Microgrid Controller Standardization
Approach, Benefits and Implementation

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Microgrids Design and Testing
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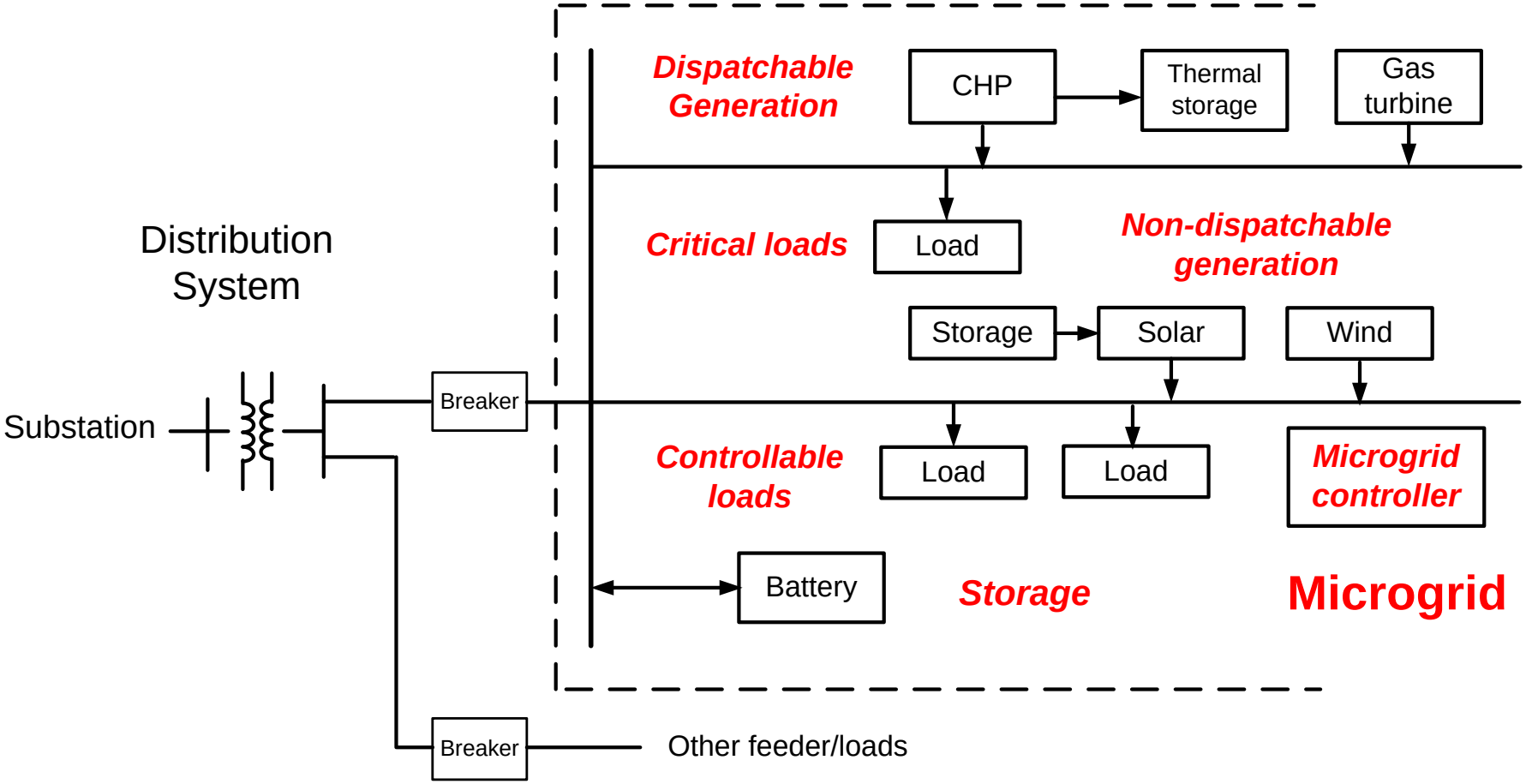
Microgrid and Microgrid Controller

- The microgrid is a concept for which the controller is the defining and enabling technology. Indeed, the microgrid may be defined as the resources – generation, storage, and loads – within a boundary that are managed by the controller.
- The microgrid controller manages the resources within the microgrid's boundaries, at the point of interconnection with the utility, interacting with the utility during normal operations ("cooperative control").
- The microgrid controller defines the microgrid's operational relationship with the distribution utility.

Microgrid – generic structure and operation

Grid resilience and stability – Grid energy security – Integrating renewable sources – Islandable – Grid ancillary services – Markets



Microgrid controller – a key control element

- Microgrid controller functions
  - Coordinates, in an optimized manner, the integration and dispatch of local Distributed Energy Resources (DER) and loads
  - Allows seamless grid disconnection and reconnection
  - Sets the power exchanges (real and reactive) with the grid
  - Enables the provision of ancillary services to the grid
  - Enables market participation of DERs within the microgrid
- Controller implementation – enabling technologies
  - A centralized controller sending commands to elements OR
  - A decentralized control system, with intelligent local controllers (agent based)
  - Sensing, monitoring, data management and information and communication technologies

Enabling microgrid benefits – role of the controller

- Microgrids – an enabling technology for
  - Reconfiguring existing distribution systems
  - Developing distribution systems in developing areas
  - Integrating local Distributed Energy Resources (DER)
  - Integrating DERs using renewable energy resources (green power)
  - Customer and end-user empowerment
- Quantifiable benefits – making a business case for
  - Enhancing grid resilience and stability
  - Enhancing energy security using local energy resources
  - Matching power quality to the end-user requirements
  - Providing ancillary services to the grid, voltage/frequency
  - Lowering the carbon footprint
  - Enabling market participation of distributed generation and storage

Need for microgrid controller standard

- Microgrid technology is being deployed in a number of places and for different applications and contexts and new standards are required to facilitate deployment
- Standards are now under development by the IEEE SA, taking into account the nature and configuration of microgrids, which integrate Distributed Energy Resources (DER), including distributed generation and storage, and controllable loads (Demand Response)
- Defining generic functions between the control and power functions of microgrid components and its controller simplifies the design, configuration and operation of microgrids.
- Interoperability requirements facilitates deployment

Need for microgrid controller standard

- Coordinated and consistent electrical interconnection standards, communication standards, and implementation guidelines are required
- Require standards that match the unique characteristics of the microgrid
- There are few standards that apply to microgrids as distinct, interconnected entities
- Ongoing IEEE and IEC standardization activities related to DER and microgrids

Requirements for a Successful Standard

The ultimate aim of a standard is to strive to enable **interoperability of diverse systems** carrying out the same functions, with an **industry consensus** on what is required to conform to the standard. There also needs to be a balance between being prescriptive and providing a sufficient latitude to users to choose from a range of implementations and options to better meet the requirements of a given application. In the case of microgrid standards, a clear and simple set of required core functions needs to be defined and used for conformance testing to ensure interoperability of the offerings from different vendors, even though differing implementations are possible. Defining **core functions** is the purpose of the IEEE P2030.7 standard initiative.

In addition to defining a set of core functions, there needs to be a **protocol for conformance testing**. This step forms the basis for a certification program to ensure conformance. Testing is covered in the IEEE P2030.8 standard project. An appropriate procedure needs to be determined for testing for compliance to the standard. There needs to be a clear and comprehensive set of test scenarios, performance requirements and specifications, and test metrics.

Broad market adoption is the best indicator of the success of a standard.

Identifying Standards for Implementation

Evaluate a standard, specification, or guideline was on whether it:

- Enables the transition of the legacy power grid to the Smart Grid.
- Has, or is expected to have, significant implementations, adoption, and use.
- Is supported by an SDO or Users Group to ensure that it is regularly revised and improved to meet changing requirements and that there is strategy for continued relevance.
- Is integrated and harmonized, or there is a plan to integrate and harmonize it with complementing standards across the utility enterprise through the use of an industry architecture that documents key points of interoperability and interfaces.
- Enables one or more of the framework characteristics as defined by EISA or enables one or more of the chief characteristics of the envisioned Smart Grid

Source: NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. January 2010.

Benefits of Implementation of Standard for Microgrid Controllers

- Facilitates acceptance of microgrid technology in an evolving industry structure
- Facilitates development of related standards-based products, increasing vendor population
- Reduces system integration costs
- Reduces time to deployment (helps resolve in-the-field interoperability issues)
- Lowers technical barriers to advanced applications for microgrids

Examples for using standards

- Regulators
  - Objective basis for tariffs
- Project planners
  - Minimal performance specifications
- Utilities
  - Interconnection and interactive operational requirements

Assurance that microgrid controller will perform as specified – provide functionality to microgrid owners and utilities; deliver returns to investors.

Implementation

- Adoption
  - Mandatory [e.g., IEEE 1547 cited in Energy Act of 2005; state PUCs]
  - Voluntary [Developers, utilities]
- Pre-conditions for adoption
  - simplicity
  - minimal number of mandatory requirements
  - flexibility in application
  - open communications protocols
  - useful to other standards [interoperability]

Dissemination

An important part of implementation for a standard is to encourage its broad and effective application to grid projects. This is true as well for Cigre research that has practical applications, but especially so for standards. Even more so for standards that compliment research.

IEEE Standards Association – microgrid controllers

- Standardization efforts – included in a series of two standards
  - P2030.7 – Specification of Microgrid Controllers
  - P2030.8 – Testing of Microgrid Controllers – based on the functional specification defined in P2030.8
- Interoperability requirements an integral requirement and a principle in the development of standards
- Participants
  - Manufacturers offering microgrid controller configuration platforms
  - Consultants configuring microgrids and service providers
  - Utilities and distribution system operators
  - Government and research laboratories

P2030.7 – Specification of Microgrid Controllers

- **New standard approved by IEEE SA, June 2014**
- **Officers:** Chair: Geza Joos, McGill University; Vice-Chair, Russell Neal, Consultant; Secretary: Jim Reilly, Consultant
- **Core functions**
  - Core functions – define the microgrid as system that manages itself, can operate autonomously or grid connected, and connects to and disconnects from the main distribution grid for the exchange of power and the supply of ancillary services
  - Scope of the standard
    - addresses the functions of the controller that are common to all microgrids, regardless of topology, configuration or jurisdiction
    - presents the control approaches required from the distribution system operator and the microgrid operator
    - links the functional specification with testing procedures

P2030.8 – Testing of Microgrid Controllers

- **New standard approved by IEEE SA, June 2015**
- **Officers:** Chair: Ward Bower, Ward Bower Innovations; Vice-Chair, Erik Limpaecher, MIT Lincoln Lab; Secretary: Geza Joos, McGill University
- **Elements under test – Core functions as a key to the operation of microgrids**
  - Functional specification and control functions – see P2030.7
  - Scope of the standard
    - Develop a set of testing procedures allowing the verification, the quantification and verification of the performance with expected/defined minimum requirements for the different functions of the microgrid controller common to all microgrids
    - Define a set of testing and performance metrics for design specification and product comparison purposes

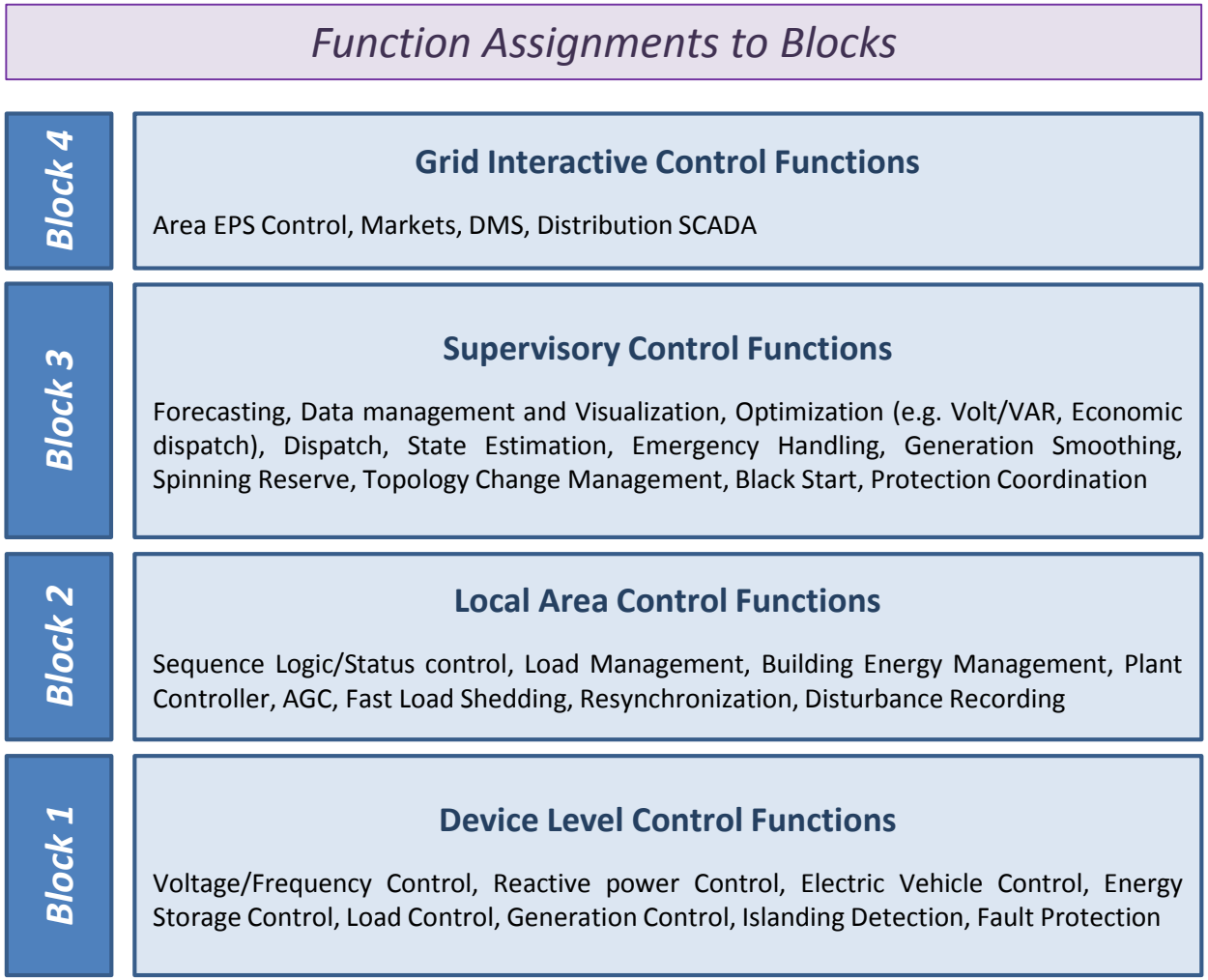
P2030.7 – Functional specification guiding principles

- Approach to developing the standard – guiding principles
- Define a generic microgrid with core devices and elements common to microgrids
- Identify the main functions and features common to microgrids – microgrids are assumed to have grid connection and islanding capabilities
- Identify generic classes of functions, internal to the microgrid, and external to the microgrid, defining the interactions with the Distribution Management System (DMS)

P2030.7 – Functional specification standardization

- Standardization efforts – requirement for universal applicability
- Defining minimum required core functions of microgrids
- Defining core functions associated with steady state operation and transitions between grid connected and islanded modes – the basic modes of operation of microgrids
- Defining core functions with verifiable and quantifiable performance

Microgrid control system – function classification

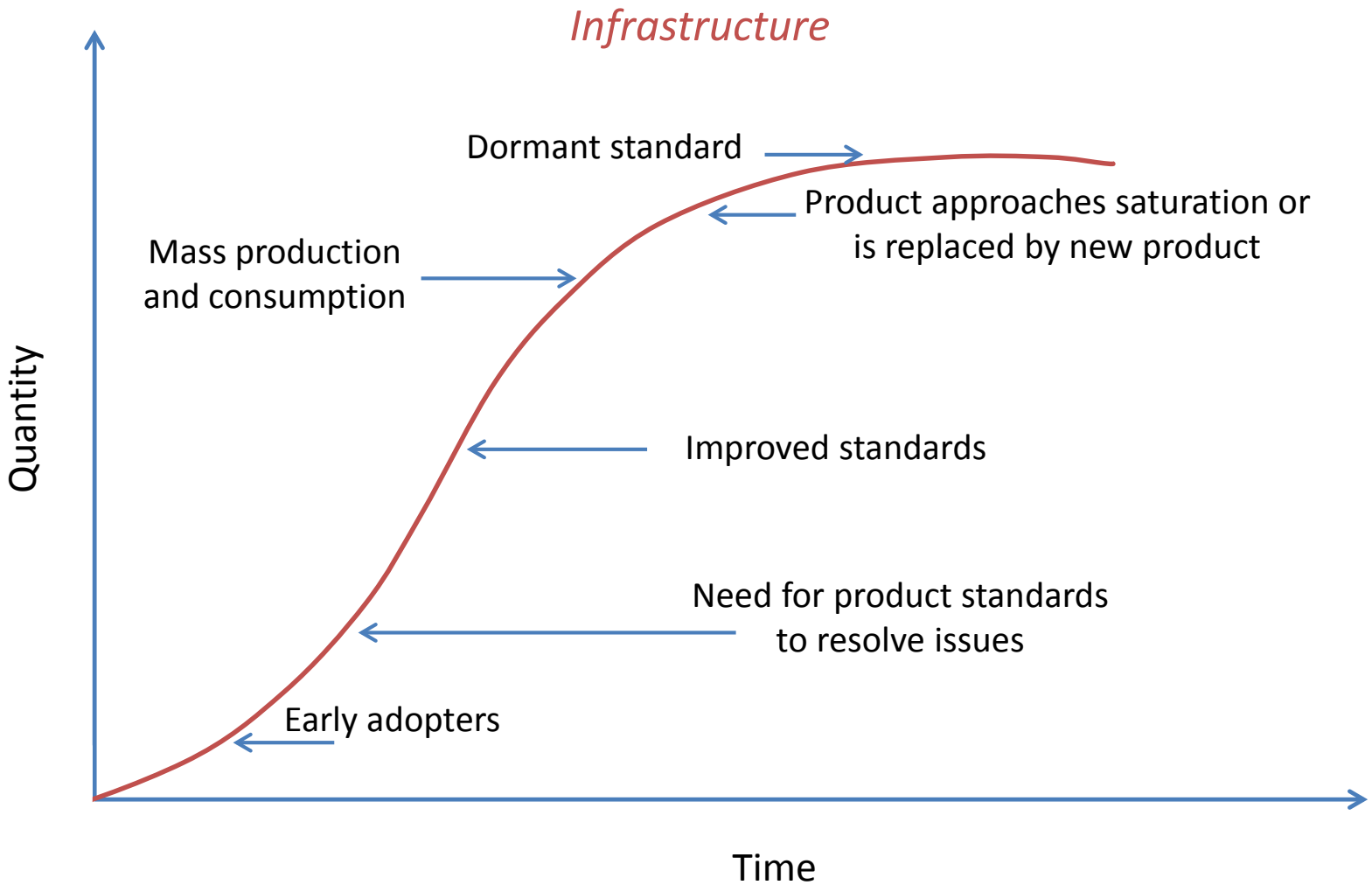


Source: IEEE p2030.7 WG

P2030.7 – Core function definition and testing

- Core functions defined in the standard
  - Transition function – defines the controller operation in transition from grid connected and islanded mode and reconnection
  - Dispatch function – defines the set-point of DERs and controllable loads in grid connected and islanded modes
- Core function testing in P2030.8 – approach
  - Define a generic microgrid that could form an environment suitable for testing microgrid controller general functions
  - Create grouping of generic functions that can be tested from the perspective of the point of connection to the distribution grid
  - Define functions that are testable using practical environments and approaches to be defined in P2030.8

Product Sales and Standards Cycle



Standards Being Developed to Facilitate Deployment of Microgrids

- IEC TS 62898-1 Guidelines for microgrid projects planning and specification, published
- IEC TS 62898-2 Microgrids Guidelines for Operation, working document
- IEC TS 62898-3-1 Microgrids – Technical/protection Requirements – working doc
- IEEE P1547-REV
  - Microgrid Connection to Distribution Utilities; Microgrid/Dist' Utility, ISO/RTO
- IEEE P2030.10 - Standard for DC Microgrids for Rural and Remote Electricity Access Applications
- IEEE P2030.9 – Recommended Practice for the Planning and Design of the Microgrid
- IEEE P2030.7 – Standard for the Specification of Microgrid Controllers
- IEEE P2030.8 – Standard for the Testing of Microgrid Controllers

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