RE Grid Integration: Thailand's Perspective

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- ***Thailand Electric Power Development Plan***
- ***RE for Electric Power***
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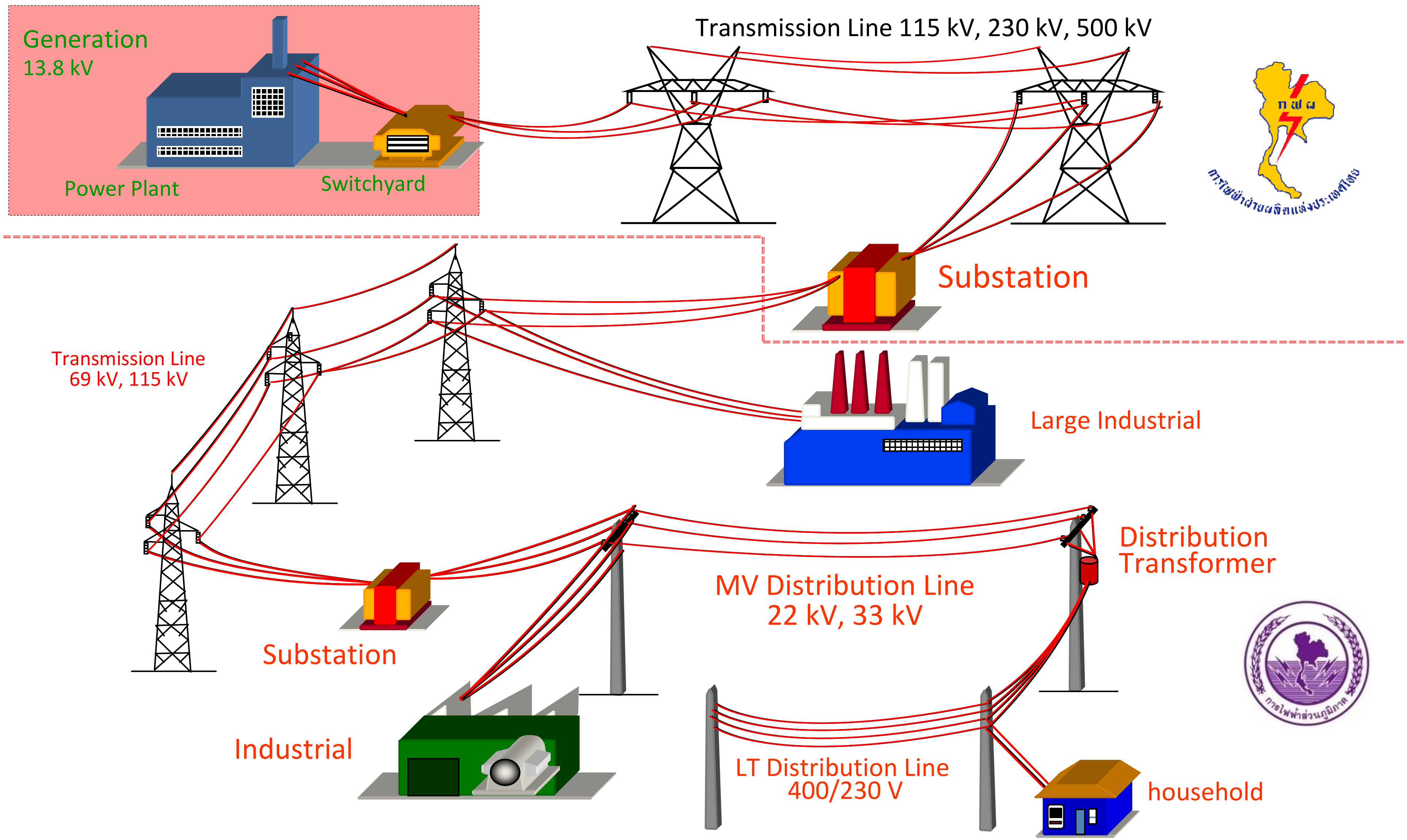
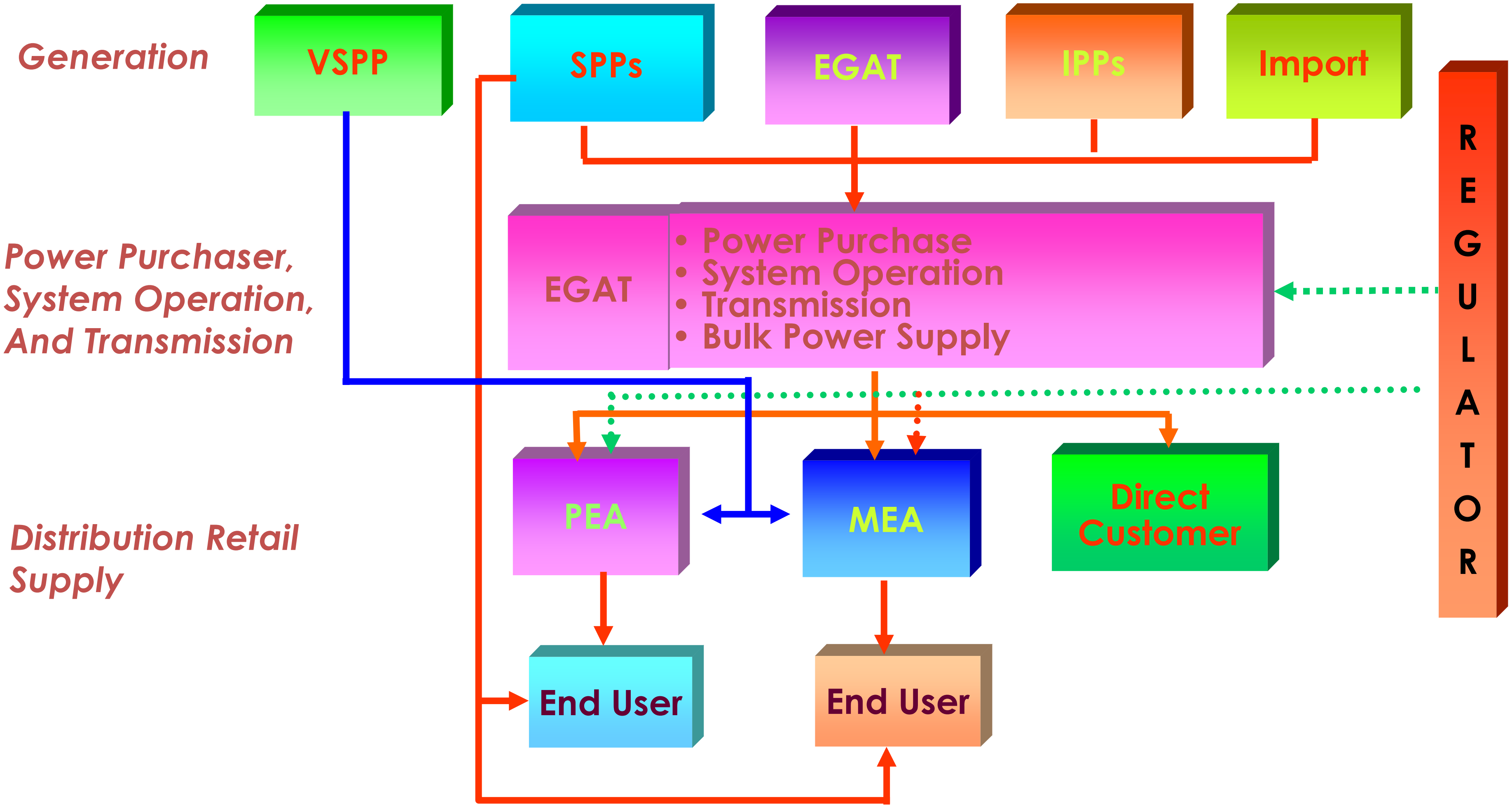
- ***Conclusions***

Thailand Generation Transmission and Distribution Power System



Thailand Electricity Supply Industry Structure



Thailand Electric Power Development Plan 2010-2030: PDP 2010 (1)

- *Projects during 2010-2020*

1. EGAT owned power plants	*4,821*	*MW*
2. IPP	*4,400*	
3. SPP	*3,539*	
4. VSPP	*2,335*	
5. New Combine Cycle PP (LPG)	*800*	
6. Purchase from neighbors	*5,699*	

Thailand Electric Power Development Plan 2010-2030: PDP 2010 (2)

- *Projects during 2021-2030*

1.	*NEW EGAT owned power plants (RE)*	*97 MW*
2.	*(NG)*	*13 X 800*
3.	*(CC)*	*8 X 800*
4.	*(Nuclear)*	*4 X 1000*
5.	*Purchase from SPP*	*3,800*
6.	*Purchase from VSPP*	*1,745*
7.	*Purchase from neighbors*	*6,000*

PDP 2010 Total Capacity

- *Total Installed Capacity 2009 29,212 MW*
- *Total Added Capacity 2010-2030 54,005*
- *Total Retired Capacity 2010-2030 (17,671)*
- *Grand Total Capacity (end 2030) 65,547*
- *Minimum Reserve Margin (%) 15.0*
- *Assumption in the Formulation of PDP 2010*

1. *System Reliability*
2. *Clean Energy and Efficient Utilization*
3. *Load Forecast*

RE for Electric Power

Unit : MW

Type	Biomass	Biogas	Solar	MS W	Wind	Small Hydro	Total
E.2009	663.04	49.04	9.23	10.82	3.07	18.33	753.52 (2.6%)
E.2022	2272.04	152.04	707.23	159.32	1231.07	281.33	4803.02
E.2030	3023.04	176.04	1107.23	183.32	1321.07	281.33	6101.02 (9.3%)

Power Generation Sector released 0.546 Kg of CO_2 /Kwh in 2009, goal of PDP 2010 is to have lower emission rate at 0.368 Kg of CO_2 /Kwh in 2030

Status of Thailand Cogeneration and Renewable Energy

Status of VSPP & SPP in Thailand (As of June 2009)

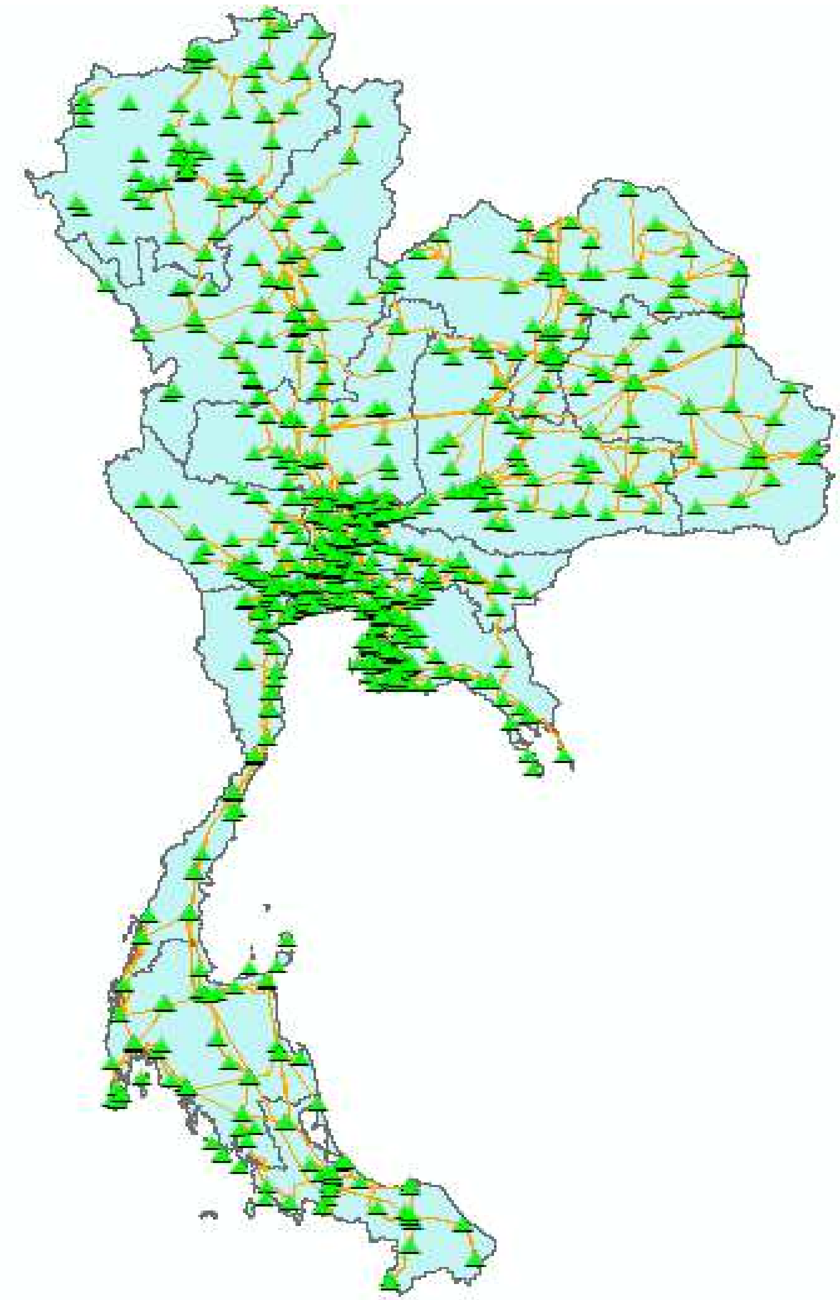
Fuel Type	Implement			Existing	Total
	Submitted	Approved	Contacted		
Biomass	933.78	759.40	530.45	583.89	2,807.52
Biogas	70.11	43.75	67.91	23.09	204.86
Wastes	120.10	91.45	70.86	5.1	287.51
Wind	1,242.79	85.80	1.50	0.33	1,330.44
Hydro					
• <50 kW	-	-	0.03	0.16	0.19
• 50-200 kW	-	-	0.18	0.25	0.43
• > 200 kW	-	5.04	1.07	13.59	19.70
Solar	819.57	356.56	998.54	9.44	
Total	3,186.35	1,342.00	1,670.54	635.85	6,834.74

Adder Rate for SPPs ad VSPPs Using RE

Energy Source	Countrywide Except 3 Most S.P. (c/kWh)	The 3 Most S.P. (c/kWh)	Area Using Diesel Engines (c/kWh)	Subsidized Period (Years)
Biomass	1-1.8	4.5-5.0	4.5-5.0	7
Biogas	1-1.8	4.5-5.0	4.5-5.0	7
Small, Micro & Mini	2.7-5.0	6-8.4	6-8.4	7
Waste	8.4-12	12-15	12-15	7
Wind Energy	12-15	17-20	17-20	10
Solar Energy	27	31.5	31.5	10

Source: NEPC, 3/2009

About PEA



Operating Environment

Supply Area: 510,000 sq km (73 provinces)
Customers: ~14.6 Millions

Max Demand

System: 14,127 MW *(Coincident Demand)*

Annual Sales :

~89,602 GWh

SPP,VSPP connected to PEA's Network : ~ 3 Gw

Overhead Lines

HV system: ~8,701 km
MV system: ~289,328 km
LV system: ~450,424 km

Underground Cables

Transmission: 1,269 km
Distribution: 18,228 km

Supply Voltage Level

HV :115 ,69 kV, MV : 22,33/19(L-N), 11 kV
LV : 400/230 V

Supply Substations

Total Substation : 631 s/s
(451 s/s owned by PEA)
(180 s/s owned by EGAT)
Distribution Trt (Total):xxxx units

Source : PEA annual report 2008

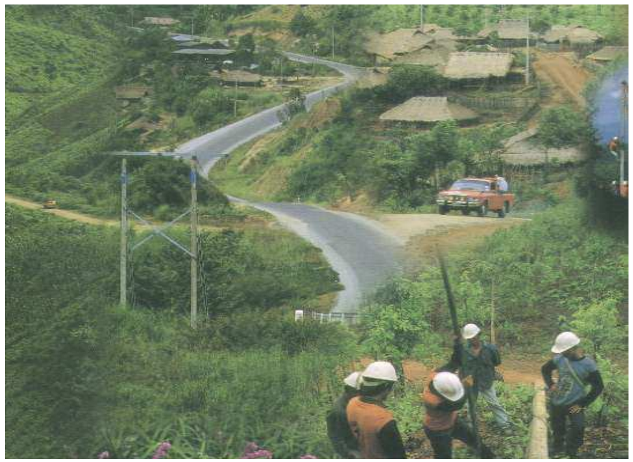
About PEA(Cont.)

- PEA is the Distribution Section

PEA : (Provincial Electricity Authority)

Responsible for providing electricity supply to provincial areas outside MEA service area. PEA was assigned to handle the Rural Electrification Programme in Thailand

Vision :
PEA is a leading organization of international standard, doing business in energy, services and related businesses.



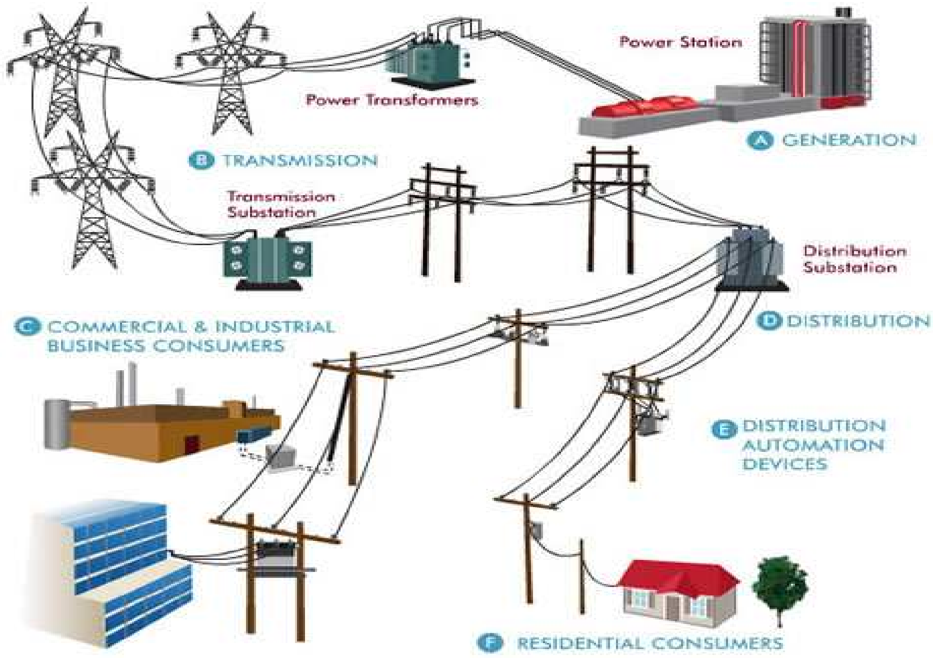
About PEA(Cont.)

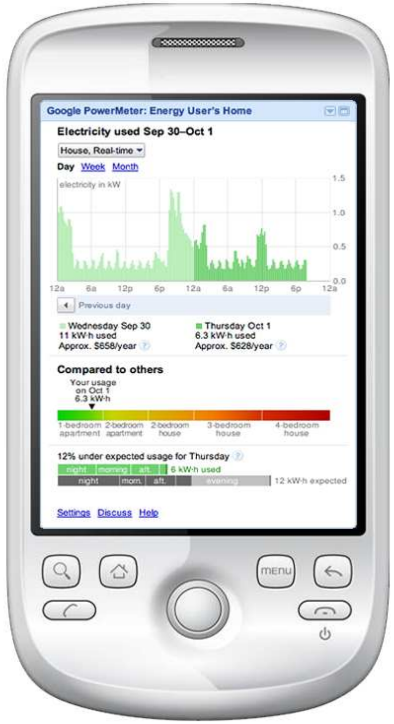
The PEA’s three major objectives are :

1. **To continue to improve its provision and distribution of electric energy for customers**
2. **To optimize its business and operations in order to be more profitable and thereby achieve sufficient revenues to facilitate further development**
3. **To develop its organizational structure, man power and resources management in order to achieve the highest level of efficiency and effectiveness**

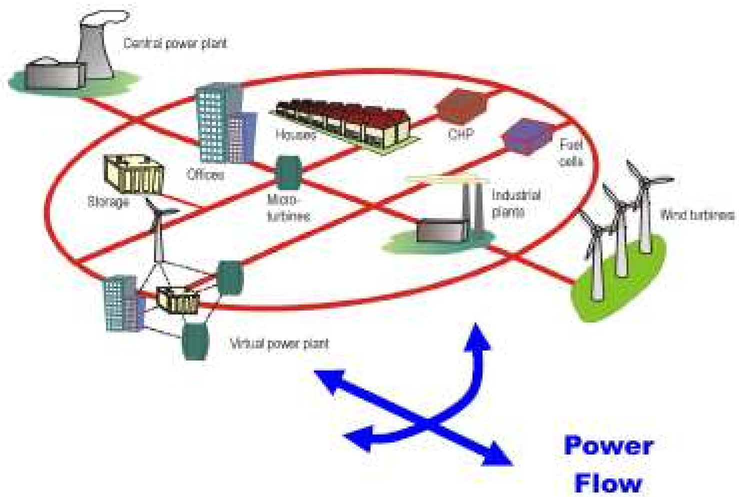
PEA understanding in “Smart Grid”

PEA understanding of “Smart Grid”

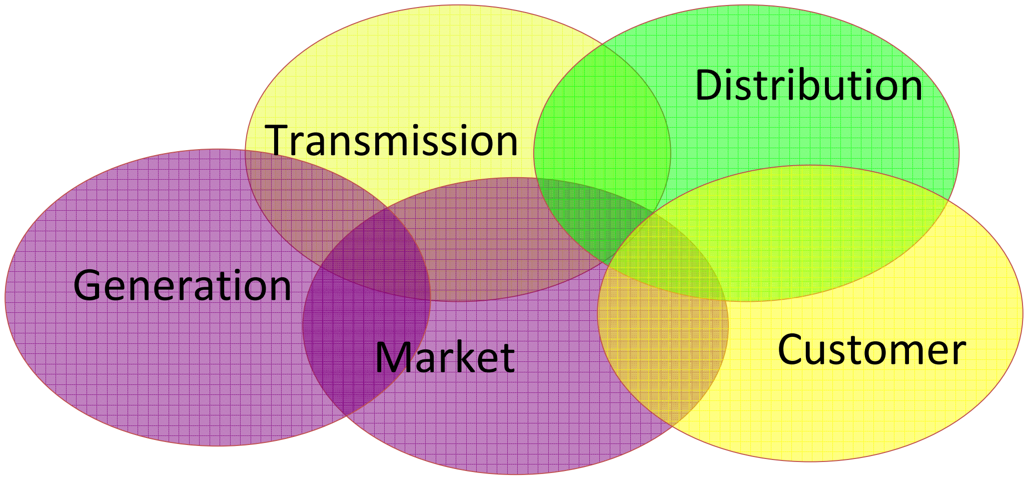




Google's PowerMeter energy monitor working on a smart phone.
(Credit: Google)



Smart Grid Domains

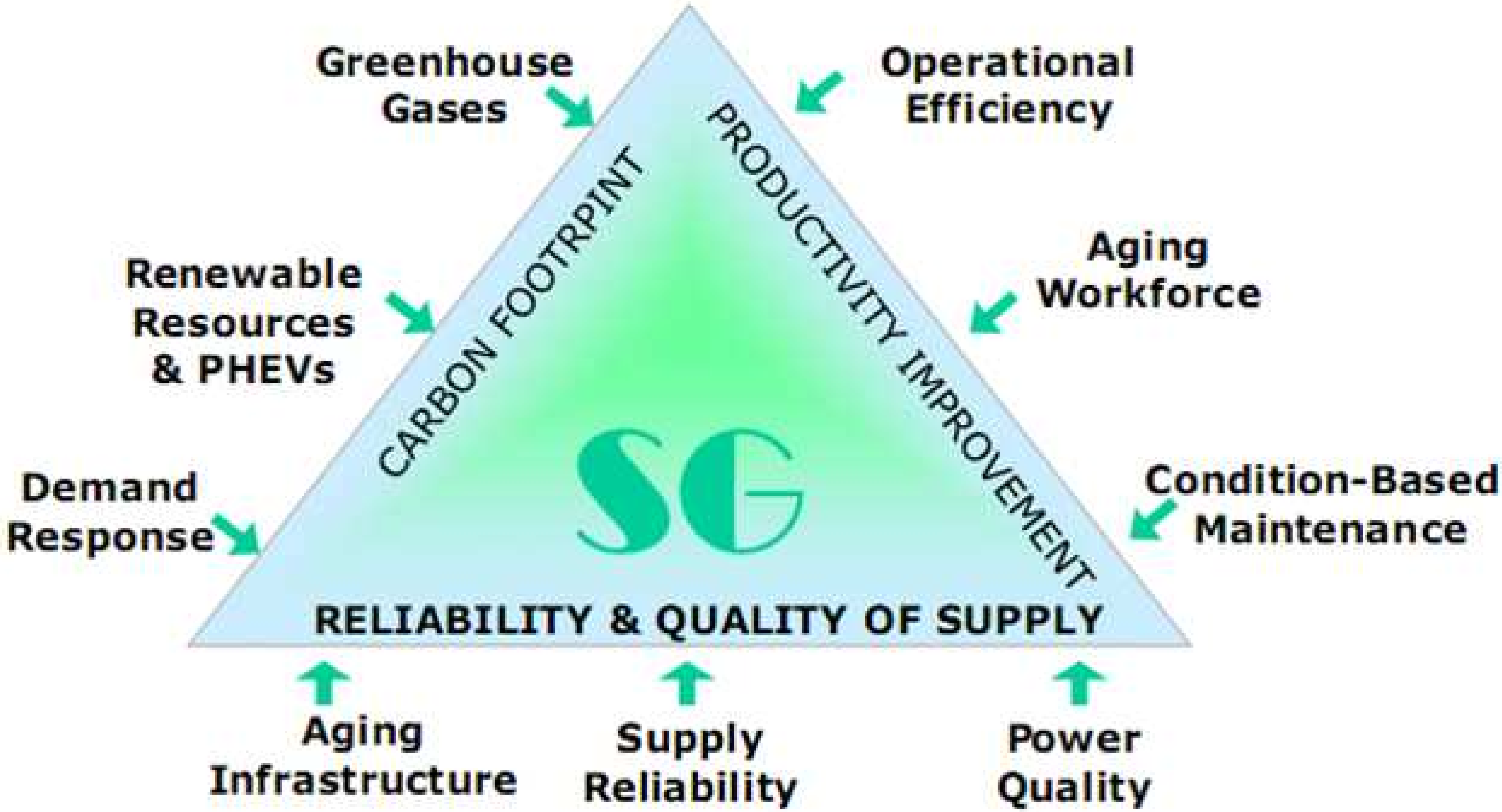


- Smart Grid implies close cooperation between the utilities and the customers
- The Smart Grid activities are cross-cutting over different domains

Observations

- **The Grid does not become smart just by adding AMI, DER, and Demand Response**
  - **The Grid is smart when it digitally performs monitoring and dynamic optimization of its operations including AMI, DER, and Demand Response**
- **The Smart Grid will not be a revolution.**
  - **It will be a gradual transformation of the systems that have served us for many years into a more intelligent, more effective and environmentally sensitive network to provide for our future needs.**

Smart Grid Business Drivers



Utility Enterprise & ICT

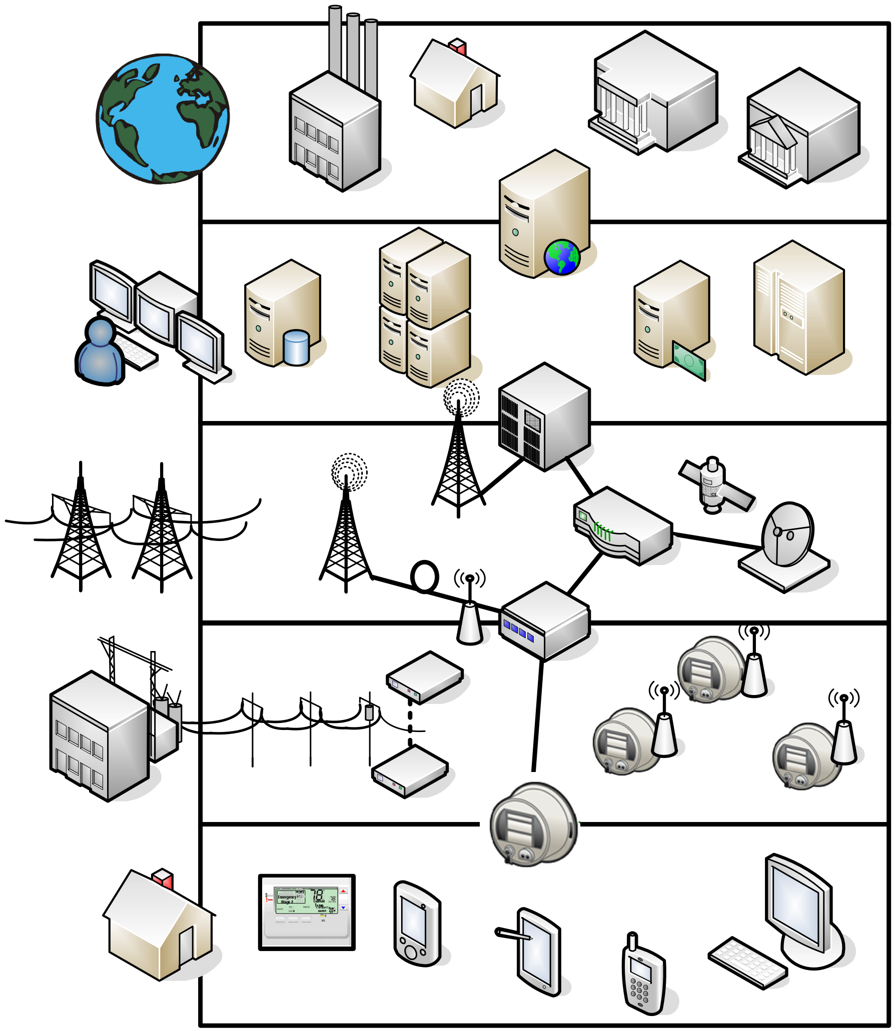
Market / Regulatory

Corporate

Transmission

Distribution

Load



Internet/ Extranet

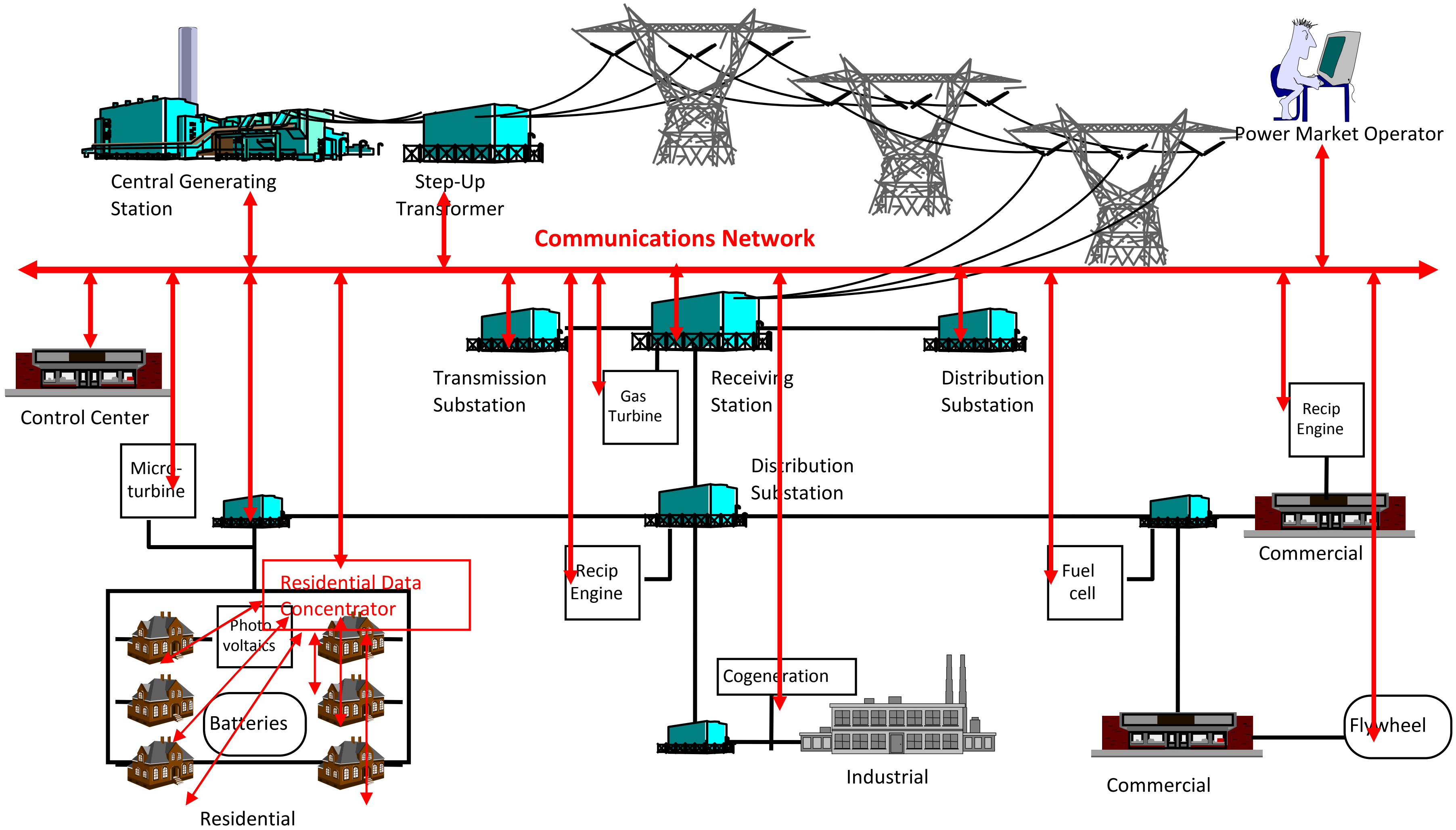
Enterprise Service Bus (ESB)

Wide Area Network (WAN)

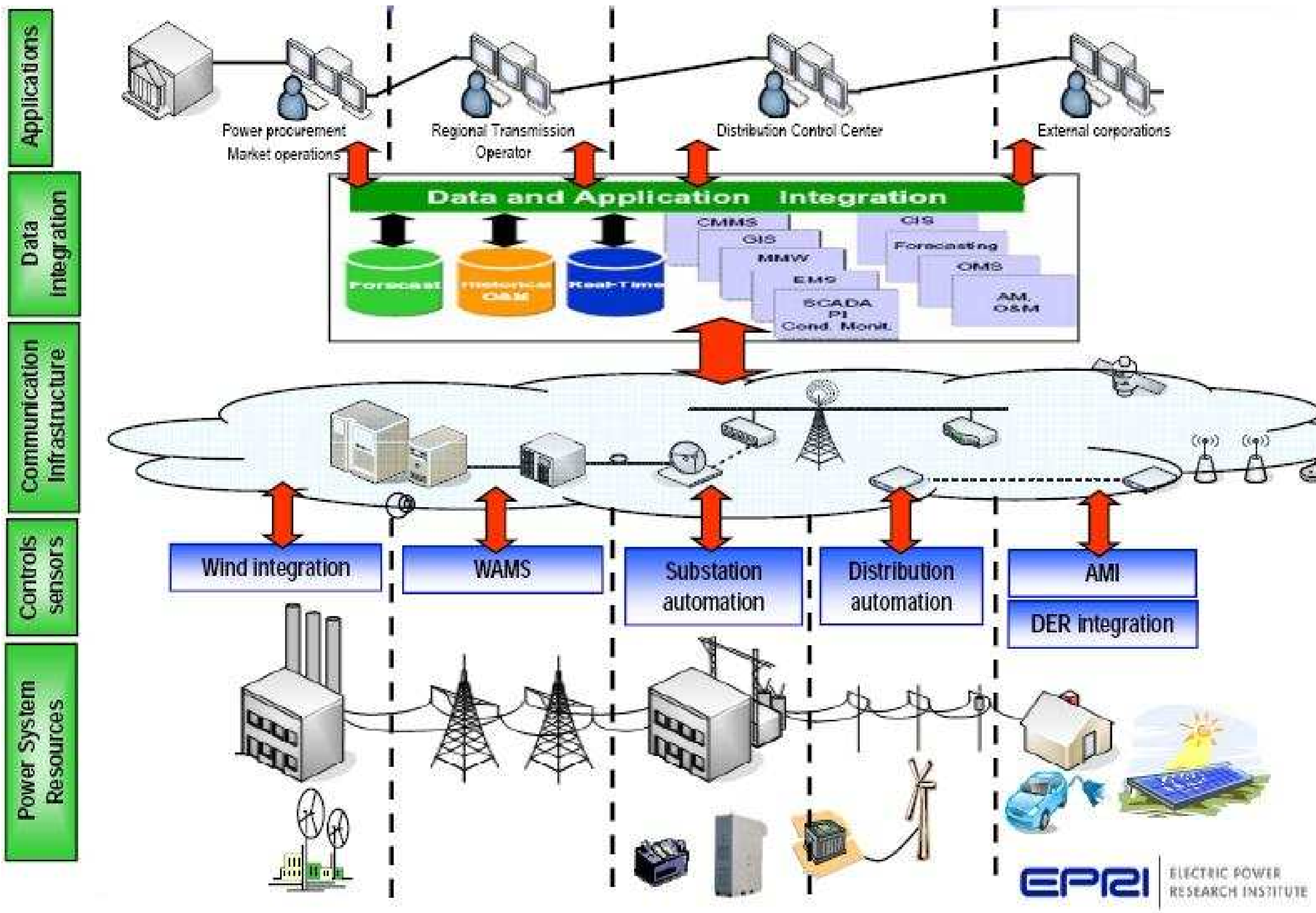
Field Area Network (FAN)

Home or Premise Area Network (HAN)

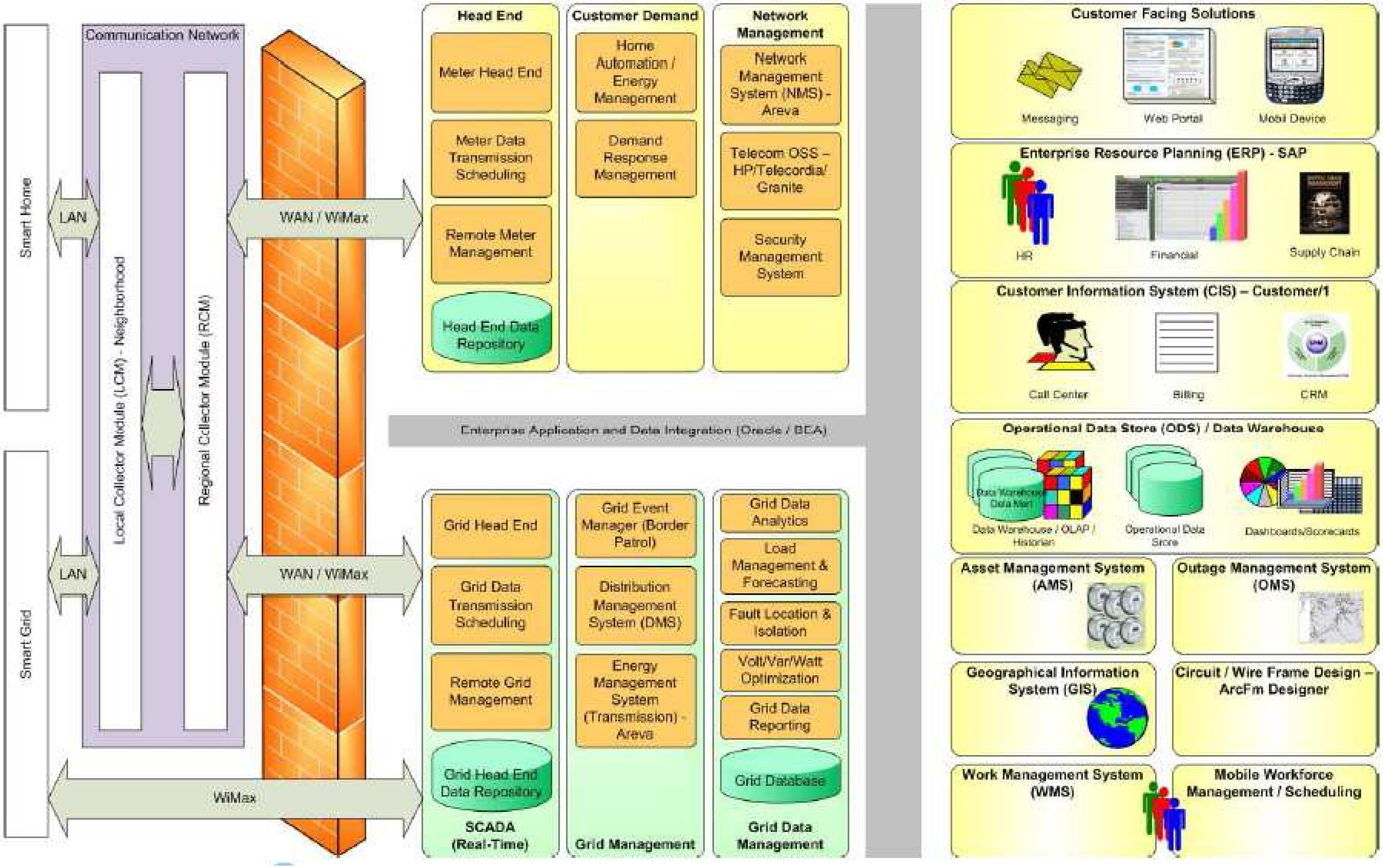
Vision of Smart Grid Components in High Level



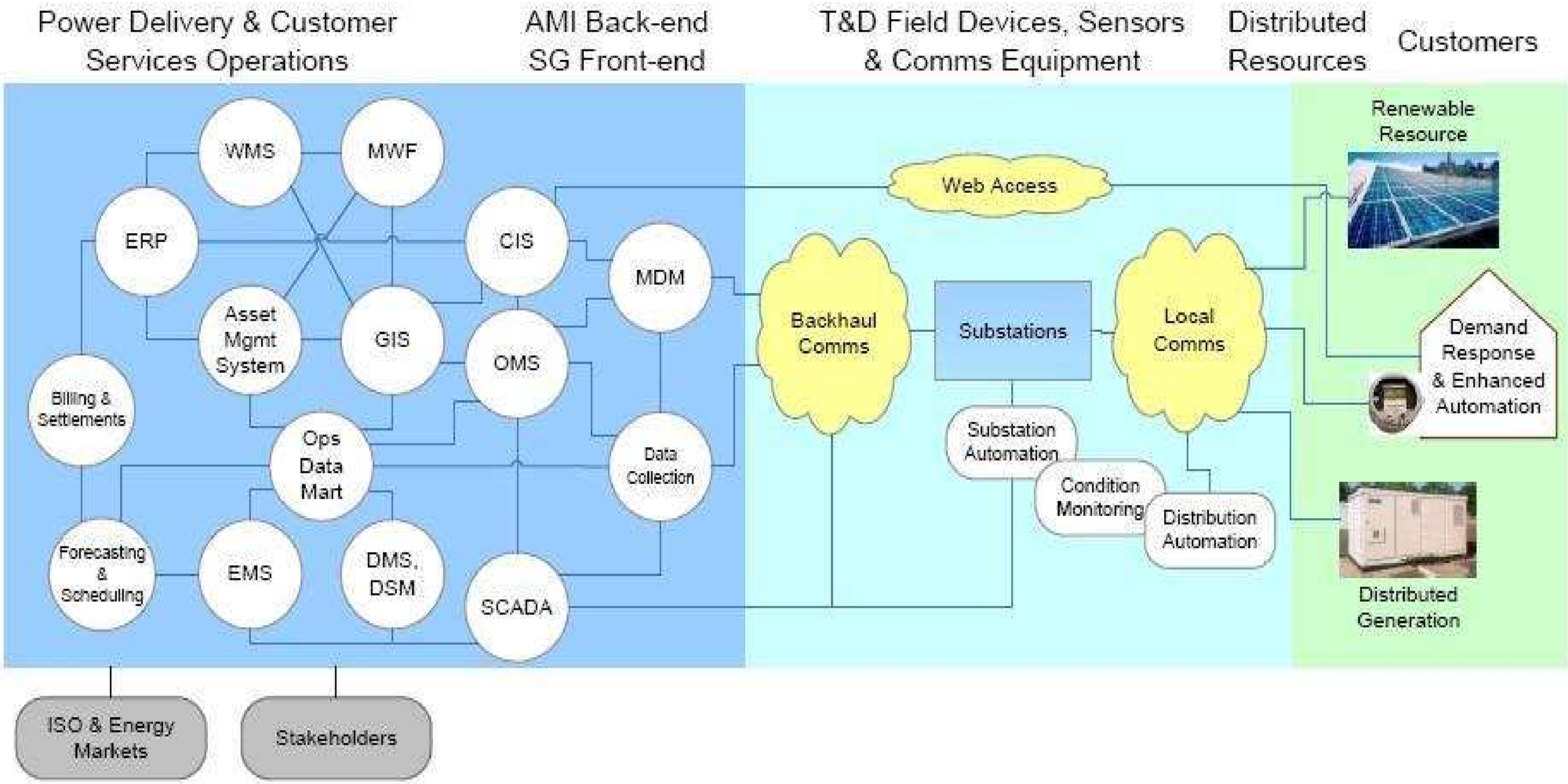
Smart Grid application at all level



Smooth Deployment need right architecture and concerned area need to be address



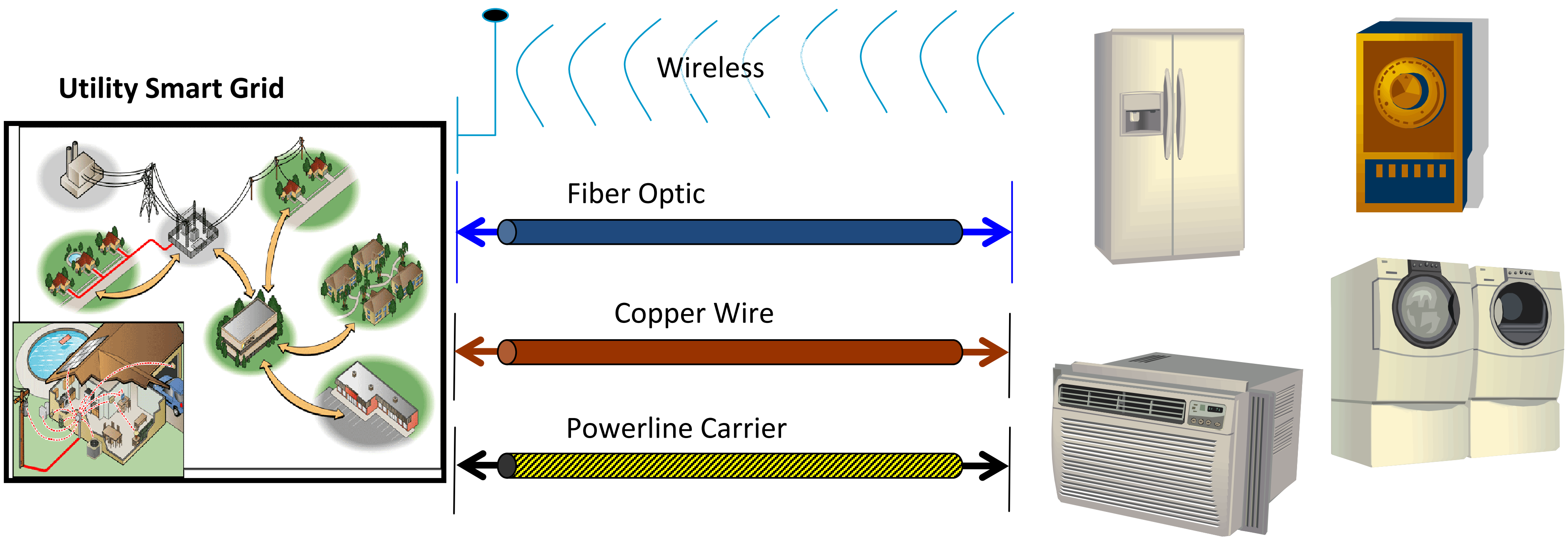
Conceptual view of distribution smart grids



Smart Grid Enabling Demand Response

Media Agnostic **Intelligent Communicating Appliances**

Utility Smart Grid

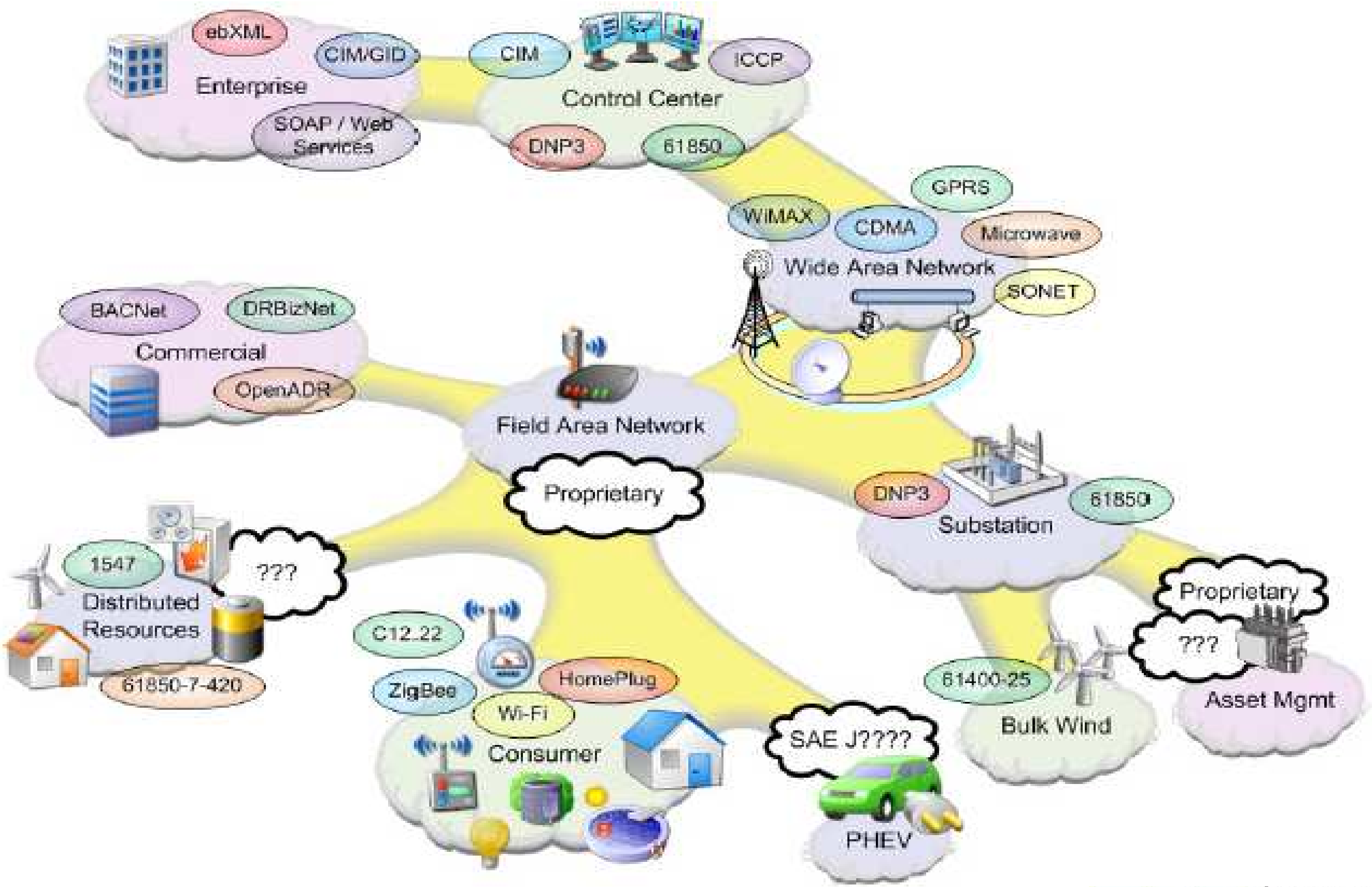


Designation & Certification to Encourage Manufacturers to Develop DR-Ready Products

Barriers: Standards for DR Interface & Market Transformation to Embed DR Interface

Smart Grid development challenge

The Standard Landscape

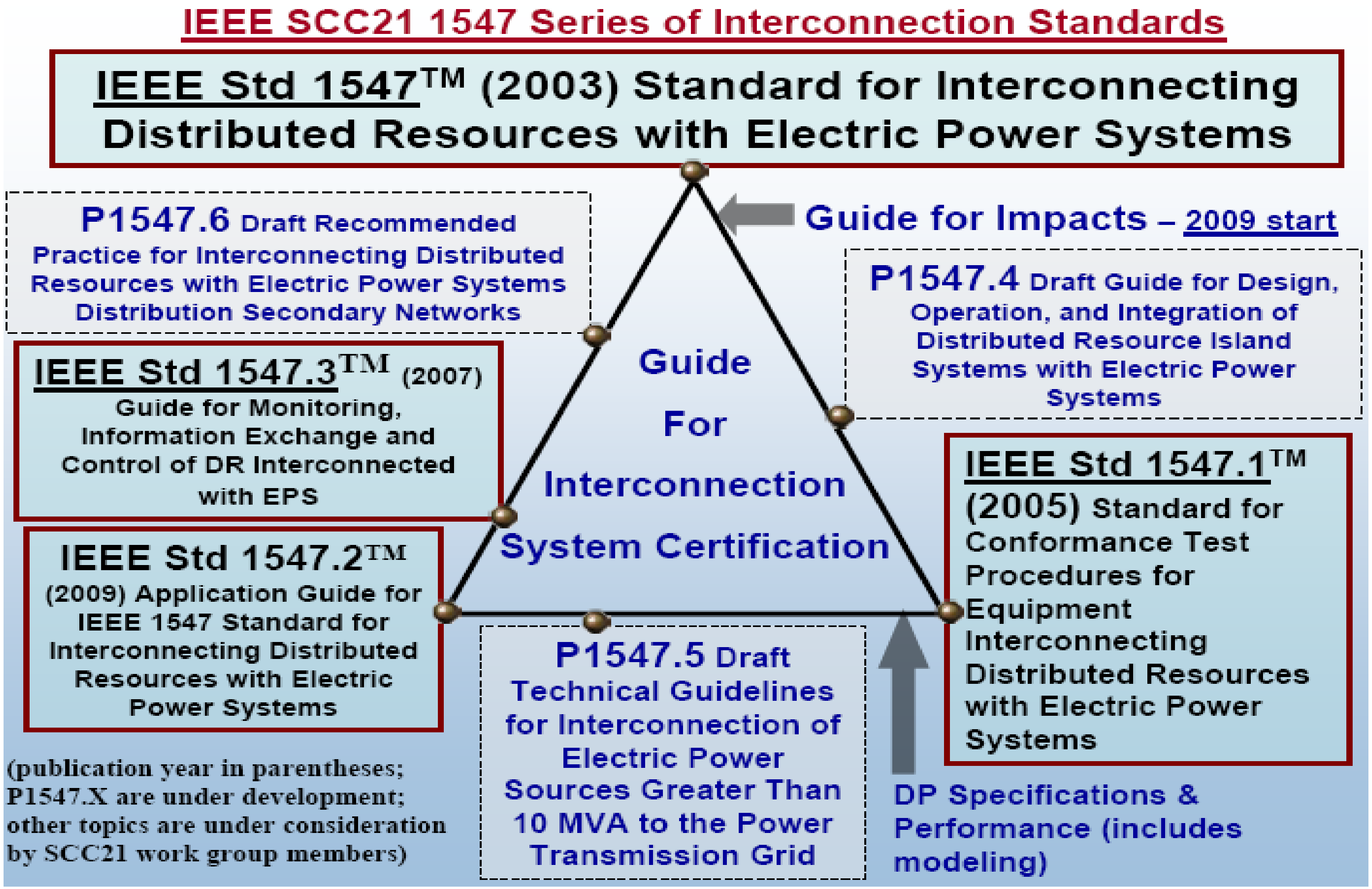


Source : EPRI ELECTRIC POWER RESEARCH INSTITUTE

Standard – Transmission and Substations Communications and information management

- Common Information Model – Middleware requirements and application integration
  - IEC 61968 and 61970
  - Generic Interface Definition
- Substation Communications
  - IEC 61850 or DNP3 (IEEE Std 1379) migrating to IEC 61850
  - IEEE Std 1646 – 2004 (Performance)
- Substations IED Configuration
  - Substation Configuration Language (61850-6)
  - DNP XML Schema for configuration
- SCADA – DNP3, IEC 60870-5, IEC 60870-6, IEC 61850
- IEC 61850 approaches for distribution communications
- Phasor Measurement Units – IEEE C37.118-2005
- NERC CIP Requirements for cyber security
- IEC 62351 security guidelines
  - TCP/IP, VPN, IEC 61850
  - DNP3 specifications for secure authentication
- Hardened substation devices
  - IEEE 1613-2003
  - IEC 61850 Part 3 & 5
- Time Synchronization
  - DNP embedded method – supports to +/- 5mSec (adequate for feeder devices in most applications)
  - NTP/SNTP – supports to +/- 10uS
  - GPS – supports to +/- 1 uS (adequate for substation devices in most applications today)
  - IEEE 1588-2002 – supports to +/- 100 nS
  - Future upgrade to IEEE 1588 Ver 2.0 (will be increasingly required for substation devices in the future)
- COMTRADE and PQDIF for data exchange
  - IEEE C37.111-1999 – COMTRADE
  - IEEE 1159.3 - PQDIF

Standard - DG Interconnection



Smart Grid benefit

- Ability to monitor and manage their power delivery down to the home or business in real time
- Can offer multiple rate structure to manage demand peak
- Allow utilities to manage outage more effectively by using real time information and advance control system
- Allow utilities to delay the construction of new plants and transmission lines and better manage their carbon output through implementing measures such as demand response and time-based rates to more actively manage load
- Allow utilities to provide real-time information to their customers and t ... ng in opera ... fici
- Allow utilities t ... ration of clean energy te ... their environmental

Key new drivers:

- Integration of renewables (intermittent resources)
- Distributed resources, microgrids
- Facilitating customer participation in markets
- New technologies (PHEV, storage, smart loads)

Utility smart grid Roadmap

- Smart Grid Roadmaps
  - Define vision, evolutionary pathway and multi-year investment strategy for individual utilities
  - Tools for evaluating costs and benefits of smart grid applications
- Interoperability standards
  - An industry architecture (a tightly coupled suite of standards) that enables interoperable systems
  - Common language
- Effective security requirements, policies and technologies
- Technology assessments and applications
  - Based on real world applications
- Field experience with large-scale deployment and integration of smart grid systems and technologies

Source : EPRI ELECTRIC POWER RESEARCH INSTITUTE

Road Map for smart Grids implementation

- Regulatory strategy *– cost recovery and regulatory alignment*
- Holistic approach *– operation and business surrounding system planning, power delivery and customer services*
- Business case Justification *– cost benefit associate with technologies and business transformation*
- Enabler and foundational capabilities *– and also people and process are the critical to the long-term success*
- Interoperability standard *– adopting interoperability standards and developing and architectural framework for data, system and technology integration is an important step for smart grids implementation*
- Practical, Balanced and leveraged Solutions - *The future models for the smart grids have to meet changes in technology, and accommodate public values related to the environment and commerce*

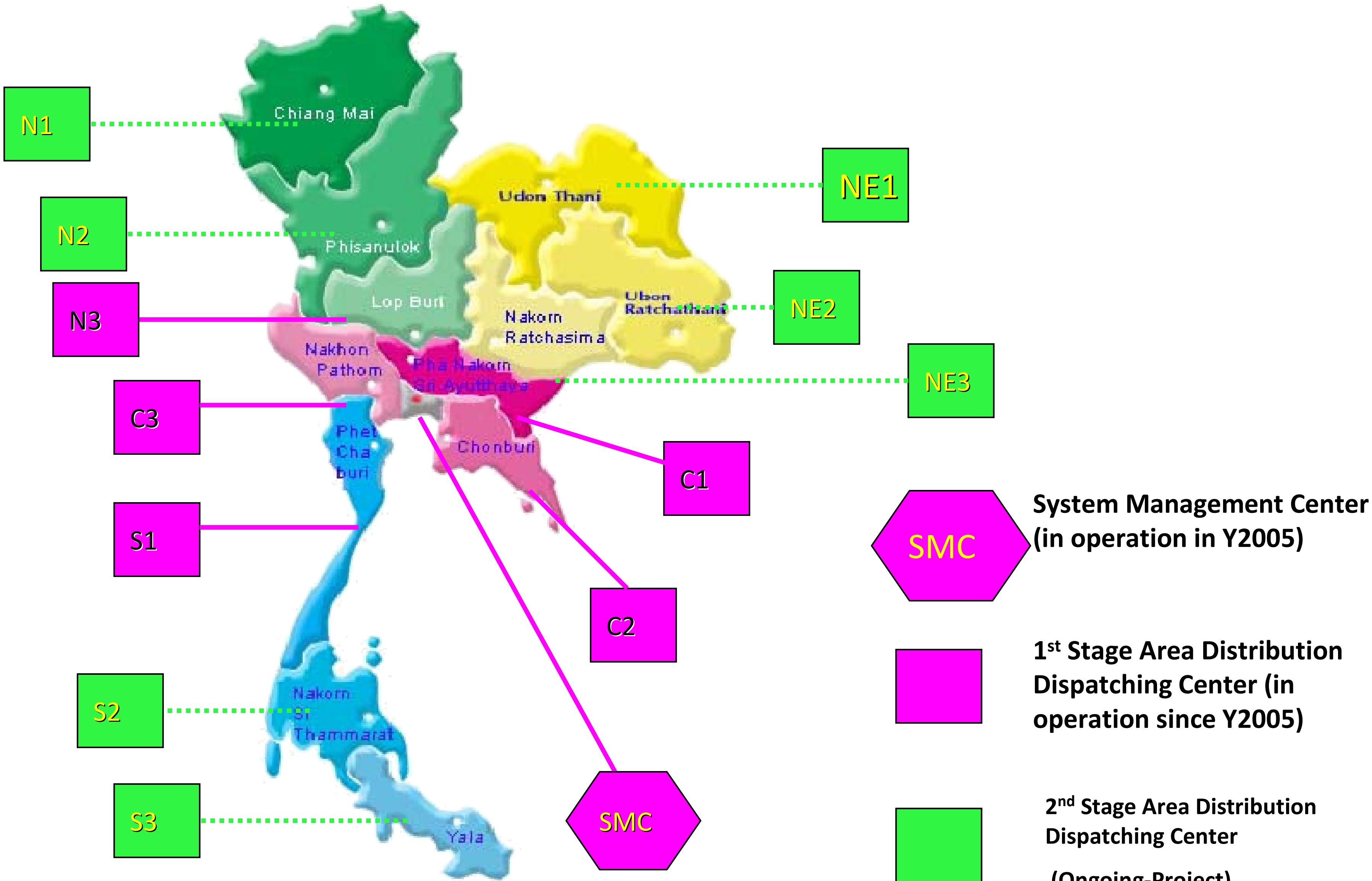
PEA – Ongoing and existing IT Project (related to Smart Grid components)

PEA's Ongoing Project

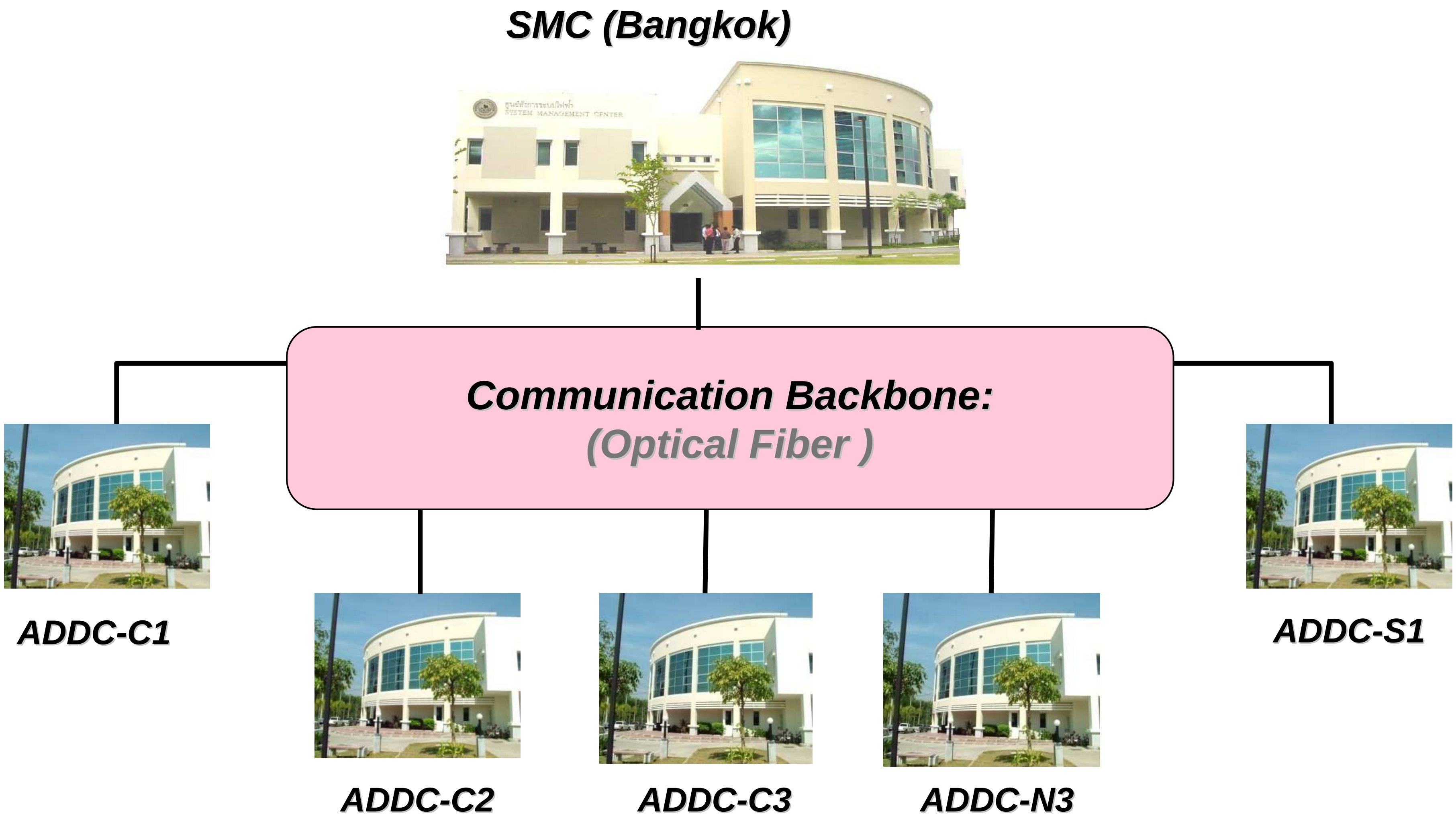
- Transmission and Substation Development Project, 8th stage (2005-2012)
- The Power Distribution System Reinforcement Project, 6th stage (2004-2010)
- Rural Household Electrification Project, 3rd stage (2003-2009)
- Submarine Cable Extension to Electrified Islands (2005-2009)
- Distribution System Dispatching Center Project, 2nd stage (2008- 2012)
- Distribution System Reliability Improvement Project, 2nd stage (2006-2010)
- Underground Cable Development in Large Town Project* (2005-2009)
- The GIS Development Project, 2nd stage* (2005-2010)

*** Were adjusted to long term plan**

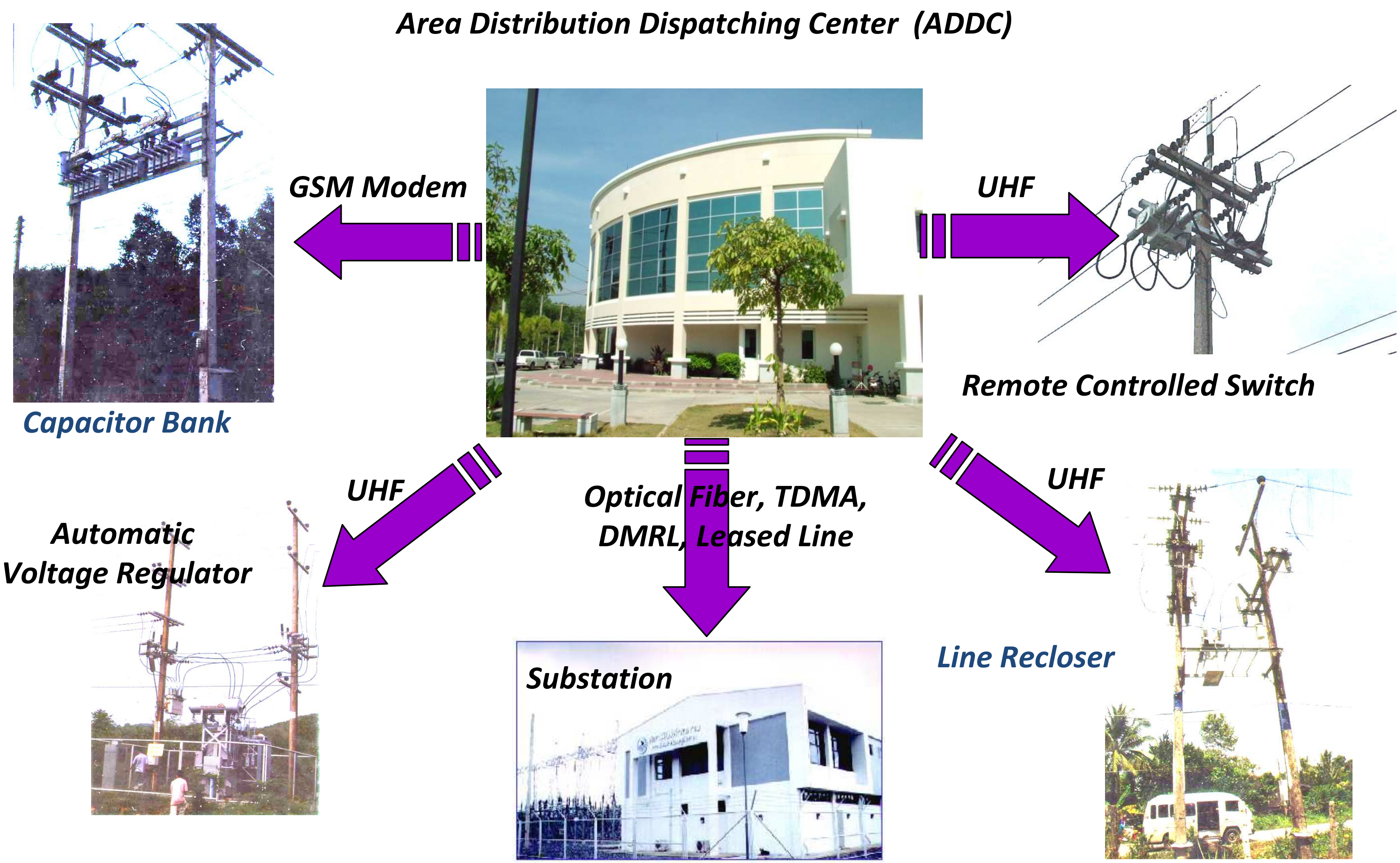
PEA-IT Project :DDC-Project



PEA-DDC.1 Project

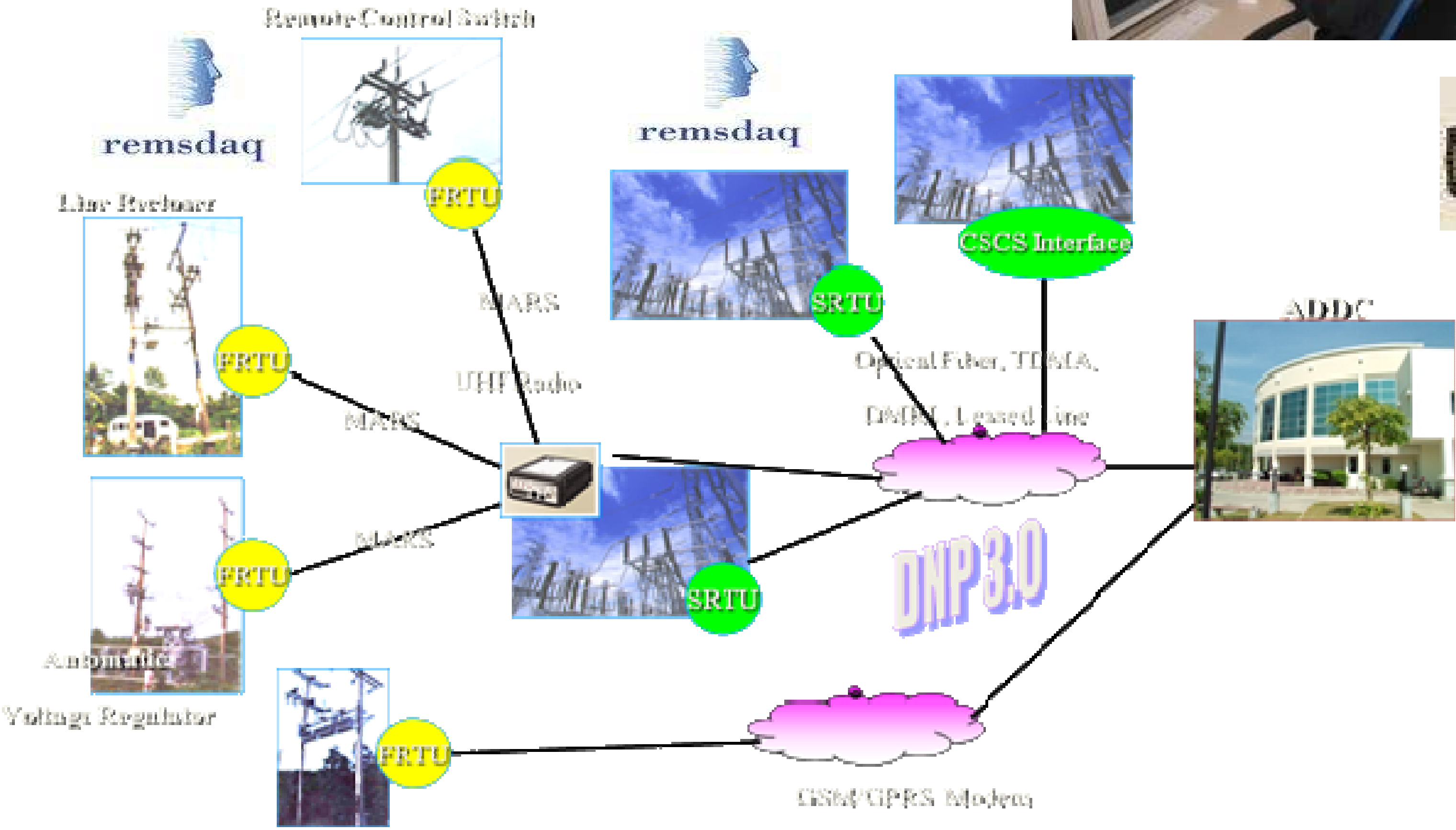


PEA-DDC.1 Project



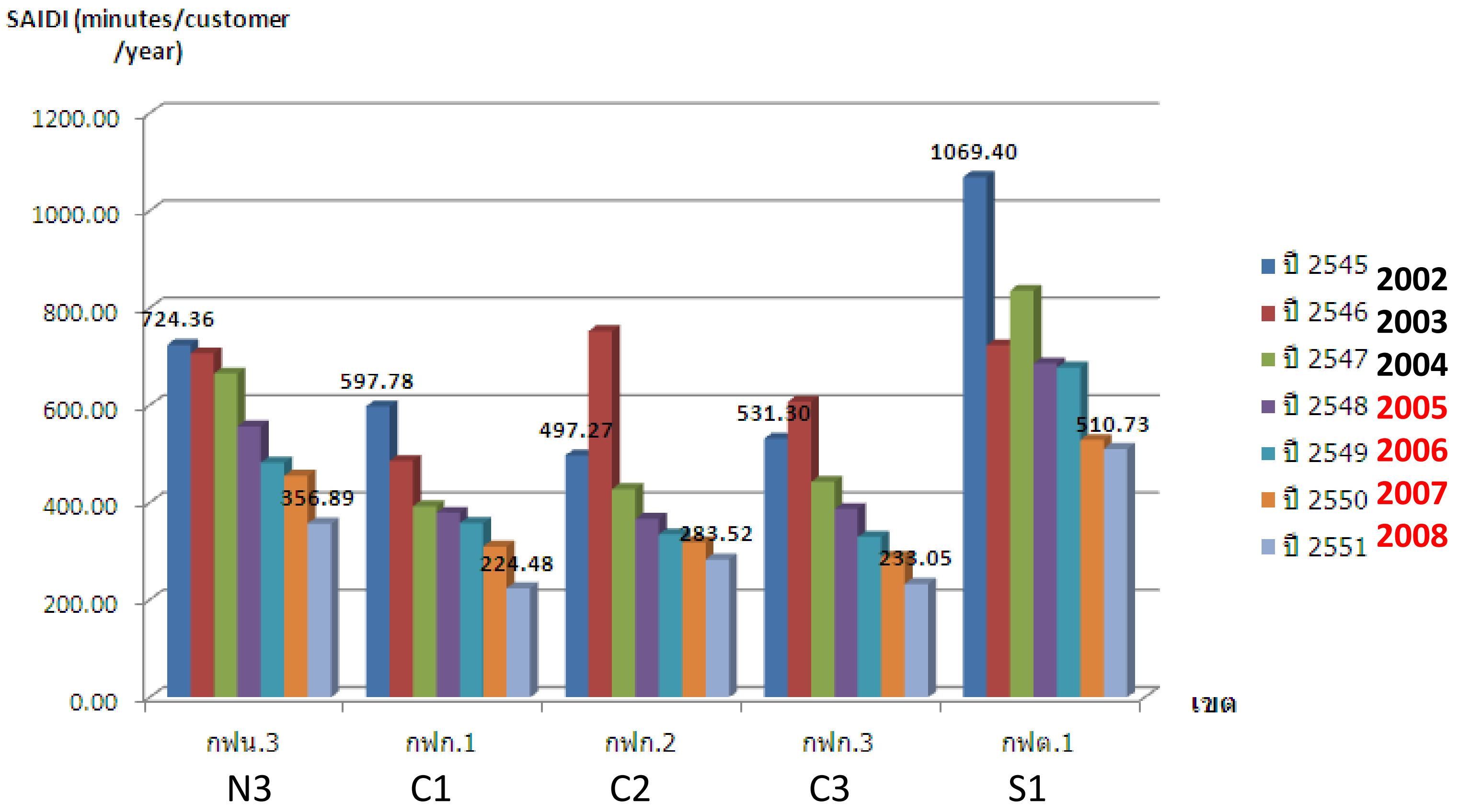
PEA's DDC.1-Project

MDS 4710/4790

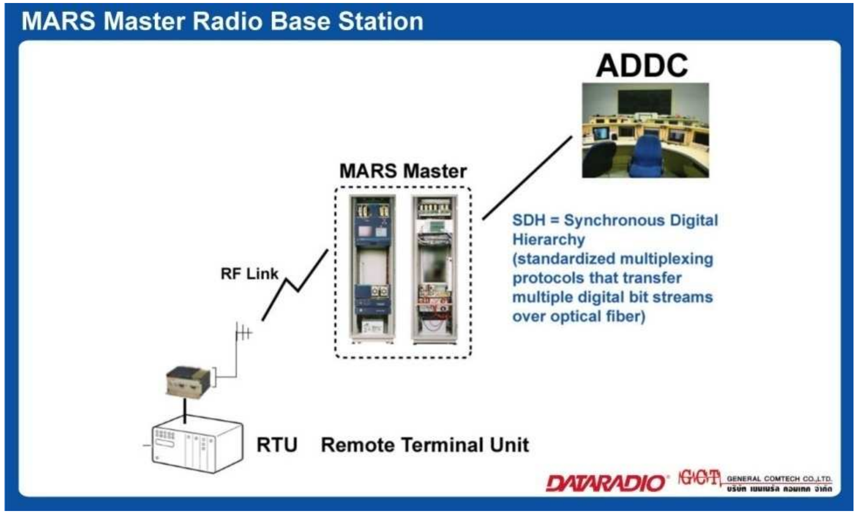


PEA-DDC.1 Project Benefit (i.e. System reliability index)

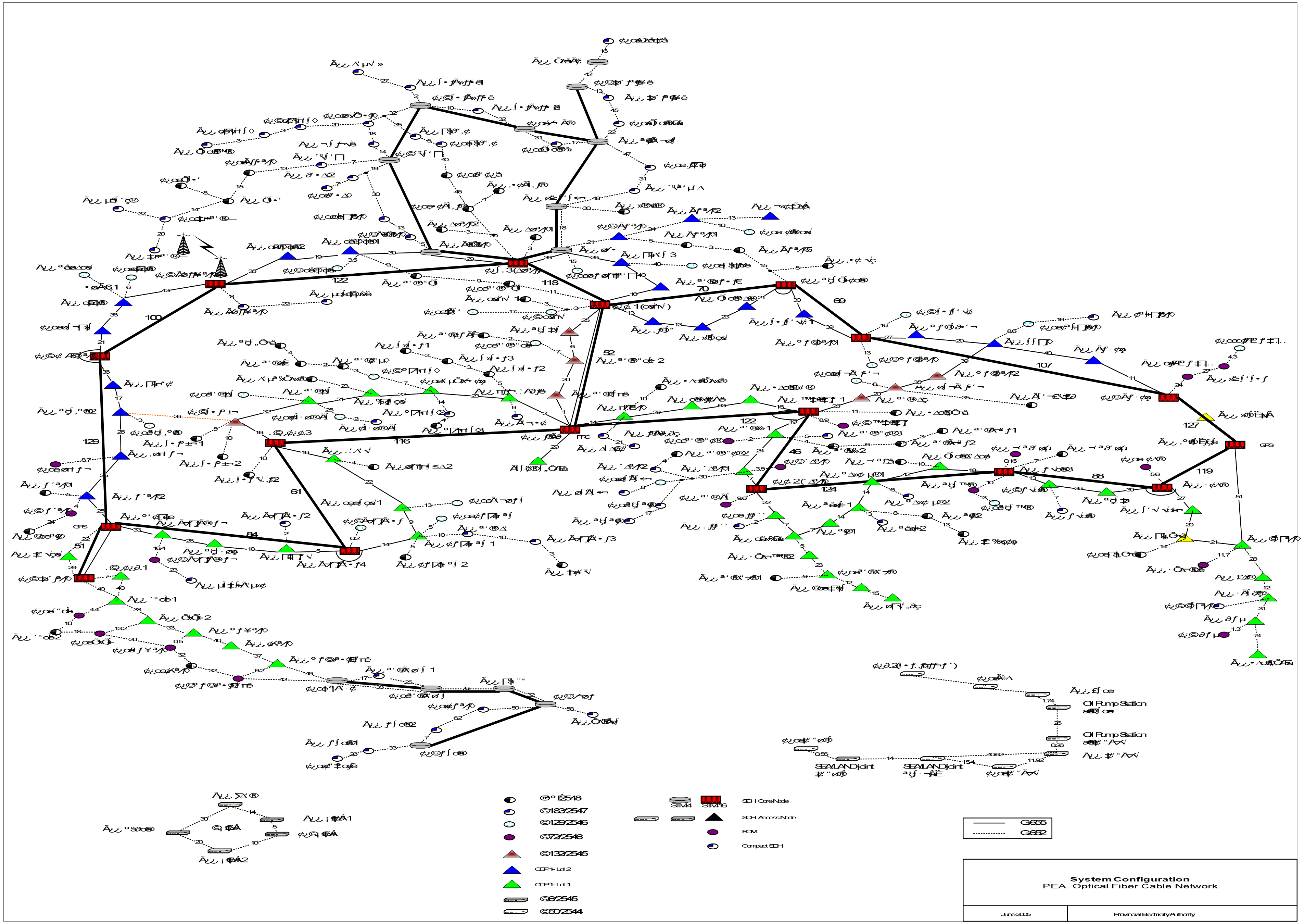
- SAIDI index



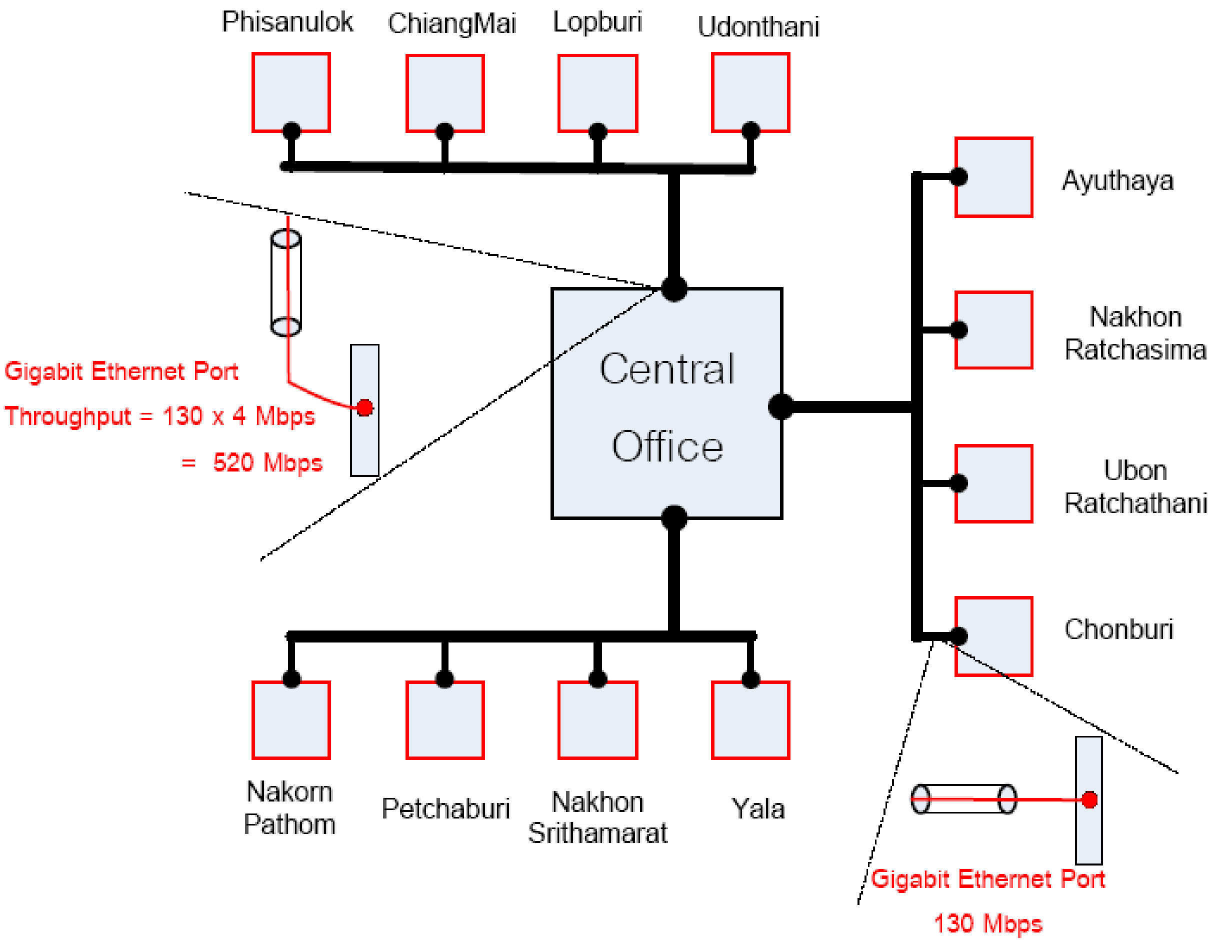
DDC.2 Project (Ongoing)



PEA’s CDP Project - Fiber Optic backbone

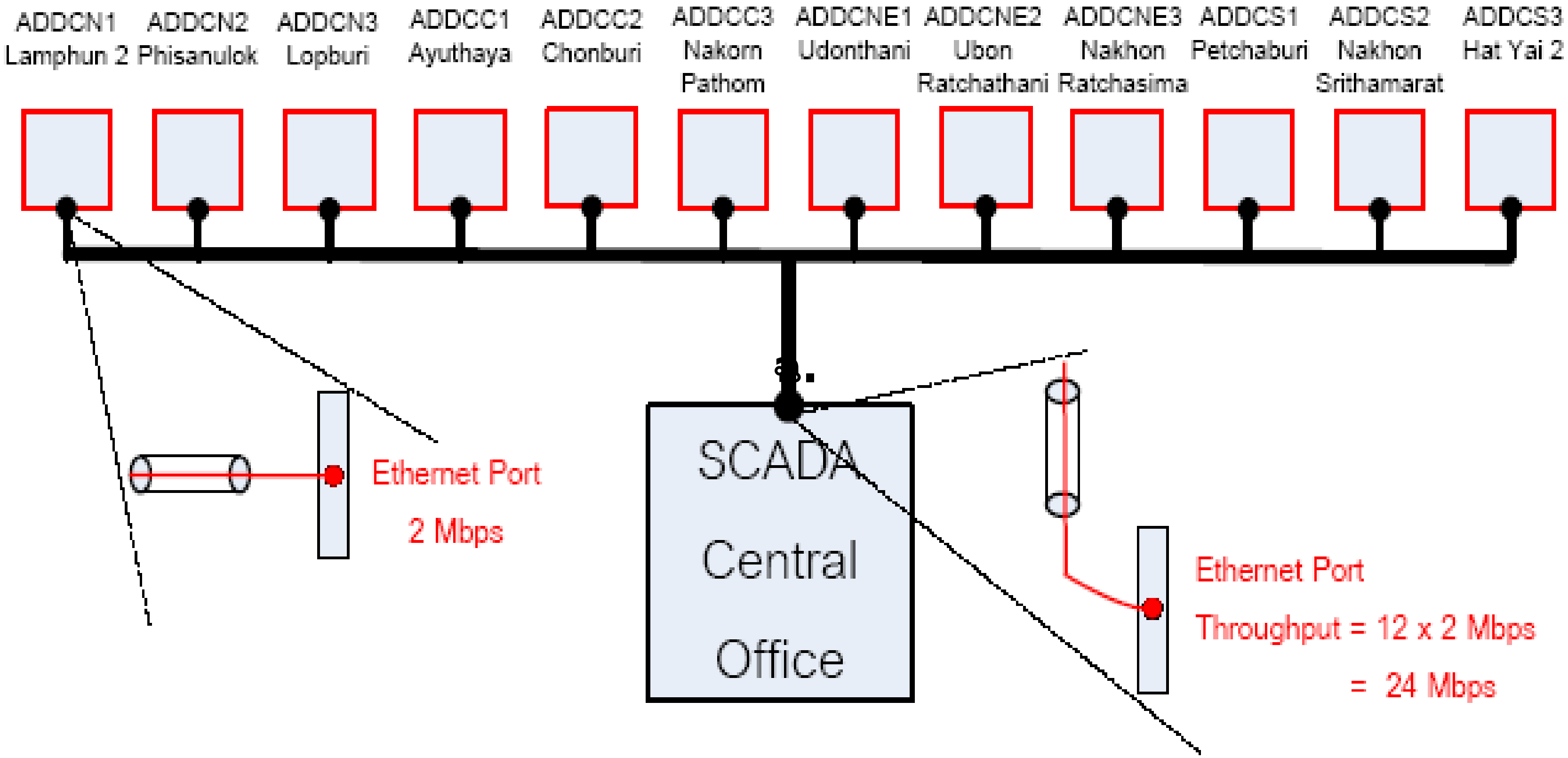


Communication Channels at Head Office



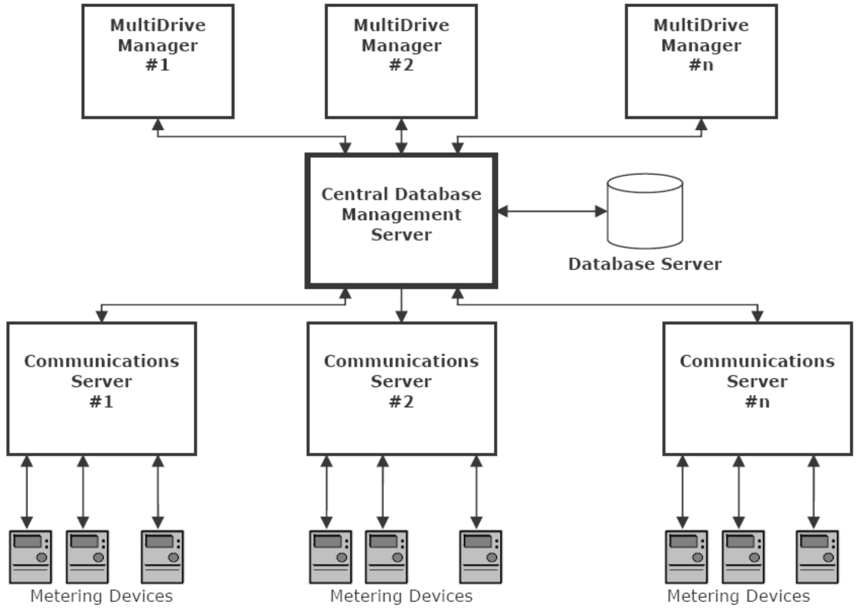
Ethernet Port Connection Diagram

Communication Channels for SCADA system

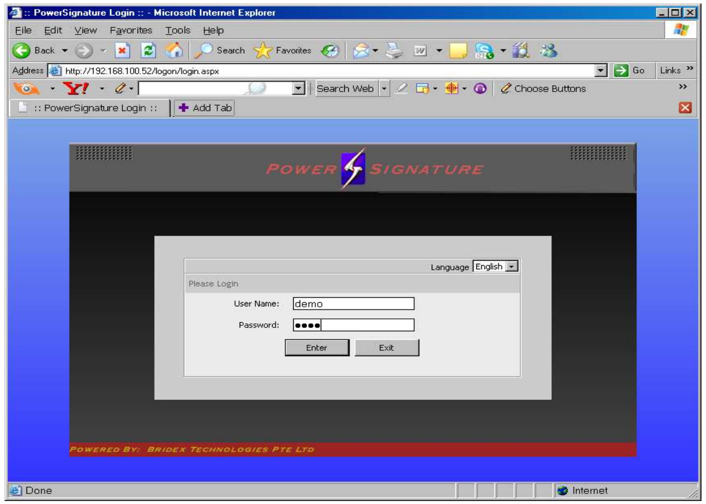


Ethernet Port Connection Diagram

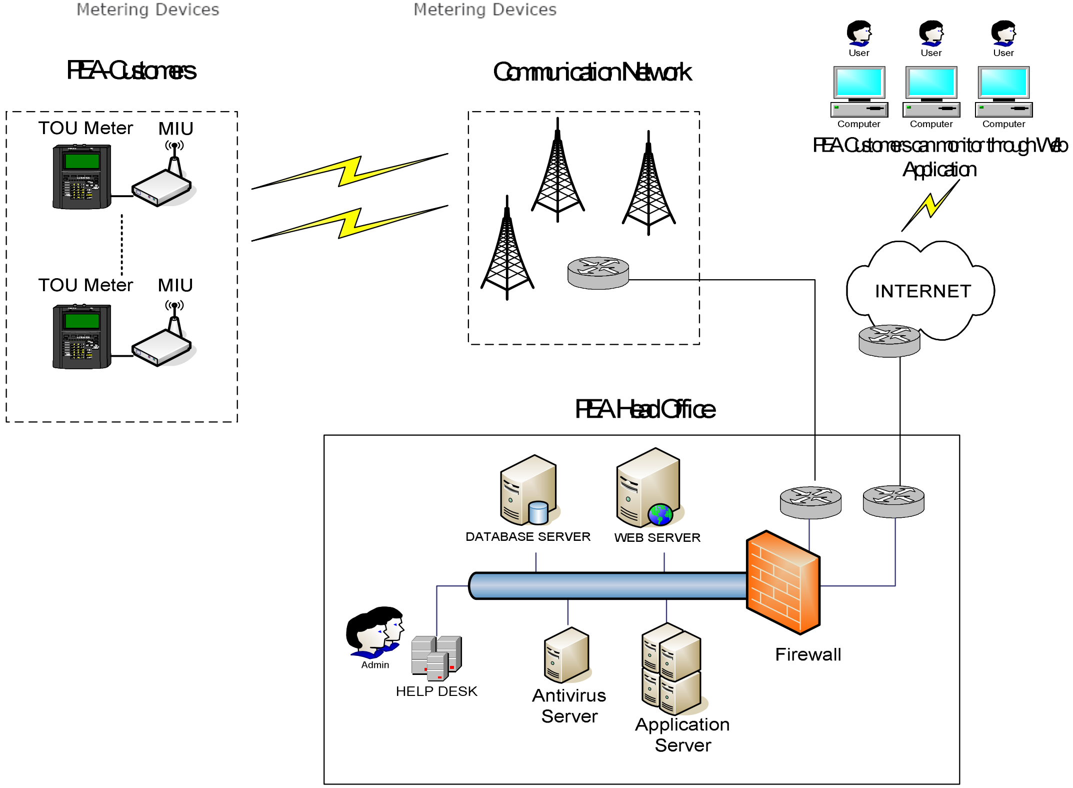
AMR Project



MultiDrive Manager #1
MultiDrive Manager #2
MultiDrive Manager #n
Central Database Management Server
Database Server
Communications Server #1
Communications Server #2
Communications Server #n
Metering Devices
Metering Devices
Metering Devices



:: PowerSignature Login :: - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://192.168.100.52/logon/login.aspx
POWER SIGNATURE
Language English
Please Login
User Name: demo
Password:
Enter
Exit
Done
Internet



PEA Customers
TOU Meter
MIU
TOU Meter
MIU
Communication Network
User
User
User
Computer
Computer
Computer
PEA Customers can monitor through Web Application
INTERNET
PEA Head Office
DATABASE SERVER
WEB SERVER
Admin
HELP DESK
Antivirus Server
Application Server
Firewall

Next Step for PEA

Review existing IT system (i.e. DDC.1 project)

DMS Master Station

- Basic SCADA
- DMS applications
- Interlink with OMS, AMR, Distributed Generation, and Geospatial Information System
- Inter center co-ordination
- Enterprise / corporate applications

Communication System

- Fiber Optic backbone with SDH
- UHF MARS radio network
- Protocol
- Data concentration and data distribution

Substation and Field Device

- SRTU or CSCS
- FRTU:
- Pole top switches
- Automatic Voltage Regulator
- Capacitor bank controller
- Line recloser switch
- Communication infrastructure

An integrated approach to evaluate overall performance in terms of efficiency, reliability, and availability

Outline of strategy for implementing the Smart Grid Concept in PEA

1. **Determine the needed changes to optimize the future operations (the CAN DO)**
2. **Determine the needed changes in the DMS hardware and software to accommodate the expected penetration of new technology (the MUST DO)**
3. **Estimate the benefits and cost of the defined changes**
4. **Develop a Smart Grid Road Map (implementation plan) based on the findings**

Outline of strategy for implementing the Smart Grid Concept in PEA (Cont.)

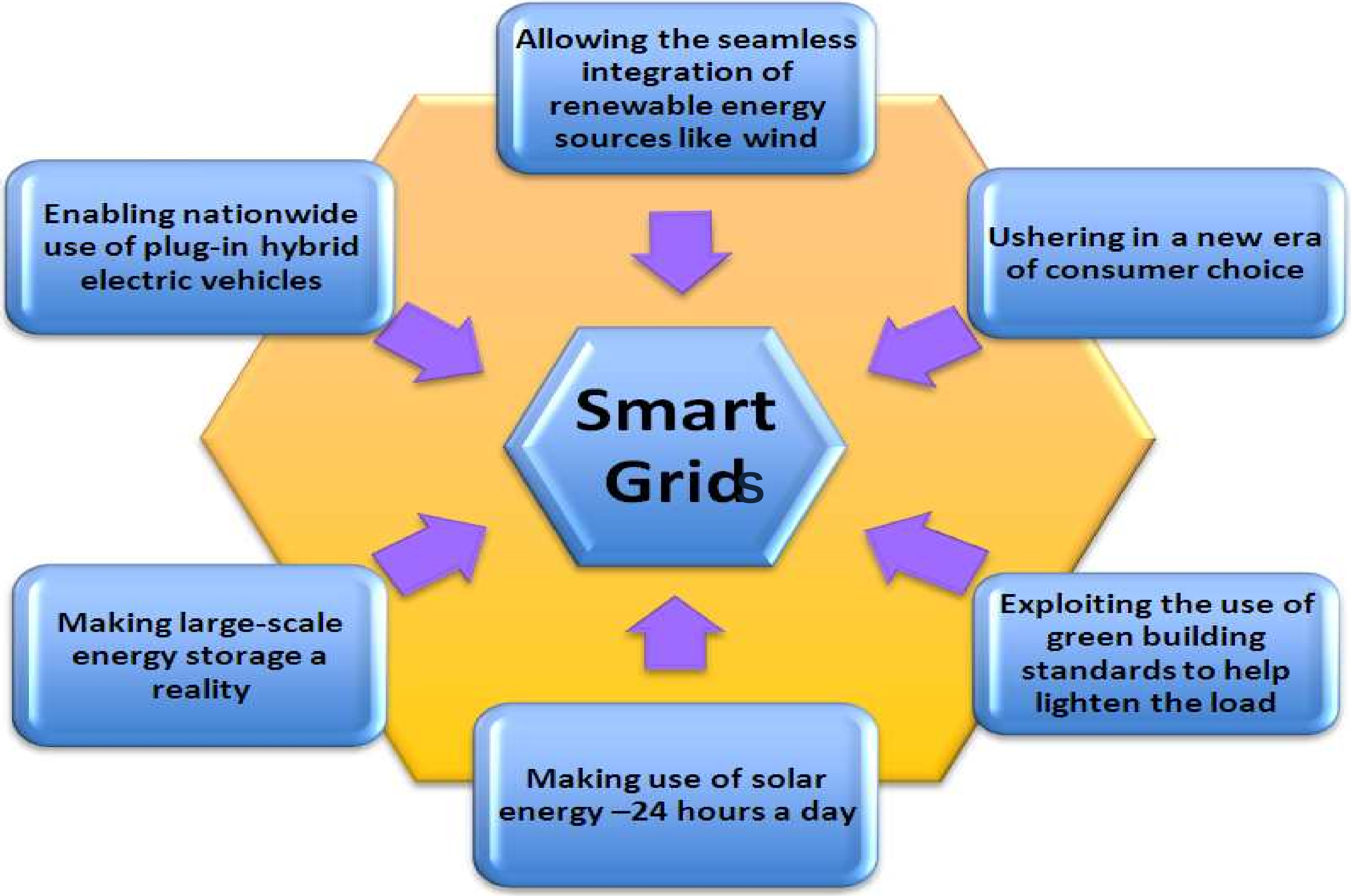
5. Develop conceptual designs of:
   - Application upgrades justified in the feasibility study
   - IT system upgrades and integration to support the upgraded applications, such as:
     - GIS
     - CIS
     - OMS
     - WMS
     - AMI data management system
     - Demand Response management system
     - DER Management system
     - PEV management system
     - Cyber Security system
   - Smart Meters meeting the requirements of the upgraded applications (to use not only for billing, but support of applications)
   - Hardware upgrades
   - Communications upgrades including interoperability standards

Outline of strategy for implementing the Smart Grid Concept in PEA (Cont.)

6. **Determine upgrades of the distribution system to accommodate the Smart Grid requirements**
   - Optimize the location of controllable switches
   - Optimize the location and sizes of reactive power sources and voltage regulators
   - Prioritize the implementation of AMI and Demand Response to maximally benefit from integration with DA

Outline of strategy for implementing the Smart Grid Concept in PEA (Cont.)

7. **Develop design and functional requirements for the**
   - **Upgraded DA applications**
   - **IT systems**
   - **Hardware**
   - **Smart Meters**
   - **Communications**



Source: US DoE

Benefits of Smart Grids

Without Smart Grids	With Smart Grids
<13% variable renewables penetration	>30% variable renewables penetration
5% demand response	15% demand response
<1% consumer generation used on the grid	10% consumer generation used on the grid
47% generation asset utilization	90% generation asset utilization
50% transmission asset utilization	80% transmission asset utilization
30% distribution asset utilization	80% distribution asset utilization

Initial PEA Grid Roadmap

Reconceptualization & Strengthening

2009-2013

- Demand 17,243 MW
- Re-Conceptualization : Planning, Engineering, Service
- Setting up : Power & ICT Integration, DG Connection, Premium Power, Automation
- EV
- AMI initiative

Preparation & Development

2014-2018

- Demand 22,796 MW
- Program Implementation : Power & ICT Integration
- Human Resource : Modern Power & ICT
- Knowledge Management : R&D Center

Realization of Smart Grids

2019-2024

- Demand 30,395 MW
- AMI era
- Web-Based Energy Management
- Advanced Distribution Management
- IT Service/Provider

Initial Timeline Of PEA Smart Grids Development

2552–2557: Define, Design, Testing

- Review Traditional Concepts
- Define PEA Smart Grids
- Set up Planning Criteria, Engineering Criteria & Service Criteria

- Conceptual Design
- Technology Selection & Development
- Field Testing
- Pilot Project

- SCADA Improvement

2557–2562: Implementation

- Integration of Technologies (e.g., SCADA, OMS, CRM, GIS, AMR etc)
- Integration and Exploitation of DGs and Renewable Energy Resources

- Large-Scale Projects

- Underground
- Voltage Levelization
- Reliability-Base Action

2562–2567: Sustentation

The Beginning of SmartGrids Era

- Further Development of the PEA Smart Grids

Conclusions: 4C Critical Success Factors

- **Customers** : Smart Grid Development must create value added to both internal and external customers
- **Collaboration** : 2 types of collaboration

(a) Stakeholders collaboration

(b) Technology and System Collaboration

- **Communication**: Between equipment and systems, personnel communication
- **Continuity**: Shared Visions, Long term policy and strategy

Acknowledgement and References

- *Electricity Generating Authority of Thailand: Summary of Thailand Power Development Plan 2010-2030, System Planning Division, April 2010*
- *Weerachai Koykul, Deputy Governor (Network Operation), Provincial Electricity Authority (PEA)*
- *National Science and Technology Development Agency (NSTDA), Thailand*