NEFUSTA - The Electrical Fuelling Station for E-Mobility *and* Grid Support

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***Abstract*— Together with the development of new energy vehicles, such as vehicles using biofuels, hydrogen or electricity, new facilities for fuelling and charging are needed. In the project NEFUSTA (New Energy vehicles FUelling STAtion), such a facility is being developed, and services to the transportation and electricity sectors, technology integration, safety and permitting, and economics are investigated. The new fuelling station will store electricity and hydrogen (and/or other green fuels) and could also include hydrogen production by electrolysis. These storage buffers create flexibility both to serve the electricity grid and the road transportation sectors. The station will provide the transportation sector with sufficient fuels, including electricity, at all times. The station will also provide flexibility services to the grid, including renewable energy storage at peak times, congestion management by demand response, emergency power supply, and power quality services. Because of the dual interaction, the new energy vehicles fuelling station will enable and speed up the energy transition, both to a greener transportation sector and a greener power system.**

Keywords—EV charging; Energy storage; Grid support; Ancillary services; Hydrogen; Risk analysis.

I. Introduction

The NEFUSTA project (New Energy vehicles FUelling STAtion) is a collaboration of DNV GL, Sweco, DEKRA, CGI and HAN University of Applied Sciences in The Netherlands. The aim of the NEFUSTA project is to design and develop a fuelling and electric charging station for different utilisation scenarios, for example a large highway transit station or a smaller city limits station, and select possible physical locations too (e.g. with good road and electric grid infrastructures at close range). The project consists of stakeholder analysis, analysis of regulations and permitting, and safety investigations, including internal and external risk analyses. Further topics are technical design and concept engineering, that take into account safety aspects of technology integration and interaction, regarding fuel handling and storage, explosion safety (ATEX), battery safety, etc. Also, the business case of the new fuelling station, where earnings and benefits in transportation services and grid services (and electricity markets) are considered, is studied, using a techno-economic simulation model of the station.

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II. Existing Developments on Smart Charging and Hydrogen Fuelling

A. New Energy Vehicles

The term ‘new energy vehicle’ (NEV) refers to vehicles not running on fossil fuels, that is electric vehicles (EV) (mainly passenger cars) and vehicles running on hydrogen or biofuels (mainly busses and trucks). The NEFUSTA concept is aimed at the infrastructure supplying energy to these NEVs, with a focus on EV charging and hydrogen filling. Apart from the ‘new energy’, autonomous vehicles can contribute to the concept, for example by moving away from a charge point (CP) when charging is finished.

B. Smart Charging Solutions in The Netherlands

Some of the main smart charging initiatives in the Netherlands are mentioned here.

Jedlix [1] manages the charging of EVs based on the balance between production and consumption of renewable energy. By selecting the optimal charging moments, the share of renewables in the energy mix is increase. The EV is charged with renewable energy when the prices are at their lowest and the financial reward generated is shared with the driver, thereby making electric driving more attractive.

The Living Lab Smart Charging [2] investigates how smart charging can become a worldwide reality. Many of the CPs in the Netherlands are turned into smart CPs. Experiments are done and real-life experience is gained in a collaboration of companies, municipalities, universities and users. The aim is to set the global standard for smart charging.

LomboXnet [3]: Lombok is a district in Utrecht (NL) and a live test area for smart charging using solar energy from local solar systems. LomboXnet is a combination of technology development and user participation in the district.

C. Hydrogen projects in Europe

Although many parties in the Netherlands are following the developments in the use of hydrogen for transportation, no large-scale projects have been started yet.

On the other hand, many other European countries have large projects on hydrogen for transportation. The main European countries active in hydrogen economy studies are Germany, the UK, the Scandinavian countries, France and Italy. Furthermore, the European Commission supports many hydrogen technology projects in the framework of sustainability research programmes. Companies and research organisations from the countries mentioned are most active in these subsidy programmes, like the 'Fuel Cells and Hydrogen (FCH) Joint Undertaking'. Two projects match best with the scope of NEFUSTA: H2ME and HyFIVE.

H2 Mobility Europe (H2ME) [4] is a large project regarding the development of the European hydrogen economy. It is a collaboration of four (inter)national projects in Germany, France, Scandinavia and the UK. The aim is to achieve a pan-European network of hydrogen filling stations enabling driving on hydrogen in fuel-cell vehicles as the best sustainable option. Large automotive companies and technology providers are participating.

The HyFIVE project [5] is a smaller pan-European project. 185 fuel cell vehicles will be driven all over Europe, with three filling station hubs (with multiple stations) in the UK, Denmark/Sweden, and Germany/Austria/Italy. Also in this project large automotive companies and technology providers are participating.

III. Scenarios

The project team consulted many stakeholders and found the following topics determining the possible scenarios of a NEV filling station:

Number of vehicles present and behaviour on fuel filling or charging:

- EV charging
  - 80% normal (low-power) charging: residential, work and transit locations;
  - 20% fast charging: along transit routes.
- Hydrogen filling (more traditional due to large range).

Conditions regarding energy supply and risk mitigation of the filling station:

- Electricity supply of charge points (CP):
  - Normal charging: to prevent grid overload, a limited number of CPs, grid reinforcement and/or smart charging is needed;
  - Fast charging power will be 350 kW in the near future (medium voltage (MV) connection).
- Hydrogen supply of filling station:
  - By electrolysis, tube trailer or pipe line;
  - The risk profiles affect the location options.
- Electricity demand profile
- Production profile of renewables (solar and wind variation during the day and during the year)
- Need for storage:
  - Match local demand and supply of electricity;
  - Provide grid support services.

Three scenarios have been defined providing the best potential for the NEV filling station, each with pros and cons concerning technology, societal and economic interests:

1. A charging plaza (multiple CPs) on a work location (business or industry) in combination with hydrogen filling: matches with the charging profile of 80% home/work charging; matches with solar and wind generation profiles (cars connected to CPs during the day when renewable power is highest); no permanent inhabitants, so permitting for hydrogen is easier; local storage of surplus renewable energy (batteries of hydrogen); cars rae connected to the CPs for a long time during the working day, so demand response (DR) flexibility can easily be utilised, e.g. to prevent grid overload and also defer grid reinforcements. Furthermore, local storage and/or hydrogen production can generate extra revenues for the station owner by: trading electricity on the wholesale markets; providing reserve power; selling hydrogen. Secondary income streams are: parcel drop-off/pick-up, shops, restaurant, meeting and work place.

2. A combinatie of hydrogen filling and EV fast charging along highways and other main roads: accommodates the estimated 20% need for fast charging; the location matches with the traditional filling station for long-range vehicles: electric charging and hydrogen filling (for cars, busses and trucks). If the location is close to a solar or wind park and has a MV connection, the fast charging grid capacity is available; solar and wind energy supply and surplus energy storage is enabled. The same benefits of electricity and hyrdogen storage as in scenario 1 are valid here. Also the same secondary income streams are foreseen.

3. Central control of CPs in a residential area, establishing a real charging plaza (at a public parking area) or virtual charging plaza (CPs distributed in the area) with battery storage: matches with the 80% of home/work charging; limited match with renewable generation profile (car not at home during the day), but a battery can improve this. Hydrogen storage and filling will not be part of this option. The 'neighbourhood battery' as part of the NEFUSTA station can store local renewable energy during the day and provide charging power during the evening/night, at the same time mitigating grid overloads. Furthermore, the aggregated control of the CPs maximises the smart charging benefits. Storage and aggregated smart charging can be used to provide electricity trade, imbalance and reserve power services. Secondary income streams in this scenario could be: drop-off/pick-up of parcels and groceries, shop, district meeting place.

IV. Functional Design

The functional design of the NEFUSTA station considers all technical elements needed for the intended functional and operations (Fig. 1).

- Charge points for EVs, normal or fast charging, depending on the scenario and location.
- Hydrogen filling points for fuel cell vehicles.
- Electricity storage (most probably in Li-ion batteries).
- Hydrogen storage tanks.
- Connection of the station to the electric grid, both for electricity supply and for feeding electricity back to the grid.
- Possible local renewable generation, within or outside of the NEFUSTA premise.

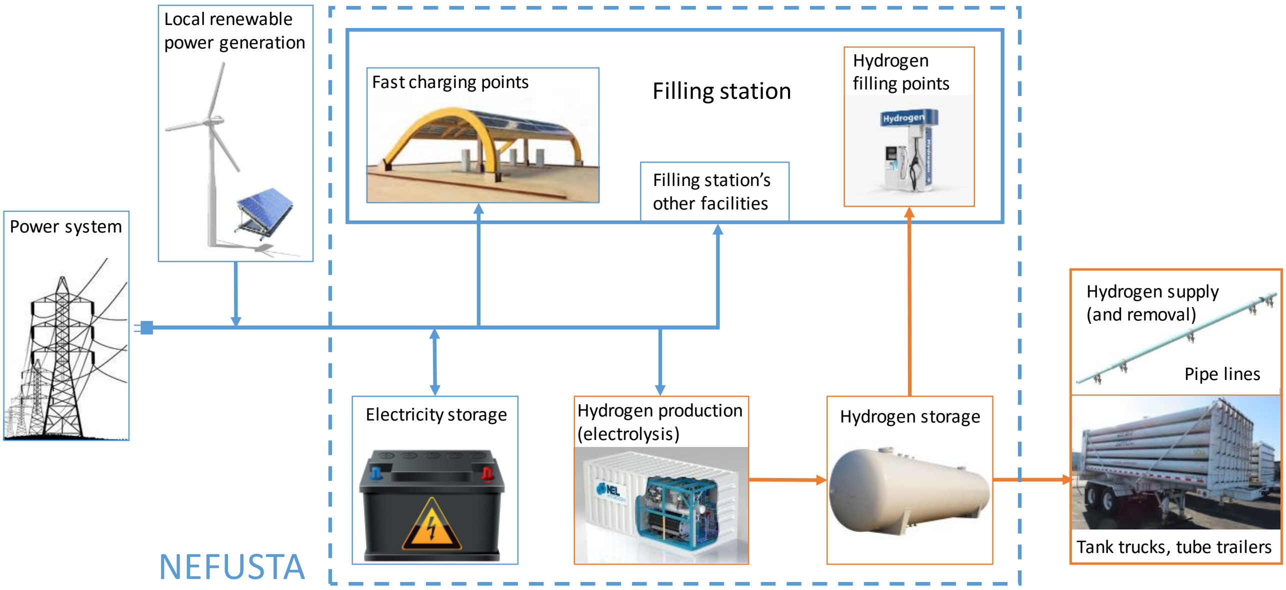

Figure 1. Schematic overview of the NEFUSTA station with electric charging and hydrogen filling points.

- Hydrogen production on site through electrolysis.
- Supply of hydrogen from outside through pipe lines or tube trailers. These might also be used to transport hydrogen out of the station, in case it is economically beneficial to have local over-production of hydrogen.

The functional design will lead to the sizing of the main components.

V. SAFETY AND RISK ANALYSIS

The NEFUSTA consortium is working on the risk analysis. The main points of the risk analysis are:

- Hydrogen safety rules according to the Dutch Hazardous Substances Publication Series: PGS 35 “Hydrogen: installations for delivery of hydrogen to road vehicles” [6].
- Safety rules regarding electricity storage systems and technologies, more particularly Li-ion batteries. Existing international standards are applicable, but new standards are under development (mainly in IEC TC120, [7]). The NEFUSTA project will use the GRIDSTOR recommended practice [8] as the main guideline for the safety analysis.
- Safety rules on explosive atmospheres (ATEX), pertaining to electrical systems and particularly Li-ion batteries in the vicinity of the hydrogen storage and delivery systems.
- External safety contours around the NEFUSTA station with hydrogen systems and Li-ion batteries.
- Internal safety issues and risk assessment pertaining to the combination of hydrogen systems and Li-ion batteries in one location.

VI. BUSINESS CASE ANALYSIS

For the business case analysis, earnings and benefits in transportation services, grid services, and electricity markets are studied, using a techno-economic simulation model of the NEFUSTA station. The main elements of the earning models are:

- The sales of transportation energy (electricity and hydrogen). This can be per amount of energy provided or through a subscription system.
- Earnings on the electricity markets (selling energy and flexibility). Flexibility could mean local services (congestion relief, power quality) and regional/national services, like balancing services and reserves. Aggregated services involving a number of stations will be studied as well.
- Sales inside the in-house shops.
- Possible additional services, like parking, car wash, meeting and working spaces, and pick-up and drop-off point for parcels and goods.

The business case analysis is work in progress.

VII. CONCLUSION

A large amount of energy is distributed in a conventional fuelling station. This will be the same in the transition to renewable energy, and filling and charging stations like NEFUSTA will become energy hubs in the energy supply system for transportation and power. One important function of the station is energy buffering. This should be physical buffering (e.g. batteries and hydrogen tanks) on the one hand, but could also be virtual buffering in the form of demand response by connected EVs. The buffers are needed for fuelling and charging services to vehicles, but especially the batteries are also strong assets for electricity trading and providing services to the power system.

The aim of the NEFUSTA project is to prove that a network of stations with this double functionality is feasible:

- Recharging or refilling new energy vehicles.
- Trading electricity *and* supporting the power system (local congestion management and regional balancing and reserve services).

Through this combination, an acceleration of two energy transitions is enabled:

- The share of renewable energy sources in the electric power system.
- The share of sustainable transportation fuels for road vehicles.

References

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