Bölüm 12

AKILLI ŞEBEKELER

Chapter 12

SMART GRIDS

Murat ALANYALI

BÖLÜM İÇERİĞİ

DOI: 10.53478/TUBA.978-625-8352-00-9.ch12

YAZAR HAKKINDA / ABOUT AUTHOR

Prof. Dr. Murat Alanyalı / TOBB Ekonomi ve Teknoloji Üniversitesi / malanyali[at]etu.edu.tr / ORCID: 0000-0002-9181-256X

Murat Alanyalı TOBB Ekonomi ve Teknoloji Üniversitesi Elektrik ve Elektronik Bölümünde öğretim üyesi. Lisans derecesini 1988 yılında Orta Doğu Teknik Üniversitesi'nden, yüksek lisans derecesini 1990 yılında Bilkent Üniversitesi'nden, doktora derecesini 1996 yılında University of Illinois Urbana-Champaign'den aldı. 2002-2014 arasında Boston Üniversitesi'nde, 1998-2002 arasında Bilkent Üniversitesi'nde akademik kadroda bulundu. 1996-1998 arasında Lucent Technologies Bell Laboratuvarları'nda çalıştı. 2003 US National Science Foundation (NSF) CAREER ödülü sahibidir.

Prof. Dr. Murat Alanyalı / TOBB University of Economics and Technology / malanyali[at]etu.edu.tr / ORCID: 0000-0002-9181-256X

Murat Alanyali is a Professor of Electrical and Electronics Engineering at TOBB University of Economics and Technology. He holds a PhD degree from University of Illinois at Urbana Champaign (1996), MSc degree from Bilkent University (1990), and BSc degree from Middle East Technical University (1988). He previously held faculty positions at Boston University from 2002 to 2014 and at Bilkent University from 1998 to 2002, and he was a technical staff at Bell Laboratories, Lucent Technologies, between 1996 and 1998. He is a recipient of 2003 US National Science Foundation CAREER award.

Özet

Akıllı şebekeler elektrik sistemlerinin modernizasyonunu ifade ediyor. Ancak enerji kaynaklarında sürdürülebilir ve temiz enerji prensibine dayanan dönüşüm bu modernizasyonun oldukça kapsamlı olmasını gerektiriyor. Bu bölümde elektrik şebekelerinin güncel işleyişleri, bu işleyişin neden ve ne şekilde değişmesi gerektiği ve akıllı şebekelerin bu yönde oynadıkları rol ele alınıyor. Ayrıca akıllı şebekelerin elektrik sistemlerini daha güvenilir ve ekonomik hâle getirmeleri için potansiyel fırsat ve zorluklar inceleniyor.

Anahtar Kelimeler

Akıllı Şebeke, Kesikli Enerji Kaynağı, Dağıtık Enerji Kaynağı, Talep Tarafı Katılımı, Enerji Depolama, Şebeke Otomasyonu, Elektrik Piyasası

Abstract

Smart grids can broadly be identified as modernization of the electricity grid. This modernization however is comprehensive due to implications arising from the guiding principle of clean and sustainable energy. This chapter describes the planning and management of traditional electricity grids, explains the major drivers of change, and provides an overview of how smart grid functionalities support to these changes. Opportunities and challenges towards more reliable and economic electricity systems are also discussed.

Keywords

Energy Storage, Mechanical Energy Storage, Pumped Storage, Thermal Energy Storage, Phase Change Materials, Electrochemical Storage, Natural Convection

12.8. KAYNAKLAR / REFERENCES

[1] US Department of Energy, "Smart Grid System Report to the Congress," 2009. [Online]. Available: https://www.energy.gov/sites/prod/files/2009%20Smart%20Grid%20System%20Report.pdf. [Accessed 11 11 2019].

[2] T. Hughes, Networks of Power: Electrification of in Western society, 1880-1930, John Hopkins University Press, 1983.

[3] Lawrance Livermore National Laboratory, "Energy Flowcharts," [Online]. Available: https://www.llnl.gov/news/usenergy-use-rises-highest-level-ever. [Accessed 11 11 2019].

[4] S. Chu and A. Majumdar, "Opportunities and challenges for a sustainable energy future," *Nature,* vol. 488, pp. 294-303, 2012.

[5] ENTSO-E, "Yearly statistics & adequacy retrospect 2014 European electricity system data," [Online]. Available: https://docstore.entsoe.eu/Documents/Publications/Statistics/YSAR/entsoe_ys_ar_2014_web.pdf. [Accessed 11 11 2019].

[6] A. vonMeier, Electric Power Systems: A Conceptual Introduction, Hoboken NJ: John Wiley & Sons, 2006.

[7] J. Grainger and W. Stevenson, Power System Analysis, McGraw-Hill, 1994.

[8] C. Growitsch, R. Malischek, S. Nick and H. Wetzel, "The Costs of Power Interruptions in Germany: A Regional and Sectoral Analysis," *German Economic Review,* vol. 16, no. 3, pp. 307-323, 2014.

[9] M. Ventosa, P. Linares and I. Perez-Arriaga, "Power System Economics," in *Regulation of the Power Sector*, London, Springer-Verlag, 2013, pp. 47-124.

[10] F. Schweppe, M. Caramanis, R. Tabors and R. Bohn, Spot Pricing of Electricity, Boston: Kluwer, 1988.

[11] Energinet, Danimarka, "Electricity Energy Data," [Online]. Available: https://en.energinet.dk/Electricity/Energy-data. [Accessed 11 11 2019].

[12] California Independent System Operator CAISO, "Flexible Resources Help Renewables," 2012. [Online]. Available: https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf. [Accessed 11 11 2019].

[13] I. Perez-Arriaga and C. Battle, "Impacts of Intermittent Renewables on Electricity Generation System Operation," *Economics of Energy & Environmental Policy,* vol. 1, no. 2, pp. 3-18, 2012.

[14] International Renewable Energy Agency IRENA, "Renewable power generation costs in 2018," [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power- Generations-Costs-in-2018.pdf. [Accessed 11 11 2019].

[15] International Energy Agency, "World Energy Outlook 2018," [Online]. Available: https://www.iea.org/weo/. [Accessed 11 11 2019].

[16] US Department of Energy, "Energy Storage Database," [Online]. Available: https://www.energystorageexchange.org. [Accessed 11 11 2019].

[17] F. Ran, T. Remo and R. Margolis, "2018 U.S. Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark NREL/TP-6A20-71714," [Online]. Available: https://www.nrel.gov/docs/fy19osti/71714.pdf. [Accessed 11 11 2019].

[18] McKinsey & Company, "How residential energy storage could help support the power grid," March 2019. [Online]. Available: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-residential-energy-storage-could-help-support-the-power-grid. [Accessed 11 11 2019].

[19] International Organization of Motor Vehicle Manufacturers OICA, "2017 PRODUCTION STATISTICS," [Online]. Available: http://www.oica.net/category/production-statistics/. [Accessed 11 11 2019].

[20] P. Andersen and et al., "Electric Vehicle Fleet Integration in the Danish EDISON Project: A Virtual Power Plant on the Island of Bornholm," in *2010 IEEE PES General Meeting*, Providence RI, 2010.

[21] EPİAŞ Şeffaflık Platformu, [Online]. Available: https://seffaflik.epias.com.tr/transparency/piyasalar/gop/arz-talep.xhtml. [Accessed 11 11 2019].

[22] J. McAnany, "2019 Demand Response Operations Markets Activity Report," November 2019. [Online]. Available: https://www.pjm.com/-/media/markets-ops/dsr/2019-demand-response-activity-report.ashx?la=en. [Accessed 11 11 2019].

[23] AEIC Load Research Committe, "Demand Response Measurement and Verification," March 2019. [Online]. Available: https://www.smartgrid.gov/files/demand_response.pdf. [Accessed 11 11 2019].

[24] Open ADR, "Open ADR Alliance," [Online]. Available: https://www.openadr.org. [Accessed 11 11 2019].

[25] MIT Energy Initiative, "Utility of the Future," 2016. [Online]. Available: https://energy.mit.edu/wpcontent/ uploads/2016/12/Utility-of-the-Future-Full-Report.pdf. [Accessed 11 11 2019].

[26] F. Gandoman and et al., ""Review of FACTS technologies and applications for power quality in smart grids with renewable energy systems," *Renewable and Sustainable Energy Reviews,* vol. 82, no. 1, pp. 502-512, 2018.

[27] E. Mengelkamp and et al., "Designing microgrid energy markets - A case study: The Brooklyn Microgrid," *Applied Energy,* vol. 210, pp. 870-880, 2018.

[28] W. Tushar and et al., "Grid influenced peer-to-peer trading," *IEEE Transactions on Smart Grids,* p. doi: 10.1109/TSG.2019.2937981, to appear.

[29] NERC North American Reliability Corporation, "Real-Time Application of Synchrophasors for Improving Reliability," 2010. [Online]. Available: https://www.nerc.com/docs/oc/rapirtf/RAPIR%20final%20101710.pdf. [Accessed 11 11 2019].

[30] US Department of Energy, "Smart Grid System Report to the Congress," 2018. [Online]. Available: https://www.energy.gov/sites/prod/files/2019/02/f59/Smart%20Grid%20System%20Report%20November%202018_1.pdf. [Accessed 11 11 2019].