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A novel hybrid prediction model for aggregated loads of buildings by considering the electric vehicles

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ABSTRACT

In this paper, a new prediction model for aggregated loads of buildings has been propose. Due to high correlation of prediction performance with related horizons and aggregated more customers, a new strategy is developed to provide a forecasting model based on high accuracy. While, consumption shape of a single users normally has low structure to be exploited and vice versa. So, combining different users develops the relative prediction performance up to special point. Outside this point, no more enhancement in relative performance can be found. This model is useful in optimal power system operation and planning in micro-grids. In this paper, besides the aggregated loads of building, the electric vehicle (EV) impact on network has been considered. While, by considering the load growth prediction and impact of EV adaption on load curves this problem can be an important issue for the power grid operation and management. So, an accurate prediction model is presented in this work which is composed of new feature selection and enhanced support vector machine (ESVM) based forecast engine. Effectiveness of the proposed model is carried out to the part of Budapest city through comparing with other prediction models. Obtained results demonstrate the validity of proposed method.

1. Introduction

1.1. State of art

Due to fast growth of renewable sources in power grids and application of new technologies such as electric vehicles (EVs), a novel architectures is demanded for electricity distribution network as well as transmission's organization. Different load users, make the network scalable in micro-grids forms. While, application of new green sources such as wind, solar, and different forms of local storage as well as demand response make the system more complicated. In such models, optimal power output and exact usage of customers are required to set the optimal system operation (Ghadimi, Akbarimajd, Shayeghi, & Abedinia, 2017a, 2017b; Kulkarni, Gormus, Fan, & Motz, 2012). For this purpose, an accurate aggregated load forecast is demanded. Generally, the buildings load are about 1–2 kW and this value is about 100–200 kW for complex buildings. However, there is a significant difference between prediction of such users and the whole network. This problem can be presented as aggregated load of users through prediction of gathered loads. In this paper the individual and aggregated loads have been considered as load prediction model while the differences of these models proves the validity of aggregated mode.

Besides the mentioned problem, EV adaption on grids can increase the network operation problems. This problem can arise in urbanized cities around the world due to providing the clean as well as green mobility of human. By improving the mentioned problem in developed societies, the EVs will be deployed from car parks to commercial buildings and residential apartments. This problem can simulate important operation drawbacks for power grids through the charging process of EVs. The effects of EV fluctuations as well as uncoordinated charging over the building and apartments can be found in (Doppstadt et al., 2016). The smart grid structure with different loads is presented in Fig. 1.

Due to the mentioned problems, an accurate prediction model is demanded. For this purpose, different prediction models have been proposed by researchers in recent years.

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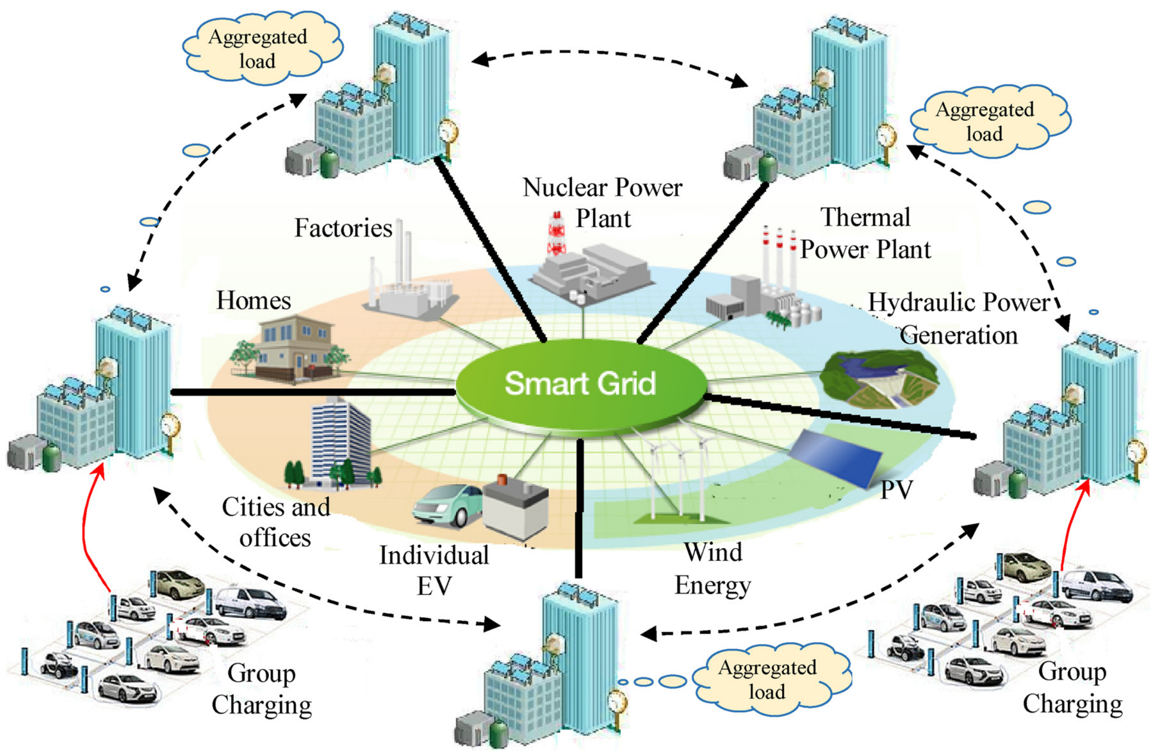

Fig. 1. Smart grid model including aggregated load and EV.

1.2. Literature review

Various short term load forecasting (STLF) models have been proposed by researchers such as Clements et al. (2016). For instance, in (Jetcheva, Majidpour, & Chen, 2014), the authors proposed multiplicative autoregressive models to predict the load. Dynamic linear method and the nonlinear method are presented in Cheng, Qi, and Zhao, (2008) and Huang and Shih (2003), respectively. The Gaussian process model is presented in Unsihuay-Vila, Zambroni de Souza, Marangon-Lima, and Balestrassi (2010). Some new prediction model which can solve the nonlinearity of signal are presented recently while in (Wei and Zhen, 2009), combination of ARIMA model is presented to deal with the linear part and a neural network with the non-linear one. However, the main backwards of statistical models is modeling of whole series without taking into account the type of the day. For this purpose, a new intelligent model is presented for STLF problem while in Azari and Ghadimi (2014) and Xiao (2016), the fuzzy logic model is presented, in Pai and Chen (2009), the expert systems, the evolutionary algorithms in Unsihuay-Vila et al. (2010), the support-vector machines is presented in Gollou and Ghadimi (2017), and different versions of neural networks are presented in Sousa, Neves, and Jorge (2010), Xia, Wang, and McMenemy (2010). The expert systems (Rao et al., 2005), and fuzzy logic (Azadeh, Saberi, & Seraj, 2010; Abedinia, Raisz, & Amjady, 2017). Also, different training models of neural network is presented in Quan, Srinivasan, and Khosravi (2014), Hernández et al. (2014), Pao (2009). To improve the forecasting models, some other new models have been proposed based on combined models such as; support vector machine (SVM) in Cortes and Vapnik (1995) with other applications. In Hong (2010), Mohammadi, Talebpour, Safaee, Ghadimi, and Abedinia (2017) hybrid model of this strategy is proposed. A review of the several prediction models for building level forecasting is presented in Roldán-Blay, Escrivá-Escrivá, Álvarez-Bel, Roldán-Porta, and Rodríguez-García (2013) for interested readers.

Besides the mentioned models for STLF problem, EV charging and consideration of this load in residential buildings or individual locations can make new problem or prediction process. In the residential loads as well as EVs can be classified through consideration of their charging procedure. In some of the cities, the EVs are charged together while in some places the individual charging is customary while the individual charging pattern can make the power grid more complicated. In Li (2005), the demand response management considering the different charging models are presented with group charging method. In Ghadimi et al. (2017a, 2017b), the demand response is presented through minimization of EV impacts on distribution circuit of a smart grid. In Pieltain Fernandez, Gomez San Roman, Cossent, Mateo Domingo, and Frias (2011), combination of EVs with green sources is considered as a future solution method for networks. In Gong, Midlam-Mohler, Marano, and Rizzoni (2012), the distribution model of demand considering the EV in smart grids is presented. In Kádár and Lovassy (2012), the authors have presented the impact of EVs charging on electricity consumption, which produce a concentrated power demand in particular points of the grid. In Xydas, Marmaras, Cipcigan, Hassan, and Jenkins (2013), the EV load forecasting is presented by authors which evaluates using different data mining models and their performance in EV load prediction. In Chunlin et al. (2012), application of EVs charging load forecast, and EV charging load forecast using the number of vehicles is proposed.

Although the mentioned models predict the load signal, an accurate prediction model is demanded yet. Furthermore, combination of EV charging in power grid can cause more problems in operation. For this purpose, this work focuses on buildings load forecast through aggregated loads and EV charging effects. The contribution of this paper can be summarized as follow:

1.3. Contributions

a) A new feature selection model is proposed in this paper to choose the best candidate inputs as feeding of forecast engine. In this model, high relevant and low redundant features are selected to increase the accuracy of forecast engine.
b) A new hybrid forecast engine is considered based on support vector machine (SVM) and an intelligent algorithm. The free parameters of