MITSUBISHI ELECTRIC RESEARCH LABORATORIES
Cambridge, Massachusetts

The Latest Development of Smart Grid Standards and Pilot Projects

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For SmartGrids China2010

Outlines

- **Part 1: Smart Grid Standards**
  - US Development Roadmap
  - NIST SGIP
  - IEEE P2030
  - IEEE 1547
  - IEEE 802.15.4g
  - IEC/ITU-T/IETF

- **Part 2: Pilot Projects**
  - Advanced Metering Infrastructure Projects
  - Regional Demonstration Projects
  - The First Smart City Project – Boulder, Colorado
  - National Grid's Smart City Project – Worcester, MA
  - Smarter City – Boston, MA
  - Mitsubishi Electric's Experimental Center
  - Tiered Communication Networks – Oklahoma Gas & Electric

- **Concluding Remarks**

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Smart Grid Standardization in US

NIST
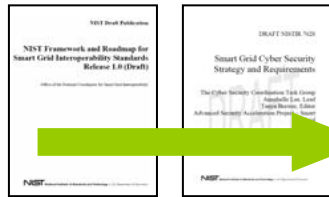
Framework & Roadmap of Interoperability

Cyber Security Strategy & Requirements

......

Federal Energy Regulation Commission (FERC)

Phase 1: Identify an initial set of existing consensus standards and develop a roadmap to fill gaps

Phase 2: Establish public/private Standards Panel to provide ongoing recommendations for new/revised standards

3rd phase: Testing and Certification Framework

Q1 2009	Q2 2009	Q3 2009	Q4 2009	Q1 2010	Q2 2010	Q3 2010	Q4 2010

Standardization Development Organization (SDO)

IEEE · ISA · NFESR · SAE · NEMA Setting Standards for Excellence · IETF · OGC Open Geospatial Consortium, Inc. · dnp Distributed Network Protocol · MultiSpeak 3 · SHARE · IEEE PES Power & Energy Society · IEEE 802 · ITU

IEC · UCA International Users Group · OASIS The Organization for the Advancement of Structured Information Standards · atis · ZigBee Alliance Wireless Control That Simply Works · NASPI · AHAM Association of Home Appliance Manufacturers · NFPA · ANSI · TIA · HomeGrid FORUM

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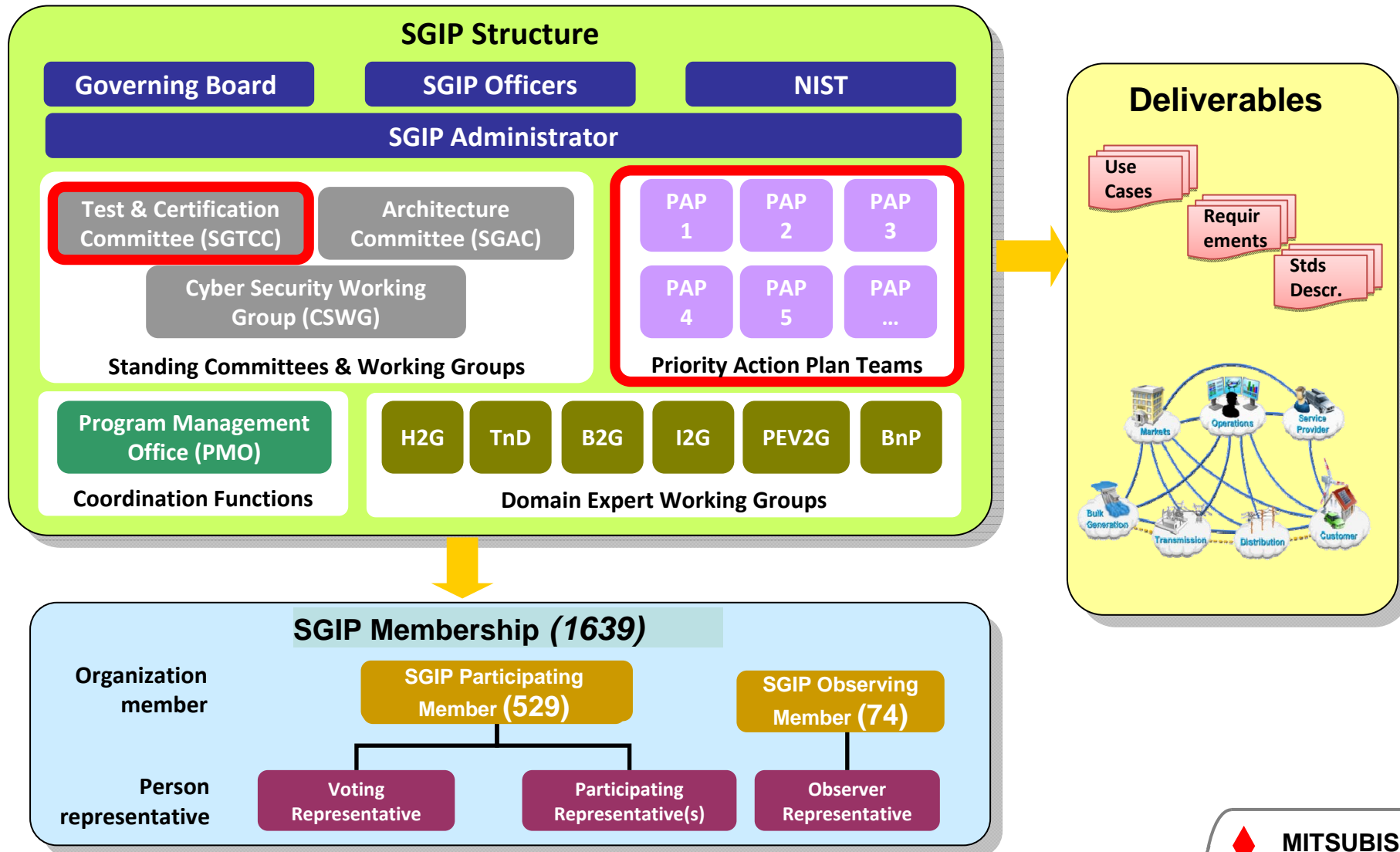*Changes for the better*

Phase 1 Outcomes

- NIST issued first release of framework for smart grid interoperability
    - January 19, 2010: **NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0**
- NIST identified 25 existing smart grid-related standards
- In addition, NIST identified additional 50 standards, specifications, profiles, requirements, guidelines, and reports for further review

1. ANSI/ASHRAE 135-2008/ISO 16484-5 BACnet − A Data Communication Protocol for Building Automation and Control Networks
2. The ANSI C12 Suite
3. ANSI/CEA 709 and CEA 852.1 LON Protocol Suite
4. DNP3
5. IEC 60870-6/TASE.2
6. IEC 61850 Suite
7. IEC 61968/61970 Suites
8. IEEE C37.118
9. IEEE 1547 Suite
10. IEEE 1588
11. Internet Protocol Suite, including but not limited to IETF RFC 2460 (IPv6)
12. Multispeak
13. OpenADR

14. OPC-UA Industrial
15. Open Geospatial Consortium Geography Markup Language
16. ZigBee/HomePlug Smart Energy Profile 2.0
17. OpenHAN
18. AEIC Guidelines v2.0
19. Security Profile for Advanced Metering Infrastructure, v 1.0
20. Department of Homeland Security, National Cyber Security Division, 2009 September Catalog of Control Systems Security Recommendations for Standards Developers
21. Department of Homeland Security Cyber Security Procurement Language for Control Systems
22. IEC 62351 Parts 1-8
23. IEEE 1686-2007
24. NERC CIP 002-009
25. NIST Special Publication (SP) 800-53, NIST SP 800-82

25 Standards Identified by NIST

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NIST Smart Grid Interoperability Panel (SGIP)

SGIP Structure

Governing Board	SGIP Officers	NIST

SGIP Administrator

Test & Certification Committee (SGTCC) | **Architecture Committee (SGAC)**

Cyber Security Working Group (CSWG)

Standing Committees & Working Groups

Priority Action Plan Teams
- PAP 1
- PAP 2
- PAP 3
- PAP 4
- PAP 5
- PAP ...

Program Management Office (PMO)

Coordination Functions

H2G | TnD | B2G | I2G | PEV2G | BnP

Domain Expert Working Groups

Deliverables
- Use Cases
- Requirements
- Stds Descr.

SGIP Membership *(1639)*

Organization member

SGIP Participating Member (529) | SGIP Observing Member (74)

Person representative

Voting Representative | Participating Representative(s) | Observer Representative

H2G: Home to Grid; TnD: Transmission & Distribution; B2G: Building to Grid; I2G: Industry to Grid; PEV2G: Plug-in EV to Grid; BnP: Business & Policy
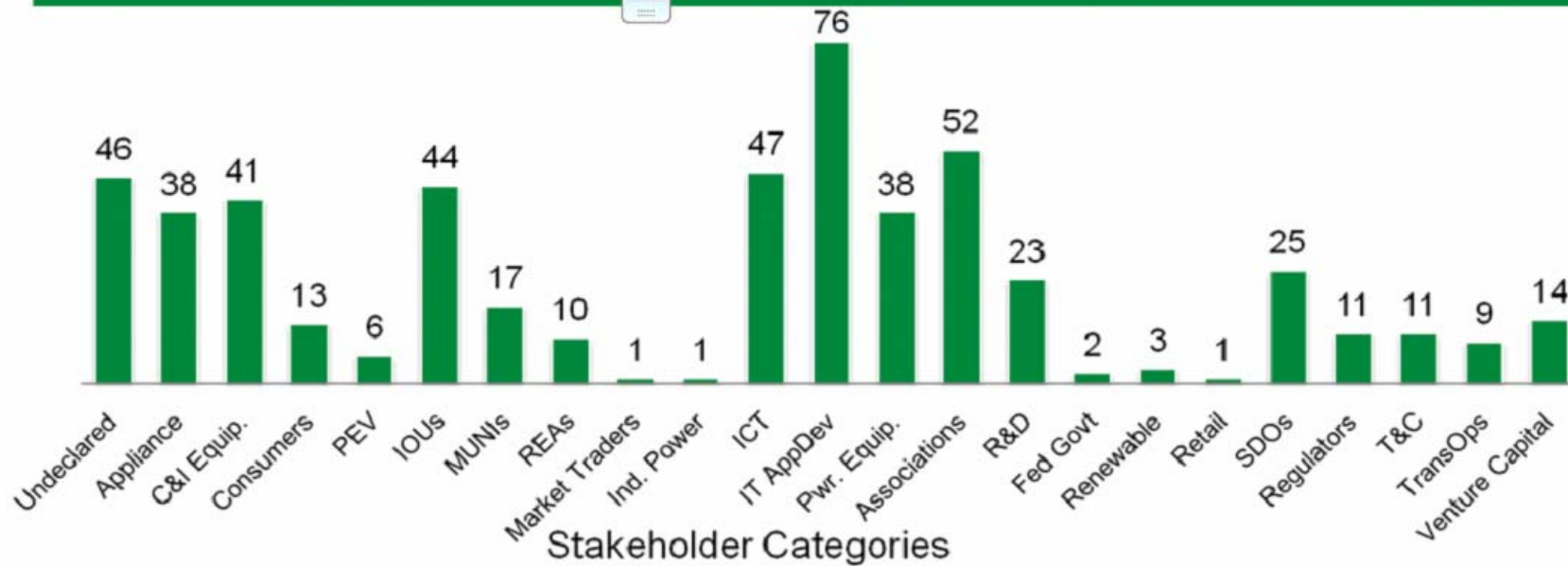
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SGIP Member Distribution – As of July 2010

- **Total # of Member Organizations: 603**
  - # of Participating Member Organizations: 529
  - # of Observing Member Organizations: 74
  - # of Organizations who joined in June: 19

# of Organizations by Country
- USA: 547
- Canada: 26
- International: 30

- **Total # of Individual Members*: 1,639** ** Omits Signatory Authorities who aren't also*

# of Participating Member Organizations by Declared Stakeholder Category

Stakeholder Category	Value
Undeclared	46
Appliance	38
C&I Equip.	41
Consumers	13
PEV	6
IOUs	44
MUNIs	17
REAs	10
Market Traders	1
Ind. Power	1
ICT	47
IT AppDev	76
Pwr. Equip.	38
Associations	52
R&D	23
Fed Govt	2
Renewable	3
Retail	1
SDOs	25
Regulators	11
T&C	11
TransOps	9
Venture Capital	14

Stakeholder Categories

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NIST Smart Grid Priority Action Plans (PAPs)

PAP-1

Core set of IP protocols identified. Need to develop guidelines on the use of IPv4 versus IPv6. The scope is too large. It will have a F2F on July 22. The networking profiles will define functions such as addressing and integration of concepts such as multi-homing.

PAP-2

Very important. Existing standards will not be sufficient to fill all the gaps. New standards will need to be developed. We shall be very active in this PAP. We must urgently study communication systems characteristics released in the matrix file.

PAP-10

June 2010 PR: NAESB has agreed to develop a basic energy usage data model standard by the end of 2010, which defines the information used to communicate between utilities and the consumer.

PAP-13

Addresses requirements for time synchronizing smart grid equipment and devices. Needs contracted help to move things forward. It is having resource issues. Last two conference calls were cancelled.

PAP-8

IEC TC57 WG14 needs additional experts and time from experts to update the CIM to meet the requirements described in the PAP 8 use cases.

PAP-9

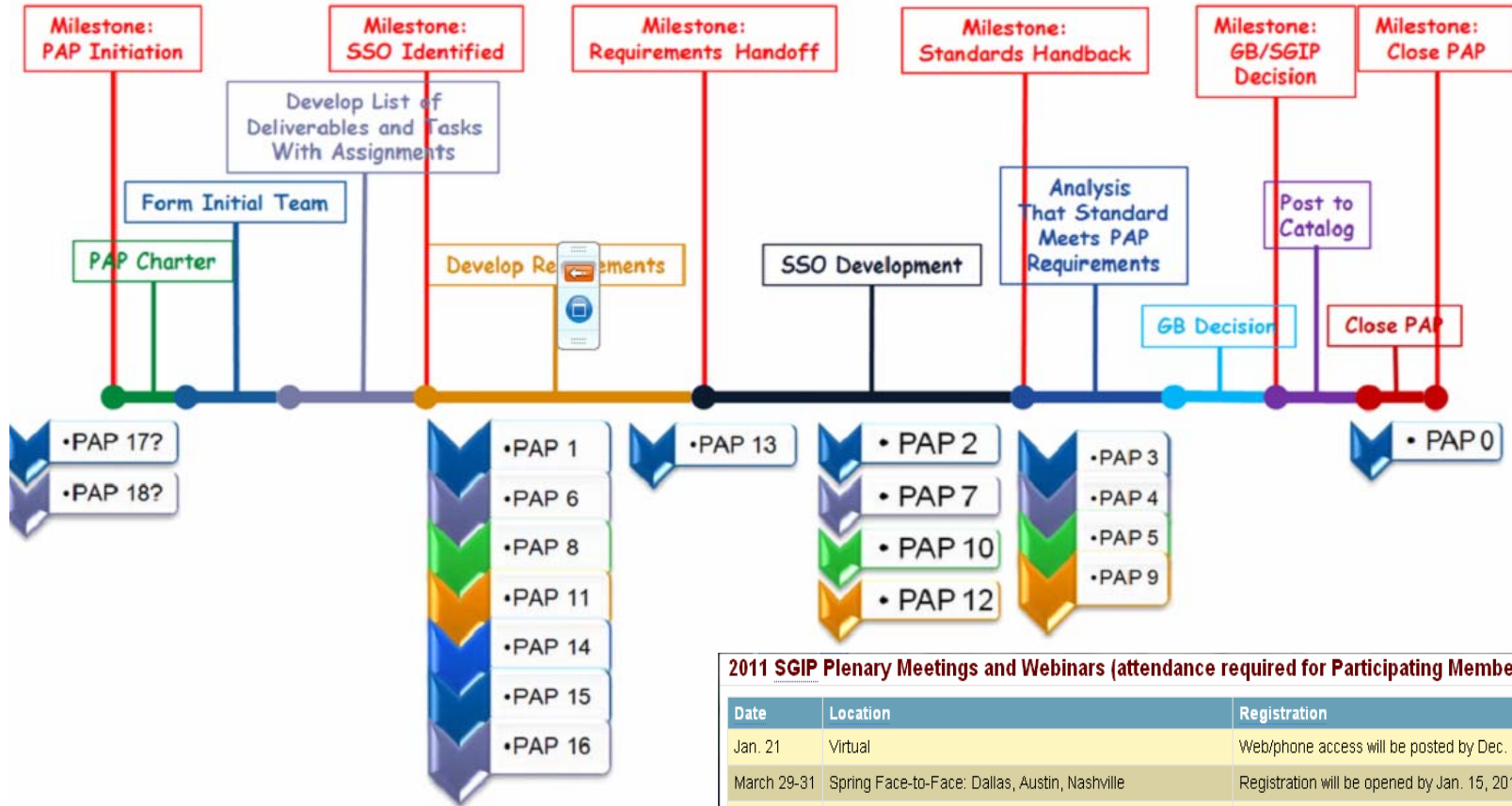Aims to specify a process for developing a common semantic model for standard DR signals. Its completion depends on completion of PAP 3 and PAP4. It needs to integrate PAP 7 requirements.

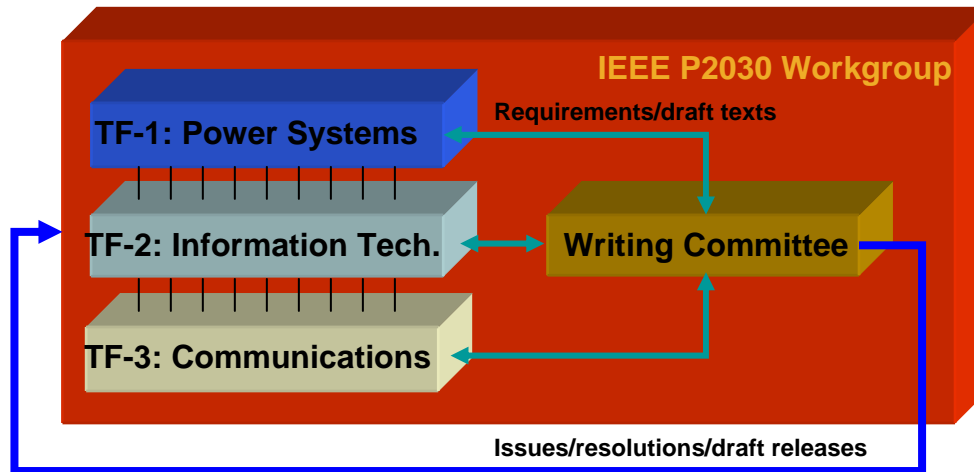| #	Area of Interest	Priority Action Plan
0	Smart Meter	Meter Upgradeability Standard
5		Standard Meter Data Profiles
6		Common Semantic Model for Meter Data Tables
2	AMI, WASA, Distribution system	Wireless Communications for the Smart Grid
8		CIM for Distribution Grid Management
12		IEC 61850 Objects/DNP3 Mapping
7	EV, PV, Battery control	Electric Storage Interconnection Guidelines
11		Common Object Models for Electric Transportation
9	BEMS and Home appliances	Standard DR and DER Signals
10		Standard Energy Usage Information
15		Harmonize Power Line Carrier Standards for Appliance Communications in the Home
13	Interested, but business unidentified	Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization
14		Transmission and Distribution Power Systems Model Mapping
1	General	Role of IP in the Smart Grid
3	Demand response	Common Price Communication Model
4	Demand response	Common Scheduling Mechanism
16	Wind Power	Wind Plant Communications
17		Facility Smart Grid Information Standard

PR: press release

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PAP Development Timeline

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IEEE P2030 – Objectives & Timeline

- Consists of three task forces, writing committee and WG.

IEEE P2030 Workgroup

TF-1: Power Systems

TF-2: Information Tech.

TF-3: Communications

Writing Committee

Requirements/draft texts

Issues/resolutions/draft releases

GOAL

To provide guidelines for interoperability of 3 systems in each of 7 smart grid domains

Each task force produces a reference architecture for entire smart grid infrastructure

Companies like PGN, a fortune 500 utility company with 22GW generation capacity is adopting P2030 reference communications architecture in its grid networks.

IEEE P2030 Roadmap
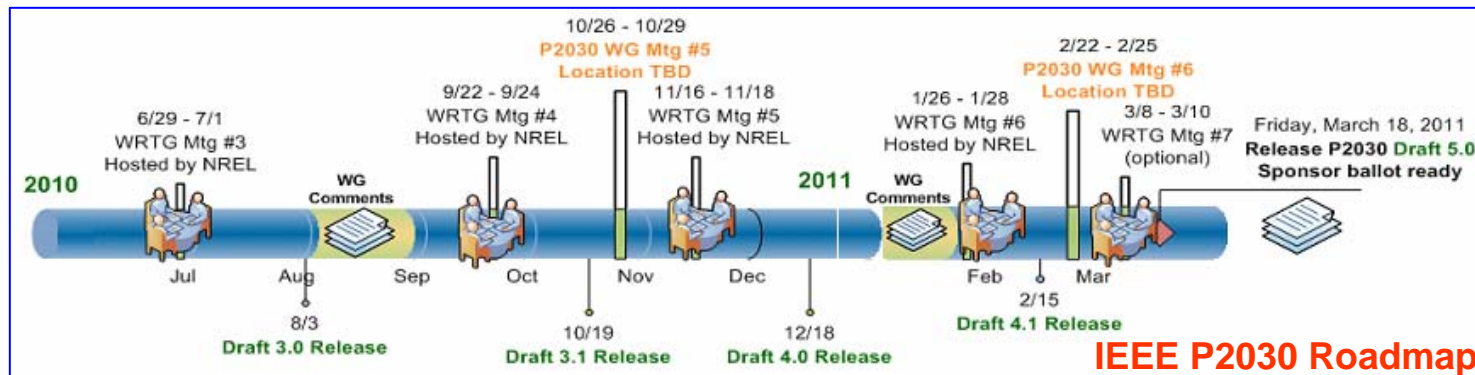
WG: Working Group; WRTG: Writing Task Group; NREL: National Renewable Energy Laboratory

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IEEE P2030 – Updated Architecture & Status
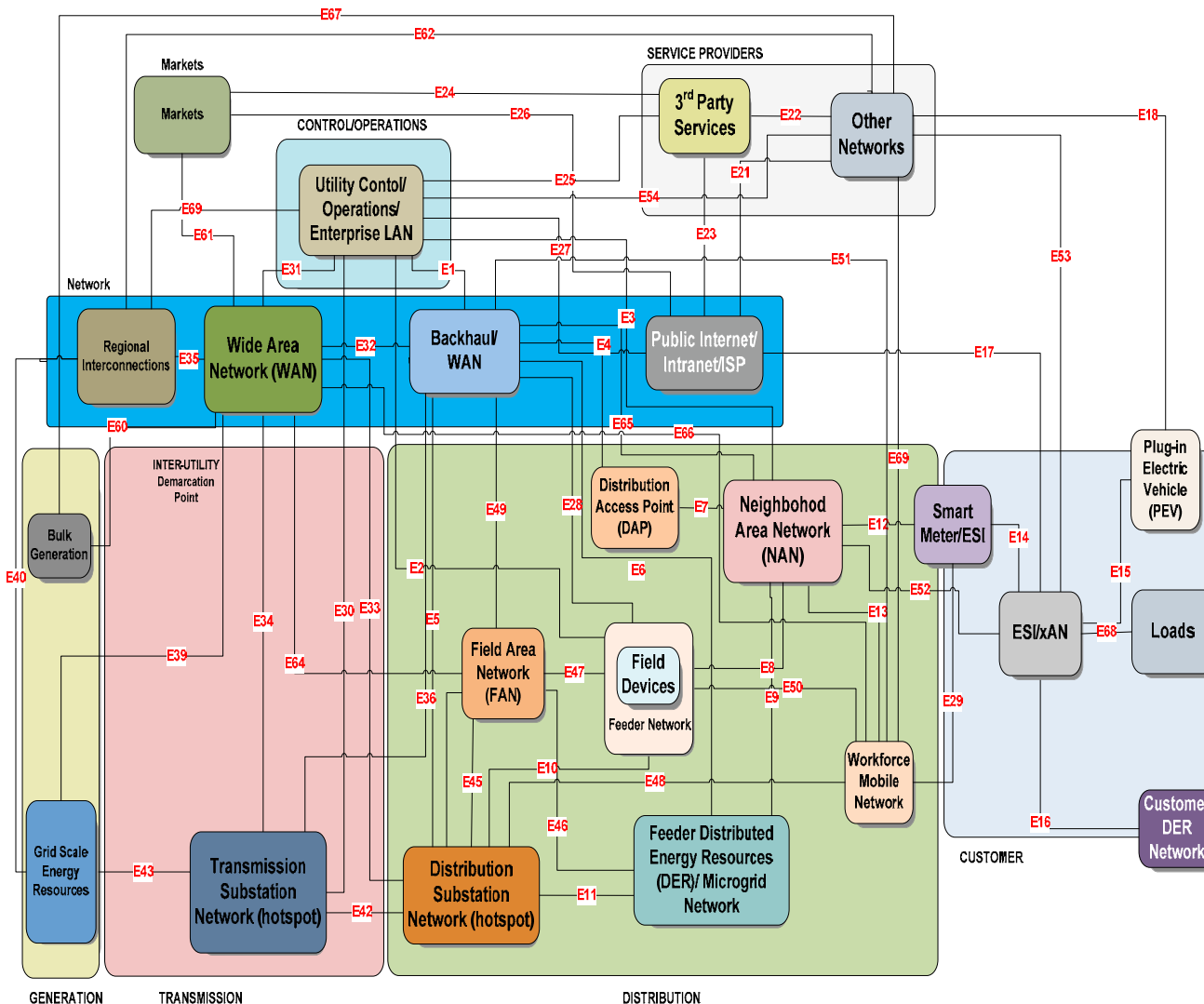
- Total 196 comments for IEEE P2030 Draft 3.0.
- The writing committee responded to all the comments in September 2010.
- There is still some text missing for clauses on
  - Communications technology interoperability
  - Privacy
  - Technology aspects
  - Regulatory aspects
- Draft version 4.0 will be released for comments in late December 2010

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IEEE 1547 – Standard Development

- **Objectives**

  – Specifies standards for Interconnecting Distributed Resources with Electric Power Systems

  – Provides a uniform criteria and requirements relevant to the performance, operation, testing, safety considerations and maintenance of the grid connection of DR.

  – Focuses on 60 Hz systems

- **Focus**
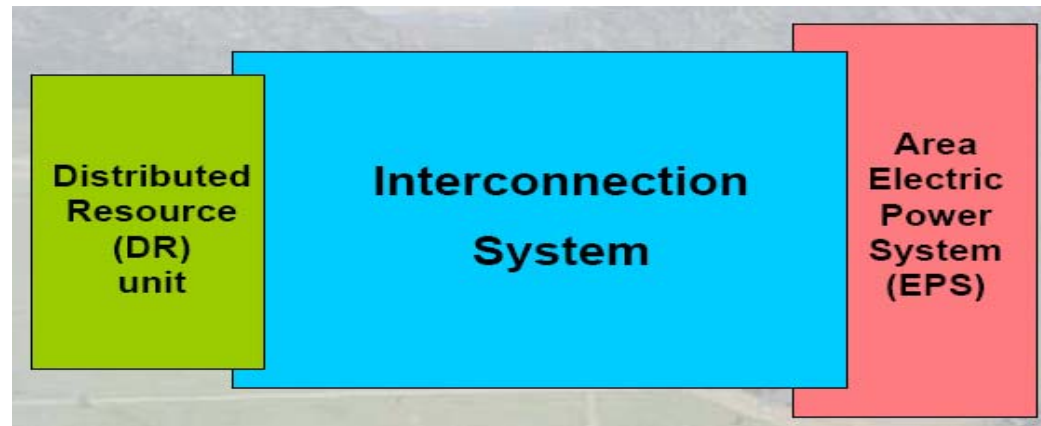
- **Status**

  – 4 standards completed: IEEE Std 1547 (2003), IEEE Std 1547.1 (2005), IEEE Std 1547.3 (2007), IEEE Std 1547.2 (Application Guide, 2008)

  – 4 standards under development: IEEE P1547.4, IEEE P1547.5, IEEE P1547.6, IEEE P1547.7

  – A new one: IEEE P1547.8 (Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547): started in August 2010

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IEEE 1547 – Status of Adoption

State Implementation of Interconnection American National Standard *IEEE 1547*

Legend:
- Implemented
- Not Adopted

States supported 2007 - 2008:
DC, DE, FL, MD, IL, NM, NY, OR, SD and UT
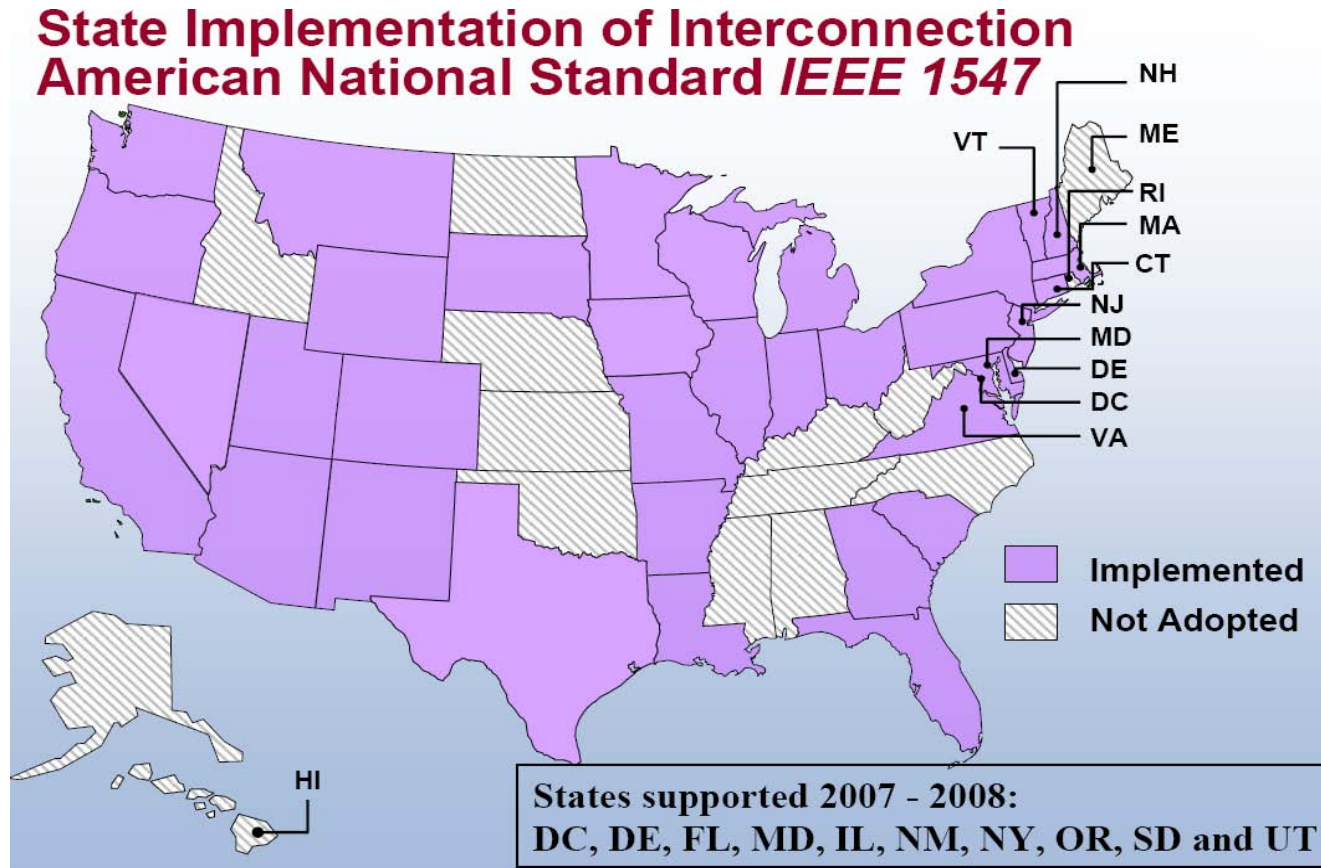
• According to IEEE 1547.8 chair, 1547 has been used/tracked by other countries interested stakeholders

• The IEC-IEEE are currently pursuing an IEC Publicly Available Specification based on IEEE 1547

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IEEE 802.15.4g – Smart Utility Networks

- One of the first effort to address the smart grid's need

- A PHY amendment to 802.15.4 to facilitate very large scale process control applications such as the utility smart-grid network capable of supporting large, geographically diverse networks with minimal infrastructure, with potentially millions of fixed endpoints
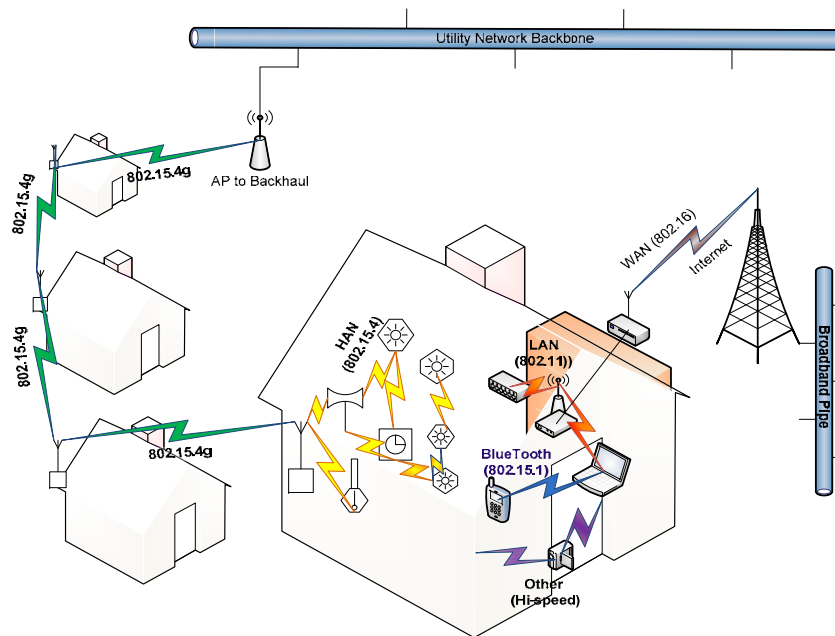
- Current Status
  - The working group is planning to have a letter ballot between September and November, 2010
  - They plan to seek conditional approval for RevCom in July 2011.

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IEC/SG3 and TC8 Smart Grid Activities

IEC

| IEC/SMB/SG3 (Smart Grid) | 2010/06 | 2010/08 | 2010/10 | 2010/12 |

Review of roadmap (completed)

7/2 Workshop @Paris

SG3 and related 25 TC/SCs

Now

Report in Oct.

Reference Architecture Task Team (RATT)
(Germany, Switzerland, Sweden, US, France)
To collect and analyze use cases,
To develop general reference architecture of smart grid

10/13-14 SG3 meeting @Seattle

Use Case Task Team
(Italy, France, Germany, Japan)
To collect use cases from related IEC TCs and NIST

Report to RATT on June 1

10/11-15 IEC GA @Seattle

2011/ 10/24-28 TC8 meeting in Australia

IEC/TC8 (Systems aspects for electrical energy supply)

Call for AHG4 members (5/14-7/9)

Not started as of Oct. 15

Start AHG4 activity
Set up task forces if necessary
to create use cases by categories

IEC: International Electrotechnical Commission; SG: Strategy Group; TC: Technical Committee; AHG: Ad-Hoc Group

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ITU-T: Focus Group on Smart Grid (FG Smart)

WTSA — TSAG ←——— report ——— **FG Smart** ⟷ Other SDOs, Forum, etc.

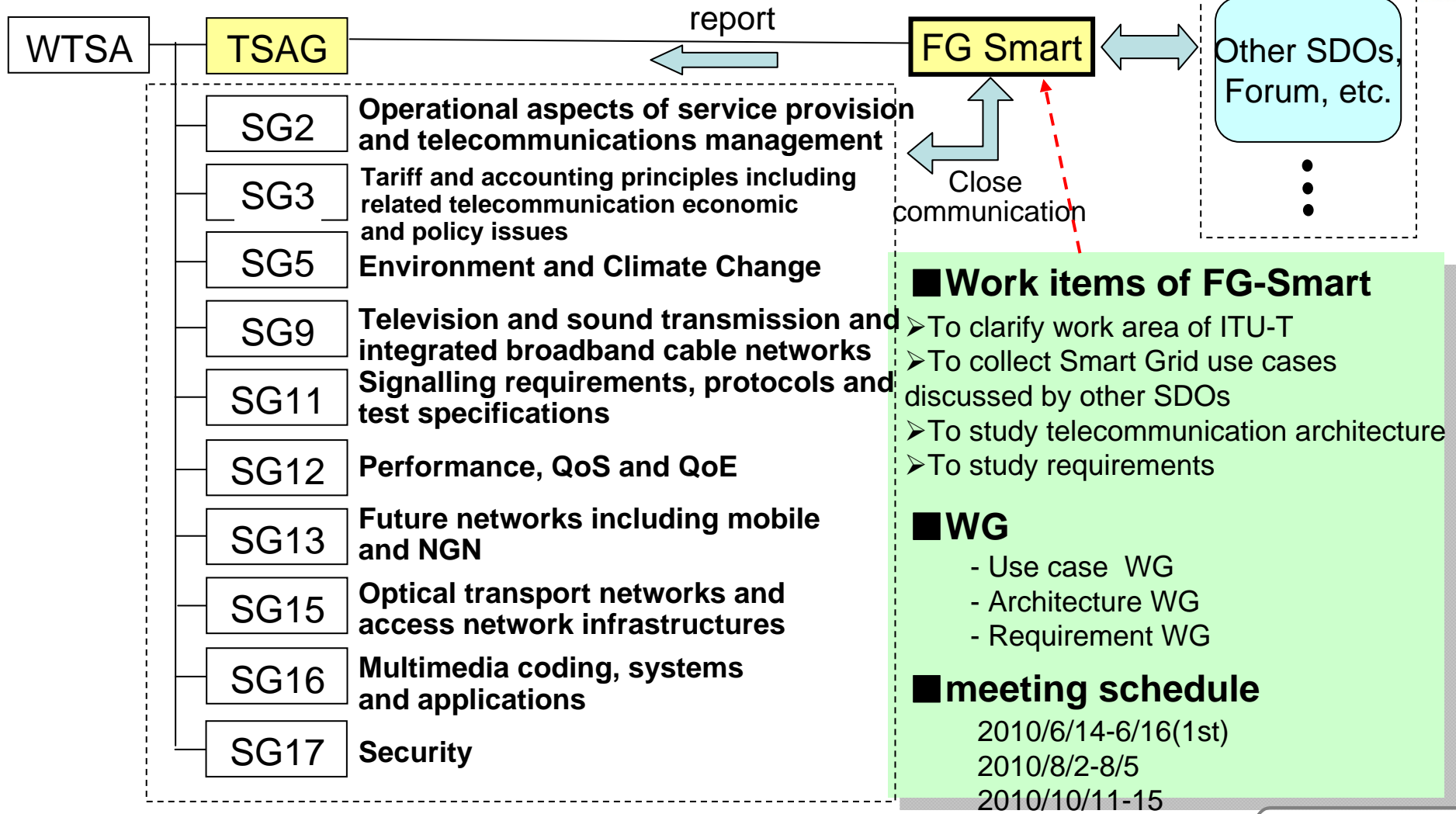|	
SG2	**Operational aspects of service provision and telecommunications management**
SG3	**Tariff and accounting principles including related telecommunication economic and policy issues**
SG5	**Environment and Climate Change**
SG9	**Television and sound transmission and integrated broadband cable networks**
SG11	**Signalling requirements, protocols and test specifications**
SG12	**Performance, QoS and QoE**
SG13	**Future networks including mobile and NGN**
SG15	**Optical transport networks and access network infrastructures**
SG16	**Multimedia coding, systems and applications**
SG17	**Security**

Close communication

■**Work items of FG-Smart**
➤To clarify work area of ITU-T
➤To collect Smart Grid use cases discussed by other SDOs
➤To study telecommunication architecture
➤To study requirements

■**WG**
- Use case WG
- Architecture WG
- Requirement WG

■**meeting schedule**
2010/6/14-6/16(1st)
2010/8/2-8/5
2010/10/11-15

WTSA: World Telecommunication Standardization Assembly,
TSAG: Telecommunication Standardization Advisory Group, SG: Study Group,

15

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IETF Development Status

```
          ISOC
I E T F
           IAB

  IETF     IRTF     ICANN

  IESG     IRSG

  ─ Applications area

        └─ WG

  ─ Internet  area

        └─ 6LoWPAN WG

  ─ Routing area

        ├─ MANET WG
        └─ ROLL WG
```

◆6LoWPAN (IPv6 over Low power WPAN) WG

Internet protocol suite to use IPv6 on low power and lossy network such as IEEE 802.15.4

→ necessary to introduce IPv6 into networking among smart meters

◆ROLL (Routing Over Low power and Lossy networks) WG

Routing protocol for low power and lossy network in factory, home, buildings, and town

ISOC: Internet Society
IAB: Internet Architecture Board
IETF: Internet Engineering Task Force
IESG: Internet Engineering Steering Group
IRTF: Internet Research Task Force
IRSG: Internet Research Steering Group
ICANN: Internet Corporation for Assigned Names and Numbers

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Advanced Metering Infrastructure Projects in US
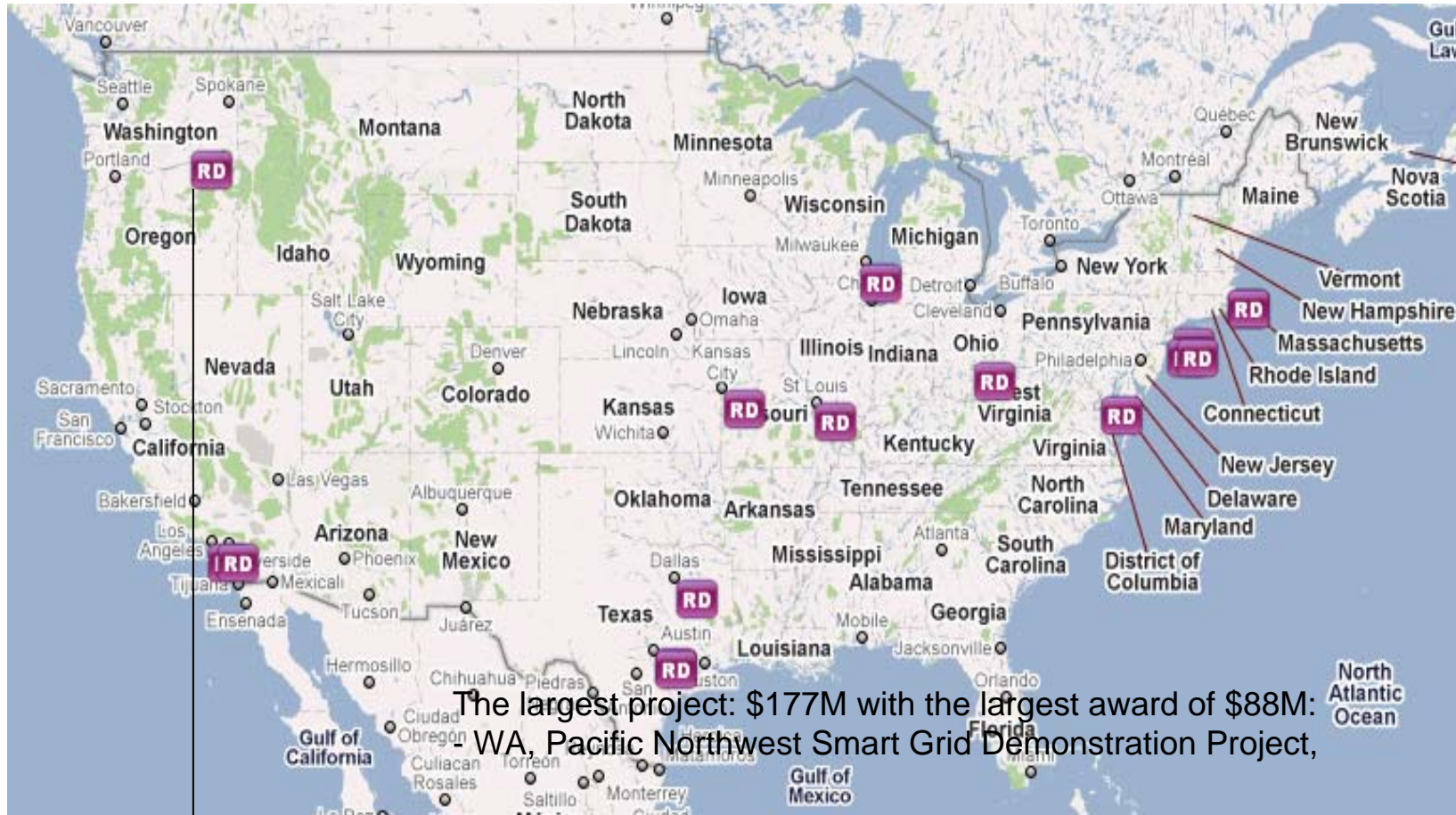

Total Recovery Act Funding Awarded: >$1.3B
Total Project Value: >$3.6B
The largest single award: $200M (CenterPoint Energy, Baltimore Gas and Electric Company, Duke Energy)
The largest project: $1B (Duke)

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Regional Demonstration Projects in US

The largest project: $177M with the largest award of $88M:
- WA, Pacific Northwest Smart Grid Demonstration Project,

This is the largest project of $177M with $88M Recovery Act Funding - spanning 5 states, affecting 60,000 consumers, demonstrate and validate new technologies, provide two-way communication between distributed generation, storage, assets and the existing grid infrastructure, …

Total Recovery Act Funding Awarded: >$435M
Total Project Value: >$877M

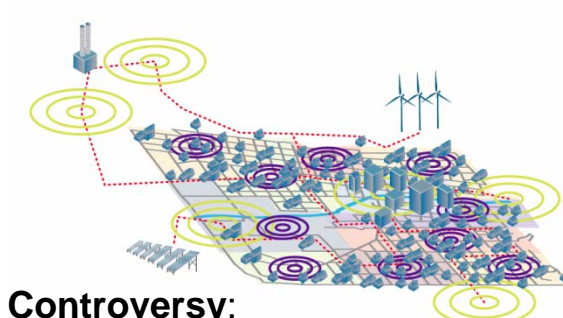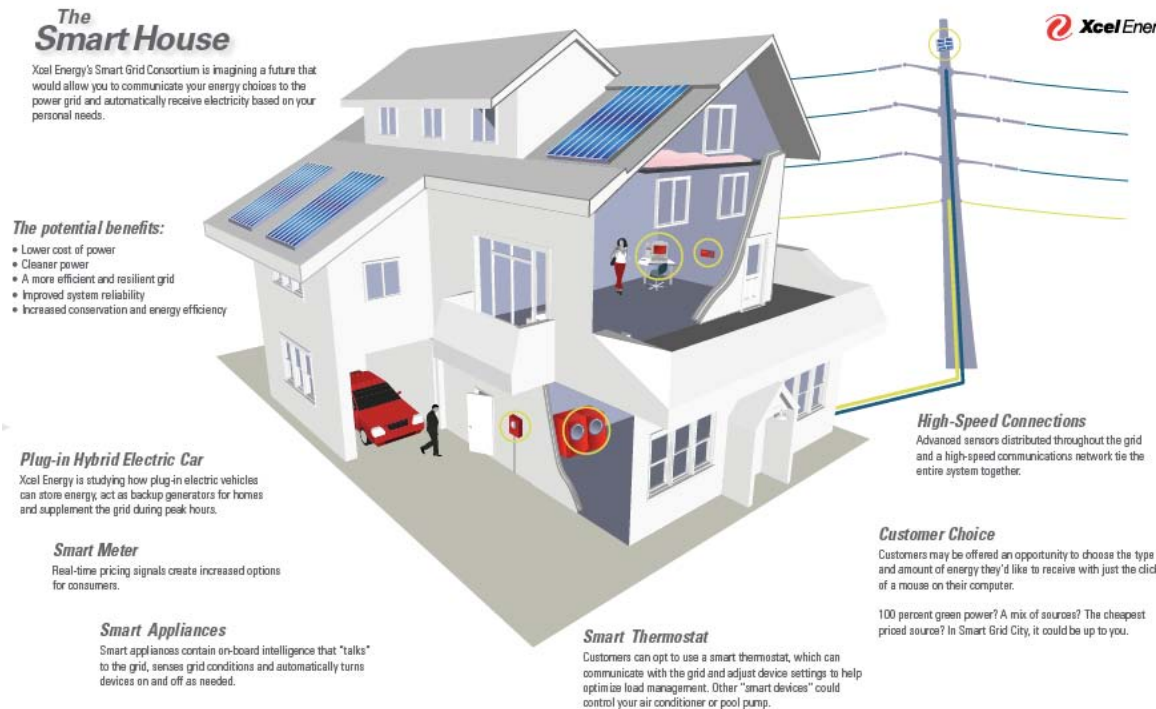**MITSUBISHI ELECTRIC**
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The First Smart City – Boulder, Colorado

- First functioning smart grid project in the world – led by Xcel Energy
- Integration of wind/solar power generation and electric vehicles
- Currently 24,000 homes are connected to smart meters
- Variable pricing and demand response will be tested
- Project Capital Cost *: $15M (Original Estimate) ➔ $45M (Current Estimate)

  * >$100M including operational and maintenance cost

SMARTGRIDCITY™

The Smart House

Xcel Energy's Smart Grid Consortium is imagining a future that would allow you to communicate your energy choices to the power grid and automatically receive electricity based on your personal needs.

The potential benefits:
- Lower cost of power
- Cleaner power
- A more efficient and resilient grid
- Improved system reliability
- Increased conservation and energy efficiency

Plug-in Hybrid Electric Car
Xcel Energy is studying how plug-in electric vehicles can store energy, act as backup generators for homes and supplement the grid during peak hours.

Smart Meter
Real-time pricing signals create increased options for consumers.

Smart Appliances
Smart appliances contain on-board intelligence that "talks" to the grid, senses grid conditions and automatically turns devices on and off as needed.

High-Speed Connections
Advanced sensors distributed throughout the grid and a high-speed communications network tie the entire system together.

Customer Choice
Customers may be offered an opportunity to choose the type and amount of energy they'd like to receive with just the click of a mouse on their computer.

100 percent green power? A mix of sources? The cheapest priced source? In Smart Grid City, it could be up to you.

Smart Thermostat
Customers can opt to use a smart thermostat, which can communicate with the grid and adjust device settings to help optimize load management. Other "smart devices" could control your air conditioner or pool pump.

Controversy:
- Xcel's performance has generated a lot of heat and criticism because of extreme cost overruns. Other have criticized the company for not delivering everything it promised.
- Hearings began in August on Xcel's SmartGridCity Cost Recovery

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National Grid's Smart Grid City - Worcester, MA

- Aggressive Plan: $57M (not funded by government; 15,000 customers will be involved)

America's Energy Future: A Smart Grid City

Plug-in Hybrid Vehicles (PHEV)
- Store energy in their batteries. When connected to the grid, they can provide power back to the grid during times of peak demand

Advanced Communications
- Including communication equipments and sensors on the grid, enable utilities to monitor, identify and quickly correct problems

Renewable Energy Sources
- Wind turbines and solar panels are integrated to the smart distribution grid

Smart Homes
- Tracks usage information through smart meters.
- Customer will have a variety of ways to learn and take the most cost-effective energy usage option

National Grid Smart Grid Pilot Proposal
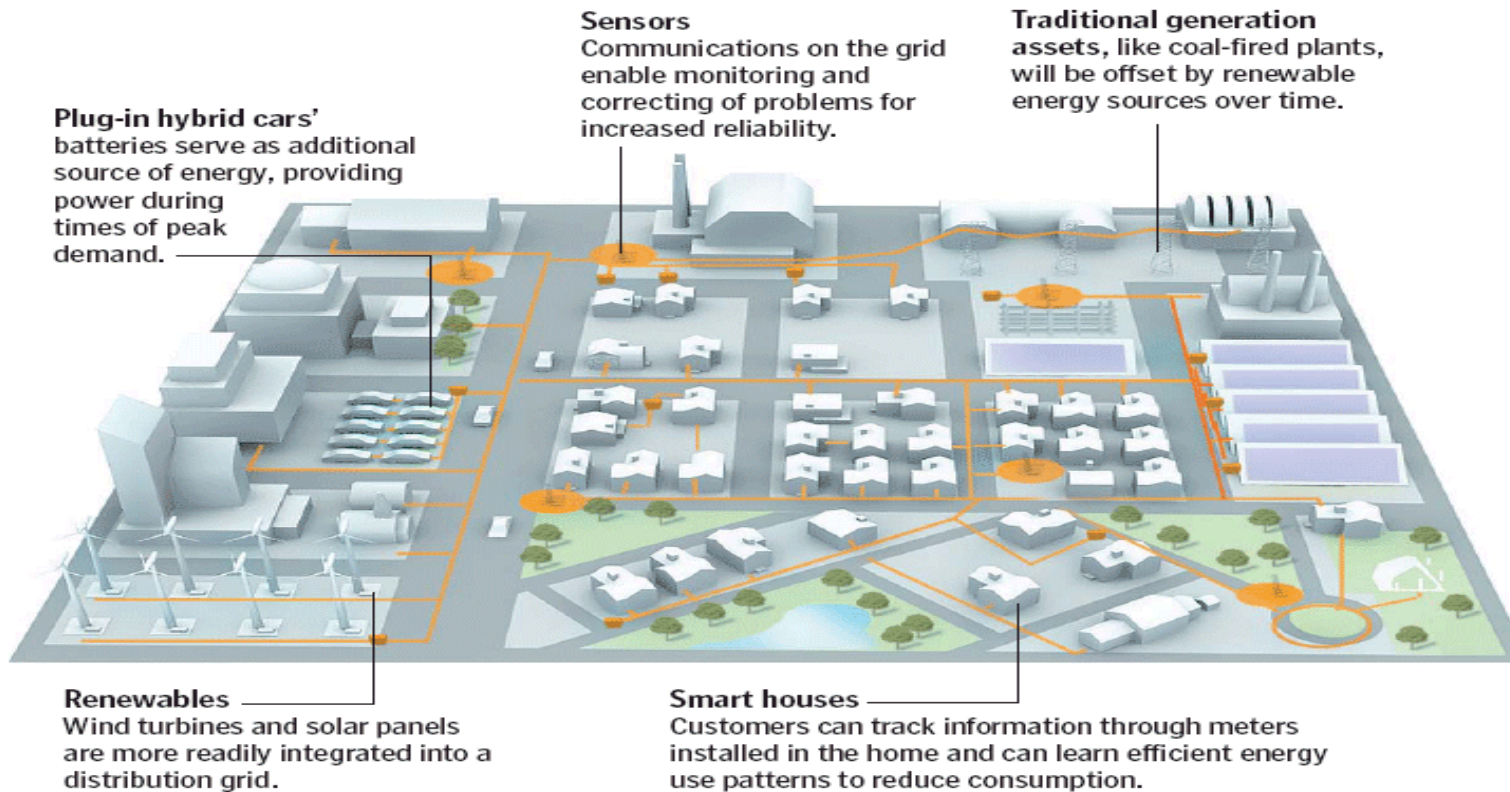Worcester, Massachusetts

Status
- Last October, National Grid announced the plan
- In this July, they are requested by MA DPU to provide additional information for approval
- It is expected to be approved this fall

nationalgrid
The power of action.

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Smarter City - Boston, MA

Plug-in hybrid cars' batteries serve as additional source of energy, providing power during times of peak demand.

Sensors
Communications on the grid enable monitoring and correcting of problems for increased reliability.

Traditional generation assets, like coal-fired plants, will be offset by renewable energy sources over time.

Renewables
Wind turbines and solar panels are more readily integrated into a distribution grid.

Smart houses
Customers can track information through meters installed in the home and can learn efficient energy use patterns to reduce consumption.

SOURCE: National Grid

JAVIER ZARRACINA/GLOBE STAFF

- **Boston has been named a 2010 Smarter City for Energy** (July 2010 update)
  – Boston has taken some major initiatives to make wind energy a viable alternative, and wind now ranks as one of the city's top three fuel sources for electricity.
  – Renewable energy is 11.7% of total and growing.
  – By 2015, Boston's solar power will be 25MW from current 0.5MW.

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Mitsubishi Electric Smart Grid Experimental Center

- Objective
  - Support the adoption of sustainable power supplies worldwide

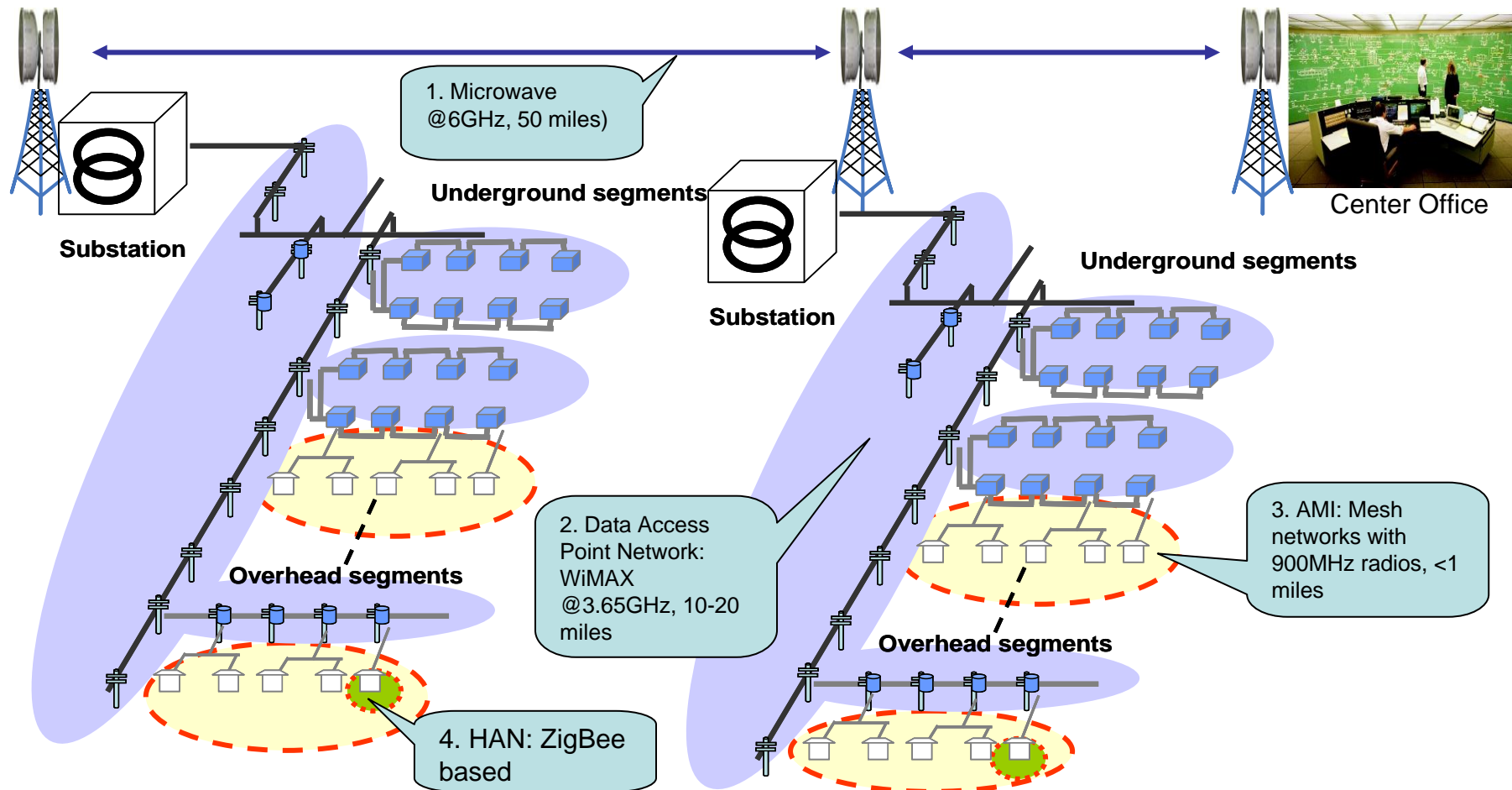**MITSUBISHI ELECTRIC**

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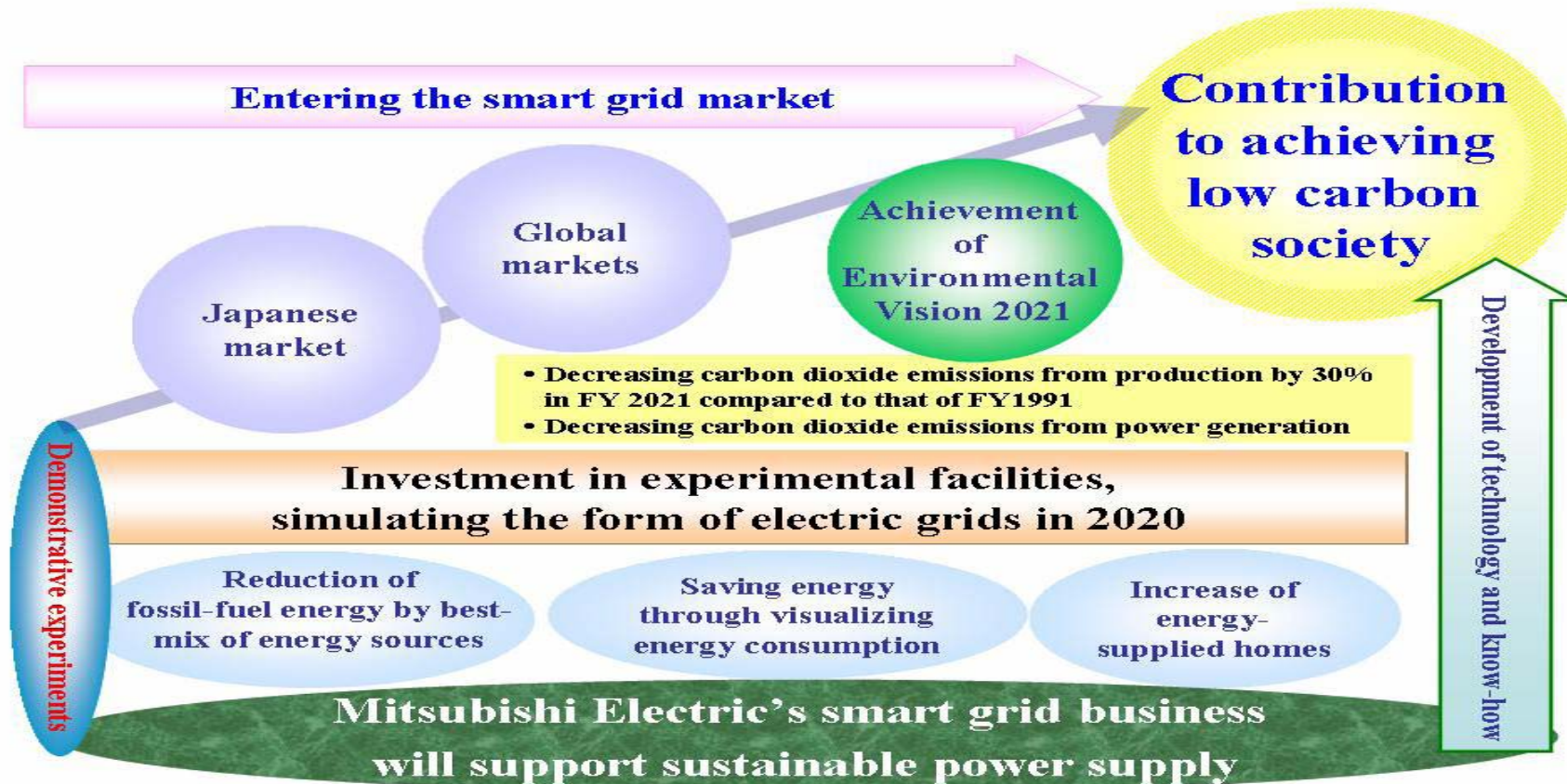
Mitsubishi Electric Smart Grid Experimental Center
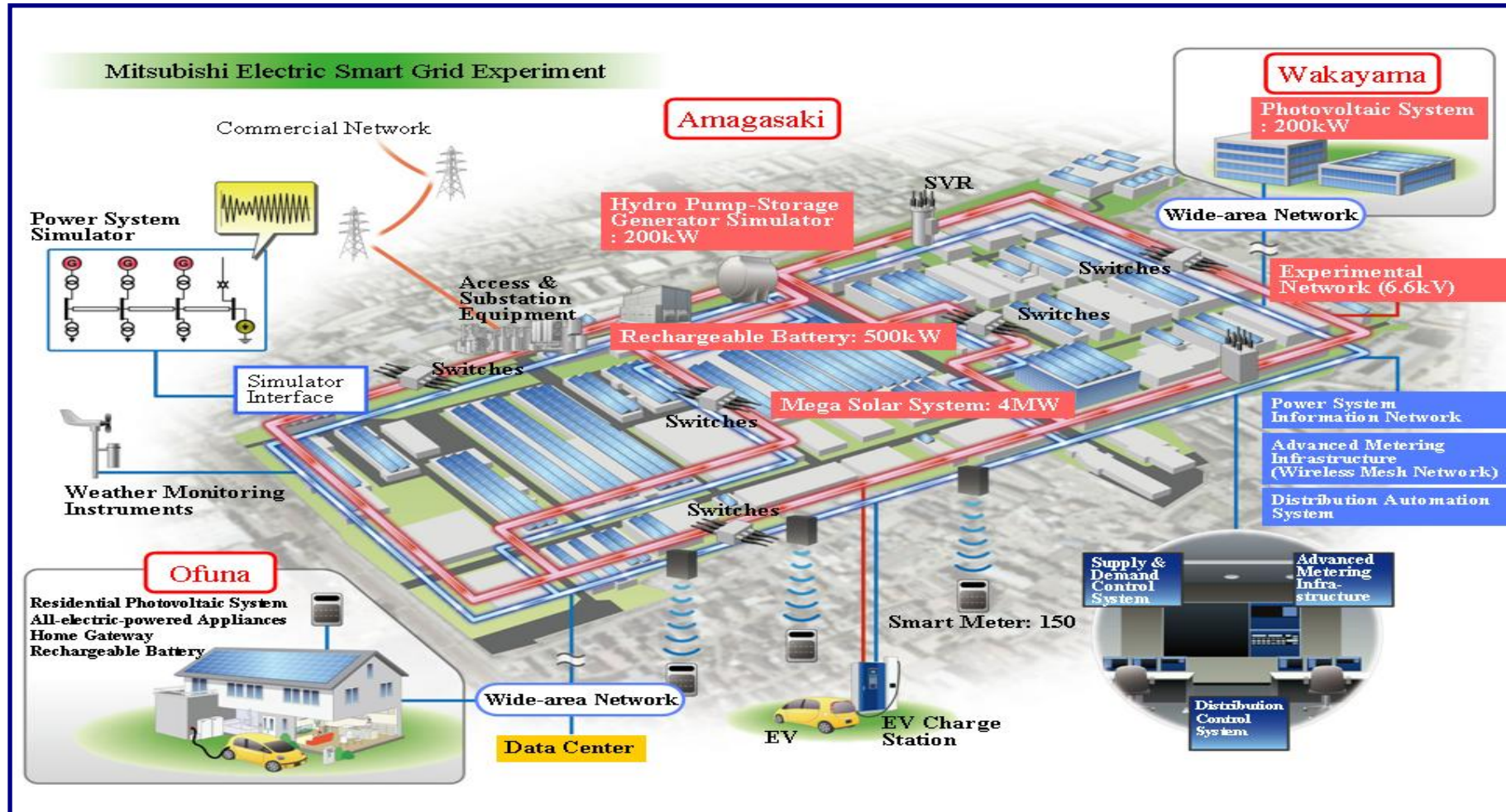
- **Development Plan**
  - 7 billion yen (US$ 80 million) Investment（2010～2011）
  - Build in three production sites to allow all-round experiments

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Tiered Communication Networks – Oklahoma G&E

1. Microwave @6GHz, 50 miles)

Underground segments

Substation

Underground segments

Substation

3. AMI: Mesh networks with 900MHz radios, <1 miles

2. Data Access Point Network: WiMAX @3.65GHz, 10-20 miles

Overhead segments

Overhead segments

4. HAN: ZigBee based

Center Office

- **Development Status**
  - $366M Investment with $130M from federal stimulus（2010～2012）
  - OG&E has more than 779,000 customers, 42,000 smart meters have been installed
  - Focus on 1) AMI and wireless technology; 2) Distribution automation

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Concluding Remarks

- SGIP plays a key role in smart grid evolution
  - ✓ Its recommendations are likely to become regulations
- IEEE P2030 produces a new guidelines on interoperability
  - ✓ It is on track for March 2011 Sponsor Ballot
- Various new standardization activities are happening
  - ✓ IEEE 1547 series, IEEE 802.15.4g, IEC/SG3/TC8, ITU-T/FG Smart, IETF/6LoWPAN/ROLL
- Tremendous development efforts are happening
  - ✓ Large number of AMI and regional demonstration projects
  - ✓ Many smart city, smart home, and smart grid experimental systems
- However, it is at the early stage
  - ✓ There are many challenges and obstacles
  - ✓ It will be a continuing evolution

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