Micro Perspectives for Decentralized Energy Supply

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Microenergy-Systems

Frequency Control Applying Plug-in Electric Vehicles Based on Costumer Behavior in Electric Power Networks and Micro-Grids

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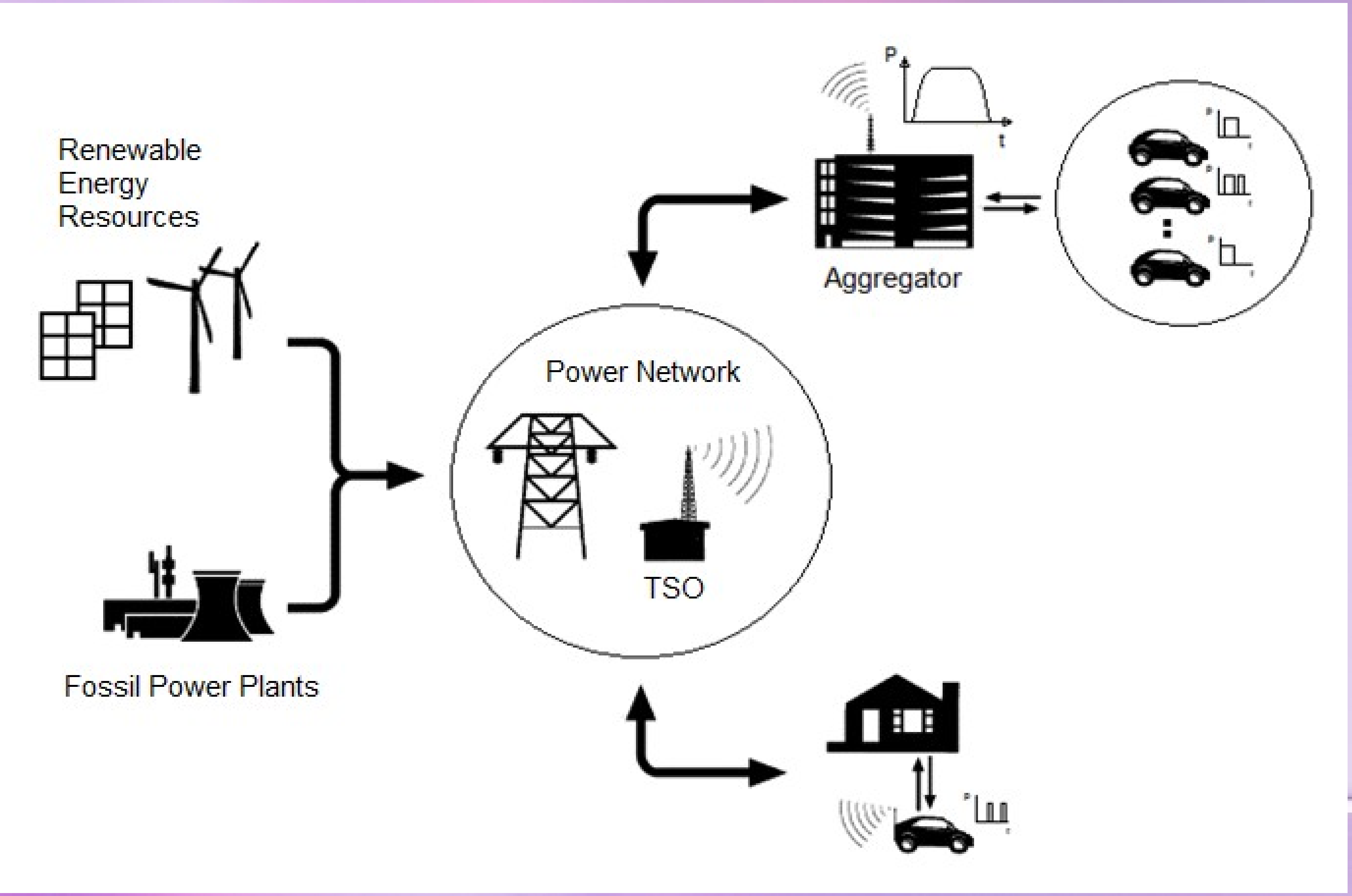
The Main Idea



Introduction

- A micro-grid is mainly consisted of distributed energy resources and energy storage systems

- Electric vehicles (EVs) can be assumed as both appropriate power generation units and storage devices

- As it is planned, one million EVs will be applied till 2020 in Germany which could provide us with a great electric power potential

Introduction

-The EVs could be very useful for secondary frequency control because of their battery's characteristics of lower energy and quick response time

- In other words in addition to the technical benefits, this potentials could be applied for maintaining the power networks stability by mean of ancillary services

- Micro-grids are commonly consisted of renewable energy resources like wind turbines or solar power units that have uncontrolled power output

Introduction

- A single battery could provide 4-20 kW which could be very advantageous for Germany's power network frequency regulation or a part of its power grid such as available micro-grids

- An Aggregator is necessary to deal with the small-scale power of the vehicles for providing the regulation service on an appropriate large-scale power

- It's also inevitable to consider the psychological behavior of the human beings in using an electric vehicle and connecting it to the power grid

Introduction

- The minimum and essential requirement of the vehicle owners for joining the ancillary service is to be guaranteed about the charge of their battery to a desired level

- In addition some incentives such as direct payment or lifetime warranty of the battery should be given for voluntary participation of the vehicle owners

-These batteries could easily replace fossil-fuel power plants for secondary frequency control and are very clean energy resources

Method

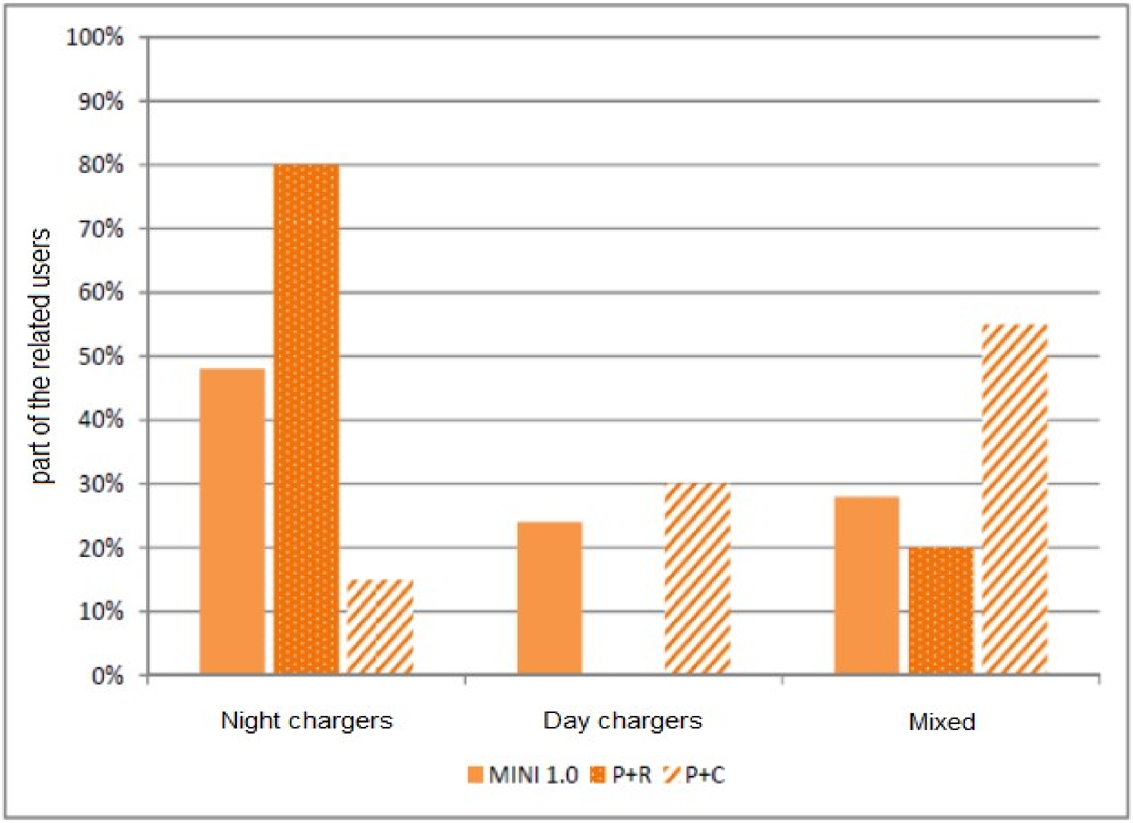
- The performed simulation in this research is based on the results of TU Chemnitz's psychological studies

- Due to these studies, the vehicle drivers are divided into three groups: park + ride users (P+R), park + charge users (P+C) and public car sharing users

- These groups are separated into day chargers (5 am- 5 pm) and night chargers (5 pm- 5 am

Method

Part of the night and day chargers in the Mini E V2.0 project



Method

- A large number of batteries will be available that could inject their stored power to the network at peak load times

- Also at low load times they could consume the generated power of the base load power plants and the unplanned generations of the renewable energy resources

- The simulation in this paper is based on these data and is carried out for different operation scenarios to show how the vehicles could maintain the power network’s frequency stability

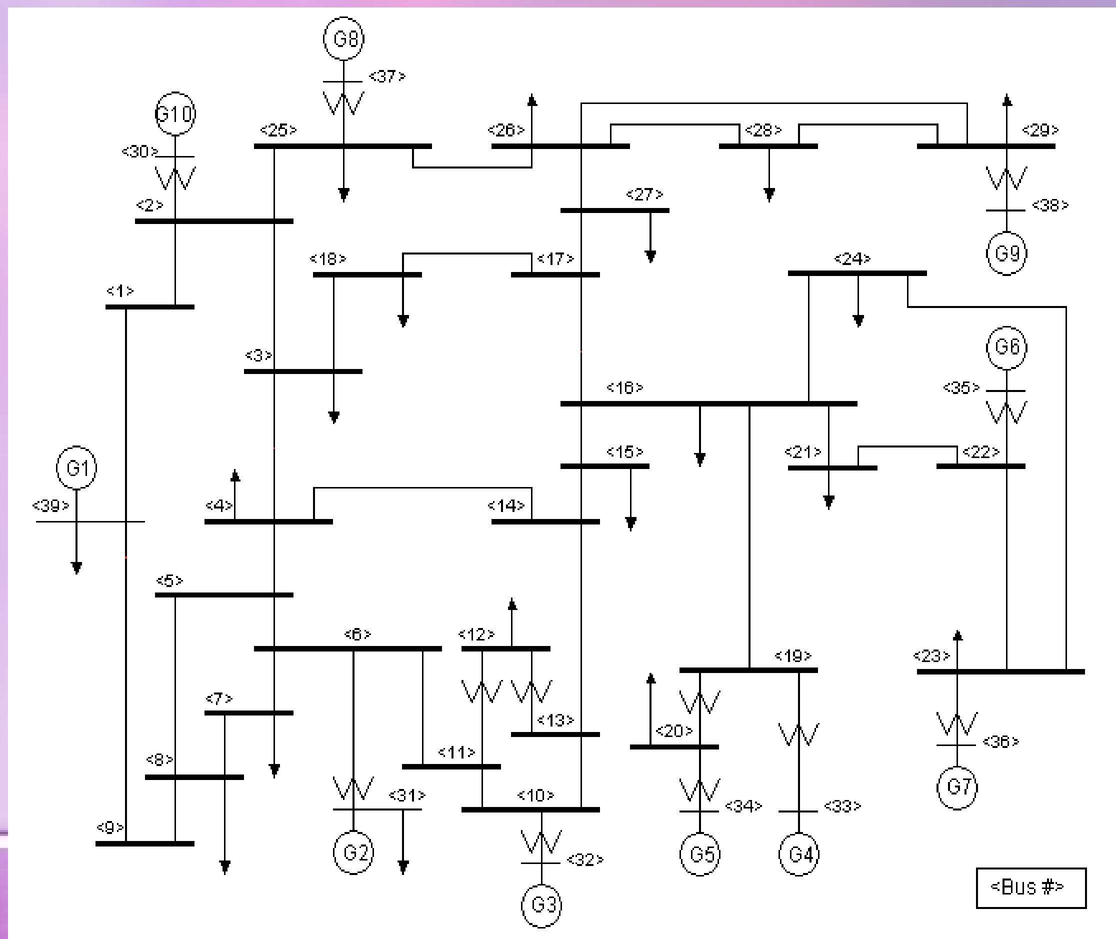
Method

-Each battery has three different states as follow: charging, discharging and standby

-The aggregator must optimally choose and organize the state of each vehicle for the power grid's regulation aspect

- The IEEE 39bus Standard Network is applied for this research simulation to show the impact of the electric vehicles for secondary frequency control purposes

Method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Mini E's Technical data

- A full charging period of the batteries lasts 4-10 hours regarding the available power amperage

- Each Mini E battery has a 28 kWh usable capacity which could provide us with circa 6 kW power per vehicle

- We consider two aggregators in the network

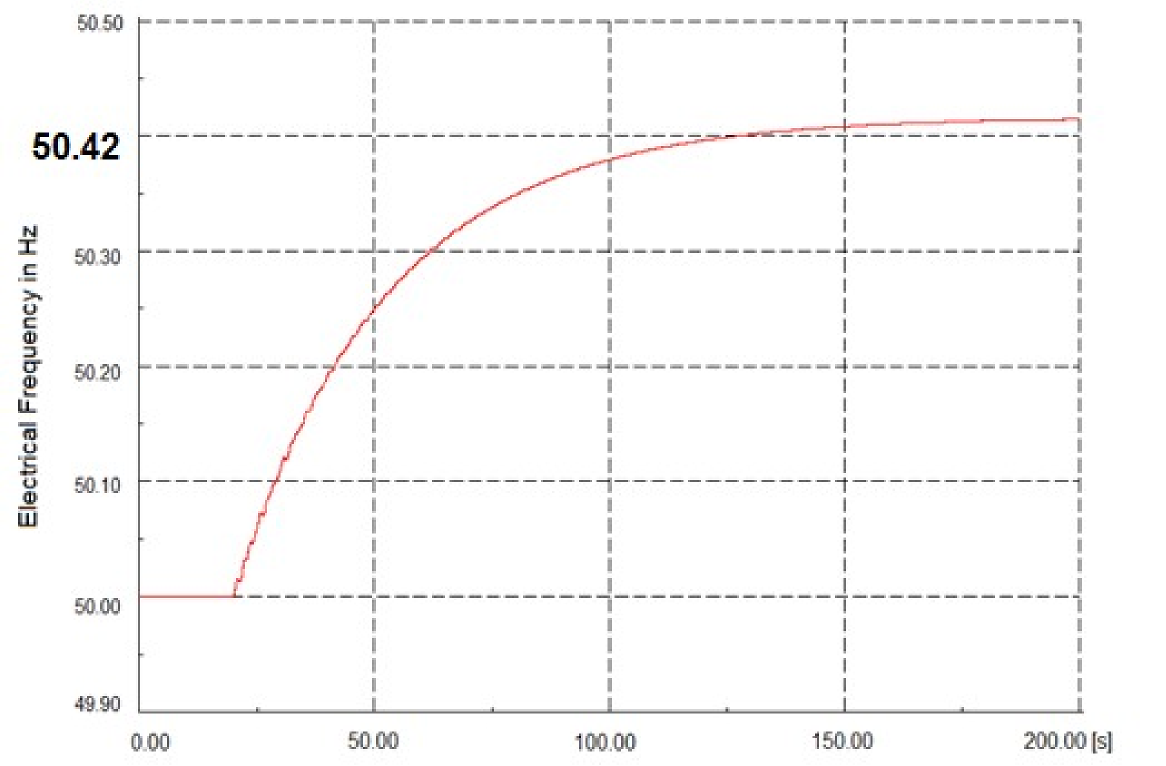
Simulation Results

Night chargers:

- Aggregator1 collects 10000 available vehicles (60MW) and Aggregator 2 includes 5000 vehicles (30 MW)

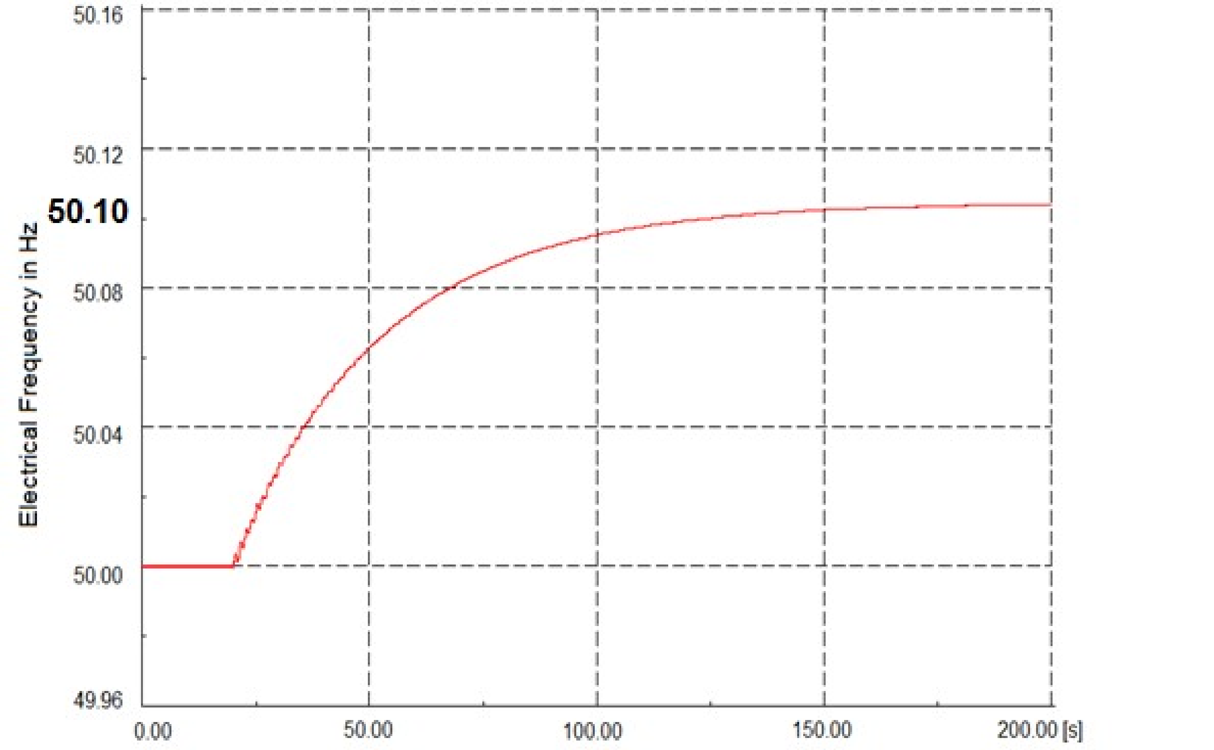
-Different case studies were simulated during this period but just two main scenarios are analyzed in this paper as follow:

Scenario1: Generation increase of 70 MW



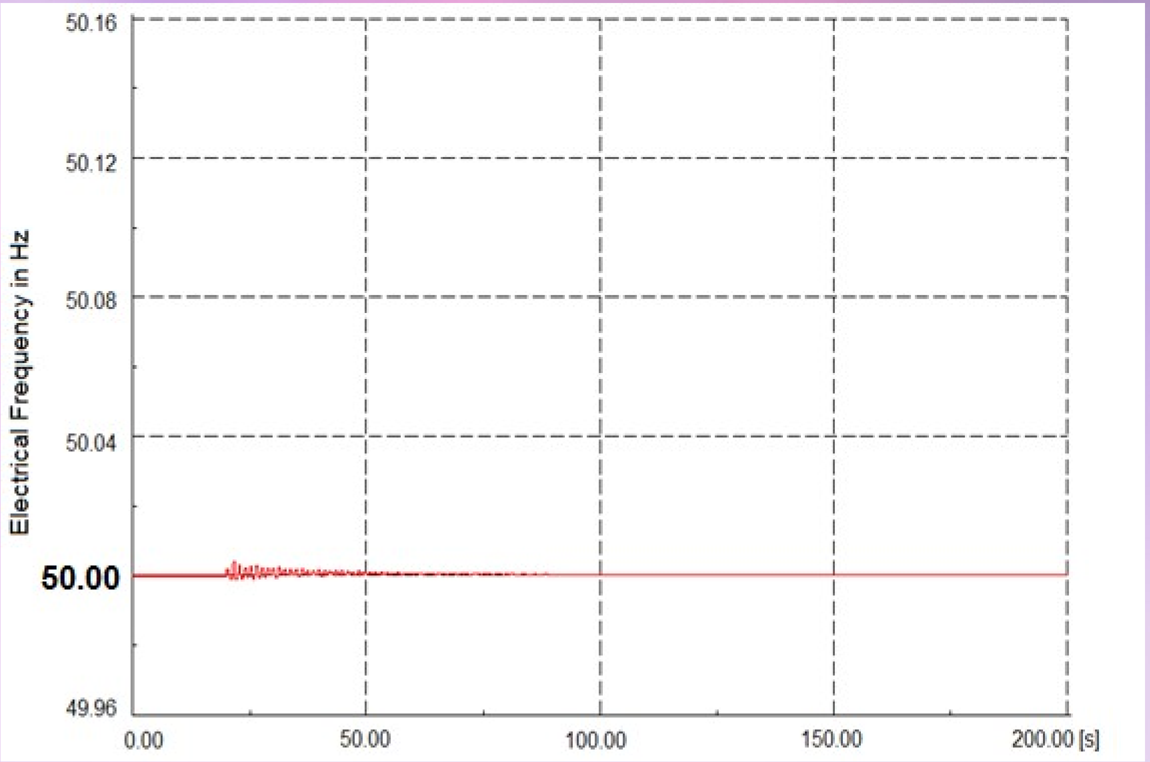
increasing network frequency after generation increase

Scenario1: Generation increase of 70 MW



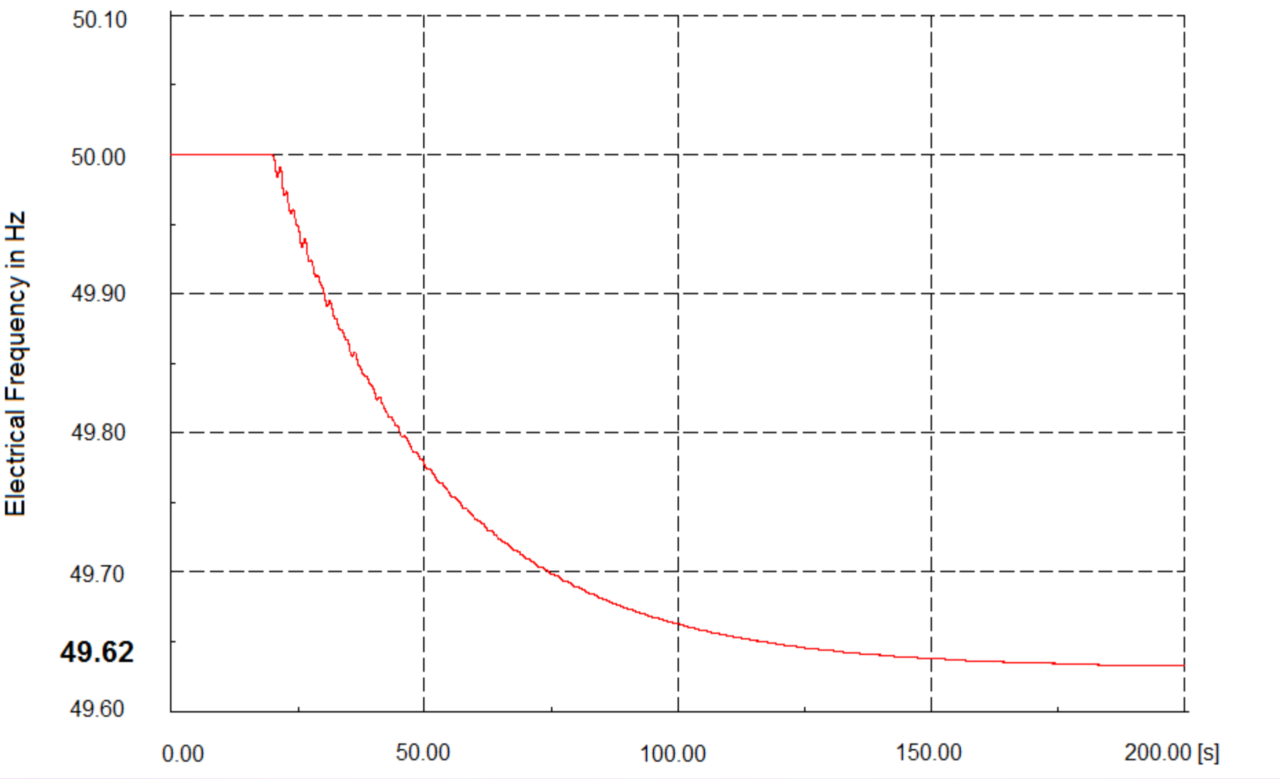
impact of the primary frequency control on the frequency deviation

Scenario1: Generation increase of 70 MW



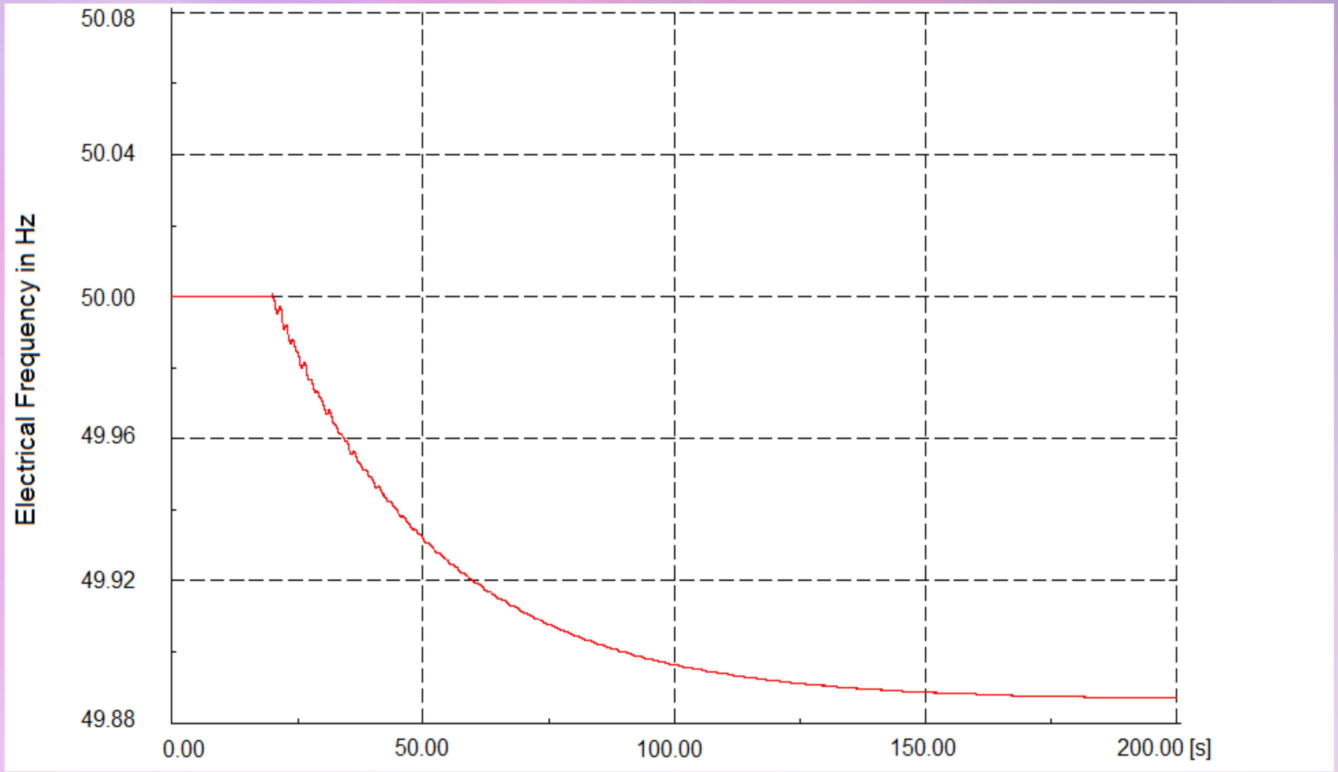
impact of the electric vehicles as secondary control on the frequency deviation

Scenario2: Load increase of 50 MW



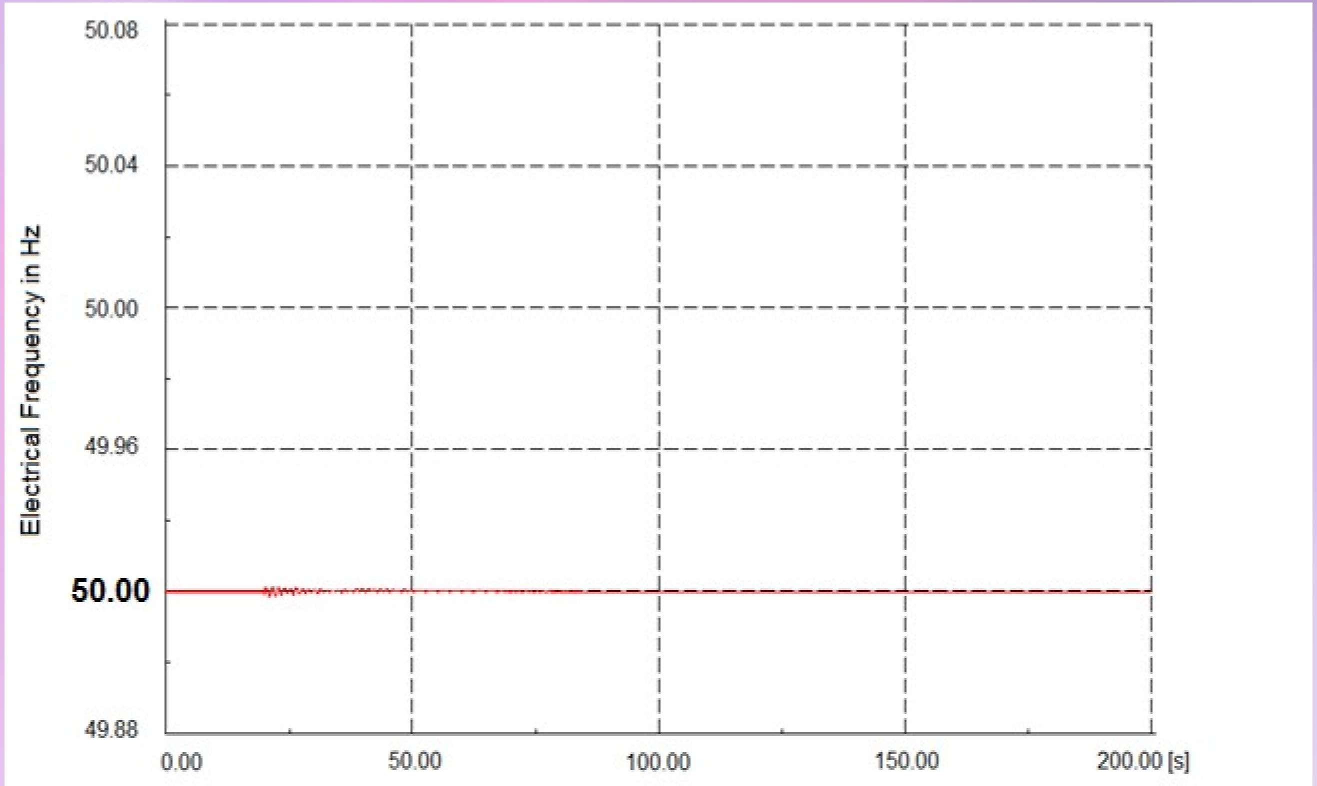
decreasing network frequency after load increase

Scenario2: Load increase of 50 MW



impact of the primary frequency on the frequency deviation

Scenario2: Load increase of 50 MW



impact of the EVs as secondary control

Conclusion

- The simulation results show that the application of electric vehicles is very effective as secondary frequency controllers for the whole power network stability and its related micro-grids
- In both scenarios were the vehicles able to bring back the frequency to its nominal value (respectively from 50.42 Hz in scenario1 and 49.62 Hz in scenario2 to 50 Hz)
- The available potential of these vehicles in 2020 (around 6 GW) could really help Germany’s power grid operators in maintaining the stability of the network without any concerns

Conclusion

- The consumers can also earn money by participating in the electric market using their vehicle's batteries
- Furthermore are these vehicles totally environment-friendly and are preventing the emission of greenhouse gases that is also a very important constraint in any power network operation planning
-Finally, the use of EVs is strongly recommended for system operation issues like secondary control, power reserves and storing the extra power of renewable energy resources

Thank you for your Attention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