Chapter 32
I-BAT:
A Data-Intensive Solution Based on the Internet of Things to Predict Energy Behaviors in Microgrids

Antonio J. Jara
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Dominique Genoud
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Luc Dufour
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Alexandre Cotting
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Gianluca Rizzo
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Yann Bocchi
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Marcin Piotr Pawlowski
University of Applied Sciences Western Switzerland (HES-SO), Switzerland

Francois Chabbey
Institut Icare, Switzerland

ABSTRACT

Microgrids present the challenge to reach a proper balance between local production and consumption, in order to reduce the usage of energy from external sources. This work presents a data-intensive solution to predict the energy behaviors. Thereby, control actions can be carried out such as decrease heating systems levels and switch of low-priority devices. For this purpose, this work has deployed an Advanced Metering Infrastructure (AMI) based on the Internet of Things (IoT) in the Techno-Pole testbed. This deployment provides the data from energy-related parameters such as load curves of the overall building through Non-Intrusive Load Monitoring (NILM), a wireless network of IoT-based smart meters to measure and control appliances, and finally the generated power curve by 2000 square meters of photovoltaic panels. The prediction model proposed is based on recognition of electrical signatures. These electrical signatures have been used to detect complex usage patterns. The modelled patterns have allowed to identify the work day of the week, and predict the load and generation curves for 15 minutes with accuracy over the 90%. This short-term prediction allows one to carry out the proper actions in order to balance the microgrid status (i.e., get a proper balance between production and consumption with respect to worked requirements).

INTRODUCTION

The balance between produced and consumer power is gaining special attention during the last decade, when a wide range of experiments and net-zero buildings are being deployed. This interest on optimize the energy usage, and focus on renewable energies, is coming as a consequence of the increase of costs of the fossil fuels, and the negative con- sequences for the nature of them. These factors have driven research of solutions for sustainability in energy production, distribution, storage, and consumption.

In energy distribution, new "smart metering" solutions have been proposed, based on the idea that exploiting properly data on power generation, distribution and consumption, a substantial increase in efficiency is achievable, Goumopoulos and Kameas (2009). This data exploitation requires the capabilities to provide bidirectional communication with the appliances, production plants, and the smart meters. For that reason, the Internet of Things plays a crucial role for the development of the energy distribution in microgrids.

Examples of the relevance of the communications have been discussed in the DINAR project. DINA project has explored technological aspects of the coordination within the low-voltage. For this purpose, the Bidirectional Energy Management Interface (BEMI) has been developed as a communication interface to each other and the utility. Thus energy consumption and generation can be coordinated.

For these communications, the Internet of Things aims at facilitating the communications. In particular, smart metering is one of the initial and more extended use cases for the Internet of Things, Fan et al. (2010). Several solution have been deployed with ZigBee in Luan, Teng, Chan, and Hwang (2009), 6LoWPAN in Castro, Jara, and Skarmeta (2013) and Watteyne, Doherty, Simon, and Pister (2013), and ZigBee- IP in Shelby (2010). In addition, Wireless Smart Utility Network (WI-SUN) is also extended with new IoT-related technologies such as IEEE 802.15.4g (subGhz) in Gungor, Lu, and Hancke (2010), and presenting a new generation of opportunities to monitor the energy consumption at different levels, i.e., overall consumption and also the independent consumption from specific devices.

An essential goal of the Internet of Things is to have ability to identify devices (using identification technology), and to allow local computing and communication among different smart devices, Cho, Lai, Lai, and Huang (2013). These essential goals are also keys for the future smart grid, and of particular importance for microgrids.

A microgrid is formed by the electric grid and connected devices, e.g. in a group of offices or apartments. Microgrids are on the low voltage level (usually 400V in Europe), in contrast to the high and middle voltage grids, used for power transmission and distribution, Vaccaro, Popov, Villacci, and Terzija (2011). The challenge for smart grids is that the topology of the grid will change dramatically due to the integration of microgrids. In current power distribution grids the energy is still transmitted from a few large power stations to a large number of consumers. The producers of energy are located at the highest level. The energy is distributed across different layers, depending on the voltage level used for transportation. There exist the extra-high, the high, the middle and the low voltage layers. The grid is hierarchically structured, and thus is the control of the grid.

For that reason, the needs for the communication, prediction, and coordination are crucial for the successful integration of the microgrids with the smart grid. The necessity of load balancing of the microgrids is demonstrated in the Figure 1, where can be found the de-synchronization between the generation and consumption in our installations. The objective is to reach a proper coordination between the local consumption and production in order to avoid external costs, i.e., consume from the grid.

Related Content

Adaptive Collaborative Work and XML Web Services: Benefits of Applications into Information Infrastructure and Human Resources

Mayumi Horiand Masakazu Ohashi (2006). *Internet Strategy: The Road to Web Services Solutions (pp. 86-100).*

www.irma-international.org/chapter/adaptive-collaborative-work-xml-web/24664

Deep Learning Neural Networks for Online Monitoring of the Combustion Process From Flame Colour in Thermal Power Plants

Sujatha Kesavan, Sivanand R., Rengammal Sankari B., Latha B., Tamilselvi C.and Krishnaveni S. (2023). *Convergence of Deep Learning and Internet of Things: Computing and Technology (pp. 224-244).*

www.irma-international.org/chapter/deep-learning-neural-networks-for-online-monitoring-of-the-combustion-process-from-flame-colour-in-thermal-power-plants/316022

Narrowband IoT for Internet of Everything

Sudhir K. Routrayand Sarath Anand (2021). *Principles and Applications of Narrowband Internet of Things (NBIoT) (pp. 301-323).*

www.irma-international.org/chapter/narrowband-iot-for-internet-of-everything/268955

Distributed Deep Learning for IoT

Amuthan Nallathambi, Sivakumar N.and Velrajkumar P. (2023). *Convergence of Deep Learning and Internet of Things: Computing and Technology (pp. 96-112).*

www.irma-international.org/chapter/distributed-deep-learning-for-iot/316016

Towards Autonomous IoT Logistics Objects

Bill Karakostas (2020). *Securing the Internet of Things: Concepts, Methodologies, Tools, and Applications (pp. 213-225).*

www.irma-international.org/chapter/towards-autonomous-iot-logistics-objects/234945