Final report

1.1 Project details

Project title	12518-Grid Connected Flow Batteries
Project identification (program abbrev. and file)	GCFB
Name of the programme which has funded the project	EUDP17-1
Project managing company/institution (name and address)	Eniig Holding A/S (Eniig Forsyning A/S) Tietgensvej 4 8600 Silkeborg
Project partners	Visblue A/S Aarhus Universitet
CVR (central business register)	39072793
Date for submission	6. september 2016

1.2 Short description of project objective and results

1.3 Executive summary

1.4 Project objectives

1.5 Project results and dissemination of results

1.6 Utilization of project results

1.7 Project conclusion and perspective

Annex
Relevant links

1.2 Short description of project objective and results

Danish

Målet med GCFB projektet var at undersøge mulighederne for at installerer et redox flow batteri i det offentlig el-net to re-balancere spændings-frekvensubalancer forårsaget af ubalancer i belastningen på de 3 faser.
Den første fase af projektet blev brugt på at definere system krav baseret på analyse af et typisk el-net med ubalance. Herefter er udvikling af systemet startet og en egnet testlokation blev valgt i Eniigs forsyningsområde.
Analyse af el netkarakteristik og typisk el forbrugskomponenter ved en række el-forbrugere, blev udført. Batteriet blev udviklet og bygget inklusiv de specielle komponenter og batteristyring der skulle til for at styre batteriet individuelt på de 3 faser.
Installation på testlokationen var ikke mulig, fordi batteriinverterne ikke blev godkendt til brug på det danske el-net i tide. I stedet for blev batteriet testet på Visblue's testlaboratorie stadig forbundet til det offentlige el-net. Testresultatet var godt, batteriet bevidste at det kan udkompensere en del af en ubalance simuleret på de 3 faser individuelt.
I en økonomisk sammenligning mellem batteriløsningen og en løsning med at opgradere kabler og transformere etc. er batteriløsningen konkurrencedygtig, og har den fordel at den er flexible mht. effekt, styring og placering.

English

The objective for GCFB project has been to investigate the possibility in installing a redox flow battery in the public grid to rebalance voltage and frequency unbalances caused by unbalanced load on the 3 phases.
The initial phase has been used to define the system based on analysis of a typical situation with unbalanced grid. Hereafter development of the system has started and a suitable test site was selected in Eniig's supplying area.
Analysis of the grid characteristic and the load types at some of the electricity consumers was done at the selected test site. The battery system was developed and built up including the special components and battery control to be able to control the battery individual on each of the 3 phases. Installation on test site was not possible because the battery inverters were not approved to be used in the DK grid. Instead the battery was tested at Visblue test facility but still on the public grid. The test results were good, the battery has proved that it can compensate unbalances caused by simulated unbalanced loads on the 3 phases.
In the economical comparison between the battery solution and a reinforcement solution of the existing cables, transformers etc. the battery solution is competitive and has the advantage that it is flexible in sense of power capacity, control and placement at site.

1.3 Executive summary

Project is ended based on laboratory tests at Visblue. As a proof of concept, the results are promising in the sense that it was proven that the battery could be controlled independently on each phase and it was capable of automatically reacting to voltage changes and start to compensate these changes. Since the test was executed in a laboratory over a short period, further tests must be done in the field with real unbalances in order to tune the battery control. However, the results prove a potential to utilize this configuration of the flow battery, because the flow battery can be configured and changed to fit the requirements from the particular site with unbalanced grid. Besides that, the flow battery can easily be moved to another site, which in comparison with upgrading the cable and transformer is a more flexible solution.

1.4 Project objectives

The project evolved as it should according to the project plan and there has been a good cooperation between the project participants. One of the risks in the project was the battery inverter used in Visblue's battery system. The inverter is a key component since it must support the functionalities required to fulfill the individual phase grid compensation and it must be approved to install on the Danish public distribution grid. The first requirement was prov-

en during the final tests but the last requirement we didn't succeed to obtain before the project as ended.
In milestone 2.3 and 2.5 cost analysis is done for different solutions to improve a grid with unbalancing issues. In milestone 3.1 'business modelling' and 3.2 'competing technologies' the overall conclusion is that flow battery can compete with other solutions like grid reinforcement with cables and other battery technologies like Lithium Ion. Compared with lithium ion, redox flow battery have advantages, in lifetime, safety, recyclability but it can't compete with lithium ion on the energy density.

1.5 Project results and dissemination of results

The main activities have been to characterize a unbalanced grid in order to set up requirements and hereafter design a redox flow battery that can solve/compensate the unbalance. These main activity steps have been a part of the original scope of the project reflected in work packages and deliverables which have been solved step by step.

It was expected to test the designed battery in a real grid situation but that was not succeeded in the project due to battery inverter that wasn't approved for the Danish grid. However the tests of the designed battery was executed in simulated setup and the battery design concept was proven to work.

The test results from final tests in a simulated setup was evaluated discussed as a part of deliverable D5.1 & D5.2 & D5.3. The conclusions here were that the designed battery havepassed the 'proof of concept' but there are still improvements in the battery control needed when going to a real site.

The project has been disseminated by two main reports from DE 'Flowbatterier I distributionsnettet' and 'Experiments with Flowbattery for phase unbalance compensation' as a part of deliverable D5.3.

1.6 Utilization of project results

Based on the promising results the project partners see the perspective and already discussed how to get out to a real test site and test the battery. DE has got a better understanding of the flow battery will use this in their work and counseling of DSO's and other interests.
Visblue expects to utilize the results in the project to use this battery configuration in their product portfolio.

1.7 Project conclusion and perspective

The project result can be used as a proof of concept of this flow battery solution and to prove that it can compete with other solutions like upgrading the electrical distribution network on site.
Visblue have achived a lot of knowledge about this type of grid issues and how to solve with their product. The battery configuration with independent control of each phase, Visblue expect to be able to adapt to other real applications of the battery.

The project partners expect to be able to use the knowledge and battery design in their future business. The project missed the results from the field site, but based on the project results there are a good base to go out in a real test. This is also needed to convince the DSO's and the industry that a flow battery is a real and sometimes better alternative to transmission upgrading and other battery systems.