IEEE STANDARDS ASSOCIATION

IEEE Recommended Practice for the Planning and Design of the Microgrid

IEEE Standards Board

Developed by the
IEEE SASB Coordinating Committees/SCC21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage (SASB/SCC21)

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 2030.9™-2019

IEEE Recommended Practice for the Planning and Design of the Microgrid

Developed by the

IEEE SASB Coordinating Committees/SCC21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage (SASB/SCC21)
of the
IEEE Standards Board

Approved 21 March 2019

IEEE SA Standards Board

Abstract: The factors that should be taken into account for planning and designing microgrids are covered in this recommended practice. It provides approaches and good practices to be considered in the planning and design, including system configuration, electrical system design, safety, power quality monitoring and control, electric energy measurement and scheme evaluation. This recommended practice applies to ac microgrids that can be either grid-connected or stand-alone microgrids.

Keywords: electric energy measurement, electrical system design, IEEE 2030.9™, power quality monitoring and control, planning and design, safety, scheme evaluation, system configuration

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

PDF: ISBN 978-1-5044-5681-4 STD23625
Print: ISBN 978-1-5044-5682-1 STDPD23625

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notices and Disclaimers Concerning IEEE Standards Documents." They can also be obtained on request from IEEE or viewed at http://standards.ieee.org/ipr/disclaimers.html.

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("The Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. A current IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Xplore at http://ieeexplore.ieee.org/ or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE SA Website at http://standards.ieee.org.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE SA Website at http://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this IEEE recommended practice was completed, the Working Group for the Recommended Practice for the Planning and Design of the Microgrid had the following membership:

Wenpeng Luan, *Chair*
Chengshan Wang, *Vice Chair*
Leiming Qin, *Secretary*

Meng Cheng
Guanglin Ge
Liang Ge
Li Guo
Tianyu Guo
Xiaogang Hou
Xiaopeng Ji
Yu Ji
Xiangyu Kong
Lingfeng Kou
Peng Li
Zhongyou Li
Huishi Liang
Haitao Liu
Hui Liu
Yixin Liu
Wenyuan Ma
Gongdan Mao
Xiaoyun Qu
Zhengdong Ren
Wanxing Sheng
Zhiyun Sun
Zhihai Tan
Peng Wang
Zixuan Wang
Jiahong Wu
Jiahua Wu
Ming Wu
Zhao Wu
Bin Xie
Jinlei Xing
Aidong Xu
Zeyang Xu
Zhipeng Xu
Yong Yan
Jing Yang
Jie Yuan
Hui Yu
Chengyan Yue
Cuihong Zhang
Fei Zheng
Xinsong Zhang
Yi Zhe
Lihong Zhou
Wenping Zhou
Jizhong Zhu

The following members of the entity balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

ABB, Inc.
Beijing Sifang Automation Co., Ltd.
China Datang Corporation
China Energy Engineering Group Co. Ltd.
China Southern Power Grid Co., Ltd.
Electric Power Research Institute, Inc. (EPRI)
General Electric
Haier Group Corporation
Huawei Technologies Co., Ltd
North China Electric Power University
Schneider Electric
Shanghai Jiao Tong University
Siemens Corporation
State Grid Corporation of China (SGCC)
Tianjin University
Xi'an Jiaotong University

When the IEEE-SA Standards Board approved this recommended practice on 21 March 2019, it had the following membership:

Gary Hoffman, *Chair*
Ted Burse, *Vice Chair*
Jean-Philippe Faure, *Past Chair*
Konstantinos Karachalios, *Secretary*

Masayuki Ariyoshi
Stephen D. Dukes
J. Travis Griffith
Guido Hiertz
Christel Hunter
Thomas Koshy
Joseph L. Koepfinger*
Thomas Koshy
John D. Kulick
David J. Law
Joseph Levy
Howard Li
Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles
Annette D. Reilly
Dorothy Stanley
Sha Wei
Phil Wennblom
Philip Winston
Howard Wolfman
Feng Wu
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 2030.9–2019, IEEE Recommended Practice for the Planning and Design of the Microgrid.

This recommended practice focuses on the factors that should be taken into account for planning and designing microgrids. It provides approaches and good practices to be considered in the planning and design, including system configuration, electrical system design, safety, power quality monitoring and control, electric energy measurement and scheme evaluation. This recommended practice applies to ac microgrids that can be either grid-connected or stand-alone microgrids.

The main task of the microgrid planning and design is to determine the configuration of DERs, electrical network structure and the automation system configurations. Grid planners should take into consideration the local load profile, energy demand and energy resources when planning a microgrid. The result of the microgrid planning should be scalable enough to satisfy the immediate demand as well as the future demand growth.

Contents

IEEE Recommended Practice for the Planning and Design of the Microgrid

1. Overview

This specification provides the recommended practice for the planning and design of microgrids. Additionally, there is a bibliography included as an annex that lists citations referred to in this document for informative purposes, but they are not required to be used in conjunction.

1.1 Scope

This recommended practice focuses on the factors that should be taken into account for planning and designing microgrids. It provides approaches and good practices to be considered in the planning and design, including system configuration, electrical system design, safety, power quality monitoring and control, electric energy measurement and scheme evaluation. This recommended practice applies to ac microgrids that can be either grid-connected or stand-alone microgrids.

1.2 Purpose

This recommended practice aims at standardization of the microgrid planning and design process by providing technical requirements and specifications. The recommended practice is to ensure the safety, economy, reliability and environmental friendliness of microgrids.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

The applicability of the following standards is determined by the specific requirements stated in this standard, such as requiring certain sections.

IEC 61000-4-30, Electromagnetic compatibility Part 4–30, Testing and Measurement Techniques-Power Quality Measurement Methods.[1]

[1]IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch) and the American National Standards Institute (http://www.ansi.org/).