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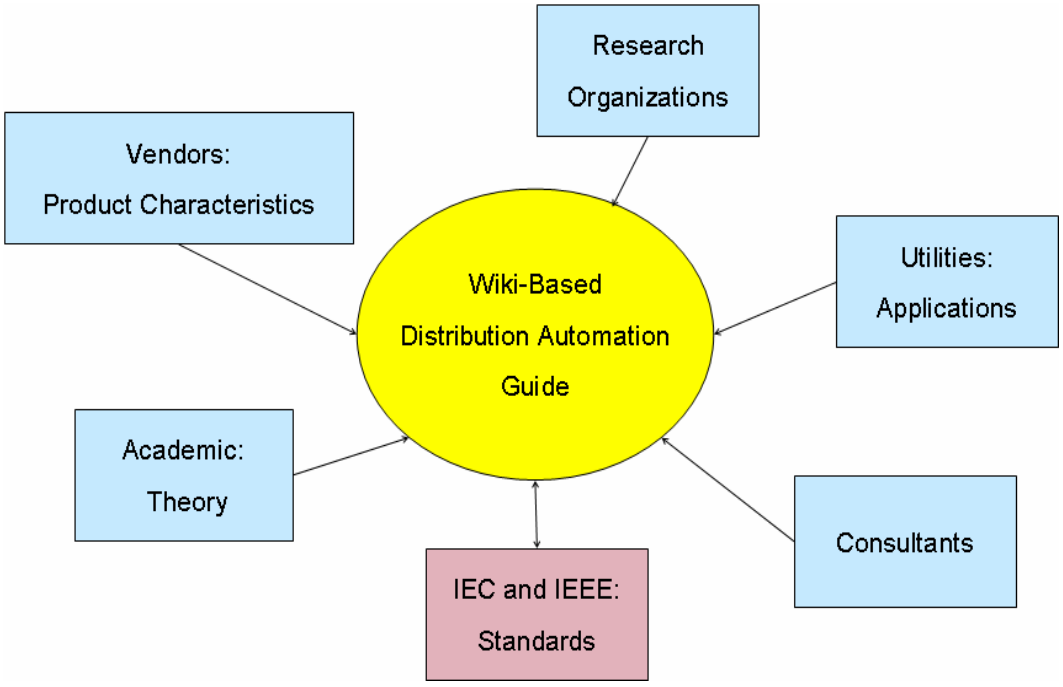
Advanced Distribution Automation Guide Development

2008 Interim Progress Report

1016030



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Technical Update, December 2008

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CITATIONS

This report was prepared by

Electric Power Research Institute (EPRI)
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Palo Alto, CA 94304

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This report describes research sponsored by EPRI.

This publication is a corporate document that should be cited in the literature in the following manner:

Advanced Distribution Automation Guide Development: 2008 Interim Progress Report. EPRI, Palo Alto, CA: 2008. 1016030.

PRODUCT DESCRIPTION

The utility industry is rapidly moving to modernize its distribution systems, including wider use of advanced distribution automation (ADA™). The smart distribution system of the future will be based on ADA™, which will make possible new capabilities to increase flexibility and reliability and to expand customer services. Smart distribution systems will use new intelligent electronic devices and will integrate advanced metering infrastructure (AMI) data into real-time monitoring systems needed to enable ADA™ operations. This interim report describes the first stages of the development of a guide intended to serve as a central tool to help utilities implement ADA™/smart distribution systems.

Results and Findings

The report describes the plan evolved during 2008 for developing and delivering the guide. The guide will be developed in cooperation with the IEEE Distribution Automation Working Group (DAWG) and will be made available as a draft on a web site, where contributors can provide written input. The structure for the guide has been developed in the form of a detailed outline, provided in this report. DAWG members will provide expert content review as the guide is developed.

EPRI's ADA™ guide will encompass the following broad information areas:

- Descriptions of equipment, software, and ADA™ integration services available from the supplier community
- Guidelines for automation for specific equipment classes
- Descriptions of information technology products, protocols, and standards for ADA™ (including current status information)
- Case studies and illustrative examples of actual automated distribution systems

Challenges and Objectives

To support the utility industry in rapidly modernizing distribution systems, there is a need to incorporate the best practices emerging from the utility and vendor communities into engineering tools to facilitate high-quality automation practices with uniform procedures and standardization wherever possible. The objective of this multi-year project is to contribute to this body of needed engineering tools by preparing a web-based, easily updated engineering guide on ADA™/smart distribution systems.

Applications, Values, and Use

The guide will help utilities:

- Begin to automate or more fully automate their systems, which in turn will improve the energy efficiency and reliability of their distribution operations

- Improve system functionality, allowing delivery of improved power quality and a wider variety of customer services
- Enable automated response to mitigate outages or speed recovery from outages
- Migrate from legacy proprietary systems to open systems based on international standards

EPRI Perspective

EPRI's ADA™ Program is developing the technical foundation for the smart distribution system of the future. ADA™ is a concept for a fully controllable and flexible distribution system that exchanges both energy and information between system components. The result will be a highly automated, responsive and resilient distribution system that delivers benefits to a broad range of participants. ADA™ will be a "revolution by evolution" in which utilities migrate to the smarter distribution system of the future over time via incremental adoption of the relevant technologies, software, and standards. The guide is one tool being developed to aid utilities in moving to smarter distribution systems.

Approach

EPRI worked with the IEEE DAWG to devise a development plan and outline for the automation/smart distribution guide. The EPRI guide will be a "wikipedia-type" resource that will be available on the web as a living draft during its development. EPRI will set up the web site and widely distribute instructions and content guidelines for seeking contributions from the smart distribution stakeholder community. Population of the guide with web entries will begin in 2009 and continue in subsequent years. When sufficient material has been developed, it will be reviewed to determine if hardcopy should be published. The material will continue to be maintained and updated on the web in any case.

Keywords

Smart power distribution systems
Advanced distribution automation
Smart distribution applications
Active distribution system management

ACKNOWLEDGMENTS

The author gratefully acknowledges the following individuals and their organizations for their support of the advanced distribution automation guide project in 2008:

- Georges Simard, Hydro Quebec
- Robert Uluski, Quanta Technology
- G. Larry Clark, Alabama Power Company

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Objectives of EPRI Advanced Distribution Automation (ADA™)/Smart Distribution Program

EPRI's Advanced Distribution Automation Program is developing the technical foundation for the smart distribution system of the future. ADA™ is a concept for a fully controllable and flexible distribution system that exchanges both energy and information between system components. The result is a highly automated, responsive and resilient distribution system that delivers benefits to a broad range of participants.

Confusion caused by the widespread use of the term "smart grid" needs to be cleared up. There are widely varying concepts of what it means, and, as has been frequently noted, power systems are already "smart", e.g., having various degrees of automation. What we are actually trying to do is make them **smarter**.

ADA™ will be a "revolution by evolution" in which utilities migrate to the smarter distribution system of the future over time via incremental adoption of the needed technologies, software, and standards. A conceptual view of future distribution systems is given in Figure 1-1.

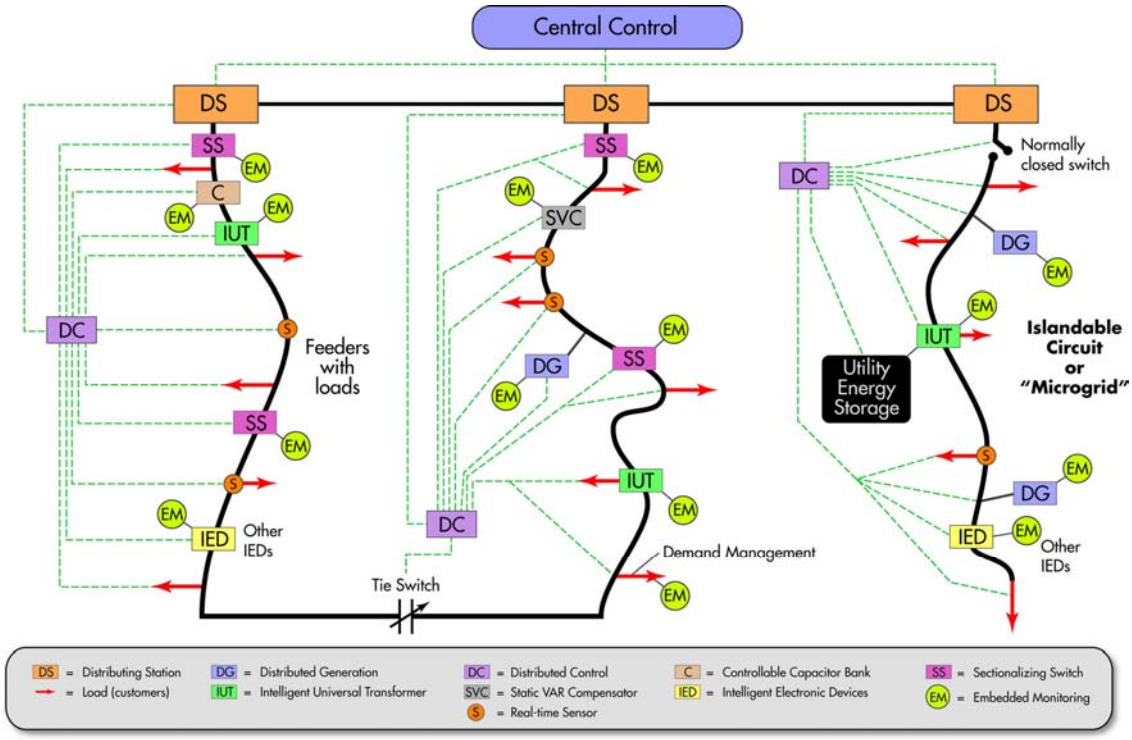

Figure 1-1
Conceptual view of future smart distribution systems

For purposes of this report, a smart distribution system (alternatively known as advanced distribution automation) is the distribution system portion of a so-called "smart grid" (the overall power system). The following are some key elements of a smart distribution system [1]:

- Active distribution management systems based on distributed control and integration of many active controllable components ("smart devices")
- Widespread real-time monitoring of the distribution system
- State-of-the-art protection and control systems
- Automated reconfiguring and outage mitigation technologies
- Real-time or predictive simulation of operations
- Communication system to allow information exchange with a wide variety of system components and cyber security
- Incorporation of data from advanced metering infrastructure (AMI) into real-time monitoring to support automation
- Integration of distributed generation and storage into automated operations
- Integration of demand management and customer systems in to automated operations

EPRI's ADA™ strategic roadmap [1] identifies five key areas of development needs (functional areas) for R&D projects to realize the ADA™ vision:

- Electronic/electrical technology development for the distribution system of the future
- Sensor/monitoring/data processing systems for ADA™
- Communication systems and standards for ADA™
- Advanced distribution control systems
- New distribution system configurations and reconfiguring capabilities

The relationships between these areas are illustrated in Figure 1-2. The EPRI ADA™ Program 124 consists of a group of projects that address these five areas. The strategic roadmap will be updated in early 2009, incorporating results from the 4th EPRI annual strategic workshop on ADA™/smart distribution systems held in late 2008.

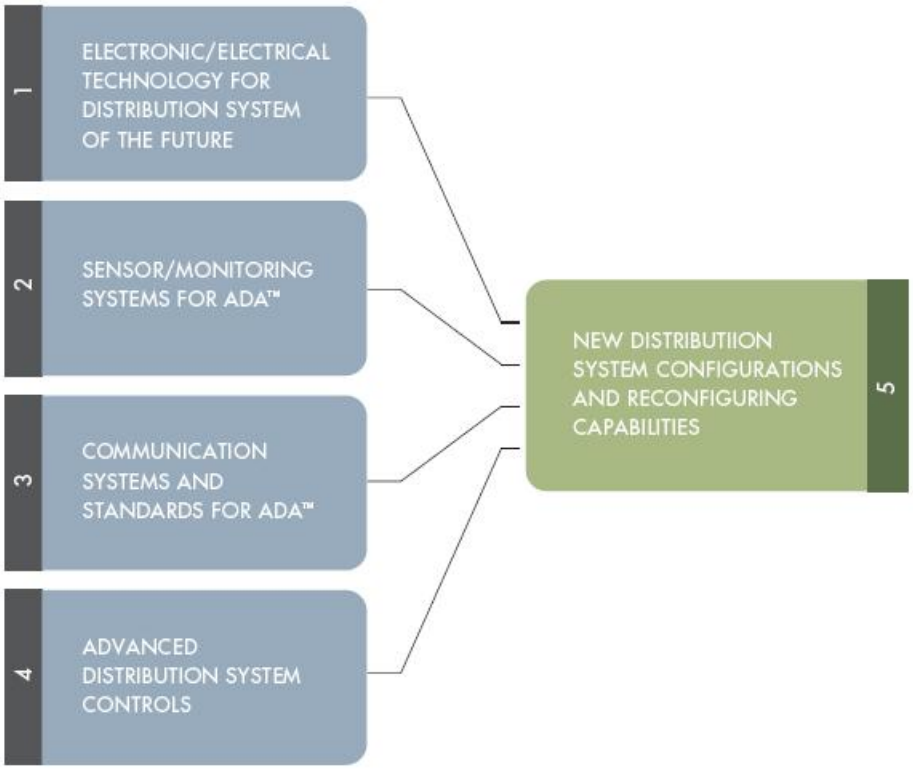

Figure 1-2
Areas of development and relationships for the ADA™ program.

EPRI Program Structure for ADA™/Smart Distribution Systems

The utility industry is rapidly moving to modernize their distribution systems, including wider use of advanced distribution automation (ADA™). The smart distribution system of the future will be based on ADA™ that includes two key aspects:

- ADA™ will enable new system configurations and reconfiguring capabilities, which will increase the flexibility and reliability of the distribution system, as well as aid in preventing outages or recovering from outages that do happen.
- ADA™ will enable integration and strategic use of new intelligent electric devices (IEDs) embedded in power electronic components, advanced volt amperes reactive (VAR) management systems, power quality enhancement equipment, distributed generation, and fault anticipators and locaters. These IEDs not only enable the more flexible electrical architecture mentioned above, but also provide the means for expanded customer service options. These IEDs also act as components of a larger monitoring system capability. Integration of AMI data will also be a key component in the monitoring system infrastructure for ADA™.

Figure 1-3 illustrates the structure of Program 124 for 2009. The program name will change from “Advanced Distribution Automation” to “Smart Distribution Technology and Applications” in 2009.

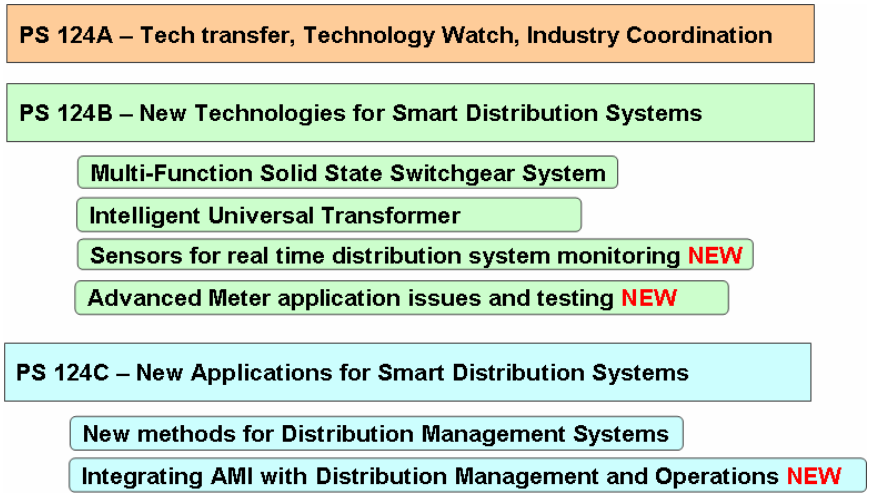

Figure 1-3
Program structure for 2009 EPRI base program on smart distribution technology and applications. PS denotes "Project Set".

At this time, the EPRI program on smart distribution is a component of an international movement to make power systems smarter. The overall relationship is illustrated in Figure 1-4.

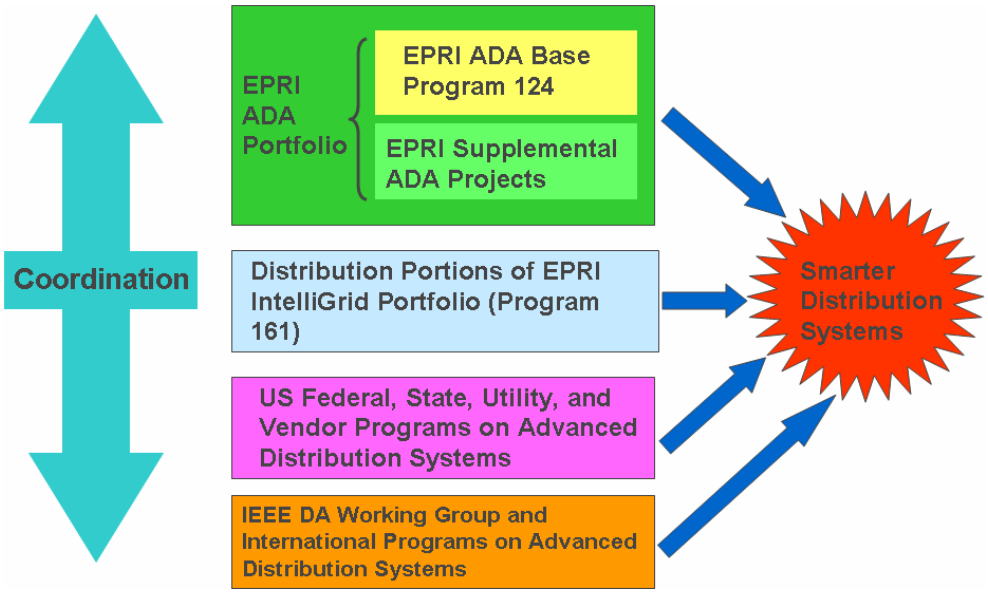

Figure 1-4
Relationship of EPRI Smart Distribution Program to Other Major Programs Targeted at Making Distribution Systems Smarter

Via the Project Set 124A, EPRI seeks to foster coordination and collaboration among the international programs, especially via the annual international workshop. This collaboration will be important in development of the smart distribution guide.

The ADA™/Smart Distribution Guide Project

This project to develop a guide on ADA™/smart power distribution systems is an element of Project Set 124A in Figure 1-3. Project Set 124A is focused on technology transfer, technology watch, and industry coordination. The project set includes activities on:

- Development and maintenance of the automation/smart distribution guide
- The annual PQA/ADA™ conference, which is a joint activity with EPRI Program 1 (Power Quality)
- The Annual EPRI International Workshop on ADA/Smart Distribution Systems
- Technical assessment and application experience for emerging smart distribution technologies

The first steps on development of the automation guide were taken in 2008, and work continues into future years. The overall approach that has been developed and implemented for the guide project is described in Section 2 of this report. Figures 1-1 and 1-2 illustrate the breadth of topics to be included in the EPRI guide on ADA™/smart distribution.

Reference

[1] *Technical and System Requirements for Advanced Distribution Automation,* EPRI Report 1010915, Electric Power Research Institute, Palo Alto, CA, 2004.

2
PROJECT APPROACH FOR GUIDE DEVELOPMENT

Project Background

The utility industry is rapidly moving to modernize distribution systems, including wider use of distribution automation. There is a need to incorporate the best practices emerging from the utility and vendor communities into engineering tools to facilitate high-quality automation practices with uniform procedures and standardization wherever possible.

This project is producing a guide to serve as a central tool to guide utilities in ADA™/smart distribution programs. Opportunities for developing additional tools will be sought as a byproduct of the work. This industry-standard tool will be updated continuously to reflect the continuous evolution of ADA™ technologies. The guide will encompass the following broad information areas:

- A directory of equipment, software, and ADA™ integration services available from the supplier community
- Guidelines for automation for specific equipment classes
- A directory of information technology products, protocols, and standards for ADA™ (including current status information)
- Case studies and illustrative examples of actual automated distribution systems

An outline was developed with sponsor input. The necessary information will be contributed by vendors, utilities, consultants, universities, and standards organizations. The guide will be drafted using the structure of the outline. The guide will be maintained and updated as new information becomes available. Throughout the work, opportunities may be identified for developing other industry ADA™ tools (e.g., reports, directories, software, etc.). These opportunities will be discussed with sponsors for prospective development as new projects or as an expansion of this project.

The guide will provide the following value to utilities that use it:

- Helps utilities begin to automate or more fully automate their systems, which in turn improves energy efficiency and reliability of distribution operations
- Improves system functionality, allowing delivery of improved power quality and a wider variety of customer services
- Enables automated response to mitigate outages or speed recovery from outages
- Supports migration from legacy proprietary systems to open systems based on international standards

Electric distribution engineers, planners, information technology specialists, asset managers, and operators can use this guide to automate their systems, based on an improved understanding of the technology options that are available and a knowledge of best practices from past utility industry experience. They will achieve better practices in implementing ADA™ using more efficient development processes. Through the advanced systems, they will realize significant gains in energy efficiency, system reliability, outage management, and variety of customer services. These in turn improve customer satisfaction and demonstrate visible action to the public and regulators of serious efforts to improve energy efficiency and be a good steward of environmental resources.

The guide can be used at all levels of automation/smart distribution systems, ranging from a utility that is just beginning to automate to a utility that is applying advanced automation to an entire distribution system. The guide can be used to aid in automating specific system components, such as capacitor banks or switchgear, or to aid in more broadly automating system operations. The guide will be of significant value to utilities who wish implement ADA™/smart distribution concepts to improve system reliability, reduce electrical losses and thereby improve energy efficiency, offer more customer services, and improve outage restoration capabilities.

Project Approach

An approach for developing the guide was developed and presented to sponsors for review and input. The approach was also presented to the IEEE Distribution Automation Working Group (DAWG) for input and support, in that the approach requires collaboration with the IEEE DAWG for implementation. An outline for the guide was presented and inputs were obtained. The development of the EPRI guide is being coordinated with the development of an IEEE DA Guidebook, as is discussed later in this section.

The approach chosen for the EPRI guide is a “wikipedia-type” resource. The resource will be developed through the IEEE DAWG and will be a living draft during its development. Open access will be given to it for both new writing contributions and use. It will grow as new contributions come in, and it will be maintained as updates are contributed to replace aging material. The quality of the resource will be overseen by the IEEE DAWG. But contributions can come from all ADA™/smart distribution groups: utilities, vendors, universities, consultants, standards groups, and research organizations. The general concept is illustrated in Figure 2-1.

EPRI will set up the web site and widely distribute instructions and content guidelines for seeking contributions from the smart distribution stakeholder community. Contributors will be given attribution for their contributions when posted. A number of DAWG members have already indicated interest in contributing material. The web site will be a DAWG working document—a living draft that is evolving with time and is openly accessible for this purpose. Users can propose corrections, if erroneous or outdated material is identified. The expertise of DAWG members will be used to review content. At the time of this writing, the web site is being set up.

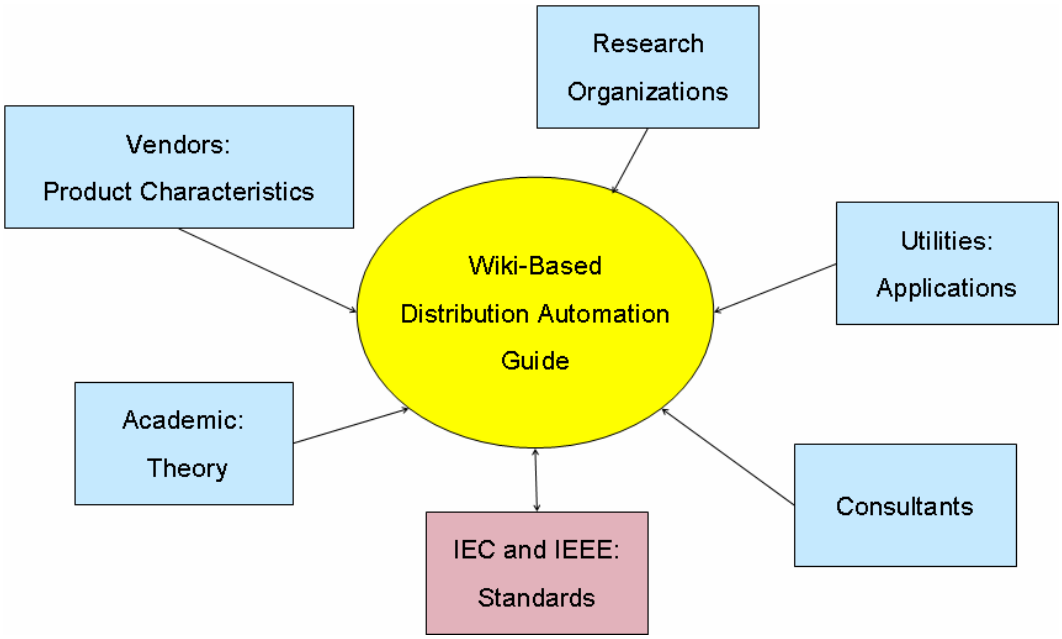

Figure 2-1
Illustration of Wiki-Based Guide Approach

A wide variety of topics related to the following smart distribution issues will be covered:

- Applications
- Technologies
- Business case

Contributions can range from short-description paragraphs to treatises on suggested practices for specific automation tasks.

The long-term vision for the guide is to get it up and running in 2008 and continue to populate it with contributions in 2009 and beyond. After about two years of content development, the content will be examined to determine if it is stabilized enough to warrant preparing a hardcopy version of the guide. In either case, the web-based version will be continued and updated. If a hardcopy version is produced, it will be reviewed nominally every two years to see if the added web material during that two-year period is significant enough to warrant updating the hardcopy version.

Relationship to IEEE Guidebook

A distribution automation (DA) guidebook is also being developed through the IEEE DAWG. This will be an IEEE publication and differs from the EPRI guide. The approach for the EPRI guide described above was developed in coordination with the IEEE DAWG to assure coordination of two with the aim of evolving what will be a complementary set of tools. Figure 2-2 differentiates the two engineering tools. Coordination of the two efforts will be facilitated by the fact that members of the DAWG are involved in both efforts.

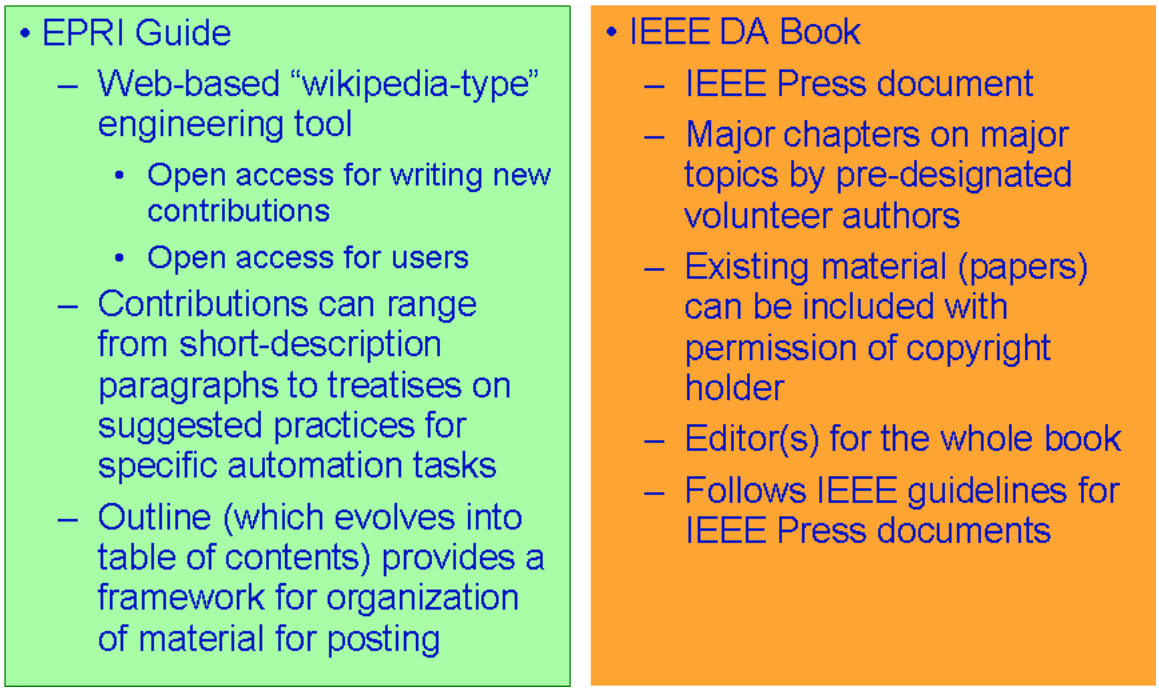

Figure 2-2
Differentiation between complementary tools: The EPRI Web-Based Guide and The IEEE DA Guidebook

The EPRI guide is open-ended as to topics covered, as long as they are relevant to smart distribution systems and fit into the structure of the guide. The IEEE guidebook will have a focused set number of topics to be written by designated contributors.

3
STRUCTURE FOR THE GUIDE

Introduction

This section presents the structure for the EPRI guide on ADA™/smart distribution systems in the form of an outline. The structure is provided to serve as a basis for organizing the material coming from contributors for posting in the wiki-based site. The structure will be adapted to users needs as the guide evolves over time. The following outline provides the initial structure for the wiki-based EPRI guide.

Structure for Guide

Basic Background

- What is distribution automation (DA)?
- What is ADA™?
- What are smart grids and smart distribution systems?
- Status and trends for the above
- Rationale, value, and business cases for the above

DA architectures

- Centralized
- Substation centered
- Distributed, peer-to-peer
- Criteria for selecting an architecture

DA technologies and infrastructure

- Monitoring systems
    - Sensors
    - Use of other equipment as monitoring sensors
    - Data processing
    - Integration of AMI into DA
- Active, automatable distribution system equipment
    - Switchgear
    - Switch capacitor banks
    - Protection systems, relays, reclosers
    - Power electronic components
        - IntelliRupter
        - Solid-state transformers
        - Solid-state switchgear
        - Sag correctors, static compensators, and other power quality enhancers
    - Others
- Communication infrastructure
    - Communication technology (media)

    - Information technology
    - International communication standards
- Control technologies
    - Hardware
    - Algorthims
    - Simulation tools
        - Software products
        - Grid-lab D
- Reconfiguring technologies and fault clearing approaches
    - IntelliTeam
    - DV2010 pod approach
    - Integrated Volt/VAR management
    - Fault anticipation, detection, and location technologies
    - Integration of distributed generation and storage
    - Intentional islanding and microgrids
    - Others

Application examples and use cases

Utility application field experience

- Major projects worldwide
- Metrics for evaluating performance of DA systems
- Maintenance considerations for DA systems

International standards

- Case for international standardization
- Status of standards
- Adoption to date
- Experiences with use of standards
- IEC 61850 series
- IEC 61968 and 61970
- Others TBD

Bibliography of additional reading

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