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Disclaimer

Executive Summary

This deliverable describes the progress in WP5.4: Transition Track #2 Smart energy management and storage for flexibility per end 2019 within the IRIS Utrecht demonstration project. Transition Track #2 focuses on four measures:

- Measure 1: Solar V2G charging points for e-cars
- Measure 2: Solar V2G charging points for e-buses
- Measure 3: Stationary storage in apartment buildings
- Measure 4: Smart energy management system.

The work in Transition Track #2 has progressed well. First actions have been taken and in 2020, most of the other actions are expected to be taken, such as the growth of the number of charging stations, installation of a stationary battery and the establishment of the Universal Smart Energy Framework (USEF) / Grid Operators Platform for Congestion Solutions (Gopacs) based smart energy management system.

The bidirectional charging/discharging stations will provide the infrastructure for the ambition to integrate smart energy management, combining sustainable transport with maximising self-consumption and reducing grid stress, and unlocking the financial value of grid flexibility. This is necessary infrastructure to demonstrate in the selected demonstration areas the opportunities for flexibility creation through district scale storage, combining the batteries from V2G e-cars and V2G e-buses with stationary batteries, supported by open ICT for interconnection, performance monitoring and new information services for aggregators, grid operators, municipality and citizens.

The e-buses charging stations will provide monitoring and data to research the ambition to integrate smart energy management, as well as an interesting case of how the large number of high-power chargers can best be connected to the grid.

The stationary battery will be installed in 2020. As the first tender resulted in the insight that present providers cannot safely install (second life) batteries in garage boxes of apartments, a new battery outside the building has now been tendered. The smart energy management system is being developed as a combination of stationary battery software and USEF/Gopacs methodologies.

Already, the impact of this work is becoming rapidly visible, as it is presently 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, a bi-directional ecosystem of V2G chargers and vehicles is created, which will work together with stationary storage, solar panels and other measures as a virtual power and flexibility plant. This bi-directional 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 open standard for V2G charging was launched by ElaadNL and the Open Charge Alliance. In November 2019, LomboXnet has installed 50 V2G charging points in the city of Utrecht and by April 2020, that number will have grown to 150. The number of smart charging shared e-cars presently in operation in Utrecht is now 50 plus an additional 10 in the region. Similarly, the bus company QBuzz is currently exploiting 13 e-buses in the city with two charging / fast charging locations; by summer 2020, 55 additional e-buses will be in

operation, plus two new large depots with in total 68 bus charging stations. The e-buses provide their services to the whole city; the charging stations at the bus depots will have their own medium-voltage connections and thus also act on city level rather than district level.

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 2023.

Table 1: overview of the demonstrators included in this deliverable.

Demonstrator	In a nutshell
Measure 1: Solar V2G charging points for e-cars	Brief summary: 18 smart solar V2G chargers in the district, at district scale interconnected with the PV-systems
	Expected impact: This measure has already led to city-wide scale-up of V2G-chargers, solar PV-systems and district energy management. This bi-directional ecosystem had its world premiere in May 2019 in the presence of King Willem-Alexander of the Netherlands and top executives of Groupe Renault. The bi-directional charging / discharging stations will provide the infrastructure for the ambition to integrate smart energy management, combining sustainable transport with maximising self-consumption and reducing grid stress, and unlocking the financial value of grid flexibility. This is necessary infrastructure to demonstrate in the selected demonstration areas the opportunities for flexibility creation through district scale storage, combining the batteries from V2G e-cars and V2G e-buses with stationary batteries, supported by open ICT for interconnection, performance monitoring and new information services for aggregators, grid operators, municipality and citizens. The bidirectional charging/discharging stations are installed in a demand-driven pace.
Measure 2: Solar V2G charging points for e-buses	Brief summary: 10 smart solar/wind V2G charging spots for e-buses in Westraven
	Expected impact: The e-bus charging stations will provide monitoring and research data for the ambition to integrate smart energy management, as well as an interesting case of how the large charging powers can best be connected to the grid.
Measure 3: Stationary storage in apartment buildings	Brief summary: District-wide additional stationary storage in 12 apartment buildings, including 2nd life batteries, interconnected to primary V2G-storage and PV-systems by green ICT
	Expected impact: The battery will make an important contribution to making the grid more stable and resilient, as well as provide an important component for the city-wide 'virtual power / storage plant' which will provide sustainable energy, emission-less mobility as well as flexibility services on low and

Demonstrator	In a nutshell
	medium tension levels.
Measure 4: Smart energy management system	Brief summary: District EMS, the district ICT platform providing interconnection and monitoring at district scale, allowing deployment of the Universal Smart Energy Framework (USEF, fundament of the business model 'Value of Flexibility)
	Expected impact: The USEF/Gopacs smart energy management system will for the first time assess the value to the TSO as well as to the DSO, of flexibility delivered at low / medium tension grids.

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List of Abbreviations and Acronyms

Abbreviation	Definition
BRP	Balance Responsible Party
CIP	City Innovation Platform
DoA	Description of Action
DSO	Distribution System Operator
EMS	Energy Management System
EU	European Union
EV	Electric Vehicle
FC	Follower City
Gopacs	Grid Operators Platform for Congestion Solutions
ICT	Information & Communication Technologies
IS	IRIS Solution
KPI	Key Performance Indicator
LH	Lighthouse
LHCSM	Lighthouse City Site Manager
LV/MV	Low Voltage / Medium Voltage
MaaS	Mobility as a Service
PoR	Programme of Requirements
PV	Photovoltaic
RES	Renewable Energy Sources
TSO	Transmission System Operator
TT	Transition Track(s)
USEF	Universal Smart Energy Framework
V2G	Vehicle-to-Grid
WP	Work Package

1 Introduction

This deliverable aims to describe the progress in T5.4: Smart energy management and storage for flexibility, in the Utrecht city.

The demonstration area for all the five transition tracks in Utrecht is situated in the district of Kanaleneiland-Zuid and the neighbouring area Westraven. The district is a densely populated multi-cultural district, characterized by social housing, schools and shops and a majority of households with a low income.

1.1 Scope, objectives and expected impact

The objective of this deliverable is to provide an overview of the work done, the plans for further implementation, updates to the planning and lessons learned so far, for the Transition Track #2: Smart Energy Management and Storage for Energy Grid Flexibility within the Utrecht Lighthouse of IRIS.

In a front running solar and EV city like Utrecht, grid flexibility and self-consumption, provided by storage and smart energy management, are prerequisites for accommodating high shares of both PV-generation and shared e-mobility. Grid operator STEDIN needs to accommodate large shares of renewables and e-mobility, while preventing grid stress due to PV-generation and e-charging peaks on the grid. Therefore, grid flexibility is crucial. Pre-proposal efforts have demonstrated the feasibility of the Smart Solar Charging system: shared e-cars and public transport e-buses are charged with solar power, demand driven and bi-directional (V2G), to be able to sell solar power to the highest profit. Activities will be focusing on the integration of a district wide power storage system for maximum grid flexibility and self-consumption, consisting of primary storage (V2G batteries of e-cars and public transport e-buses) and additional secondary storage (stationary batteries in all buildings including 2nd life batteries), demonstrating how grid stress and grid investments are minimalized and how to best deploy storage at district level, supported by an open ICT system for interconnection, performance monitoring and cost effective new information services for aggregators, grid operators, municipality and citizens.

The demonstration activities will comprise of the installation of:

- 18 smart solar V2G chargers in the district, at district scale interconnected with the PV-systems
- 10 smart solar/wind V2G charging spots for e-buses in Westraven
- district-wide additional stationary storage in 12 apartment buildings, including 2nd life batteries, interconnected to primary V2G-storage and PV-systems by green ICT.
- district EMS, the district ICT platform providing interconnection and monitoring at district scale, allowing deployment of the Universal Smart Energy Framework (USEF, fundament of the business model 'Value of Flexibility).

By further installing performance testing and measurement equipment, the ratio storage needed in e-car batteries to supplementary stationary storage will be analysed, allowing the optimisation of algorithms for integrated energy system, matching USEF standards.

The objectives for this Transition Track are to Integrate smart energy management and renewable energy storage for

(1) maximum profits of renewable power,
(2) maximum self-consumption reducing grid stress,
(3) unlocking the financial value of grid flexibility and
(4) optimizing the second life of car and bus batteries.

Transition Track #2 aims to realize an electricity grid capable of accommodating renewable energy and providing sufficient flexibility to create a robust grid that contributes to a self-supporting district.

1.2 Contributions of partners

The Key Partners in TT#2 are:

LomboXnet	MaaS "We Drive Solar" provider; TT leader.
Bo-Ex	Owner of the apartment buildings which host PV-panels and 2nd life batteries
Stedin	Owner of the electricity grid and individual grid connections
Eneco	Supplier of hybrid heat pump=0-7 with smart control in light of flexibility
Jedlix	Aggregator and supplier of smart management and charging strategy of 2nd life batteries and V2G-cars and V2G-chargers
Qbuzz	Local bus company, that owns and deploys e-buses and V2G-chargers and creating RES at bus depots with PV-panels

1.3 Relation to other activities

The Smart Energy Management system and storage of TT#2 play an integrating role between the local renewable energy production in TT#1 (Smart renewables and closed-loop energy positive districts) that might produce electricity production peaks as well as demand peak on the one side, and the smart charging vehicles in TT#3 (Smart e-Mobility Sector) that, if not managed correctly might produce partly coincidental electricity demand peaks. The aim is to learn about managing and aligning the demand and supply sources towards a more robust, stable solution that poses less challenges to electricity distribution and grid balancing.

The five Transition Tracks are embedded in the project as depicted in Figure 1 below. In the figure, TT#2 / Tasks 5.4 is one of the five Transition Tracks mentioned and this deliverable is one of the Deliverables D5.3-D5.7 mentioned.

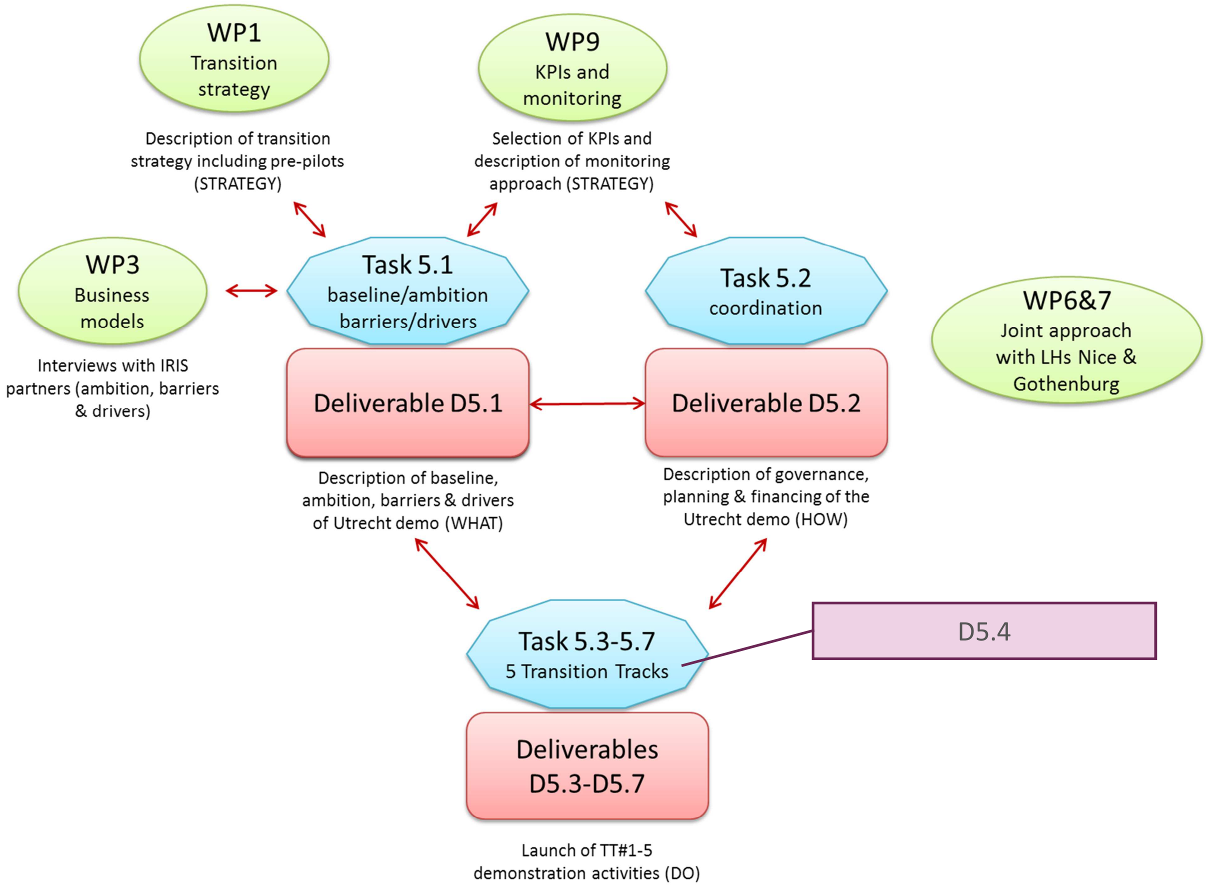

Figure 1.Relation of this Deliverable to other activities

1.4 Structure of the deliverable

In Chapter 2, the demonstration activities in TT#2 are introduced. In Chapter 3, baselines, drivers and barriers are discussed. Chapter 4 describes the organization of the work. In Chapter 5 to 8, each of the four Measures in Transition Track #2 is elaborated in more detail.

In Chapter 9, societal, user and business impacts are described. Chapter 0 deals with KPI's and their monitoring and Chapter 11 with ethics requirements such and GDPR compliance. In Chapter 12, links to other work packages are described and Chapter 13 presents conclusions and next steps to be taken.

2 Demonstration in a nutshell

2.1 Ambitions for TT#2

The DoA states that within the IRIS project Utrecht has the ambition to integrate smart energy management and renewable energy storage for

- Maximum profits of renewable power,
- Maximum self-consumption reducing grid stress,
- Unlocking the financial value of grid flexibility, and
- Optimizing the second life of car and bus batteries.

The ambitions are to include (1) solar V2G charging points and storage in e-cars, (2) smart charging of e-buses, (3) additional stationary energy storage partly by means of second life batteries (4) smart ICT to interconnect EMSs at home, building and district level, for the integration of maximal renewables production. The lighthouse project will demonstrate in the selected demonstration areas how to best deploy district-scale storage, combining the batteries from V2G e-cars and V2G e-buses with stationary batteries, supported by open ICT for interconnection, performance monitoring and new information services for aggregators, grid operators, municipality and citizens. The measures and *adapted implementation schedule* are listed in Table 2.

Measures	2017	2018	2019	2020	2021
Measure 1: Solar V2G charging points for e-cars/e-vans		4	14		
Measure 2: Solar V2G charging points for e-buses			10		
Measure 3: Stationary storage in apartment buildings			4 X 300 kWh		
Measure 4: Smart Energy Management System (EMSs)		Start	Extension	Extension	Complete

Table 2. Implementation Schedule (Source: D5.1)

2.2 Demonstration area

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

Figure 2 provides an aerial view of the district depicting the location of the first V2G-chargers, V2G-cars and 2nd life batteries and a display of the overall planning.

Figure 2. Aerial view of Kanaleneiland-Zuid with TT#2 planning (source: D5.1). See Figure 5 for location of e-bus chargers

2.3 Integrated Solutions in TT#2

In TT #2 the following two Integrated Solutions are demonstrated (see DoA P122 and D5.1 p17):

- IS-2.1: Flexible electricity grid networks and
- IS-2.3: Utilizing 2nd life batteries for smart large-scale storage schemes

The first Integrated Solution IS-2.1 Flexible electricity grid networks is implemented by means of all four Demonstrators in this TT:

- 18 smart solar V2G chargers in the district, at district scale interconnected with the PV-systems
- 10 smart solar/wind V2G charging spots for e-buses in Westraven
- district-wide additional stationary storage in 12 apartment buildings, including 2nd life batteries, interconnected to primary V2G-storage and PV-systems by green ICT.
- district EMS, the district ICT platform providing interconnection and monitoring at district scale, allowing deployment of the Universal Smart Energy Framework (USEF, fundament of the business model 'Value of Flexibility).

Also important for the implementation of this Integrated Solution are the controllable heat pumps and PV and the smart housing solutions in TT#1 that are described in Deliverable 5.3.

The second Integrated Solution, IS-2.3: Utilizing 2nd life batteries for smart large-scale storage schemes, is likewise implemented by the same Demonstrators, but here, the accent lies on the third Demonstrator:

- district-wide additional stationary storage in 12 apartment buildings, including 2nd life batteries, interconnected to primary V2G-storage and PV-systems by green ICT.

2.4 Integration of Demonstrators

The first three Demonstrators of TT#2 listed above (smart V2G car chargers, smart e-bus charging spots and additional stationary storage and the smart apartment solutions in TT#1 co-operate with the goal to enhance grid network flexibility, under the direction of the fourth Demonstrator (District EMS) as provided by the LomboXnet consortium in which Stedin also partners. In this way, an integrated network flexibility solution is created to collect demonstration experience, which also connects the 12 IRIS buildings to the nearby Westraven e-bus charging location towards a larger smart grid network on medium voltage level in the larger city district.

2.5 Deviations according to the Grant Agreement

With respect to the Grant Agreement, the following deviations are expected:

Measure 1 – 18 solar V2G charging points for e-cars / e-vans

No deviation.

Measure 2 - 10 smart solar/wind V2G charging spots for e-buses in Westraven

The Westraven location will feature 35 e-bus charging spots instead of 10, however these will not be V2G, as V2G technology for buses is not yet available. The bus company QBuzz has set up an extensive monitoring programme and has started a research action with Utrecht University, USI and LomboXnet to research the feasibility of V2G charging, smart charging and solar charging.

Measure 3: stationary storage in apartment buildings

It has proven not possible to obtain bids for stationary batteries to be placed in the garage boxes of the buildings concerned, due to safety concerns and spatial reasons. Therefore, the storage will be realized in the form of one 845 kWh storage unit in the public space of the district. With this capacity in place, the related IRIS Objective 2: Demonstrate smart energy management and storage solutions targeting Grid flexibility, will be achieved. The tender also resulted in a bid for 2nd life batteries with much lower battery capacity than new batteries, with less possibilities for development of energy management strategies for a similar price; in order to best attain the flexibility ambitions, after ample consideration the new battery bid was chosen.

Measure 4: smart energy management system

No deviations, other than that the USEF Framework will be used in conjunction with the Gopacs platform.

3 Baseline / Drivers and Barriers

3.1 Baseline

In the baseline, hardly any *public charging points* were available in the district of Kanaleneiland Zuid (see Figure 3). None of these were solar and/or smart-charging points.

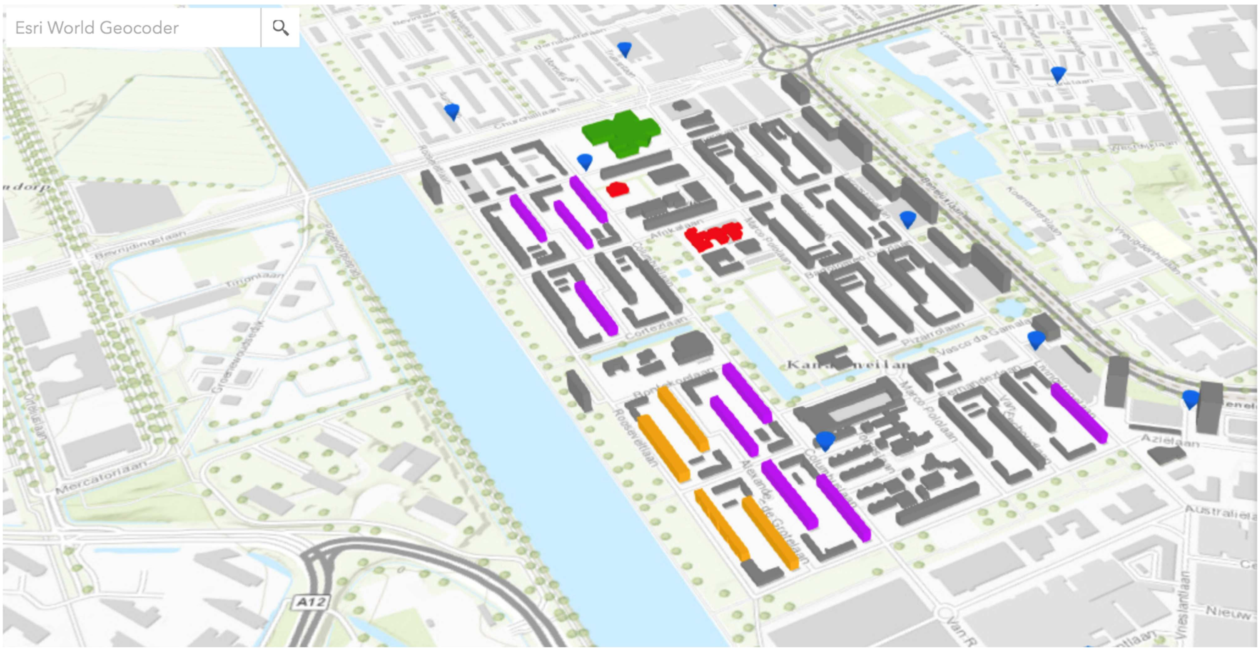

Figure 3. Location of charging points for electrical vehicles (marked in blue) in Kanaleneiland-Zuid. Source: Municipality of Utrecht

In the baseline, no e-buses were deployed or charged in or near the district. Also, there was no stationary storage of electricity in the district.

The *local electricity grid* in the demonstration area was designed in the sixties and includes three middle to low Voltage (MV/LV) transformers. This infrastructure is not outlined to accommodate for interventions taking place within the IRIS project and without changes there is a high risk of grid-stress occurrences.

3.2 Drivers and Barriers

The drivers and barriers for TT#2 identified in D5.1 (see D5.1, pp. 47-49) are given in boxes below and reviewed below the boxes:

Economic

- Investments in 2nd life batteries behind the meter are currently not yet economically viable. Without subsidies there is no business models for operating 2nd life batteries. Legal and financial circumstances need to be changed to ensure replication of the solution.

- Use of 2nd life EV batteries allows addressing the set priority of EU policy for circular economy and business development. The innovative re-utilization scheme can delay the recycling process and extend the useful lifetime of already used batteries up to 10 years, obtaining in the meantime new revenues. Additionally, by increasing the lifetime value of a battery, the cost for primary and secondary users will lower. Finally, the implication of these second-life batteries can enable a shift towards an EU renewables-based economy faster.
- The innovative re-utilization scheme can delay the recycling process and extend the useful lifetime of already used batteries up to 10 years, obtaining in the meantime new revenues.

These barriers and drivers have not essentially changed. The business model is still absent. A new experimental regulation is expected to be published by the end of 2019, in which a limited number of projects can apply for exemption from certain regulations in the national Electricity and Gas Laws, under certain conditions. These exemptions can be expected to generate a limited number of projects where exploitation and business models can be experimented with, in order to generate experiences and lessons for future adaptation of these laws. This is a new, extended version of the earlier regulation, which had only very limited effect: only a handful of actual projects were realised.

A learning experience from this project is that at this moment, 2nd life batteries of the size appropriate for this project are very expensive, even more expensive than new stationary batteries, due to low supply (EV batteries appear to have a better lifetime than expected) and high demand from a number of innovation projects.

<u>Sociological</u>

- It is yet uncertain which role households can and are willing to play in offering flexibility to lower grid stress.

From the contacts with the tenants in the IRIS district, this barrier was confirmed in the sense that the target group of multicultural social housing tenants does not appear to be interested in playing such a role. This is probably strongly connected to the fact that there are no financial incentives for households to do so.

<u>Technological</u>

- Equipment to monitoring performance of the electricity grid and the various components of the smart district energy system are well known and broadly available in the market.
- Utrecht has no experience yet in operating 2nd life batteries for storage of sustainable electricity and placing these in garage boxes with the apartment buildings. This implies that the demonstration will need to be carefully designed and performance of the batteries will be closely monitored.

The lack of experience described above has made itself visible during the tendering of the stationary batteries. None of the suppliers could deliver stationary batteries fit and safe for use in the garage boxes, forcing the project team to shift to a battery placed outdoors.

Also, the possibilities for smart control of the heat pumps (TT#1) are still under investigation.

Legal

- The government started a process to revise the electricity regulations with the aim to incentivise stakeholder to provide flexibility resulting in a lowering of the grid stress in periods of high demand or high production with renewable energy sources. Currently a "Regulation experiments under the electricity law" is in place under which stakeholders can apply to be exempted from the rules under the electricity law to e.g. experiment with maximizing electricity consumption behind the meter.
- Current regulatory barriers in the Netherlands for energy storage, in static as well as in E-vehicles these encompass:
    - Current netting rules do not provide any incentive for optimization of storage in batteries behind the meter. E-drivers with (their own) solar panels are not financially stimulated to optimally use the self- generated renewable electricity and the storage capacity from the car for their own electricity (peak) demand. [..]
    - Double energy tax discourages bidirectional charging. (Each charging and discharging cycle (bi-directional charging), energy tax needs to be paid on either the stored or consumed kWh. Private charging points at low-volume consumers are currently exempted from this rule. It is currently, however, unclear which regime applies to (semi-) public charge points.)
    - Uncertainty about the possible use of smart charging for the grid operator's congestion management. The Electricity Act currently prohibits regional grid operators to own/operated storage capacity themselves. It is unclear whether they may use the flexibility that can be accessed using storage in batteries.

See above under 'Economic' for a short update on the 'Regulation Experiments'. The other barriers are still in place.

Environmental

- Storage of electricity in 2nd life batteries can potentially lead to lowering of CO2 emissions as it enables higher shares of renewable energy sources to be integrated into the grid and reducing demand for peak capacity (which is usually fossil fuelled).
- The innovative re-utilization scheme can delay the recycling process and extend the useful lifetime of already used batteries up to 10 years. Reducing the mining of new raw materials.

The above barrier and driver are still in place.

Other drivers include:

- The municipality of Utrecht, triggered by the IRIS demonstration, 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 2023.
- As a DSO, Stedin has shown significant interest in the peak load reductions, in order to obtain more insight on the potential that the IRIS technologies demonstrated will have to avoid future investments in grid reinforcement.
- The recent Green Deal of the European Commission is expected to result in policy drivers, especially the ambitions on quick growth of the number of e-car chargers and e-cars.

4 Organisation of work

The Key Partners in TT#2 are:

LomboXnet	MaaS “We Drive Solar” provider; TT leader.
Bo-Ex	Owner of the apartment buildings which host PV-panels and batteries
Stedin	Owner of the electricity grid and individual grid connections
Eneco	Supplier of hybrid heat pump
Qbuzz	Local bus company, that owns and deploys e-buses and chargers

The work is organised as part of WP5, in collaboration with the other Transition Tracks.

5 Measure 1: Solar V2G charging points for e-cars/e-vans

5.1 Specifications

5.1.1 Hardware

Locally produced solar energy from the PV-panels at the roofs of the apartment buildings can be stored in cars via Vehicle2Grid technology: a smart and dynamic quick load and storage system. This creates flexible storage capacity that can reduce peak loads on the power grid. The stored energy is being used in the cars or released to the district at a later time, when energy demand is high.

A total of 18 solar V2G charging points for e cars will be deployed in the demonstration area Kanaleneiland-Zuid.

Main component	Technical specification
Smart Solar Charging system	• Custom Built by Siers BV • 22 kW fast AC charging and 11 kW discharging • 2 x type 2 IEC 62196-2, supporting mode 3 charging & IEC 15118-2 Vehicle Communication V2G-support • Immunity IEC 61000-6.2 Emission IEC 61000-6.3 • Compatibility: EV-ready / PTB eich-ambt • Multifunctional EV AC charging station controller supporting mode-3/ IEC 15118 charging G2V & V2G with 2 “type2” outlets with servo lock and LED signaling can be set-up using this controller. • The module can be managed by a Cloud back-office using OCPP 1.5/1.6/2.0 or LMS interfacing. Load management for smart grid applications is implemented in the built-in embedded software. • The controller can be inter-connected with the EVC52AC/ EVC52AC modules by CAN bus (slave module) to extend the number of outlets up to 24.

Figure 4: Two V2G charging points and We Drive Solar shared E-car at the Krachtstation, Utrecht

5.1.2 Software

The charging points are operated by the V2G smart charging software operated by LomboXnet. The charging points will be operated in such a way that evening peak loads are avoided and that the potential market value of V2G shared cars will be maximized.

Main component	Technical specification
Operating software	Charging system operated by software developed by LomboXnet / LMS: • Remote firmware update • The available power for charging will be calculated real-time on bases of public grid power and the Solar/wind energy power. • OCPP 1.2/1.5/1.6/2.0 or LMS protocol • Cloud back-office by LMS or by OEM using OCPP • A Local Micro Smart Grid function can be set-up adding two extra kwh meters on the mod-bus.

5.1.3 Procurement of equipment and/or services

The new, bidirectional charging stations used in IRIS have been designed and developed by LomboXnet and its partners mainly Last Mile Solutions and Siers. They are unique products, compatible with normal car charging hard- and software, and are produced by the company Siers, partner of LomboXnet.

5.2 Societal, user and business aspects

These are discussed on Transition Track level in Chapter 9.

5.3 Impact Assessment

5.3.1 Expected impact

The bidirectional charging/discharging stations will provide the infrastructure for the ambition to integrate smart energy management, combining sustainable transport with maximising self-consumption and reducing grid stress, and unlocking the financial value of grid flexibility. This is necessary infrastructure to demonstrate the opportunities for flexibility creation through district scale storage, combining the batteries from V2G e-cars and V2G e-buses with stationary batteries and smart apartments, supported by open ICT for interconnection, performance monitoring and new information services for aggregators, grid operators, municipality and citizens. See below and also 6.3.1 for more on how this will be analysed.

The IRIS Utrecht demonstration is presently serving as a living lab and a catalyst for fast upscaling of Smart Solar Charging points in the whole city of Utrecht. LomboXnet is rolling out the same technology in the whole city and even in the region around Utrecht city. In November 2019, LomboXnet has installed 50 V2G charging points in the city of Utrecht. By April 2020, that number will have grown to 150 V2G charging points throughout the city, and is on the path to unite these, and several stationary storage units, into a virtual power and flexibility system on city level. 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 2023 (see also Chapter 10).

5.3.2 KPIs

This measure contributes to the following KPI's of TT#2:

Table 3. Summary-list of KPIs and related parameters for Measure 1

KPI	Parameter(s)	Baseline	Target (as described in DoW or declared)
Peak Load Reduction	Peak load at all transformer stations in the district; peak load / load reduction at meter of storage; PV load (and effect of curtailment)	Baseline: the same measures (renovations, heat pumps, PV, e-cars, buses) without smart DEMS measures.	No target specified, because this KPI was formulated for research purposes. We hope to achieve a peak load reduction of over 10%.

5.3.3 Monitoring plan

The monitoring plan for the KPI Peak Load Reduction is being developed as follows:

- Stedin as the DSO for the district will monitor and store the peak load in all relevant transformer stations in the district, using additional monitoring equipment and data collection systems as part of the need to enhance more detailed insights on utilisation of the grid under the influence of the energy transition and the potential for grid stress reduction by applying flexibility. The exact transformer stations are not fully clear yet; at the time of writing this report, Stedin is planning the detailed monitoring system, in synchronization with the progress of the renovation of the apartments buildings. The peak load data will become available as peak load per hour or quarter.
- As a DSO, Stedin has shown significant interest in the peak load reductions, in order to obtain more insight on the potential that the IRIS technologies demonstrated will have to avoid future investments in grid reinforcement. Therefore, a pilot data service is planned to be established in the City Information Platform to supply that insight. In that data service, the peak load can be monitored, the reduction against the baseline determined and the calculated reduction offered as a service to the DSO.
- In order to determine the baseline, the peak load at each transformer will be estimated based on equivalent hardware (houses, heat pumps, PV, charging stations) without smart energy management. Stedin will do this according to their usual methods for doing this, so that the most realistic and commonly used baseline will be calculated.

The monitoring plan is being finalised and is expected to start monitoring in the second quarter of 2020 until the end of the project. Monitoring at the charging points starts immediately after the point has been taken into usage. Monitoring includes charging point usage, currents and powers. The monitoring data contributes to the monitoring plan to calculate the KPI’s. From the monitoring at the charging points, no personal information is stored. Monitoring and data handling are GDPR compliant.

5.4 Commissioning Plan

The charging points have been developed, engineered and produced by LomboXnet and its partners, mainly Siers. They are installed, tested and completed by the same partnership, mainly Scholt Energy.

Table 4: Commissioning Plan for this measurement

Phase	Activity	Parties involved	Responsibility	Relevant standard
1 Design	Design WeDriveSolar V2G charging points	LomboXnet, Siers	LomboXnet	Vehicle-to-grid in ISO 15118, OCPI, OCPP, OSCP (ElaadNL)
2 Engineering	Engineering of the charging points	LomboXnet, Siers	LomboXnet	Idem
3 Contracting	Contracting of production	LomboXnet, Siers	LomboXnet	Idem
4 Realization	Production and installation	LomboXnet, Scholt	LomboXnet	Idem
5 Testing	Testing after installation	LomboXnet, Scholt	LomboXnet	Idem
6 Completion	Commissioning	LomboXnet, Scholt	LomboXnet	Idem

5.5 Implementation plan

5.5.1 Planning of activities

The next post (two points) is being planned close to the location of the stationary battery (see 7.1.1). The other 8 charging points will be installed following actual demand and in connection to the larger-scale installation plan throughout the whole city (see also Chapter 10). The demand for the charging points is being actively stimulated with various actions (see D5.5).

5.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The main order for the contractor is assigned after sufficient demand has been observed.
- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

5.5.3 Risk management

In the Project Team and WP5 Coordination Team meetings, risks and their management are regularly discussed.

D5.2 does not list any risks specific for this measure. But it is good to mention here the risk that is connected to the fact that the charging points are placed following actual demand for e-car charging points in the district. From the view of citizen engagement as well as financially, it would not be wise to just place a number of charging points without any assurance of them being used. That has shown in other districts to cause serious resistance from conventional car owners, who see scarce parking places being converted to empty charging places. The demand-driven approach might lead to a larger, but also to a smaller number of charging points realized in the area than planned before. As we will discuss in D5.5, a number of measures have been taken to actively stimulate the demand for shared e-cars and charging points, in order to minimize this risk.

5.5.4 Progress achieved up to M24

In 2019 the following charging points have been realised:

- 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.

5.6 Conclusion

The realisation of V2G charging points for e-cars is progressing well with 8 of the 18 planned charging points realised and two others in planning. Demand stimulation measures are being taken to minimise the risk of the intended number not being reached within project duration.

6 Measure 2: Solar V2G charging point for e- buses

6.1 Specifications

6.1.1 Hardware

IRIS partner QBuzz is relocating its bus depot from the Europalaan in Utrecht to Westraven, a district just south of the IRIS district in Kanaleneiland-Zuid, and at the Remiseweg, across the Amsterdam-Rijn channel from Westraven. In this location QBuzz will investigate smart charging options at its new bus-depot with the objective to demonstrate and optimize smart charging. At this moment, 13 e-buses are in operation by QBuzz and by summer 2020, this number is expected to have grown to 68. In the DoA implementation of the 10 V2G charging points was anticipated, but the necessary V2G-technology for e-buses is not yet available, which means that the charging stations will not be V2G. Actual implementation of 68 buses on city level is now planned for 2020.

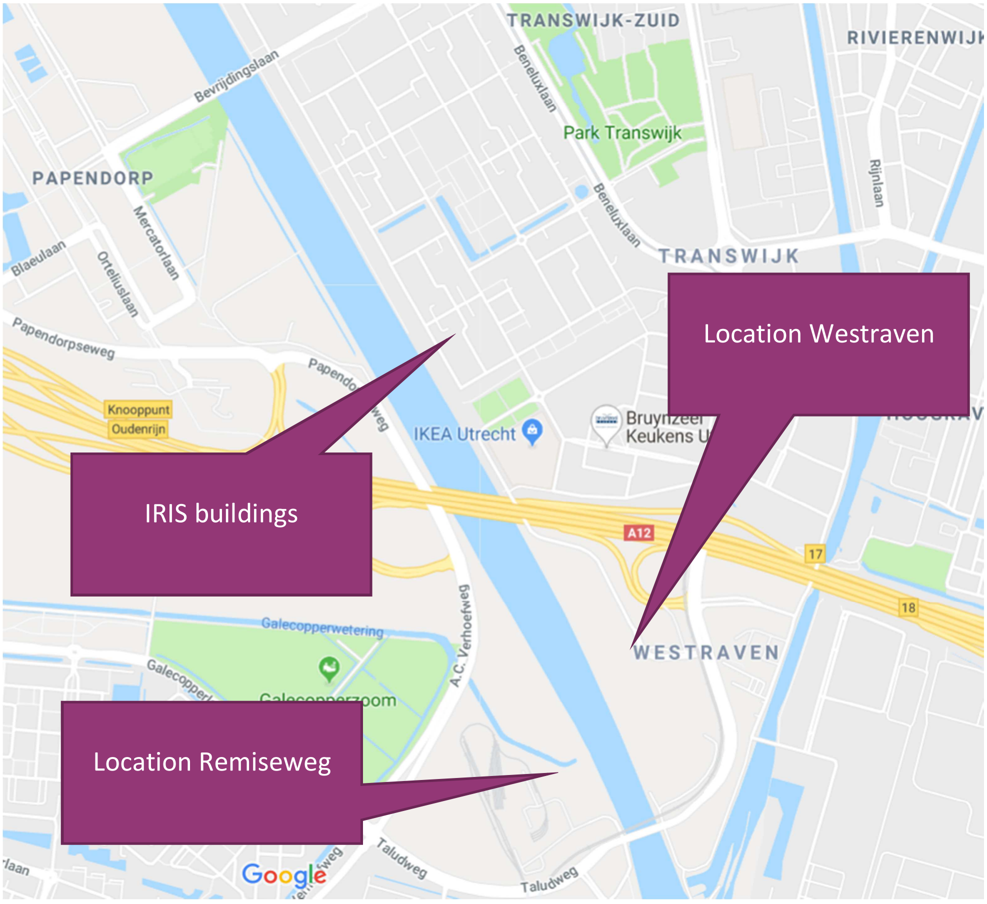

Figure 5: New e-bus charging locations of QBuzz

Main component	Technical specification
Qbuzz: electric bus chargers	• Fast charging power: 450 kW at 400V, using roof pantographs, connected to medium voltage grid • Normal chargers 30 to 100 kW, using plugs, connected to medium voltage grid • Charging time: 1 to 4 hours • Charging capacity at Westraven: 20 buses • Charging capacity at Remiseweg: 48 buses

6.1.2 Software

The chargers feature monitoring and data storage equipment, monitoring voltage, currents. QBuzz has appointed a Data Scientist to analyse the data being generated.

Main component	Technical specification
Qbuzz: software	• Monitoring of many parameters including voltage, current, State of Charge, operation of the accelerator and (for some buses) parameters per battery cell. • Collection and processing on Vericiti dataplatform for monitoring of charging power, past charging transactions, amount charged by each charger • Smart charging: peak shaving and load shifting

6.1.3 Procurement of equipment and/or services

QBuzz is realising the charging locations under own direction.

6.2 Societal, user and business aspects

These are discussed on Transition Track level in Chapter 9.

6.3 Impact Assessment

6.3.1 Expected impact

The e-bus charging stations will provide monitoring and research data for the ambition to integrate smart energy management, as well as an interesting case of how the large charging powers can best be connected to the grid.

A cooperation is being set up between QBuzz, Utrecht University, USI and LomboXnet to start to analyse the available data towards answering a number of research questions related to flexibility. These will be described below under 6.5.1.

6.3.2 KPIs

This measure will contribute to the KPI 'Peak load reduction' as discussed in 5.3.2.

6.3.3 Monitoring plan

The buses feature detailed monitoring and data storage equipment based on the Vericiti [5] platform, which continually monitors many parameters including voltage, currents, state of charge, accelerator usage and others. QBuzz has appointed a Data Scientist to analyse the data being generated.

QBuzz will cooperate with Utrecht University, USI and LomboXnet to research monitored data, see 6.5.1.

6.4 Commissioning Plan

QBuzz is procuring the e-buses and charging points at own costs (not in project budget).

Phase	Activity	Parties involved	Responsibility	Relevant standard
1 Design	Design of the chargers	QBuzz	QBuzz	
2 Engineering	Engineering of the chargers	QBuzz	QBuzz	
3 Contracting	Contracting of the chargers	QBuzz	QBuzz	
4 Realization	Realisation and installation of the chargers	QBuzz	QBuzz	
5 Testing	Testing	QBuzz	QBuzz	
6 Completion	Commissioning	QBuzz	QBuzz	

6.5 Implementation plan

6.5.1 Planning of activities

At this time, the two e-bus charging locations are being designed and realized under direction of QBuzz. At this moment, 13 e-buses are in operation by QBuzz and by summer 2020, this number is expected to have grown to 68; QBuzz is procuring these e-buses.

A research program has started in which QBuzz, Utrecht University (Copernicus Institute), USI and LomboXnet are cooperating in order to answer the following research questions:

1. What is the value of smart charging of e-buses in relation to electricity and network tariffs, is there a business case?
2. How does this value compare to a risk of an e-bus not able to complete its schedule, or of no local sustainable electricity being available?
3. Can the availability of e-buses for smart charging be predicted, for instance as function of air temperature or battery degradation?
4. Can battery degradation be predicted, possibly as a function of seasonal influences, driving behavior and other factors?
5. What is the impact of e-buses on the electricity grid (medium voltage level, congestion)?
6. What is the impact of e-buses on the IRIS district (houses, heat pumps, PV, shared cars) energy system?

These questions will be addressed in the next two years (first activities have started in autumn 2019) by UU students under coaching of scientists and using the district electricity system simulation model available at UU.

6.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, the following conditions are applicable:

- The purchase order from the contractor to the supplier is assigned shortly after the main order to the contractor.

6.5.3 Risk management

In the Project Team and WP5 Coordination Team meetings, risks and their management are regularly discussed.

D5.2 does not list any risks specific for this measure. While the buses will not actually be smart-charged, the data that QBuzz is gathering them will provide an excellent basis for the above-mentioned research on opportunities for smart charging and flexibility on a higher level (medium voltage network, city level), together with the 150 Smart Solar Charging stations that are being placed throughout the city of Utrecht this year by LomboXnet.

6.5.4 Progress achieved up to M24

At this moment, 13 e-buses are in operation by QBuzz in Utrecht and by summer 2020, this number is expected to have grown to 68. In the DoA implementation of the 10 V2G charging points was anticipated in 2019. Actual implementation of 68 buses on city level is now planned for 2020.

6.6 Conclusion

The implementation of this measure ensures a good basis for quantitative research on the value of flexibility provided by e-buses and e-cars on city level.

7 Measure 3: Stationary storage in apartment buildings

7.1 Specifications

7.1.1 Hardware

The third measure in this Transition Track is the establishment of stationary electricity storage. As will be explained below, after a first tender for batteries in the garage boxes did not deliver acceptable results, a battery outside one of the building has been procured.

Figure 6: Planned new location for the stationary battery

Main component	Technical specification
Stationary batteries	Type: lithium-ion battery pack in outdoor enclosure Capacity: 845 kWh Power: 590 kW / 630 kVA Grid connection: new, in transformer house Inverters: bi-directional with DC-to-DC converter System warranty: 10 years, extension up to 15 years Safety: system complies to IEC 62109, UL 9540, UL 1741 and others.

Figure 7: Location of battery and new grid transformer station (source: RFP energy storage system)

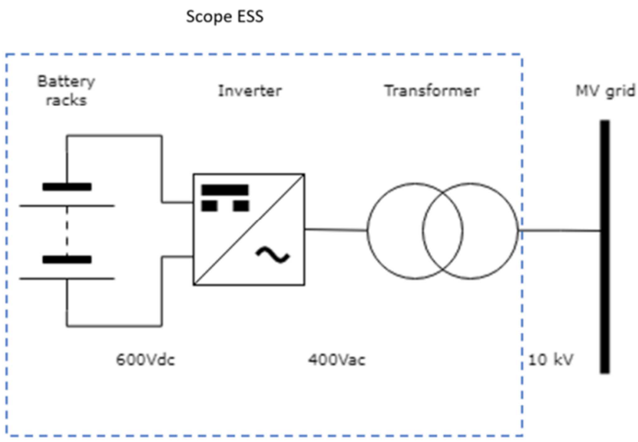

Figure 8: Electric connection of stationary battery (source: RFP energy storage system)

7.1.2 Software

LomboXnet and Bo-Ex are setting up the exploitation plan for the battery. The battery will deliver a mix of flexibility to the TSO, local flexibility and storing PV-power, which will be tailored to the research and development needs of the project. The battery software will be able to respond to flexibility requests from the DSO Stedin with flexibility and price offers, so that flexibility negotiations can be made with the DSO on the USEF/Gopacs platform.

Main component	Technical specification
Battery software	Tesla Powerpack Controller coordinating the operation of the battery system with ability to communicate with external controllers Onsite monitoring of Site power, Site reactive power, Battery power,

	Energy available, Energy remaining, Energy exported/imported @ battery meter, Voltage, Current, Power targets. Telemetry for Powerpack, solar PV, net load at grid interconnection, and 3rd party generation assets, for a fully-integrated view of the site Compatible with LomboXnet system and District Energy Management System Able to make flexibility offers to DSO upon request

7.1.3 Procurement of equipment and/or services

Procurement of these stationary batteries has required significant time and effort. A first tender for second-life stationary batteries in the garage boxes of the building did not deliver acceptable results. The main lessons learned have been that second-life stationary batteries of the size needed for this project are presently relatively expensive, more expensive than new stationary batteries, as the price for these has dropped steeply in the last years. A second lesson was that it is hard to find any stationary batteries suitable for the garage boxes in the apartment buildings they were intended to be placed in. This was related to the size of the garage boxes and to safety concerns.

For these reasons, a second tender was issued for a stationary battery to be placed outside, near a new-to-be-built transformer house close to one of the buildings, see Figure 6. In the second tender two bids were received: one for a second life battery and one for a new battery. It has turned out that the bid for the new battery offered almost 50% more battery capacity than the bid for the second-life battery for a similar price. Apart from that, the new battery bid offered more electrical power, better aesthetics and a better track record. As all these factors are important for the IRIS ambitions, LomboXnet and Bo-Ex, who directed the tender and selection, have selected the new battery bid (from Tesla) for realisation. The fact that the battery will not be a second life battery is more than compensated for by the advantages of the Tesla battery bid, mainly the capacity being almost 50% larger and therefore closer to the target, the higher power and the better track record.

The stationary battery will have its own electricity grid connection. PV-panels will be installed near the battery, behind the battery connection meter, and used for direct charging of the battery. The battery is expected to become operational in spring 2020, depending on the time needed for the new transformer and electrical connection to be installed. Bo-Ex and LomboXnet are still making arrangement for the exploitation model of the battery and are planning to finalize this early 2020.

7.2 Societal, user and business aspects

These are discussed on Transition Track level in Chapter 9.

7.3 Impact Assessment

7.3.1 Expected impact

The stationary battery will make an important contribution to making the grid more stable and resilient, as well as provide an important contribution to the city-wide 'virtual power / storage plant' which is being developed to provide sustainable energy, emission-less mobility as well as flexibility services on low and medium voltage levels (see Chapter 10). The responses to the DSO flexibility requests will enable analysis of the value of those flexibility services.

The total capacity of the stationary batteries is aligned to the available IRIS equipment budget. This will not impact the main related IRIS objective (Objective 2: Demonstrate smart energy management and storage solutions targeting Grid flexibility.) because with the stationary storage capacity of 845 kWh this demonstration will still be feasible in the Utrecht district demo site.

7.3.2 KPIs

The battery will make an important contribution to realization the KPI 'peak load reduction' as discussed in 5.3.2. Also there is the KPI 'Storage capacity installed', see the table below.

Table 5. Summary of KPIs and related parameters for Measure 3

KPI	Parameter(s)	Baseline	Target (as described in DoW or declared)
Storage capacity installed	kWh storage capacity installed	Present storage capacity (zero)	845 kWh

7.3.3 Monitoring plan

Monitoring is foreseen to start immediately upon delivery, installation, connection to the grid and commissioning of the stationary battery, and to continue at least until the end of the IRIS project.

Bo-Ex and LomboXnet are still designing the way the battery is operated, but probably, LomboXnet will operate the battery and be responsible for the monitoring and data collection.

7.4 Commissioning Plan

The battery is tendered, procured, owned and operated by LomboXnet and Bo-Ex.

Phase	Activity	Parties involved	Responsibility	Relevant standard
1 Design	Design of tender	Bo-Ex, LomboXnet	LomboXnet, Bo-Ex	
2 Engineering	Engineering of battery system	Tesla	Tesla	
3 Contracting	Contracting	Bo-Ex, Tesla,	Bo-ex	

		LomboXnet		
4 Realization	Tesla	Bo-Ex, Tesla, LomboXnet	Tesla	
5 Testing	Tesla	Bo-Ex, Tesla, LomboXnet	Tesla	
6 Completion	Tesla	Bo-Ex, Tesla, LomboXnet	Tesla	

7.5 Implementation plan

7.5.1 Planning of activities

The selection of the bid in the second tender took place in November 2019. The battery is expected to be realized in spring 2020; the electrical connection is expected to be installed as soon as possible; depending on current lead time at the DSO this might occur later in the year.

From this moment on the battery is fully operational and will be operated, thus being able to provide flexibility while other parts of the projects (building renovations, e-cars and charging points, PV, e-buses) are being realized.

7.5.2 Planning of costs and (equipment) investments

The tendering procedure contains the request to provide maximum power and capacity within the available IRIS budget. This has resulted in a battery capacity of 845 kWh and a charging / discharging power of 590 kW.

7.5.3 Risk management

In D5.2, the following risks were identified for the stationary battery:

Table 6: Risks related to the stationary battery (source: D5.2)

Transition Track	Identified risk Utrecht	Mitigation measures Utrecht
TT#2	1. No viable business case for 2^{nd} life batteries without subsidies 2. No garage boxes become available to place the 2^{nd} life batteries	1. Legal and financial barriers will be addressed by starting a EU-wide lobby on smart charging and use of storage as flexibility source 2. Bo-Ex has a few garage boxes for its own storage, that can be used Tenants are encouraged to stop renting garage boxes by a small financial compensation 3. Carefully design the demonstration

	3. No prior experience available in Utrecht with 2nd life batteries in garage boxes 4. Regulatory barriers regarding self-consumption, smart charging strategies, double energy taxes could hamper the replication of 2nd life batteries	(safety, loading capacity of floor, etc) and closely monitor when implemented 4. Learn from the Utrecht demonstration and use lessons learnt in EU-wide lobby.

At this point, we can make the following remarks on these risks (numbering refers to Table 6):

1. Presently, the only business model available is delivering flexibility to the TSO (The TSO for the Netherlands is Tennet). As described above, the battery will be operated to do this, while also offering and negotiating local flexibility to the DSO and buffering PV-electricity. Lobby activities are being carried out to improve regulations with this respect. With double energy taxation on the battery operation (see under 4 below) the business case will not be positive without the Horizon 2020 subsidy under current regulations.
2. As discussed above, the first tender led to the important lesson that it is hard for present stationary batteries to be installed in the garage boxes of these buildings. Therefore, the battery is now planned to be installed outdoors.
3. See above under 2.
4. Present regulations will indeed influence the battery operation, as it will be impossible for the battery to contribute to direct self-consumption of the PV on the building because it will be connected through its own grid connection. Also, when delivering flexibility to the TSO, the battery current will have to pay double electricity tax. These barriers and several others still seriously hamper replication. Lobby activities are being carried out to improve this. Specifically, for 2nd life batteries, the lesson learned that these are presently more expensive than new batteries will provide a further market barrier for replication of 2nd life batteries. However, this situation will change rapidly in the coming years, as many more used EV batteries will become available for 2nd life use as a result of the present boom in the electric vehicle market.

7.5.4 Progress achieved up to M24

The second tender was concluded in November 2019

7.6 Conclusion

Valuable learning points were encountered in the first tender of the battery. When operation is started, the battery will deliver a mix of national and local flexibility services and more important experience will be gained and data produced.

8 Measure 4: Smart Energy Management System (EMSs)

8.1 Specifications

8.1.1 Hardware

In the demonstration area an integrated smart energy management system will be realised. The district energy system will interconnect 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
- Stationary battery
- Public street lighting
- Smart ICT to interconnect EMSs at home, building and district level, for the integration of maximal renewables production.

The local electricity grid in the demonstration area was designed in the sixties and will, during the building period of the demonstration, be adapted to fit in all elements as summarized above. In the new situation three additional transformer stations, transforming the voltage from medium voltage to low voltage will be added to the existing three stations in the local low voltage grid. These three additional transformer stations are 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 on the map in Figure 9.

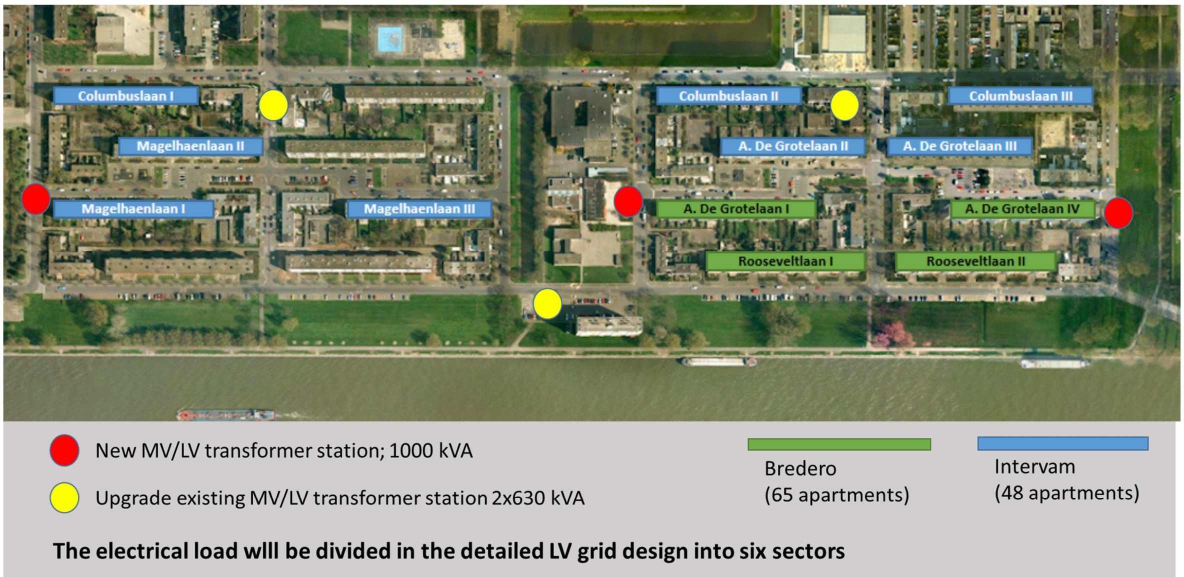

Figure 9. Location behind of the 6 medium voltage station to be used as test bed to solve congestion points.

The transformer stations will be equipped with additional special measuring sensors to measure transformer and cable loads to feed the smart energy management system to optimize the energy flows in the demonstration area. A district energy management system will interconnect the EMSs at home, building and district level.

The transformation of the district energy system into a smart district energy system will have serious impact on the energy flows. The apartment buildings are planned to be fed by six medium voltage to low voltage transformation stations. The district energy management system will have a double function:

- During the transformation of the apartment buildings, including installing solar panels, and the introduction of the charging points for electrical vehicles the changes in energy flows will be measures and can be analysed to also estimate the effect on the electricity system when, due to replication, the solutions in the demonstration area are duplicated on a large scale at other places.
- The real time measurements of the electricity flows will be essential input for the aggregator for using flexibility to help Stedin keep the maximum flow within acceptable values and monitor the status of the grid.

In order to be able to control the load in the electricity distribution grid, accurate data on the status of this grid is essential. Therefore, homes and transformer stations will be equipped with telemetric systems.

Main Component	Technical Specifications
Smart meters	One of the standard smart meters is distributed by Stedin among its households https://www.stedin.net/slimme-meter/overzicht-handleidingen • Is able to monitor consumption and delivery of electricity into the grid • Storage of measurements every 15 minutes 
Telemetrics systems for the trafo stations	Technical specification will be further elaborated in the coming months.

8.1.2 Software

In the demonstration area the **Universal Smart Energy Framework (USEF)** will be applied to deliver a market model for the trading and commoditisation of energy flexibility, and the architecture, tools and rules to make it work effectively. In principle USEF comprises of a set of rules and standards for cost-effectively unlocking flexibility in the energy system. The roles as described in USEF and of interest for the IRIS-project are the following:

	A Prosumer can be regarded as an end user that no longer only consumes energy, but also produces energy. USEF does not distinguish between residential end-users, small and medium-sized enterprises, or industrial users; they are all referred to as Prosumers. We also use the term Prosumer for end users that have controllable assets (Active Demand & Supply) and are thereby capable of offering flexibility.
	The role of the Aggregator is to accumulate flexibility from Prosumers and their Active Demand & Supply and sell it to the BRP or Supplier, the DSO, or (through the BSP) to the TSO. The Aggregator's goal is to maximize the value of that flexibility by providing it to the service defined in the USEF flexibility value chain that has the most urgent need for it. The Aggregator must cancel out the uncertainties of non-delivery from a single Prosumer so that the flexibility provided to the market can be guaranteed. This prevents Prosumers from being exposed to the risks involved in participating in the flexibility markets. The Aggregator is also responsible for the invoicing process associated with the delivery of flexibility. The Aggregator and its Prosumers agree on commercial terms and conditions for the procurement and control of flexibility.
	A Balance Responsible Party (BRP) is responsible for actively balancing supply and demand for its portfolio of Producers, Suppliers, Aggregators, and Prosumers. In principle, everyone connected to the grid is responsible for his individual balance position and hence must ensure that at each imbalance settlement period (ISP) the exact amount of energy consumed is somehow sourced in the system, or vice versa in case of energy production. The Prosumer's balance responsibility is generally transferred to the BRP, which is usually contracted by the Supplier. Hence the BRP

	holds the imbalance risk on each connection in its portfolio of Prosumers.
 DSO	The distribution system operator (DSO) is responsible for the active management of the distribution grid and introduces the system operation services defined in the USEF flexibility value chain. The DSO is responsible for the cost-effective distribution of energy while maintaining grid stability in a given region. To this end the DSO will 1) check whether DR activation within its network can be safely executed without grid congestion and 2) may purchase flexibility from the aggregators to execute its system operations tasks.

USEF positions the Aggregator centrally within the USEF flexibility value chain. The Aggregator is responsible for acquiring flexibility from Prosumers, aggregating it into a portfolio, creating services that draw on the accumulated flexibility, and offering these flexibility services to different markets, serving different market players. Flexibility provided by prosumers comprises of a variety of sources, ranging from heat pumps and PV panels with households, to cooling systems at large offices indicated. In return, the aggregator receives the value it creates with the flexibility on these markets and shares it with the Prosumer as an incentive to shift its load. Through the Aggregator, Prosumers gain access to the energy markets. Prosumers can comprise of a variety of stakeholders ranging from households with heat pumps and PV panels to large offices with cooling systems. USEF distinguishes 3 parties with demand for flexibility services:

- The Balance Responsible Party (BRP)
- The Distribution System Operator (DSO)
- The Transmission System Operator (TSO), which is indirectly served by the Aggregator through a BRP.

Detailed specification on the framework can be found in *USEF (2015): The Framework specification 2015*

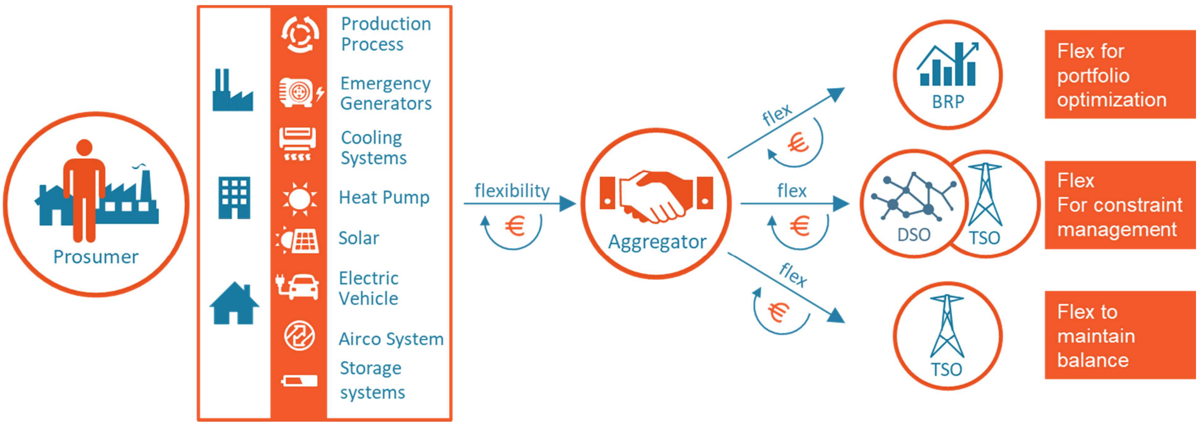

Figure 10. Overview of the USEF model with potential sources of flexibility (left hand side), the role of the aggregator and the demand for flexibility by various stakeholders (right). Source: [6]

The USEF system will be used in conjunction with the new Gopacs system that adds direct flexibility market access to the above specifications.

8.1.3 Procurement of equipment and/or services

The DEMS system in operation by LomboXnet for smart grid management in different projects across the city and region will be used for this task. Stedin will investigate the USEF/Gopacs couplings.

8.2 Societal, user and business aspects

These are discussed on Transition Track level in Chapter 9.

8.3 Impact Assessment

8.3.1 Expected impact

The USEF/Gopacs smart energy management system will for the first time assess the value to the TSO as well as to the DSO, of flexibility delivered at low / medium tension grids. The project will investigate business models whereby stationary batteries may profitably be used for static energy storage in a building or district. The project will also examine depreciation against longevity of these specific batteries and potential extended use of stationary battery storage (see further details in the section on business models under transition track #3).

Such business models will be coupled to the exploitation of the smart grid and Smart RenewableV2G Charging systems. Extra sources of flexibility emerge from the static storage, the V2G cars, from smart charging of these cars and from the PV-panels and hybrid heat pumps. The project will investigate the exploitation of these extra sources of flexibility in order to:

- Maximize the value of PV electricity production for the houses, which will increase the profitability of the PV and the system as a whole for the housing association and its tenants;
- Minimize local grid congestion, which will lead to cost advantages for the DSO (Stedin) and, because the DSO is IRIS project partner, again increased profitability for the whole system;
- Sell flexibility to the TSO and contribute to their primary reserves, which will lead to additional income to further increase profitability.

These value sources will emerge as a part of the total, complex business case for the smart grid including PV, V2G e-cars and storage, and can lead to more attractive price propositions to the tenants, drivers of V2G cars, housing association and LomboXnet. Of these parties, LomboXnet will most probably be the principal party to carry the business models, but this will also be investigated.

The development of the business models is an extension of on-going activities at several other locations, including living labs in the residential area Lombok and the Jaarbeurs where a static battery is functioning as part of a similar smart grid since spring 2018. During the development of these business cases, attention will be giving to advanced monitoring of the long-term performance of the static batteries, which will provide an important future input to improving the accuracy of business models.

8.3.2 KPIs

The KPI ‘peak load reduction’ as discussed in more detail in 5.3.2 will be evaluated using the DEMS. Using the USEF/GoPacs coupling of Stedin, Stedin will be able to assess the peak load reduction. It is being investigated if this evaluation can be implemented on the City Information Platform (CIP) as a prototype data service.

8.3.3 Monitoring plan

Data that will be collected within the demonstration area Kanaleneiland Zuid and Westraven include:

- Real time energy consumption on the household level. Data collection through the Toon. Because of Privacy legislation, permission of the tenants to obtain this data is required.
- Real time energy consumption and production on the apartment building level. Data collection through the district energy monitoring system.
- Real time electricity production of the PV panels on the homes and bus depot. Data collection through electricity (sub)meters.
- Real time energy consumption and production by the stationary battery. Data collection through the battery energy monitoring system and network connection meter.
- Real time consumption of locally produced electricity with the PV panels. Data collection through ‘TOON’ devices (with the permission of the tenants).
- Real time load demand at the LV/MV station that will service the first renovated buildings.

The details of the USEF/Gopacs implementation in terms of exact measurement plan are still in elaboration.

8.4 Commissioning Plan

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

Phase	Activity	Parties involved	Responsibility	Relevant standard
1 Design	Global design completed	LomboXnet, Stedin	Owner and operator of DEMS software	
2 Engineering	Ongoing	Stedin, LomboXnet	Owner and operator of DEMS software	
3 Contracting	Partly completed as part of other Measures	LomboXnet, Stedin	Owner and operator of DEMS software	
4 Realization	Planned 2020	LomboXnet, Stedin	Owner and operator of DEMS software	

5 Testing	Planned 2020	LomboXnet, Stedin	Owner and operator of DEMS software	
6 Completion	Planned 2020	LomboXnet, Stedin	Owner and operator of DEMS software	

8.5 Implementation plan

8.5.1 Planning of activities

The stationary battery management system will be connected to the USEF DEMS which is now being planned in detail by LomboXnet and Stedin. In 2020 the DEMS and exchange platform are expected to become operational.

8.5.2 Planning of costs and (equipment) investments

Regarding costs and investments, most costs will be borne by LomboXnet, Bo-Ex and Stedin. Any data connections needed will be covered by the monitoring budget.

8.5.3 Risk management

In D5.2, the following risk was identified that have a relation to the Smart Energy Management System:

Table 7: Risks related to the Smart Energy Management System (source: D5.2)

Transition Track	Identified risk Utrecht	Mitigation measures Utrecht
TT#2	4. Regulatory barriers regarding self-consumption, smart charging strategies, double energy taxes could hamper the replication of 2nd life batteries	4. Learn from the Utrecht demonstration and use lessons learnt in EU-wide lobby.

Real district-level energy management is being hampered by regulations in a.o. the electricity law and tax regulations. Lobby activities are being carried out to improve this (see under Measure 3 above).

8.5.4 Progress achieved up to M24

Design of the Smart Energy Management System carried out for the most part, in relation of the tendering of the stationary battery and the updates in the other Transition Tracks.

8.6 Conclusion

The Smart Energy Management System will be implemented in 2020, as a combination of the battery management system, USEF, Gopacs and LomboXnet software. It will possibly be established as a pilot data service in the City Information Platform.

9 Societal, user and business aspects

As these aspects are best discussed on Transition Track level, they have been placed in this separate chapter.

9.1 Citizen engagement

The citizen engagement activities in TT#2 and TT#3 are interconnected with TT#3 in the leading role, and are presented in 7.1 of the D5.5 report.

9.2 Business model

At this point, the business model of the charging stations is in a demonstration phase and driven by public demand. Public incentives are in most cases necessary for the costs to be covered – but because these Smart Solar Charging points are compatible with regular electric vehicles, the public demand is present. The municipality of Utrecht plays an important role with its current project to place 150 smart charging stations throughout the city, based on local demand and the expected steep growth of the number of electric vehicles in the city.

In the meanwhile, LomboXnet is exploring business models based on the multiple values that can be created by car sharing systems and smart charging infrastructure in large new housing development projects that take place under stringent mobility and environmental boundary conditions. First experiences from the citizen engagement activities and research described above indicated a limited interest amongst the inhabitants of social housing districts such as the IRIS district, which however might be turned around if addressed properly.

The business case of e-buses is strongly driven by municipal concessions and policies. As described above, QBuzz is very rapidly expanding its e-bus fleet in Utrecht. QBuzz is intent on winning the next concession which will be tendered in 2022/2023 and even further expand the e-bus fleet and services.

Regulatory barriers – EC Innovation Deal

The business case for the stationary battery and smart energy management system are at this moment hampered by regulations and taxation; lobbying activities are going on at different levels to influence this.

LomboXnet has actively participated in and contributed to the execution of the Innovation Deal 'From e-mobility to recycling: the virtuous loop of the electric vehicle' which was signed between the EC, The French Ministries for Ecological and Inclusive Transition and Economy and Finance, the Dutch Ministries of Infrastructure and Water Management and Economic Affairs and Climate Policy, the Province of Utrecht (Netherlands), Renault, Bouygues and LomboXnet [7], [8]. This deal has resulted in a publication by PWC analysing the main regulatory barriers for smart charging of EVs and second life use of EV batteries in the spring of 2019 [9]

9.3 Governance

While LomboXnet started as an exploiter of smart e-car charging stations and shared electric cars, its Smart Solar Charging approach couples this to domestic energy use and local sustainable energy production, which turns it into a new form of sustainable energy service provider. LomboXnet's network partnership includes network operator Stedin, car manufacturer Renault, mobility service provider Jedlix, e-car leasing companies and research bodies and thus provides a broad expertise base for developing this new combined market.

The municipality of Utrecht as a very active, stimulating partner ensures public support while the commitment of housing association Bo-Ex ensures the practical execution in such a way that the tenant interests are safeguarded.

10 Summary on monitoring of KPIs

10.1 Expected impact

City-wide innovation, smart energy management and smart mobility

The IRIS Utrecht demonstration is presently serving as a living lab and a catalyst for fast upscaling of smart energy and mobility management for the whole city of Utrecht. The V2G e-car charging points and smart shared electric vehicles in the IRIS demonstration area are an important step but, in the meanwhile, LomboXnet is rolling out the technology in the whole city and even in the region around Utrecht city. This bi-directional 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 open standard for V2G charging was launched by ElaadNL and the Open Charge Alliance. In November 2019, LomboXnet has installed 50 V2G charging points in the city of Utrecht. By April 2020, that number will have grown to 150 V2G charging points throughout the city. Similarly, over 50 smart charging shared e-cars are presently in operation in 10 of the 12 districts of the City of Utrecht and an additional 10 in the region.

The IRIS demonstrator has contributed considerably to the large step that was made in the introduction of V2G-technology on the market. Renault has sped up the development of AC V2G technology based on the new open standard IEC 15118. But also the Sono Motors company has committed to the standard and will introduce compatible V2G-cars in 2020 and three other car manufacturers (OEMs) are considering following the open standard. Also, Enedis, the network manager in France, will embrace the AC-V2G technology.

Bundling 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. With smart grids, MaaS (Mobility as a Service) and smart energy management, the laws of large numbers favour cooperation on larger scale than one district. A recent change in regulations now makes it possible for a network aggregator to operate a group of V2G e-cars as one ‘virtual battery’ to deliver flexibility to the TSO. A larger network will have more options to virtually group V2G-cars that are connected to charging points at a certain moment in time into such a ‘virtual battery’, and to deliver different kinds of flexibility.

Similarly, the bus company QBuzz is currently exploiting 13 e-buses in the city with two charging / fast charging locations; by summer 2020, 55 additional e-buses will be in operation, plus two new large depots with in total 68 bus charging stations. The busses provide their services to the whole city; the charging stations at the bus depots will have their own medium-voltage connections and thus also act on city level rather than district level.

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 2023. Utrecht will participate (on the level of Alderman) in the EVS32 event in Lyon where main sponsor Renault will launch the large-scale introduction of V2G.

Figure 11: Opening of the 'City-wide bi-directional Ecosystem' in Utrecht by Willem-Alexander, King of the Netherlands, a member of Groupe Renault's Executive Committee and EVP Design Groupe Renault

As the batteries in about 8,500 e-cars have enough capacity to power all houses in the city of Utrecht, the Smart Solar Charging 'city-wide bidirectional eco-system' can quickly become a significant factor in the energy network management of Utrecht. This also connects to the ambitions of Stedin, the electricity network operator, to enable the upscaling of both EV and fossil-free housing while avoiding excessive network investments. Renault will produce the V2G shared e-cars, to realise its ambition to showcase Utrecht as the first bidirectional city in the world.

10.2 Aggregation of KPIs for each LH city

Each LH city has its own set of KPIs that can be related to the IRIS KPI house; the top level of the house containing the IRIS level KPIs (IL) is however the same for all cities. On solution level (STT1-5), the KPIs may vary between the cities since different solutions are implemented in each city and the cities have different objectives, but in many cases the same KPIs can be found in all cities, thus allowing comparison between the Transition Tracks of the cities. For some Transition Tracks the evaluation of integrated solutions cannot be separated and the KPIs are hence calculated at Transition Track level (TT1-5). The KPIs for each transition track and possibilities to aggregate them are presented in Table 8.

The KPIs for TT#2 are defined on TT level:

- Peak Load Reduction
- Storage Capacity Installed

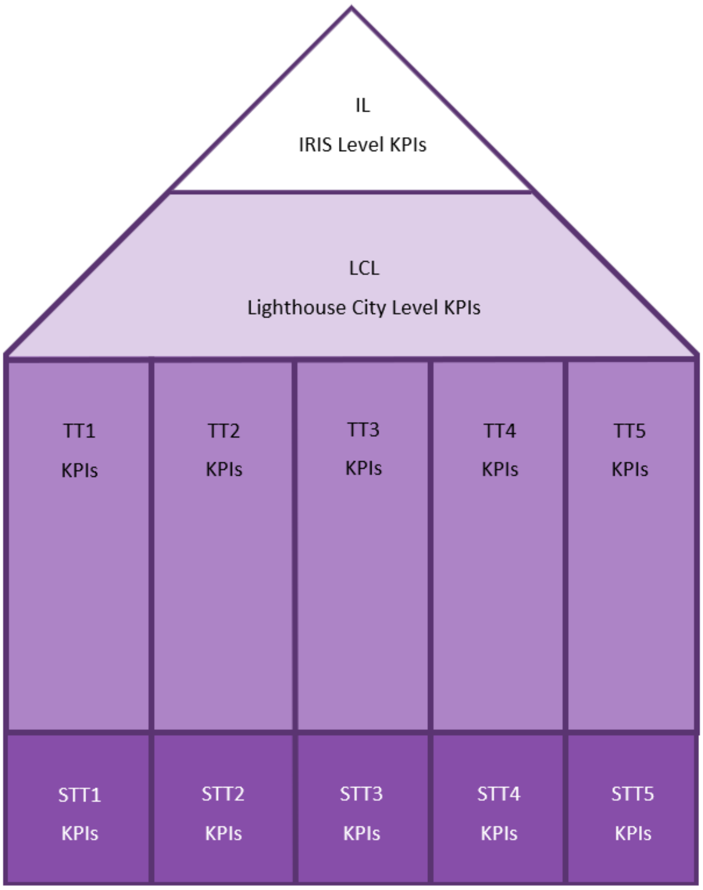

Figure 12 IRIS KPI-house. The KPIs presented in Tables 4-6 are, if possible, aggregated to transition track level (TT1-5) or higher.

10.2.1Utrecht / Nice / Gothenburg

In the below table, for each KPI a position in the KPI-house is proposed.

Table 8. Relation and possible aggregation of KPIs to solutions and the IRIS KPI-house in Figure 12.

KPIs	Solution	Proposed position in IRIS KPI-house
Peak Load Reduction	Smart Energy Management System including shared smart solar charging stations, electric cars and buses local PV production, house energy	TT#2

	systems, stationary battery and USEF/GoPacs energy management system	
Storage Capacity Installed	Stationary battery and local smart solar charging electric vehicles	TT#2

11 Ethics requirements

11.1 GDPR compliance

The overall Data Protection officer (DPO) of LomboXnet is mr. Robin Berg. Robin Berg is involved in the IRIS project in the role of Project Legal Signatory.

11.1.1 GDPR compliance per IRIS demonstration measure

The following table shows the GDPR elements per measure of TT#2.

Demonstrator	Element and description	
Measure 1: Solar V2G charging points for e-cars	Data controller:	LomboXnet is exploiter of the charging points.
	Personal Data:	LomboXnet collects charging card info and transfers it to the charging card service providers for handling of charging fees, without knowing the identity of the charger or collecting personal information. Other than this, no special actions are taken in IRIS connected to this data.
	High risk involved:	No
	DPIA:	Not applicable
	Informed Consent Procedure	Not applicable
Measure 2: Solar V2G charging points for e-buses	Data controller:	Qbuzz is operator and owner of the charging points.
	Personal Data:	No personal data involved; QBuzz charges only its own buses.
	High risk involved:	No
	DPIA:	Not applicable
	Informed Consent Procedure	Not applicable
Measure 3: Stationary	Data controller:	Bo-Ex owns the storage battery. LomboXnet operates the battery.

Demonstrator	Element and description	
storage in apartment buildings	Personal Data:	No personal data involved; only handling of the battery.
	High risk involved:	No
	DPIA:	Not applicable
	Informed Consent Procedure	Not applicable
Measure 4: Smart energy management system	Data controller:	The smart energy management system is operated by LomboXnet, in cooperation with Stedin (USEF system) and Eneco (TOON in-house monitoring).
	Personal Data:	The smart energy management system operates without any personal data involved. The TOON system involves personal data; see D5.3 (TT#1) for more information. Other than this, no special actions are taken in IRIS connected to this data.
	High risk involved:	No
	DPIA:	Not applicable; see D5.3 for TOON
	Informed Consent Procedure	Only for TOON (see D5.3)

If other research methods will be used in the future of the project in which personal data is recorded or shared, DPIA and informed consent procedures will be followed.

11.2 Ethical aspects

No sensitive data is shared and the respective partners have stated to be GDPR compliant.

No people are excluded from the work based on ethnicity, gender, religion or similar reasons.

Persons or organisations are not exploited or exposed to unnecessary pressure – they will only be deployed in client – contractor relationships.

Care is taken that the work in this project does not lead to fear distrust or other negative outcomes.

12 Links to other work packages

Task 5.4 (TT#2) is closely connected to the other Tasks in WP5 on the Utrecht demonstration, with the main connections to:

- TT#1: PV, street lighting, Home EMS, Smart (hybrid) heating
- TT#3: E-cars and E-buses.

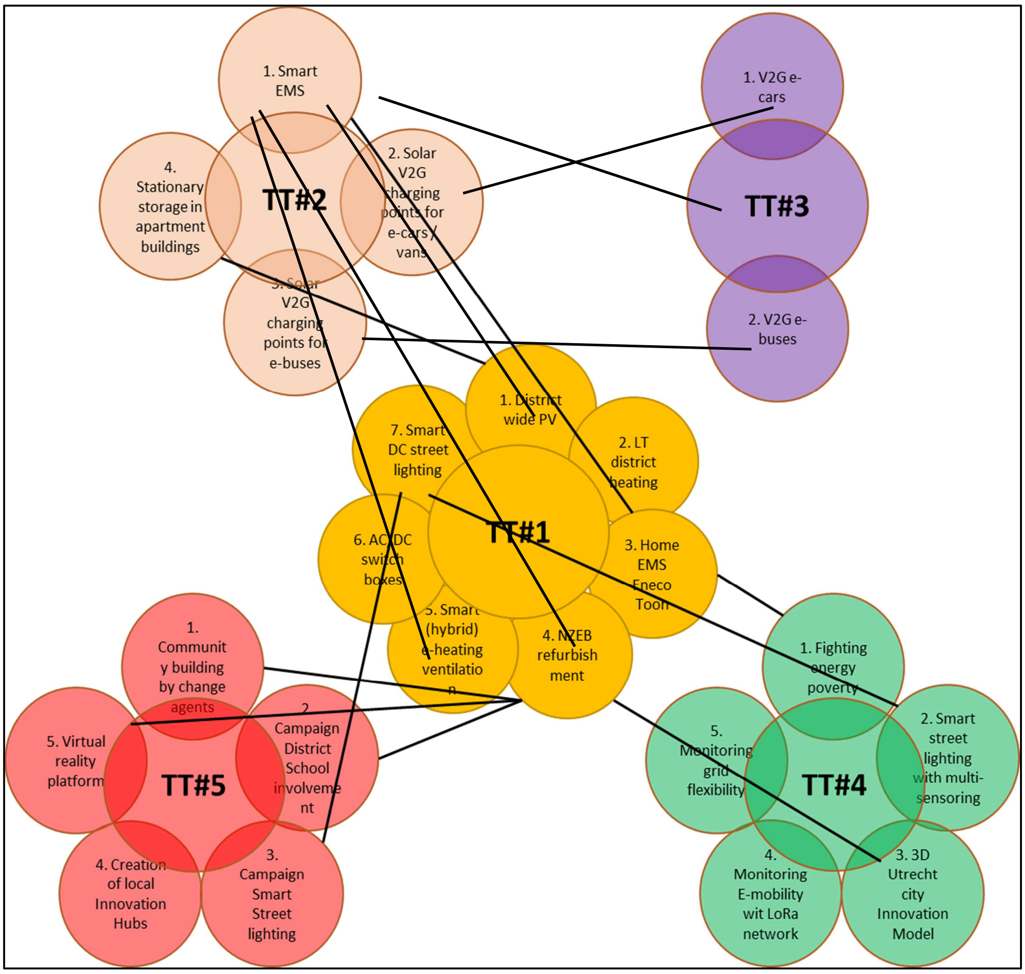

Figure 13: relationships between the Transition Tracks in WP5.

As discussed in 9.2, there are number of barriers in current regulations, which are being investigated and addressed in the framework of the Innovation Deal and the PwC report that was written about the barriers. This important barrier for V2G, stationary batteries and smart charging of e-cars, e-vans and e-buses has a strong connection to WP2, as European cooperation on these subjects can make an important contribution to alleviating these barriers.

The development of the business cases for the stationary battery and the district energy management system have a relation to WP3. Finally, there are relations to WP4 and WP9 on monitoring and KPI evaluation.

13 Conclusions and next steps

13.1 Conclusions and lessons learned

In general, activities are progressing according to plan. There are some deviations (see 2.5) but the overall ambitions of TT#2 of demonstrating smart energy management and storage are not affected.

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 is a main driver towards the quick development of a city-wide flexibility and e-mobility ecosystem.
- The realisation of stationary batteries in garage boxes has proven to be more difficult, with respect to spatial restrictions and electrical / fire safety concerns, than realisation of a stationary battery outside.
- Second life batteries are presently significantly more expensive than new batteries, which appears 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.
- 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 flexibility 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 to use USEF – in the meanwhile the newer Gopacs platform has started to develop which means that it is now intended to use the two platforms together to establish the flexibility mechanisms.

13.2 Next steps

Next steps are:

- Continue realisation of V2G chargers in a demand-driven way, with support of citizen engagement activities and the involvement of local entrepreneurs.
- Research on the practical feasibility of V2G e-bus charging
- Realisation and exploitation of the stationary battery and develop the flexibility request handling systems so that the actual value of local flexibility services on the Dutch market can be investigated
- Realisation of the smart energy management system and quick extension towards virtual power plant and a a city-wide ecosystem of green mobility and sustainable energy management.

14 References

[1] Grant Agreement nr. 774199 — Integrated and Replicable Solutions for Co-Creation in Sustainable Cities (IRIS) Amendment, Reference No AMD-774199-24

[2] Deliverable 5.1 Baseline, ambition, activities, and barriers & drivers for Utrecht lighthouse interventions, 30 September 2018

[3] Deliverable 5.2 - Coordination of Utrecht integration and demonstration activities, 30 September 2018

[4] Deliverable 11.5 - Quality Assessment Plan, Risk Assessment and Contingency Plans, 16/04/2019

[5] https://viriciti.com/

[6] USEF (2015) USEF: The Framework explained

[7] https://ec.europa.eu/info/research-and-innovation/law-and-regulations/innovation-friendly-legislation/identifying-barriers/signed-innovation-deals_en#emobility

[8] https://ec.europa.eu/research/innovation-deals/pdf/jdi_emobility_recycling_112017.pdf

[9] Regulatory barriers for Smart Charging of EVs and second life use of EV batteries, Final Report, PWC 17-5-2019

15 Annex 1

The Peak Power will be measured using a set of electricity meters in the district, measuring powers of:

- Apartment buildings (apartments, solar power systems)
- V2G E-car charging stations
- Stationary battery
- Transformers in the district.

All these meters will be owned and operated by Stedin using their normal hard- and software. Exactly what meters will appear where, is currently being engineered. Here, a table is filled in for a generic electricity meter.

Table 9 Description of parameter Peak Power

No	Parameter	Value
1	Data Variable Name *i.e. Thermal energy consumption, locally produced electrical energy, etc.*	Electric power / peak power
2	Measure Number *As it is stated in the measure tracker*	2
3	KPI Number *KPI('s) that are related to the data*	1
4	Units of measurement *i.e. kWh, Euro, etc.*	W
5	Baseline (of data variable) *e.g. relating to BaU or previous performance data*	Power through same meter in absence of smart energy management
6	Meter *i.e. smart meter, survey, energy bill, etc.*	Smart meter
7	Location of measurement *Where the measurements take place*	- Apartment buildings (apartments, solar power systems) - V2G E-car charging stations - Stationary battery - Transformers in the district
8	Data accuracy	Standard required accuracy of smart meter

	How accurate is the measurement	
9	Collection interval *How often the data is recorded*	15 minutes
10	Start of measurements *i.e. 1-1-2019, 0:00CET*	2020
11	End of measurements *i.e. 31-12-2020, 24:00CET*	Measurements will continue after the project.
12	Expected availability *i.e. open data, public, confidential, no data available*	Confidential; Stedin can supply aggregated data on demand.
13	Expected accessibility *i.e. 1) online without access constraints, 2) online, but requires authentication, and, 3) offline*	Online, but requires authentication
14	Data format *i.e. csv file, json…*	To be decided.
15	Data owner *i.e. the name of the company that will give access to data*	Stedin
16	Comments *Further info*	