

NSERC SMART MICROGRID NETWORK
nsmg-net



Managing Demand Through a Smarter Distribution System

Symposium ID 4120, Reza Iravani, NSMG-Net
iravani@ecf.utoronto.ca

American Association for the Advancement of Science
Vancouver, BC, Canada, February 2012

Outline:

- Overview and Introduction
- Definitions of Smart Distribution System as a Microgrid
- Virtual Power Plant (VPP) operation of Microgrid
- Microgrid as a Building Blocks of the Smart Grid
 - Technology Requirements
 - Technical Challenges
- Research, Development and Demonstration Needs
- Concluding Remarks

Electric Power Systems:

- Generation: Conventional Power Plants, **Wind Power Plants** (highly automated and “smart”)
- Transmission: High Voltage Lines, Large Industrial Loads (relatively “smart”)
- Distribution: Distribution Lines, Loads, **Distributed Energy Resource (DER) Units (Generation and Storage Units)**, **Electric Vehicles (EVs)** (least automated and not “smart”)

Why Distribution System?

North American energy investment requirements up to 2030
(OECD data):

- **Electricity: \$2.0 trillion (US)**
 - 48% generation (960 billion)
 - 16% transmission (320 billion)
 - 36% distribution (720 billion)
- **Natural Gas: \$1.2 trillion**
- **Oil: \$856 billion**
- **Coal: \$80 billion**

Smart Grid Definition:

The Smart Grid vision is a unified and automated operation of the grid based on exploitation of

- power electronic-based apparatus,
- information and communications technologies (ICTs),

to:

- minimize environmental adverse effects,
- improve asset utilization and performance,
- facilitate/enable real-time interactions among customers, operators, power producers, service providers and market.

The degree of grid “Smartness” is defined in terms of level of automation:

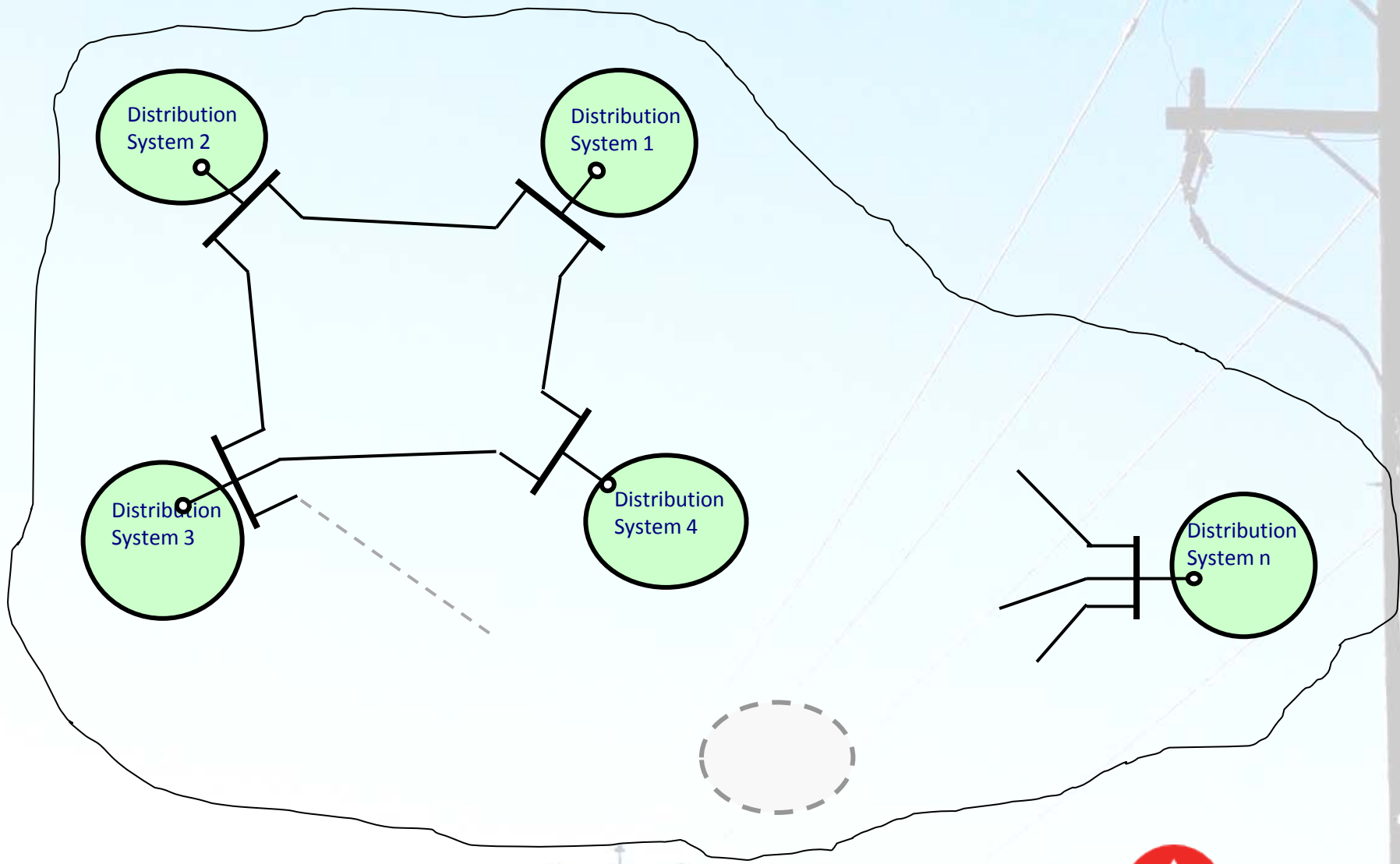
Present Status: automated operation with human **assistance**

Required Status: automated operation with human **intervention**

Proposed strategy for realization of smart grid:

A hierarchical grid management, control and protection that accommodates each distribution sub-system (distribution substation and down stream feeders) as a “manageable” and “controllable” entity with respect to its connection node to the grid.

Distribution subsystems as Building Blocks of Smart Grid



Justifications:

Relatively higher degree of “smartness” of transmission and bulk-power generation units as compared to distribution sub-systems

Addressing challenges due to high-depth of DER penetration in distribution systems

Addressing anticipated issues due to high-depth of EV/PHEV penetration systems

Limited and gradual investment

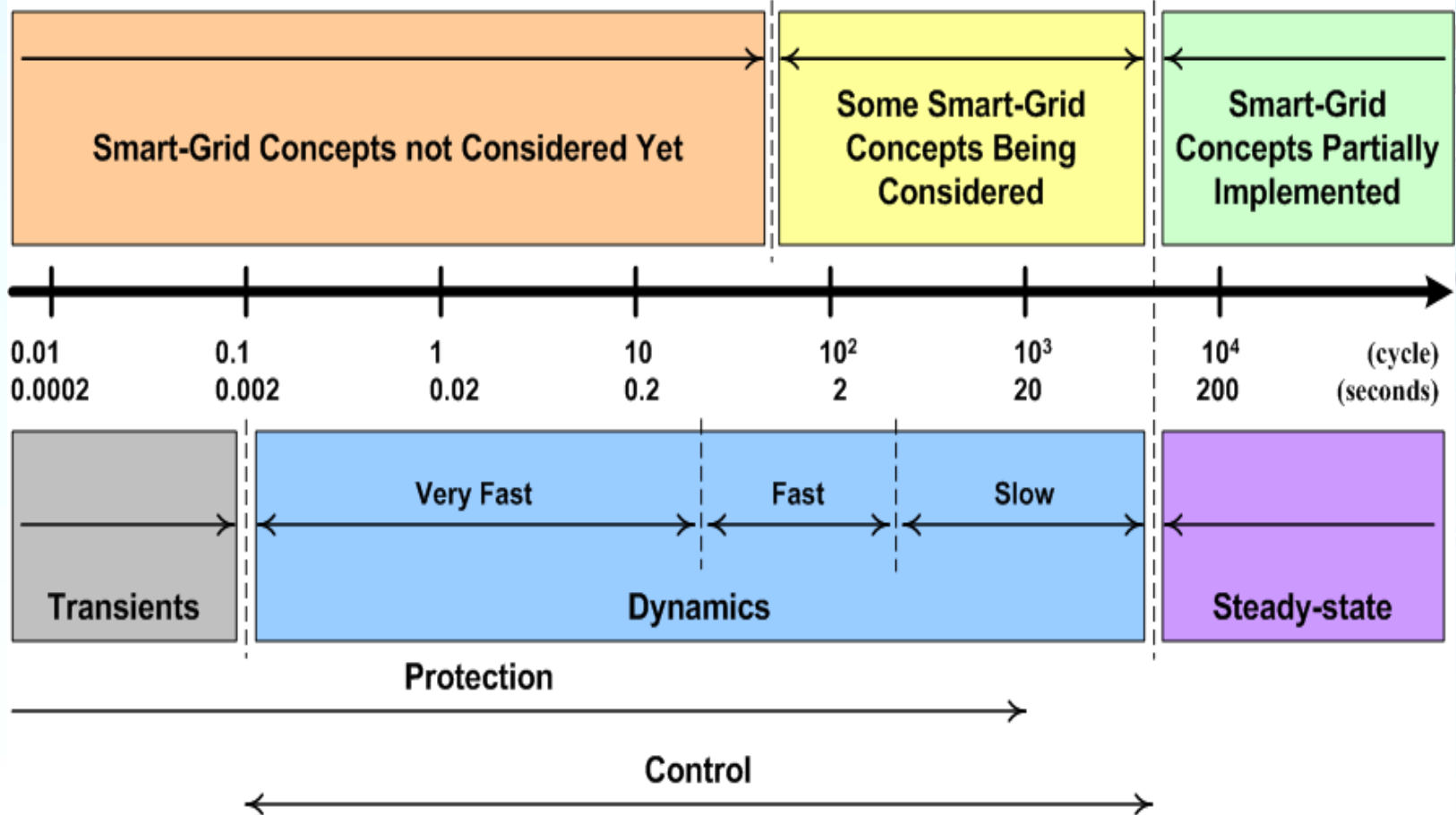
Justifications (continued):

Flexibility to address system requirements and as deemed necessary/desirable

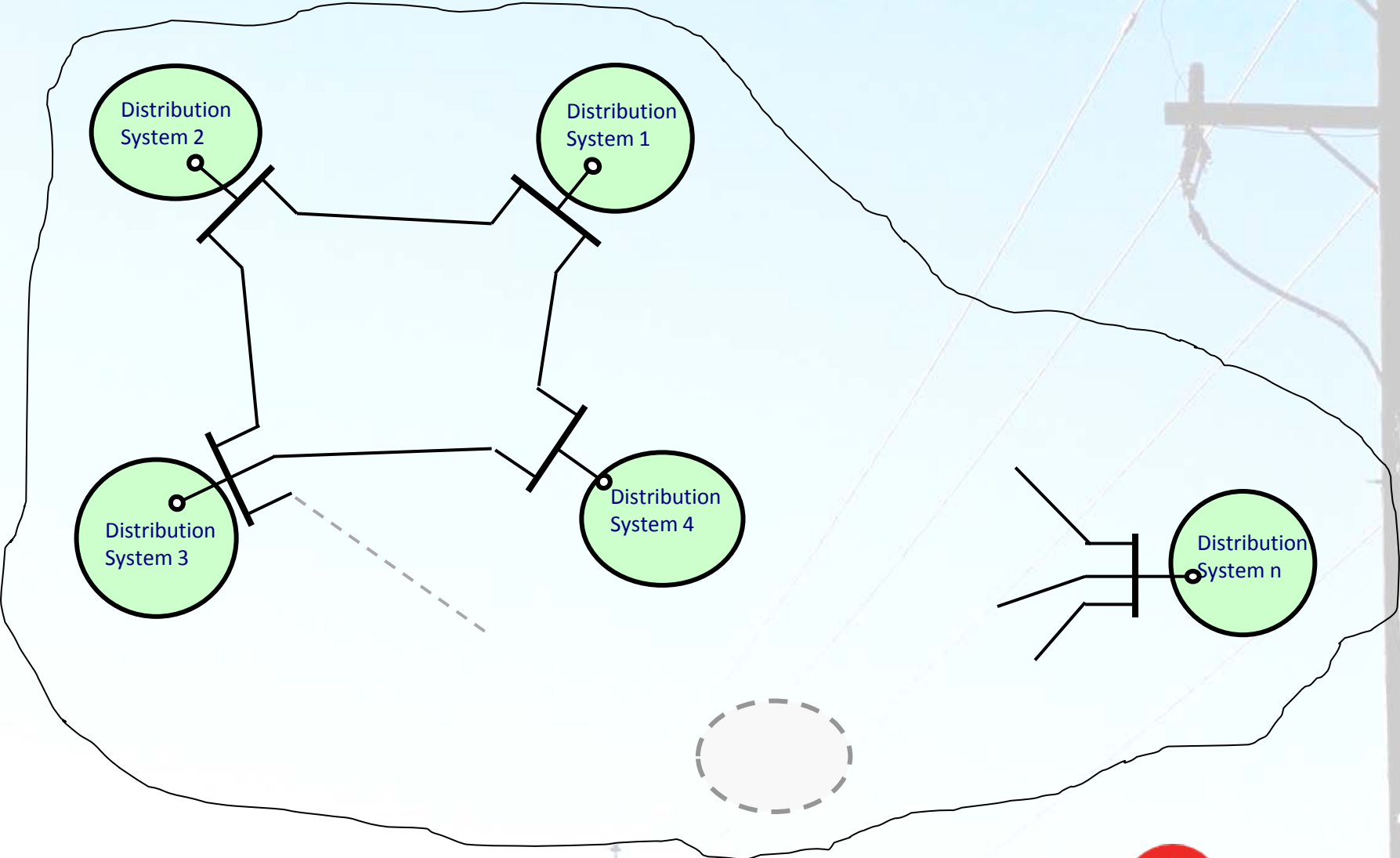
Flexibility to integrate “new” technology based on local decisions

Continuity of supply subsequent to natural disasters and man-made events

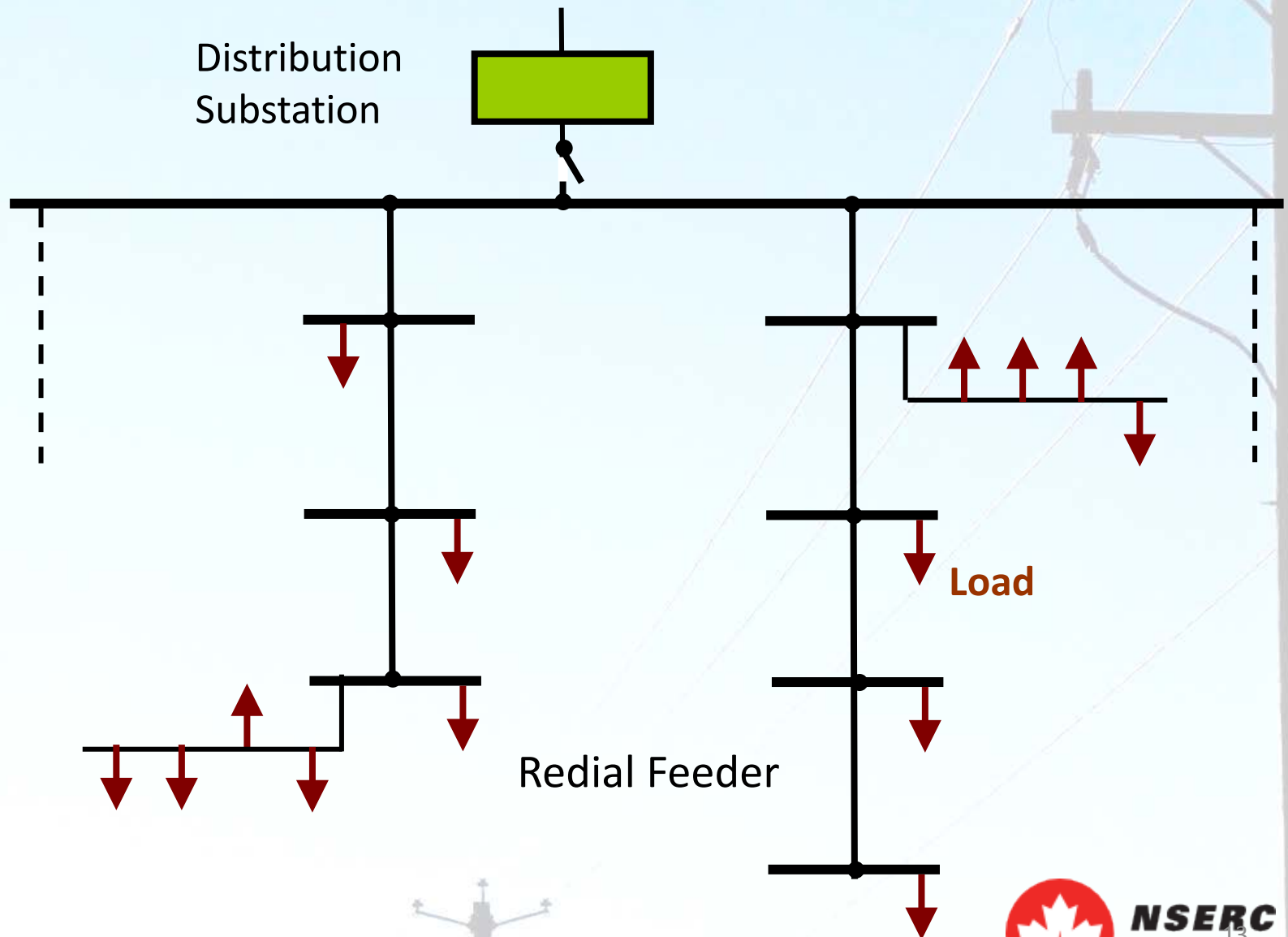
Time-Frame of Events in the Power System and Applicability of Smart Grid Concepts



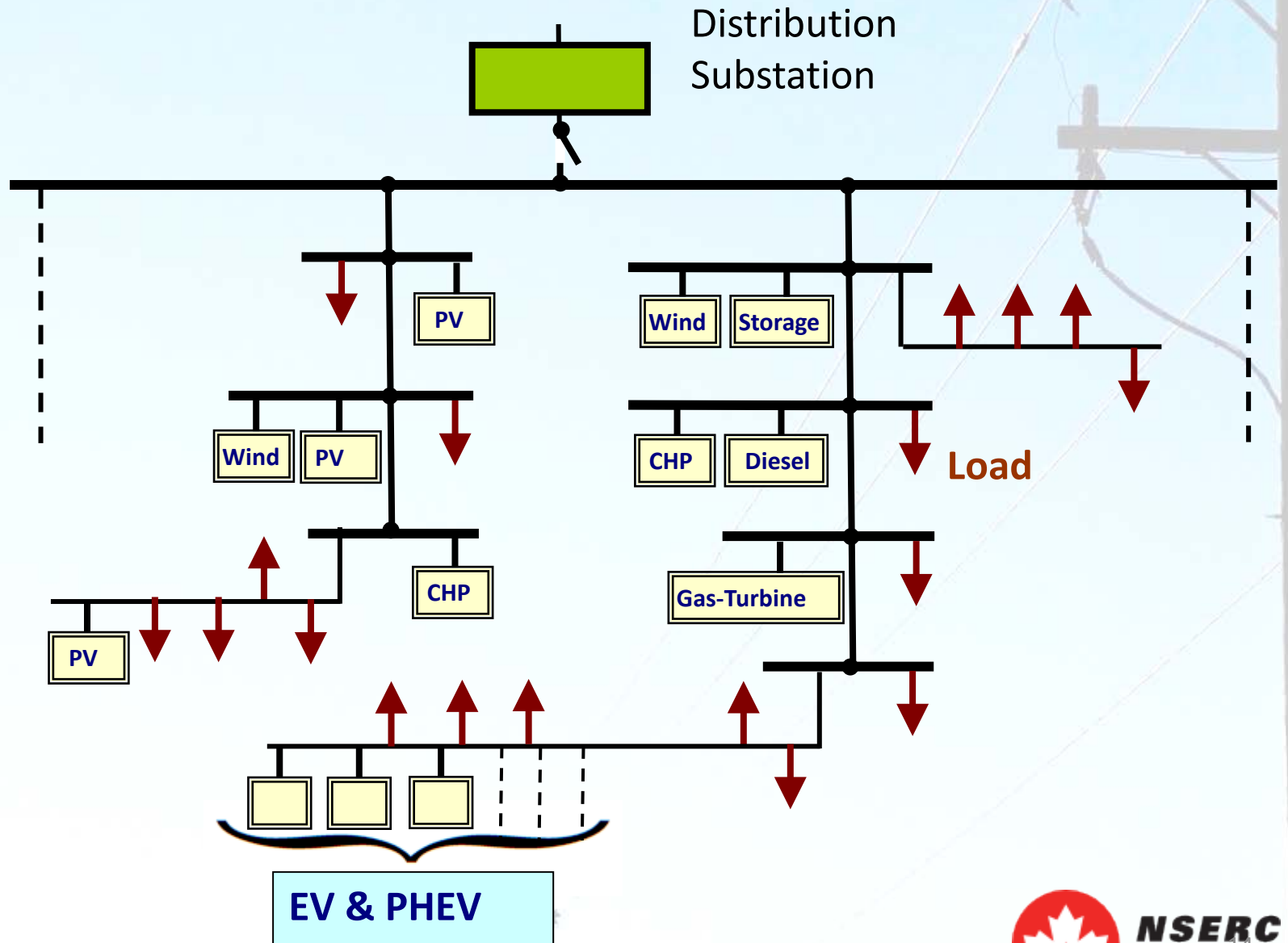
Distribution Sub-systems



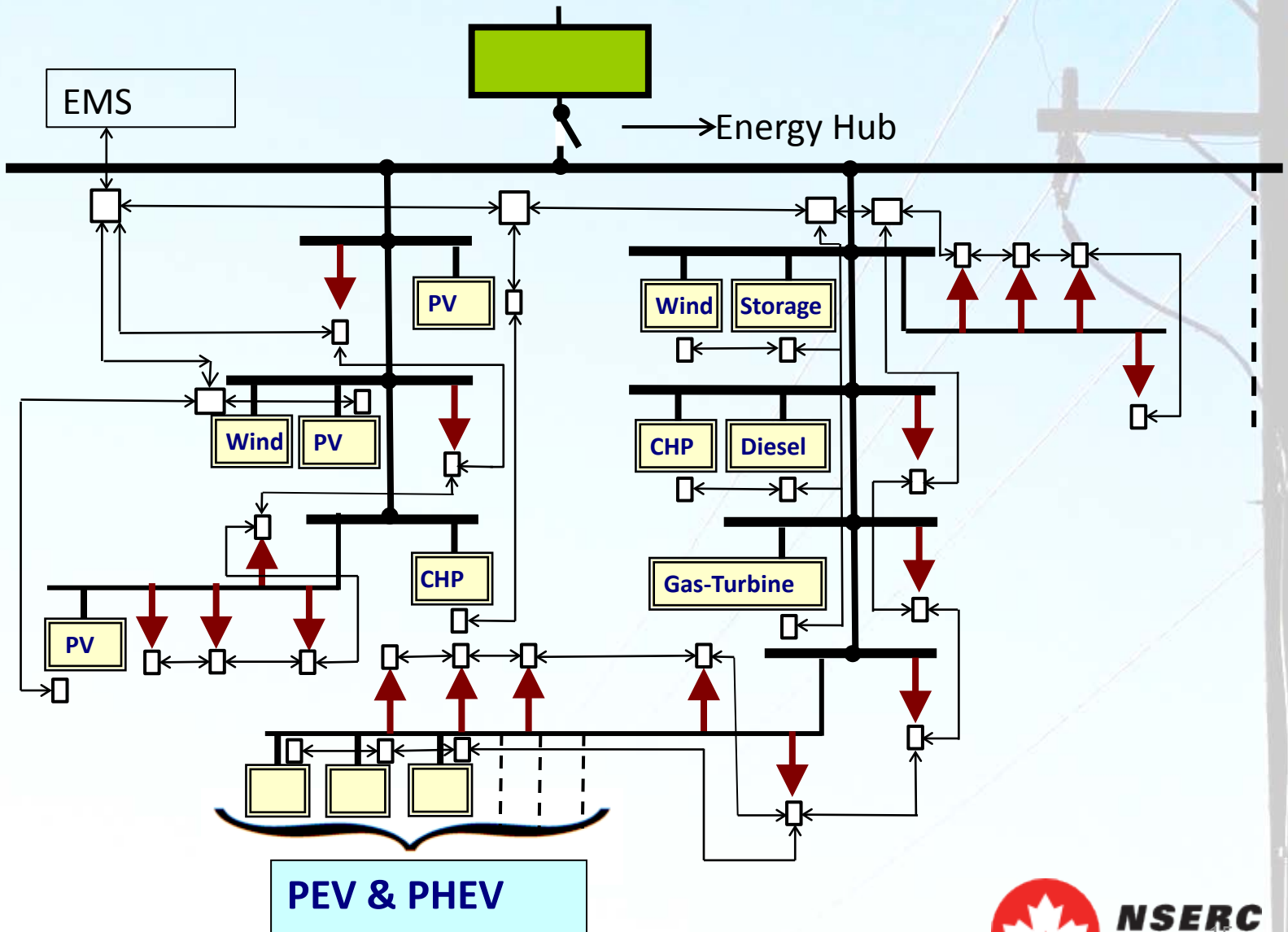
Conventional (Existing) Distribution System



Active Distribution System



Microgrid



www.smart-microgrid.ca

Definition of “Microgrid”:

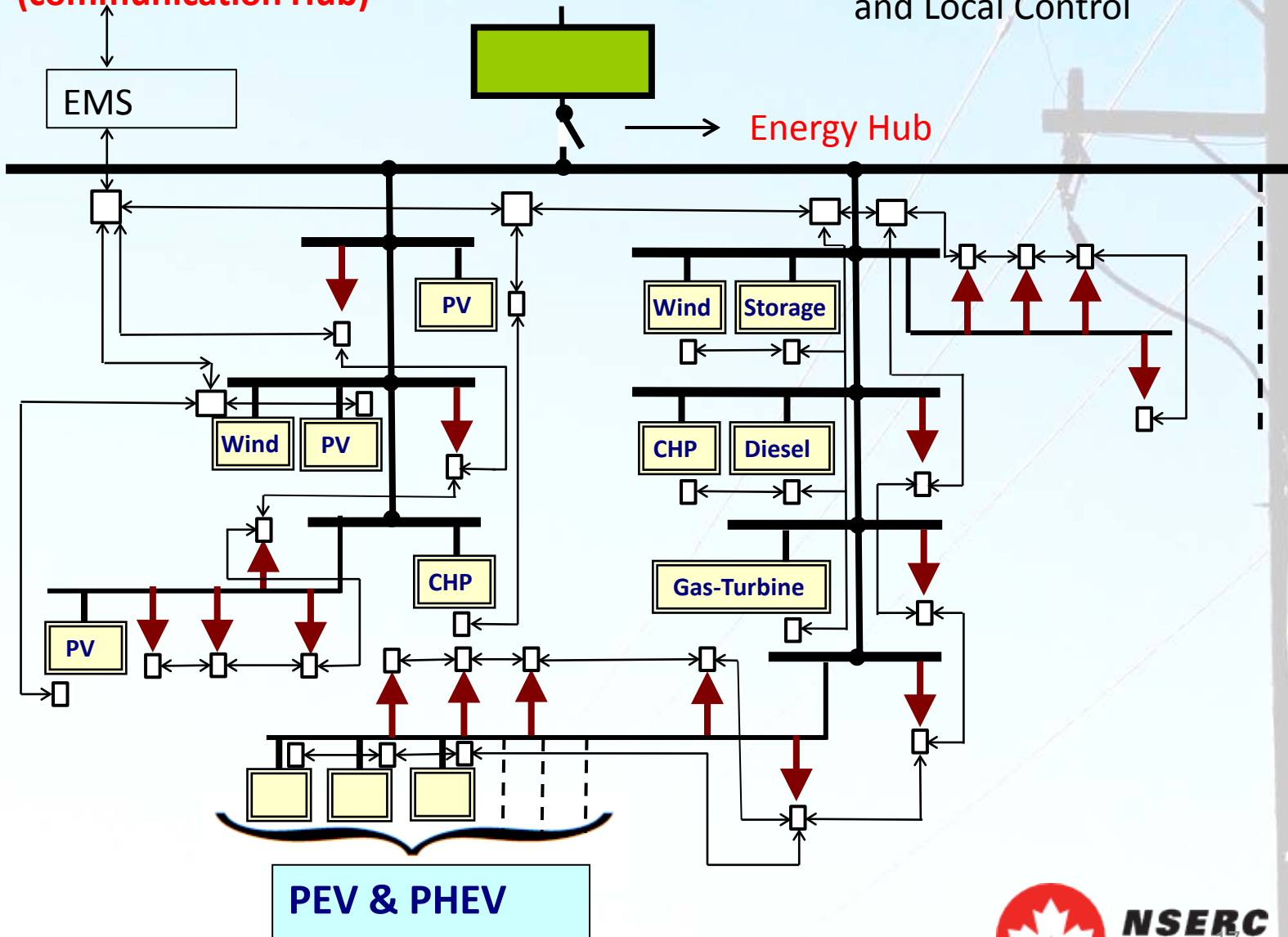
A “microgrid” is a cluster of distributed energy resource (DER) units and distributed loads, serviced by a distribution system, and can:

- operate in the grid-connected mode,
- operate in the islanded (autonomous) mode,
- provide smooth transition between the two modes.

Communication with External System
(communication Hub)

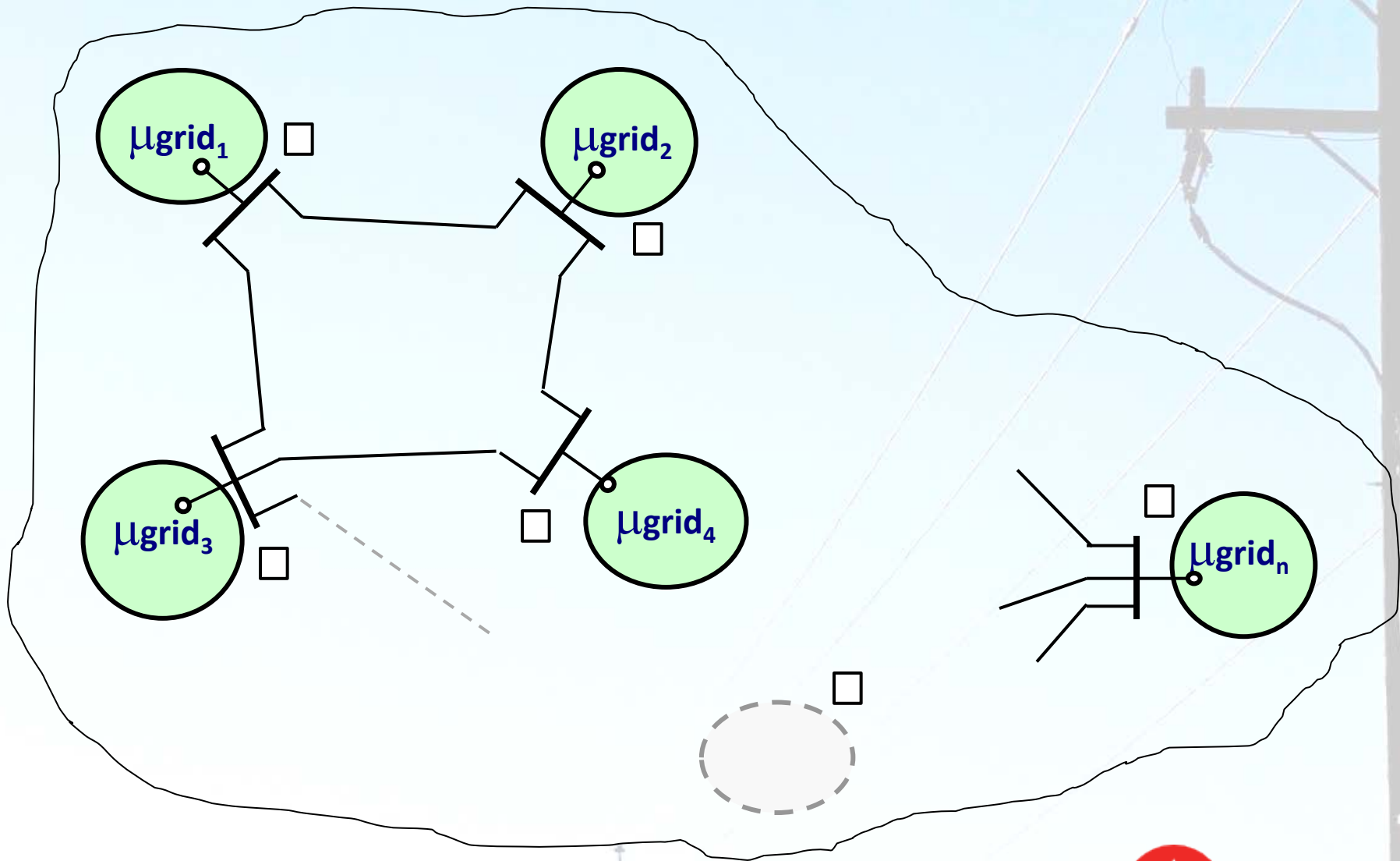
Microgrid

□ Local Communication Hub and Local Control

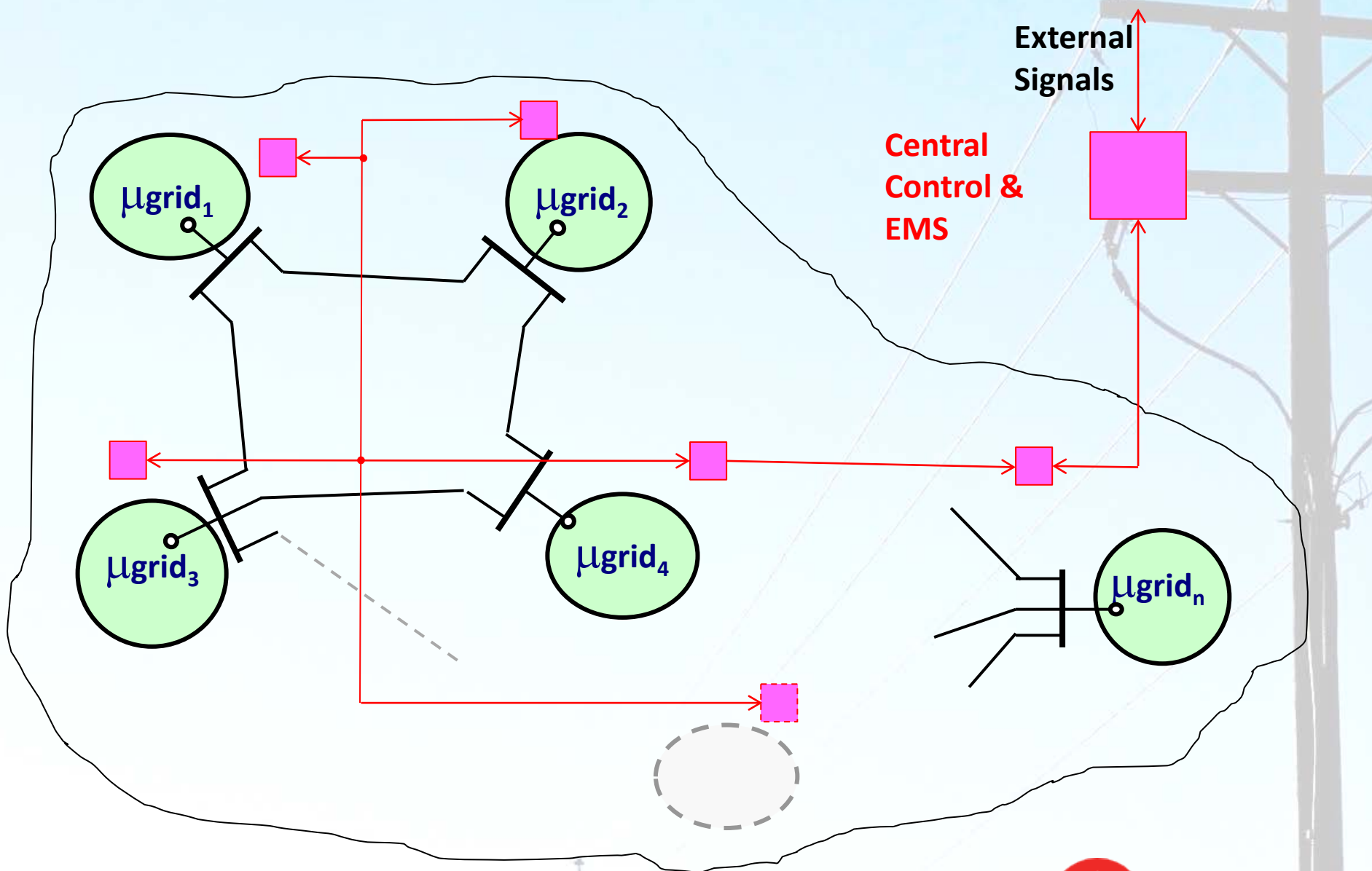


PEV & PHEV

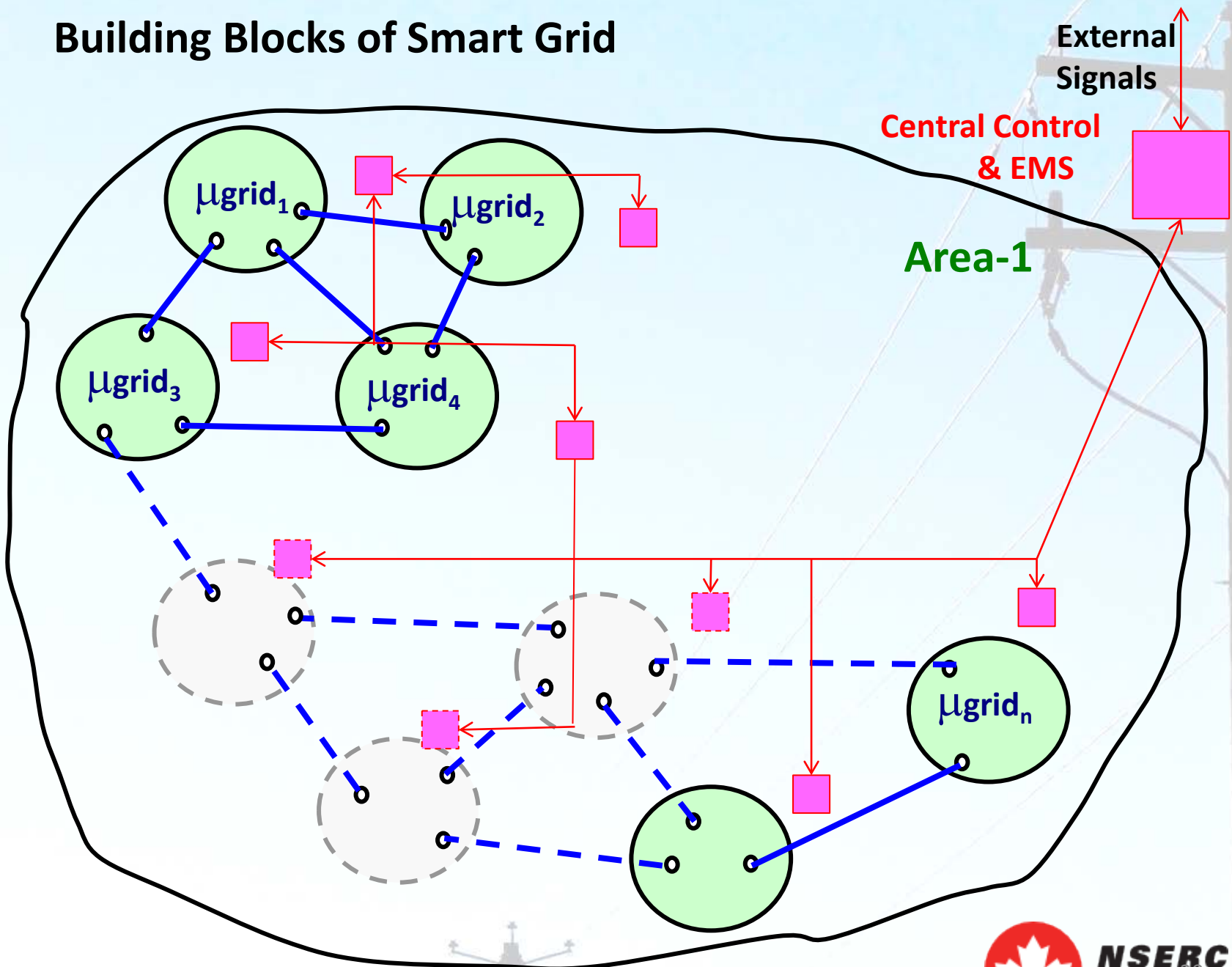
VPPs as Building Blocks of Smart Grid



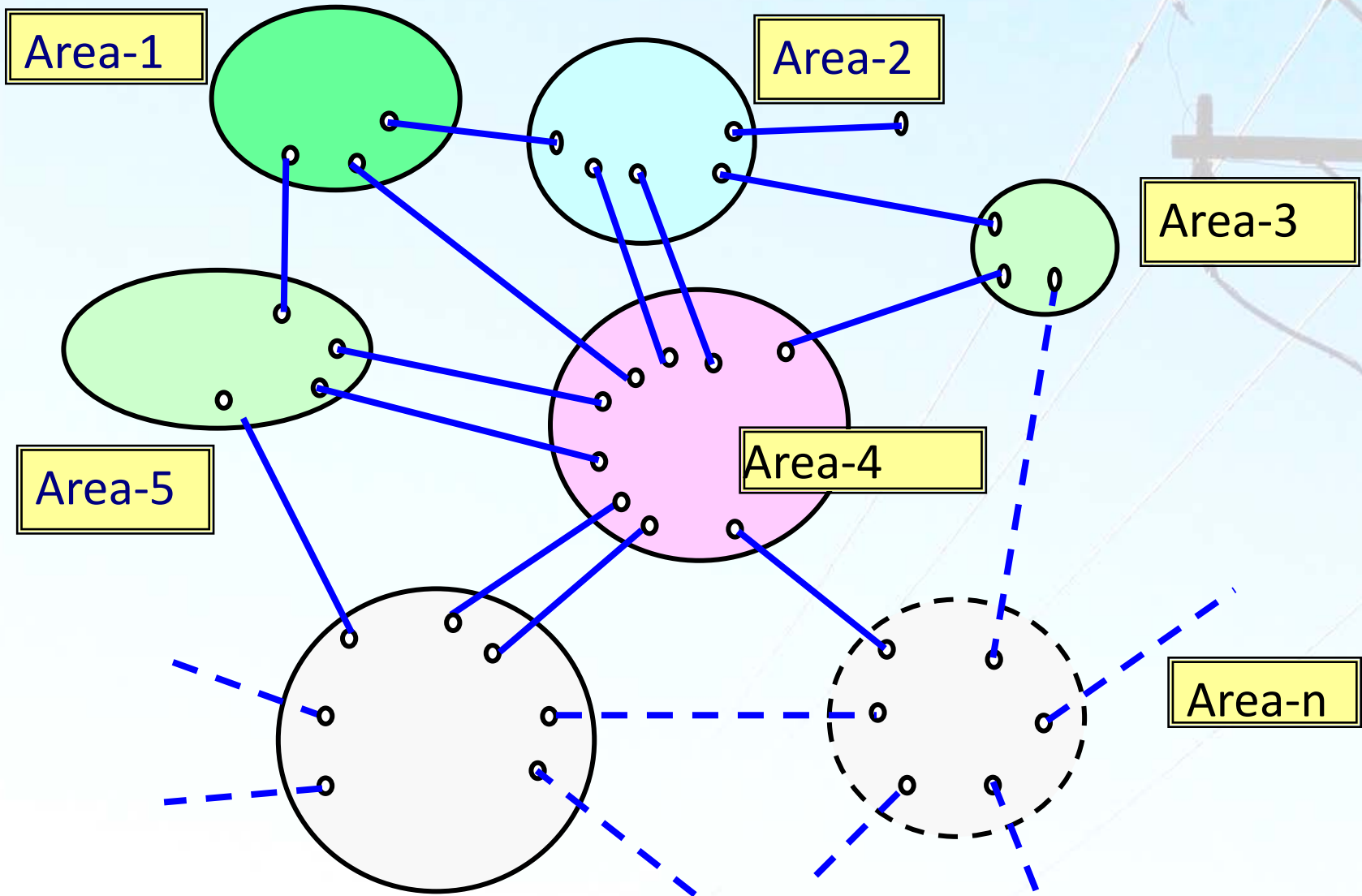
Microgrids as Building Blocks of Smart Grid



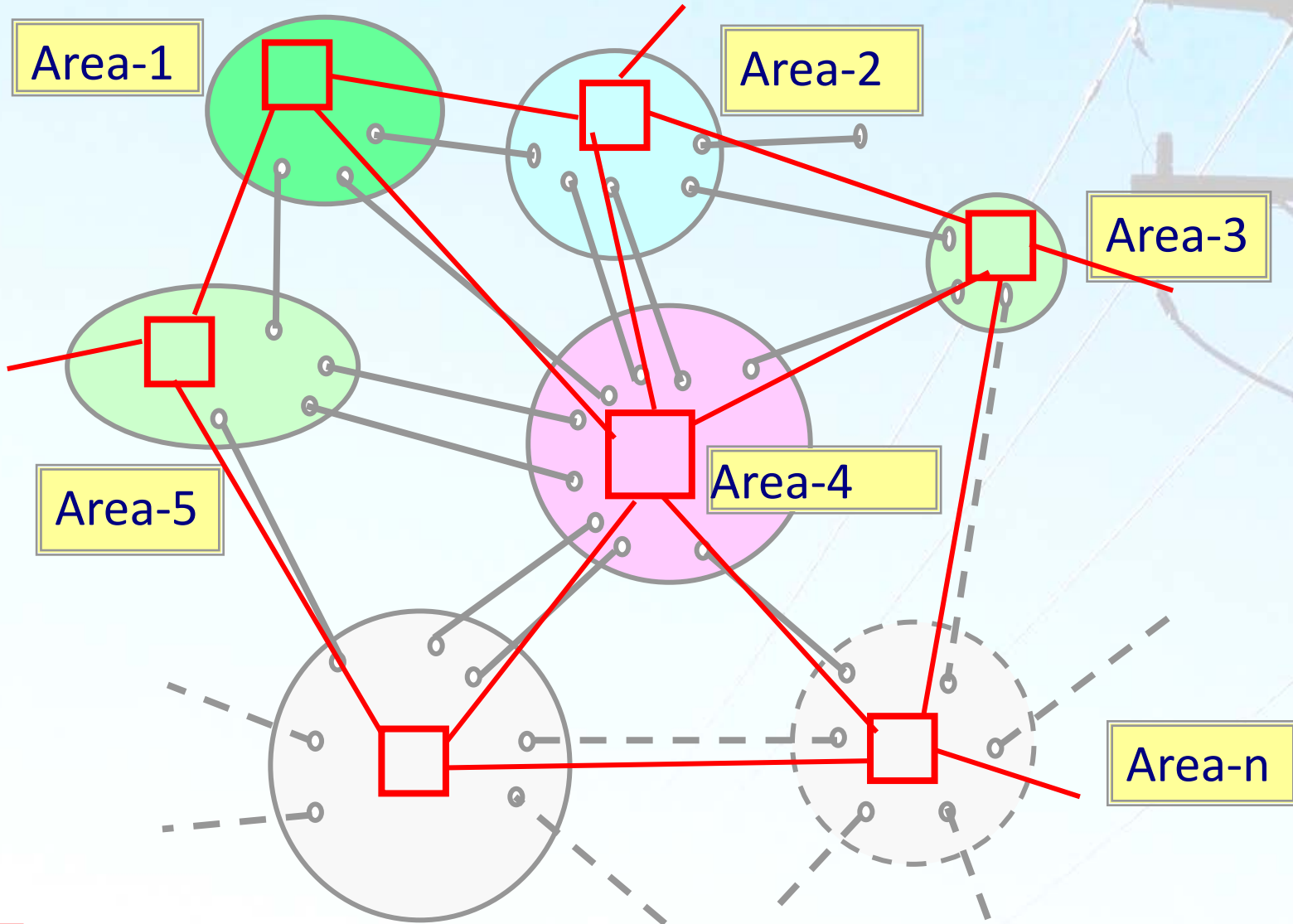
Building Blocks of Smart Grid



Wide-Area Power System

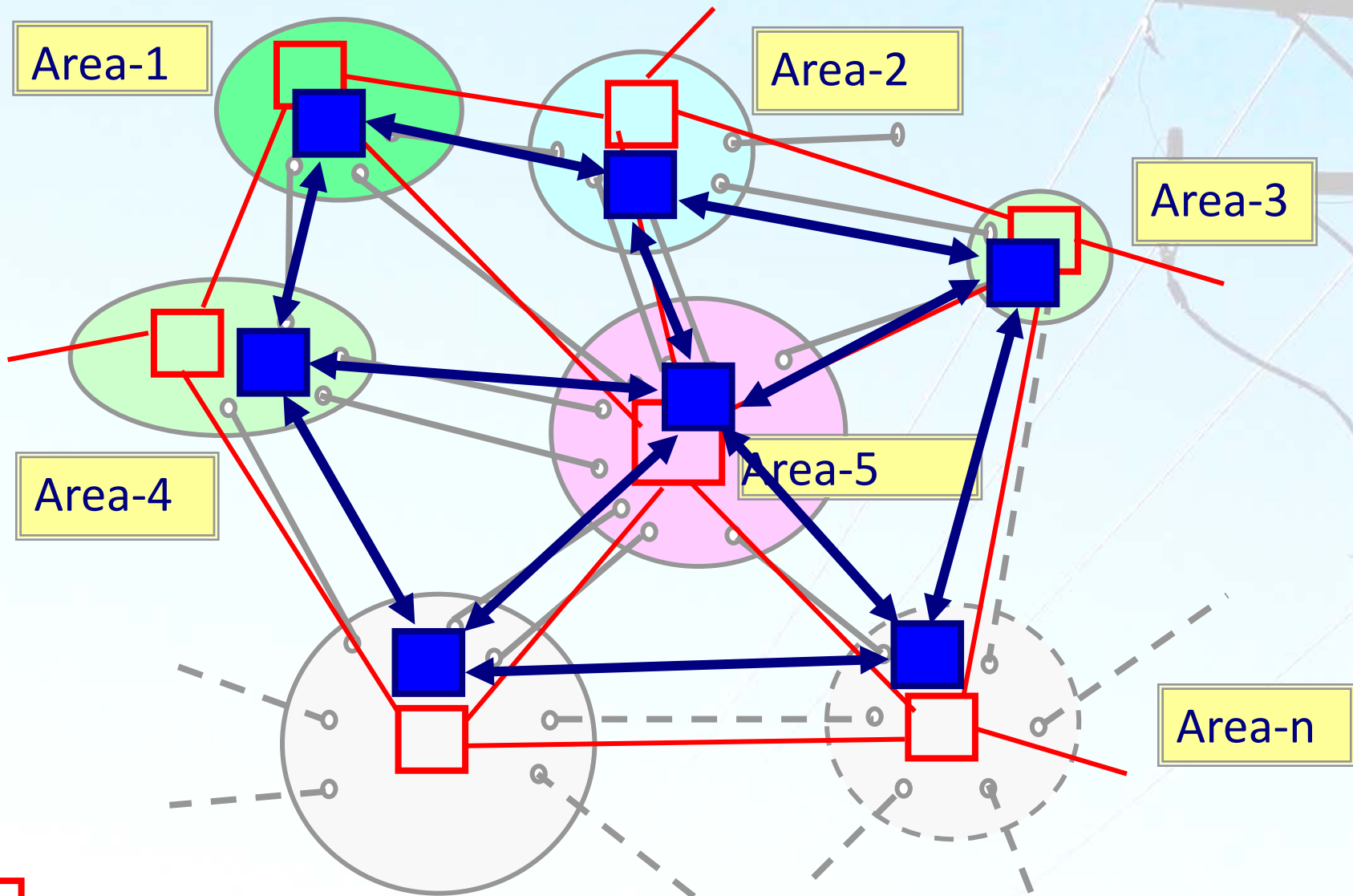


Wide-Area Power System



Existing (slow) communication links

Wide-Area "Smart Grid"



 Existing (slow) communication links

 Future (fast) communication links

www.smart-microgrid.ca



Challenges and Barriers:

- Legacy regulatory requirements and standards
- Lack or consistency/uniformity of the incoming regulatory guidelines and/or standards
- Unwillingness and /or inadequacy of technical knowledge and awareness regarding technical possibilities
- Cyber security concerns associated with significant reliance ICTs
- Lack of knowledge (unwillingness) to applying unconventional control, protection and operational strategies
- Lack of analytical methods and computer based tools for analysis, design and performance evaluation

Ongoing RD&D concept:

- Development of a communication-based robust controller and energy management strategies for microgrids
- Development of a back-up control to maintain microgrid operation when communication not available.
- Development of a real-time energy management system to enable operation for the microgrid
- Development of analytical and digital computer-based simulation tools

Concluding Remarks:

The concept of microgrid, based on high-depth of penetration of Distributed Energy Resource (DER) units, as a building block for the smart grid is a technically viable option.

The main “technical” challenges in realization and performance evaluation of the concept are actively being addressed.

Realization of the concept required ongoing developments in standards and operational guidelines and reconsiderations in regulatory aspects.