Technologies that brings the Smart Grid to Life

NATIONAL ACADEMY OF ENGINEERING
OF THE NATIONAL ACADEMIES

Greatest Engineering Achievements
OF THE 20TH CENTURY

#1 - Generation, Transmission & Distribution of Electricity

Smart Phone

Convergence:

The combination of two or more different technologies in a single device

Navigation

Music

TV

E-mail

Game

PDA

Internet

Camera

Phone

Video Recording

Text Message

Complexity :

The degree to which a system has a design that is difficult to understand

iPhone

"Suddenly, the interface isn't fixed and rigid, it's fluid and molten. Software replaces hardware."

-Time Magazine on the Apple iPhone

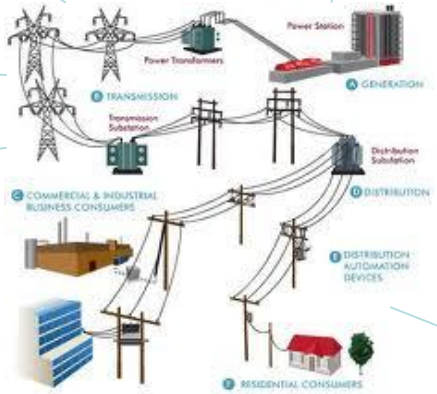
Grid: Measurement – Visualization – Automation

Transformer Monitoring

Alarm Event Recorder

Recloser Control

Sectionalizer Control



Phasor Measurement Unit

Capacitor Control

Substation Automation

Demand Response

Metering

Power Quality Analyzer

Grid: Measurement – Visualization – Automation

- 100's of Devices
- Multiple Protocols
- Multiple Buses
- Obsolescence
- Fixed Functionality
- Hundreds of Vendors

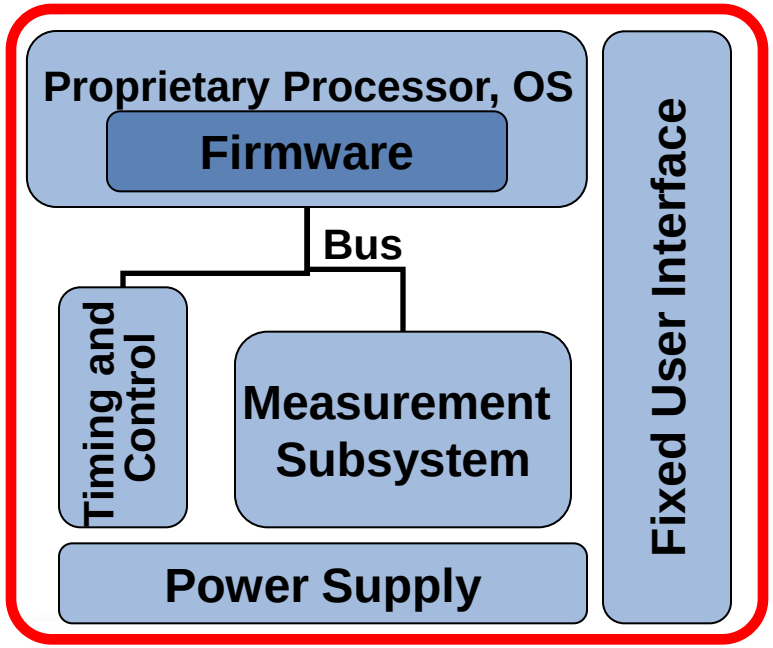
How do we Drive Convergence?

What's Needed to Drive Convergence?

- **High Performance Platform**
  - *High Speed Data Acquisition*
  - *High Performance Real Time Processor and FPGA*
  - *High Fidelity ADCs with 24bits and Filtering Capabilities*
  - *I/O Expandable*
- **Remotely Firmware Upgradable**
- **Multi port and Multi Protocol Support**
- **Advanced Embedded Analytics and Storage Capabilities**

Software-Defined vs. Standalone

Standalone Instrumentation



Software-Defined Instrumentation

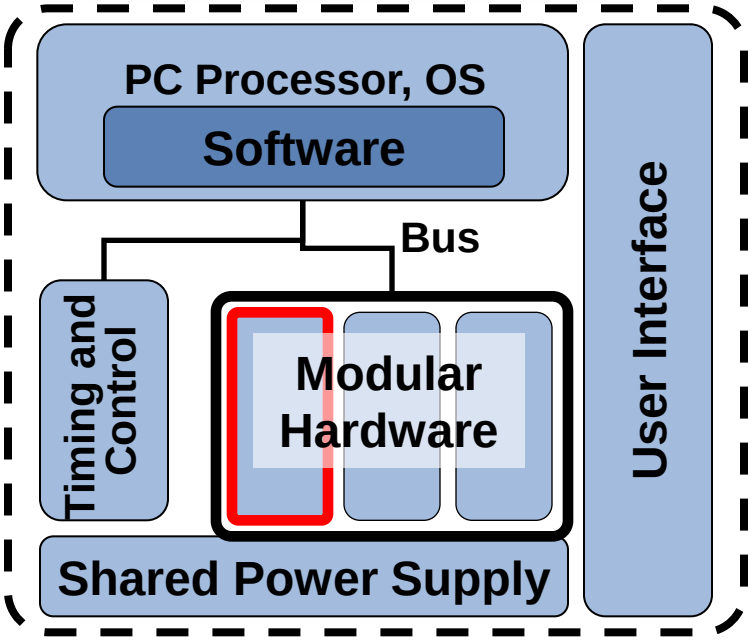
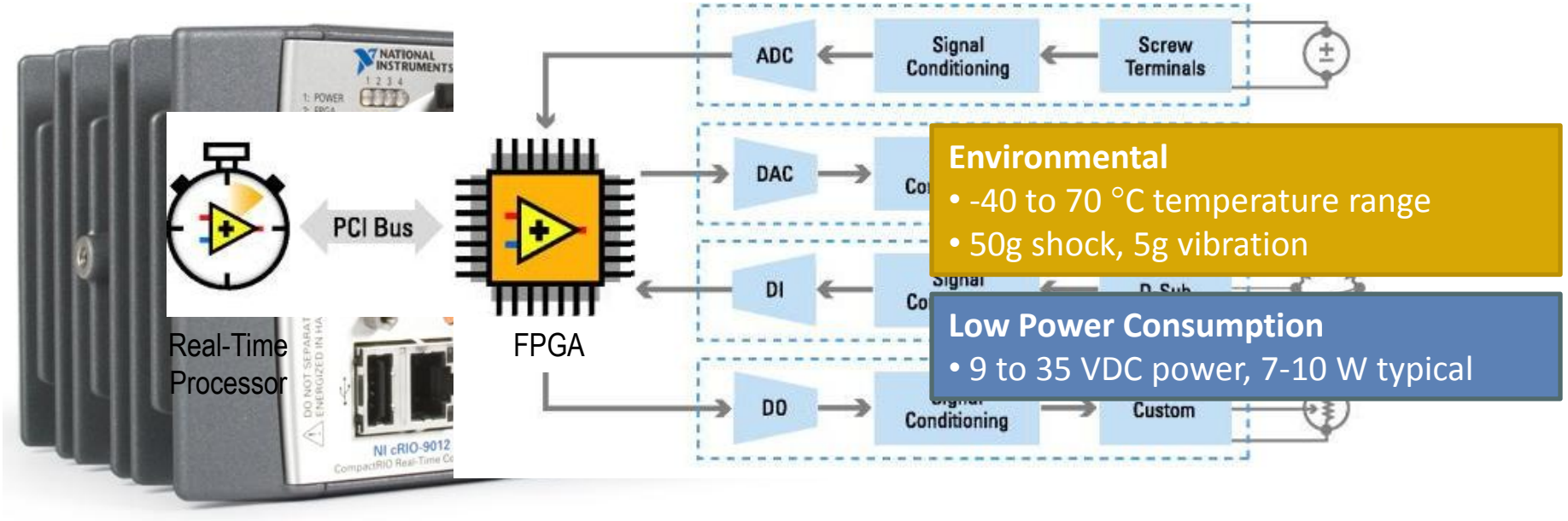


Photo Courtesy of Agilent

NI CompactRIO FPGA-based Platform



- **Reconfigurable FPGA** for high-speed and custom I/O timing, triggering, and control
- **I/O modules** with built-in signal conditioning for connection to sensors/actuators
- **Real-time processor** for reliable measurement, analysis, connectivity, and control

Electric Power Measurement Software Module

Voltage and Current	Power and Energy	Power Quality
Three Phase RMS (V and I)	Power per Phase	Voltage Sag (dip)
THD	Three Phase or Total	Voltage Swell
Harmonic (up to 64th)	Once per sec and once per cycle	Impulsive Transient (V + I)
Interharmonics (0.5 to 63.5th)	Power Factor	Oscillatory Transient (V + I)
Voltage Unbalance	Active Power Total	Overvoltage and undervoltage
Frequency Oscillation	Active Power Harmonic	Overcurrent
Flicker	Apparent Power Total	Phasor Imbalance
DC Portion	Apparent Power Harmonic	Three Phase Voltage Harmonic
	Reactive Power	Four Current Harmonic
	Reactive Power Harmonic	Harmonic per sec and per cycle
	Energy Active Total	Synchrophasor IEEE-C37.118
	Energy Apparent Total and +/-	
	Energy Reactive Total and L/C	

NI SmartGrid Analyzer ™

Applications

- *Power Quality Analyzer – IEC 61000*
- *Flicker Meter - EN 50160 / IEC 61000-5-15*
- *PMU – IEEE C37.118 (optional)*
- *Transient Analysis – 512 S/cycle*
- *Energy Metering and Power Flow Monitoring*
- *Control , Alarming, and Recording*

Features

- *Reconfigurable Real-Time Processor*
- *Multi-port & multi-protocol communication*
- *DNP3.0, Modbus RTU, and IEC Protocols*
- *GPS 1us time stamp resolution (optional)*
- *24 bits resolution*
- *4GB Storage built-in*

NI Advanced Phasor Measurement Unit

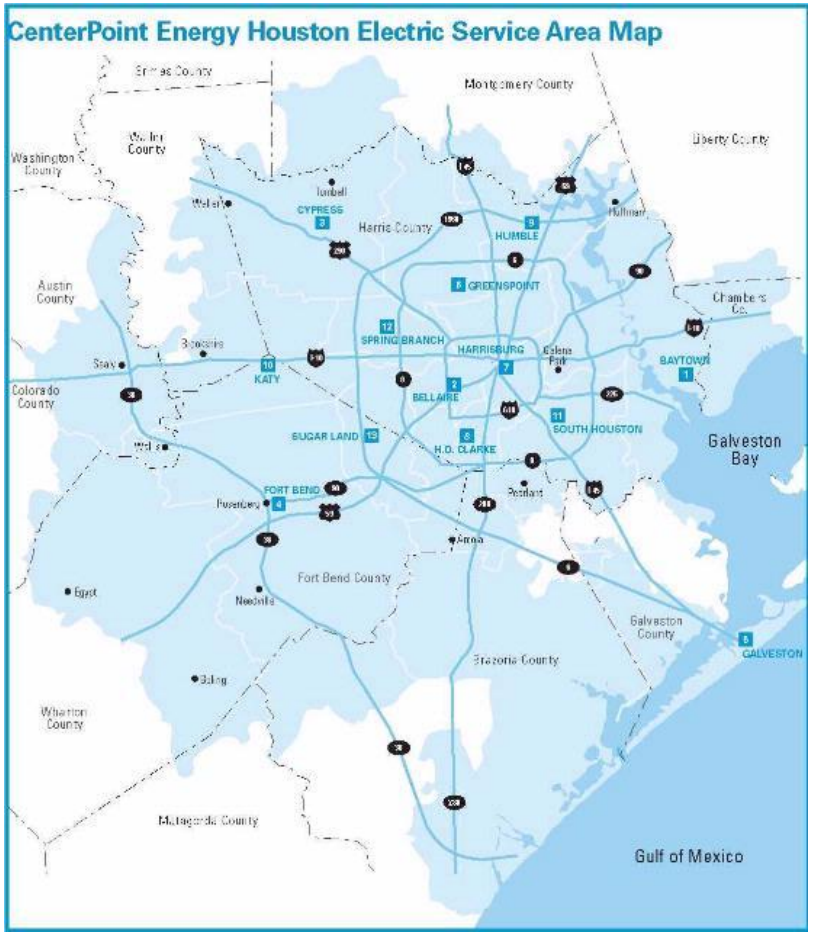
- **Multichannel Synchrophasors**
  - Expandable up to 32 channels (Voltage and Current)
  - Data/Message rates up to 240 /sec
  - IEEE C37.118
  - Stand-alone or control capable
  - Built-in or external GPS (IRIG-B)
- **Remote Firmware Upgrade**
  - HTTPS using SSL
- **Advanced Features**
  - Hybrid: PMU and Power Quality algorithms in one unit
  - Flexible open software architecture
  - Logging and event recording
    - Up to 833/1000 Samples/cycle
    - 24-bits ADC with Filtering Capabilities
    - Multi-Protocol TCP/IP, DNP3, Modbus
  - Dual-Ethernet, Serial Ports and Digital Communication
  - Built-in and expandable storage capabilities
  - Rugged Design (-40 to 70 C)

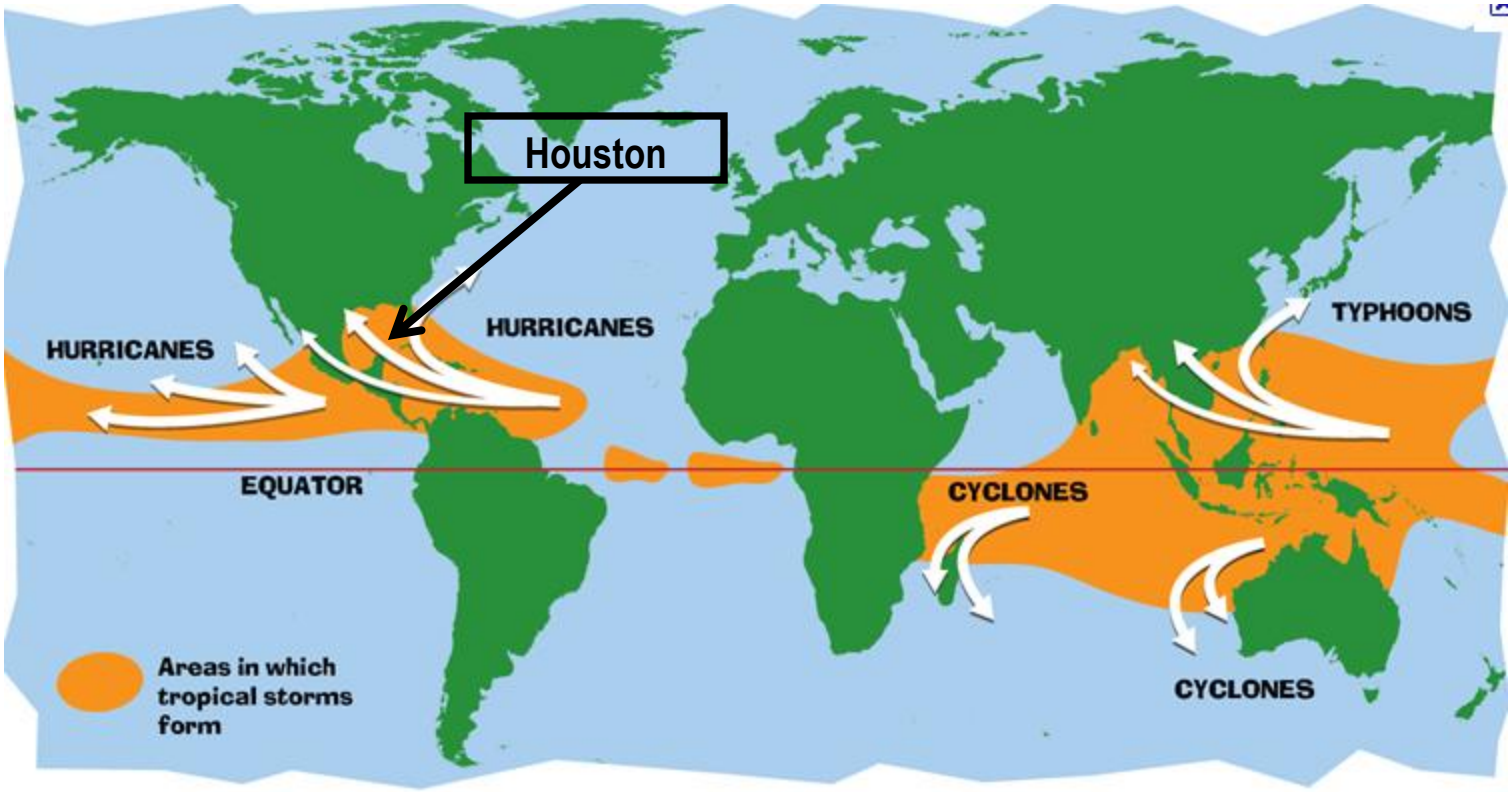
Smart Grid Implementation Example

CenterPoint® Energy

Houston, Texas

4th Largest City in the U.S.




Houston
HURRICANES
HURRICANES
TYPHOONS
EQUATOR
CYCLONES
CYCLONES
Areas in which tropical storms form

Centerpoint Energy Smart Grid Goals (3 R's)

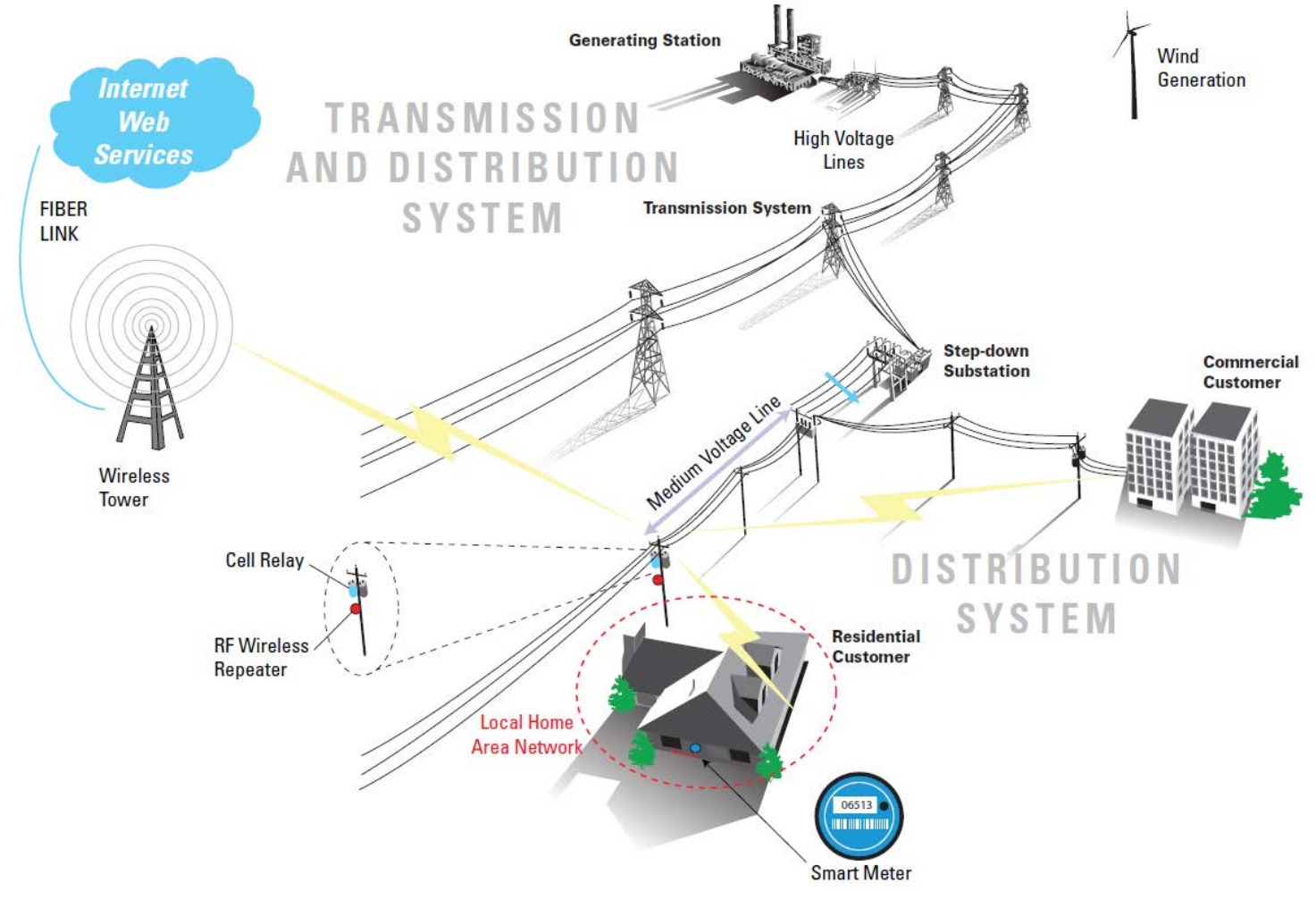
Resilient

Reliable

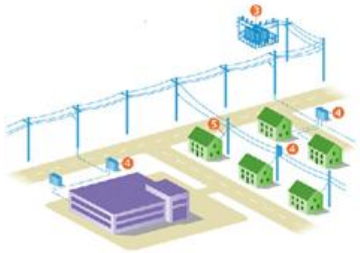
Restore

Secure

Centerpoint Energy Grid Architecture



Smart Switch



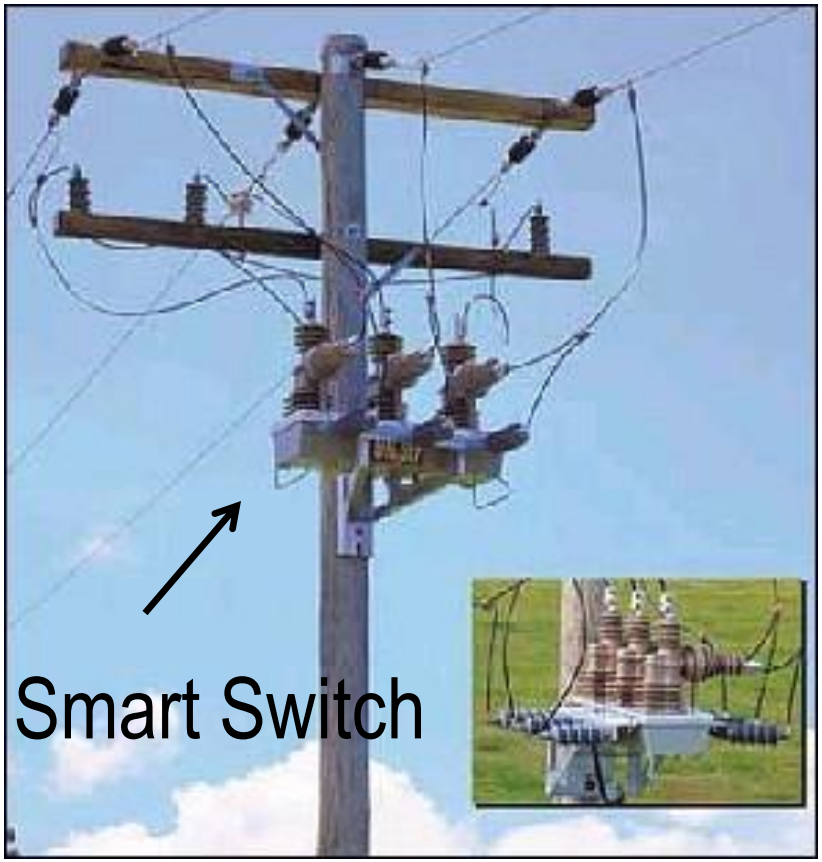
Reliability and System Efficiency

Distributed Sensing

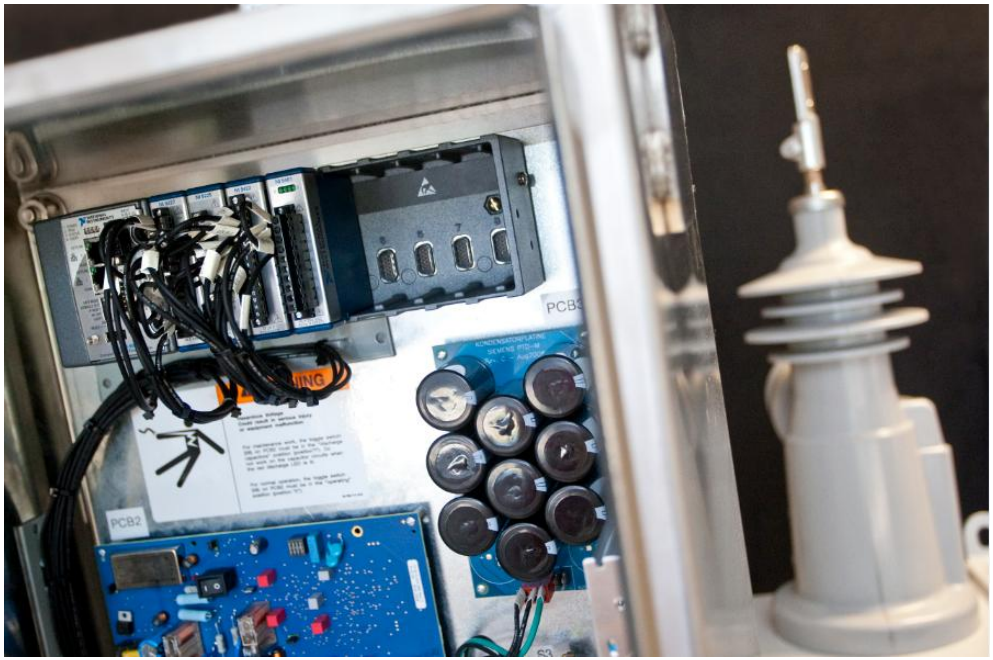
Self Healing

Distribution Automation

Fault Location / Anticipation



Smart Switch



SIEMENS

- **NI-SGA brings advanced capabilities to Siemens SDR enclosure controller**
  - *Analytics + Switch Functionality*
  - *With optional future upgrades*

Lockheed Martin - Microgrids

Island Interconnected Microgrids

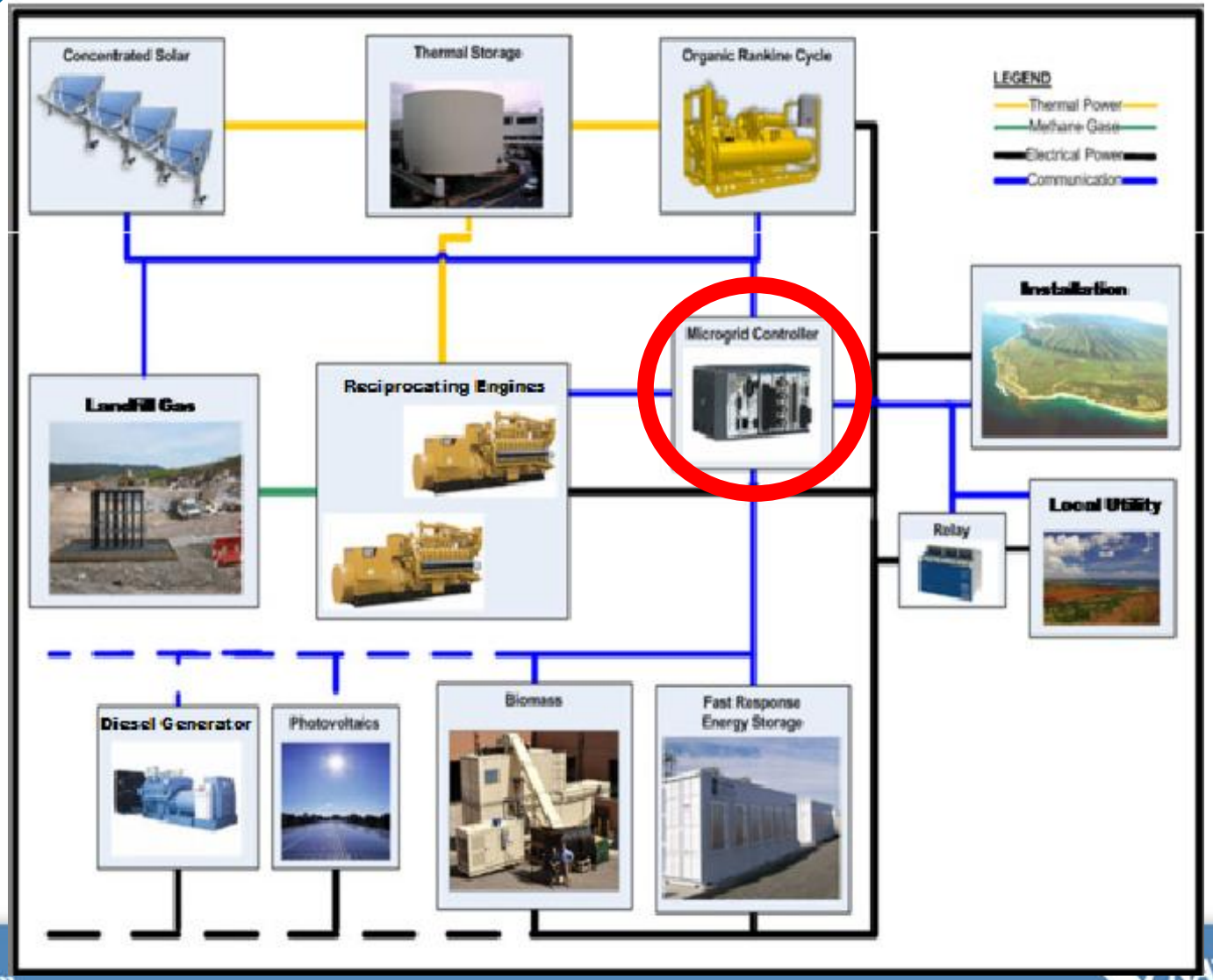
Customer's Goals:

1. **Supply renewable energy to the island to meet demand**
2. **Plug-and-play Research Test bed to Demonstrate Close to Market DER/renewable energy technology**

- 200kW – 1.5MW
- Microgrid Control Station
- Smart meter at each end user
- Additional interfaces for test bedding
- Interfaces for future adjacent grids
- Remote monitor/control of each source
- Sized for future growth in capacity
- Overhead and underground transmission

Design, Build, Own, Operate, Maintain Microgrid to Provide Power to Grid Isolated Island

Lockheed Martin – Microgrid Complexity




INDIA
States and Union Territories
N
JAMMU & KASHMIR
Srinagar
HIMACHAL PRADESH
Shimla
Chandigarh
PUNJAB
UTTARANCHAL
Dehradun
DELHI
HARYANA
PAKISTAN
CHINA (TIBET)
ARUNACHAL PRADESH
NEPAL
SIKKIM
Gangtok
BHUTAN
Itanagar
UTTAR PRADESH
RAJASTHAN
Jaipur
Lucknow
Patna
BIHAR
ASSAM
Dispur
NAGALAND
Kohima
Shillong
Imphal
MANIPUR
MEGHALAYA
Agartala
TRIPURA
Aizawl
MIZORAM
GUJARAT
Gandhinagar
Bhopal
MADHYA PRADESH
Ranchi
JHARKHAND
WEST BENGAL
Calcutta
MYANMAR
CHHATTISGARH
Raipur
DIU
DAMAN
DADAR & NAGAR HAVELI
MAHARASHTRA
Mumbai (Bombay)
ORISSA
Bhubaneshwar
BANGLADESH
Hyderabad
ANDHRA PRADESH
YANAM (Pondicherry)
ARABIAN SEA
Panaji
GOA
BAY OF BENGAL
KARNATAKA
Bangalore
Chennai (Madras)
PONDICHERRY (Puduchchery)
KARAIKAL (Pondicherry)
LAKSHADWEEP
MAHE (Pondicherry)
TAMILNADU
KERALA
Port Blair
ANDAMAN & NICOBAR ISLANDS
Thiruvananthapuram
Map not to Scale
Copyright (C) Mapience India Limited 2001

United States has Electrical Losses of 6.5%

(Difference Between Electricity Generated and Electricity Billed)

India has Electrical Losses of 35%

(Difference Between Electricity Generated and Electricity Billed)

Why is this so High?

This is a real picture!

Unmetered Usage

Bypassing the meter

Indian State - Rajasthan

Rajasthan Utility

Rajasthan is situated in the North Western part of India

Area of 342,214 sq. km

District - 32

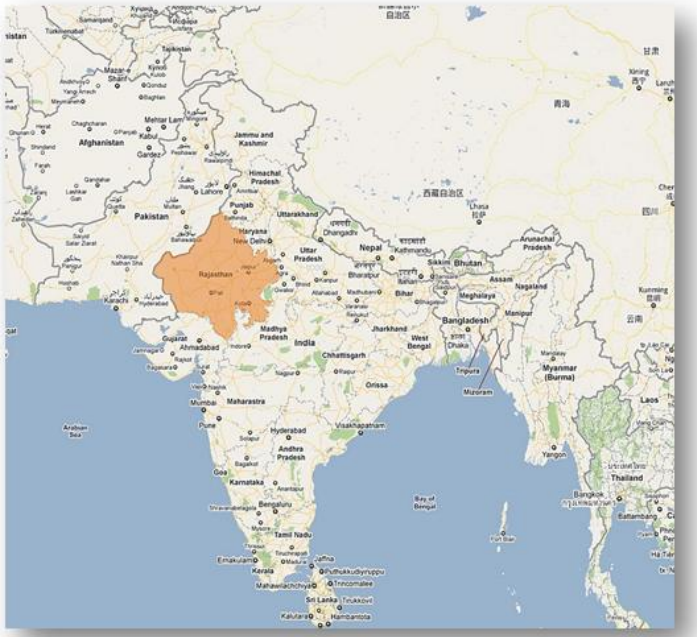
Population - 56 million

Total no of consumers – 6,701,017

Domestic consumers – 4,894,726

33kV lines (kms) – 31,560

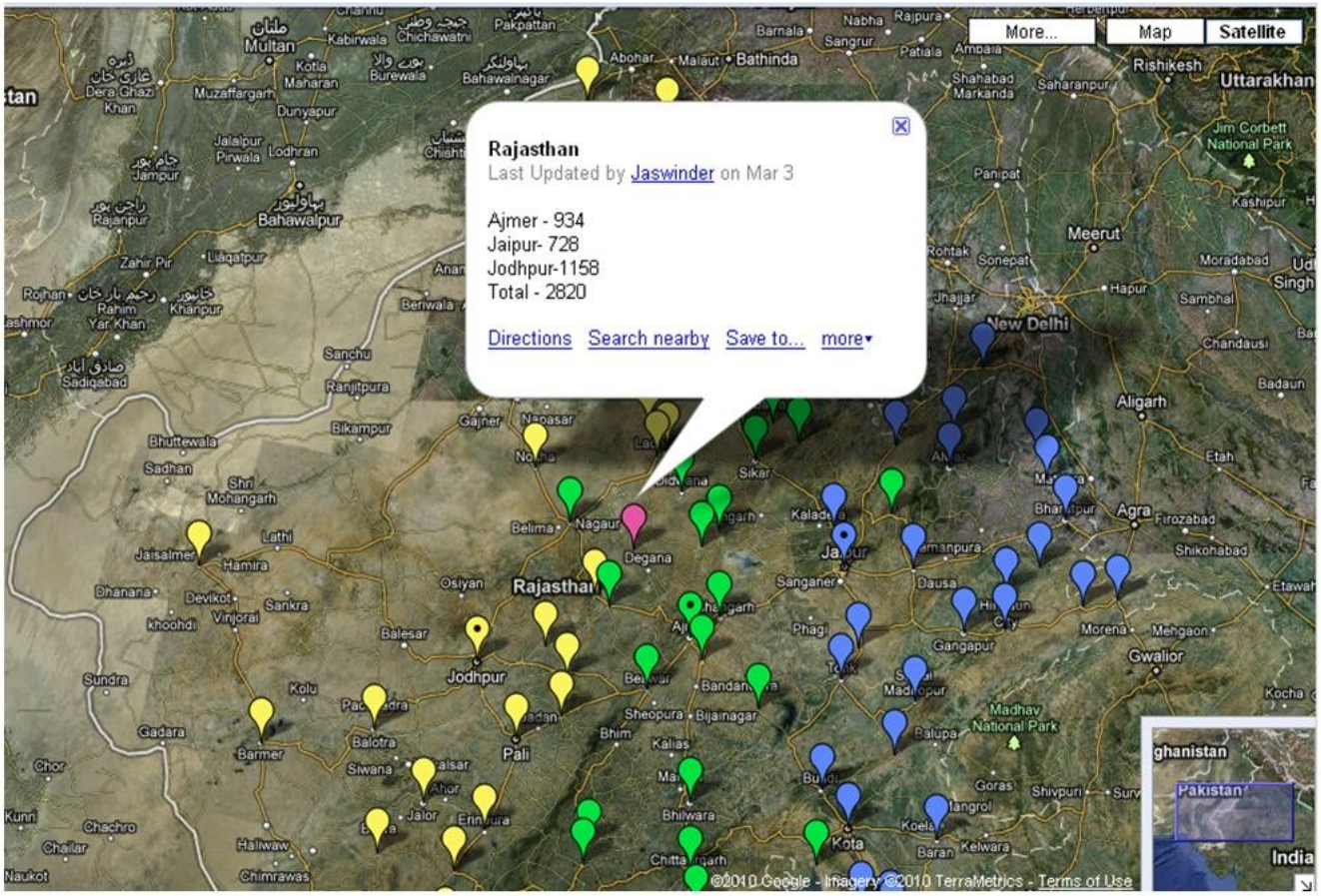
Temperature various from 5°C – 45°C



NexGEN

2820 Substations - Rajasthan

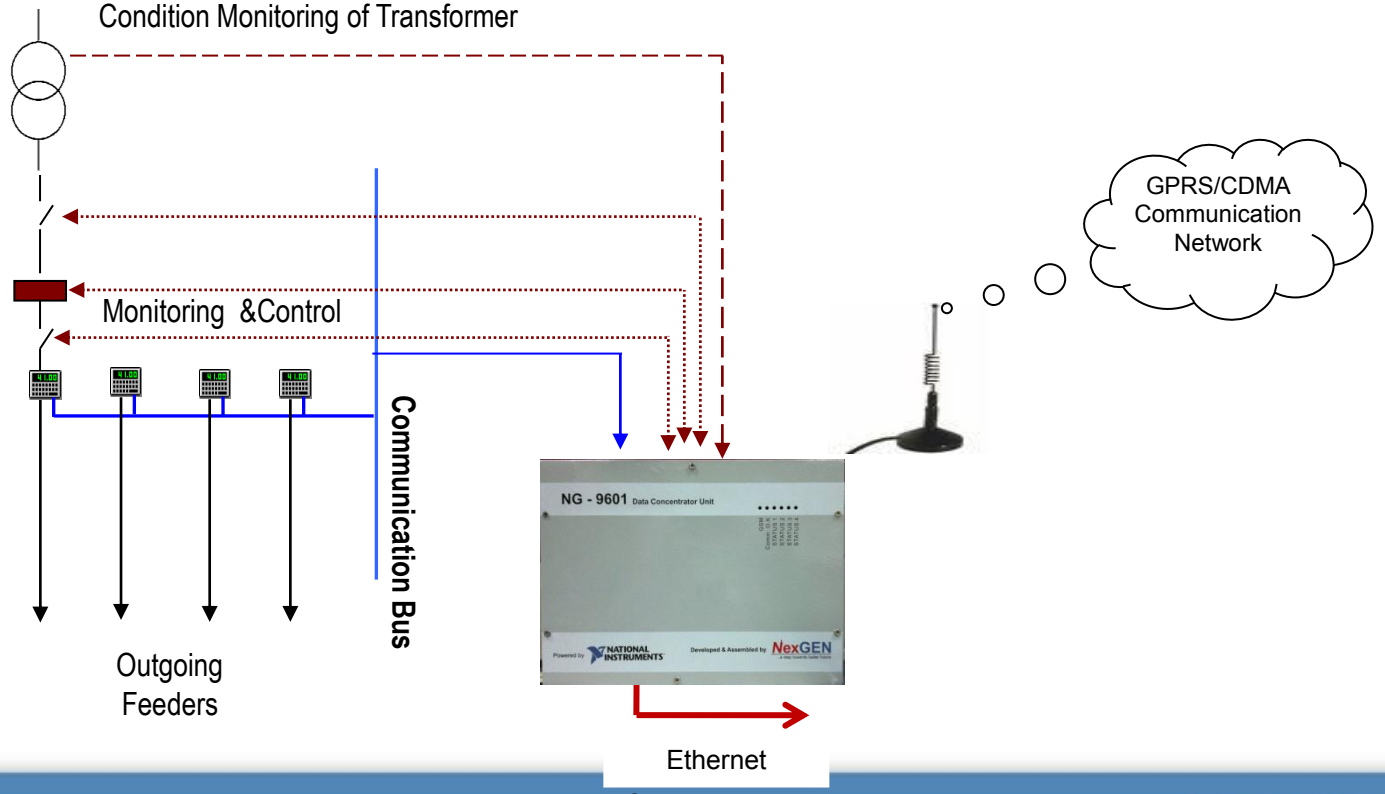
Data Concentrator Units- Installation Plan



NexGEN Consultancy Pvt Ltd
NI Week 2010-
Electrical Substation Monitoring & Control

NexGEN

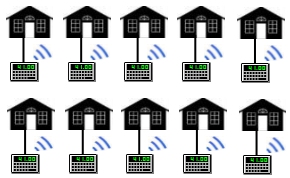
Data Concentrator Unit – Monitoring & Controlling



Data Concentrator Unit – Consumer Metering

Feeder

Service Main



Meter with Wireless Module with Wireless Interface

Zigbee Module (Router/End Device)

Zigbee Module (Coordinator)

Data Concentrator Unit

GPRS/CDMA Communication Network

Data Concentrator Unit

Daughter Card

NI Sbrio-9601

Requirements to Drive Convergence

1. High Performance Open Modular Architecture

2. Remotely Upgradable Firmware to meet Evolving Needs

3. Multi Port Multi Protocol Support to allow Insertion into Existing Infrastructure