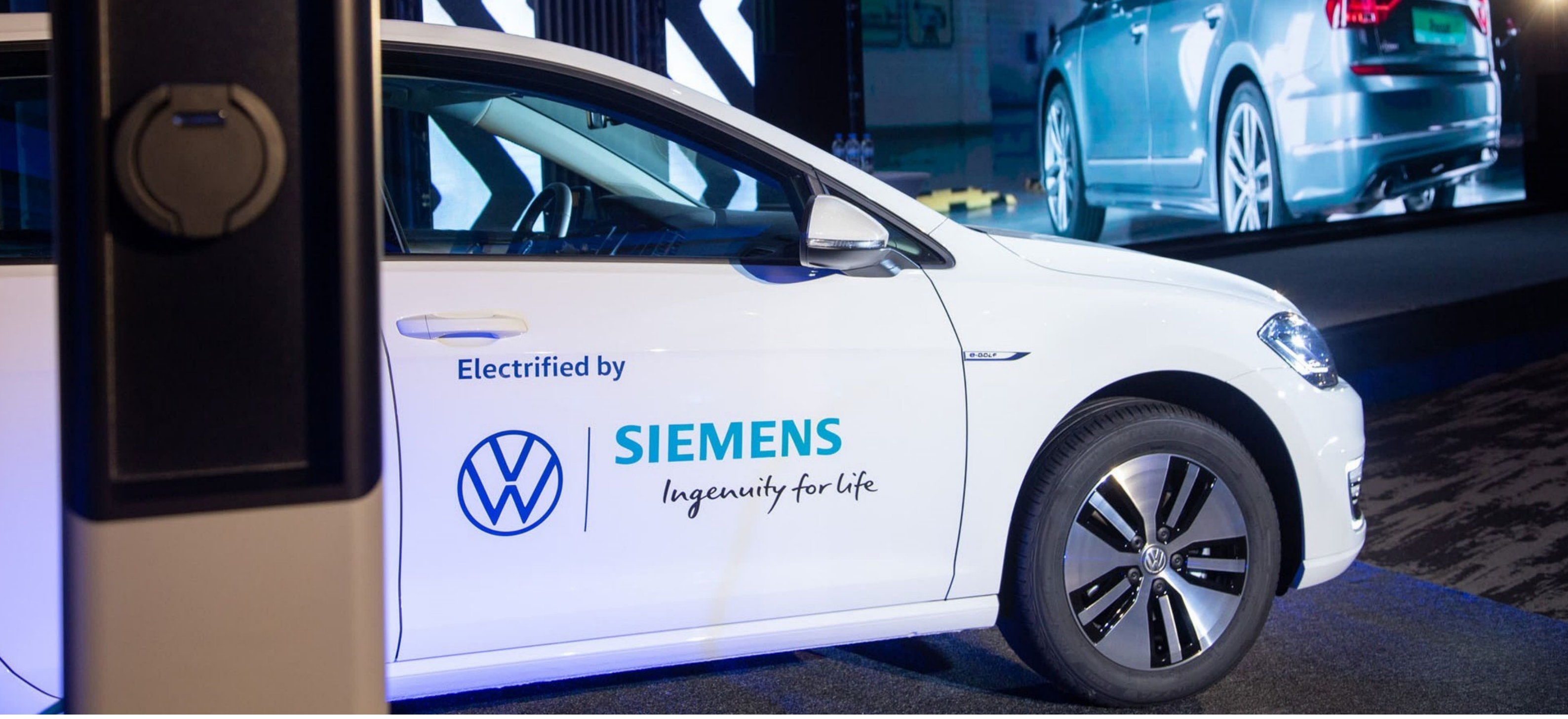


SUSTAINABLE EMOBILITY CONCEPT FOR RWANDA’S DISTRIBUTION GRID

# Grid integration of new **eMobility services**

SIEMENS

## At a glance

Mobility-on-demand concepts are perceived to cover an increasing share of the total mobility demand, especially in cities and (sub-)urban areas. When combining these concepts with the on-going discussion on greenhouse gas emission and (urban) air quality, the (green) electrification of the mobility sector stands in the center of discussion, not only in Europe, but in Africa as well.

## Initial situation and challenges

Since starting of 2018, Moving Rwanda is a cooperation between several key stakeholders of the private sector as well as the German Federal Ministry for Economic Cooperation and Development as part of the strategic partnership “Digital Africa”, with the objective to evaluate and develop digital mobility concepts and support a sustainable development in Rwanda. Electromobility (eMobility) is one opportunity to support the aspired development. This creates new challenges for the electrical distribution system in Rwanda when planning and implementing the required charging infrastructure.

## The solution

Based on the concrete application of electrical vehicles (EV) by the Volkswagen Group South Africa in Rwanda’s capital Kigali, Siemens PTI conducted an eMobility study to support the reliable, efficient, and sustainable integration and supply of eMobility in Rwanda and provide answers to key questions of the EV integration in Africa:

- **Which benefits do EVs provide** for the implementation of sustainable car sharing models in Rwanda?
- **What are the key challenges** of the integration of electric vehicles into the current electrical network of Kigali?
- **Which solutions and strategies** could be applied to ensure a reliable, efficient, and sustainable energy supply?

## Shared mobility services in Kigali

Volkswagen Mobility Solutions Rwanda offers mobility solutions services such as ride-hailing and corporate car sharing. The services are offered on the Move App, an innovative IT mobility solution which was developed by a local IT start-up company, Awesomity Lab. Move App has about 27,000 registered users. Over 75,000 rides have been completed in the ride-hailing service since the beginning of 2019.

- **Ride hailing:** Similar to taxis, this car sharing service consists of cars driven by a dedicated and trained driver, which can be booked via a call center or on a smartphone using the Move app, and then carry the passenger(s) to his/their destination.
- **Corporate Car Sharing:** This shared mobility service is represented by a company fleet of vehicles to be used by the employees, driving themselves during the day (e.g., sales, delivery), but for private purpose as well (similar driving behavior like private car).

## From eMobility scenarios to a reliable charging concept

As each shared mobility concept reflects a different customer need but has not been realized in Kigali before the study started in 2018, the translation of customer need into driving behavior was prepared based on specific scenarios, typicals and variations of the anticipated driving respectively parking patterns. With the experience over the upcoming years, user and driving behavior is analyzed and will lead towards a data-based reflection of the mobility demand. Combining several profiles, the driving/parking patterns of multiple vehicles were then translated into status information about cars, which are parking at one specific charging site and could be connected to the charging pole over their parking time.

Taking 10 EVs with different ride hailing profiles as an example the following figure shows an exemplary allocation of parking times over one day at one specific site.

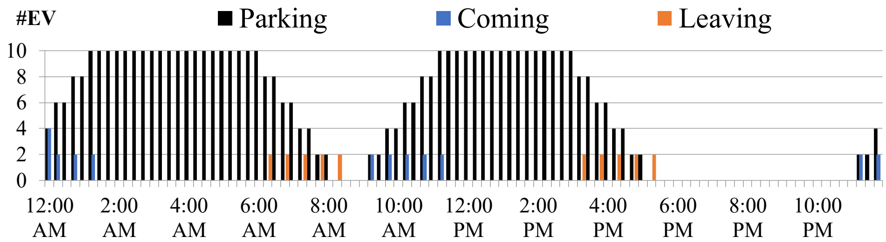


Figure 1: Exemplary variation of driving/parking for ride hailing service

Subsequently, multiple driving/parking patterns of the different mobility services including their variations were combined based on the anticipated number of EVs per charging site. To evaluate the optimal number of charging points (CP) per charging station (CS) several aspects needed to be considered. They also had to be valued, as different objectives like redundancy of charging points and economic efficiency are contradictory and required a case specific trade-off. Therefore, the decision strategy to identify the optimal number of charging points is reflecting the following implications and priorities:

1) Drivers and mobility services shall not be restricted in their driving demand due to delays caused by long charging times or waiting for free charging points.
2) Full energy demand must be supplied per charging event (100% state of charge, when leaving the charging station).
3) Number of charging points shall be limited to an economic reasonable EVs per charging points ratio (increase number of EV/CP).
4) (n-1) redundancy of charging points has to be ensured to avoid the non-fulfillment of 1) to 3) in case that one charging point fails, is permanently occupied or has to be maintained.

In accordance with 1) multiple scenarios and variants were analyzed to identify the appropriate number of charging points per charging station. The following figure 2 shows the exemplary 24h-evaluation of one RH charging station with 10 EVs requesting 15 kWh each coming to the charging station and one (graph a), resp. two (graph b) and three (graph c) CPs (see Figure 2).

## Optimal grid connection of charging infrastructure

Subsequently the different maximum charging power values occurring at different sites were used to evaluate the connection to the electrical network in Kigali. After analyzing the network connection of the charging sites, the Kigali network model was updated with the anticipated loads of possible charging locations/technologies to the distribution grid or independent charging hubs. Therefore, the eligible ring main units (RMUs) in the network were identified and the additional peak load coming from the demand analysis was connected to the selected RMU. The investigation identifies different network measures to avoid overloading or critical conditions if necessary. In addition, it provides a techno-economic evaluation of the different charging options.

Besides the connection to the distribution grid, another option of supplying the charging sites with the requested power is an off-grid solution combining the CPs with a photovoltaic power plant (PV) and an electrical energy storage system (Li-Ion battery) to provide the power during the night and times the PV does not generate enough energy to meet the load.

"Within the Moving Rwanda partnership and as a first of its kind for the African continent, Volkswagen has launched this pilot project to test the feasibility of electromobility in an African country. By partnering with Siemens PTI, we were able to develop an optimal integration strategy and charging infrastructure concept which can be applied to other African markets like Ghana and Ethiopia in the future."

Thomas Schaefer (CEO), Volkswagen of South Africa (Pty) Ltd

To ensure a reliable power supply, the PV plant as well as the Li-Ion battery have to be dimensioned to cover the EV load over the whole year. Therefore, the PV generation is simulated based on the solar radiation in Kigali and the battery is dimensioned accordingly. In consequence different installed capacities (installed power/installed storage capacity) of PV and battery as well as different load profiles (ride hailing, corporate, community) are analyzed to identify the techno-economical optimum. The comparison to a grid connected charging site is prepared based on levelized cost of electricity to enable a comparison to the grid rate. The following figure shows the exemplary dispatch simulation over one day.

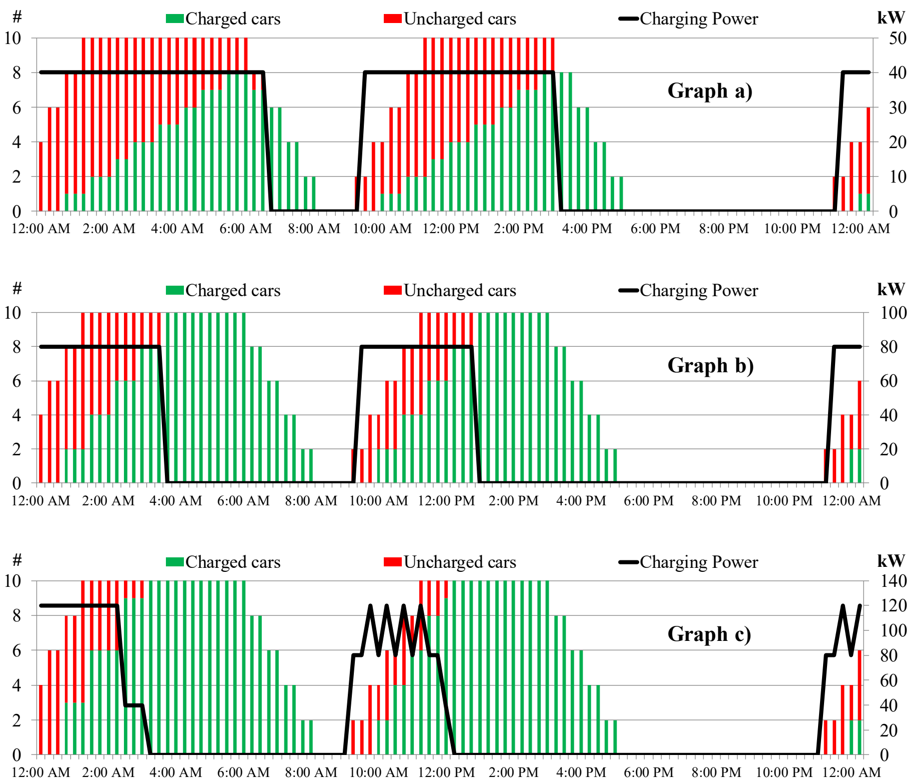


Figure 2: Exemplary load profiles for 10 EVs and different number of CPs per charging station

For this means, Volkswagen is offering to use a fleet of vehicles assembled at Volkswagen Rwanda's assembly facility in Kigali. By the end of 2019, Volkswagen Mobility Solutions Rwanda will have a fleet of more than two hundred vehicles providing data and experience for Volkswagen and Siemens to further drive the development of eMobility in the region.

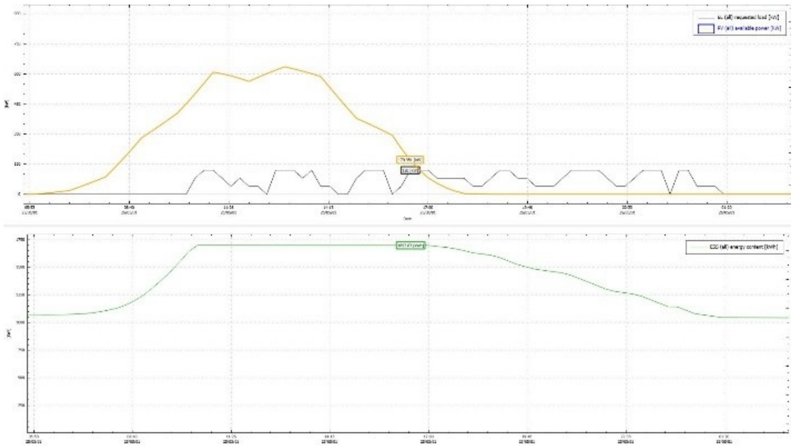

Figure 3: Dispatch simulation of an off-grid charging station

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When compared to the current electricity tariff in Rwanda, the prices of today's off-grid solution exceeded the network tariff. Yet the off-grid solution could reduce the specific $CO_2$ emissions even further as the km-specific emission of a PV plant results in only approximately 13% of the emission of the current generation mix.

## Summary

Siemens PTI's EV study of the actual shared mobility services and the electrification of the respective fleet highlights the current and future challenges when planning the integration of EVs and the necessary charging infrastructure into the distribution network –not only in Europe, but in other continents like Africa, as well.

One of the biggest challenges is the anticipation of the driving behavior, which in the end determines the required charging infrastructure and, in consequence, the necessary network components. Nevertheless, it is possible to identify the potential investments if specific objectives (e.g., 'mobility services shall not be restricted in their driving demand') are translated into corresponding strategies (e.g., reduced EV per CP ratio).

To overcome the planning insecurity, a stepwise approach was proposed, which uses field experience and driving data to verify the number of required charging points.

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