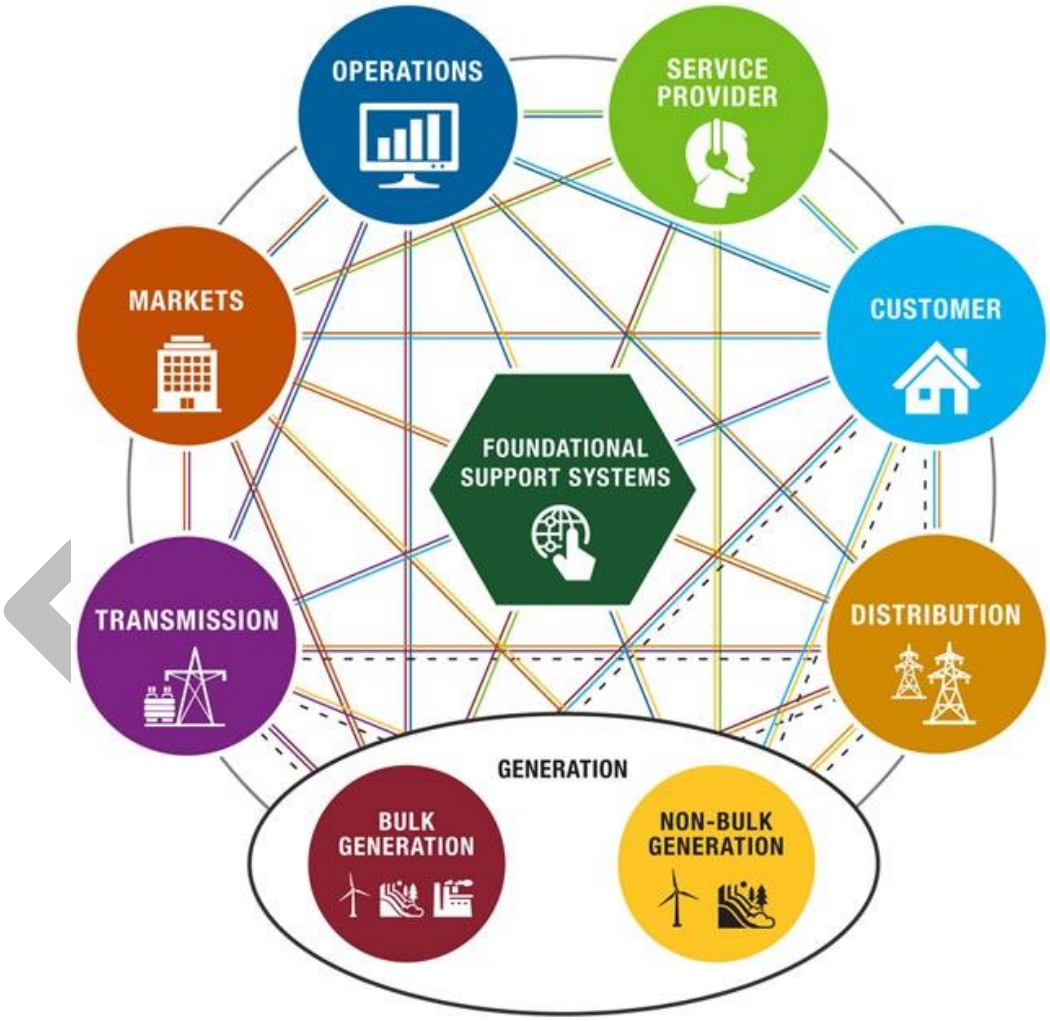
IEEE Smart Grid R&D Committee: Process and Synopsis of Collation of Topics

White Paper #1 – Draft

Topic: IEEE Smart Grid R&D Committee: Process and Synopsis of Collation of Topics

Authored by: Anu Annaswamy, Abedalsalam Bani-Ahmed, Andy Knight, Wei-Jen Lee, Sivapriya Mothilal, Panayiotis Moutis



1.

CONTRIBUTORS

IEEE Smart Grid R&D Committee

Chair

Peter Wung IEEE Industry Applications Society

Members and Contributors

Anu Annaswamy IEEE Control Systems Society
Abedalsalam Bani-Ahmed IEEE Computer Society
Andy Knight IEEE Power & Energy Society
Wei-Jen Lee IEEE Industry Applications Society
Sivapriya Mothilal IEEE Power & Energy Society
Panayiotis Moutis IEEE Power & Energy Society

Staff

Angelique Rajski Parashis IEEE Smart Grid
Bill Ash IEEE Standards Association

ACKNOWLEDGEMENT

IEEE Smart Grid Initiative brings together IEEE's broad array of technical societies and organizations through collaboration to encourage the successful rollout of technologically advanced, environment-friendly and secure smart-grid networks around the world. As the professional community and leading provider of globally recognized Smart Grid information, IEEE Smart Grid Initiative is intended to organize, coordinate, leverage and build upon the strength of various entities within IEEE with Smart Grid expertise and interest. Additional information on IEEE Smart Grid can be found at http://smartgrid.ieee.org.

TABLE OF CONTENTS

Process and Synopsis of Collation of Topics 1

1. Introduction 4
2. IEEE Smart Grid R&D White Paper Series 5
3. Process and Synopsis of R&D Topic Collation 6
   - 3.1 The Guiding Principles 6
   - 3.2 The Collation Process 7
   - 3.3 Topic Identification and Solicitation 7
4. IEEE Smart Grid Domains & Sub-Domains 8
5. The Parking Lot Concept 8
6. Key Topics from the Vision Documents 9
7. References 11

1. Introduction

Smart Grid deployment is a reality on the international landscape. But the Smart Grid is a revolutionary undertaking—entailing new communications-and-control capabilities, energy sources, energy transfer models and adherence to cross-disciplinary regulatory structures. Success of the Smart Grid demands objective collaboration, integration, and interoperability among a vast array of disciplines, including computational and communications control systems for generation, transmission, distribution, consumers, operations, markets, service providers, and regulatory authorities.

IEEE is well-positioned to assume the critical unifying role in the Smart Grid movement for a variety of reasons. IEEE is an international non-profit organization with a high degree of involvement in research and development. It has a diversity of global expertise across both established and emerging technologies, innovation rich programs, proven standards, and a lifecycle of related processes that promote technology adoption which build global markets. Finally, IEEE brings objective coordination among the huge cast of public and private organizations that contribute to smart grid development.

IEEE Smart Grid Initiative was conceptualized and led under the direction of Wanda Reder, former President of the IEEE Power & Energy Society, as a New Initiative in the IEEE Future Directions Committee (FDC) in 2011.

The IEEE FDC, in association with Societies, Councils, and Organizational Units (OUs), anticipates and determines the direction of existing, new and emerging technologies and related issues, and spearheads their development. Taking a holistic view, the FDC emphasizes new, emerging technical areas and drives them to maturity within the IEEE infrastructure. Additionally, the FDC serves as a liaison to and fosters cooperative efforts among, Societies, Councils, and industry to develop new products' and services in emerging topics.

In November 2013, after two years as an incubation project of FDC, IEEE voted to graduate IEEE Smart Grid from the IEEE FDC to a fully functioning program of IEEE. It was agreed that the IEEE Power & Energy Society would become the new administrator of the Initiative and continue and grow upon its momentum, beginning in January 2014.

Currently, the IEEE Smart Grid Initiative is an IEEE-wide collaborative with 14 partner organizational units including:

1. IEEE Communications Society
2. IEEE Computer Society
3. IEEE Control Systems Society
4. IEEE Dielectrics and Electrical Insulation Society
5. IEEE Industry Applications Society
6. IEEE Industrial Electronics Society
7. IEEE Instrumentation & Measurement Society
8. IEEE Power Electronics Society

9. IEEE Power & Energy Society
10. IEEE Reliability Society
11. IEEE Signal Processing Society
12. IEEE Standards Association
13. IEEE Systems, Man, and Cybernetics Society
14. IEEE Vehicular Technology Society

Each of the societies appoints volunteer representatives to serve in the standing committees of the IEEE Smart Grid Initiative:

1. Marketing Committee
2. Publications Committee
3. Education Committee
4. Research and Development (R&D) Committee
5. Policy Technical Support Committee
6. Technical Activities Committee

Volunteers from each of the OUs are experts from government, industry, academia, and research institutions, reflecting the multi-dimensional aspects of the Smart Grid arena.

2. IEEE Smart Grid R&D White Paper Series

This white paper is the second in a series of white papers developed by the IEEE Smart Grid R&D Committee. The intent of the series is to provide a concise view into the thought process and the mechanism employed by the R&D committee in its independent survey of Smart Grid emerging technologies[1].

The *IEEE Smart Grid Survey Structure Emerging Technologies White Paper Series* will be comprised of the following white papers:

1. Introduction to the R&D Committee: This white paper provides the motivation, philosophy, and structure of the R&D committee in its survey of emerging technologies.
2. Process, Synopsis of Collation of Topics
    a) Selection, collatio,n and categorization of the individual topics, and
    b) Details of the selection process for the readers to understand how the topics are categorized into their respective domains.
3. A sub-series of topic-specific white papers will highlight important areas of research that are not yet explicitly represented within the IEEE Smart Grid Domains and Sub-domains categorization that is employed in the initial R&D committee effort[1]. Topics will include:
    a) Control Systems
    b) Power Electronics
    c) Industry Applications
    d) Industrial Electronics
    e) Big Data Analytics

4. Relational Database User Guide
    a) Rationale for creation of a relational database
    b) How to use Smart Grid Database

3. Process and Synopsis of R&D Topic Collation

The initial collection of topics for the R & D committee comes through solicitation and collating of topics from many sources. These topics are sorted into Domains, Sub-domains, and Focus areas as defined by the National Institute of Standards and Technology (NIST).

The main tasks of the IEEE Smart Grid R&D Committee are to:

- Identify the emerging pivotal R&D areas in Smart Grid related domains,
- Engage the participating IEEE societies in all pertinent areas for collaboration, and
- Support and collaborate with public/private enterprises to assess priority areas and disseminate Smart Grid and sustainable energy research and implementation strategies.

Broken down further, the tasks are to:

- Generate an existing list of R&D topics already being undertaken by industry, legislation, academia, and private enterprise.
- Generate a list of R&D topics that have been recognized as necessary areas of research
- Categorize them into the NIST defined Domains and Sub-domains bailiwicks without forcing orphan topics into awkward sub-domain definitions.
- Create a list of R&D topics that are enabling technologies necessary to implement the vision of the Smart Grid, even though the definition of the R&D interest area is evolving.
- Create a list of R&D topics which will necessarily enhance the Smart Grid or will depend on the Smart Grid to exist, from a long term perspective.
- Create a big picture view of research areas and categorize them out into the following: what exists now, what needs to be done in the short term, and what must be done to ensure a future of Smart Grid and what is required to enable the long term viability of the Smart Grid.

3.1 The Guiding Principles

One key guiding principle can be summarized by paraphrasing the Occam's Razor: *"Everything should be kept as simple as possible, but no simpler."*

- Simplicity allows easier comprehension and integration of the vast structure which describes the reality of the Smart Grid R&D landscape.
- However, oversimplified structures obfuscate the underlying interconnectedness of the topics and the subject of the Smart Grid.
- The mission is to constantly challenge the complexity and the simplicity being imposed on the information.

Another guiding principle is to maintain the relational links between topics, even across the walls of the domains, sub-domains, and focus areas. This can be achieved by:

- Keeping the vision in mind and make the vision broad in order to be inclusive of topics as yet undiscovered.
- Keeping the structure flexible to accommodate future research and development results.

3.2 The Collation Process

The transitory nature of the R&D Committee's research and development renders a need for the development of a cogent organizational system that will allow for efficient and effective processing of the existing research topics into the IEEE Smart Grid Domains, Sub-Domains and Focus Areas structure. This process with require collection, categorization and collation into an imposed structure that will allow for organic growth and evolution with the changing landscape of the Smart Grid R&D world.

The R&D committee will take those topics which already fall into the existing categories and expand their attributes in order to account for:

- The OUs which are most closely associated with the topics, as there is usually more than one OU associated with most topics.
- The topics IEEE Smart Grid Domain, Sub-domain and Focus Area
- The preceding technology which necessarily spawned this technology.
- The topics depend on the success of this technology topic for their evolution.

This list will be the first milestone of the R&D committee's work. It will be passed on to the IEEE Technical Activities Committee for their consideration in their work tracking the progress of the topics, acting as conduit to the industry for introduction of these nascent technologies into the marketplace, and identifying potential areas for standard development. This list will also serve as the initial test records for a relational database that will be the deliverable for this phase of the R&D committee's work.

3.3 Topic Identification and Solicitation

The initial solicitation of topics involves seeking out the IEEE OUs and incorporating the topics proposed in the IEEE Vision documents developed by five of the participant societies. These IEEE Standards Association Vision documents were solicited from each of these five societies: Power & Energy, Communications, Computer, Control Systems, and Vehicular Technology, as an exercise in identifying the long range vision for IEEE. The horizon had been set at the year 2030. The R&D committee volunteers combed through the Vision documents and were able to identify Smart Grid related topics and have collated these topics.

The electric power utility industry and the associated academic, government, trade, and standard making bodies have also contributed many topics. The emphasis is on the shopping

list of improvements for the existing national power grid. Many of these topics have already gone through the R&D process and are in the process of being commercialized.

The next group of topics derives from the DOE affiliated national laboratories such as Pacific Northwest National Laboratory (PNNL), National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory (ORNL) and other similar laboratories.

4. IEEE Smart Grid Domains & Sub-Domains

In 2015, IEEE Smart Grid members developed the IEEE Smart Grid Domains & Sub-domains inspired by the National Institute of Standards and Technology (NIST) Conceptual Model. Each of eight identified domains features its own sub-domains, for a total 32 sub-domains.

The idea behind the development of the IEEE Smart Grid Domains & Sub-Domains was to establish a categorization that would allow Smart Grid contributions and activities to be combined into specific areas for better understanding of the activities and their correlations.

The NIST Smart Grid Framework 3.0 is based on the major processes which get executed in conducting the day to day businesses within the energy industry. The IEEE Smart Grid Committee used this diagram as a reference document, but it needed to expand it to cover all the important areas of the Smart Grid.

The initial list of topics from the vision documents were placed through the IEEE Domains and Subdomains characterization. Many of these topics fall naturally under the identified Domains and Subdomains, while a number of other topics do not. This is expected since the Smart Grid concept is forward looking and predictive in its outlook.

Rather than forcing those topics that do not fall into the pre-defined categories, those topics that have no obvious home will be placed into the Parking Lot.

5. The Parking Lot Concept

The term “Parking Lot” is used to define those topics that belong in the future Smart Grid but do not fit comfortably in the existing IEEE Smart Grid Domains, Sub-domains, and Focus Areas.

It is a fool’s errand to assume that the original structural definition – as passed on to the Smart Grid R&D committee by NIST and embodied in the Domains, Sub-Domains, and Focus Areas – is the definitive structure of the future direction of Smart Grid research and development which forces the committee to forcer future topics into an aging, unnatural and predetermined niche.

The Research & Design committee has agreed to err on the side of caution by placing potential topics that are unnatural fits into the “Parking Lot”. These are topics which may be orphaned by

technological evolution, topics which seemingly fit into many different existing niches, or topics that are so new that there are no existing definitions within the structure to accommodate them. These topics will be examined and categorized by the committee as more research results and other topics evolve. The new information will, we hope, clarify and broaden the structure and help clarify the riddle of topic identity and allow the committee to best categorizes the topic under the most logical branch of the Domains, Sub-domains, and Focus Areas research tree.

One other aspect of the parking lot is that the committee also feels free to create additional structures that are new to the NIST structure, as well as reorganize the existing structure. This decision was made based on the previous logic: that the initial definitions of the IEEE Smart Grid Domains, Sub-domains, and Focus Areas are not written with the prescience to predict future innovations; the structure may therefore be lacking in potential structures which are much more logical. Once again, the committee will examine the topics with a detail oriented vision from a high level view to accommodate the breadth and depth of the Smart Grid as it evolves.

Rest assured that great patience will be exercised as the topics are examined and re-examined. No changes will be made before it is time. The committee must ensure that the R&D community is not led astray by decisions based on impatience.

6. Key Topics from the Vision Documents

While the fourteen (14) societies partnering with and participating in the IEEE Smart Grid have been elaborating plans, roadmaps, activities and joint actions, five (5) societies had been identified by the IEEE Standards Association to provide their vision of the state of their societies in the year 2030. These are the Power & Energy (PES), Control Systems (CSS), Computer (CS), Communications (ComSoc) and Vehicular Technology (VTS) Societies. These societies produced Vision documents at the behest of the IEEE as an exercise in brainstorming the possibilities of the technical future in 2030. In these Vision documents, broader focus areas and more specific topics have been outlined by experts in the aforementioned societies and the main considerations that have arisen will be discussed.

All of the above entities show on an interesting degree of consensus on the broader areas of infrastructure and technology as the drivers of novel and innovative paradigms. Those areas of consensus are expressed as:

- Concerns over the development of new and existing topologies for the use of Renewable Energy Sources (RES),
- The improvement, redesign or rethinking of Transmission and Distribution (T&D) networks and corresponding equipment,
- The architecture and incorporation of advanced control and communication enabling devices.

PES, CSS and VTS have shown particular and more specific interest in R&D efforts on:

- Infrastructure and devices, which will concern new RES applications,
- Methods and strategies promoting wider penetration and energy absorption of existing RES technologies, and
- The wide deployment of Electric Vehicles (EVs) not only as novel transportation paradigms, but also as the medium which enables grid interactions (Vehicle to Grid – V2G and vice versa).

On the same focus area, the R&D initiative of ComSoc on power line-borne optical fiber communication should necessarily be highlighted as a critical component.

Two more specific topics have also been identified as being important and singularly critical R&D areas of emphasis across all five of the Societies: (1) Security and (2) Markets.

Security has been defined as the means, method and standard to ensure the protection of the operating integrity, the privacy and the robustness of all Smart Grid enabling devices and data. To this end, the identification of all risk and the preparation of appropriate mitigation schemes for any threat to the cyber-physical infrastructure of power systems concerns predominantly the R&D on the Smart Grid. The recent events that affected major power system equipment (either due to malicious attacks or natural causes) are not the only reason for this concern. The ever expanding and complex nature of the information and communication technologies, which are intimately coupled to the operation and control of modern power systems, means that major research efforts are required, to prepare for the IoT era of the Smart Grid.

The subject of markets – although it could be argued that it represents a broader focus area – addresses the need to describe, develop and regulate flexible, unbundling and innovative mechanisms capable of handling the ever-evolving generation, T&D, power quality and customer characteristics and requirements is prominent and urgent. For example, the stochastic nature of RES implies that proper market tools are in place to ensure availability of reserves or – even – allow for RES themselves to participate in regulating actions. Deferring of T&D infrastructure upgrading due to the fact that distributed generation and storage system installations may be optimized or incentivized according to proper studies. Market influence and market volatility are also concerns that need to be reconsidered in the face of vertical and horizontal market deregulation. Lastly, the future tools enabling the participation of numerous end-customers to demand response and/or other real-time markets, will ensure the true unbundling of electricity.

Some other Smart Grid R&D considerations that have emerged as collaborations among various societies are the following:

1. Information & Communications for Demand Management & Control, led by the CS and followed by the PES, CSS and ComSoc,
2. Renewable Energy Forecasting, led by CS and followed by PES and CSS,
3. Interaction between vehicles and the road, energy and communication, led by VTS and followed by PES and ComSoc,
4. Big Data, led by CS and followed by PES, ComSoc and VTS,

5. Reconfigurable design of basic infrastructure, led by PES and followed by VTS, CSS and ComSoc
6. EV end-user interfaces, led by VTS and followed by CS and ComSoc, and
7. Cloud Services led by CS and followed by ComSoc and VTS.

Some further and more detailed elaboration on selected R&D focus areas and specific topics can be found in the Grid Vision 2030 Document developed by IEEE PES and IEEE Standards Association and in the "Vision for Smart Grid Controls: A Roadmap for 2030 and Beyond" IEEE report. The IEEE Smart Grid is also developing a relational database which will keep interested parties and stakeholders up-to-date with the identified R&D topics their associations across technical societies, existing paradigms and expected aspirations.

7. References

- IEEE Grid Vision 2050 Reference Model
- IEEE Grid Vision 2050 Roadmap
- IEEE Grid Vision 2050
- IEEE Vision for Smart Grid Controls: 2030 and Beyond
- IEEE Vision for Smart Grid Communications: 2030 and Beyond Reference Model
- IEEE Vision for Smart Grid Communications: 2030 and Beyond
- IEEE Vision for Smart Grid Communications: 2030 and Beyond Roadmap
- IEEE Smart Vision for Computing: 2030 and Beyond
- IEEE Vision for Smart Grid Controls: 2030 and Beyond Reference Model
- IEEE Vision for Smart Grid Controls: 2030 and Beyond Roadmap
- IEEE Smart Grid Vision for Vehicular Technology: 2030 and Beyond