Intelligente flexibiliteit door geïntegreerde hybride opslagtechnologieën

FLEXINet

Public Yearly Progress Report

Period covered

M1 (May 2021) – M12 (April 2022)

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Duration	4 years

Het project is uitgevoerd met Topsector Energie subsidie van het Ministerie van Economische Zaken en Klimaat, uitgevoerd door Rijksdienst voor Ondernemend Nederland. De specifieke subsidie voor dit project betreft MOOI-subsidie ronde 2020

TABLE OF CONTENTS

1 Summary of the principles and the objectives of FLEXINet and its cooperating parties (beneficiaries)

Project Title
Intelligent flexibility through integrated hybrid storage technologies (“FLEXINet”)

Objective
The objective of FLEXINet is to develop an integral smart system for the intelligent and integrated control and implementation of hybrid energy storage technologies in the built environment. The smart system will improve the flexibility and sustainability of energy supply (via solar PV and heat pipes) through underground power electronic conversion technology by combining stationary lithium-ion battery storage, sea salt batteries, electric vehicle charging with vehicle-to-grid technology and thermal energy storage. FLEXINet integrated control strategy for hybrid energy storage will be validated in living labs.

Outcome
FLEXINet follows a research model that consists of 4 layers: 1) Flexibility-enabling hardware, 2) Integration, conversion and smart control, 3) System flexibility and Living Labs, and 4) Social acceptance and Learning community. The hybrid energy storage technologies that are being developed in layer 1 will be integrated in arrangements for homes and utility buildings, to make the heat and cooling facilities more sustainable and to integrate renewable energy sources and electric vehicles. The smart solutions developed in layers 2 and 3 improve the flexibility and sustainability of electricity supplies by combining stationary battery storage, reused batteries, electric vehicle charging, vehicle-to-grid technology and flexible heat pumps and storage. We strive for the most complete, integrated and validated solution that is attractive to users who are further involved in layers 3 and 4. End-result of the project is an integral smart system for the intelligent and integrated control and implementation of hybrid energy storage technologies in the built environment.

Activities
FLEXINet consist of four interlinked layers. The activities belonging to the first layer of Flexibility-enabling hardware concern the development of innovative low-cost and high-energy battery chemistries and power electronics for hybrid energy storage systems, including the design, development and testing of prototypes. In the second layer the activities concern the design, integration and smart control of an underground heat storage system, the development of a life-extending battery optimization, the design and testing of a generic and open-source EMS platform and the development of intelligent hybrid EMS algorithms. Later these systems in the System flexibility and Living Labs layer lead to new services and revenue models for reliable networks. Here in this layer the demonstration, testing and validation of the FLEXINet solution is also done (TRL4-6). In the fourth layer, Social acceptance and learning community, the activities concern the investigation of social acceptance and knowledge dissemination. In this way, we offer a complete and integrated solution to exploit the potential flexibility of the built environment through hybrid energy storage systems.

2 Description of the activities performed, the results achieved per milestone, the bottlenecks and the perspective regarding application (<1 page)

Result	Activities performed, results achieved, bottlenecks and perspective
R1 - Innovative battery technology	Recoy undertook market research to choose K-star Li-ion packs for delivery to the Green Village and to VITO for parameterisation and testing/modelling battery degradation. LeydenJar developed a 3-electrode battery cell with silicon anode and NMC622. 400 cycles tested in lab setting. First efforts on larger format cell making started (1,5 Ah). Feasibility check of LFP cathode was positive. Dr.Ten did literature and patent studies to plan an improved polymer-carbon processing and synthesis of large surface area electrodes. Measurement data were converted into useful guidelines for electrode synthesis. TU Delft has done several experiments to measure the sea salt battery performance and comparing the results with the measurements by Dr. Ten. No deviations from the project plan. Ongoing discussion on how to demonstrate the conventional and silicon battery cell in Green Village including safety considerations.
R2 - Power electronics for hybrid energy storage systems	The specification for the FLEXIGRID+ box is finalized as V1.0 by PRE and TU Delft. TU Delft is working on modelling the converter with focus on efficiency, power density and the (underground) cooling concepts. The first prototype of the Partial Power Storage converter for second life batteries is made and is currently tested in solar projects. The BMS board is under development, entering the design phase.
R3 - Heat storage integration	This result focuses on the integration of heat storage. TU Delft started the description and modelling of the Thermal Energy Storage System (TESS) within a household building. Borg installed the underground thermal buffer at the living lab The Green Village. Additionally, Borg provided TU Delft with measurements of the prototype installed in the GV to validate the TESS model once built. An MSc student from TU Delft is studying the Vapour Heating Unit (VHU) in order to couple it with the other elements in FLEXINet. Attempts were made to see if the model of the VHU could be derived in the software that is used by TU Delft for the full FLEXINet project. There are no delays encountered so far.
R4 - Life-extending battery optimization	Recoy and VITO have started the parameterization LeydenJar 0.2Ah silicon anode cells and traditional Li-Ion K-STAR batteries. Start modelling of the batteries based on Parameterization for calendar life and degradation performance. Use Cases definition for deploying batteries for different purposes. Possible bottleneck is the long time needed to make realistic estimates of the degradation behaviour of the batteries

R5 - Generic and open-source EMS platform	Specifications are made by PRE-Heliox for the first prototypes of the open-source EMS-platform along with alignment with result 6 (hardware and software). Currently, an inventory is being made of the interfaces of all assets in FLEXGRID+ project. Next step is to test and validate the first prototype
R6 - Intelligent Hybrid EMS	TU Delft is working on literature review, understanding the energy systems of various results/partners and modelling of the different energy storge systems to allow a proper optimization by the Energy Management System. Development of a three-level hierarchical control for the EMS as part of milestone 6.2. Exploring the communications protocols esp. S2 protocol required for the integration of all the energy components to the EMS. Requirements identification for controller hardware together with R5 to properly deploy the EMS. The result is marginally delayed since the PhD at TU Delft did not work for the entire 12 months.
R7 - New services and revenue models	Result 7 studies system flexibility through the integration of hybride energy storage systems. TU Delft has done a study on the ancillary services the multi-carrier energy storage system can provide, which was part of a review paper submitted by Joel Alpízar-Castillo to a journal. Moreover, Emmett Green started to draft financial models for batteries and is now looking for ways to combine the outcome of a heat pump system into a financial model. In addition to that, a stakeholder pre-analyses was started on the possible implementation integration of Dr Ten FLEXINet solutions on a larger scale in similar housing and building scenes. A fundamental question remaining is if systems should be sold, leased-, rented out or if kWh should be traded. This will be studied in the coming months. There are no delays so far.
R8 - Living labs	Result 8 focuses on Living Labs. Borg and DC opportunities are already experimenting with parts of their hardware at The Green Village. These two companies have been introduced to rules applicable to use The Green Village. TU Delft-GV has had several conversations with Recoy and Dr Ten about dimensions and requirements for a successful experiment. Finally, TU Delft-GV has produced the 'FLEXINet - stappenplan test op The Green Village'. A document that describes in detail what steps have to be taken before an experiment can start on The Green Village. No delays so far.
R9 - Social acceptance	Result 9 focuses on social acceptance and energy justice. With the help of interviews with members of HET cooperation and with residents from the Green Village factors regarding social acceptance and energy justice will be identified. PRE, Dr Ten & DC-opportunities are joining in a co-creation workshop with residents from the Green Village. This workshop will mainly serve as an intervention and dialogue and will study 1) how acceptance can change when circumstances/ implications change 2) provide a dialogue regarding the design details of the technologies to be developed in the FLEXINet research project. This result goes according to plan.
R10 - Learning Community and Dissemination	With the launch of Energy Switch, a structural and sustainable partnership to organize learning, working and innovation close together has been created. With Energy Switch we are building a national expertise platform to exchange resources of knowledge. This will be combined with the national expertise platform that is being built for the national network of learning communities on system integration. Resources from the FLEXINET consortium can be shared here as well. This Result runs according to plan.

3 Description of FLEXINet's contribution to the objectives of the subsidy scheme (MOOI)

Main innovation theme	Innovation theme (Innovatiethema)	Results
1. Further development of natural gas-free arrangements and supporting processes/services	1. Development of integral arrangements for renovation	2,3
	4. Smart energy use in/between buildings by users, smart grid	5,6, 7,10
2. Making the (collective) heat and cold supply more sustainable	5. Collective heat and cold supply	3
3. Solutions for a reliable, affordable and fair electricity supply	6. Flexibility of/for the energy system (in the built environment)	1-10
	7. System design for the electricity system in the built environment	5,6,8,10
	8. Local flexibility for the overall electricity system	6,7.9

(1) Further development of natural gas-free arrangements and supporting processes/services.

- Intelligent and integrated energy management hardware and control – FLEXInet will develop intelligent and integrated control algorithms to increase the flexibility of electricity and heat supply through hybrid energy storage and develop a hardware controller to interface with various power generation/conversion devices. The EMS will implement a multi-objective optimization to reduce/eradicate the use of natural gas, increase the use of renewables, improve grid integration and offer ancillary services *Results: Algorithms, Controller (product) demonstration*

- (Underground) power conversion cabinet - Space is often a challenge for the placement of batteries and hardware. We develop the FLEXGRID-PLUS solution, an invisible (underground) box that contains the batteries, power electronics including solar MPPT converter, inverters, and EV chargers for controlling the hybrid storage system. We also develop power electronics for the efficient use of discarded traction batteries that get a second life as a stationary energy storage system and to connect sea-salt batteries to the grid. *Results: FLEXGRID-PLUS (product), demonstration*

(2) Making the (collective) heat and cold supply more sustainable

- More sustainable heat supply through thermal storage, heat pipes and heat pumps - FLEXInet will develop an underground heat buffer connected through flexible heat pumps and heat pipes. The buffer works with an intelligently controlled weather and demand forecasting model to control the behavior of the connected energy sources. We will also develop sea salt based vapor heating unit as a means to reduce the use of natural gas, *Results: Algorithms, thermal buffer (product), vapor heat unit (product), demonstration*

- Social acceptance and experience of flexibility - We investigate social factors and draw up a business case for the investment and financing and build a cooperative neighborhood organization as a basis and management organization for the hybrid storage facilities. The basis for the business case is an investigation into the circumstances under which users in the neighborhoods want to make flexibility available in which both financial and non-financial costs and benefits are considered. *Results: Social factors and optimization of willingness to participate, business model*

(3) Smart solutions for the reliability, affordability and fairness of electricity supply

- Novel energy storage technologies - to increase the flexibility of hybrid energy storage, we will improve sea-salt batteries technology; develop silicon anodes to increase the energy density of lithium-ion batteries; study the ageing behaviour and develop optimization algorithms to improve lifetime of Li-ion cells. *Results: sea-salt battery (product), silicon anodes (product), Algorithms, demonstration*

- New services and revenue models for hybrid storage. We evaluate the possibility of using demand management to enable the aforementioned storage technologies to reinforce each other. We will also design transactional energy solutions, based on peer-*to-peer* delivery, through the potential complementary effect of using hybrid storage technologies. Finally, we determine guidelines and requirements for the provision of additional services to the grid (DSOs/TSOs) through hybrid energy storage in the built environment. *Results: Algorithms, simulations, guidelines, business models*
- Learning community and dissemination - As an integral part of the project, we ensure an adequate link between innovative technologies that support the energy transition and the knowledge and skills needed to implement these technologies in practice. *Results: Information, training materials, guidelines*

4 Spin off inside and outside the sector

Not applicable for now

5 Overview of project's open access (public) publications and where to find/obtain them

Project website - https://www.tudelft.nl/en/flexinet