driving range, battery wear and state of charge over the day. Based on these data, QBuzz and Utrecht University have conducted research on the potential of smart charging and V2G operation of city e-buses in the Utrecht setting. The results were promising and QBuzz is now implementing smart charging of their e-buses. Moreover, Qbuzz has set up an experiment to reuse a battery from an e-bus that was sold at the end of its service life, as a stationary battery on one of its charging plazas. The battery has received hardware modifications to serve as a stationary battery. The goal of this experiment is to research the possibilities for scaling up, using the batteries from all their e-buses at the end of their service life, and to research the added value for future trading at electricity markets.

Within TT#4 various data services have been developed. The services are aimed at the monitoring of EV charging points, smart street lighting, making smart city applications visible in a 3D application and fighting energy poverty through data-driven energy advice. These services run on datasets made available through the urban data platform City Innovation Platform (CIP). The services contribute to solving social problems such as the increasing misuse of EV charging points, energy poverty, traffic safety and support the energy transition. The data services prove that services based on the use of open data sets available in the CIP can be used to solve societal challenges. The financial exploitation of the services and the translation into profitable business models is still quite challenging.

The continued presence and communication in the district Kanaleneiland-Zuid leads to better connections with the citizens and more participants for the different measures (TT#5).

The personal approach with installing the HEMS Eneco TOON and personal connections with the social networks in the district have led to a good cooperation with the district. This has also benefited the refurbishment actions in TT#1.

COVID-19 has hampered the initial progress of citizen engagement activities for over a year. Despite the challenging COVID-19 situation, we have been able to create satisfying results that will be continued after the IRIS project. For example, education of citizens to ‘environmental coaches’ has proven to be a successful approach to enlarge the number of people reached but also to create more support and understanding from citizens for sustainable topics like energy, garbage in public space and added value of green in the city. Another good example is the education program for primary, secondary and vocational schools. Involving children and teaching them about climate change and energy transition creates a possibility to interact with adults in the district.

The progress with citizen engagement in the district Kanaleneiland-Zuid will be continued after the IRIS project by connecting the results, local networks etc to stakeholders that will be working on making this district carbon neutral in the coming years until 2030.

Table of Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

Abbreviation	Definition
AC	Alternating current
AFRR	Automatic Frequency Restoration Reserve, a grid balancing mechanism
BESS	Battery Energy Storage System
CIP	City Innovation Platform
DC	Direct Current
DH(N)	District Heating (Network)
DoA	Description of Action
DSO	Distribution System Operator, for the Utrecht region this is Stedin
EMS	Energy Management System
EU	European Union
EV	Electric vehicle
FC	Follower City
FCR	Frequency Containment Reserve, a grid balancing mechanism
HEMS	Home Energy Management Systems
ICE	Internal combustion engine
IoT	Internet of Things
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
PEB	Positive Energy Building
PoR	Programme of Specification
PV	Photovoltaic
RES	Renewable Energy Sources
SEAP	Strategic Energy Action Plan
SoA	State Of the Art
TSO	Transmission System Operator, for the Netherlands this is TenneT
TT	Transition Track(s)
V2G	Vehicle-to-Grid (or: bidirectional) charging of electric vehicles
WP	Work Package

1. Introduction

1.1 Scope and objectives

The objective of this deliverable is to provide a detailed overview of the final results of the Utrecht demonstration. This deliverable is intended for the following audiences:

- Stakeholders in the Utrecht ecosystem as it should provide a detailed overview of the solutions that are implemented by each of the partners;
- Stakeholders in the demonstration districts as it should provide them with an overview of the solutions and on how local stakeholders are involved;
- Project partners in the other lighthouse and follower cities;
- Broader public, which is interested in the details of the demonstration.

This deliverable will facilitate the common understanding of the demonstration activities and the final results. It will allow the Steering Committee of the project to assess the current status and compare with what is stated in the DoA and possibly provide feedback on the last period (M49-M66) of the IRIS project.

1.2 Lighthouse demonstration project

Home to 340.000 inhabitants, Utrecht is the fourth municipality in the Netherlands. It is the fastest growing city in the country and expects to have 400.000 inhabitants in 2025. The city is characterized by its beautiful historical centre, its relatively highly educated population and its attractiveness to company headquarters, university, and research institutes thanks to its central position in the Netherlands.

Utrecht is very consistent in its sustainable energy policy. As of 2009, Utrecht takes part in the Covenant of Mayors. The city's 2008 Strategic Energy Action Plan (SEAP) was updated in the 2016 Strategic Energy Action Plan (SEAP), aiming at transforming the urban energy systems into sustainable, yet reliable and affordable systems. A core principle is that Utrecht wants to be a climate neutral and a climate robust city in 2030. It wants to become less fossil-fuel dependent and have buildings heated by renewables (power and waste heat) rather than by natural gas (the main heating system in the Netherlands since the 1960s). Although Utrecht is very densely populated, the city has the highest rate of PV-systems installed in the Netherlands (10 MWp, 2015). In 2021 24% of the roofs in Utrecht was covered with solar panels, and the city aims to let the energy production by solar grow from 45 GWh in 2020 to 168 GWh in 2030[1]. These numbers illustrate the city's ardour to boost local production and use of renewables, and to adapt the urban energy system to accommodate high shares of both renewables and EVs.

[1] Programma zon op dak en netinpassingen 2022-2026, https://utrecht.bestuurlijkeinformatie.nl/Reports/Document/3485fbbd-e0f2-4360-90df-06f04a58b6ef?documentId=805f2771-b060-4cd7-ab4a-ccecb567ac19

In summary, the Utrecht lighthouse demonstration aims to address the following challenges:

1. To become energy neutral districts, a high penetration of renewables is necessary, in addition to low energy buildings and infrastructures. There is a clear need for integration of decentralized renewable energy systems in the district, making efficient use of space and infrastructure.
2. For high penetration of renewable electricity, increasing the flexibility of the electricity grid is essential. Therefore, demand response management as well as integrating storage capacity at district scale are necessary solutions.
3. The districts are characterised by a variety of energy infrastructure, the majority of which was installed decades ago and has become obsolete. The resulting need for renewal of the energy infrastructure is an opportunity for transforming the district into a Near Zero Energy district. The aim is to use renewable power for heating and cooking rather than natural gas, and to create an all-renewable electric district.
4. Kanaleneiland Zuid and Overvecht are low-income districts, asking for low and stable energy and mobility bills. Mobility bills can be reduced by means of a cost-effective car sharing system. A district-wide car sharing system deploying solar powered V2G e-cars is seen as a major chance, providing cost effective mobility, offering grid flexibility thanks to the storage capacity of the V2Gbatteries, as well as resulting in low emission and noise levels.
5. The diversity in stakeholders and the crucial role of citizens as enablers of the energy transition, especially in the low income and multicultural districts Kanaleneiland Zuid and Overvecht, require co-creation and attractive and inclusive services that support citizens in their own objectives to engage, express ownership, and change behaviour.
6. In order to integrate energy efficiency solutions and renewables with storage for grid flexibility and sustainable mobility, integrated urban planning methods and data sharing tools are essential. Data based services for integrated urban district planning, as well as an urban ICT platform based on open specifications can be major enablers to manage the successful transformation towards intelligent, user-driven and demand-oriented infrastructures and information services, at household, district and city level.

1.3 Structure of the deliverable

The final results of activities in the five Transition Tracks of the Utrecht demonstration are described in chapters 2 to 6. Chapter 7 describes the impact of the Utrecht demonstration at city level.

2. Results of Transition Track 1 - Smart renewables and closed-loop energy positive districts

The ambitions of Transition Track #1 'Smart renewables and closed-loop energy positive districts' consist 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.

KEY MESSAGE
After the first three difficult years, when several activities faced delays, we managed to reverse the negative flow and were able to start with the NZEB refurbishment in the district Kanaleneiland-Zuid in 2020, along with implementing PV-panels and smart hybrid heat pumps. In this district, four apartment buildings have been refurbished, counting almost 200 dwellings. We have also installed over 300 HEMS Eneco TOON in dwellings and successfully launched the DC-pilot by installing DC-equipment in a pilot dwelling. Furthermore, the PEB refurbishment in the district Overvecht has been successfully finished, and the monitoring of the energy performance confirms that the building is actually a PEB. In the district Lombok, the NZEB refurbishment has been completed, 354 dwellings have been refurbished over the last three years despite the corona pandemic.
Finally, smart street lighting with 50 lampposts and a smart pedestrian crossing, creating a safer traffic situation, have been implemented. The results are taken into account for the city-wide street lighting program of 60,000 lamp posts.

2.1 Overview

In this paragraph the designed Measures and activities are explained including the timeline over the past five and a half years (October 2017 till March 2023).

Measures:

This Transition Track consists of 8 Measures (initially 7 measures, due to an approved amendment changed to 8 measures):

- Measure 1 District wide PV
- Measure 2 LT district heating
- Measure 3 HEMS Eneco Toon (Home Energy Management System device from Eneco: 'Toon')
- Measure 4 NZEB refurbishment (in the districts of Kanaleneiland-Zuid and Lombok)
- Measure 5 Smart (hybrid) e-heating systems
- Measure 6 AC/DC home switchboxes
- Measure 7 Smart DC Street Lighting
- Measure 8: PEB refurbishment (project Henriëttedreef, in the district of Overvecht)

These 8 Measures are executed in three districts in the city of Utrecht, as indicated in Figure 1

- District of Kanaleneiland-Zuid (apartment buildings of the Intervam building typology)
  - Measure 1 District wide PV
  - Measure 2 LT district heating
  - Measure 3 HEMS Eneco Toon
  - Measure 4 NZEB refurbishment
  - Measure 5 Smart (hybrid) e-heating systems
  - Measure 6 AC/DC home switchboxes
  - Measure 7 Smart Street Lighting
- District of Lombok
  - Measure 4 NZEB refurbishment (Complex 507)
- District of Overvecht
  - Measure 8: PEB refurbishment (Henriëttedreef)

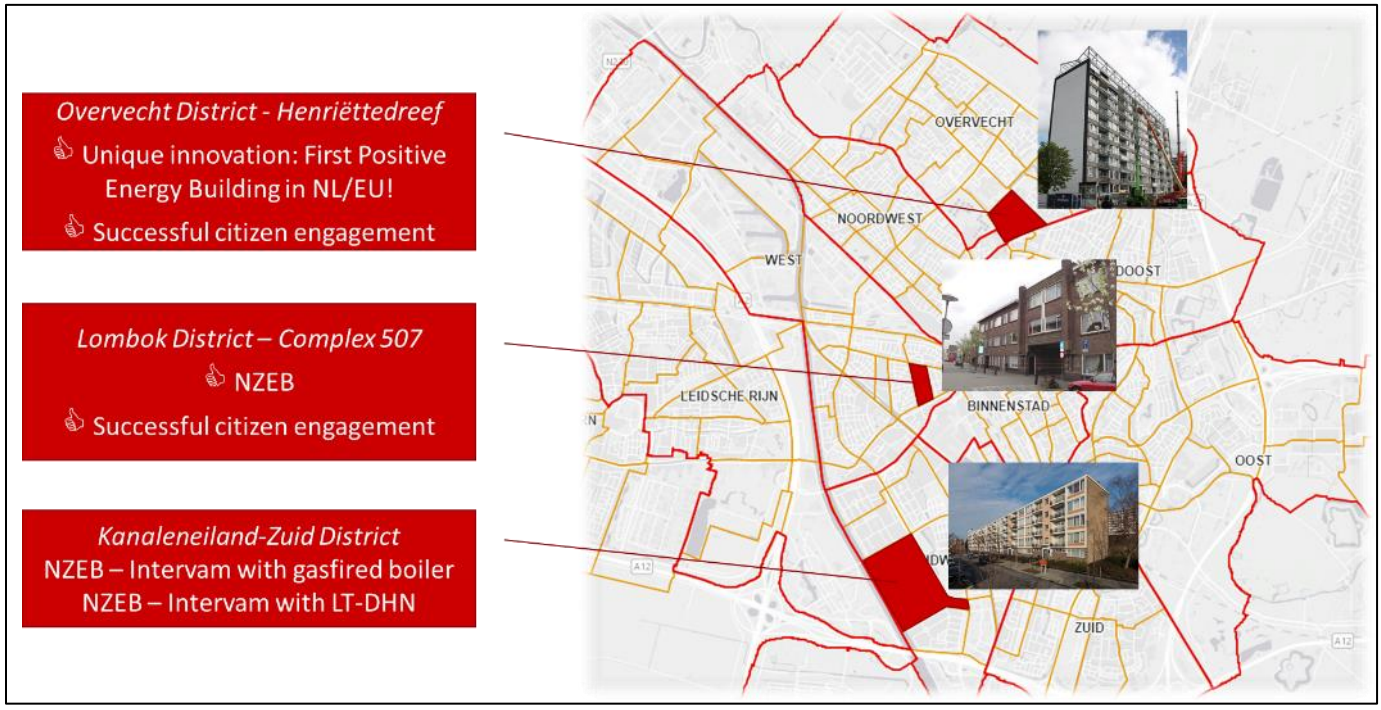


Figure 1. Overview of the demonstration areas in the city of Utrecht

Main activities and timeline:

In the original schedule (DoA) most of the measures were linked directly to the schedule of the refurbishment works of the apartment buildings in the district of Kanaleneiland-Zuid. Measures 1 till 6 were dependent on the schedule of the refurbishment works. After two years it became clear that a substantial delay of the refurbishment works had occurred due to two main reasons:

- The process of tenant engagement for creating a refurbishment plan, which has been subject to the support measurement amongst tenants, took far more time than originally planned.
- For the first IRIS apartment building, named Columbuslaan III, Bo-Ex initially did not obtain enough consent rate (support) amongst the tenants for the refurbishment plan. 67% of the

tenants voted in favor of the plan, while the Dutch constitution law prescribes a minimum of 70% consent rate.

It was not possible to solve this delay within the runtime of the IRIS project. Therefore, we proposed to change the scope of works by introducing the projects in the district of Lombok and Overvecht in the city of Utrecht. Both these projects have a unique character and valuable outcomes. This change of scope has been approved by the EC.

2.2 Implementations

In this paragraph the implementation results of each Measure are described:

Measure 1 District wide PV

- What has been implemented?: As part of the total refurbishment works 192 dwellings of the four apartment buildings named Alexander de Grotelaan II and III and Columbuslaan II and III, have been equipped with PV-panels on the roof (4 panels per household + 22 panels for central facilities). The regulation in The Netherlands states that every household may only have an independent connection to PV, a centralized PV system (which divides generated energy to households) is not allowed at this moment. Another 30 PV-panels have been realized on the roof of apartment building named Columbuslaan I, which are connected to the district battery (see Chapter 3 on TT#2 for more information). This results in 798 PV-panels of each 350Wp, total 279.3 kWp.
- How has it been implemented?: The PV-panels for the tenants of Bo-Ex are part of the 'package deal' for the refurbishment of the apartment buildings. This package deal consists of a set of maintenance and improvement works and are gathered into a brochure. This brochure is sent to every tenant together with a vote form. When enough tenants vote 'for' the plan, the plan is by law considered to be acceptable and brings Bo-Ex to the decision to execute works. For the four apartment buildings (Alexander de Grotelaan II and III and Columbuslaan II and III (in the second round after 2 years and retrofitting the other three buildings first) there was enough support amongst tenants for the plan: respectively 74%, 73% and 75% of the tenants voted in favour of the refurbishment plans, where 70% is needed. Still, the tenants have the freedom to not use the PV panels. This means that they do not receive solar energy production but also do not pay Bo-Ex a monthly fee. This happens frequently strangely enough (approx. 40%), mainly due to distrust.

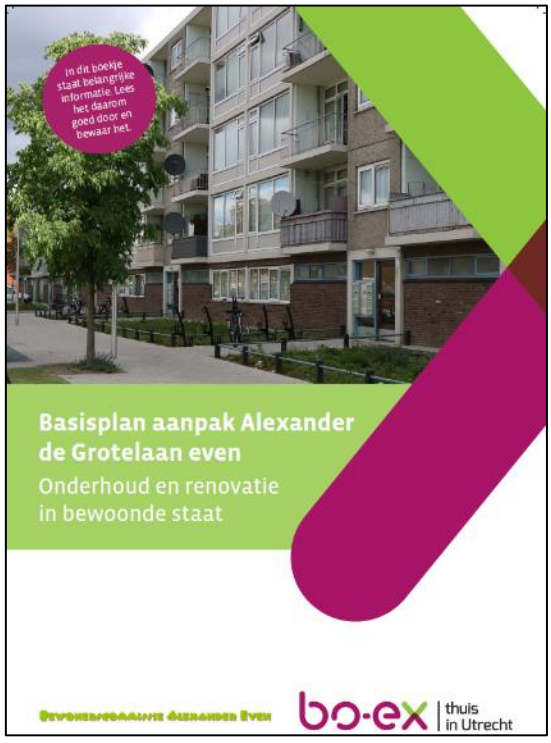


Figure 2 Brochure refurbishment plan A de Grotelaan II and III (Bo-Ex)

- What activities/implementations are still in planning?: Together with energy coaches (see Chapter 6), Bo-Ex will try to get into contact with tenants that have switched off the PV-panels and try to find out why the tenants do not want to participate in order to motivate them to connect their installation. The tenants can profit from the PV-panels and the electrical installation is completed, making it possible to generate more sustainable energy. .

Measure 2 LT district heating

- What has been implemented?: Initially, as part of the IRIS proposal, four of the twelve apartment buildings with district heating, within the district of Kanaleneiland-Zuid, were planned to be refurbished within the runtime of IRIS. These four apartment buildings are located at the left side of the district map (Figure 3).

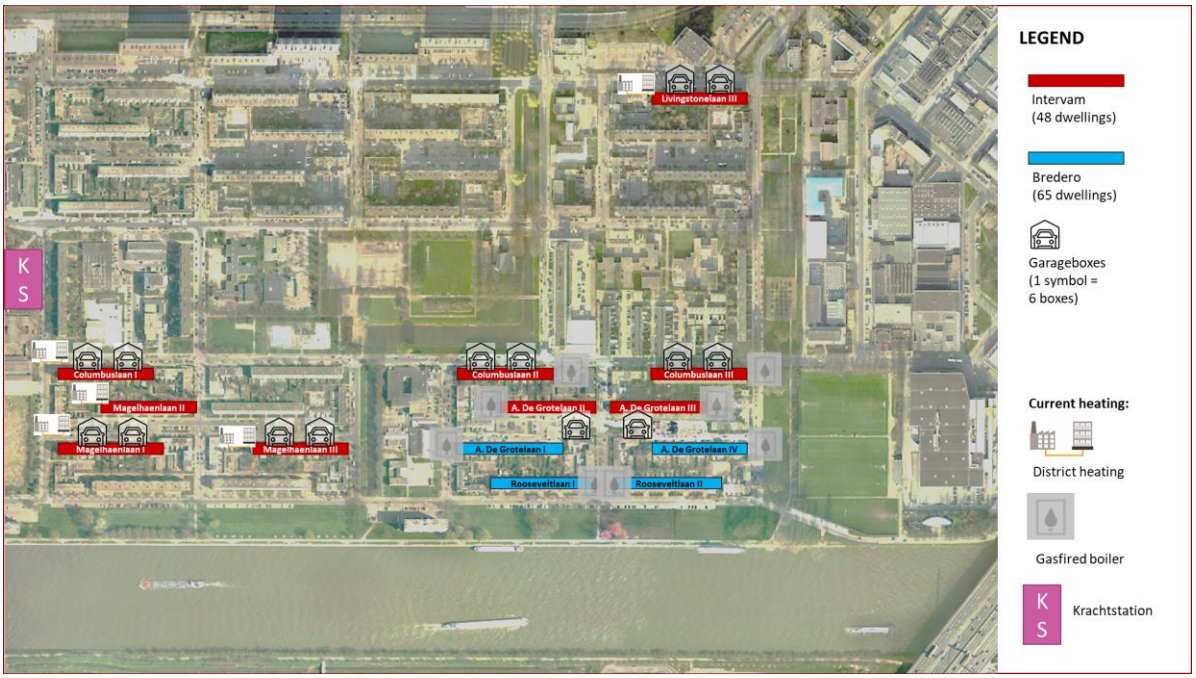


Figure 3 District map of Kanaleneiland-Zuid

Due to the delayed schedule of this programme (see 'Main activities and timeline'), Bo-Ex refurbished as much apartment buildings within the lead time of IRIS, beginning with the four apartment buildings which are not connected to the district heating. Bo-Ex followed this path because the renovation concept of the apartment buildings which are not connected to district heating, was elaborated fully with all the partners. For the four apartment buildings which are connected to the district heating, the concept was unclear at that moment and needed financial and technical engineering by both Bo-Ex and district heating owner Eneco. Bo-Ex together with the district heating owner Eneco have elaborated three feasible but different scenarios for the district heating:

- Baseline scenario: in this scenario, which was realized in the pre-pilot building Livingstonelaan III, the incoming (90°C) and outgoing (70°C) temperatures are similar to the existing situation. The only change is the inner infrastructure: every dwelling will get an individual usage meter and main connection which feeds the heating network inside an apartment, instead of a collective system as it is now (central block heating). If the

occasion arises not only the heating is provided by the district heating but also the hot tap water.
In this scenario the calculated average energy usage per household per year is 17 GJ for comfort heating and 5 GJ for hot tap water (without the technical measurements, before the refurbishment works (e.g. the insulation of the shell of the building), the average energy usage per household per year is 21 GJ for comfort heating).

- Mid-temperate scenario: in this scenario the incoming (70°C) and outgoing (40°C) temperatures are decreased in comparison with the existing situation. Likewise, to the baseline scenario the district heating can also provide hot tap water. The consequences for the technical requirements are manageable: this temperature does not require any additional techniques/installations in comparison with the baseline scenario.
  In this scenario the calculated average energy usage per household per year is 14 GJ for comfort heating and 5 GJ for hot tap water.
- Low-temperature scenario: in this scenario the incoming (50°C) and outgoing (40°C) temperatures are decreased substantially in comparison with the existing situation. The consequences for this scenario though are substantial: an additional (heat pump) booster for hot tap water is required, other types of radiators are needed due to a lower heat dissipation per m2, and an alternative ventilation circuit is necessary (mechanical feed and mechanical exhaust with heat recovery).
  In this scenario the calculated average energy usage per household per year is 12 GJ for comfort heating and 5 GJ for hot tap water.

All these three scenarios bring different investment costs for Bo-Ex and different revenues for the tenants. Besides, Bo-Ex can choose to outsource the realization of the inner infrastructure and administration to Eneco or realize the infrastructure themself for all three scenarios. In case of high investments by Bo-Ex and high revenues for the tenants, it is a fair deal to ask the tenants an increase of their rent.

Bo-Ex started to discuss the different scenarios with the tenants in the tenant engagement process since Spring 2022 which resulted in an elaborated plan of refurbishment. In February 2023 enough support from the tenants (79% has been obtained by Bo-Ex for the first of the four apartment buildings called Magelhaenlaan III. In April 2023 the refurbishment works will take place.

Measure 3 HEMS Eneco Toon

- What has been implemented?: over the past five years, in the following apartment buildings more than 300 HEMS Eneco Toon devices have been installed:
  - Apartment buildings prior to the refurbishment:
    - Columbuslaan II: 22 of 48 households (46%)
    - A de Grotelaan I/IV: 55 of 130 households (42%)
    - Rooseveltlaan I/II: 42 of 130 households (32%)
  - Apartment buildings which have been refurbished:
    - A de Grotelaan II 48 of 48 households
    - A de Grotelaan III 48 of 48 households
    - Columbuslaan II 26 of 48 households (remaining dwellings)

- Columbuslaan III 48 of 48 households

- How has it been implemented?: due to the delay of refurbishment works in the district of Kanaleneiland-Zuid, already in month 20 of the IRIS project another strategy for the implementation of the HEMS Eneco Toon was implemented. This strategy consists of installing the Eneco Toon in dwellings prior to the refurbishment works at tenants on a voluntary basis. So Bo-Ex together with Eneco ask the tenants of an apartment building to sign-up for the installation of the Eneco Toon. Tenants receive an individual letter and posters are put up in every staircase to inform the tenants and ask them to sign-up. A couple of weeks after this moment, energy consultants call the tenants which have not signed-up already for this action and inform them about this action.
  With this strategy not only the tenants are introduced with the Eneco Toon on a special way, the tenants become also aware of their energy usage before the refurbishment and, last but not least, the tenants are activated in the coming engagement process linked to the refurbishment plan.
  After the implementation of the Eneco Toon prior to the refurbishment works, the Eneco Toon has also been installed in the apartment buildings which have been refurbished. So, the tenants who did not choose an Eneco Toon beforehand, eventually received an Eneco Toon during the refurbishment of their dwelling.

Figure 4 Posters for tenants for the Eneco Toon call (Bo-Ex)

Measure 4 NZEB refurbishment (Kanaleneiland-Zuid and Complex 507)

For this measure the refurbishment projects in Kanaleneiland-Zuid and Complex 507 are described separately.

Kanaleneiland-Zuid Intervam apartment buildings:

- What has been implemented?:
  - The support measurement of the apartment buildings A de Grotelaan II and III ended up in enough support in 2020: 74% of all the tenants voted For. In 2021, the support measurement of the apartment building Columbuslaan II succeeded with 73% of the tenants who voted Yes. And in 2022, 75% of the tenants of the apartment building Columbuslaan III voted Yes. With these outcomes, Bo-Ex decided to execute the refurbishment works for these four buildings.

- The refurbishment works of all four apartment buildings (4x48 dwellings) have been completed for most of the dwellings.
  In 2021 the two apartment buildings Alexander de Grotelaan II and III were refurbished, in June 2022 the last dwelling of the apartment building Columbuslaan II was completed and the last dwelling of the apartment building Columbuslaan III will be completed in January 2023.
  To obtain a NZEB apartment building, the following measurements have been realized:
  - insulation of the shell of the building, including better insulated window frames and glazing (High Performance ++ - glazing)
  - Installation of a ventilation heat pump (Eneco Warmtewinner) in every dwelling (which results in a hybrid heat supply solution together with the existing gas heating device)
  - Installation of PV-panels on top of the roof, consisting of 4 panels per dwelling.

Figure 5 Construction works of refurbishment A de Grotelaan II and III (Bo-Ex)

- <u>How has it been implemented?:</u>
  - After the failed support measurement amongst tenants of apartment building Columbuslaan III, a new tenants engagement process was started with the tenants and tenants committee of both the apartment buildings A de Grotelaan II and III. Bo-Ex combined these two buildings because they are similar in a technical way and are located near to each other. Besides, it also saves time because Bo-Ex has to go through only one engagement process instead of two. Due to the success of this refurbishment and the rising energy prices, the tenants of the next apartment building (Columbuslaan II) were interested and motivated to support the refurbishment plan of their building. And finally also the tenants of the apartment building Columbuslaan III, where Bo-Ex did not manage to obtain enough support in an earlier stage, supported the refurbishment plan of their apartment building.
  - The preparation works mainly consists of (an intensive) tenants engagement process to set up a refurbishment plan for all the tenants and engineering process together with the contractor and consultants. The tenant engagement process consists of:
    - several meetings between Bo-Ex and the tenants committee about the scope of works, the offered options (free and paid options) to the tenants, the tenant's survey, possible rent increases and the brochure which is subject to the support measurement amongst all the tenants. These meetings have been chaired by an independent chairman, to prevent conflict of interests. The tenants committee

has a right to give an advice at the end of the participation process. With this advice, Bo-Ex finalises the brochure for the tenants for the support measurement;

- an individual survey amongst tenants, held by an independent consultancy firm. The outcomes of the survey – Bo-Ex tried to reach a high response to obtain a good overview – consists of what tenants like, what tenants don't like, what wishes the tenants have with the refurbishment and some specific questions about proposed activities;
- the support measurement amongst the tenants, also held by an (other) independent consultancy firm to avoid a conflict of interest. In this measurements, all the tenants are requested to fill in a voting form: say Yes or No against the refurbishment plan as described in the brochure. At least 70% of all the tenants shall vote Yes, to consider a refurbishment plan as acceptable. A missing vote means a No, so it's necessary to obtain as many as possible filled voting forms.

Complex 507 apartment blocks:

- What has been implemented?: fortunately the contractors have been able to realize the works continuously since the start of the Covid-19 disease (despite some infections amongst construction workers) and also almost all the tenants wanted to refurbish their dwelling immediately and did not request a postponement. Since April 2020, Bo-Ex together with their project partners have refurbished all 354 dwellings successfully.

Another aspect which was implemented is to improve the communication and involvement process towards the tenants continuously: Bo-Ex started with the inquiries amongst tenants in June 2020. Every tenant where the refurbishment works has taken place, is asked to fill in two forms with questions about the product (refurbished dwelling) and process (involvement and communication). The outcomes of these inquiries are discussed with the tenants / tenants committee and the contractors and other involved parties to optimize the process. One of the main changes due to the received forms which was incorporated, is the introduction of a so called 'sociale opname' (social intake). In this intake, held by tenant consultants, every household is implicated in the impact of the works for their situation. The consultants assist the tenants to prepare for the refurbishment works and explain where they can find information or who they can contact in case of problems/questions.

Figure 6 Refurbished apartment block in Complex 507 (Bo-Ex)

- How has it been implemented?: the refurbishment works of this project started in April 2020. In March 2021 the project was supposed to start, but at that moment the Covid-19 disease appeared. Together with all involved parties including the tenants committee a dedicated project protocol for the Covid-19 disease was set up. In this protocol the impact and procedures for the project organization and tenants are mentioned. This also affected the runtime of the refurbishment. Instead of starting every week 5 new dwellings and realize the works of a house block within 4 work weeks, Bo-Ex together with their project partners had to change the schedule substantially: every 1,5 week a start of 5 new dwellings and a runtime for every house block of 7 work weeks. Furthermore, the tenants had the opportunity to postpone the moment of refurbishment. Therefore, the Covid-19 disease made it more complex to realize the works within the project framework. Since May 2022 the limitations due to the Covid-19 disease have expired. Nevertheless, the consequences of the lockdown were noticeable: the capacity of the supplying industry was still limited, so the runtime of the refurbishment remained till the end of the project 7 work weeks. In October 2022 the last apartments have been completed and the project has ended.

Measure 5 Smart (hybrid) e-heating systems

Figure 7 Eneco Warmtewinner heat pump icw gas heated boiler (Bo-Ex)

- What has been implemented?: in the first four apartment buildings which have been refurbished (A de Grotelaan II and III and Columbuslaan II and III), the heat pump device Eneco Warmtewinner® was implemented. This device, as shown in the picture, will use the warmed ventilation air to heat up water for heating and tap water. For peak demand, the existing gas heated device will supply additional heat.
- How has it been implemented?: the hybrid e-heating system is an installation consisting of a heat pump connected to the (existing) gas heated boiler. In the apartment buildings of Bo-Ex in the district of Kanaleneiland-Zuid, 50% of the Intervam building typology is equipped with a gas heated device. This device produces hot water for heating and hot tap water. By combining this device with an electrical heat pump, gas usage will decrease substantially. Most of the heat is supplied by the heat pump and only in cold conditions or a peak demand, the gas heated boiler is used. The exact amount of decreased gas and increased electricity usage differs per type of heat pump and per household. Preliminary calculations show that combining the gas heated boiler with the Eneco Warmtewinner®, will decrease the gas usage by 300m^3 per year and increases the electricity usage of 700kWh per year. From a cost perspective, this is interesting for tenants since the price per m^3 gas in The Netherlands is almost four times higher than the price per kWh in the last years.
  Note: since 2021 the electricity and gas prices have risen enormously in comparison with the prices of 2020. Besides, it is expected that the gas prices will increase substantially in the coming years, while the prices of electricity will increase slowly.
  This calculation also convinced the tenants of the two mentioned apartment buildings to vote for this option and make it part of the refurbishment plan.

Measure 6 AC/DC home switchboxes

- What has been implemented?: for the pilot with Direct Current, in 2021 a pilot was realized in one apartment. To create this pilot, two tenants have been contacted by Bo-Ex to participate in this pilot on a voluntary basis. Both tenants responded positive, but one has moved to another house in the meantime. For the other tenant, the pilot was executed.
- How has it been implemented?: the implementation of Direct Current was part of research. Based on research held by students from University of Utrecht and further investigations by installation contractor BOS Installatiewerken, Bo-Ex has chosen for a partly direct current network solution.

This means that a part of the apartment is equipped with a direct current network to supply in energy for dedicated devices such as mobile phones. In the first pilot, the apartment will get a DC-network which supplies five LED lamp bulbs, two USB sockets and outlets for Power Over Ethernet (POE++ protocol). The principle of this Direct Current pilot is to prevent energy waste from converting energy. That is why in the pilot energy from the PV-panels is distributed directly to these outlets or, if no energy is requested, saved in a small battery pack to provide at a later moment in time.
Unfortunately, the pilot did not bring the advantages for the end user as hoped. Due to the chosen configuration, the battery pack is filled with energy from the PV-panels. But when the battery is full, the energy from the PV-panels is not used and can not deliver energy back to the grid. This causes a lot of unused solar energy (just a little amount of the total energy usage is used by the Direct Current devices), and a lack in revenues for the end user. Given this feedback, Bo-Ex and their partners searched for another configuration where these disadvantages were not in place. In the renewed configuration, solar energy first fills the battery pack. When the battery pack is full, the remaining energy is given back to the grid (via the fuse box). This concept is based on the application of a specific product of manufacturer Solar Edge (SolarEdge 3-phase StorEdge Home Hub 5kW), a specific product which fits for this objective. But unfortunately and despite other messages form supplier SolarEdge, the production and delivery of this product has been delayed more than once. Eventually, begin 2023 Bo-Ex decided to cancel the other seven pilots because it was not possible anymore to realize the pilots within the IRIS lead time (nor gain valuable information of this concept from the tenants and system to evaluate).

Measure 7 Smart Street Lighting

In chapter 5.3 the demonstration of smart street lighting and a co-created smart pedestrian crossing is reported.

Measure 8: PEB refurbishment (Henriëttedreef)

- What has been implemented?: With a prefabricated renovation concept a ten storey high rise apartment building was retrofitted to a Positive Energy Building. It is the first high rise apartment building in the EU that has been retrofitted in this way. Figure 8 provides an overview of the aspects of the renovation concept.

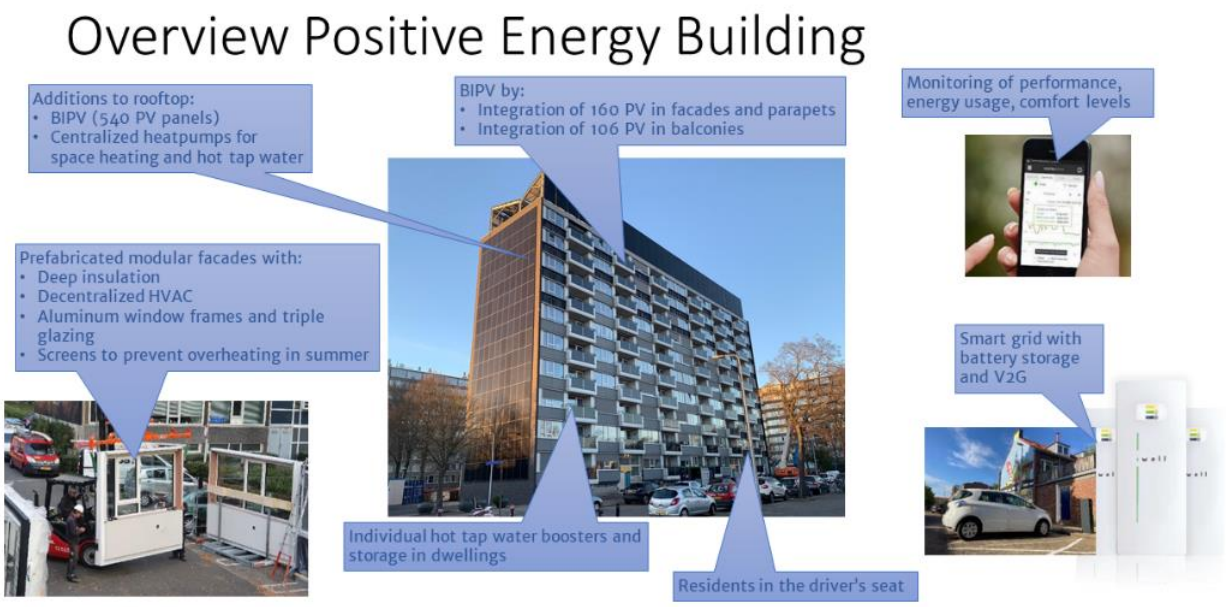


Figure 8. Overview of measures for Positive Energy Building in Overvecht

In Spring 2021 the last of the 58 apartments have been completed by Bo-Ex. From that moment on, all the tenants live in their refurbished houses and pay a fixed fee for energy per month (a so-called energy service fee).

- How has it been implemented?: In 2017, a triple-helix consortium took up the challenge of demonstrating that it is possible to renovate a high-rise apartment block into a positive energy building. The consortium developed prefabricated façade elements with HVAC installations. The aim was to investigate the energy performance of these façade elements on a laboratory scale and to come up with a design to renovate one pilot house. As the results were promising, a pilot house was renovated into a positive energy dwelling in 2018. The results of the pilot house were then translated into a renovation concept for the entire apartment building. What is unique about this renovation concept is that the facades of the houses are demolished in one day, after which the prefabricated facades are assembled. This has made it possible to carry out the renovation in semi-inhabited state.

  After obtaining enough support from the tenants, Bo-Ex has started the refurbishment works in March 2020. Just like the refurbishment project Complex 507, also this project was suddenly confronted with the Covid-19 disease. With adjustments of the planning, facilities for the tenants (living rooms for tenants to spend time during the works in the daytime) and cooperation of the tenants, Bo-Ex was able to start and finish the project on time (finished in October 2020). Bo-Ex has concluded a performance contract with an installation company (Bos Group). Bos Group was the main contractor for the renovation and is also responsible for delivering the energy performance, a positive energy building, for a period of 20 years.

  Two years after the completion, Bo-Ex and their partners can look back on a successful project. The promises made to tenants have come true, and the monitoring results show that the apartment building truly delivers energy (5-15% extra compared to energy usage)!

2.3 Results

With the executed activities of the described measures, results have been gathered for all measures except for Measure 2, where only engineering and preparation works have been done due to the circumstances. Results in terms of feedback from the (end) users have been and are collected in the coming (last) period of the IRIS project as well as the monitoring data coming from several meters.

Experiences and feedback

The following table contains a summary of the experiences, feedback per Measure:

Table 1. Summary of experiences and feedback per measure in TT#1

Measure	Experiences and feedback
Measure 1 District wide PV	768 PV panels (total 279,3 kWp) have been installed on the roofs of the four apartment buildings which have been refurbished. Each household owns 4 PV-panels which provide in almost all their used electricity. Despite the attractive terms of conditions for the tenants of Bo-Ex and the increased electricity prices in the past year, there still are people who do not like the PV-panels. Before the end of the IRIS project Bo-Ex tries to motivate those people to connect the PV-panels to their switch box.
Measure 2 LT district heating	*t.b.d. (no data is already available) The first showcase is planned for Spring 2023 (refurbishment of one apartment building with district heating).*
Measure 3 HEMS Eneco Toon	Almost 300 HEMS Eneco Toon devices have been installed. From the approximately 300 end-users where a HEMS Eneco Toon was installed, no complaints have been received so far. In the winter 2022-2023, a big survey will be held amongst the tenants of the four apartment buildings. In this survey, not only the tenants are requested to give answers on questions, Bo-Ex also provides energy coaching to help the tenants understand how they can use their home on an efficient but also comfortable way.
Measure 4 NZEB refurbishment (Kanaleneiland-Zuid and Complex 507)	In January 2023 all the 192 dwellings in the district of Kanaleneiland-Zuid have been refurbished. The energy performance of these refurbished dwellings was increased from energy label D/C towards energy label A/A+. Inquiries amongst tenants from all these four apartment buildings have been held in winter 2022-2023, also related to energy coaching and the objectives of TT#5. The results of these inquiries are described in chapter 6 of this document. In November 2022 all the 354 dwellings of Complex 507 in the district of Lombok have been refurbished. Inquiries amongst tenants from the Complex 507 tells us that: - 10% of the tenants responded to the inquiry and responded are happy with the process and product. The

Measure	Experiences and feedback
	average score the tenants give to the refurbishment is 3,5 on a scale from 1-5. Almost every tenant is happy with the realized measures to increase energy performance!
Measure 5 Smart (hybrid) e-heating systems	In January 2023, 192 dwellings in the district of Kanaleneiland-Zuid have been equipped with a hybrid solution, which might cause a decrease of the gas consumption of the tenants. But the insulation of the apartment building also leads to a decrease of gas consumption. Since these measurements have not been realized separately, the specific impact on gas consumption by the hybrid solution is hard to distinguish. Inquiries amongst tenants from all these four apartment buildings have been held in Winter 2022-2023, also related to energy coaching and the objectives of TT#5. The results of these inquiries are described in chapter 6 of this document.
Measure 6 AC/DC home switchboxes	End of 2022 still only one dwelling has been equipped with a partly DC network. Due to delivery problems of equipment and the limited time remaining in IRIS, it is decided in consultation with IRIS Project Coordinator to not further implement the DC-pilot. An inquiry with the tenant of the first pilot was held in Autumn 2021.
Measure 7 Smart DC Street Lighting	See chapter 5.3 of this document for the results and evaluation.
Measure 8: PEB refurbishment (Henriëttedreef)	All 58 dwellings have been refurbished and the apartment building generates electricity from PV and provides in heat and domestic hot water from the centralized heat pumps. Monitoring hardware in every dwelling measures the actual usages. The tenants pay a monthly fee, for this fee Bo-Ex supplies a certain amount of electricity, heat and domestic hot water. Based on the monitoring analysis, we can conclude that over the first full year after the refurbishment works, the apartment building Henriettedreef indeed delivered more energy than it uses on a yearly basis: 163 MWh was generated and 147 MWh was used. In 2022 the generated energy was higher than the demand, with 255.4 MWh generated and 180.9 MWh energy used.

Progress of the KPI's:

Table 2 contains an overview of each KPI within TT#1:

Table 2. KPI results in TT#1

KPI	Current state
General KPI's: 1. Energy savings for the tenants 2. CO_2 emission reduction 3. Reduced energy costs for tenants 4. CO_2 reduction cost efficiency	The data for these KPI's is collected from several sources. The energy usages have been collected and are compared with a reference period: - Intervam apartment buildings Kanaleneiland-Zuid: information from the grid operator Stedin (the balance of the average energy/gas usage and electricity generation per year) per apartment building and information from the HEMS Eneco Toon on an aggregated level for used and generated energy. - Complex 507 Lombok: information from the grid operator Stedin (average energy/gas usage and generation per year) per street. - Henriëttedreef: information from the supplier of monitoring hardware BeNext (average energy/heat usage and electricity generation per year) Based on these information (including the construction cost related to a better energy performance), the reduced energy costs and CO_2-reduction cost efficiency is calculated. Intervam apartment buildings Kanaleneiland-Zuid Based on the data of gas usage of 2021-2022, coming from the HEMS Eneco Toon, we can conclude that the gas usage from the refurbished apartment building Alexander de Grotelaan III is 60-70% less than the comparable apartment buildings Columbuslaan II and III. The effect of less gas consumption is primarily noticeable during the winter months (September till March), during the summer months the gas usage is just a little bit lower than Columbuslaan II and III. In total, the gas consumption is reduced with 400-500m^3 gas which means approximately 30% reduction on a yearly basis. The main cause for this decrease is the improved insulation in combination with the installation of the smart hybrid heat pump in each dwelling. On the other hand, the electricity usage increases due to the heat pump and ventilation devices which have been installed. The increased electricity usage, based on preliminary data output, is now estimated at 300-400kWh more than which means approximately 20-25% increasement on a yearly basis. Summarized, we estimate that:

	- the electricity usage will increase with 20% on a yearly basis (not considered the energy delivered by the PV-panels) - the gas usage will decrease with 30% on a yearly basis With the installed PV-panels, the increased usage of electricity is covered as well as a substantial part of the normal usage of electricity. Monitoring during a longer period can refine this conclusion. <u>Complex 507</u> The first apartment blocks have been refurbished in 2020. To measure the gas and electricity savings caused by the refurbishment, the usages of 2019 (baseline) have been compared with the usages of 2020 and 2021. Based on this comparison, we estimate that: - the electricity usage will decrease with 10-20% on a yearly basis - the gas usage will decrease with 20-30% on a yearly basis <u>Henriettedreef</u> The refurbishment works of this apartment building was completed in 2020. To measure the gas and electricity savings caused by the refurbishment, the usages of 2019 (baseline) have been compared with the usages of 2020 and 2021. Based on this comparison, we evaluate that: - the electricity usage will increase with 125% on a yearly basis (not considered the energy delivered by the PV-panels) - the district heating will decrease with 100% on a yearly basis - the gas usage will decrease with 100% on a yearly basis - the total energy demand decreases due to optimization of installations and energy coaching of tenants
<u>KPI's related to Measure 1 District scale PV:</u> 1. Degree of local renewable energy production 2. Degree of energetic self-supply by RES 3. CO_2 emission reduction 4. Amount of renewable energy	The generated energy from the PV-panels is measured by the HEMS Eneco Toon which was installed in the refurbished dwellings. The amount of directly used energy from the PV-panels can't be monitored by the smart meter as well as the HEMS Eneco Toon. Based on these amounts, the four KPI's have been calculated easily. The information from the HEMS Eneco Toon is collected in the City Innovation Platform (CIP).

KPI's related to Measure 3 HEMS Eneco Toon: 1. Increased awareness of energy usage	Every tenant who had a HEMS Eneco Toon installed, is requested to fill in an inquiry with a couple of questions. This survey has been held in Winter 2022 by energy coaches, who also provide tips and trics for tenants to use their dwelling energy efficient. The outcomes of this survey: - 25 respondents - 2.84 average score (on a likert scale 1-5)
KPI's related to Measure 6 AC/DC switchbox: 1. Increased awareness of energy usage	Every tenant who participates in the pilot for DC, is requested to fill in a questionnaire with a couple of questions about the process, the product and the profit they gain. Only one questionnaire was received due to the cancellation of the realization of the other seven pilots. The outcome of this survey is: - 1 respondent - 1 (on a likert scale 1-5)
KPI's related to Measure 7 Smart street lighting: 1. Reduction in annual final energy consumption by street lighting 2. CO_2 emission reduction	By comparing the energy usages of the old and new lamp bulbs, the reduction in energy consumption will be measured. Based on this amount, the CO_2-reduction is calculated.

2.4 Business models and exploitation

The Measures in Transition Track 1 don't contain a Bankable Business model (financial nor societal) in the way these are executed by involved parties. Though there are Measures which might be considered as a Key Exploitable or Replicable Results:

- Measure 1 District wide PV: Key Exploitable Result: in the proposition for their tenants, Bo-Ex offers every tenant the investment of PV-panels. The pay back of this investment is created by a monthly fee from the tenants, which is equal to 50% of the generated energy. After 20-25 years, the investment of Bo-Ex will be paid back.
- Measure 2 LT district heating: Key Exploitable Result: a Low Temperature infra requires an investment and technical adjustments in a dwelling and will probably decrease the energy bill of a tenant, but that depends on the business case of the energy provider and it is also not a fact that the energy bill will decrease due to fluctuating energy prizes and the rebound effect of a more comfortable house. Considering an economical lifetime of 40 years, these investments can be paid back by an increase of the monthly rent.
- Measure 3 HEMS Eneco Toon: no business model opportunities acknowledged.
- Measure 4 NZEB refurbishment (Kanaleneiland-Zuid and Complex 507): Key Exploitable Result: for the improvement works, Bo-Ex asks their tenants to pay an additional rent. With this money, the improvement works can be paid back considering an economical lifetime of 40 years.
- Measure 5 Smart (hybrid) e-heating systems: a smart hybrid e-heating system requires an investment and technical adjustments in a dwelling but will also decrease the energy bill of a

tenant. The amount of energy saved by tenants (increase of electricity and a decrease of gas usage) is not a fact at this moment. Maybe this measure could lead to a Key Exploitable Result in analogy to the LT District Heating, but this requires more data.

- Measure 6 AC/DC home switchboxes: no business model opportunities acknowledged.
- Measure 7 Smart DC Street Lighting: no business model opportunities acknowledged.
- Measure 8 PEB refurbishment (Henriëttedreef): Key Exploitable Result: for the improvement works, Bo-Ex asks their tenants to pay an additional energy service fee. With this money, the improvement works can be paid back considering an economical lifetime of 40 years. For the tenants it is beneficial that they can better predict their energy usage (through monitoring apps) and their energy bill (fixed energy service fee for a certain amount of energy), leading to a feeling of being more in control amongst tenants.

2.5 Lessons learned

During the runtime of the IRIS project and especially in the last period (from M36) of this project, after overcoming the hurdle of enough consent rate for retrofitting the first apartment building in Kanaleneiland-Zuid, a lot of activities in this Transition Track have been executed and implemented. The period starting from M36 till the end of the project (M66) was the most productive since the start of the IRIS project. The reason for this is that we managed to start with the refurbishment works of the four Intervam apartment buildings in Kanaleneiland-Zuid which include Measure 1 District wide PV, Measure 3 HEMS Eneco Toon, Measure 4 NZEB refurbishment and Measure 5 Smart (hybrid) e-heating systems. Also the amount of installations of the HEMS Eneco Toon was higher than before and the Smart street lighting was realized and commissioned. Big steps in the implementation of activities have been made, which also led to good results!

In report D5.3 the reported major lessons learned for this Transition Track were formulated. Actually, these lessons learned are still applicable and relevant:

1. It is not easy to get in 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.
   This was not new for housing corporation Bo-Ex, but the level of barriers and resistance amongst tenants was higher than expected (and this is not something which occurs only in this demonstration area).
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 to the tenants of Bo-Ex. Some tenants thought that the money from the IRIS subsidy could also be spend on items they wish, such as new elevators.
   This was also not new for housing corporation Bo-Ex, communication about the IRIS project required a sensitive approach from the beginning of the project. See also TT#5 for changes in tactics and approaches.

Besides, the following lesson has been learned:

1. The (recent) increasements of the gas and electricity prices in the Netherlands increases the awareness of energy consumption and an energy efficient house amongst tenants. Last year, Bo-Ex achieved enough support amongst tenants for the refurbishment of two apartment buildings (Columbuslaan II and III) also because of this fact. The tenants of the next apartment buildings can't wait till the refurbishment works starts at their home, according to Bo-Ex.
2. Tenants of apartment buildings that had to be renovated got enthusiastic after seeing the refurbishment of the first apartment building, which gave a positive vibe amongst these tenants. So, creating a first example is important to let people understand what the refurbishment entails.
3. The acceptance of the PV systems amongst tenants still requires attention and effort. Despite improved communication and the deployment of an independent organization which organizes the PV rollout, the number of tenants who don't want to be connected is still significant.
4. The most effective measure consists of the package deal of insulation, smart hybrid heat pump and PV-panels, which caused eventually a significant decrease of gas consumption and electricity consumption.

3. Results of Transition Tracks 2 and 3 – Charging stations, stationary battery, shared EVs, energy management system

KEY MESSAGE
The development and demonstration of the smart charging system for electric cars and the installation of a large stationary battery in the Kanaleneiland-Zuid demonstration district have enabled the rapid evolvement and growth of an energy network management system at city level with currently 650 bidirectional charging stations and thousands more to come, which has made Utrecht a world-wide pioneer in bidirectional charging. IRIS has sped up that development and the focus now is to speed up further demonstration, expansion and replication. Interest from various parties in the Netherlands and the EU is rapidly increasing.

3.1 Overview

IRIS has sped up the development and upscaling of a unique innovation in the field of smart charging: *the bidirectional ecosystem in Utrecht*. A fast-growing network of bidirectional EV-charging points offers advanced V2G smart charging using open protocols, while being fully backwards compatible to (and hardly more expensive than) regular Type 2 charging points. This has allowed for fast upscaling to 650 V2G charging posts by early 2023. Part of these V2G charging points is used in conjunction with the fast-growing E-car sharing scheme of We Drive Solar, which includes the first V2G-enabled production e-cars in the world: the new Hyundai IONIQ5. In co-operation with Hyundai[2] and Koolen Industries, the innovation consortium led by We Drive Solar has a bright outlook towards fulfilling the ambition to realize the energy- and mobility system of the future: hundreds of electric shared cars that reduce air pollution, reduce the amount of cars on the road and provide a potential buffer for large scale application of solar and wind energy in the region. In IRIS, this is combined with a large stationary battery to complement the flexibility potential of the V2G e-cars in the bidirectional ecosystem, to trade on the electricity markets and to help make the electricity grid flexible and resilient with respect to the expected high penetrations of e-cars and variable renewable energy sources.

Since the solutions relate to each other in the bidirectional ecosystem, this chapter describes the results booked per November 2022 in Transition Track #2 “Smart energy management and storage for flexibility” and #3 “Smart e-mobility” within the IRIS Utrecht demonstration project with respect to EV charging stations, the stationary battery, shared EVs and the energy management system. These demonstration activities comprise the realisation and operation of:

[2] On April 21, 2022, this cooperation was publicly announced in an event that received large worldwide press coverage : https://www.irissmartcities.eu/content/utrecht-first-bidirectional-city-world-due-collaboration-hyundai-and-we-drive-solar

- Smart solar V2G chargers in the Kanaleneiland district, Lombok and Henriettedreef, at district scale interconnected with PV-systems;
- District-wide additional stationary electricity storage, interconnected to primary V2G-storage and PV-systems by green ICT;
- A District EMS, the district ICT platform providing interconnection and monitoring at district scale;
- Deployment of V2G E-cars and e-vans.

In the next chapter, results of Transition Tracks 2 and 3 with respect to E-buses and e-bus charging stations will be discussed.

Figure 9: In September 2022, the Utrecht Bidirectional Ecosystem received the IEA International Smart Grid Action Network Award 2022. The Award was issued by Rob Jetten, Minister of Climate and Energy of The Netherlands, to the partners of the Smart Solar Charging Utrecht project[3], represented by Baerte de Brey of Stedin, at the 13th Clean Energy Ministerial in Pittsburgh, USA.

Location of the measures in the city area

The original focus of IRIS was on the district of Kanaleneiland-Zuid in the city of Utrecht. This is a residential area of 64 hectares situated in the Utrecht Centre-West area, just southwest of the historic

[3] https://smartsolarcharging.eu/en/smart-solar-charging-internationally-recognized-with-iea-isgan-award/ The results of this project which ended in 2021, provided the technical base for the activities described in this report.

city centre and the Utrecht Central Station. The district is surrounded by two large canals (hence the name Kanaleneiland which translates to 'canal island'), one of which is used intensively for freight transport (Amsterdam-Rhine Canal)

Figure 10 provides an aerial view of the district depicting the location of the first V2G-chargers, V2G-cars and the stationary battery.

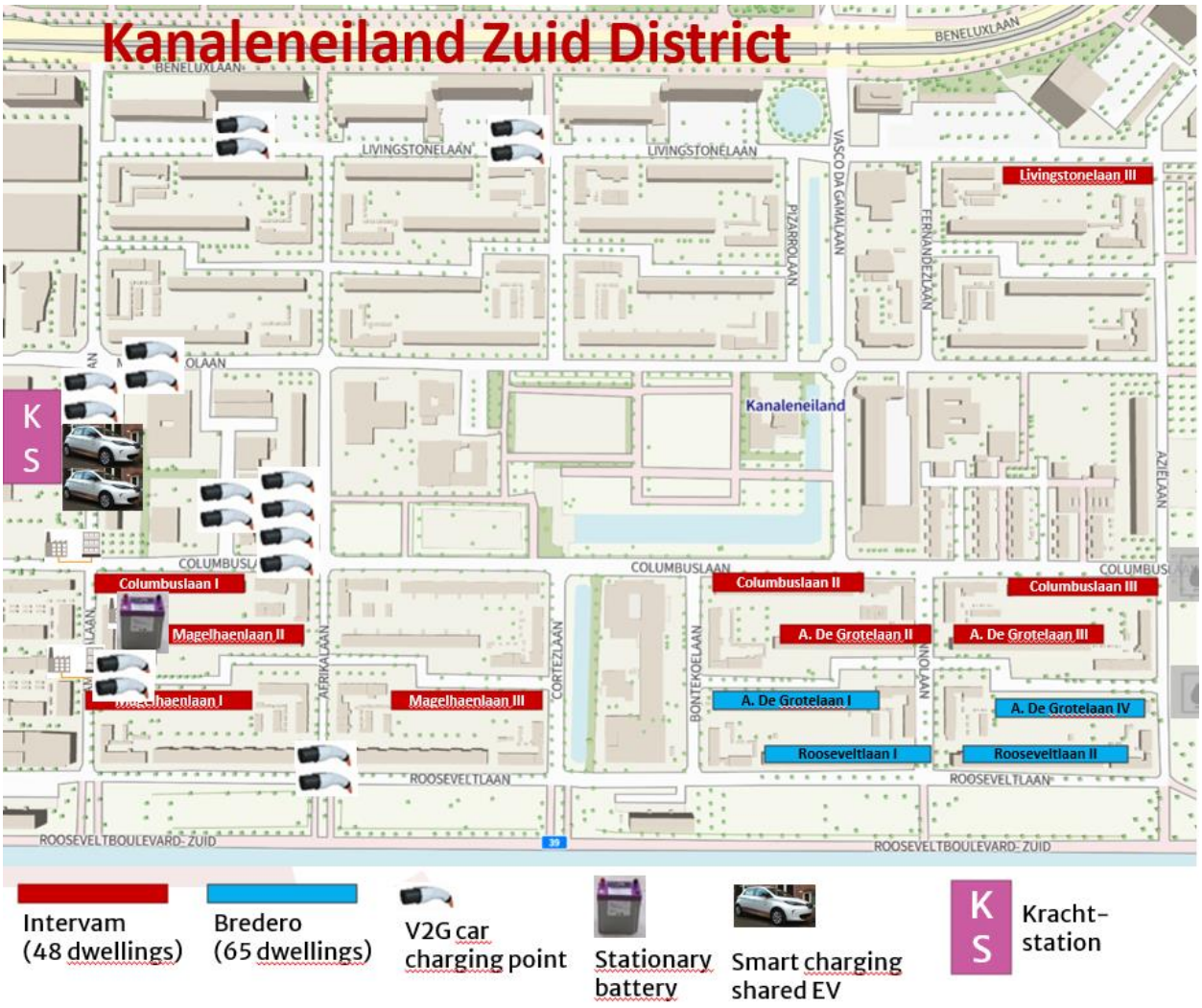


Figure 10. Map of Kanaleneiland-Zuid with IRIS demonstration measures for TT#2 and TT#3: V2G charging points, stationary battery and smart charging shared EV

During the project, the scope was widened to also include as demonstrators two other locations (in the districts of Overvecht and Lombok) as well as the city-wide Bidirectional Ecosystem. The implementation of V2G charging stations and smart charged shared EV's is depicted in Figure 11. The rapid growth of the numbers of V2G charging stations and smart charged EV's in Utrecht is illustrated in Figure 12 below.

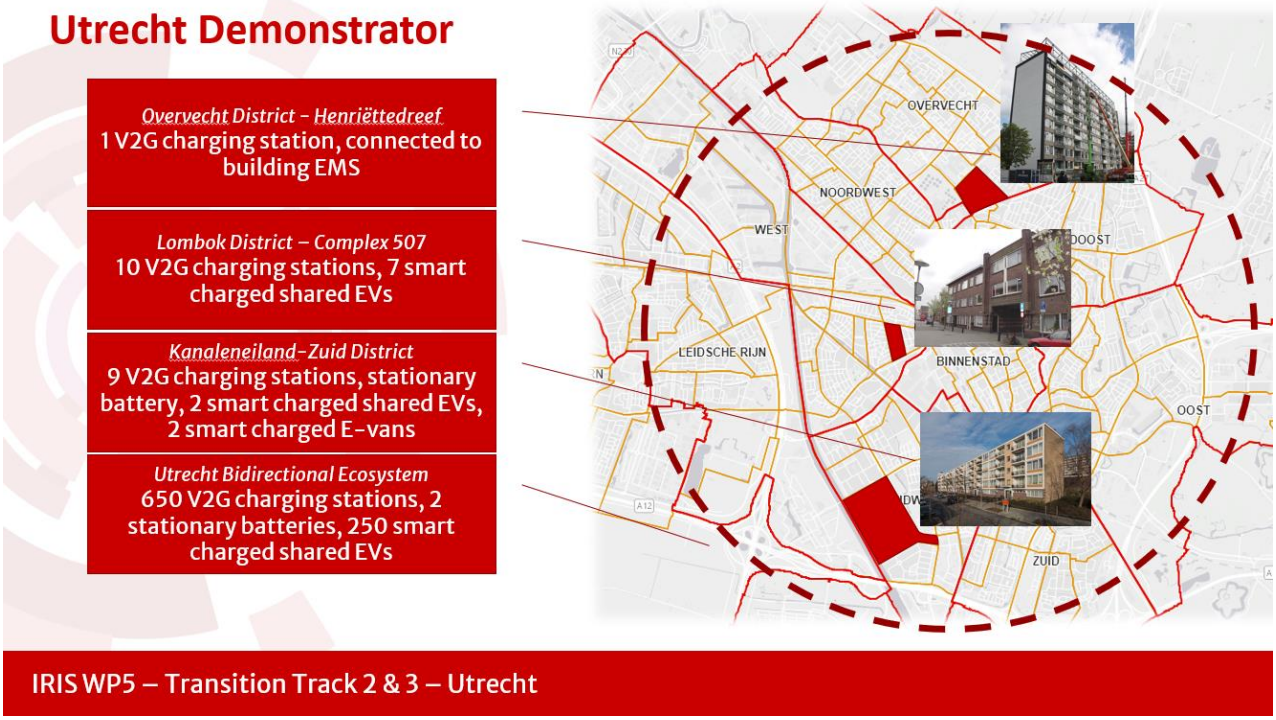


Figure 11. IRIS TT#2/3 activities in Utrecht. Indicated are the activities in the Overvecht District / Henriettedreef, the Lombok District / Compex 507, the Kanaleneiland Zuid District and the city-wide Utrecht Bidirectional Ecosystem.

An overview of main activities and timeline

The main activities have been:

Since the start of the project, nine **Solar V2G charging posts** (18 charging points) for e-cars/e-vans have been realised in the Kanaleneiland Zuid district. That number has followed the actual demand for charging services and has reached the planned amount of 18 charging points in Kanaleneiland Zuid. Also, at the location 'Complex 507' in Lombok, 10 V2G charging stations (20 charging points) were placed. At the Henriettedreef location, one V2G charging post (2 points) has been realised that is directly connected to the advanced energy management system in the energy positive building, so that it interacts with the solar power plants, heat pumps and batteries in the building. In the city-wide development of the bidirectional ecosystem, the number of V2G charging post is growing and has reached 650 by November 2022.

Two shared **e-cars** and two e-vans are in operation in Kanaleneiland Zuid. At the location 'Complex 507' in Lombok, 7 smart charged shared e-cars were placed. The demand for shared e-cars in Kanaleneiland-Zuid turns out to be lower than expected, apparently this is related to the demographics of this district.

In 2021, an 845 kWh and 590 kW / 630 kVA **Stationary storage battery** was installed in a shared area between IRIS housing blocks at the Columbuslaan and the Magelhaenlaan, see Figure 10, and is in operation.

This stationary battery, connected PV panels (in TT #1) and the V2G e-car charging posts are combined into a unique **Smart Energy Management System** that bundles the flexibility and helps with congestion management of the grid in the city. This energy management system is being scaled up to the level of the whole city, as part of the establishment of the Utrecht bidirectional ecosystem. Bundling all flexibility assets (the 650 V2G charging posts, the soon-to-be-operational V2G shared cars, the above-mentioned stationary battery and another stationary battery of comparable size already in operation in the city, and the PV systems) will result in a powerful city-wide network congestion management and flexibility system that will profit from the laws of numbers as it grows, and will have far more impact than when these assets were managed separately.

3.2 Implementations

Measure 1 of TT #2: Solar V2G charging points for e-cars/e-vans

Regarding Solar V2G charging points for e-cars/e-vans**,** 18 V2G charging points have been realised in the Kanaleneiland Zuid district:

- One charging post (2 charging points) near the Local Innovation Hub “Krachtstation” (former school building that now hosts start-ups and functions as a meeting place).
- One charging post (2 charging points) near the corner Afrikalaan – Rooseveltlaan.
- Two charging posts (4 charging points) at the parking place of the office of Bo-Ex in Kanaleneiland.
- One charging post (2 charging points) near the corner Amerikalaan – Magelhaenlaan.
- One charging post (2 charging points) on the Maylaan.
- Two charging posts (4 charging points) on the Livingstonelaan.
- One charging post (2 charging points) on the Marco Pololaan.

These charging points were installed during the project following actual demand and accompanied by active citizen engagement activities (see below). The growth of the V2G charging network is connected to the growth of the city-wide charging network as part of the Utrecht bidirectional ecosystem, with an expected total number of 800 V2G charging posts in Utrecht (1600 charging points) by end of 2023 and foreseen rapid further growth in the next years (see Figure 12).

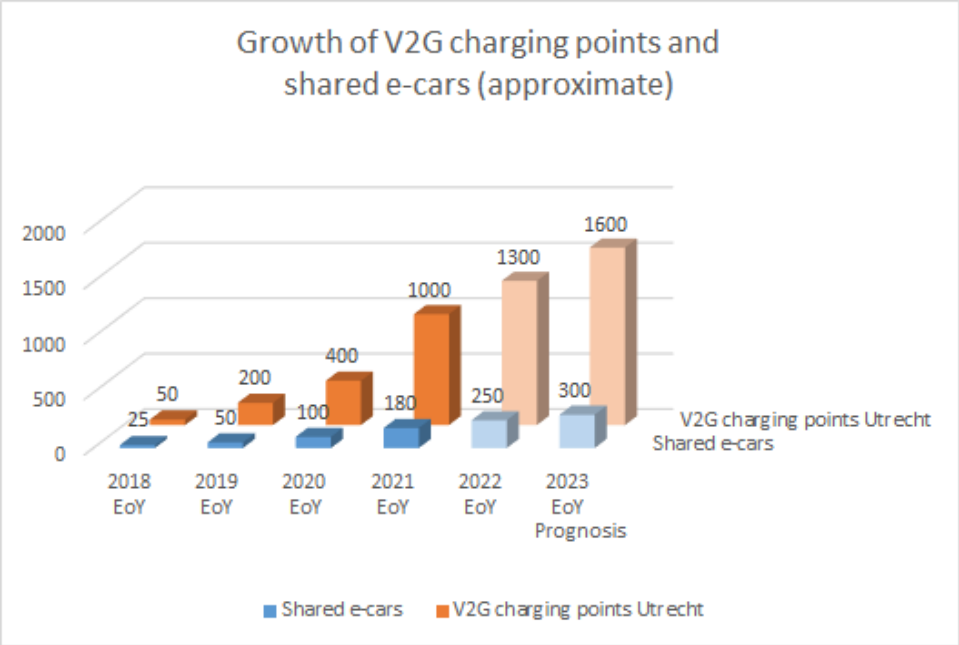


Figure 12 Growth of shared e-cars and V2G charging points of We Drive Solar (affiliated to IRIS partner LomboXnet) in the Utrecht Bidirectional Ecosystem between 2018 and 2023 (prognosis). One charging station has two charging points.

Measure 1 of TT#3: V2G e-cars and e-vans

In the Kanaleneiland Zuid district, two shared e-cars are providing MAAS mobility services in the district and two e-vans are being operated by housing association Bo-Ex for maintenance and service use. The demand for shared e-cars in Kanaleneiland[4]. The relatively low response in this district as compared to other districts in Utrecht is associated with the demographics and economic situation of the citizens. The number of e-cars is foreseen to increase in the future, following demand.

[4] IRIS Report on Utrecht citizen engagement activities by Labyrinth, May 2019

Figure 13 Public information session at Kanaleneiland Zuid

The plan to implement bidirectional, V2G e-cars in the demonstrator was delayed because, despite earlier expectations, V2G production cars were not available. Car manufacturer Renault had developed and supplied two prototype V2G e-cars, but due to external conditions, Renault was forced to postpone series production of their V2G cars.

Figure 14: Shared WDS e-car at Krachtstation, Kanaleneiland, Utrecht

In Spring 2022, Hyundai and We Drive Solar launched the world's first series produced V2G car (the model IONIQ5, see Figure 15) in Utrecht, in an event that was in the news on all continents except Antarctica, and was a result of the IRIS cooperation with LomboXnet. The LomboXnet / We Drive Solar fleet of smart charged shared EV's was at that moment enlarged with 26 Hyundai IONIQ5 V2G e-cars. At the moment of writing, a process of testing and protocol alignment between the V2G chargers of We

Drive Solar and the IONIQ5 cars is ongoing. This testing and alignment period became necessary as a result of late changes in the final ISO 15118-20 standard, which was issued in May 2022 with significant changes with respect to the draft versions.

In the meanwhile, LomboXnet has procured 25 Korean V2G charging stations that were produced in co-operation with Hyundai to be V2G compatible with the Hyundai IONIQ 5 e-cars. Six of these have been installed at various locations in and around Utrecht and are now in V2G operation with connected IONIQ5 cars. This means that in fact, the Utrecht Bidirectional Ecosystem has come into operation using these Korean charging stations. The remaining Korean chargers will be installed and put into V2G operation in spring 2023, expanding the scale of V2G operation of the Ecosystem. When the IONiQ5 cars will reach full ISO15118-20 interoperability by end of 2023, the bidirectional ecosystem will scale up to full scale V2G operation using the 650 V2G We Drive Solar chargers, expand its fleet of V2G operated e-cars and fully realise its ambition to use EV batteries as a virtual battery at large scale, to reduce electricity network congestion and maximise renewable electricity use.
Two more of these Korean bidirectional charging stations were installed at the National Testing Center of Stichting ElaadNL, where the bidirectional charging is tested and demonstrated with other (prototype and production) e-cars. This results in essential information to scale up bidirectional charging to DSO's including Stedin for upscaling in Utrecht, and validation to the car OEMs interested in ISO15118 V2G charging.

Also as part of IRIS, LomboXnet has supported the German start-up car maker Sono Motors in developing full ISO 15118-20 compatibility of their Sion V2G e-cars. The Sono Sion was expected to reach the market by 2023 and LomboXnet had placed an order for 100 units, but unfortunately in March 2023 Sono announced that they will not be able to bring these cars to the market. Sono Motors is continuing its activities, focusing on solar technology application for B2B consumers, such as buses and trucks. The Sion V2G e-car program is currently for sale and several companies have shown interest. Chances are that, with some delay, the Sion V2G e-car will come to the market in 2024.

Already, the fleets of V2G charging stations and smart charged EV's are realising their goals in the mobility field to reduce air pollution, increase healthy mobility and reduce the claim of cars on urban (parking) space.

Figure 15 On April 21, 2022, the worldwide launch of the IONIQ5 V2G e-car in Utrecht marked the advent of the first production car with AC-V2G capabilities as well as the unique position of the Utrecht Bidirectional Ecosystem. The event was fully powered from the batteries of the IONIQ5 cars presented and received wide press coverage around the world. On the photo: Robin Berg, Director of We Drive Solar; Vivianne Heijnen, Minister of Infrastructure and Watermanagement; Sharon Dijksma, Mayor of Utrecht; Anneke de Vries, Dutch Railroad NS; Michael Cole, President & CEO Hyundai Motor Europe; Onno Dwars, Ballast Nedam Development; Bart Meijer, CEO of MRP (from left to right)

Measure 3 of TT#2: Stationary storage battery

Secondly, a Stationary storage battery was installed in a shared area between IRIS housing blocks at the Columbuslaan and the Magelhaenlaan, see Figure 10. Realising this battery proved to be challenging, as an earlier tender to realise 2nd life batteries installed in garage boxes of buildings did not result in viable options. There were serious concerns on fire safety issues connected to installing such batteries in garage boxes under houses, and the second life batteries on the market were too tall to be installed in the relatively low garage boxes. Also, the prices quoted were very high – even higher than prices of comparable new batteries. This was probably due to the steep decrease in stationary battery prices at the time.

A second tender, for a new battery energy storage system to be placed outside, proved successful and cost-effective. The offer of Tesla was selected. The installation was further delayed because the planned location of the battery, on a public sidewalk, was rejected by the City of Utrecht. A better location was found in a shared area between the apartment buildings which was approved by the City. An initiative was started to engage citizens in redesigning the location (more on that below). In 2022, a Tesla PowerPack with a capacity of 845 kWh and a power of 590 kW / 630 kVA was installed and interconnected to a PV-system and the V2G EV-sharing system.

Citizen engagement activities were organized, in which children and citizens were asked to suggest improvements to the integration of the stationary battery enclosure, so that it will become a more attractive element in the area. These are described under chapter 6.2. If the battery can (as expected) generate net positive cash flow from the above services to the electricity grid, these proceedings will be used by Bo-Ex to improve / refurbish the small park in which the battery is located, so that the surrounding citizens also have direct profit in that respect.

Figure 16 Citizens of Kanaleneiland being involved in designing improvement of the park where the stationary battery is located

This stationary battery provides flexibility services to the electricity grid by trading on the TSO electricity markets. It is bundled with the other assets of the growing Utrecht Bidirectional Ecosystem, especially the V2G charging stations throughout the city and the other stationary battery already in operation at the site of the Jaarbeurs trade fair. At the same time, the stationary battery is used by Utrecht University, Utrecht Sustainability Institute and Stedin to analyse in what amount it can contribute to reduction of network congestion, and what value it could create when delivering that contribution. These results are being used to determine the business case for the parties that deliver flexibility (the battery is being operated on behalf of housing association Bo-Ex by an aggregating party) and for the DSO Stedin as future customer for these services. This has provided the DSO Stedin with information on how much flexibility is available from the battery, and at what price that flexibility would become available for local congestion management, at the desired moments. At moments when the battery is used to provide congestion management services to the DSO, it is not able to optimally operate on the national energy markets and therefore it will lose some revenues there. The demonstrator has given Stedin insight into the actual amount of revenues lost by doing so, now and in the future.

To deliver these services and to generate these data, the battery has used the monitoring equipment included in the battery management software, electricity measurements on the connected PV panels and measurement data of the electricity connection meter.

Two single-purpose battery models were developed to estimate potential profit for operating providing ancillary services, one of the models focused on the FCR electricity market and the other on the aFRR market. These two models were combined into an optimization battery model which showed significant potential for combining provision of two ancillary services by the BESS. The resulting optimized model was applied to the case study to assess the potential to combine provision of ancillary services by the BESS with local peak load shaving.

Local peak shaving was technically not necessary (yet) at the location of the case study. A new grid layout was recently done and after retrofit, buildings are still mainly heated without electricity. For these reasons, demand peaks were not as high as they should for an effective case. But this may be different in the future, or for other similar districts. Therefore, different scenarios were developed to estimate the need for local peak shaving in a situation where grid reinforcement is required and electricity demand is expected to significantly increase, see Figure 17.

These scenarios were based on the type of grid layout and the energy demands. In the all-electric retrofit scenario, the measured gas demand of the buildings is substituted by the equivalent electricity demand of heat pumps. The old grid layout scenario describes a situation where a battery is placed without the grid reinforcement that took place in Kanaleneiland-Zuid.

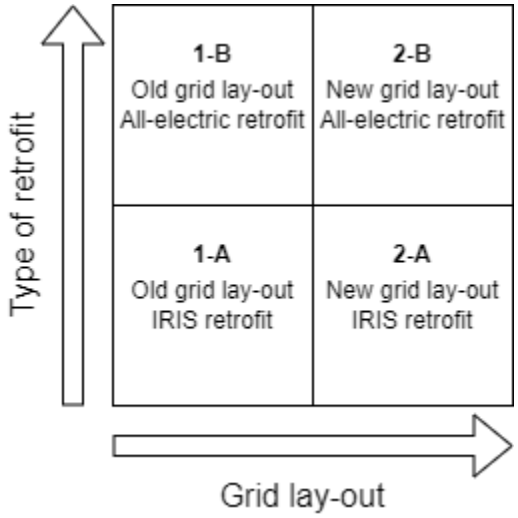


Figure 17 Overview of the case study scenarios.

The load profiles developed for these scenarios (Figure 18) show that with the new grid layout the peak loads at the transformer station remain relatively low for all cases. Without grid reinforcement, peaks are around 300 kW and 400 kW for the two different retrofit scenarios, where the transformer had a limit of 590 kW. In the summer situation peaks were much lower, therefore the research focused on the winter loads only.

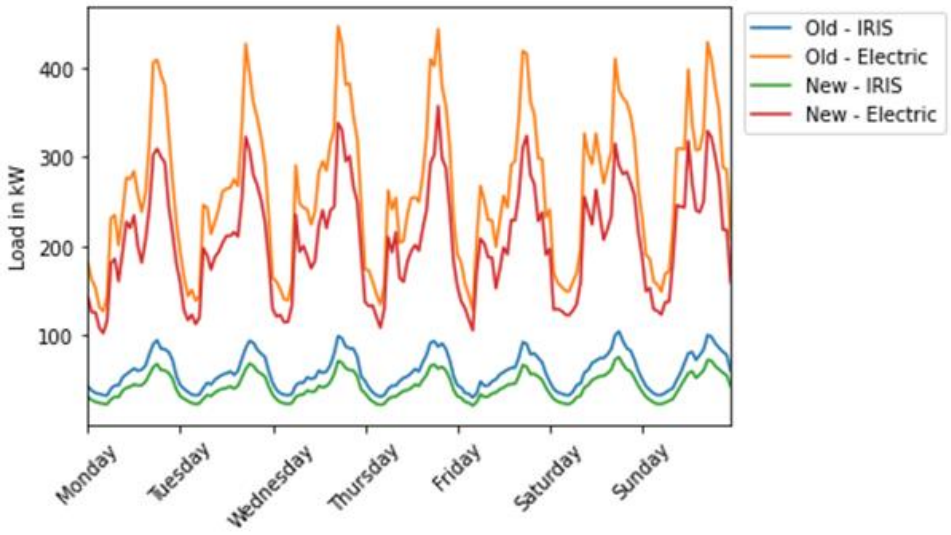


Figure 18 Load profile of the neighborhood for each scenario over an average winter week.

It was found that only in in the all-electric scenario with the old grid topology, the load on a single transformer station exceeded the transformer limit. It was estimated that this exceeding peak load could be provided by the battery at a cost of roughly €26 per day. Over an assumed battery lifespan of 20 years, the total deferment of grid investments was estimated to cost up to €200.000.

To further assess the potential of BESS for peak load shaving, two peak load shaving scenarios were developed to calculate the cost of maintaining peak loads within 30% and 50% above the average load. Table 3 shows that in the IRIS scenario, the cost of maintaining peak loads within 30% and 50% was estimated to be around €21 and €3 per day respectively. For the all-electric scenario, the cost for maintaining peak loads within 50% is significantly higher at €57 per day. Maintaining peak loads within 30% above the average load was not possible in the all-electric scenario due to constraints in battery capacity.

Table 3. Overview of the potential cost for DSOs to use BESS for peak load shaving. Total profit is projected over the full timeframe, the cost for peak load shaving per day is the difference in profit between the optimized model with and without providing peak loads.

	Total profit €	**Profit per day € / day**	**Cost PLS € / day**	**Total cost over 20 year period €**
IRIS 50%	28,765	350.79	3.47	25,331
IRIS 30%	27,365	333.72	20.54	139,900
Electric 50%	24,393	297.48	56.78	414,500
Electric 30%	-	-	-	-

Finally, the influence of energy market operations by a BESS on the neighbourhood peak loads was analysed. It was concluded that the use of the BESS for ancillary services did not lead to additional cases of transformer limit exceedance in all scenarios. However, the influence on the grid from using the BESS

for ancillary services is highly dependent on the bid size for ancillary services, the local grid topology and the transformer capacities.

The results of this demonstrator show that the costs lost by the battery operator by providing network congestion services instead of operating on the energy market cannot be neglected. This means that when a DSO would actively request congestion management services from such stationary batteries, the financial compensation offered needs to be sufficient to cover the above lost revenues on the electricity markets.

Re-use of decommissioned batteries from e-buses

At the e-bus charging location of QBuzz in Utrecht, the bus service company QBuzz has implemented a pilot for the re-use of decommissioned batteries from e-buses after their technical life span. Already one 90 kWh battery has become available from an e-bus that was decommissioned, in the near future many more and larger batteries are expected to become available after decommissioning of their respective e-buses. QBuzz has converted and installed the above-mentioned decommissioned 90 kWh battery as a second-life stationary battery on its charging plaza. This battery is operated to provide peak load reduction, congestion and flexibility services.

Figure 19. The second-life stationary battery in its container at the QBuzz charging plaza at the Remiseweg, Utrecht.

The development of this demonstrator involved selecting and designing hardware, software, data flows and the test location. This innovative pilot has been realised early 2023, testing and operation has started, see Figure 19. Based on the experience so far and continued testing in 2023, Qbuzz is determining the value that can be achieved by combinations of optimization behind the meter, trading on the energy markets and congestion management services, to choose exploitation models and to determine the present and future business case for routinely re-using e-bus batteries as stationary batteries to provide smart charging on their bus depots. The pilot will be continued after the end of IRIS, to gather more data on the results in the (at this moment very volatile) electricity markets and to investigate the benefits for the electricity grid operators, as part of the Utrecht Ecosystem, and for the operators.

During the Scalable Cities Community Event in June 2022, which was hosted by IRIS, Qbuzz organized a dissemination activity in which the lessons learned on the transition from fossil-fuel buses to e-buses was shared. Also, the pros and cons of smart charging were discussed with the IRIS cities and follower cities. Numerous questions on the implementation, benefits and bottlenecks were discussed. See Figure 20 for an impression. An article published March 2023 on the innovations by Qbuzz further informs fellow cities and other interested parties on the activities.

Figure 20: QBuzz dissemination event at the Scalable Cities Event in June 2022

Measure 4 of TT#2: Smart Energy Management System

A Smart Energy Management System has been realised which interconnects energy consumers, energy producers and energy storage providers including the following components:

- PV panels and hybrid heat pumps (in TT#1)
- Solar V2G charged e-cars and charging points
- Stationary battery

The local electricity grid in the demonstration area was designed in the sixties and has been reinforced to fit in all elements, as summarized above. Three additional transformer stations, transforming the voltage from medium voltage to low voltage have been added to the existing three stations in the local

low voltage grid. These additional transformer stations were necessary due to the foreseen feed-in of large amounts of solar power produced on the apartment buildings, additional electricity demand due to the hybrid heat pumps replacing natural gas boilers and charging of electric vehicles. The locations of all 6 transformer stations are indicated in Figure 21.

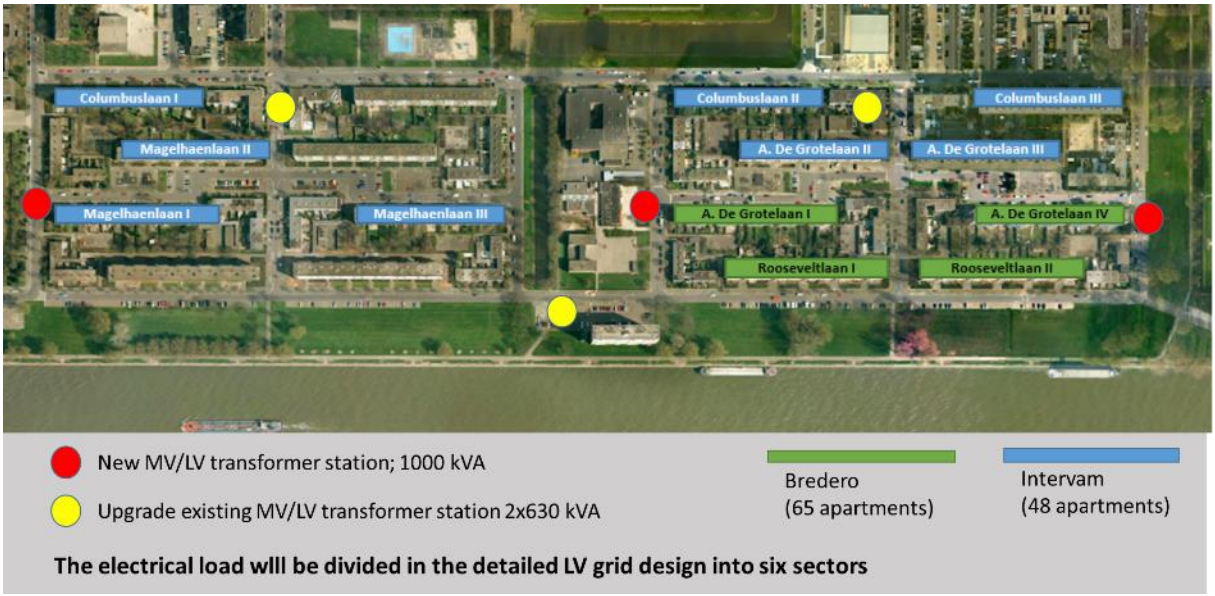


Figure 21. Location of the 6 medium voltage stations in the IRIS area to solve foreseen congestion points.

The district energy management system has two main functions:

- The effects on energy flows in the districts as a result of the transformation of the apartment buildings, installing solar panels, and the introduction of the charging points for electrical vehicles are measured and analysed to also estimate the effect on the electricity system when, due to replication, the solutions demonstrated in the demonstration area are duplicated on a large scale at other places.
- Real time measurements of the electricity flows are essential input for the management of the smart / V2G chargers and of the shared EVs in the district, to help the DSO keep the maximum flow within acceptable values and monitor the status of the grid.

The IRIS project has brought about a rapid development in Utrecht city - the growth of what is called the Utrecht Bidirectional Ecosystem. This bidirectional ecosystem had its world premiere in May 2019 in the presence of King Willem-Alexander of the Netherlands and top executives of Groupe Renault; at the same event the new draft ISO15118-20 open standard for V2G charging was launched by ElaadNL and the Open Charge Alliance. The main elements of the Utrecht Bidirectional Ecosystem at this moment are:

- The same district energy management system that was initially foreseen to be used as DEMS in the Kanaleneiland demonstrator, has spread over Utrecht. Spread over the whole city, there are now about 650 bidirectional charging points in operation; this number is still increasing because of an active municipal program and steadily increasing demand.
- The company We Drive Solar (affiliated to LomboXnet) is operating a network of about 250 smart charging electric shared cars in the whole city, including the first prototype AC-

bidirectional Renault Zoe cars worldwide and the Hyundai IONIQ5, the first AC bidirectional production car. Further growth is foreseen, as well as the implementation of bidirectional cars at larger scale in Utrecht.

- A new strategic cooperation between Hyundai and We Drive Solar has resulted in the worldwide launch of the first V2G production car as part of the Utrecht bidirectional ecosystem in April 2022.
- Also, the German car maker Sono Motors and We Drive Solar have started a cooperation, with the intention to bring 100 Sono Sion cars to Utrecht as V2G shared EV's, once on the market. Unfortunately, in February 2023 Sono announced discontinuation of the production of the Sion because of insufficient financing for the production phase. The knowledge developed is available to We Drive Solar for further developments.
- Solar power installations on schools are delivering electricity that (partly) feeds the charging stations. Also, a second stationary Battery Energy Storage System is in operation on the premises of the Jaarbeurs trade fair as mentioned above.

Therefore, the IRIS project was amended in 2021 to broaden the District Energy Management System for the Utrecht demonstration site to a City Energy Management System in which flexibility is exchanged between the IRIS demonstration sites in Utrecht and other flexibility assets throughout the city. This has enabled the Utrecht demonstration partners to increase the impact of the IRIS innovations greatly, as the three demonstration district areas Kanaleneiland, Lombok and Overvecht as well as a fast-growing number of other new assets in the whole city can then be connected into one city-wide energy flexibility network.

3.3 Results

Regarding end-user experiences, the public interest in shared EV's has shown to be relatively low in Kanaleneiland, but the demand for charging stations has increased steadily in the past years. In the rest of the city, the demand for charging stations and shared EV's is soaring. A research action to investigate this difference was conducted to gain more insight amongst the inhabitants of the Kanaleneiland district in the demand for shared mobility. Main results were that about half of the interviewed people owned a car and most of those car owners used it less than once a week. Half of the car owners reported having parking problems occasionally. People that expressed interest in electrical shared cars were young and mostly did not have a car or shared a car. The interest was connected to environmental aspects and location. Reasons for not being interested in shared electrical cars were the wish to have an own car, appearance/luxury, the wish to choose the car brand and fear that sharing cars with unknown others might cause problems.

An action to mobilise central key persons and ask them to approach other citizens turned out to be hard to realize. The actions that had proved to work in other neighbourhoods did not result in a sufficient number of key persons. This may be linked to the fact that many residents in Kanaleneiland are in a constant struggle regarding financial security, health, food security and safety.

The stakeholder experience on the installation of the stationary battery has been that integration of such batteries into housing buildings is still a challenging task – initial plans to place the batteries in the storage boxes below the apartments were discontinued as suppliers could not fulfil the tender regarding

fire safety (batteries under the houses) and physical integration (height of the boxes). The second plan to integrate the batteries on a public sidewalk next to the buildings was disapproved by the municipal welfare committee on grounds of visual attractiveness and accessibility of streets / sidewalks. Finally, the battery was placed in a green area between housing buildings and accompanied by an activity towards the surrounding citizens to help design the installation. This was received positively; the feedback led to a redesign and greening of the square together with the citizens, with a mural painting that explains the energy system.

The stakeholder experience with the charging stations has been positive, as demonstrated by the increased demand for the charging stations in Kanaleneiland Zuid, like in the rest of the city. The district energy management system is operational.

The progress of the related IRIS KPI's is displayed in Figure 22 to Figure 27.

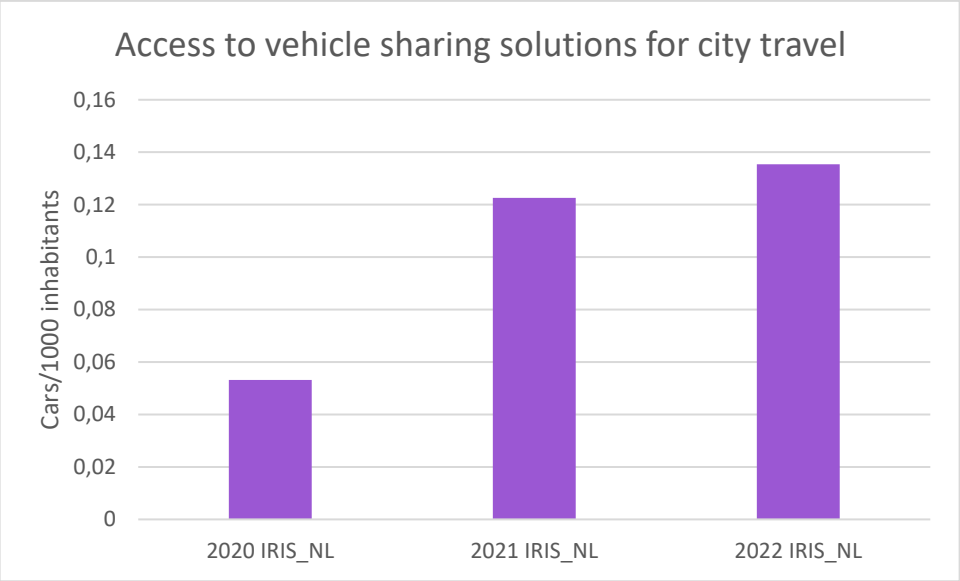


Figure 22 Results on KPI 2: Access to vehicle sharing solutions for city travel (source: IRIS KPI Tool)

In Figure 22, the access to vehicle sharing solutions for city travel (in terms of the number of shared vehicles per 1000 inhabitants) is shown for the last three full years of IRIS. Figure 23 shows the CO_2

emission reduction associated with the e-cars and e-vans in Kanaleneiland Zuid. The number of shared vehicles per 1000 inhabitants increased from 2020 to 2022, resulting in more emission reductions.

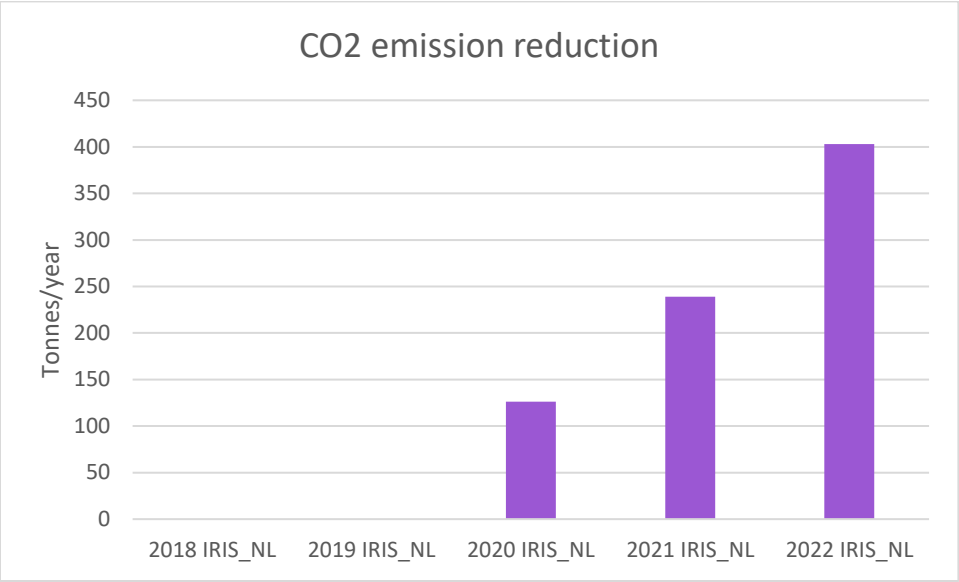


Figure 23 Results on KPI 5: Carbon dioxide Emission reduction (source: IRIS KPI tool) for e-cars and e-vans.

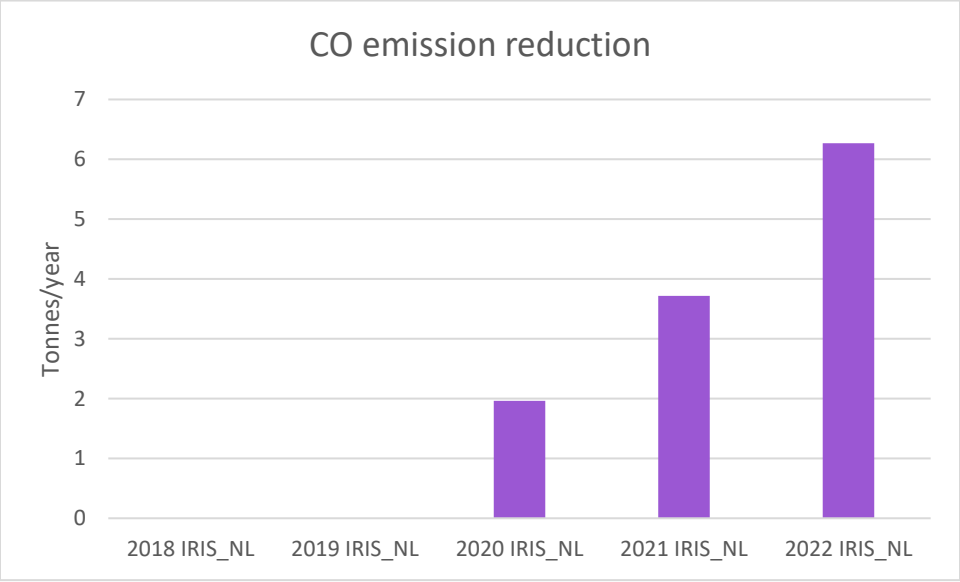


Figure 24: Results on KPI 6 Carbon monoxide emission reduction (source: IRIS KPI Tool) for e-cars and e-vans.

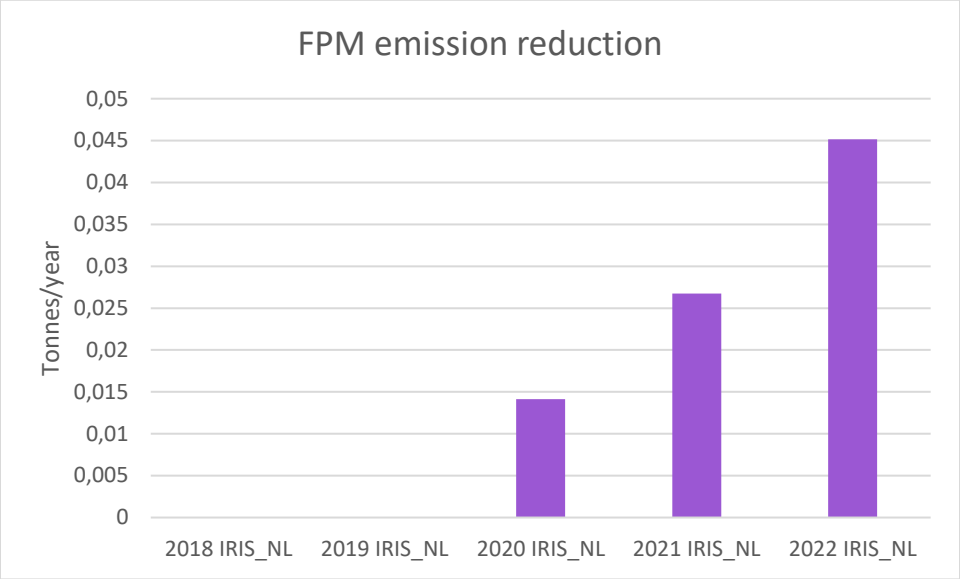


Figure 25: Results on KPI 15 Fine particulate matter emission reduction (source: IRIS KPI Tool) for e-cars and e-vans.

Figure 24, Figure 25 and Figure 26 indicate the reduction in emissions of carbon monoxide, fine particular matter and nitrogen oxide resulting from the e-cars and e-vans in Utrecht. An increasing reduction is visible for these three emission types.

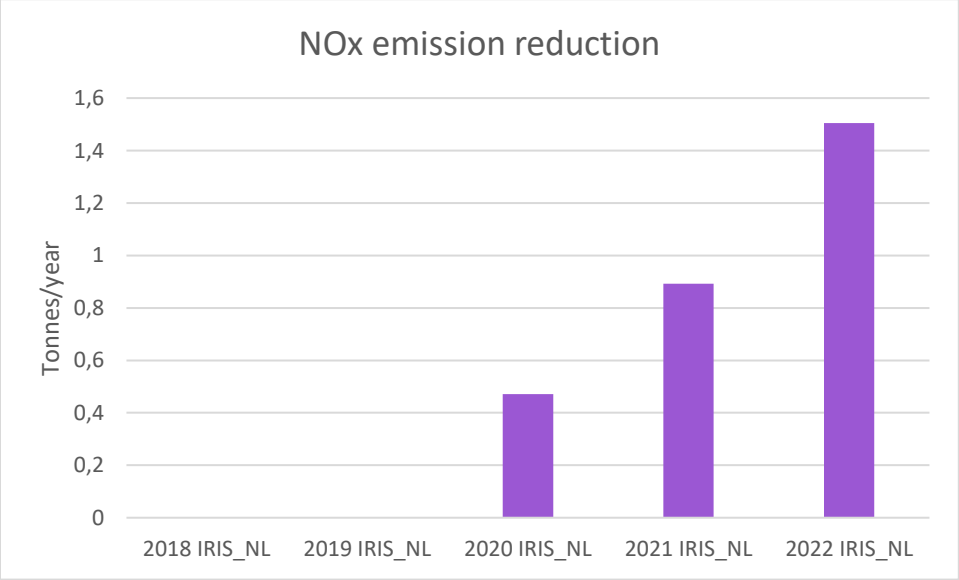


Figure 26: Results on KPI 24 Nitrogen oxide emission reduction (source: IRIS KPI Tool) for e-cars and e-vans

In Figure 27, the number of kilometers driven in the shared e-cars in Utrecht is given. A large increase is visible from 2020 to 2022.

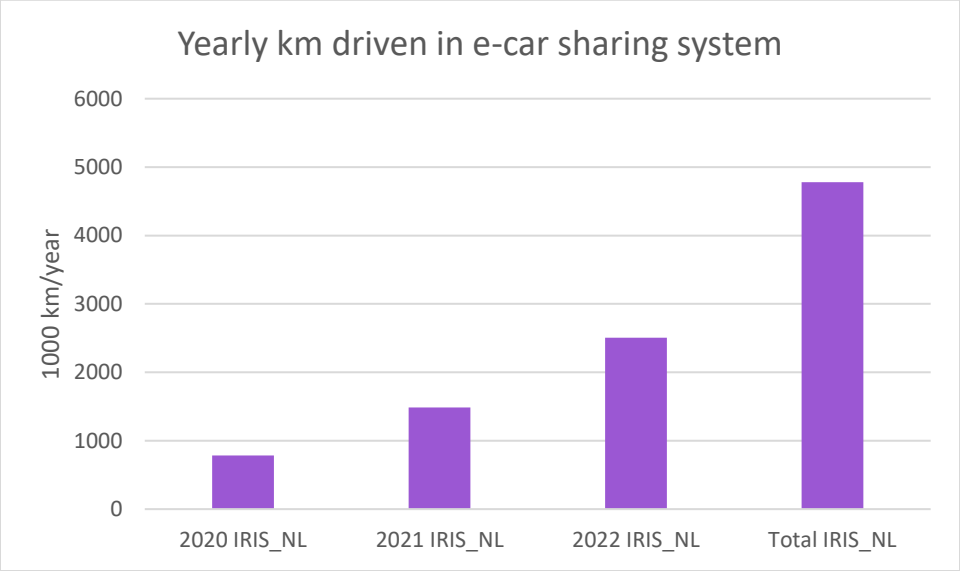


Figure 27: Results on KPI 46 Yearly km driven in e-car sharing systems (source: IRIS KPI Tool)

As described above, the IRIS demonstrator is serving as a living lab and a catalyst for fast upscaling of smart energy and mobility management for the whole city of Utrecht. LomboXnet is rolling out the technology in the whole city and even in the region around Utrecht city.

Thus, on the level of the whole city the flexibility provided by smart charging vehicles, stationary batteries and smart district energy systems provides an amplification of the benefits. The municipality of Utrecht is embracing these developments, triggered by the IRIS demonstration it is now scaling up the technology in the whole city, driven by its ambitions to become energy-neutral by 2030 and to have 25,000 e-cars in the city by end of 2023 – for which the city seems well on course. In a tender by the municipality for new EV charging stations, V2G compatibility has been included.

Figure 28 Smart charged shared We Drive Solar e-cars at the Krachtstation, Kanaleneiland Zuid

3.4 Business models and exploitation

The Smart Solar Charging approach scaled up in IRIS comprises of an interconnected set of bankable and societal business models with multiple value propositions. It is the combination of these business models that describes the full value of the approach. The business models are described here.

3.4.1 Bankable business models

EV Sharing Schemes

EV sharing schemes are profitable for Mobility Service Providers in urban areas, with a growing though competitive market. Smart charging EV sharing schemes deserve to be stimulated by cities as a green and healthy mode of transport which reduces greenhouse gas emissions, vehicle kilometres per household and the need for urban parking space. Smart and V2G charging shared EV have a high potential to alleviate the electricity grid congestion that has rapidly become a major problem in the Utrecht region and The Netherlands, and can be expected in the near future in many other places.

Value Proposition:	Shared EV solutions provide competitive, green, clean mobility. They offer a full alternative for an urban household to owning one or two cars. Using a shared EV, a household saves depreciation and maintenance costs and costs for parking permits.
Customer:	Households, especially urban
Channels:	Internet, press exposure, social marketing
Costs:	V2G charging infrastructure, V2G cars, car sharing solution
Revenue:	Participants in the sharing scheme pay a fixed amount per month for the possibility to use a car for a certain number of days per month; there are several tiers. On top of that fixed amount, an amount is charged per km driven, which includes charging costs.
Replication actions:	Urban municipalities can stimulate EV sharing by proactively promoting and accommodating them. They can do this by supplying sufficient numbers of parking places and EV chargers for shared EVs. While doing this, they should seek good contact with citizens to avoid resistance from people who see the number of parking places for private cars reduced.

Flexibility services (balancing, congestion) to the electricity grid

Centrally managed fleets of (shared) EVs can be smart charged or V2G operated and aggregated to provide electricity grid flexibility services, such as balancing services, smart energy procurement / trading on the balancing markets or congestion management services. This can provide significant additional incomes and/or cost advantages for EV charging point operators, while at the same time alleviating grid congestion problems. This business model is at moment partially in place (trading on balance markets and smart charging based on energy prices) while another part (congestion management services) is expected to become operational in the Netherlands once congestion management platforms such as GOPACS[5] are fully accessible to distributed small flexibility sources such as groups of EV charging stations.

Value Proposition:	Smart / bidirectionally charged EV's provide flexibility services to electricity markets and/or congestion management services to DSO's.
Customer:	Grid operators: TSO and in the Netherlands in future also DSO's
Channels:	Electricity markets such as day-ahead, FCR, aFFR. Congestion management platforms.
Costs:	V2G charging infrastructure, V2G cars, car sharing solution
Revenue:	Electricity price variations on markets, reimbursements for grid congestion mitigation (in development)

5 GOPACS is the congestion management platform adopted by the major grid operators in The Netherlands, see https://www.gopacs.eu/

Replication actions:	Grid operators together with regulators can intensify work on developing grid congestion management platforms, including sufficiently attractive reimbursement schemes for suppliers of grid flexibility, and making these available for distributed grid flexibility sources such as fleets of V2G EV charging stations.

3.4.2 Societal business models

Several business cases for upscaling of the stationary battery and smart energy management system are at this moment hampered by regulations and taxation; lobbying activities are going on at various levels to influence this, but at this moment the following societal business cases can be distinguished:

Avoiding or postponing electricity grid reinforcement

For electricity grid operators as well as for urban municipalities, the energy transition is bringing a challenge in the form of expected increase in electricity grid loads. The societal costs to adapt electricity grids to meet that challenge are enormous – billions of Euros for the Netherlands alone. Bidirectional charging of EV's has a high potential to reduce that challenge and to spread it over time, so that the aforementioned societal costs can be substantially lowered.

Value Proposition:	Smart and especially bidirectionally charged shared EV's provide a solution to the challenges that a sustainable energy supply brings to the electricity grid, avoiding grid reinforcements which are not only costly but also have an impact on public space availability and municipal human capacity.
Customer:	Electricity grid operators, municipalities
Channels:	To be established (apart from the above-mentioned energy markets)
Costs:	Stimulation measures for investments in V2G charging infrastructure and V2G cars and car sharing solutions.
Revenue:	The potential avoided costs for grid reinforcement, as estimated by Dutch grid operators (DSO's and TSO), are in the range of billions in the Netherlands alone.
Replication actions:	Grid operators together with regulators can intensify work on developing grid congestion management platforms, including proper reimbursement schemes for suppliers of grid flexibility, and making these available for distributed grid flexibility sources such as fleets of V2G EV charging stations.

Parking space

Shared car schemes reduce the need for parking space – a rare commodity in many cities.

Value Proposition:	Shared EV schemes also offer a mobility solution which requires far less parking space to urban, zero energy new housing districts. For each shared car, between

	5 and 24 private car purchases are suppressed or postponed, thus increasing public parking space availability by similar numbers[6].
Customer:	Project developers developing urban zero energy housing districts
Channels:	Professional publications and symposia
Costs:	V2G charging infrastructure, V2G cars, car sharing solution
Revenue:	Participation fees in new housing projects. For instance, the new housing district Cartesius in Utrecht, for which the construction will start in 2022, will have very few parking places, relying on V2G charging shared e-cars to not only provide green mobility but also energy management for its all-electric, zero fossil energy system.
Replication actions:	Urban municipalities can promote the use of shared EV's. They can also discourage the addition of new parking space at new housing developments, for instance by requiring a strict parking norm of i.e. less than 0.3 parking place per house in tenders for new housing developments.

Reduction of air pollution

EV's reduce local air pollution in cities; shared EVs also contribute to health because they encourage citizens to choose healthier modes of transport. Smart and bidirectional charging augment the attractiveness for these innovations and increase their potential.

Value Proposition:	Smart and bidirectional charging enhance the business case for electric mobility, thus providing societal value in terms of air pollution and urban health.
Customer:	Municipalities, especially of cities
Channels:	Professional media, municipal policy media, social media. The municipality of Utrecht plays an important role with its unique living lab of 650 smart charging stations throughout the city.
Costs:	V2G charging infrastructure, V2G cars, car sharing solution
Revenue:	The potential avoided societal costs connected to air pollution and urban health in cities are high.
Replication actions:	Urban municipalities can promote the use of EV's and shared EV's.

[6] https://www.electrive.com/2021/08/25/icct-details-winning-factors-for-electric-car-sharing-offers/

3.4.3 Key Exploitable Result

In the Annex, a Key Exploitable Result table is given, which was identified in 2020 in an Exploitation Strategy Seminar and was updated in 2021 and 2022. The upscaling and replication of the We Drive Solar / Smart Solar Charging approach, as demonstrated in the Utrecht Bidirectional Ecosystem, has taken off with as major highlights:

- In September 2022, the Utrecht Bidirectional Ecosystem was awarded the ISGAN Award of Excellence 2022 by an international jury from the International Energy Agency (IEA). Rob Jetten, Minister of Climate & Energy of The Netherlands, presented the award to project partner Stedin in Pittsburgh, USA. With this, the collaborative project received international recognition as the most innovative technology for a future-proof smart electricity grid with the highest potential for global application (see Figure 9).
- In June 2022, a new Horizon Europe project "SCALE" started with the goal to advance smart charging infrastructure and facilitate the mass deployment of electric vehicles, with the Utrecht Bidirectional Ecosystem approach as especially highlighted Use Case for scaling up[7].
- In April 2022, the worldwide launch of the Hyundai IONIQ 5 took place in Utrecht as a joint statement of Hyundai and We Drive Solar. The event marked the delivery of the world's first AC V2G production car to the Utrecht bidirectional ecosystem. Since May 2022, 26 IONIQ5 cars are being operated by We Drive Solar as shared e-cars, with growth expected in 2023.
- In June 2021, Koolen Industries, an investment company targeting sustainable innovations, made a large investment in We Drive Solar. This large private investment enables faster scaling up of the Key Exploitable Result.
- Large insurance company ASR has established in 2022 the world's largest V2G parking garage, with 250 V2G charging point at its headquarters complex on the East side of Utrecht city.

Other ways in which replication and upscaling are taking place include:

- We Drive Solar has won concessions to roll out large numbers of V2G charging points in Rotterdam, Amsterdam, and Arnhem.
- In the Dutch innovation project ROBUST, the Utrecht Bidirectional System will be replicated to Arnhem and the possible impacts of V2G charging on the electricity grid more deeply researched and elaborated.
- The ISO 15118-20 standard was published in its final form in spring 2022 and is an open standard with the goal to further stimulate replication of ISO 15118-20 compatible smart charging systems. The Utrecht Bidirectional Ecosystem is now by far the largest living lab where ISO 15118-20 compatible AC charging is demonstrated. As mentioned above, several car manufacturers (including Hyundai, Kia, Polestar, Renault) are adopting the standard in their product range. This is being taken up in several initiatives, including the European Horizon Europe project INCIT-EV.
- Research by the consulting and management company Moneypenny indicated good opportunities for upscaling the V2G shared e-car approach in sustainable new housing districts.

[7] https://scale-horizon.eu/

In urban settings, where sustainability ambitions are high and parking requirements are strict, V2G shared e-cars can provide an attractive solution for smart e-mobility as well as energy management. Several housing development projects in Utrecht (Cartesius, Wisselspoor) and in other cities in The Netherlands are being realised, with V2G shared car fleets as a standard element of their propositions to new house owners and tenants.

3.5 Lessons learned and next steps

IRIS has catalysed the development of the Utrecht Bidirectional Ecosystem, which is based on the V2G charging stations and shared e-cars, the stationary battery in Kanaleneiland and the city-wide energy management system. The V2G charging stations are compatible with public charging of private EV's which has enabled their fast growth to 650 stations in Utrecht by early 2023, and with 250 smart charged, shared EVs in operation by We Drive Solar, with V2G operation with Hyundai EV's on proprietary charging stations realised early 2023 and on all WDS charging stations expected before end of 2023. Also, when other 15118-20 supporting e-cars come on the market, they will be fully V2G compatible with the WDS charging stations. In general, activities are progressing with some delays in the full V2G operation because of delays in software updating in the EVs, with the replication / upscaling on city level running ahead of earlier schedules.

Important lessons learned include:

- Energy and flexibility systems are developing on city level, as well as e-bus and V2G shared e-car roll-out. IRIS has been a main driver towards the quick development of a city-wide flexibility and e-mobility ecosystem.
- In low-income districts with a lot of social housing like Kanaleneiland Zuid and Overvecht, the adoption of shared e-cars lags behind the fast-growing demand in the city of Utrecht as a whole.
- The realisation of stationary batteries in garage boxes has proven to be difficult, with respect to spatial restrictions and electrical / fire safety concerns. For this reason, the stationary battery was placed outside.
- Second life batteries proved (in 2019) significantly more expensive than new batteries, which appeared to be due to quick price drops and production growth, and the low number of used e-car batteries available. This is expected to change in the next years as more batteries will terminate their first life cycle.
- The interest in the demonstration of smart energy management from related parties such as authorities, DSO and other power network parties is large, but because developments in the field of electricity grid flexibility and congestion management are fast in the Netherlands, the interest of partners and external parties in the innovative solutions in the project also changes. An example is the intention at the start of the project to use the USEF Universal Smart Energy Framework– in the meanwhile the newer GOPACS platform has been adopted as the main congestion management platform in The Netherlands.
- Re-use of e-bus batteries as stationary batteries at e-bus charging plazas is expected to create new opportunities for load management and smart charging of e-buses.

Next steps are:

- Continue fast expansion of the network of V2G chargers in a demand-driven way, with support of citizen engagement activities and the involvement of local entrepreneurs. The major private investment into We Drive Solar in 2022 is an important milestone to make this possible.
- Determination of the actual value of local flexibility services from combinations of large numbers of V2G charged cars, stationary batteries and other flexibility providers in the city (this has been taken up in the Dutch ROBUST project).
- Further development of the city-wide smart energy management system in order to be able to offer flexibility services on the national platform GOPACS to network operators, and quick extension towards a virtual power plant and a city-wide ecosystem of green mobility and sustainable energy management, this has been taken up in the European SCALE project.

4. Results of Transition Tracks 2 and Track 3 – E-buses and e-bus charging stations

In Utrecht, 68 e-buses are in operation with two large charging plazas just outside the city and several fast chargers along the route. As part of IRIS, bus company Qbuzz has fitted the buses with detailed monitoring and logging devices that are providing valuable data on battery behaviour, driving range, battery wear and state of charge over the day. Based on these data, QBuzz and Utrecht University have conducted research on the potential of smart charging and V2G operation of city e-buses in the Utrecht setting. The results were promising and QBuzz is now implementing smart charging of their e-buses. Moreover, Qbuzz is setting up an experiment to reuse the battery from an e-bus that was sold at the end of its service life, as a stationary battery on one of its charging plazas, to research the possibilities for scaling this up using the batteries from all their e-buses at the end of their service life.

4.1 Overview

This chapter describes the results booked so far (November 2022) in Transition Track #2 and #3 regarding e-buses in Utrecht. The specific measures are:

- Smart charging spots for e-buses in Westraven (Measure 2 of TT#2)
- Smart charged e-buses (Measure 2 of TT#3).

The location of the measures in the city area;

The two large charging plazas are situated in the district of Kanaleneiland-Zuid in the city of Utrecht, in three locations: Westraven and Remiseweg (see Figure 29) and Zeist. The 68 e-buses that are parked and charged in these plazas have routes in the city of Utrecht and partially in the region. Also, Qbuzz realised a charging depot in the nearby town of Zeist.

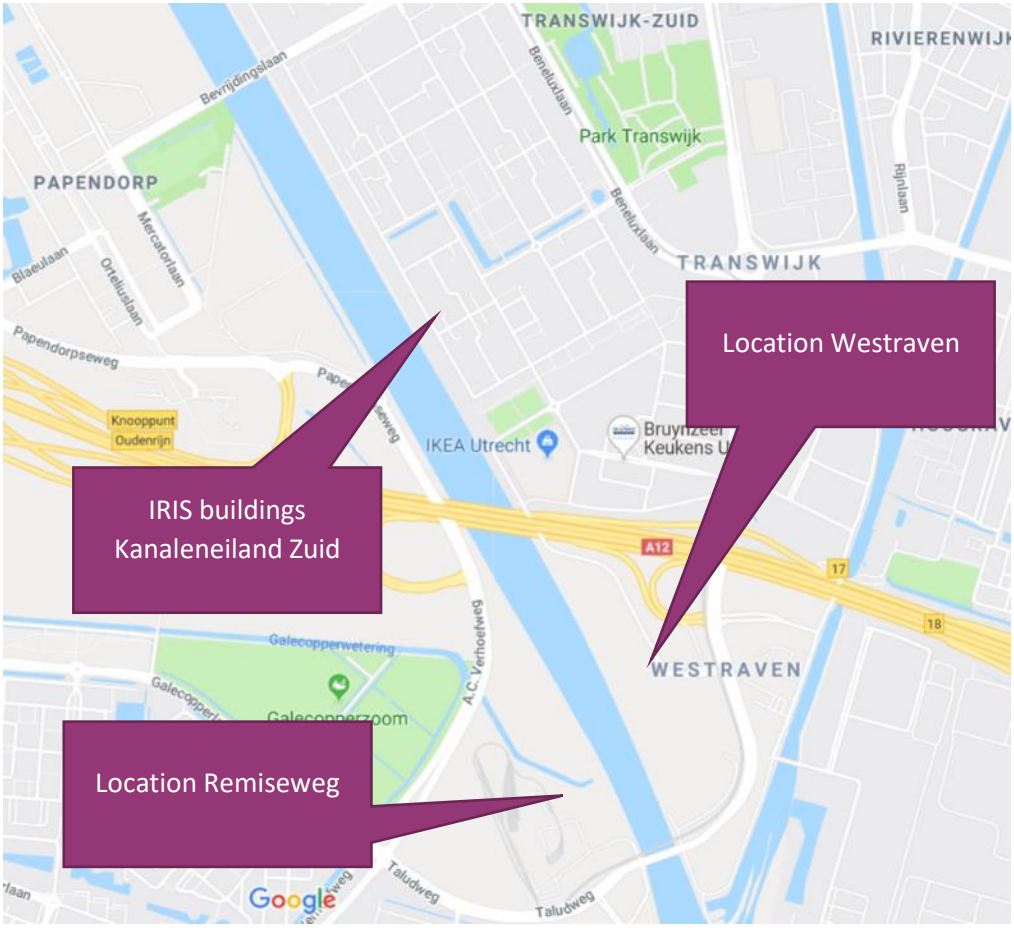


Figure 29: New e-bus charging locations of QBuzz

In the three **charging plazas for 68 e-buses** (Measure 2 of TT#2), the buses are charged during the night and daytime with renewable electricity (Dutch wind power). Research is ongoing on the benefits of adopting smart charging strategies at the two e-bus charging plazas.

Since 2020, **68 e-buses** (Measure 2 of TT#3) of Qbuzz are providing public transport to the city and region.

4.2 Implementations

Measure 2 of TT#2: Solar V2G charging points for e-buses

In the three charging plazas for 68 e-buses, the buses are charged during the night and daytime with renewable electricity (Dutch wind power). IRIS has carried out research on the benefits of adopting smart charging strategies at the two e-bus charging plazas. This research has been performed by Utrecht University together with LomboXnet, Utrecht Sustainability Institute and QBuzz. In October 2021, one of the Utrecht University students that were involved in that research became employed as data specialist at Qbuzz and is continuing her research about upscaling of smart and V2G charging options there.

Qbuzz has realised a pilot to re-use a battery from an e-bus that had reached the end of its service life, as a stationary battery on one of its charging plazas. This second-life battery is used to investigate the new possibilities it will give with respect to smart charging, load management and delivery of flexibility services as part of the Utrecht Bidirectional Ecosystem. The goal of Qbuzz is to scale this up using more batteries from their e-buses once they reach the end of their service life. The research cooperation on this subject with Utrecht University and Utrecht Sustainability Institute is also investigating how to connect the smart charging plazas to the Utrecht Bidirectional Ecosystem. The latter research is taken up in the research project ROBUST, where the Utrecht Bidirectional Ecosystem will be further developed. See paragraph 3.2 for more details.

Measure 2 of TT#3: V2G e-buses

Since 2020, 68 E-buses are now in operation by partner Qbuzz to provide public transport to the Province of Utrecht. The e-buses are charged in the above-mentioned depots. The e-buses provide their services to the region; the charging stations at the bus depots have own medium-voltage connections and thus act on city level rather than district level. The buses have been fitted with detailed monitoring and data logging equipment which provides a valuable pool of data that is being used to optimize driving efficiency and investigate the options for smart charging.

4.3 Results

The e-buses and their chargers are in operation for more than two years now. The detailed monitoring gear in the buses is delivering substantial amounts of detailed data which is analysed by Qbuzz and which has resulted in various optimizations of the operation of the e-buses, such as giving the drivers feedback on the impact of their driving style on the energy consumption of the buses.

Utrecht University has, together with Qbuzz, Utrecht Sustainability and LomboXnet, performed a modeling and research action to investigate the prospects of smart and V2G charging of the e-buses on these depots. The result has been published in a paper: “A comparative analysis of charging strategies for battery electric buses in wholesale electricity and ancillary services markets”[8]. The result was that smart charging of the e-buses is now applied by Qbuzz on the depots, with the goals of cost reduction and contributing to reduction of electricity grid peak loads. Also, this study has led to the installation of a second life battery at one of the depots, see chapter 3. V2G charging of the e-buses is being researched in more detail as a possible next step.

The progress of the related IRIS KPI’s is displayed in Figure 30 to Figure 33.

Figure 30 shows the CO_2 emission reduction associated with the e-buses.

8 https://www.sciencedirect.com/science/article/pii/S136655452300073X

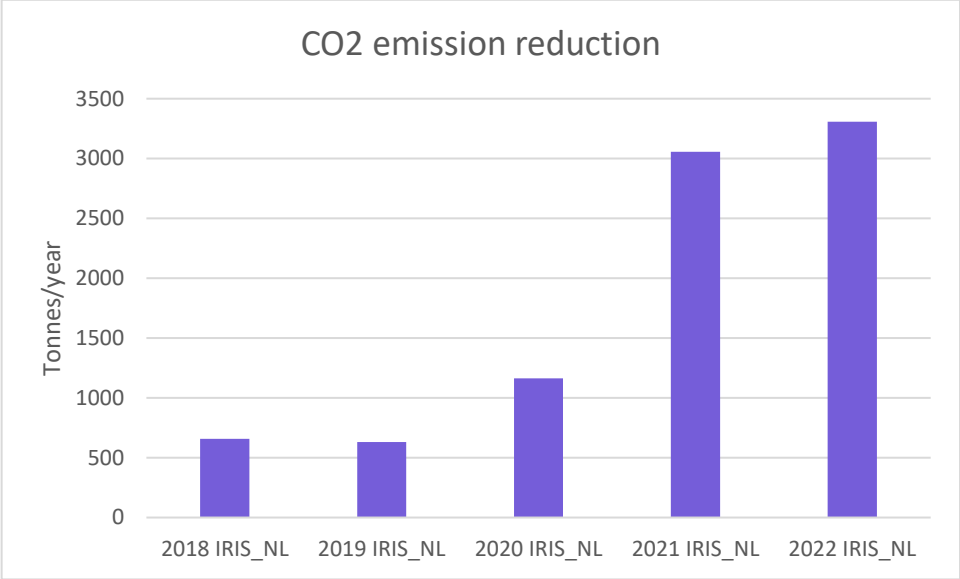


Figure 30 Results on KPI 5: Carbon dioxide Emission reduction (source: IRIS KPI tool) by e-buses.

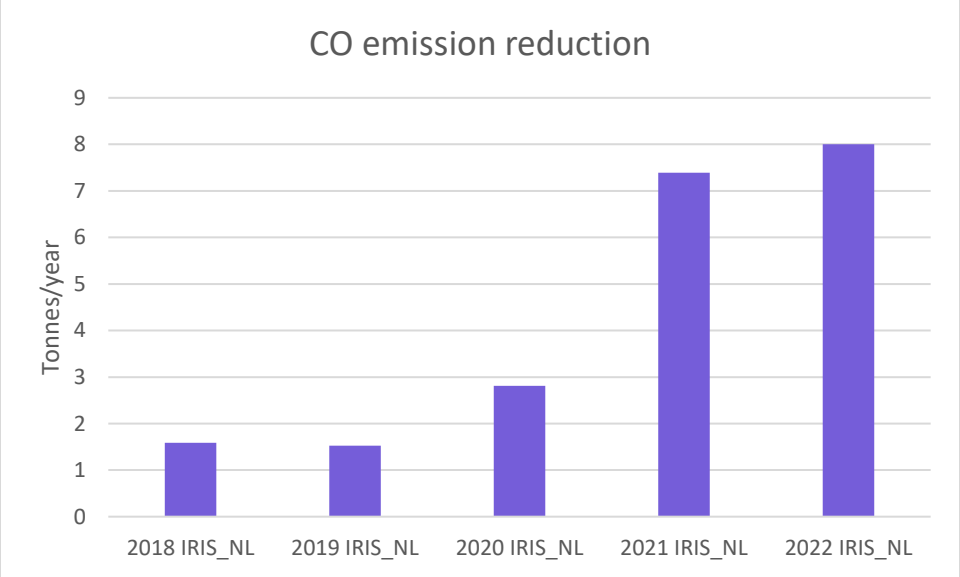


Figure 31: Results on KPI 6 Carbon monoxide emission reduction (source: IRIS KPI Tool) by e-buses.

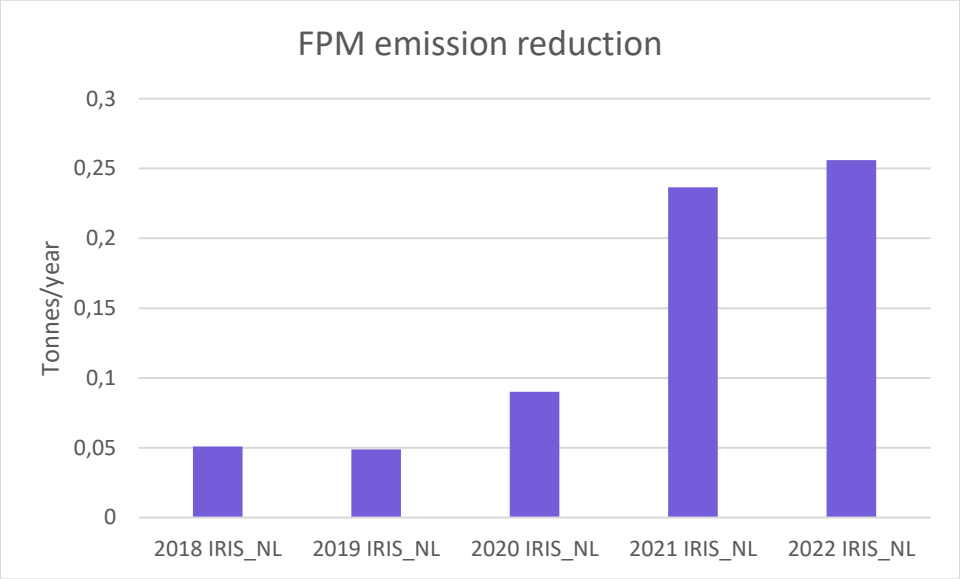


Figure 32: Results on KPI 15 Fine particulate matter emission reduction (source: IRIS KPI Tool) for e-buses.

Figure 31, Figure 32 and Figure 33 indicate the reduction in emissions of carbon monoxide, fine particular matter and nitrogen oxide resulting from the e-buses in Utrecht. Increased reduction is visible for all three emission types.

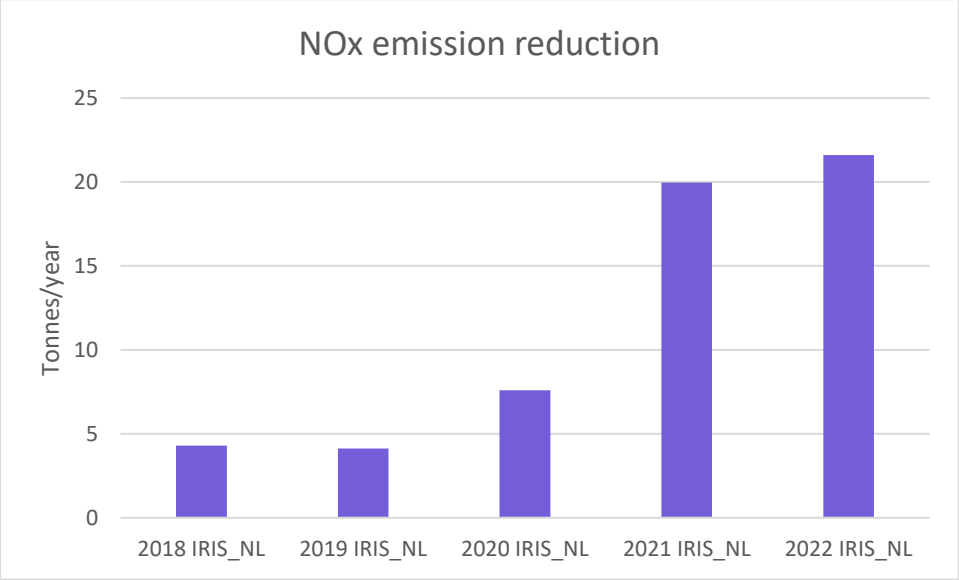


Figure 33: Results on KPI 24 Nitrogen oxide emission reduction (source: IRIS KPI Tool) for e-buses.

Bankable business models

As described above, Qbuzz has strongly expanded its e-bus fleet in Utrecht. Qbuzz hopes to win the next concession of which the tender outcome is expected by end 2024, and further expand the e-bus fleet and services.

Flexibility services (balancing, congestion) to the electricity grid

Smart and V2G charging of e-buses and/or the application of stationary batteries in e-bus charging plazas can provide electricity grid flexibility services, such as balancing services, smart energy procurement / trading on the balancing markets or congestion management services. This may provide significant additional incomes and/or cost advantages for e-bus operators, while at the same time alleviating grid congestion problems.

Value Proposition:	Smart E-bus charging provides flexibility services to electricity markets and possibly grid congestion services to DSOs
Customer:	Grid operators: TSO and in future DSO's
Channels:	Electricity markets such as day-ahead, FCR, aFFR; congestion management platforms, direct contracts with DSO
Costs:	Smart e-bus charging infrastructure, e-buses, ICT
Revenue:	Electricity price variations on markets and/or savings on capacity tariffs. In the future, revenues from providing congestion management services.
Replication actions:	E-bus providers can further identify and elaborate opportunities for smart and V2G charging and stationary battery deployment. Qbuzz will communicate on their actions and results. Grid operators can promote this by encouraging net flexibility actions (for instance congestion management contracts) when e-bus operators apply for new grid connections for charging locations.

4.3.1 Societal business models

The business case of e-buses is strongly driven by municipal concessions and policies.

Avoiding or postponing electricity grid reinforcement

For electricity grid operators as well as for urban municipalities, the energy transition is bringing a challenge in the form of expected increase in electricity grid loads. The societal costs to adapt electricity grids to meet that challenge are enormous – billions of Euros for the Netherlands alone. Smart and bidirectional charging of e-buses provides opportunities to reduce that challenge and to spread it over time, so that the aforementioned societal costs can be substantially lowered.

Value Proposition:	Smart / V2G e-bus charging contributes to the challenges that a sustainable energy supply brings to the electricity grid, avoiding impact on the built environment.
Customer:	Municipalities, especially of cities and DSO's and TSO's.
Channels:	To be established.
Costs:	Smart e-bus charging infrastructure, e-buses.
Revenue:	Potential avoided costs for spatial planning of grid reinforcement measures in cities (cables, low and medium voltage power stations).

Replication actions: Grid operators together with regulators can intensify work on developing grid congestion management platforms, including proper reimbursement schemes for suppliers of grid flexibility, and making these available for e-bus companies.

Important lessons learned include:

- E-buses are developing strongly on city level and further expansion is expected.
- Smart e-mobility systems and V2G charging are quickly developing on city level, not only for e-cars but also for e-buses; IRIS has been a main driver of these developments in Utrecht.

5. Results of Transition Track 4 – City Innovation Platform and data services

The objective of this deliverable is to provide a detailed overview of the activities for Transition Track #4 within the Utrecht demonstration. The Grant Agreement states the objective as: "Through cross-cutting open ICT (1) enable the integration of the IRIS solutions, maximising cost-effectiveness of the integrated infrastructure, (2) provide the City Innovation Platform (CIP) and (3) develop meaningful information services for households, municipality and other stakeholders, (4) together allowing for new business models." The chapter is aimed at giving insight into the progress made on the diverse data services developed within the IRIS project in the demonstration area Kanaleneiland-Zuid in Utrecht. It helps other lighthouse cities and follower cities within the IRIS project to see and learn about possibilities for services and how they can be replicated.

KEY MESSAGE
Within Transition Track 4 various data services have been developed. The services are aimed at the monitoring of charging stations for electric cars, smart street lighting, making smart city applications visible in a 3D application and fighting energy poverty through data-driven energy advice. These services run on datasets made available through the urban data platform CIP. The services contribute to solving social problems such as the increasing misuse of charging stations for electric cars, energy poverty, road safety and support the energy transition. The data services prove that services based on the use of open data sets available in the CIP can be used to solve societal challenges. The financial exploitation of the services and the translation into profitable business models is still quite challenging.

5.1 Overview

The activities since the last report in month 49 include the implementation of the data services. The services have been implemented and most of the results can be shared. The following services have been developed as part of TT#4:

- Data service 1: Monitoring E-Mobility with LoRa network
- Data service 2: Smart Street Lighting with multi-sensoring
- Data service 3: 3D Utrecht City Innovation Model
- Data service 4: Monitoring Grid Flexibility
- Data service 5: Fighting Energy Poverty

The results of data service 4: Monitoring Grid Flexibility are presented in chapter 3 on Transition tracks 2 and 3.

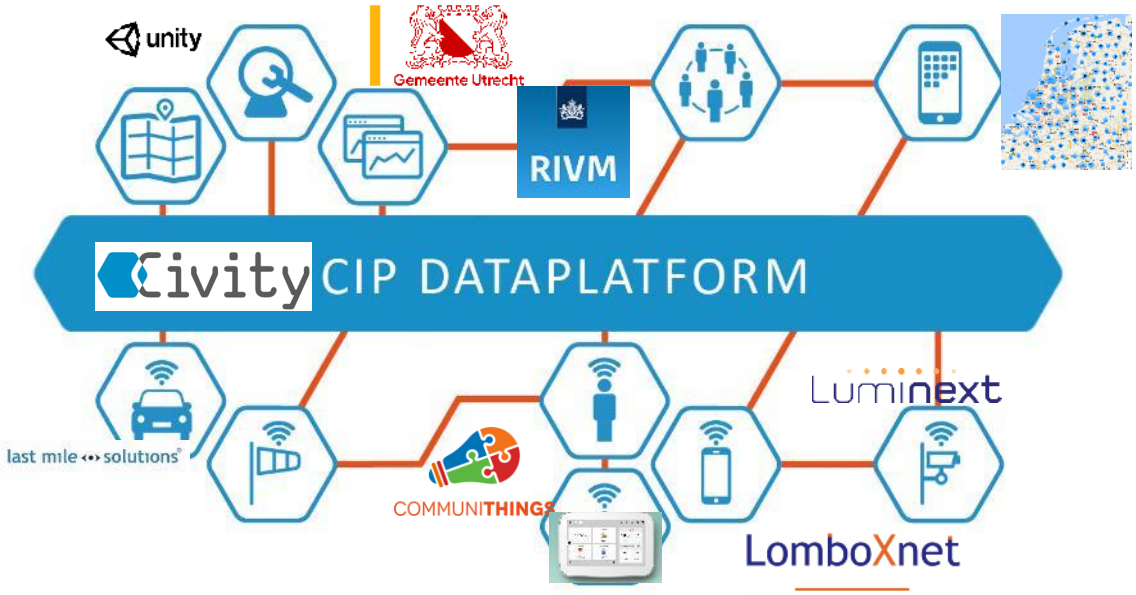


Figure 34. Utrecht City Innovation Platform

City Innovation Platform (CIP)

The CIP is a data platform that can host different static and dynamic data sets through which integrated data services can be developed. To connect various data sets and enable new information and data services, CIP is used for measures 1, 2, 3 and 5. The CIP collects the data from different data sources (charging points, sensors, HEMS, etc.) and processes the data into usable data sets. The datasets are then offered to third parties in a data marketplace through which (commercial) arrangements are made between the data suppliers and the data users. In order to demonstrate the usefulness of public urban data platforms like the CIP, TT4 seeks to develop data services based on this principle and encourages data users to do so by utilizing the CIP's available data sets.

Different data connections have been established (charging point data, parking sensor data, energy usage data, TOON data, cable capacity data, and shared car data), and other connections can be established in the future. More information on the development of the CIP can be found in Deliverable D4.6 (Figure 34).

5.2 Data service 1: Monitoring E-Mobility with LoRa network

5.2.1 Implementations

Deploying and operating EV charging bays is a substantial investment, which requires the most optimal and efficient use for a feasible business case. In the current situation, it is not possible to provide EV-car users and charging pole operators with information about the rightful or illegal usage of the parking bay. The aim of this *use case* within the IRIS project is to create insight into the (in-efficient) usage of parking bays and charging infrastructure by measuring the illegal use of EV charging bays by ICE-cars with the use of parking sensors.

A second objective was to research the effectiveness of traffic signs designating parking bays for EV charging. If the traffic signs are effective, the city can install public chargers without creating a unique traffic rule for each charging bay. This potentially saves time and money spent on creating 2.500 traffic rules decisions while still having efficient usage of the chargers. Parking sensors have been installed at 40 parking bays spread over town for EV charging to measure usage. 20 locations had a parking sign, and 20 only had cross markings on the ground (Figure 35).

Figure 35: EV charging bay with and without traffic sign

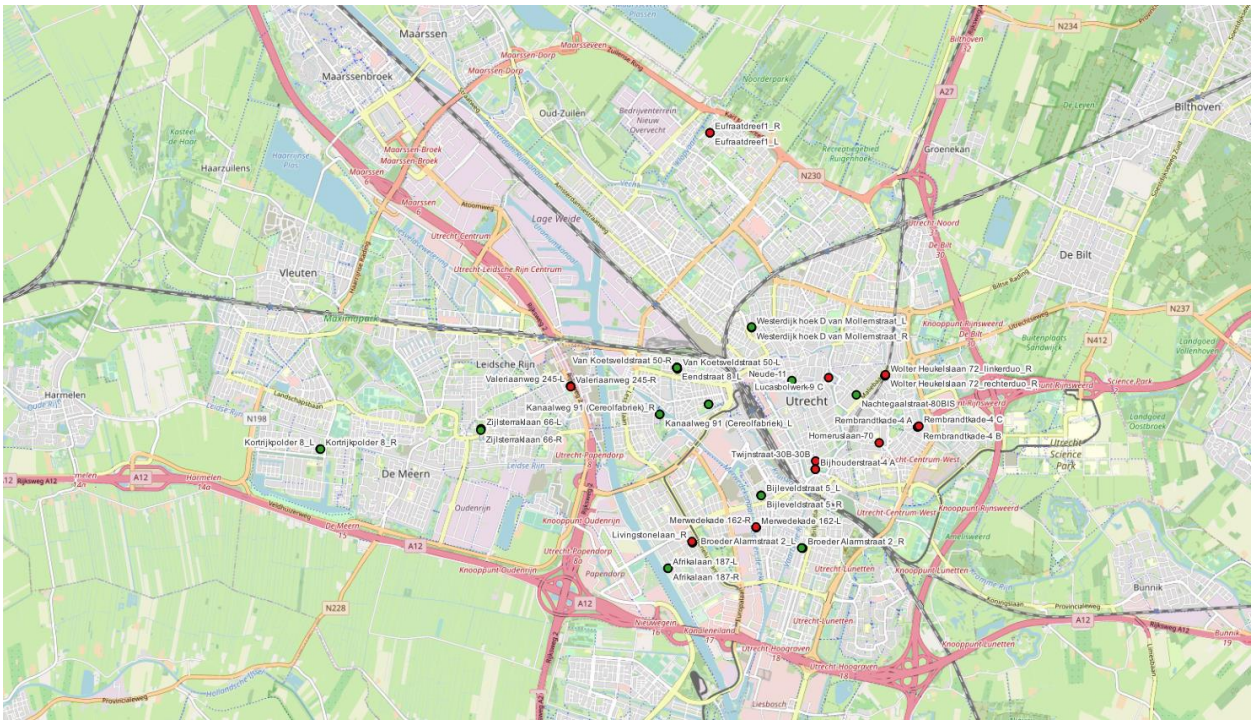


Figure 36. Location of parking sensors (red dot = occupied EV parking place; green dot = free EV parking place)

The LoRaWANi in ground parking sensor is equipped with triple detection technology magnetic, ultrasound and infrared detection to increase the accuracy (Figure 37). The sensor is equipped with a replaceable battery. The sensor performs measurements with a frequency of every 0,5 seconds.

The parking sensor therefore detects a quick vehicle rotation, namely a car leaving (car1) and another car (car2) entering the parking spot within 5 seconds. This is important to ensure car 2 is not charged for parking duration of car 1. The sensor supports open standard radio interface, which ensures no vendor lockin. For this project, an IOT sensor is offered. The LoRa connection is provided by IRIS partner KPN.

Figure 37: Specifications of the installed parking sensor

By combining the data from the parking sensor with the data from the charging pole an information service emerges, monitoring the rightful use of the charging bay (Figure 38).

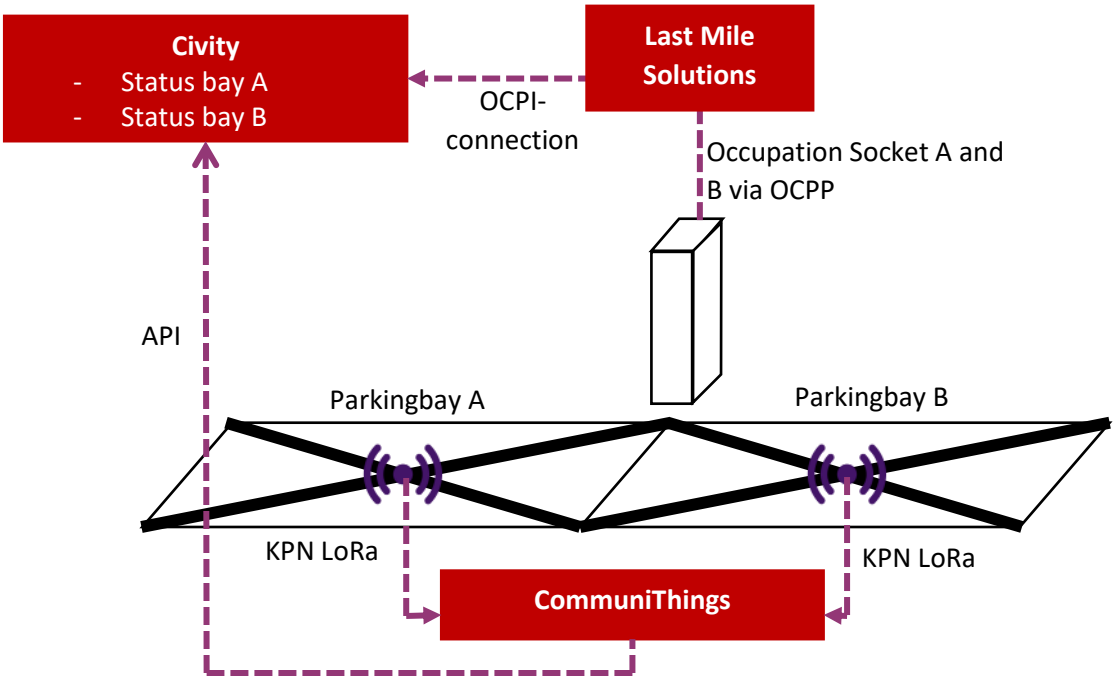


Figure 38: setup data service

5.2.2 Results

The main results are shared in Table 4. Results monitoring mis-use EV parking bays. The results show that no significant difference between 'sign' or 'no sign' parking bays has been found.

A less expected result is that about 60% of occasions and time parking bays are misused. That is a figure that is much higher than we expected. About 10% of this percentage can be explained by a period of snow cover in February. But even if figures are corrected for that period, the misuse amounts to about 50% of time and moments.

Table 4. Results monitoring mis-use EV parking bays

	Parking moments	Parking time
With parking sign	61%	54%
Without parking sign	62%	60%

Looking closer at the detailed figures (Table 5) shows lots of variation between locations. This probably is due to a lack of law enforcement, which would prevent EV drivers from misusing the infrastructure by plugging in but not charging.

Flaws in the data collection or a mismatch between sensor locations and charging points might be another explanation for the variations between locations. An extra check on the data is executed on the

Table 5: full figures monitoring misuse EV parking bays

With parking sign

Laadlocatie		Parkeermomenten (aantal)		Parkeertijd (in uren)		Percentage onjuist (%)	
Adres	Project opstelling	Aantal totaal	Aantal onjuist	Uren totaal	Uren onjuist	Parkeermomenten	Parkeertijd
Bekkerstraat (hoek Griftkade15)	Zonder bord	518	355	7.498,85	5.329,97	69%	71%
Broeder Alarmstraat 2	Zonder bord	598	395	6.286,60	3.048,61	66%	48%
Eufraatdreef1	Zonder bord	491	221	7.303,94	3.759,07	45%	51%
Kortrijkpolder 8	Zonder bord	476	141	6.211,94	2.687,85	30%	43%
Livingstonelaan	Zonder bord	622	341	12.837,18	9.687,47	55%	75%
Nieuwe Koekoekstraat 102 (J Bekastraat)	Zonder bord	478	313	4.273,31	1.907,31	65%	45%
Nieuwe Pijlsweerdstraat 61	Zonder bord	527	511	773,34	656,33	97%	85%
Van der Duijnstraat 1	Zonder bord	528	379	4.693,81	2.754,03	72%	59%
Westerdijk hoek D van Mollemstraat	Zonder bord	670	300	8.780,54	3.795,45	45%	43%
Wolter Heukelslaan 72_linkerduo	Zonder bord	639	502	9.053,49	6.748,27	79%	75%

Without parking sign

Laadlocatie		Parkeermomenten (aantal)		Parkeertijd (in uren)		Percentage onjuist (%)	
Adres	Project opstelling	Aantal totaal	Aantal onjuist	Uren totaal	Uren onjuist	Parkeermomenten	Parkeertijd
Afrikalaan 187	Met bord	496	435	4.118,43	3.364,90	88%	82%
Bijleveldstraat 5	Met bord	230	112	5.314,84	2.399,61	49%	45%
Eendstraat 8	Met bord	54	46	619,92	576,46	85%	93%
Floresstraat, hoek van Riebeeckstraat 10	Met bord	956	575	7.192,50	3.159,48	60%	44%
Kanaalweg (Cereolfabriek)	Met bord	420	223	4.239,50	1.875,12	53%	44%
Merwedekade 162	Met bord	607	429	8.996,77	6.696,85	71%	74%
Valeriaanweg 245	Met bord	758	297	9.142,30	3.765,62	39%	41%
Van Koetsveldstraat 50	Met bord	1004	764	5.228,09	2.579,01	76%	49%
Wolter Heukelslaan 72_rechterduo	Met bord	491	333	6.409,02	3.801,25	68%	59%
Zijlsterraklaan 66	Met bord	460	150	6.358,89	2.816,04	33%	44%

data in an effort to get the flaws out. Some records show strange results, since these results can not be linked to a probable cause. Although we could decide to ignore the incorrect measurements, it is very difficult to determine where the data is incorrect or where deviations relate to actual events (use or misuse of parking bays). Unfortunately, we have to conclude that the parking sensor measurements may not be adequate for the research question we want to answer.

5.2.3 Business models and exploitation

Business model

The aim of the executed experiment was to investigate if a specific parking decree/rule is needed which enables the municipality to reserve public parking bays specifically for the charging of electric vehicles. For every charger currently put into place, such a rule costs about € 300 - € 400 per rule. An additional cost is € 150 for the traffic sign. Investment in the sensor is approx. € 250. The societal business case for the service is € 200 to € 300 positive in this case.

The counter effect of putting no traffic sign up is that in some cases the charging pole might be used less effectively. Although the results show there is no difference, the operator of the chargers is a little bit hesitant to let go of the traffic sign. The operator has two main objections:

1. If car drivers find out they can not be fined without a traffic sign, then misuse will increase.
2. The traffic sign also helps users/e-drivers to locate the charge pole.

These issues might be mitigated by:

1. A traffic rule at a specific location if many complaints about misuse at a certain location arise;
2. Another, unofficial traffic sign can be installed to help findability of the charge pole.

Exploitable results

The research done in this measure is not designed as an exploitable commercial service. One could think of another setup of the measure that could be exploitable. Examples are:

- *Law enforcement:* When a traffic rule is implemented, the sensor data could inform law enforcement about a vehicle using the parking space without a charging activity taking place. Officers could receive an automated message informing them about the misuse of the parking bay so they can implement law enforcement. This service prevents fossil-fuelled cars from using the parking bays, or EV's parking without connection to the charging pole or idle charging for a configurable time. When implemented correctly, this could potentially lower the misuse of chargers and thus boost revenues and return on investment.
- *Authentication*: authentication of the user with the parking sensor to check for eligible use of the parking/charging facility. Non-eligible use can also trigger the officer for control and/or fine.

These services were not in the scope of this research. Further research is needed to find out if and how these potential services are exploitable and bankable.

5.2.4 Lessons learned and next steps

Conclusions

The average misuse is almost the same in both setups. Also, based on a statistical analysis we can conclude that there is no significant difference between the two setups ($p = .3262$). Based on this outcome, it can be concluded that it is possible to build charging locations without an associated traffic sign, without this being at the expense of the availability of charging locations for electric drivers.

The important but unexpected outcome is that a relatively large amount of incorrect use happens at charging locations, both in the number of parking moments and the total parking time. The incorrect use is on average 62% for all charging locations in the trial and 59% of the total parking time. The height of this figure can be explained in different ways:

1. As mentioned in the setup, some records show very strange data flaws that can't be directed to a cause. We tried to correct these records, but we need to conclude that the measurements of the parking sensors might not be good enough.
2. In practice, it is known that there is hardly any enforcement on incorrect parking at charging locations and it seems that motorists are aware of this. The IOT platform offers the option of an automated reporting function to the enforcers. A possible follow-up study would be to apply enforcement to the signposted locations to see if parking behaviour changes.
3. Another explanation may be that a correct connection between the car and the charging station is not established more often than expected and therefore a charging transaction does not start. In a follow-up study, it would be interesting to compare registration actions at the charging station with the incorrect parking moments. If a connection can be found between this, a possible solution is to send a push message to the user that the car is parked but no charging

transactions are taking place. This prevents a disappointed user and provides the CPO with extra revenue.

Another conclusion is that the percentage of parking moments with incorrect use is higher than the percentage of incorrectly parked time. This mainly applies to the locations with a sign. This could possibly be explained by the fact that loading locations are often free and are then used for short-term parking, for example for loading and unloading. Environmental factors such as parking pressure have not yet been included in this study and could explain such actions.

Lessons learned

Applying IOT applications in public spaces is relatively new. During the design and implementation of this trial, we encountered various obstacles. Two lessons learned have been distilled from this:

- Jointly formulate good principles for interpreting the data: Establishing principles and KPIs at the start of the project is an important phase. We have had to adjust the definition of an 'incorrect parking moment' several times. For example, there is time between the vehicle arrival (the sensor detects the vehicle) and the start of the charging transaction. As a result, the same parking moment goes from incorrect to correct and can cause pollution of the data. It is useful to draw out the process flows of the use cases and ensure that all data is available and clear. For example, we ran into the fact that it was unclear from the charging data which socket belonged to which parking space. Only start building a data dashboard after working out the use cases to ensure you interpret all the data correctly.
- Take enough time for setting up the research: Public space is constantly changing, which means the setup encounters all kinds of problems. When the sensors were installed, for example, despite a parking ban, cars were still parked at the intended locations. At another location, there was a heap of sand on the charging locations. As a result, no sensor could be installed at that time. Take enough time, plan several installation rounds and make good agreements between the parties involved.

5.3 Data service 2: Smart Street Lighting with multi-sensoring

5.3.1 Implementations

The GA stated the objective to introduce Smart Street Lighting in Kanaleneiland-Zuid, which encompasses equipping lamp posts with smart multi-sensors and connectivity. Data collected through these sensors should be used to enhance data-driven district policies aimed at reducing/minimizing problems faced by citizens in public spaces. The connected lamppost can pave the way for using city lampposts for IoT services.

The municipality of Utrecht is currently facing the procurement for replacement of 60.000 lamp posts within the city. A tender will be put into the market. The municipality of Utrecht wants sensor and connectivity services to be a part of this procurement. The city aims at deriving lessons from the IRIS project to put a successful tender into the market for the 60.000 lampposts.

The implementation is done in three subprojects.

1. Connected lamp posts
2. Smart pedestrian crossing and smart poles
3. Lamppost charger

which are described in the following paragraphs

Connected lamp posts

One of the projects is focused on connectivity. In a city block in the demonstration area Kanaleneiland-Zuid, all lampposts are equipped with a new LED fixture containing a standard Zhaga connector providing room for a smart plug connecting all fixtures with the Luminizer backend of Luminext.

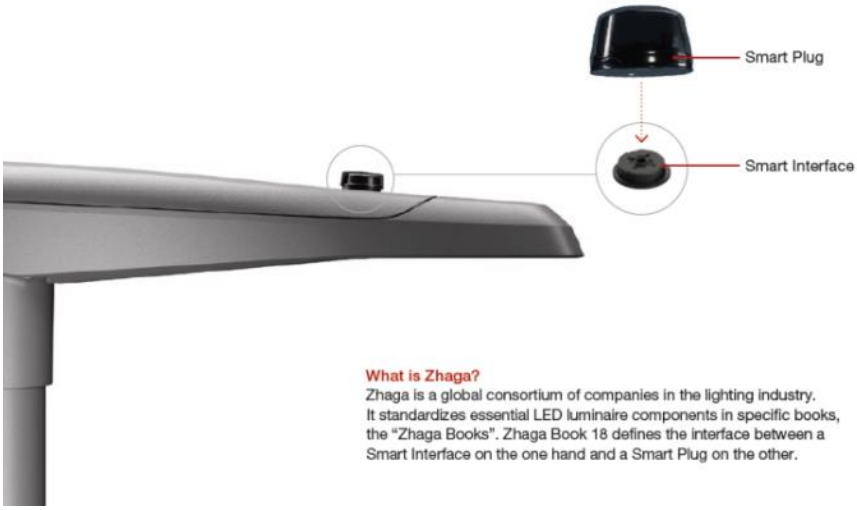


Figure 39: Lamppost fixture with Zhaga connector en smart plug

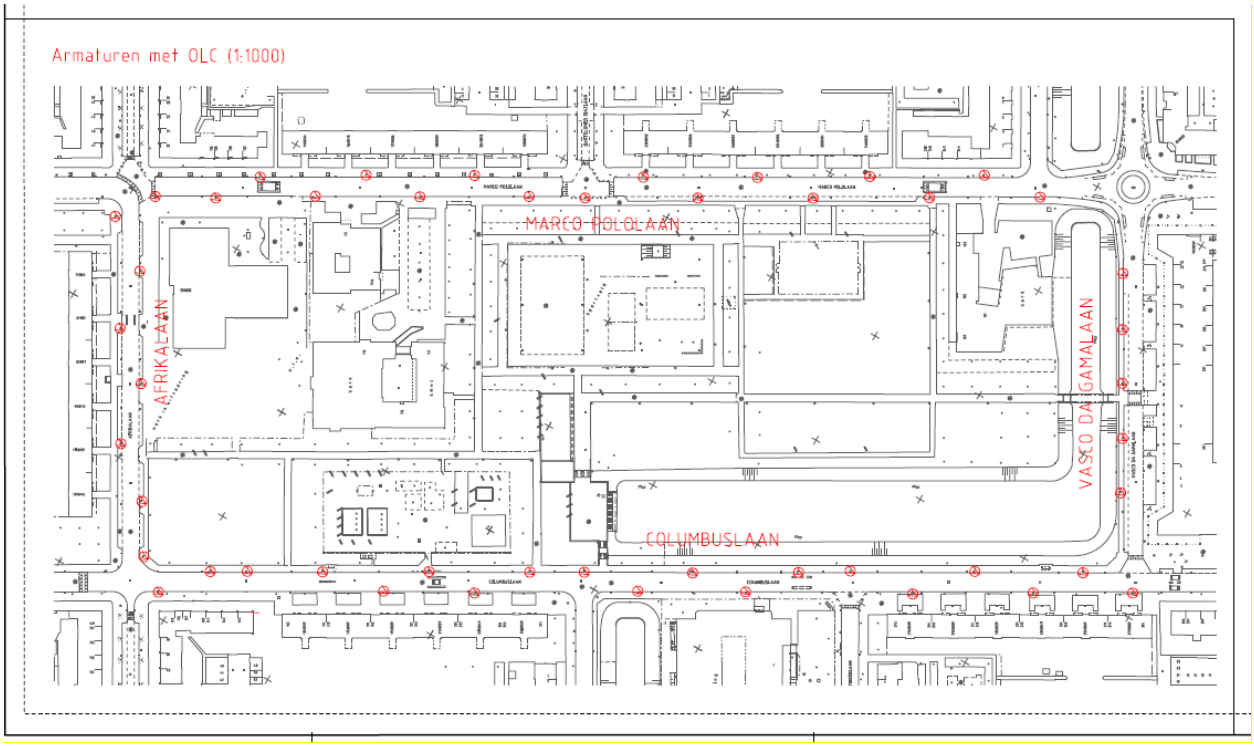


Figure 40: map showing locations of the connected lamp posts

Currently in Utrecht, lamp posts are switched on and off from a central street cabinet using 3G messaging. Historically in other municipalities, lampposts are switched using a so-called Toon Frequent (TF-)signal via the grid. The downside of these systems is that power in the lampposts switches off during the daytime. This limits the possibilities for implementing smart city solutions that require permanent power.

Connected lamppost fixtures can also be helpful for more effective asset management by providing real-time data on malfunctions and energy usage. Energy saving is possible by dimming the light in more quiet hours of the night.

Smart pedestrian crossing and smart poles

A successful citizen engagement and co-creation process around the development of smart street lighting solutions was carried out in June 2018. A diverse group of stakeholders including residents, entrepreneurs, and market parties, developed several concepts in a workshop. This workshop followed a design thinking approach. Details on the co-creation process can be found in chapter 6.

The result of the co-creation session is shown in Figure 41. The following functions have been installed:

Figure 41: Luminous smart pedestrian crossing and smart poles

- A smart pedestrian crossing with luminous white strips with LED lighting. Sensors that detect the proximity of traffic and pedestrians control the light.
- Multiple sensors are attached to a Smart Pole on one side of the crossing. The smart pole is a light column with various functions, such as cameras, measurement sensors for noise levels and air pollution, dynamic lighting, and traffic detection. The sensors can distinguish between traffic type and speed.
- Collection and assessment of data are done via the Luminext management system via WiFi and LoRa connections. The following data sets are uploaded into the CIP:
    - Power usage (kWh)
    - Burntime (hours)
    - Malfunctions
    - Air quality (not implemented)
    - Noise (not implemented)

The data collected with the sensor attached to the smart pole will be transferred and disclosed on the CIP. The main purpose of this stage is to learn what it means to implement sensors, connectivity and

smart lighting in public spaces. The municipality needs these lessons to implement third-party (commercial) services in the second stage. Currently, it has proven to be a challenge to implement these kind of sensoring and create a reliable data set from these sensors. This first prototype suffered from some malfunctions that were not noticed right away. Also, the sensors did not provide a continuous data stream. At the end of IRIS, involved stakeholders are discussing these issues and how/when to solve them.

Lamp post charger

The 3rd project is not to be seen as a data service, but as a spin-off of the smart pole development. One of the objectives of the municipality was to investigate what other functions lampposts could have besides lighting public spaces. In the coming years, the municipality will have a major task in facilitating charging infrastructure for electric vehicles in the city. There are currently 1,000 charging stations in the city that supply electric cars with power. Approximately 70% of households in the city do not have their own driveway and depend on charging points in public spaces for charging. It is expected that in 2025 approximately 2,500 public charging stations will be needed to provide power to all 25,000 EVs. The growth in the number of charging stations puts considerable pressure on public space. This is the reason to look for ways to combine charging points with other street furniture to limit the number of objects.

The intention is to design a pilot on integrating charging infrastructure into a public lamppost. The pilot focuses on existing lampposts in residential areas. Figure 42 is the design for a charging point for an existing lamppost in Utrecht that was designed by charging station manufacturer NieuweWeme in collaboration with the municipality and Equans (=Engie). The design has been adapted to the Utrecht 4 meter mast, which is often used in residential areas. The idea is to feed this charging point from the reserve core of the cable that is available in the municipal public lighting electricity grid. In this set-up, permanent power is therefore put on part of the public lighting grid. This system is now switched day and night.

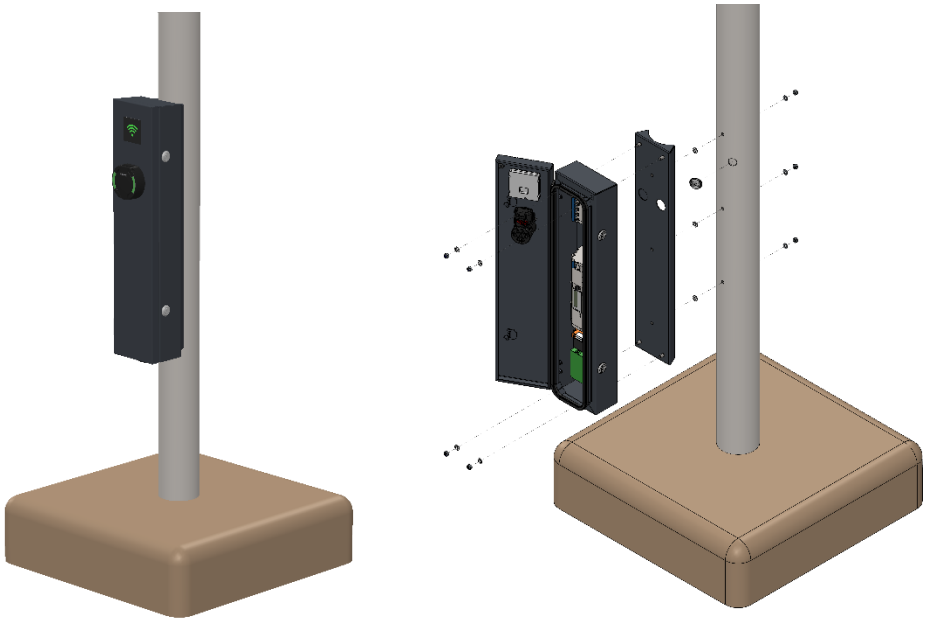


Figure 42 Design of a charging point on an existing lamp post in Utrecht

Because existing cables are used in this set-up, the capacity of the network is limited. In principle and under certain conditions, the cable thickness allows a maximum current of 16 amps on 1 phase. This allows a maximum of 3.7 kW to be charged. That is less than the available power on regular charging stations, which is between 11 and 22 kW. However, 3.7 kW is in almost all cases sufficient to fully charge a car in 1 night. The average connection time in Utrecht is 13 hours. In that time, 48 kWh can be charged with 3.7 kW, while the average charging session is only 20 kWh. We call this Low Power Charging (LPC). If a user still wants to charge faster in a short time, they can make use of the other 11 kW charging points or the urban fast charging network.

Three phases of 25 Amp are available per public lighting cabinet. A maximum of 1 charging point can be added per phase. This means that at every phase where there is a need for an LPC, a mast can be found that is accessible from a parking space. A permanent power supply must be installed on that cable in the control cabinet. Up to 9 cables are fed from each public lighting cabinet. There is a total of 600 such cabinets in the city, which means that 1,800 charging points can potentially be added to the network. Exactly how many depend on the position of the lampposts in relation to the parking spaces. The LPC can be installed and operated by our current supplier of charging infrastructure Equans (=Engie).

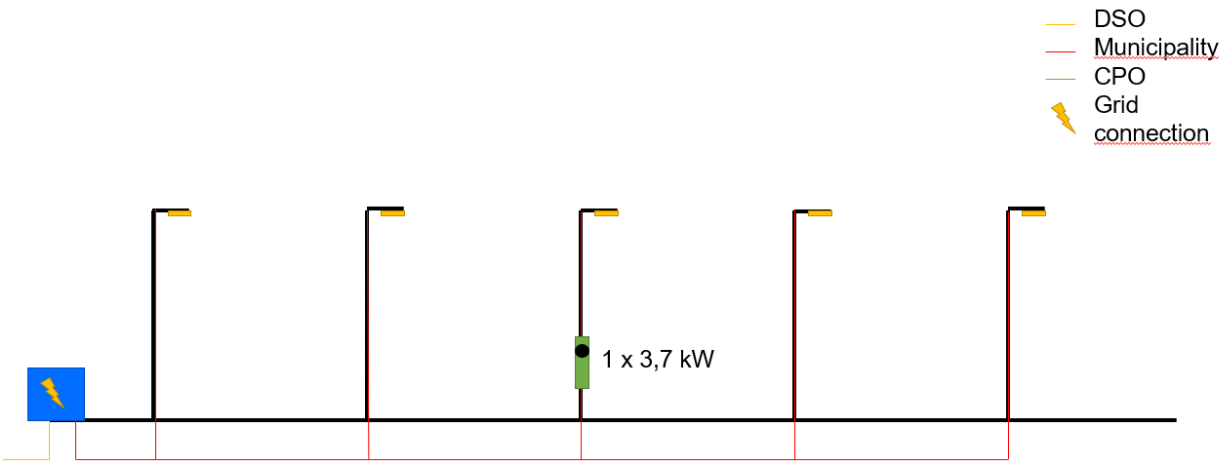


Figure 43 Visualization of a charging point added at a public lighting cabinet

5.3.2 Results

Connected Lampposts

The connected lampposts were installed successfully and work correctly. Also, the data is successfully uploaded into the CIP. After installation there were some difficulties with getting the correct locations of the lampposts into the CIP, but that was solved after an update of the connection.

The municipality has evaluated the functional use of the connected lamppost to the current system where public lighting is switched in a central cabinet. The outcome of this evaluation is that advantages of connected posts are not big enough to justify for a direct city wide roll out, but will be implanted in situations where permanent power is required or where other smart city applications require the implantation of connected lampposts.

Smart pedestrian crossing and smart poles

The smart street lighting has been installed and activated in June 2021 and was launched with an informative video that can be found on the Utrecht IRIS website[9]. The evaluation of stakeholder end-user experience is currently being executed. The evaluation consists of doing interviews with stakeholders and surveys and interviews with users (pedestrians, car drivers) in the neighbourhood and a field study. Unfortunately, the results are not finished before the publication of this report.

The field study consists of 3 parts:

1. Reference measurements of the lighting
2. Perception survey of pedestrians and road users
3. Perception survey of people with a visual impairment

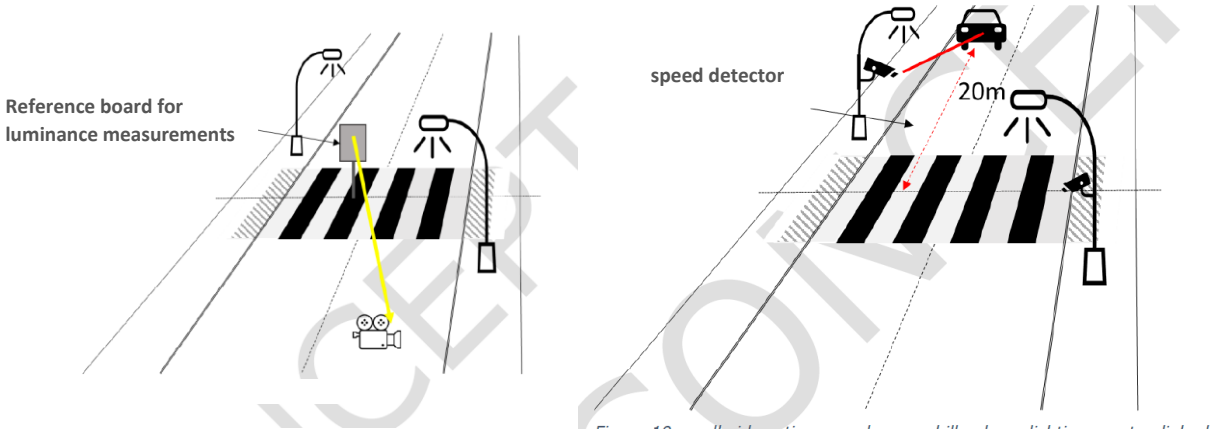


Figure 44 Concept drawing (above) and picture (below) of the smart street lighting

[9] https://iris-utrecht.nl/met-slimme-straatverlichting-naar-een-duurzamer-en-veiliger-kanaleneiland-zuid/

Translation of learnings into city wide tender

The city also used the experiences with the development of the smart poles in the tender for the selection of a contractor for the placement of public lighting. While working with different partners developing the smart poles, we notice it is very important to have a contractor who has overview and feeling for system integration and project management. We translated this into a qualitative selection criterion called system integration. The tender entries were asked to write a project plan for a fictive smart city case so that the tender team could select what contractor has the best skills on this subject. The team made a successful selection based on price and quality. Unfortunately, the tender was redrawn from the market due to an error unrelated to this subject, so the tender has not yet been awarded.

Lamppost charger

The prototype of the lamppost charger is finished early 2023. Locations were found and safety and regulations issues were covered within the municipality so that permission could be granted for installation. Safety issues came forward form the use of one null for the return of 3 core of the same phase. This would lead to a higher current than de cable was engineered for. The implication was that we need to choose locations with a shorter cable length. That is not really a problem. Locations were selected and a circuit design was made (Figure 45). Installation is due in April 2023.

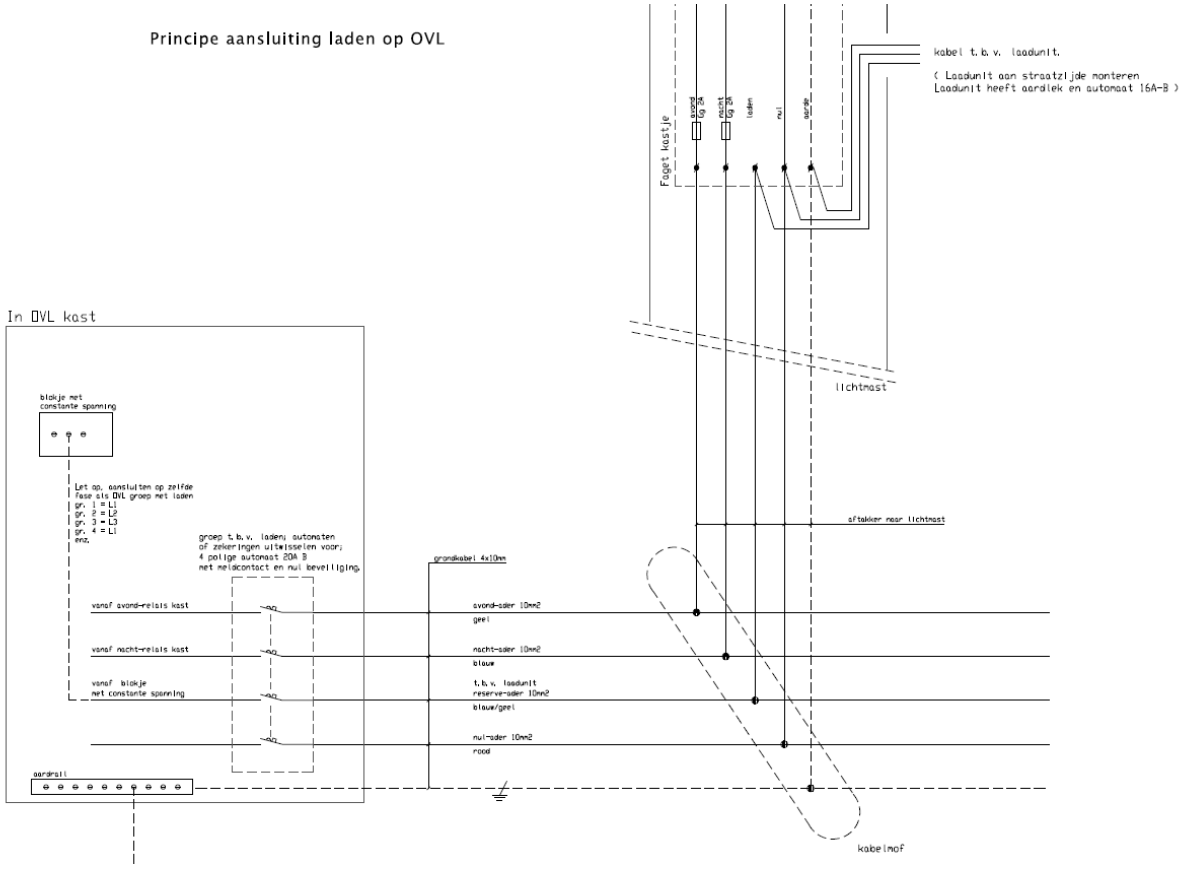


Figure 45: Circuit design of installation of lamppost chargers

5.3.3 Business models and exploitation

Commercial business model Smart Pole

For analysing the business potential of the developed smart pedestrian crossing and smart poles the exploitable result is outlined in Annex II. The markets to be targeted with this solution are municipalities and other local governmental organisations responsible for traffic safety.

Exploitation model Smart Pole

The concession model for the exploitation of sensor and connectivity services offers in the long run possibilities for a profitable business model and exploitation. We learned this from the exploitation of public EV chargers. The city of Utrecht started granting concessions for public charging services from 2013 onwards. A charging point operator is selected based on price and quality and wins the right to operate public chargers for a certain amount of time. The first year of the operation had a negative financial result and subsidies were needed to develop the market. Over a few years, scaling effects reduced costs and the demand for charging services grew. Now the market is mature and in the most recent concession, the city earns 6 cents per kWh charged on public chargers contributing to a total of € 2 to € 6 million in 10 years.

In the long term, similar exploitation models can be implemented for smart street lighting. Expected revenues for sensor services are difficult to predict. Expected is that sensor services will mainly be used for policy making and public management information services therefore offering social value. An estimate of investments and exploitation costs for 60 000 lamp post in Utrecht has been given in Figure 46, which was mainly used to kickstart the discussion within the municipality of Utrecht.

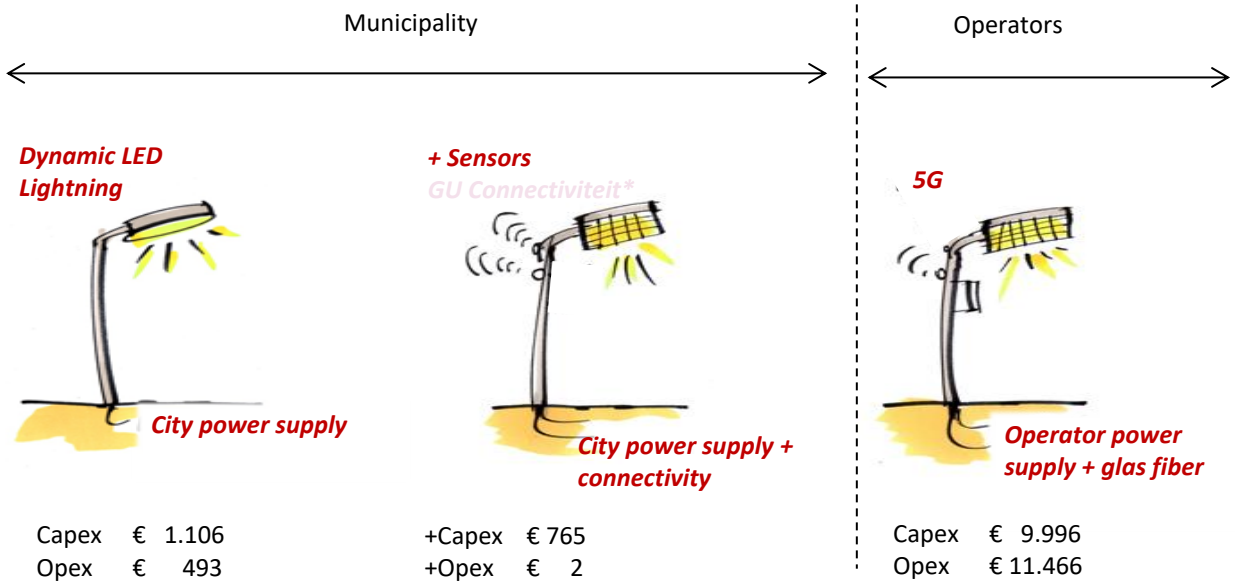


Figure 46: Estimated investments for 60.000 light posts in Utrecht (source: Municipality of Utrecht)

The Dutch knowledge network *OVLNL Smart Lighting* estimates revenues from commercial connectivity services such as 5G or WIFI at € 600 to € 1.200 per lamp post. In the long-term positive business case for the exploitation of connectivity services can be expected.

Business model lamppost chargers/LPC

An LPC offers a number of advantages compared to a regular charging station:

- A network of LPCs will be created at little cost with which we can charge cars at many places in the city. There is potentially room for a maximum of 1,800 of these charging points.
- It saves a lot of extra charging stations (and therefore cluttering public space).
- Lower cost of investment. A charging station costs 4,500 euros. It is estimated that the costs of an LPC will be much lower in terms of hardware, installation and operation. Prices of the LPC are to be determined but will follow soon. Expected hardware and installation cost are around € 1.500-.
- Lower exploitation cost:
- It can be installed without excavation work and the effort of the network operator. This saves a lot of time and the network operator is currently very busy with other work.
- It leads to more optimal use of existing assets and infrastructure because the existing connections and networks are used better. This also leads to cost savings.

5.3.4 Conclusions, lessons learned and next steps

To make conclusions on the pilot, we have to wait for the evaluation that is planned for the coming period. The lessons we have learned so far have to do with the procurement and realization process of the smart street lighting. So far, the outcomes have been used as input for a tender for the framework agreement for the procurement of new public lighting.

The most valued lessons are:

- The co-creation and design process leads to a solution that is more valuable to citizens and contributes to their problems and needs in a more direct manner.
- Currently, the city has procurement contracts with very technical detailed specified requirements for the demanded products and services. One question is if complex and innovative smart city applications can be specified in such technical detail up-front, or if a more functional approach could fit better. A functional specification of requirements leaves more room for innovative solutions from supply partners.
- Technical integration is complex. It is important to select a partner who can carry responsibility for system integration. This should be an important selection criterion for future suppliers of public lighting services.
- The city is working on the roll-out of 60.000 LED fixtures. Based on the experience in the IRIS project the city has proposed to install fixtures with a Zhaga connector, so the city is prepared for future IoT solutions and a permanent power supply becomes an option.
- The city also used the experiences with the development of the smart poles in the tender for the selection of a contractor for the placement of public lighting.
- One of the solutions for permanent power supply is to install low-power chargers in lampposts that are powered by the public lighting grid. This grid could supply power to approximately 1.800 charging points city-wide at 16 amperes at the installation cost of about € 2000 per charging point with very limited exploitation costs. A normal charger with a standalone grid connection cost € 2,250 per charging point for installation. This could potentially give a big boost to the charging network at a relatively low cost. The biggest advantage over normal public

chargers is that lamppost chargers are easier to integrate into narrow public spaces that we have to deal with in older inner cities.

5.4 Data service 3: 3D Utrecht City Innovation Model

5.4.1 Overview

Various smart city solutions are being applied in the demonstration area. The solutions are aimed at making the district's energy system more sustainable, in which battery storage, solar panels, heat pumps and charging stations work together smartly to use electricity efficiently and sustainably. In addition, smart street lighting is applied and tested with sensors using several sensors in public spaces. For example, air quality, noise and traffic speed are measured. The aim is to gain experience with the operation of these types of systems so that they can also be applied elsewhere in Utrecht or Europe.

The IRIS project aims to increase the involvement of residents in the transition of their neighbourhood. However, the visibility of the developed solutions is limited. Solar panels are invisible on the roofs, battery storage is a bare box and sensors on lampposts are not noticeable. However, behind all these solutions is data; the air quality, the amount of electricity generated, the status of the battery, etc. This 3D Utrecht City Innovation Model aims to make this data visible to residents in an AR application within the demonstration area and wants to develop a 3D AR experience.

Figure 47: 3D city model (digital twin) of Utrecht in Unity

5.4.2 Implementations

All data generated by these solutions in the district is collected in the City Innovation Platform (CIP). The aim is to unlock these data sets in an attractive application that can be used on a smartphone or tablet. The municipality has issued a challenge to develop this application on the game platform Unity. The party that has won the challenge has made a detailed application within Unity that shows the added value of 3D visualizations. The municipality offered a ready-to-use 3D model of the city available in the 3D gaming platform Unity (Figure 47). This makes the application a perfect use case for the further development of Utrecht's 3D ambitions on the one hand, and the added value in the IRIS project by informing residents of Utrecht and raising awareness about the complex challenges and benefits of a modern energy system on the other hand.

The relevant topics form the challenge description are:

Description of the challenge

The challenge is aimed at the development of an Unity AR application that informs the target group via their smartphone about the complex challenges and benefits of a modern energy system and smart city applications in their residential area. The user target group is residents and passers-by with an Android or iOS smartphone and without additional resources (think of 3D glasses or something similar). The municipality has not provided exact result descriptions and wanted to leave the call as open as possible and wants to be inspired. A possible result could be a game or a route through the neighbourhood, but other solutions that contribute to the stated objective are also possible.

Cooperative work process and maximum learning

The winner of the challenge was asked to work out the assignment together with the municipality. The involvement of residents and user groups was also desirable. Because the municipality also aims to learn about gaming principles and the Unity platform, we askedthe developer to develop the application within the Azure cloud of the municipality. In addition, the municipality made a GitHub available to secure sub-products, scripts and process documentation.

Requirements

In the tender the developer were asked to deliver an application consisting of a minimum of 5 from the 9 datasets below, from the CIP, through OGC services:

- Code of the 3D platform (explanation is in Readme)
  - https://github.com/GemeenteUtrecht/3d.utrecht.nl
- Package with asset bundles of land and buildings
  - Delivery by the municipality of Utrecht
- Battery storage status (state of charge profile)
- Location of batteries
- Location of light poles
- Location of energy pipes underground Location data cables and pipes
- Occupancy of charging stations (OCPI)
- Energy labels of houses (colour code)
- Location and status of PV plant

- Sensor data from sensor hotel (air quality, noise)

Delivered application was to be made available as a Unity web application one year after delivery and will be managed by supplier during this time. A total budget for the challenge was €25,000.;

5.4.3 Results

The challenge has been put into the market in early 2022. Below an overview is given of the setup of the challenge, the (co)design of the application and the functionality of the application. The results of the user experience with the application have been used to further shape the application.

Challenge

At the beginning of 2020, a market survey was conducted to investigate under which conditions Unity developers could participate in the challenge. Results from the market consultation have been reported in IRIS deliverable D5.8.:

- The budget has been increased;
- The number of required functions is limited;
- The number of datasets that have to be used is limited;
- The marketing of the application has been left out of scope;
- More insight has been provided into the API of the data sets to be accessed.

The challenge was published on the IRIS website in the spring of 2022. The team actively invited all companies who took part in the market consultation. Eventually, one company admitted an offer, and the team decided the entry was very promising. The relationship between cost and what was demanded was still challenging. In May 2022 the start-up Protofunk was selected, and their goal was to involve citizens in the energy transition neighbourhood.

Iterative design process

Protofunk suggested an iterative design process that resembles the way other IRIS solutions have been developed. The design process was done in four iterations.

Iteration 1

A kick-off meeting was held with the project team. A target group research was done that led to a refocus of the target group to primary school children. The game can be used in the IRIS educational program (see Transition Track 5). The testing implementation of different datasets and Digital Twin, setting up the Unity project. Interviews with residents of Kanaleneiland-Zuid and stakeholder sessions have been held (see Figure 48 for an impression of the first iterative step).

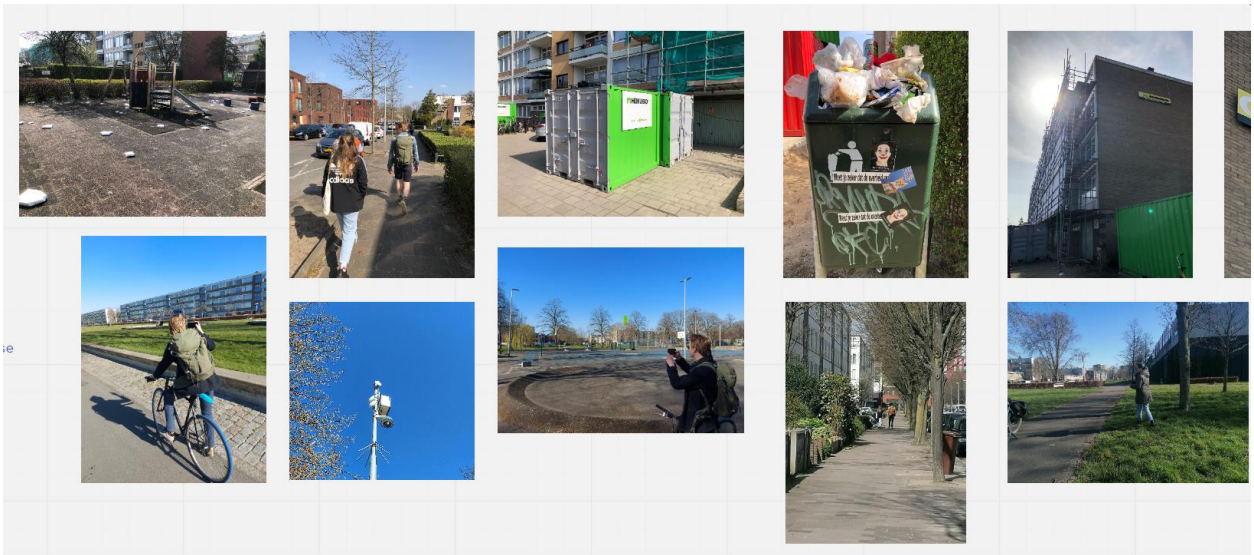


Figure 48 Researching the neighbourhood

Iteration 2

Co-creation session with the target group (school children). A first paper prototype was developed and tested with a user group and a school class (see Figure 49). A first digital minimal usable prototype was developed and tested in a stakeholder session. The development and testing led to many design changes in the application.

Figure 49 Testing the paper prototype

Iteration 3

The first playable digital prototype was developed with the integration of several datasets and assets in prototype. A concept design application and elaboration of UX/UI was made (Figure 50). Again, user testing with school class and other children has been performed. In addition, an online game test was preformed by online gamers that let to additional input. This iteration let to some changes in UI feedback, the minigames and gameplay.

Figure 50 The first digital prototype in which several datasets are integrated.

Iteration 4

Final design and elaboration application, presentation to involved stakeholders, deliver Unity web application/mobile application, and make it available via GitHub and (possibly) bug fixing. The application is available through: http://www.geengezeikindewijk.nl

Figure 51: Screenshots of the final game

5.4.4 Business models and exploitation

The municipality of Utrecht sees great potential in the 3D applications for both integrated urban planning and informing citizens about plans in their living environment. That is why the municipality has

developed a digital twin of the city in Unity and is seeking opportunities to use this digital twin. The developed solution in this task is a first application in which the digital environment is filled with real-life data and serves more as a proof of concept than as a solution with a business model. The potential for digital twin applications is great, but it is still very much in development.

The upside of the application/game is that it can be applied to different neighbourhoods in the same Unity digital twin. So, if there is demand from another school or program, the same application can be used and customised for that neighbourhood. This makes it possible to scale up the application to other cities. Already, other parts of Utrecht showed interest.

5.4.5 Conclusions, lessons learned and next steps

We have learned that it is possible to set up a 3D model that can inform residents about the smart city applications in their living environment. It is important to provide good insight into how the data is made available and made accessible for participants in the challenge. The parties also request a limitation of the required functionalities in relation to the available budget and the necessary freedom to give their own creative interpretation of the solution.

Even though we commissioned a market survey and adjusted the framework and requirements for the challenge, still we had only one entry for the challenge. So, it seems to be difficult to get the right question into the market with the right companies and the right budget.

In the design process, we learned that different iterations with user groups lead to a better product that is more in line with the expectations of the users. If and how that works out needs to be shown in real life use in the educational program, which will take place in the final months of IRIS and beyond IRIS.

5.5 Data service 5: Fighting Energy Poverty

5.5.1 Overview

Housing association Bo-Ex has the ambition to contribute to improving the financial position of its tenants. A large proportion of its tenants have a relatively low income and, after deducting all fixed costs such as rent and energy, less than 100 euros per month to spend freely. The objective is to develop a data service for tenants of housing corporation Bo-Ex, which gives them control over and/or a better understanding of their energy bills, resulting in reduced energy bills and increased disposable income for tenants.

Research: scoping of the problem

We started with research into the topic of energy use and poverty, which revealed that[10]:

- The energy consumption of households in comparable homes can vary enormously;

[10] Complete overview of used sources and finding is available in report Harmelink M, L Zanders (2019 “Evaluatie Challenge “Grip op uw Energierekening” (in Dutch available on request)

- The tenants have little / no insight into their energy bill because, for example, they do not understand the bill, insufficiently understand the Dutch language and/or have no knowledge of energy use in the home and what the influence is of their own behaviour;
- Chronic money stress leads to short-term thinking;
- Tenants consider energy use issues as a task for the housing corporation which they cannot influence themselves;
- Tenants value personal contact and are best approached from existing structures and are sensitive to positive incentives and framing.

The data service has been developed in two steps that will be described in this report.

1. An Energy Poverty Challenge was put into the market.
2. A combined effort was done to improve the existing energy advice service for tenants with energy data-based advice.

Implementation of the Energy Poverty Challenge

In 2019 an Energy Poverty Challenge was organized by the municipality of Utrecht. The objective was to 'challenge' both new and incumbent market parties to propose innovative solutions that allow tenants of social housing with a low income to get a better grip on their energy bill. An additional requirement for the market parties was to apply data sets available through the City Innovation Platform in their proposed solution.

In May/June 2019, the challenge was widely communicated and deployed in the Utrecht network. This resulted in 5 entries. 2 entries were ineligible, and 3 were invited to pitch their idea before a jury in July.

The challenge aimed for a suitable solution for tenants of social rental properties, with which they can get a better grip on their energy bill, lower their housing costs and increase their disposable income. The service must thereby meet the following conditions:

- Scalable, i.e., the solution must be replicable towards other areas/cities;
- Use (open) data that is made available through the City Innovation Platform (which is based on the open FIWARE architecture);

We also asked market parties who want to propose a solution that they:

- Have demonstrable experience with open APIs, mobile applications, and knowledge of data (flows)
- Are willing to share their knowledge and have the ambition to realize national solutions.
- Have demonstrable experience with co-creation of solutions together with end users

A total of 20,000 euros was available for the winning entry to further develop the idea into a scalable product or service. The winner was allowed to use these resources to further develop the idea supported by the incubation program of Utrecht Inc. Bo-Ex would act as a launching customer for their product.

Implementation of the Data Based Energy Advice

Home Energy Management System TOON is a dashboard giving tenants real-time insight into energy usage and costs. This already provides a big step toward controlling energy consumption and thus reducing energy poverty. Eneco has an extra data service developed that gives insight into energy spillage/leakage in the household. It tells TOON owners where energy inefficiencies and loss are

happening. Based on energy usage profiles, it shows stand-by losses, inefficient household equipment, etc.

In anticipation of the refurbishment of apartment blocks in the demonstration area, the HEMS TOON has been installed in 20 dwellings. The HEMS TOON is offered to the tenants of two other apartment blocks with 96 dwellings. In these dwellings, the TOONs are currently being installed. Also, in the apartment block with 48 dwellings that is currently undergoing refurbishment, installation of the TOON is planned. So, at the end of 2023, approximately 100 to 150 TOONS will be installed.

Together with different partners on March 25th, 2020, a workshop was planned to work out a concept to help tenants save energy using the TOON data.

Figure 52: HEMS TOON and Eneco Wast Manager

These partners took part in the workshop:

- Yvette Feld — Feldkracht
- Willem-Jan Renger — HKU
- Hanneke Peters — Eneco/Quby (TOON developer
- Jan Sanders — Eneco/Quby
- Jurgen Tielbeke — JMA/EnergieBox (Energy Advice BOEX)
- Kees Stap — Energiepaleis (Energy Advice private house owners)
- Patrick van der Hofstad — Stichting Technotrend
- Matthijs Kok — Gemeente Utrecht

In the workshop, a concept was developed of giving data-based energy advice to tenants and house owners and connect this to related initiatives like Energy Coaches and Energy Box (a box with energy saving materials like LED lights, water saving shower head, etc). Both Energiepaleis and JMA have an assignment from the municipality to give energy advice. Currently, energy advisors give advice based on a conversation and what they see in the dwelling. It would be helpful to collect data from a Home

Energy Management System (HEMS) like the TOON before the energy advisor starts, so the energy profile can be analysed to offer better, more specific energy advice.

The concept is worked out for the first apartment block where the TOONs were installed. Tenants would get the option to get a TOON and after two months they would get the offer to get an *Energiebox* (containing energy saving items like radiator foil, standby killers, douche timer, LED lights; see Figure 53) and free energy advice. A participant would need to sign that the HEMS TOON data will be used to optimise the energy advice, this also provides a legal GDPR basis for the processing of the data. Two energy advisors from JMA were educated to interpret the energy profiles that were provided to them via the CIP data connection. In this way, the advisors could add measures and enlarge possible energy savings.

Figure 53 Energiebox that is offered to tenants together with the energy advice

The measure was implemented in the second half of 2020 during the corona pandemic. A lot of effort was put into convincing people to install a TOON in their homes and to be open to energy advice. Due to the COVID-19 situation tenants were hesitant to do a TOON installation and even more to receive an energy advisor into their homes. So far about 70 TOONs have been installed, but energy advisors have only made 2 visits to these houses. Since the COVID-19 situation has become less of a problem, we expect to have some more advice over the next months, especially in the refurbished apartments.

In 2022 the first apartment blocks were refurbished, and the project got a continuation in a slightly different setup. BOEX assigned energy cooperation Energie-U to help tenants get familiar with their newly refurbished house. A visit from an energy advisor will be offered to all tenants. The energy advisors get a short course into how to use the TOON for energy saving so they can advise the tenants on this during the visit.

The tenants will be asked to sign a GDRP form allowing us to measure the effect of energy advice. This allows us to measure the effect of energy savings between the apartments where energy advice was offered and the average development of energy usage in all apartments. In this way, we can directly measure the effect of energy advice on energy consumption.

Results of the Energy Poverty Challenge

The jury was unanimous in its decision that none of the entries was of sufficient quality and, therefore, none of the parties received the budget of 20,000 euros for the further development of their idea. The main shortcomings were:

- Ideas were insufficiently in line with our problem "Grip on the energy bill" for people on low incomes. Ideas on how to reach this target group were insufficiently elaborated.
- In all cases, there was a lack of solid ideas about a good business case for scaling up the service to be developed.
- Unbalanced composition of the presented project teams, which reduces the chance of completing the incubation process.
- Parties who registered did not give the impression that they had insight into the possibilities of how to use the offered datasets and develop an innovative analysis/approach based on these data.

Results of the Data Based Energy Advice

- About 70 TOONs have been installed before the refurbishment of the apartment blocks, giving direct insight into energy usage before the renovation of the dwellings.
- A data connection between the CIP and the HEMS TOON has been established, giving input for KPI monitoring and improved energy advice.
- Two energy advisors have been educated to interpret the energy data and improve their energy advice for tenants.
- We have had four tenants that allowed us to use their TOON data for the energy advise on a total of 40 advises given. So it seems tenants are a little hesitant to provide the data and sign the form for this porous. The energy advise with the use of TOON data was not yet given at the time of publication of this document.

5.5.2 Business models and exploitation

Since there was no follow-up on the Energy Poverty Challenge, there is not much to say about potential business models or exploitation.

For the Data Based Energy Advice, partners see potential business opportunities. Currently, about 300.000 TOONs are installed, and multiple other HEMS are available and installed in potentially millions of households. If a system is developed that allows owners of a TOON or another HEMS to get offered energy advice based on their energy data, this provides a potential market for energy advisors. In the project, partners hope to get more insight into the customer journey, market potential, exploitation model and possible business models.

5.5.3 Conclusions, lessons learned and next steps

Lessons Learned of the Energy Poverty Challenge

We evaluated the challenge with a couple of people involved in the process. The following lessons were learned:

- Question: We asked the market the right question and were also clear about what we wanted. The requested product was a data service, but we could possibly have investigated even better whether the intended end users need a data service for this specific challenge. We might have been able to define the problem even more clearly, which might have led to parties being able to generate a better idea.

- Network: putting the challenge out into the right network of market parties and teams is challenging. We used many channels, all linking to the stakeholders involved in the IRIS project, and we also saw a peak in visits to the IRIS website. However, we do not know whether we have reached the right parties. During a previous, similar type of program (the 'Start up in Residence program' of the municipality of Utrecht) a budget was allocated to networking parties (such as start-up managers) for promoting the Start up in Residence challenges to the attention of parties. We do not have that marketing budget within IRIS.
- Requested result/product: we asked for a 'complete' product, a data service. However, experience with this kind of process shows that the price offered is too low to attract the right parties. The practical rule is 1:10: the development of an idea (a prototype) is 10% of the costs, and the realization of a complete product costs a factor 10 of this.

Conclusions of the Energy Poverty Challenge

- It generally seems useful to align the data-challenge/-development better with ongoing initiatives within the IRIS partnership. This enables more productive integration of the challenge results in ongoing processes.
- We, therefore, decided that further development of a data service would be linked to the implementation process of TOON. In this implementation process, we are going to try to find a user group that wants to be engaged in the development of a data service (with data via TOON and complementary data via CIP).

We furthermore concluded that instead of a challenge through a tender, it would be more effective to approach several parties with a good team of designers and experts (energy, behaviour, energy data) to sharpen the problem with a user group and realize a first idea (Minimum Viable Product, MVP). This is followed by a second step in which a product is developed based on this MVP with an entrepreneur, who can bring the product into operation. However, the question is how we can realize this second step within the IRIS project given the 1:10 rule.

Lessons learned and conclusions of the Data Based Energy Advice

Conclusions on the data-based energy advice are that it is possible to use HEMS data for optimisation of energy advice to tenants and potentially also house owners. Data connections are in place, energy advisors are committed and educated, the customer journey is working and GDPR issues are solved.

The tenants seem to be hesitant to give permission to use their TOON data. The view data we got was usable for the energy advisers to base their advice on, but the actual advice was not given yet at the publication date of this report.

6. Results of Transition Track 5 - Citizen engagement and Co-creation

The ambitions of this transition track #5 'Citizen engagement and Co-creation' consist of: design and demonstrate feedback mechanisms and inclusive services for citizens to achieve that citizens are motivated to (1) save energy, (2) shift their energy consumption to periods with abundant renewables and (3) use shared e-mobility instead of private cars.

KEY MESSAGE
The continued presence and communication in the district Kanaleneiland-Zuid leads to better connections with the citizens and also more participants for the different measures.
The personal approach with installing the Eneco TOON and personal connections with the social networks in the district have led to a good cooperation with the district. This also benefits the refurbishment actions in TT#1.
COVID-19 has hampered the progress , but by now it is again possible to organise events with citizens.
Next steps include extending the local network and execution citizen engagement activities at schools and in the district.

6.1 Overview

In this paragraph the designed measures and activities are explained including the timeline over the past five years and a forecast for the last half year.

Measures:

This Transition Track consists of 6 measures (initially 5 Measures, but increased to 6 due to the approved change of scope, refer to paragraph 2.1 of this Deliverable):

- Measure 1: Community building by Change agents
- Measure 2: Campaign District School Involvement
- Measure 3: Co-creation in Local Innovation Hub
- Measure 4: Campaign Smart Street Lighting
- Measure 5: VR New Home and District Experience
- Measure 6: Citizen engagement and Self-Maintenance within project Complex 507

The activities related to these Measures are executed in two districts in the city of Utrecht, the district of Kanaleneiland-Zuid and the district of Lombok:

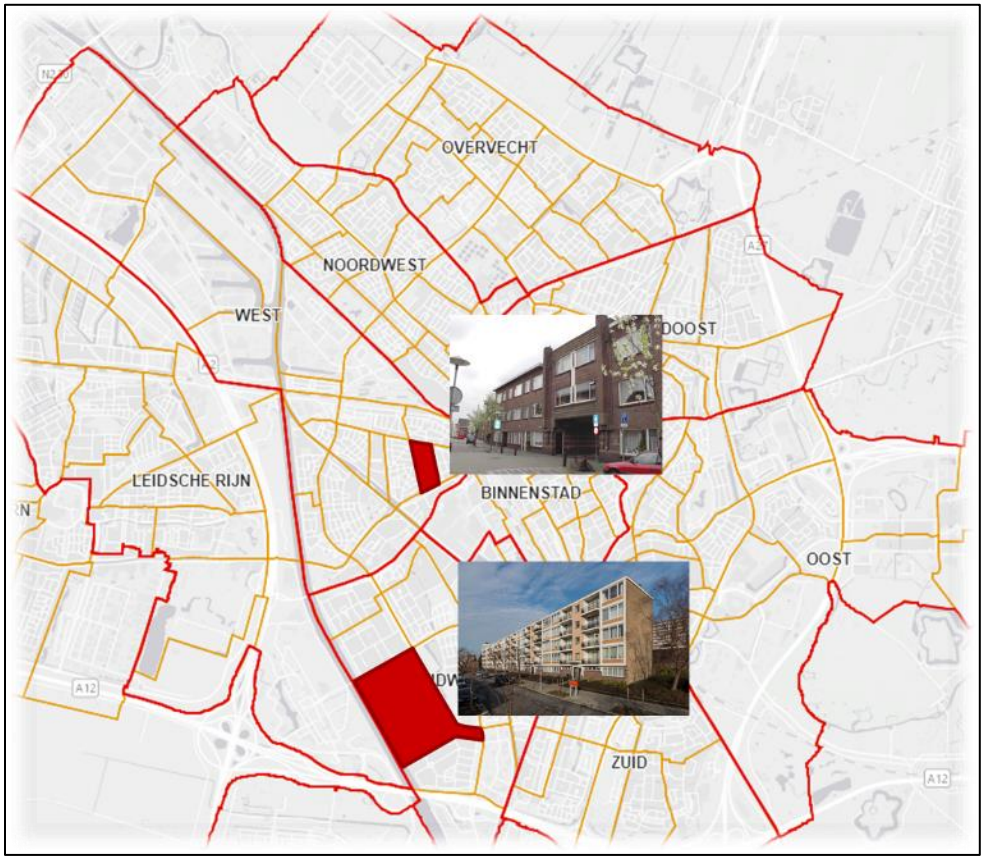


Figure 54 Overview of the demonstration areas in the city of Utrecht

6.2 Implementations

In this paragraph the implementation results of each measure are described.

In Deliverable 5.7, the 'Changed tactics' for the activities/measures in this Transition Track have been explained. The performed activities, experiences and lessons learned have been evaluated and led to clues to set up a different approach. This reconsideration of strategy and approach has been conducted by the involved IRIS Utrecht partners Bo-Ex, Municipality of Utrecht, HKU, LomboXnet, Energie-U and Utrecht Sustainability Institute. The change of tactics consists of a 'push' strategy towards the citizens. The first activity in which this has been tested is in the implementations of HEMS Eneco Toon.

By getting in contact with residents and gaining a better insight in the target group, we hope to create a better relationship and more engagement. This is key in the Utrecht demonstration activities, especially to get support of the tenants for the refurbishment plans, an important anchor of transition track #1 and dependencies with several of the measures within this transition track.

In the following description of results, other and new activities are described which initially were not part of the DoA. For example, the Whatsapp-group EnergieKanaleneiland was not an activity within Measure 1 (community building by change agents) but is a result of an iterative process as mentioned before. The same applies to Energiecoaching, the seminar with Bouchra Dibi, and the Climate Fair Marshallaan.

Measure 1: Community building by Change agents

- What has been implemented?:
  1. Informing tenants personally about IRIS projects: the company EnergieStudent and a tenant consultant of Feldkracht visited the tenants of five apartment buildings (Columbuslaan II, Alexander de Grotelaan I and IV and Rooseveltlaan I and II). The tenants were informed personally about the free HEMS Eneco TOON, individual energy saving options through the 'Energiebox' (an Energy savings box) and the upcoming renovation process. Furthermore, for each apartment building, a call amongst tenants was held to take part in the tenants committee that will be working on the upcoming renovation plan. With these visits, a social map of the buildings was created, which makes it easier to address social problems. Also, contact has been made and a first seed has been sown for more awareness and involvement in the renovation process.

Figure 55 Energiebox (soucre: www.energiebox.org)

  2. The residents Whatsapp-group EnergieKanaleneiland: in the demonstration district of Kanaleneiland-Zuid, a dedicated Whatsapp-group has been set up called 'EnergieKanaleneiland'. IRIS, together with two residents of Kanaleneiland-Zuid, is the initiator of this app group. In May 2021, this group counted 74 residents as a member of this app-group. In this app-group, all kind of news regarding sustainability and energy efficiency is shared. From this initiative, actions concerning litter pick-up, creating tiny forests and vegetable gardens have been realized. Also, IRIS related activities are shared, such as the Treasure Hunt, the sustainable weekend with the tour and jurors for the ChangeU hackathon. In januari 2023 a new group of Kanaleneiland residents is formed and organises green projects, such as greening squares and streets.
  3. Henriettedreef EnergieCoaching: In the summer of 2021, Energy Coaches from Energie-U visited the tenants of the renovated dwelling of the apartment building Henriettedreef in the district of Overvecht. The Energy Coaches gave the tenants individually insight in the relationship between the energy consumption and energy bills of the tenant, the correct use of all (new) facilities and installations in the home and the impact of behaviour. The tenants were happy with the practical instructions and are very positive about these visits.

4. Seminar Citizen engagement: how do you build trust? by Bouchra Dibi: Bouchra Dibi is a former resident of Overvecht and served eight years on the council of the municipality of Utrecht. She knows a lot about the issues of resident participation and the different target groups in the district of Kanaleneiland. In May 2022, Bouchra gave a seminar on how we can involve more Kanaleneiland residents in the IRIS projects. But also: how we can design future European projects in such a way that we take co-creation with residents into account beforehand. This seminar gave a better understanding of the people who live in the demonstration area, their believes and how you can approach and involve them.

Figure 56 seminar Bouchra Dibi

5. Seminar about the use of the IRIS stationary battery: In February 2022, IRIS Smart Cities, Nature and Environment Federation Utrecht / U-Thuis and Energy of Utrecht organized a seminar where entrepreneur Robin Berg of We-Drive-Solar shared knowledge about the use of a stationary battery and so-called Vehicle-to-Grid (V2G) electric sharing cars in the energy system. This was a great success, with over 80 people participating, of which many policy makers of the Province of Utrecht. Within the Horizon 2020 project IRIS Smart Cities, among others, We Drive Solar gained knowledge about the possibilities of using a stationary battery in a neighbourhood energy system. We like to share these lessons so that others can learn from them as well. The evening was particularly intended for local initiatives that had many questions about the business model of a stationary battery. In March 2023, a paper was produced on implementing a district battery, which contained the different parties within this initiative, lessons learned and the business case.
6. IRIS signs: In June 2022, signs with explanations have been placed at various locations where IRIS project activities are taking place. The signs feature a QR code that links to a website. The opening of the signs took place together with children from the Kaleidoskoop school (primary school within the demonstration area of Kanaleneiland-Zuid) and the director of City Companies of the municipality of Utrecht.
7. Climate Fair Marshalllaan: Climate fairs are being held at various locations throughout the city of Utrecht. A Climate Fair consists of several thematic stalls regarding climate issues, litter, housing sustainability, plastic garbage through fun games for adults and children. In June 2022, the Climate Fair was located at the Marshalllaan fairgrounds (within the demonstration area of Kanaleneiland-Zuid), IRIS contributed to this initiative. The

Figure 57 opening of the sign at the Smart Street Lighting project

Alderman for Sustainability of the City of Utrecht opened the Climate Fair and the fair was very well attended by Kanaleneiland residents.

8. Environmental chats: Together with the neighbourhood cooperative (Wijkcooperatie Kanaleneiland) and the neighbourhood information point, an Environmental Conversations course will be set up for and by residents of Kanaleneiland-Zuid and in collaboration with the mentioned Whatsapp group. Course leaders from the neighbourhood will be trained and together with the Utrecht Environmental Centre, Energie-U and residents we will create and teach the Environmental Conversations course. In January 2023, 7 fathers and mothers were trained to give energy lessons. Energy talks were held in 10 groups and 119 people were reached. In March and April, the 7 fathers and mothers will teach the waste and green lessons to their supporters.

- How has it been implemented?

  It is important that IRIS is visible in the neighbourhood, and that initiatives and projects are linked to IRIS. Residents can read about IRIS in the neighbourhood newsletter of the city of Utrecht. Furthermore, more and more tenants have had an individual conversation about IRIS activities such as the district battery, the upcoming renovation, energy savings or the HEMS Eneco Toon.
  Also, events such as a guided tour and the 'EnergieKanaleneiland sustainability market' are organized to involve residents. And the mentioned app-groups are an approachable means to learn, discuss and participate in initiatives that are organised in the district.
  In the Winter of 2023, and still running till April 2023, the tenants of the refurbished apartments (Alexander de Grotelaan II and III and Columbuslaan II and III) are visited by Energy Coaches. The Energy Coaches give tenants insight in the relationship between their energy consumption and energy bill, the correct use of all (new) facilities and installations in their dwelling and the effect of their behaviour. The Energy Coaches have also conduct an evaluation of the renovation project.

Measure 2: Campaign District School Involvement

- What has been implemented?:

  1. Primary schools:
     The first series of technical education lessons for pupils of primary school De Kaleidoscoop (in the district of Kanaleneiland-Zuid) were held by Stichting Technotrend (Technotrend Foundation) in 2018/2019. These lessons were quite a success and resulted in a programme of technical education lessons for pupils on three primary schools in the district of Kanaleneiland-Zuid for the school years 2019/2020, 2020/2021 and 2021/2022. The lesson series, called Energy Detective and the Treasure Hunt, planned for last year were cancelled due to the Corona pandemic unfortunately.

Stichting Technotrend therefore launched the online lesson series Energy Detective and the Treasure Hunt. These lesson series can be used in class at school but can also be used at home: pupils can follow the lessons/workshops at home and fill in the worksheets and submit them at school or digitally. Three schools in Kanaleneiland were enthusiastic about the series of lessons, but unfortunately none of them used it. Because of the Corona pandemic the schools focussed on keeping track of their children and pay attention to children who were underperforming due to the pandemic. The Treasure Hunt can also be carried out by parents with children, next to the school curriculum. In January 2022, the lessons restarted at three different primary schools in collaboration with the Globe College high school. Technotrend Foundation ('Technotrend') offers five lessons around the IRIS projects and the Globe College offers five lessons about technology and sustainability. These 10 lessons in total match with different issues in the district of Kanaleneiland-Zuid, awareness around climate issues, knowledge off the different IRIS projects and getting involved and introducing more students to technical professions.

Figure 58 The IRIS Treasure Hunt in Kanaleneiland-Zuid

In school year 2022-2023, a few things have changed. Class time has been extended to allow more time for lesson implementation. The energy detective lesson has been replaced for one that involves making a solar house from an old milk carton with a solar cell. All classes organise an energy market at school. And the game developed by Protofunk is played in all classes.

2. Secondary schools: IRIS seeks contact with secondary schools in the area to collaborate. A number of students from the UNIC secondary school designed a postcard for the District Battery project, the winning concept was used in the project. The secondary school X11, also established in the city of Utrecht, will organise and execute the evaluation of the smart street lighting in cooperation with the IRIS project leaders.
   In collaboration with Globe college in Kanaleneiland, we have worked on improving the Technology and Application module Sustainable Renovation over the past few months. Due to new teachers and family circumstances, the start of this module has been delayed and now set on 27 March 2023. This course will end just before the summer of 2023. Part of this course is the visit of a model house of the refurbished apartement buildings in Kanaleneiland-Zuid and guest lectures by Bo-Ex.
3. MBO schools (post-secondary vocational education): Technotrend works together with the MBO Utrecht and other schools to achieve:
   a. More primary and secondary school pupils to follow technical education (construction, installation technology, etc.) by getting the pupils acquainted with the subjects, the relevance and professional work.
   b. b. More internships/jobs for MBO students in the technical area, for example at IRIS projects. The MBO Utrecht has already had several interns at Bo-Ex. On this subject, Bo-Ex acts as client for 2nd and 3rd years students Architecture and Engineering for dedicated assignments regarding the refurbishment plans for the apartment buildings in the district of Kanaleneiland-Zuid.

c. Since 2021, Technotrend has been involved in the curriculum of the MBO Architecture course, level 4, from IRIS. Their role is to contribute to the curriculum from a network of companies in order to align the curriculum with what is happening in Utrecht, regarding the energy transition. The need and demand from companies was mapped out this year by means of a survey. More attention will also be paid in the curriculum to the sustainable side of architecture: the effects of insulation and all technical aspects of the energy transition. The revision of the curriculum is proceeding slowly but steadily and the planning for next year is to continue with this.

- How has it been implemented?
  Stichting Technotrend has regular contact and seeks coordination with the three primary schools in the district of Kanaleneiland-Zuid. Unfortunately, this was reduced to a minimum during the Corona pandemic last years. In the 2022-2023 school year, seven schools have indicated their intention to participate in the classes. However, 5 schools are participating. Two schools have capacity problems and therefore no teachers free to participate.
  Stichting Technotrend and project leaders of the IRIS project regularly consult with schools in Utrecht in, among other things, the 'Bouw = Wouw project'. The Bouw = Wouw project aims to make more pupils enthusiastic for technical education and jobs, especially in the poorer districts of Utrecht such as Kanaleneiland-Zuid.
  There is a network of (high) schools that meets regularly to share experiences and to look for new projects in which pupils can work together and receive assignments from the business community. This network meets once or twice a year. IRIS and Stichting Technotrend participate in these meetings. The education activities will proceed till the end of the IRIS project. And funding is being sought to continue the classes in the coming years.

Measure 3: Co-creation in local innovation hub

- What has been implemented?:
  1. HEMS Eneco toon installation process: the engagement and installation process of the HEMS Eneco Toon has been implemented in five apartment buildings. In chapter 2 of this deliverable numbers of installed Toons are presented.
  2. Treasure hunt Kanaleneiland-Zuid for children: a treasure hunt for children aged 10-13 along IRIS projects and other sustainable hotspots in Kanaleneiland-Zuid.
  3. Event EnergieKanaleneiland! This took place at the 8th of October 2021 (originally planned for October 2020): At this green sustainable market for residents of the district of Utrecht Kanaleneiland, residents are introduced in IRIS and other green initiatives and companies. The idea is to inspire residents, help them to become more sustainable and greener and to make them aware of what is going on in sustainable and green Utrecht.

4. SNAP (SNAP is the Dutch word for Understand) service: How to reach residents in their language? Residents often find communication via letters difficult and complicated. In the summer of 2020 we worked together with SNAP Service to find out how we can better communicate with residents in writing. The SNAP service is a toolbox that helps promote the readability of letters from civil service organisations, using ordinary people. Bo-Ex made a number of letters available to the SNAP Service. Ten residents and the SNAP Service have jointly read the letters and assessed their readability. The SNAP Service has made a list of what we can do to make clear, better readable and better understandable letters.

Figure 59 SNAP service meeting

5. Co-creation process with residents for the square of the district battery: On the square between Columbuslaan and Magelhaenlaan a District battery has been placed (refer to chapter 3 of this document). The square is old and rarely used. Owner of this square Bo-Ex wants to renovate the square together with the involved residents who live near or next to this square. Together with a professional gardener and based upon requests from people living around this square, a design is made for the refurbishment of this square. In March 2023 the realization of this new square has started and will be finalized in May 2023 and 'celebrated' with the people from this neighbourhood.
6. Jury of ChangeU hackathon: In March 2021 the ChangeU Hackathon took place. More than 70 students thought and worked on solving various problems in Kanaleneiland. Topics for the hackathon included: improving community health, public space, work for all, local energy transition. Fourteen teams of students came up with solutions for loneliness, better use of public space, an energy saving app et cetera. The hackaton was won by Room for Living. The prize was awarded by a group of professionals and a residents' jury, organised by IRIS. And Room for Living thinks along with the refurbishment of the square of the District Battery.

- How has it been implemented?

  During the incremental process of the HEMS Eneco Toon installation, the installation of the HEMS device is not the only desired result. The other objective is to get in touch with the tenants. When having a positive contact with a tenant, space is created to move on with other things. Such as becoming more aware of energy usages and also the Bo-Ex' call for becoming part of a feedback group (or tenants committee) for the upcoming refurbishment plan. In the first apartment building Columbuslaan II, a group of 6 out of 46 tenants has reacted positively of becoming part of a feedback group. Meanwhile several meetings with this feedback group have been held and the refurbishment plan for this apartment building becomes more concrete. The Corona

pandemic has influenced the schedule for the implementation process and delayed the installation process, but we're on track to get a lot of HEMS Eneco Toon devices installed within the lead time of the IRIS project. After the installation process of the HEMS Eneco Toon, tenants are requested by mail and phone to fill in a short inquiry. The outcomes of the inquiry helps Bo-Ex and their partners to further optimize the process of installation.

The Treasure hunt is included in the regular offer for the schools of Kanaleneiland, but also towards the sustainable weekend and after-school care.

The Event EnergieKanaleneiland! on 8 October has been organised with a group of residents (and the app group) and some local businesses. A number of Moroccan mothers made soup and savours. Companies from the Krachtstation (the neighbourhood cooperation) organised sports clinics and the communication for this event.

The SNAP Service gave us a number of tips that we consistently apply in our communication with residents (many residents get stressed when they receive a letter from the housing company, always put a phone number in a letter, keep it short, don't cover too many subjects at once et cetera.

The refurbishment of the battery square is completed in 2023. The followed path to this renewed square was as follow:

- In April 2021 Bo-Ex together with Energie-U and Lomboxnet sent out an information letter to the area residents about the battery and asked them also what they think of the square and what they want to do with the square. Citizens could respond by filling in a postcard or visiting an information event (see Figure 60).
- Children with ages ranging from 4 to 16 years have been asked what they use the square for. This has led to room in the design for playground toys for the younger kids and a place to chill for the older kids.
- Based on the outcomes of the inquiries, the landscape architect has set up two designs of the square including a wall paint, which is part of the renewed square. Besides, the landscape architect visited the area three times for a couple of hours to get into contact with users of the square and people who live near the square, to pick up ideas and details of the current use of this square. He also asked people to give their opinion on the two designs. In February 2022 the preferred preliminary design was chosen unanimously by Bo-Ex and the citizens (see Figure 61).
- In July 2022 the winning design was presented to the neighbourhood: all residents who live near the square received the plan and were asked to give any suggestion or ideas about the plan. With this feedback, the design was finalized in Autumn 2022.
- In Spring 2023 the winning design is/was realized. Due to the breeding season, some activities (felling of two old trees in a bad condition and planting two new trees) will be executed later in 2023.

TEKST EN FOTO'S **SELÉNE VAN DER POEL**

IRIS ontwerpt samen met aanwonenden nieuw binnenplein

Energie is duur en opslag van zonne-energie wordt steeds belangrijker. In Kanaleneiland wordt gekeken met project IRIS hoe opslag van zonne-energie kan helpen.

De buurtbatterij op het binnenplein achter Columbuslaan 1 t/m 109 is verbonden met zonnepanelen op een gerenoveerde flat van Bo-Ex. Met de opbrengst van de batterij krijgt het binnenplein gelijk een opknapbeurt.

Rob Vleeming van Hoveniersbedrijf Natuurlijk heeft samen met aanwonenden een ontwerp gemaakt. In het voorjaar van 2023 wordt het binnenplein omgetoverd tot een vriendelijk, goed verlicht en verzorgd plein met veel groen, vrolijke beplanting en speelruimte voor de allerkleinsten.

Binnenplein met buurtbatterij

"Met de buurtbatterij kunnen we kijken hoe opslag van zonne-energie kan helpen in de energietransitie. Het is belangrijk om eerst te leren hoe dat precies werkt," vertelt Ragnhild Scheifes, betrokken bij het IRIS project. Woningcorporatie Bo-Ex en deelauto bedrijf We Drive Solar, beiden betrokken bij IRIS, hebben de buurtbat-

"Met alle informatie van indrukken en gesprekken met mensen die ik in een paar dagen opdoe, maak ik een ontwerp," aldus Rob. Voor iedere groep aanwonenden heeft hij een aanspreekpunt waar hij het ontwerp aan heeft voorgelegd. IRIS heeft de lokale artiest Jan is de Man gevraagd een muurschildering te maken. "Het is een wens

MEER INFORMATIE

Wil je meer weten over IRIS?
Neem dan contact op met Rianne Bakker:
rianne@energie-u.nl,
06-4600 1684
of kijk op www.iris-utrecht.nl.

Figure 60 Article in the local magazine Zuidwester about the design of the battery location in cooperation with citizens.

Figure 61 Design of the square with more green and space to play and chill.

Measure 4: Campaign Smart Street Lighting

- What has been implemented?:

In 2018, a group of professionals together with area residents, used co-creation principles to think about the following question: How can smart street lighting contribute to a better/healthier/safer/more funnier neighbourhood for and from the residents and entrepreneurs in Kanaleneiland-Zuid? 11 concepts were created and in the end one concept won: the self-illuminating pedestrian crossing. A pedestrian crossing that lights up in the dark and is accompanied by two poles that detect air quality, traffic speed and movement. In a final meeting with residents in June 2020, a group of residents jointly decided where the pedestrian crossing would be placed. In May 2021 the self-illuminating pedestrian crossing was installed at the street Columbuslaan in the demonstration district of Kanaleneiland-Zuid.

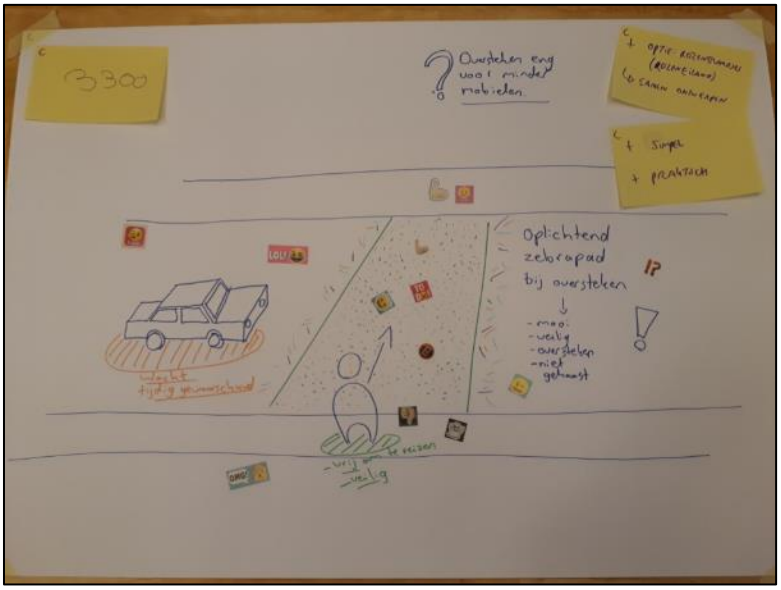


Figure 62 Outcome of a co-creation session about smart street lighting

New low-energy light bulbs: 50 low-energy light bulbs have been placed at the Columbuslaan. The fittings are dimmed and as soon as a car or cyclist approaches the light intensity increases. Once the traffic has left, the luminaires dim again. The light intensities can be varied. In this way, we save a lot of energy.

In November 2022, a group of 15 students from the X11 school in Utrecht evaluated the zebra crossing (Figure 63). Five groups investigated the opinion of residents of the realized zebra crossing. Four groups threw a poster/flyer through the letterbox at residents around the zebra crossing. The flyer contained a QR code that allowed residents to fill in a form with relevant questions. The response from residents was not high. A total of 17 residents completed the question forms. A group of students addressed five residents on the spot and interviewed them directly.

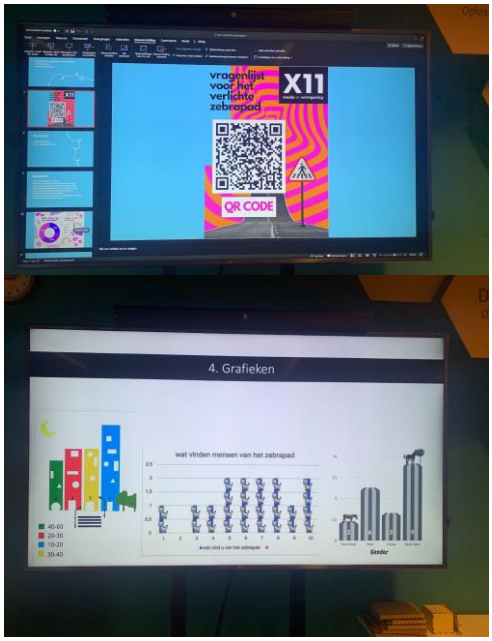


Figure 63 Evaluation of the zebra crossing done by students from the X11 school

- How has it been implemented?
  The design of the smart street lighting took place together with residents. The primary school The Kaleidoskoop was also involved in working out the options and the location of the self-illuminating pedestrian crossing. Luminext and their partners developed and installed the pedestrian crossing and the poles with the measuring equipment.

Measure 5: VR New Home and District Experience

- What has been implemented?:
  XR-experience (XR: extended reality) in physical and digital form: the HKU has designed and developed an XR experience. The aim of the XR experience is to enable tenants and pupils/students to become acquainted with energy saving (measures) in an enthusiastic and interesting way. The XR-experience is a kind of game and consists of two forms: the actual experience, a kind of television that represents a flat in which a lady called IRIS lives. By pressing buttons you can react to what is happening in the flat. You can turn the lights on and off, charge your phone, install solar panels, take a shower etc. At the end of the game you can see how energy-efficient you have been. The other form is the digital XR experience. On the website you can play the game, press the buttons and measure how energy efficient you are. You can find the XR experience here: http://huntedwumpus.nl/Box/

Figure 64 screenshot of the digital XR-experience

- How has it been implemented?
  Unfortunately the implementation of the XR experience was not a success. Technotrend, involved in technical education, was not happy with the design and user-friendliness of the experience. A lot of effort has been put in the development of this experience, thought it didn't work out yet to get the experienced used by many people.

Measure 6: Citizen engagement and Self-Maintenance within project Complex 507

- What has been implemented?:
  Self-maintenance is an answer on the needs of the tenants of Complex 507 to obtain more control and guidance on how the dwellings in this complex are maintained. Bo-Ex owns the dwellings in this complex and will remain the owner. At this moment, Bo-Ex is also responsible for the maintenance of the dwellings, not only the replacement of building parts over a time but also the everyday administration and tenant-contact. Bo-Ex fulfils these activities from their centralized

office. The tenants aim to have better maintenance, administration and communication when this is organized decentralized, with a local office in this complex. Self-maintenance is not a proven concept, it is used in situations where there tenants and/or citizens wants to have more control and influence on their living environment.
With self-maintenance the tenants of 353 dwellings in Complex 507, owned by Bo-Ex, aim: 'an office dedicated for the tenants of this complex which will result in fast action, better service, better maintenance, less bureaucracy and more customization. And even more important: more influence from the tenants on how things should go.' Thus the tenants of Complex 507 will have more influence in their neighbourhood. At this moment, the last open standing items are discussed between Bo-Ex and the tenants committee TC507. These items concern financial and governance arrangement.

- How has it been implemented?
Many meetings and (for some tenants voluntary) hours have been spent by a lot of people to set this plan. This plan has been designed from scratch and it took a long period before the framework was suitable, feasible and attractive for both Bo-Ex and the tenants. From 2017 till end 2019, this plan has been elaborated, also with the support of external advisors and an external chairman who led the meetings. In 2019, the principal framework was ready to officially submit to the tenants. During the period 2017 till begin 2019 several presentations have taken place to inform and involve the tenants of Complex 507. Based on this feedback information, the framework for self-maintenance has been elaborated. In the first half of 2019 independent tenants consultants have visited most of the tenants individually to explain and clarify the plan of the retrofitting works and self-maintenance. Based on the feedback of these house visits both the plans for retrofitting as well as self-maintenance have been adjusted and finalized.

Figure 65 Brochure self-maintenance for the support measurement end of 2019

In November 2019 the formal support measurement took place, parallel to the support measurement of the retrofitting works for this complex. The outcome of this measurement was

that 74% of the tenants of Complex 507 supports this plan of self-maintenance, enough to further finalize and implement this initiative!
Due to personal circumstances of the initiators, the implementation of Zelfbeheer has been delayed. The refurbishment works of the 353 dwellings in this district have been completed in October 2022. The dust generated by the refurbishment works have literally landed, the tenants have space for reflection and creating plans. We expect that in the summer of 2023 the self-maintenance organization will be formalised, and the first activities will take place by the new established self-maintenance organization. These activities consist of the assignment of a board with a supervision board for the new organization and the nomination of a local self-maintenance is scheduled for early 2023.

6.3 Results

With the executed activities within the described measures, several results have been gathered. Except for Measure 5 (XR experience), where the testing and implementation activities have been reduced by the Corona pandemic which makes it very difficult to reach the target group. Besides, the XR experience didn't work out as we thought it would. For most of the measures the monitoring data is still not sufficient and representative. In the coming and last period of the IRIS project, Bo-Ex together with their partners will focus on gathering validated monitoring data.

Experiences and feedback

The following table contains a summary of the experiences and feedback per Measure:

Table 6. Summary of experiences and feedback per measure in TT#5

Measure	Experiences and feedback
Measure 1: Community building by Change agents	The HEMS Eneco Toon installation process achieves positive results: more and more tenants chose for the Eneco Toon and people are informed about the refurbishment plan process in the future and respond on the call for becoming a member of the peer-group. The amount of members of the Whatsapp-group EnergieKanaleneiland grows and more and more sustainable initiatives by residents are planned. Energy Coaching at the tenants of the Henriettedreef apartment building worked out successfully. The two seminars which have been held resulted in knowledge exchange on the topics of resident engagement and stationary batteries were visited well. In the district of Kanaleneiland-Zuid signs have been placed on five IRIS project activities to show people what some physical results of the IRIS project. The Utrecht Climate Fair event visited the district of Kanaleneiland-Zuid. At this event, we informed residents/visitors about the IRIS project and results.

	In the design process of the renewed square of the district battery in district of Kanaleneiland-Zuid, citizens have been asked to give their input and subsequently response on two elaborated designs of which one design has the preference of the involved citizens as well as Bo-Ex. This design responds to the demand of creating a green, safe and pleasant place to stay or walk through. As part of the environmental talks, 7 trainers were trained to conduct short training sessions on energy saving and energy bills. 8 groups with 119 residents attended the training. In March 2023, 7 trainers were trained to conduct short training sessions on greenery and waste. Training of residents will take place in March and April 2023.
Measure 2: Campaign District School Involvement	The activities together with MBO-Utrecht are continued, the students and teachers appreciate the involvement of Bo-Ex and the possibility to work on a concrete project. The activities on the primary schools are being paused by the Corona pandemic unfortunately. The first round of activities held by Technotrend in 2018-2019 were successful. The lesson series on three schools in Kanaleneiland-Zuid for three school years fortunately resumed after the corona pandemic. Also activities on Globe college (secondary schools) started in 2022. In our experience, primary schools are keen to participate in IRIS but there is often a lack of available teachers. Over the past few years, the range and type of designed lessons and tools has evolved: the Energy detective lesson for example seems too much work for the teachers, but the game of Protofunk fits perfectly into the curriculum and responds to pupils' interests .
Measure 3: Co-creation in Local Innovation Hub	The experiences and feedback differs per activity: - HEMS Eneco toon installation process: the response of tenants on the call is rather high in comparison with other sustainable initiatives and services tenants can make use of. - Treasure hunt Kanaleneiland-Zuid for children is done by only a few children. The Treasure hunt is promoted to increase the amount of participants. - Event EnergieKanaleneiland! has been held in October 2021. The attendance of residents was rather low, for the next event we are committed to increase the amount of visitors substantially. - SNAP service: the participants of the workshop were pleased to participate and happy to give feedback on the communication style of Bo-Ex towards their tenants. - Co-creation process square district battery: people who live in the area are happy with this initiative (and no wrong feelings amongst other people). The design and process have been evaluated well.

	- Jury for the ChangeU hackathon: the participants of the Hackathon were happy with the input and feedback from the IRIS jury member.
Measure 4: Campaign Smart Street Lighting	Inquiries amongst involved citizens shows that the overall opinion about the realized solution is rather good (a score of 4 out of 5 on the likert scale, with 28 respondents).
Measure 5: VR New Home and District Experience	T.b.d. (no testing and implementation activities took place due to the corona pandemic and limited interest from the educational organizations).
Measure 6: Citizen engagement and Self-Maintenance within project Complex 507	More than 70% of the tenants of complex 507 (353 dwellings in total) supported the plan for self-maintenance End of 2019. Inquiries amongst the tenants of complex 507 will be held after the implementation of this initiative.

Progress of the KPI's:

For all the KPI's within TT#5 it is clear what information is requested and who is responsible for the information supply. But, this transition track consists of mainly social activities of which the effect is not easy to capture in a score on a likert scale. Eventually we would like to measure and describe the impact of the activities on people in the demonstration area. Therefore several sources are used and also the effect of activities is measured, not only quantitatively but also qualitatively. For example, the effect of a Whatsapp-group EnergieKanaleneiland is to be considered in relation to the total population of the demonstration area. We can measure the amount of participants, but this does not give information on the effect of this activity, the drivers behind this activity and the key participants in this group.

As mentioned, at this moment already some data is gathered from several measures. In the coming last months most of the data is gathered.

The following table contains an overview of the current state of each KPI within TT#5:

Table 7. KPI results in TT#5

KPI	Current state
Measure 1: Community building by Change agents: - increased environmental awareness - people reached - local community involvement	The sources for these KPI are the following: Increased environmental awareness: - district survey by Gemeente Utrecht with specific questions about sustainability: information is provided in 2022. The municipality yearly sends out inquiries amongst all the citizens in every district of Utrecht, of which Kanaleneiland-Zuid. In the last years, the response rate of citizens from Kanaleneiland-Zuid was very poor (the lowest of whole Utrecht). - tenants survey HEMS Eneco Toon and Refurbishment: in Winter 2022-2023 surveys are held amongst tenants of the four refurbished apartment buildings; - activities from the Whatsapp-group EnergieKanaleneiland and the new Whatsapp-groep are measured.

	People reached - amount of people who visit the IRIS website is measured (at this moment approx. 1600 visitors), see also Transition D10.10 (communication and dissemination); - reactions on IRIS on social media is measured, see also D10.10 (communication and dissemination); - amount of people who uses a shared V2G-car (as described in TT#2); - amount of members Whatsapp-group EnergieKanaleneiland is measured (at this moment approx. 70 members); - amount of visitors of several events: EnergieMarkt Kanaleneiland: 35 persons Informatieavond wijkbatterij (november 2021 and februari 2022): 310 persons Seminar Bouchra Dibi in 2022 (two events): 55 professionals IRIS signs: 20 persons (attended the opening) Climate fair: 50 persons - Enviromental talks: Eight groups with a total of 119 people attended the environmental talks energy training. The groups include coffee/bike and language groups, a savings circle, a group of Syrian refugees and several groups taking place at the pizzeria/café - Energy Coaching Columbus- and Alexander de Grotelaan: From February to April 2023: 75 tenants were visited and informed about energy saving and moving into their renovated homes en using them accordingly. The tenants completed a survey, the preliminary outcomes shows that the ease of use for the end-users is rather high (average of 4 on a Likert scale 1-5). But the outcomes also shows that tenants were not involved and exert influence fully on the presented refurbishment plans (average score of 3 on a Likert scale 1-5). Local community involvement - tenants survey DC pilot: for the first pilot the survey has been sent out; Results show that DC does not have advantages yet for tenants. It was decided to cancel the further implementation of the DC-pilot (see chapter 3) - in Winter 2022-2023 surveys are held amongst tenants of the four refurbished apartment buildings; - SNAP service workshop has been held. This workshop brought on several do's and don'ts for communication activities for the target group; - participants survey for the renewed district battery square, after the realization of the square; - participants survey smart street lighting have been send out in 2022.

Measure 2: Campaign District School Involvement: - people reached	People reached: Primary schools: - in school year 2018/2019: 150 out of 500 children have been reached (= 30%); - in school year 2019/2020: 100 out of 500 children have been reached (= 30%). - In school year 2020/2021: very few children have been reached due to the restrictions of the corona-pandemic, which caused that lessons on schools have been cancelled. - in school year 2021/2022: 171 out of 500 children have been reached (= 34%). - In school year 2022-2023 174 out of 500 children have been reached (35%) Professional education: - in school years 2017/2018 till 2019-2022: each schoolyear 20 students from the MBO Utrecht (high school) have worked on assignments regarding the refurbishment plans in Kanaleneiland-Zuid.
Measure 3: Co-creation in Local Innovation Hub - local community involvement	*Refer to Local community involvement at Measure 1.*
Measure 4: Campaign Smart Street Lighting - ease of use for end-users - advantages for end-users - local community involvement	For all the KPI's: - 22 residents were interviewed about the zebra crossing by live interview or questionnaire. About 60% of the interviewees knows the zebra crossing. The zebra crossing is perceived positively. The location of the zebra crossing is rated as fine because there is a school nearby. In the evening, the zebra crossing works best. Eight residents gave the zebra crossing a 7.8. (4 on the Likert scale 1-5) There were some comments: the lights shine into my house, people still drive too fast, it is dirty, maintenance is needed.
Measure 5: VR New Home and District Experience - ease of use for end-users	No data is gathered. Initially the corona pandemic caused a delay of the implementation of the XR-experience. Hereafter, Stichting Technotrend was not enthusiastic about the set-up of the experience and possibilities to implement this in the education programs.
Measure 6: Citizen engagement and Self-Maintenance within project Complex 507 - local community involvement in development process	The support measurement on this initiative resulted in 74% (74% of all the tenants are favour of this plan). Tenants survey about self-maintenance will be held after implementation (after the IRIS project has ended).

6.4 Business models and exploitation

The Measures in Transition Track 5 don't contain a Bankable Business model (financial nor societal) in the way these are executed by involved parties. Though there are measures which might be considered as a Key Exploitable Result:

- Measure 4 Campaign Smart Street Lighting contains a Key Exploitable Result in terms of a co-creation amongst citizens which can be applied on many subjects and in many circumstances to find the best solution for all involved parties.
- Measure 6 Citizen engagement and Self-Maintenance within project Complex 50 contains a Key Exploitable Result in terms of decentralization of maintenance tasks can result in lower exploitation cost due to a higher commitment amongst tenants regarding the maintenance of "their" assets.

6.5 Conclusions, lessons learned and next steps

In the last three years (from M30) a lot of activities in this Transition Track have been implemented, despite the corona pandemic. Of course, the corona pandemic suspended some planned activities such as the lesson series at primary schools. Also, the testing and implementation activities for the XR-experience, were suspended.. More than in the other Transition Tracks, the activities within this Transition Track are rather dependent on the response of tenants/residents. Some activities have shown to be a success, others not. This resulted in adjustments of activities (such as the HEMS Eneco Toon approach) and some new activities which contribute to the objectives of this track and of the IRIS project (such as the co-creation sessions with area residents of the district battery).

In earlier reports (report D5.7 and D5.8) and again in chapter 24 of this document, the reported major lessons learned for this Transition Track included the following two:

1. It is not easy to get in 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 to the tenants of Bo-Ex.

Still these lessons learned are actual and the most important for TT5, but we have achieved improvements on these topics. With the approach we follow to install the HEMS Eneco Toon, we came into personal contact with more and more tenants in an earlier stage. This resulted in a wider group of tenants who want to participate in the plan formation for the refurbishment: in 2021-2022 two support measurements have been launched successfully by Bo-Ex: the tenants of the apartment buildings Columbuslaan II and III supported the plan of refurbishment.

7. Results at the Lighthouse City Level

7.1 Introduction

Utrecht wants to be a sustainable and healthy city, in line with the ambition of 'healthy urban living'. A climate-neutral and circular Utrecht is a dot on the horizon. Utrecht has formulated two objectives in this area:

- Utrecht is saving energy and generating renewable energy
- Utrecht is a city with a healthy, quiet and safe living environment (as little noise pollution as possible, a safe living environment, clean soil and clean air).

Utrecht aims to be climate neutral by 2050 and has been working with a Strategic Energy Action Plan since 2015. In 2019, the Dutch national government presented the Climate Agreement; a package of measures to achieve a 49% reduction in CO_2 emissions by 2030. The Climate Agreement implements the 2015 Paris Climate Agreement.

In the Netherlands, the transition towards a sustainable energy system is split into electricity and heat. For electricity each city has worked together with other cities and municipalities in regions, to create a policy document named in Dutch *Regionale Energie Strategie.* In this policy document is stated how a region can generate sustainable power with wind and solar production. In the next 25 years this will be worked out and implemented, which will be facing challenges with net congestion. In IRIS we demonstrated the solution of V2G, which will be a key solution next to investments in grid reinforcements.

For sustainable heat, municipalities have drawn up a Transition Vision Heat. In 2022, the city council of Utrecht committed to a Transition Vision Heat for Utrecht, consisting of two parts. Part I of the Transition Vision Heat describes the strategy and vision. It sets out how the existing homes and buildings in Utrecht can gradually, and neighbour-by-neighbour, be converted to new forms of heating and cooking. In a way that is affordable and feasible for everyone. Part I was adopted by the municipal council on 3 June 2021.

Part II of the Transition Vision Heat indicates when and in which neighbourhoods we will start the preparations to become gas-free. In total, until 2030, about 40,000 homes will be involved, spread over 24 neighbourhoods. That is about 1/3 of the total number of homes. The rest will follow afterwards.

Besides energy, the city of Utrecht (as fast-growing city) is facing challenges to create a city that is healthy and a nice place to live in. A Mobility Plan 2040 was created in 2021 that contains an approach to create this healthy and reachable city. The approach consists of 5 steps (see Figure 66)

- smart zoning,
- travelling differently,
- networks in order,
- smart parking

- smart management.

And very important: we organise mobility in such a way that everyone can participate.

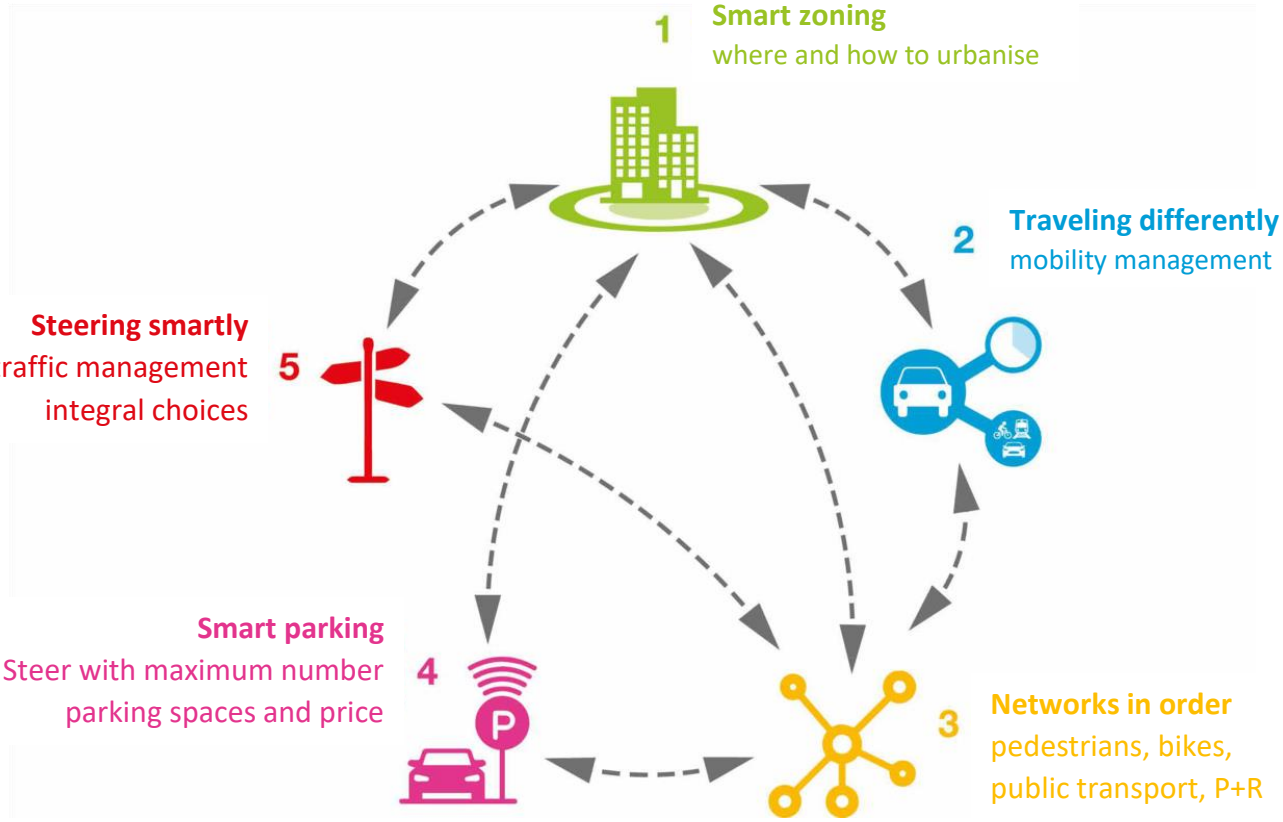


Figure 66. Five steps of Mobility Plan 2040, Utrecht

7.2 Impact on the Lighthouse City Level

Every year, the city of Utrecht writes a sustainability report to find out where we stand as a city and organisation in terms of sustainability. This report provides an overview of the state of sustainability within the Utrecht municipal boundaries. Attention is paid to:

- The policy objective on the various themes
- The results of implemented policies
- Utrecht's performance compared to Amsterdam, Rotterdam, The Hague and the Netherlands

At present, Utrecht is only at the beginning of a major revolution when it comes to energy supply in the city. Recent years have focused mainly on the emissions that the municipality itself can influence, such as the purchase of sustainable energy from its own buildings and installations. A plan has also been drawn up to make the municipal buildings more sustainable by 2040. Looking at the total CO_2 emissions in the city, this action is a small part of the total CO_2 emissions. Only when the large numbers of homes and businesses are made sustainable, and the energy sources are sustainable, will significant CO_2 reductions be reflected in the figures.

CO_2 emissions in the municipality of Utrecht were around 1.2 million tonnes in 2019. In the period 2015-2019 CO_2 emissions decreased by 16% in total. Despite an increase of number of houses with 5% and an increase in number of inhabitants with 6%, the overall energy usage only rose with 0,2% in the period 2015-2019. Installed solar energy capacity increased between 2018 and 2019 with 50% to 70 kWp (Figure 67).

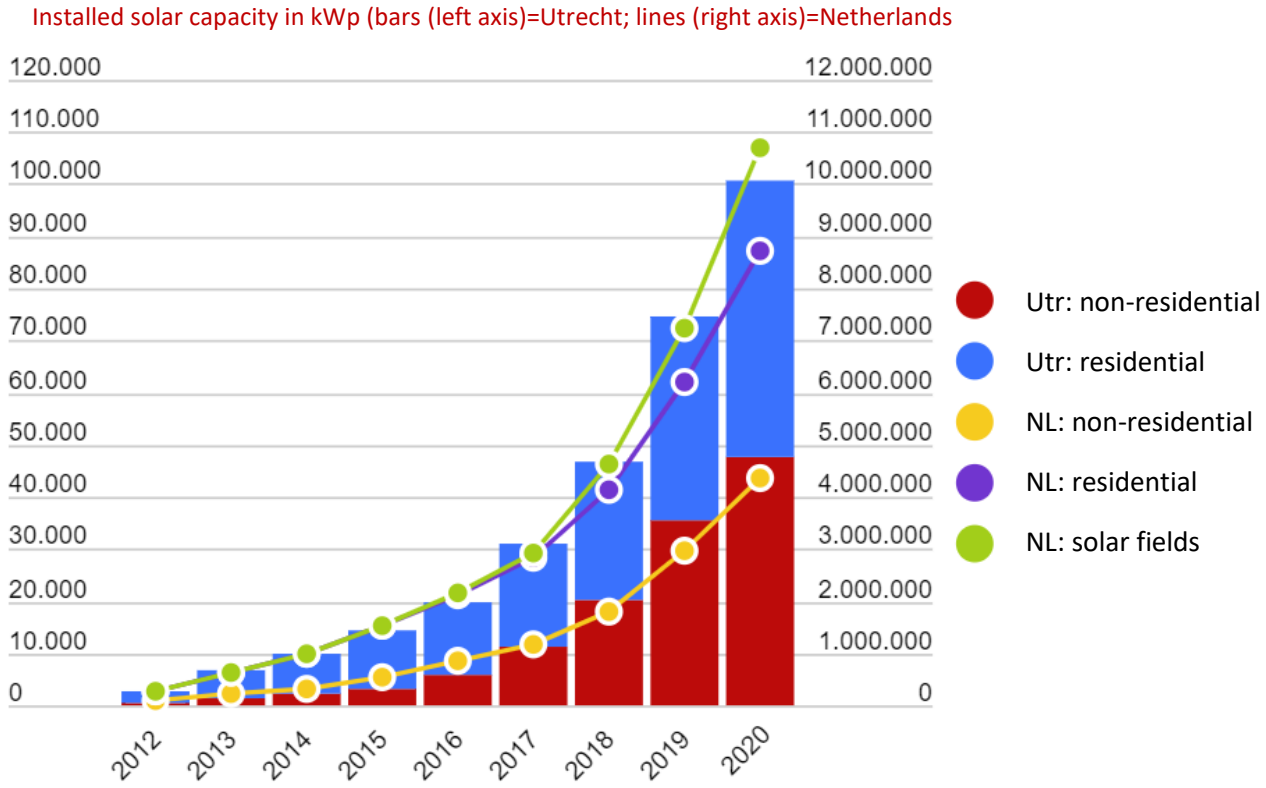


Figure 67. Installed solar capacity in Utrecht compared to the Netherlands (source: Klimaatmonitor RWS)

It is difficult to quantify the impact of the IRIS project to these results of the sustainability report. However, the IRIS project is a well-known project in the city of Utrecht and attention is paid to the progress and results by the city council, grid operators and local stakeholders in the district.

Especially, the V2G bidirectional ecosystem as detailed in chapter 3, has a huge impact at city level. It not only creates the results as described in chapter 3, but also leads to design criteria for new-built districts like Merwedekanaalzone, Carthesiusdriehoek and also for the redevelopment of areas like the transformation of the Jaarbeurs exhibition centre to become an integral part of the city centre of Utrecht. Also, the interest of car manufacturers like Renault, Hyundai and Sono Motors to launch their V2G-enabled cars in Utrecht, is an indication that Utrecht is world-leading in bi-directional energy-mobility systems.

Furthermore, Utrecht has the highest number of shared mobility compared to other big cities in the Netherlands (Figure 68).

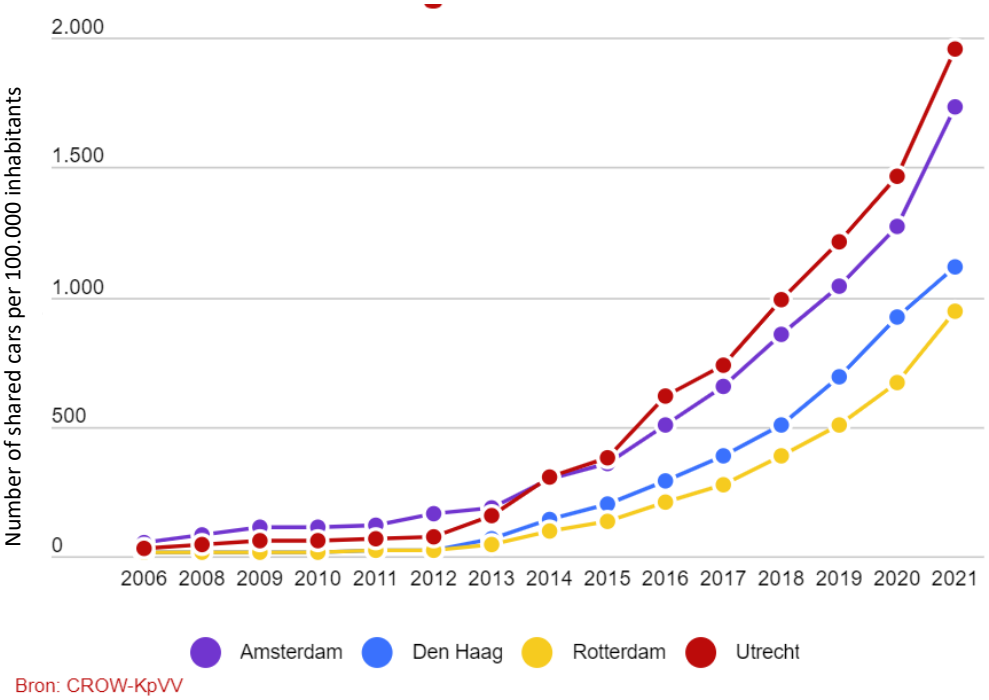


Figure 68. Number of shared cars in four biggest cities of the Netherlands

7.3 Conclusion and next steps

The IRIS project has led to networks of stakeholders that want to continue the cooperation in new innovation projects. For the refurbishment of mid- and high-rise apartment buildings, a new Horizon2020 project has been granted, as part of the European Green Deal call (LC-GD-4-1-2020). In this project, called ARV - Climate Positive Circular Communities, the renovation concept *Inside Out,* piloted at the Positive Energy Building in Overvecht, is being further developed and industrialised, aiming to speed up the renovation wave. And in January 2022 a proposal, called SCALE, has been rewarded in Horizon Europe, to scale-up and replicate the V2G-ecosystem and V2G-standard ISO15118, with involvement of a.o. car manufacturer Polestar. The involvement of Polestar is a direct success of peer-to-peer knowledge exchange between Lighthouse Cities Utrecht and Gothenburg. In 2023, the cooperation between Gothenburg and Utrecht is continued in the writing of a proposal that is connected to the e-buses in both cities.

The results of Utrecht activities in IRIS are and will be disseminated in the remainder of 2023 to other actions like:

- The neighbourhood / district approach for the heat transition: the aforementioned Transition Vision Heat will be elaborated into a district-by-district approach. The city of Utrecht wants to create citizen-inclusive approaches for its districts. A good connection to citizens and their wishes and needs is crucial to create an approach that will get good support from the citizens. One of the first districts that the city of Utrecht will work on this district approach is

Kanaleneiland-Zuid. Lessons learned, identified local ambassadors and social networks, stakeholder networks from the IRIS project are valuable to make this a successful approach.

- Implementation of shared mobility: In Utrecht, several new districts will arise in the coming years. The design of these new-built districts takes shared mobility into account, opening up a new design of space in these districts. Adding shared mobility and making it harder to park a private car, will motivate people to transition to shared mobility and using public space for other things like room for children to play, more possibilities for walking and cycling, more space for trees and green spaces (positive for preventing urban heat islands).

The IRIS project has helped the city of Utrecht a lot in its ambition to become climate neutral by 2050, and it is determined to build upon the results of the IRIS project.

Annex 1: KER table – Bidirectional Ecosystem

KER No. 3 Lomboxnet Smart Energy Management

Characterization of the result

Problem	The problem is the need for the electricity grid to robustly accommodate the expected large amounts of intermittent renewable electricity generation as well as growing loads from EV charging and electric / heat pump heating. This calls for new means to maintain grid balance and avoid congestion. We illuminate here the problem from a viewpoint of two main players: DSO (regional electricity grid operator) and municipality. From DSO viewpoint, the Dutch DSO's have in the past year published several press items and other publications on the need for rapid grid reinforcement in order to deal with the requirements of the energy transition: intermittent renewable energy generation, increased EV charging and increased heat pump utilization. DSO Stedin has published the estimation that up to 9 billion Euro is needed until 2030. Stedin has also identified V2G charging as a major factor in reducing these costs: potentially, V2G EV charging could almost totally eliminate the expected grid congestion problems and thus create grid stability with much less need for reinforcement of the Utrecht city grid. As grid congestion is at this moment already severely limiting the connection of new renewable energy generation and new houses and enterprises in the Utrecht region and all over the Netherlands, V2G EV charging is a spearhead at Stedin and other grid operators to reduce these problems. From a municipality viewpoint, the City of Utrecht has repeatedly expressed that electricity grid reinforcement has considerable impact on the city. Not only would possibly one third of all roads have to be opened to reinforce cables, but also a number of low voltage and medium voltage transformer stations would have to be placed into the existing city. These operations will be difficult, time-consuming and costly. For this reason, the city of Utrecht is proactively involved as it is in extending its Bidirectional Ecosystem.
Alternative solution	▪ For the TSO, alternative solutions are stationary batteries, curtailment of wind and solar and grid reinforcement. ▪ For the DSOs, alternative solutions are upgrading the grid by putting extra transformers on the street and cables in the ground; purchasing services from exploiters of stationary storage; curtailment of wind, solar or local electricity consumers; procuring flexibility services from companies. ▪ For municipalities, the alternative is to realise a number of new and/or enlarged low and medium voltage transformer stations within the existing city, and to allow the DSO to reinforce numerous underground power cables.

Strengths and weaknesses of these alternative solutions:

Alternative solution	Strengths	Weaknesses
Stationary batteries	Proven, relatively easy to implement.	Expensive, limited capacity (as compared to the needs of the grid)
Curtailment of wind and solar	Proven, relatively easy to implement	Counteracts the feasibility of renewable energy generation and thus of the energy transition
Grid reinforcement, extra / reinforced cables / transformers	Proven	Expensive, will take longer (workforce, planning) than required
Procuring flexibility services from companies	The GOPACS platform can serve as a place where flexibility services can be exchanged.	GOPACS is not yet accessible to smaller / distributed flex sources, such as EV chargers. The market is not yet well developed and prices for flexibility high.

Unique Value Proposition (UVP)

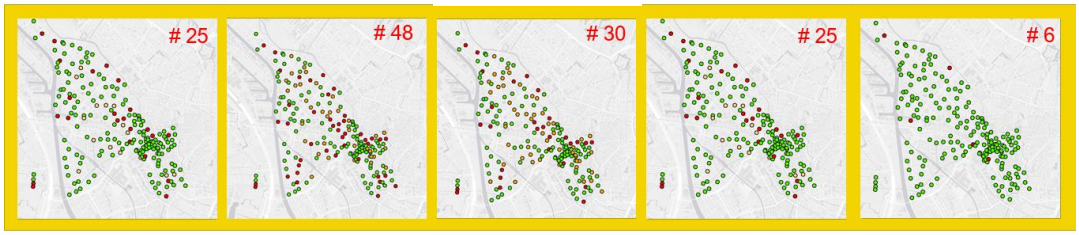
The proposition is that AC bidirectional charging as part of the Utrecht Bidirectional Ecosystem approach provides DSO's and cities with a new powerful means of electricity grid congestion management, which they will need to balance the fast-increasing network loads as a result of the energy transition. Because Smart Solar Charging utilizes batteries in e-cars that 'have already been paid for', the flexibility generated will be considerably less costly than that of its competitors.

The value consists of the use of existing assets to obtain large-scale grid flexibility, greatly and quickly enlarging electricity storage capacity by using AC-bidirectional charging of cars. Thus, the upscaling of EV charging can be turned from a problem (increased grid congestion) to a solution (decreased grid connection, even the potential to resolve grid congestion stemming from other developments such as upscaling of PV and heat pumps.

The adoption in 2022 of the ISO 15118-20 standard has provided a universal solution for car manufacturers and other users for AC-bidirectional charging.

Because the V2G chargers are downward compatible with regular charging stations, they can be used for both public smart charging and V2G charging of shared EV's. This greatly flattens the introduction / upscaling path for V2G infrastructure as compared to DC solutions, as the present roll-out in Utrecht shows (600 charging stations in 2022).

The smart / V2G charging approach has the potential to almost eliminate the expected local grid congestion, as calculation results by DSO Stedin and the Utrecht University indicate, and as illustrated in Figure 1. Scaled up to the level of city regions, this technology generates major positive impact on local congestion problems.

	 *Figure 1: "Opportunity map" made by DSO Stedin for part of the Utrecht city, visualising scenarios for 2035. : transformer station with load below 80% : transformer station load 80-100% : transformer station with load above 100% # 48: number of transformer stations in overload (total: about 200 transformer stations). The rightmost figure shows that dynamic EV smart charging with V2G can reduce the number of transformers in overload from 48 to 6, thereby almost eliminating the expected local grid overload as a result of EV charging, PV and electric heating.*
Description	A fully bidirectional ecosystem management system, combining smart charging electric cars, renewable energy plants, and storage in vehicles and stationary batteries with supporting structures as ICT backbone and user apps. The bidirectional ecosystem management system uses existing assets (cars, batteries, renewable plants) to sell flexibility/energy services to different energy markets and grid operators. The AC bidirectional charging stations are cheap and compatible to normal e-car charging, are therefore already being rolled out in Utrecht and other cities. Bidirectional shared e-cars connected to these stations will be managed by the shared car operator as a network of electric flexibility generators and will supply flexibility services to the DSO, thus enabling the grid to accommodate the increased loads expected as a result of the expected EV, PV and heat pump upscaling.
"Market" – Target market	The main final market is the European electricity market with as main consumers of the innovation: • TSO's and DSO's • Municipalities • EV owners For TSO's, networks of managed, shared, bidirectional e-cars will act as flexibility suppliers that will be able to offer flexibility on the national markets. For DSO's, the bidirectional networks will reduce local grid congestion and thus decrease the need for costly electricity network reinforcements. As described above, Stedin has estimated the expected costs to amount to up to 9 billion Euro in the Netherlands and sees V2G having the potential of V2G to almost eliminate local congestion. Urban municipalities face considerable spatial, financial, and urban development impact of the grid reinforcement that will be otherwise required. The amount of extra costs is being researched but avoiding or reducing that impact can save considerably on planning costs, legal procedures, and inconvenience to the public and companies. EV owners will save money (estimated at hundreds to thousands of Euros per year) when they can charge at moments when electricity is cheaper and can offer V2G flexibility

	services from their cars to the grid operators. The first market segment to be developed is shared EV car fleet owners; private car owners will follow later.
"Market" – Early Adopters	A first mover is DSO Stedin, which is an active partner to LomboXnet in developing the UVP and its benefits. Already contacts are ongoing with ElaadNL, a platform of DSO's in the Netherlands that represents the other DSOs in the country. We can add the City of Utrecht as first mover city from the municipality side. Early adopters are grid operators (TSO and DSO's), and urban municipalities with strong sustainable transport policies. After that, North-West European countries will probably be the next phase.
"Market" - Competitors	What local flex services are competitive depends on the cost effectiveness of the flex solutions. For instance, car batteries are already paid for, while in stationary batteries a large investment needs to be completely returned by flex services. This puts additional pressure on the business case. For hydrogen storage, similar arguments are valid as for stationary batteries. Additional flex services (TSO balance management, portfolio management) and further aggregation of flex sources can improve the business case. Smart charging is being developed and exploited by other parties, but not with the unique characteristics of the We Drive Solar approach: cheap, downward compatible V2G chargers that can also be used for conventional public charging; a growing fleet of shared EV's that allow intelligent management and smart / V2G charging; the shared EV's are always connected to charging stations when not in use, as opposed to publicly charged private EV's.
Go to Market – Use model	Sale of aggregated grid flexibility / congestion management services through aggregators and/or other ecosystem parties, to DSO's and TSO. Towards municipalities, the roll-out of the downward compatible V2G chargers is an interesting proposition, as most cities are expanding their charger networks.
Go to Market – IPR (Background)	The smart charging technology and the protocols used are open-source and actively disseminated, for instance as part of the development of the ISO15118-20 standard. The USEF and Gopacs flexibility platforms are open source as well; information on these platforms is freely available and the use is encouraged. The shared e-car management software is proprietary of partners of LomboXnet. It is used in IRIS as background knowledge.
Go to Market – IPR (Foreground)	LomboXnet does not claim ownership of any information generated within IRIS. Instead, sharing of the information and results is encouraged.

Go to Market (Timing)	• The bidirectional chargers are ready to market; • The AC-bidirectional cars are expected to market in 2023 (NB. Hyundai has launched its IONIQ5 in 2022); More in details the ecosystem is now being developed, validated and extended by: • Producing and exploiting bidirectional AC-V2G chargers based on ISO15118-20; • Developing marketing of flex services; • A new marketplace (GOPACS) is developed for this trade by DSOs supported by an open source 'Universal Smart Energy Framework' (USEF); • Promoting and implementing the use of the V2G standard by car manufacturers, charge point manufactures and aggregators (to bring the services to the customers: DSO and TSO). While the GOPACS market platform is still in development and early use, roll-out of the V2G charging stations and shared EV's is continuing with growth rates close to 50% per year.

Annex 2: KER table – Smart Pedestrian Crossing

KER No. 3 Smart Pedestrian Crossing

Characterization of the result

KER name: Smart Pedestrian Crossing	
Description	A smart pedestrian crossing including smart public lighting and luminous white LED strips in the crossing itself. The light is controlled by sensors that detect the proximity of traffic and pedestrians. Furthermore feedback is provided to approaching vehicles based on colours depending on their speed
Problem	In the area there was an unsafe traffic situation, including speeding traffic especially at night. It was decided to develop a smart solution for the traffic safety issue in combination with the replacement of the aging streetlight system in the area with energy efficient smart LED lighting. Hereby, the smart functionality of the street light system was utilized to add to the safety situation.
Alternative solution	Alternatives to increase the safety situation consisted of fixed traffic regulation obstacles, such as speed bumps
Unique Selling Point USP - Unique Value Proposition UVP	The remotely managed smart pedestrian crossing enables adapting the behaviour of the system after installation. Once installed, there is no need for any ground work in case a change in the functionality of the installation is required This saves costs and energy. Fixed systems would require a team to visit the site to make any changes in the system, including ground work. In fact the introduction of the smart pedestrian crossing means the replacement of a fixed infrastructure system with a smart electronics and software solution.

"Market" – *Target market*	The system can be applied in all traffic situations with a need to increase traffic safety and pedestrian crossings in particular. The target market therefore consists of lower governments (municipalities) that have responsibility for street maintenance and traffic safety.
"Market" - Competitors	The alternatives available to road owners are classical street furniture including speed bumps and other fixed obstacles. These can not be actively regulated and adapted to the actual environment (light/dark etc) or to the present situation (high/low traffic, speeding vehicles)
Go to Market – Use model	The business model for this solution consists in duplicating the installation at other locations. Since the system concerns a 'plug and play' solution with a working demo installation it can be offered to other municipalities. The system installation work and hardware will be sold to the client, whereby a software license will be offered to manage and monitor the system in operation.
Go to Market – IPR	As the developer of the integrated solution Luminext will be the commercial party offering the product in the market.
Go to Market – IPR	
Go to Market	After completion of the demo installation in Utrecht in Q2 2021 the system can be offered to other interested parties.