TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	**EVACC**
Title	**An Autonomous Charge Controller for EVs Using Online Sensitivity Estimation**
ERIGrid Reference	**05.020-2018**
TA Call No.	**05**

HOST RESEARCH INFRASTRUCTURE			
Name	**MultiPower Laboratory - VTT Technical Research Centre of Finland Ltd**		
Country	**Finland**		
Start date	**8-Jan-2020**	**Nº of Access days**	**13**
End date	**27-Jan-2020**	**Nº of Stay days**	**19**

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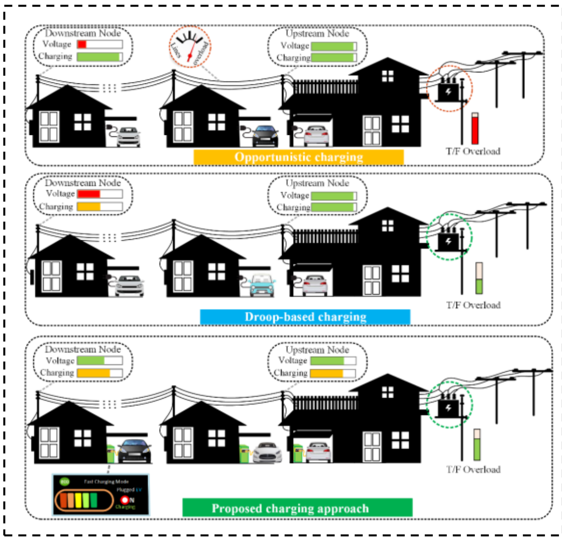
Country	**Saudi Arabia**

1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)



Electric vehicles (EVs) are becoming ubiquitous and their large-scale integration into the power distribution system affects the power quality unless the proper charging strategy is implemented. To mitigate such issues, an EV charge controller is required that throttles the charging rate of EVs. A proportional voltage-based charging strategy can avoid voltage violations to happen. However, this charging scheme unfairly charges the EVs available at various nodes of the power system. The EVs connected at upstream nodes are undesirably charged at a faster rate since they have a good voltage profile as these nodes are closer to the feeding point. On the other hand, the EVs connected at downstream or farther nodes are unfairly charged at a very low rate as they experience lower voltages. Some other controllers are also presented in the literature, such as the voltage-based nonlinear controller and voltage-and-sensitivity-based controller. These controllers perform comparatively better in terms of ensuring fairness among the EVs available at different charging points in the system. However, they have conservative charging behavior especially when the load in the system is low. The purpose of the work conducted at VTT MultiPower lab is to develop an autonomous EV charge controller that can avoid voltage violations while fairly charging the EVs at maximum possible charging rate. These objectives have been achieved by applying a neural network-based machine learning technique. The EV charging curtailment factor is calculated based on the local measurements, such as nodal voltage and its sensitivity. The upstream nodes generally have a good voltage profile and are less sensitive to the load changes. However, downstream nodes usually have lower voltages but they are more sensitive to the variations in the load. These complementary characteristics help to ensure fairness among the EVs available at upstream, midstream, and downstream nodes of the power system.

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

The system is subjected to different loading conditions in order to incorporate daily, monthly, and yearly load variations, shown in Fig. 1. The data set is then generated using nodal voltage, it's sensitivity, and the corresponding EV charging reduction factor. Many controllers are trained using the generated data set and then implemented on an EV-rich test distribution system.

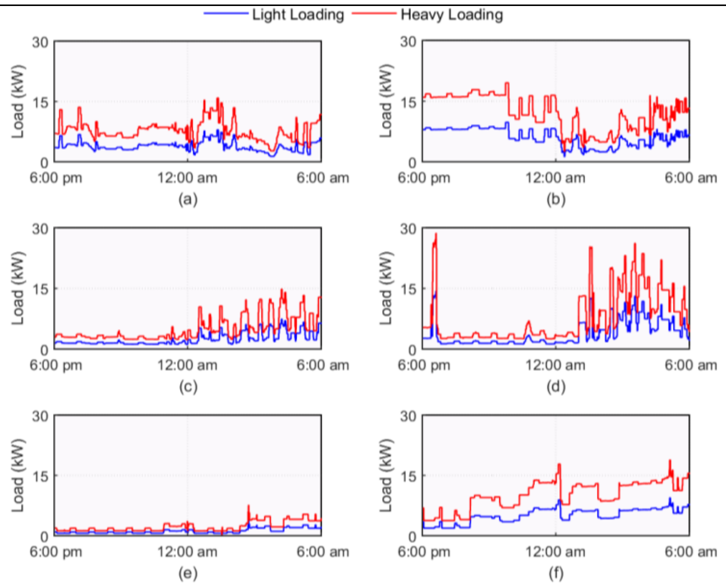
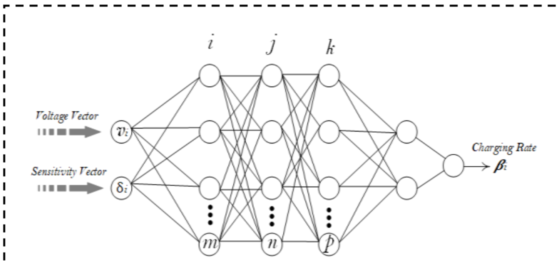


Figure 1: Non-EV load profile at (a) Node-2 (b) Node-3 (c) Node-4 (d) Node-5 (e) Node-6 (f) Node-7.

Finally, a neural network-based controller is proposed that ensures fairness among the EVs available at various locations in the distribution system. Moreover, it effectively avoids voltage violations to happen. The results are compared with different charging strategies, such as opportunistic, proportional voltage-based strategy, voltage-based nonlinear strategy, and voltage-and-sensitivity-based strategy. The results of the proposed controller are deemed far better in terms of both power quality improvements and fairness enhancement as shown in Figs. 2 and 3, respectively.



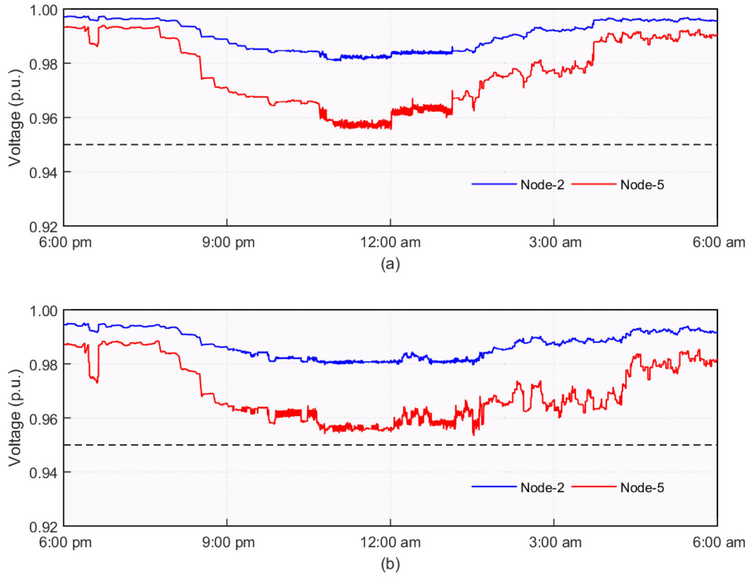


Figure 2: Proposed charging voltages at Node-2 and Node-5 during (a) light loading (b) heavy loading.

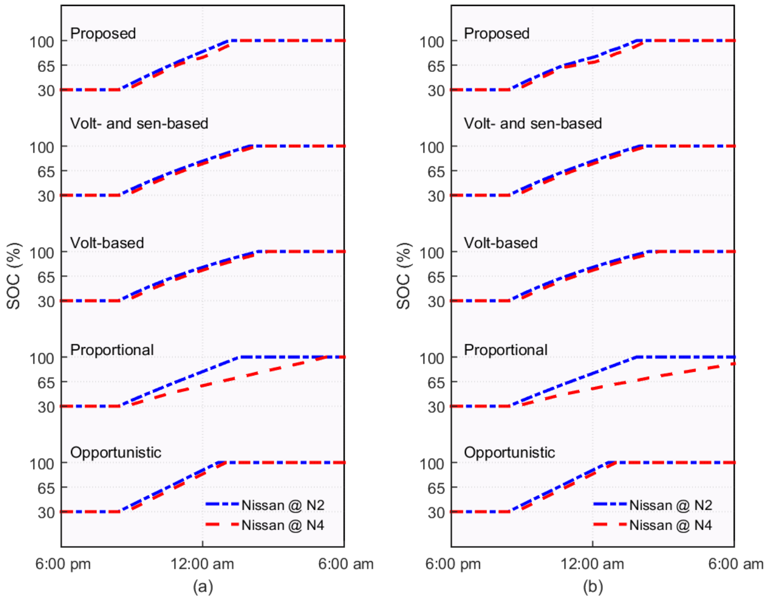


Figure 3: Comparison of Nissan Leafs available at Node-2 and Node-4 with different controllers during (a) light loading (b) heavy loading.

Moreover, the proposed controller charges the EVs faster as compared to voltage-based and voltage-and-sensitivity-based controllers as shown in Fig. 4. These results prove the efficacy of the proposed controller.

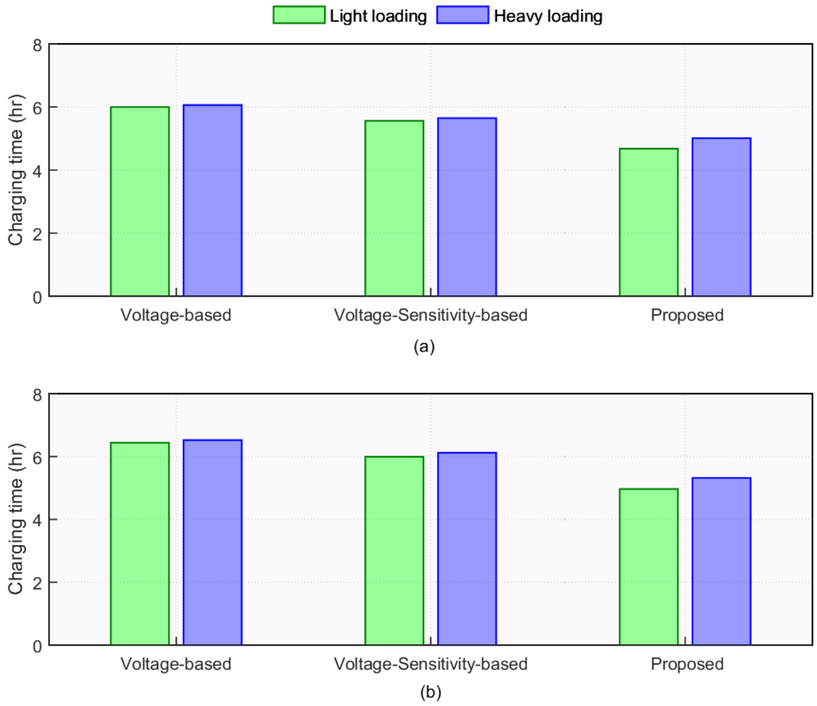


Figure 4: Comparison of the average charging time with different controllers for (a) Nissan Leaf (b) Tesla.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

The plan is to publish one conference and one journal article from the work done at the VTT MultiPower lab. The journal article will be submitted to one of the following well-reputed peer-reviewed journals:

1. IEEE Transactions on Industrial Informatics
2. Applied Energy
3. IEEE Access

It is also planned to submit a small part of this work to one of the following conferences:

1. 10th IEEE PES Innovative Smart Grid Technologies (ISGT) Conference-Asia
2. 12th IEEE PES Innovative Smart Grid Technologies (ISGT) Conference-North America