Research outputs:

**Peer-to-peer and community-based markets: A comprehensive review**
The advent of more proactive consumers, the so-called "prosumers" with production and storage capabilities, is empowering the consumers and bringing new opportunities and challenges to the operation of power systems in a market environment. Recently, a novel proposal for the design and operation of electricity markets has emerged: these so-called peer-to-peer (P2P) electricity markets conceptually allow the prosumers to directly share their electrical energy and investment. Such P2P markets rely on a consumer-centric and bottom-up perspective by giving the opportunity to consumers to freely choose the way they buy their electric energy. A community can also be formed by prosumers who want to collaborate, or in terms of operational energy management. This paper contributes with an overview of these new P2P markets that starts with the motivation, challenges, market designs moving to the potential future developments in this field, providing recommendations while considering a test-case.

**General information**
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Organisations: Center for Electric Power and Energy, Energy Analytics and Markets, Department of Electrical Engineering , University of Porto, Ecole Normale Superieure de Rennes
Corresponding author: Sousa, T.
Contributors: Sousa, T., Soares, T., Pinson, P., Moret, F., Baroche, T., Sorin, E.
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**Added Value of Individual Flexibility Profiles of Electric Vehicle Users For Ancillary Services**
Vehicle-Grid Integration (VGI) research may serve to limit the self-induced adverse effects of electric vehicles (EVs) in terms of additional grid loading, but also as to make the EV an active asset in supporting a stable, economic power system based on renewable energy. Any use of the vehicle for grid services requires an accurate understanding of the user’s driving needs. This paper proposes the introduction of a user profile, describing the energy requirements for driving in terms of an energy deadline, target and minimum. To explore the use of such a profile, the paper analyses data from a Danish pilot project where the driving patterns of ten electric Nissan e-NV200 vans are investigated in terms of leave times...
and energy consumption. It is shown that the data can be fitted with a log-normal distribution that can be used to establish a per user profile which provides a certain statistical probability of fulfilling the driving needs while allowing an aggregator to optimize earnings. Initially, aggregators may apply similar driving assumptions across an entire fleet. Considering that the driving needs of individual EV owners are different, statistical representations of the individual behaviour may result in more flexibility, and thereby time, for providing grid services. The paper quantifies the value of such added flexibility based on the Danish market for frequency containment reserves.

**General information**
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Organisations: Distributed Energy Resources, Center for Electric Power and Energy, Department of Electrical Engineering, Energy Analytics and Markets, Statistics and Data Analysis, Department of Applied Mathematics and Computer Science
Contributors: Andersen, P. B., Sousa, T., Thingvad, A., Berthou, L. S., Kulahci, M.
Number of pages: 6
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Source: PublicationPreSubmission
Source-ID: 156429844
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**Cross-brand validation of grid services using V2G-enabled vehicles in the Parker project**
The Parker project seeks to experimentally validate that contemporary series-produced electric vehicles (EVs), capable of V2G, are ready to participate in a number of both known as well as new and advanced grid services. In such services the timing, size and direction of power and energy exchanged between the EV battery and grid is controlled as to support either a single building, the local neighborhood or the regional power system. Vehicles purposely designed for such services are referred to as grid integrated electric vehicles (GIVs). The field of research, describing how GIVs may be used to actively support the power system is called VehicleGrid Integration (VGI). The purpose of this paper is to present how the Danish Parker project has systematically categorized a range of grid services, collected in a service catalog, and then, illustrate state-of-the-art EVs ability to support such services through experimental validation. Results are presented for three different tests performed in Parker; marginal emission factor charging, frequency containment reserves and a performance test for controlling power setpoints. The ultimate aim of this paper, and the Parker project, is to promote the GIV concept so that it may inform the design and capabilities of present and future EVs, EV supply equipment (EVSE) and communication standards.

**General information**
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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Distributed Energy Resources, Energy Analytics and Markets, Nuvve Corporation, Aarhus University
Contributors: Andersen, P. B., Hashemi Toghroljerdi, S., Sousa, T., Sørensen, T. M., Noel, L., Christensen, B.
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Research output: Article in proceedings – Annual report year: 2018 – Research › peer-review
Optimal Offering Strategy of an EV Aggregator in the Frequency-Controlled Normal Operation Reserve Market

Electric vehicles (EVs) are to play an important role in electricity markets, since their energy storage capability can be beneficial to power systems operation. Electric vehicle aggregators will consequently develop adequate offering strategies to participate in energy and reserve markets, accounting for the market rules and operational capabilities of EVs aggregators (e.g., fleet of EVs). In this paper, we propose an offering strategy model for an EV aggregator to participate in the frequency-controlled normal operation reserve service (FCR-N) in Eastern Denmark. The aim is to maximize the expected revenue of the aggregator, accounting for potential penalties for missing the provision of both upward and downward reserves. The methodology has been modeled and tested under the scope of the PARKER project, which considers a case study based on real data from a small fleet of electric vehicles. An important conclusion relates to the availability patterns of the EVs that significantly changes the strategical participation of the EV aggregator in the service.

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Energy and Reserve under Distributed Energy Resources Management-Day-Ahead, Hour-Ahead and Real-Time

The increasing penetration of distributed energy resources based on renewable energy sources in distribution systems leads to a more complex management of power systems. Consequently, ancillary services become even more important to maintain the system security and reliability. This paper proposes and evaluates a generic model for day-ahead, intraday (hour-ahead) and real-time scheduling, considering the joint optimization of energy and reserve in the scope of the virtual power player concept. The model aims to minimize the operation costs in the point of view of one aggregator agent taking into account the balance of the distribution system. For each scheduling stage, previous scheduling results and updated forecasts are considered. An illustrative test case of a distribution network with 33 buses, considering a large penetration of distribution energy resources allows demonstrating the benefits of the proposed model.

General information
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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Energy Analytics and Markets, INESC Technology and Science, Polytechnic Institute of Porto
Contributors: Soares, T., Silva, M., Sousa, T., Morais, H., Vale, Z.
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Web of Science (2017): Indexed yes
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以用户为中心的新兴电力市场模式
随着可再生能源在现代能源产业中的占比不断提高，其对现行电力系统和电力市场的运行机制所带来的影响也日趋明显；同时，通过与数字信息产业深度结合，分布式能量管理手段也处于飞速发展阶段。在这二者的驱动下，一种以用户为中心的新兴电力市场模式正以不同的表现形式出现在世界各地。文章以高度概括的方式介绍了这一新兴电力市场模式，浅析了其在不同表现形式下的机理和特征。基于这一新兴电力市场模式在短期内所取得的发展成就，有理由相信此类新兴电力市场模式将逐步成为未来电力市场中的重要组成部分。

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Projects:

Parker project
The Parker project seeks to validate that series produced electric vehicles, as part of an operational vehicle fleet, can be made to participate in advanced, vertically integrated, smart grid services.
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Træholt, C., Project Participant, Department of Electrical Engineering, Center for Electric Power and Energy, Distributed Energy Resources
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