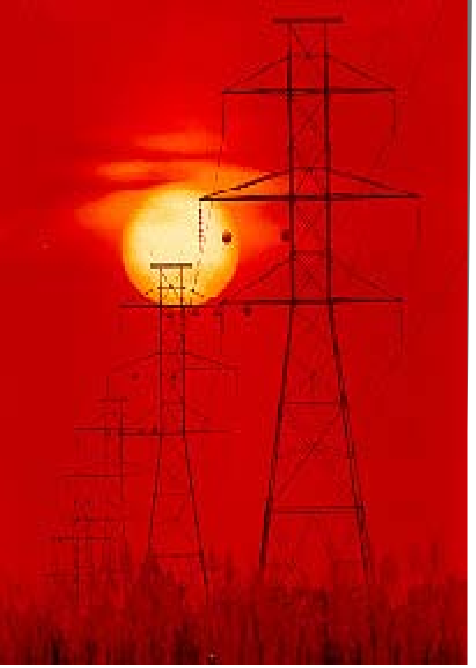

Benefits of Interoperability Using IEC Standards for DER Management

Frances Cleveland

Xanthus Consulting International

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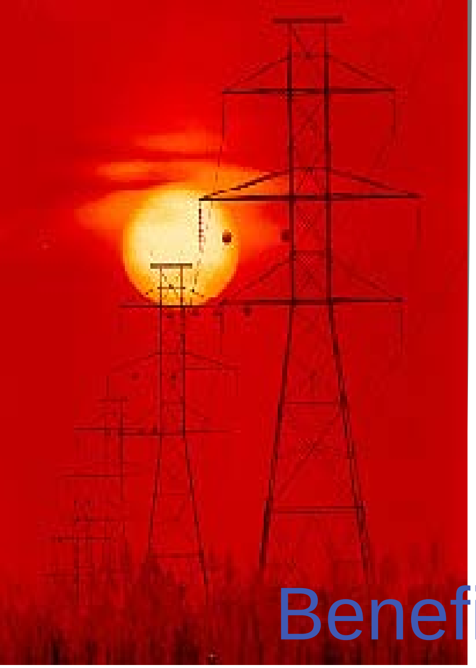
Consulting International

Topics

- Benefits of DER to stakeholders
- Benefits of Standardization
- IEC Communication Standards: IEC 61850 and IEC 61870 (CIM) for DER
- Next Steps



Benefits of DER to Utility Operations, Customers, and Society

Market opportunities, improved energy reliability, reduced environmental impacts, cost savings

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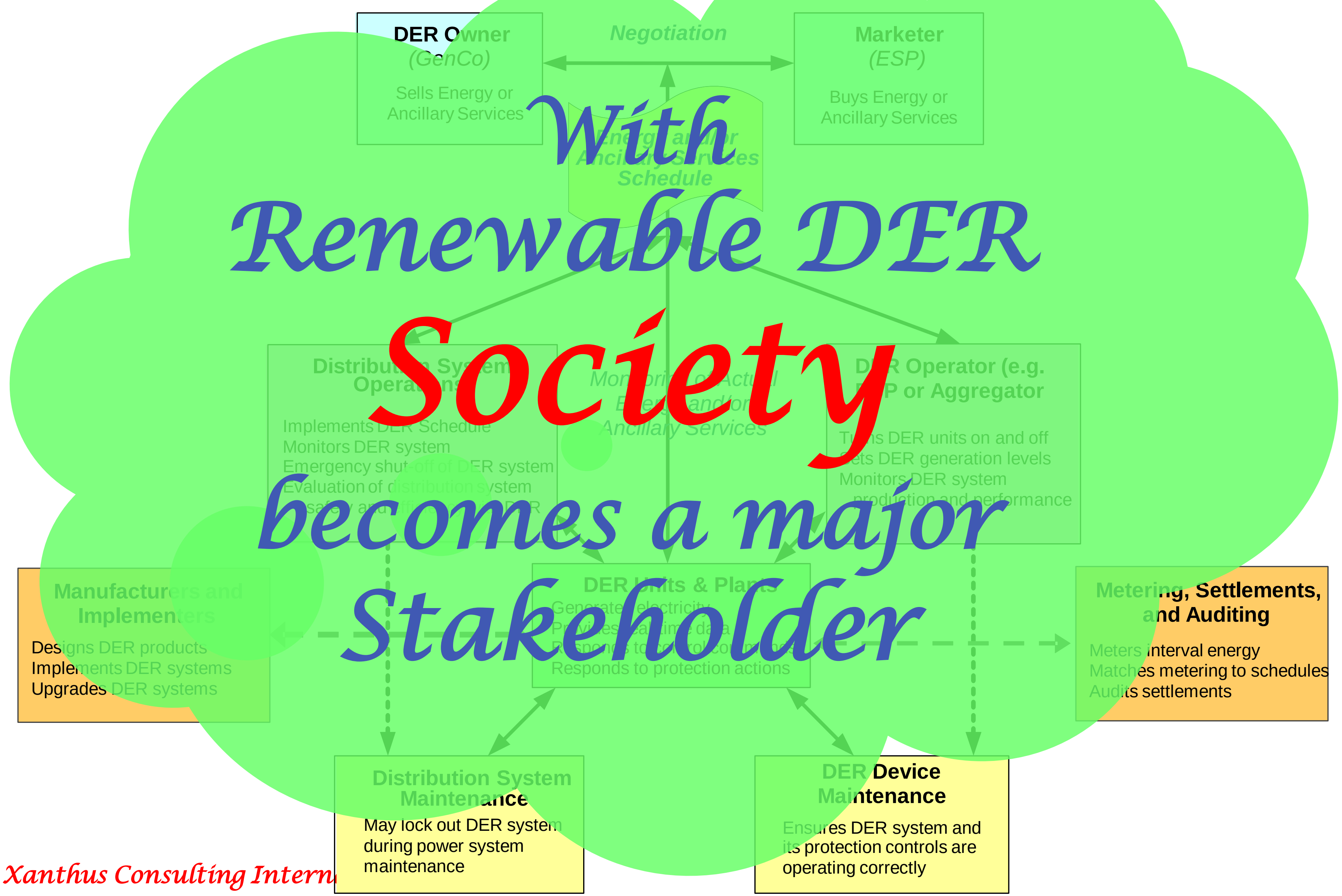
DER Stakeholders



Benefits of DER to Utility Operations #1

- **Increase generation capacity / decrease load:**
  - Provide energy to offset load within a customer site
  - Provide energy with net metering and feed-in tariffs
  - Provide energy within a substation for local generation
- **Improve energy efficiency:**
  - Provide energy close to loads, thus minimizing losses
  - Provide voltage support along feeders in place of voltage regulators, so that voltage levels from the feeder substation could be lowered, while still remaining within the nominal limits
  - Provide VAr support to improve power efficiency
  - Support load-following of local loads to improve power efficiency
  - Counteract any large non-conforming loads of the DER owner, thus providing a more stable load profile to utilities

Benefits of DER to Utility Operations #2

- **Increase reliability**
  - Provide spinning or operational reserve for local areas
  - Support intentional islanding for campuses, housing developments, and industrial/commercial areas if normal energy supply is not available
- **Decrease costs**
  - Defer construction of distribution facilities through DER generation, which acts as negative load, provides peak shaving, and supports voltage and VArs on the feeder
  - Directly control DER generation to provide peak shaving to minimize start-up of costly peaker generation
  - Use Demand Response or market incentives to increase DER generation during peak times
- **Improve power quality**
  - Provide smooth transitional VAr support in place of switched capacitor banks to minimize harmonics

Benefits of DER to Customers #1

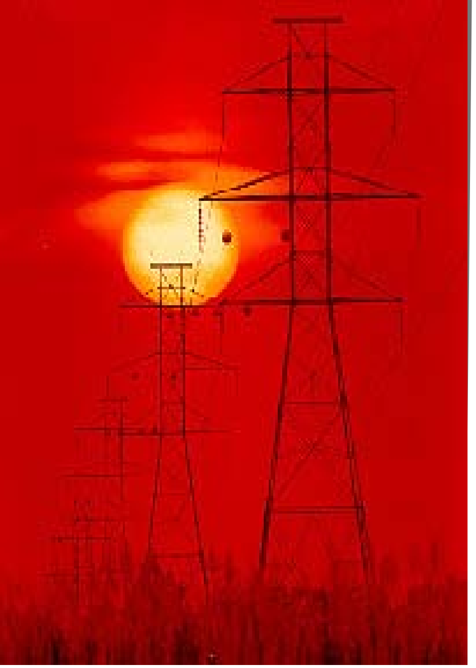
- **Provide shared cost-savings for utilities and customers**:
  - Through net metering, to reduce overall electricity usage and costs
  - Through different types of tariffs such as Demand Response
  - Directly through direct market participation and/or dynamic pricing tariffs
  - Indirectly through overall lower electricity costs due to utility gains in efficiency
- **Provide emergency backup generation**
  - Customers can install DER for emergency power to their critical loads
  - Customers can sell emergency power into a microgrid island which was formed due to a loss of utility power

Benefits of DER to Customers #2

- **Use by-products from customer industrial processes to generate and sell electricity:**
  - Use heat to generate electricity through Combined Heating and Power (CHP) systems, thus off-setting some of the customer’s costs.
  - Provide biomass as source of gas, production of hydrogen as transportable energy.
- **Participate in carbon trading:**
  - If and when carbon trading becomes a reality, customers can “trade” their low-carbon DER generation

Benefits of DER for Society

- **Minimize carbon and pollution production:**
  - Renewable DER units produce less carbon dioxide, thus helping in the battle against global climate change
  - Efficient re-use of “waste heat” or other by-products of industry improve the overall efficiency of energy usage
  - Many DER units, including burning biomass and CHP, can also minimize non-carbon pollutants
- **Meet mandated renewable portfolios:**
  - Many states have legislated renewable portfolios that mandate increasing use of renewable sources of energy. Most renewables to-date are small generators
- **Provide “green power” for socially conscious people**
  - Many people are willing to pay extra for power or to off-set their carbon “footprint”



Benefits of Standardization for Information Exchanges

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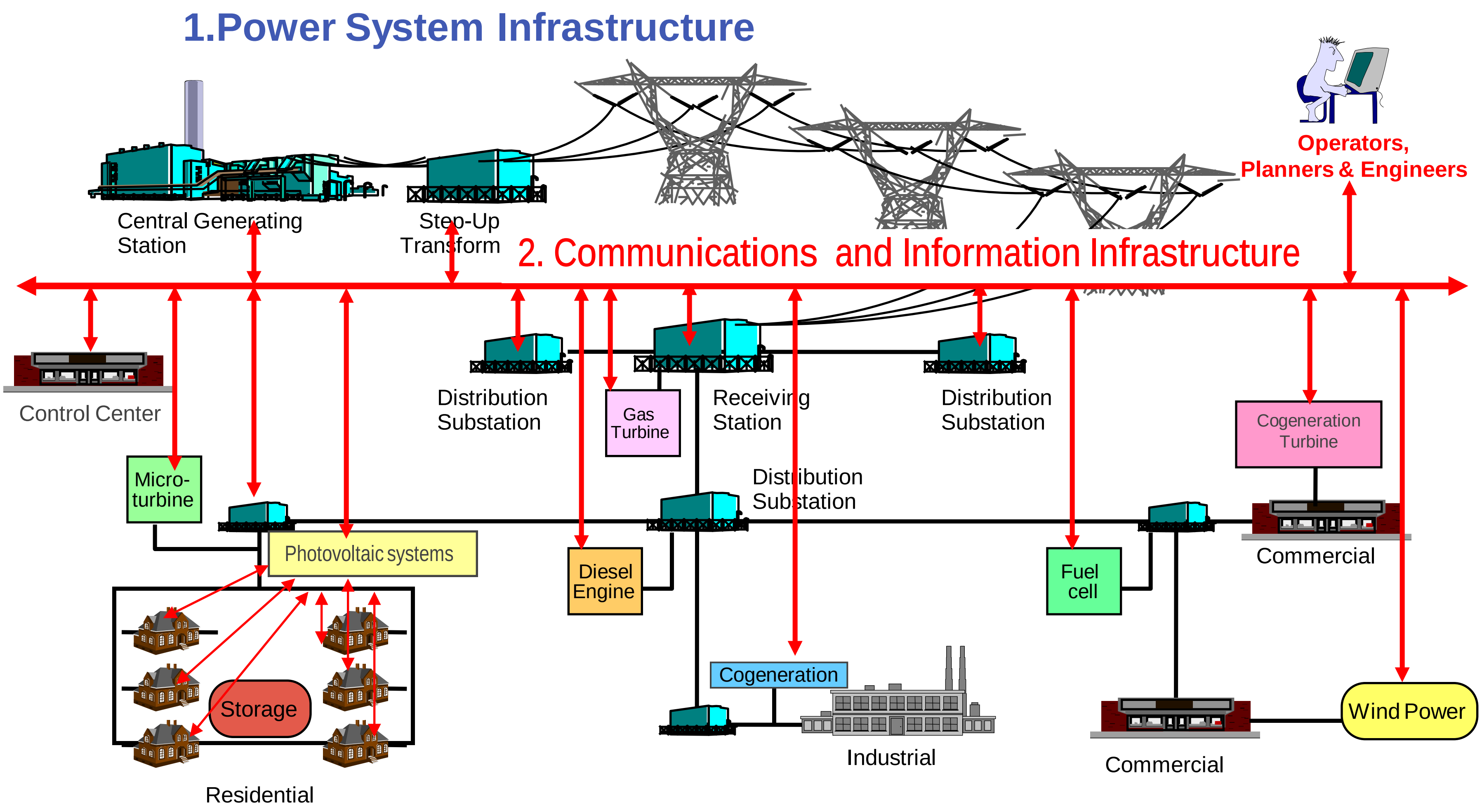
Need to manage both the power system infrastructure and the information infrastructure



Why Are Communication Standards Important?

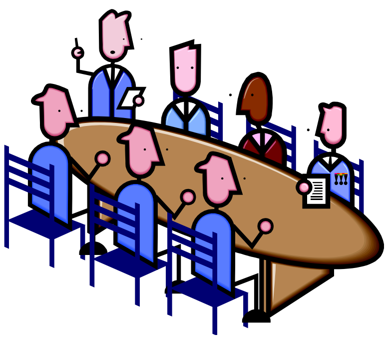
How do disparate human groups communicate with each other?

Germans sprechen Deutsch zusammen

Argentineans hablan espaňol juntos

??

English!



French people parlent le français entre eux

Martians speak ںگ♣☻∂??

English has been accepted as the common business language

Similarly, System Integration establishes common "data" languages for "interoperating" among computer systems

U.S. Senator Maria Cantwell:

"*Reducing Demand through Electricity Grid Intelligence*" Proposed Act*

- **This Act,** released April 25, 2007:
  - ***"proposes a broad and flexible definition of smart grid technology,*** *which includes*
    - ***smart metering systems,***
    - ***demand response systems,***
    - ***distributed generation management systems,***
    - ***electrical storage management systems,***
    - ***distribution automation systems, ..."***
- **Standards (Section of Senator Cantwell's Act)**
  - ***"Standard-setting provisions are considered to be vital to ensure interoperability and allow for smart appliances and equipment.*** *…*
  - ***This section insures that smart grid systems and components by different manufacturers will in fact someday be able to constitute an "electranet" (Al Gore's term) - a "community" of intelligent devices on the grid."***

* http://cantwell.senate.gov/news/Grid_White_Paper.pdf

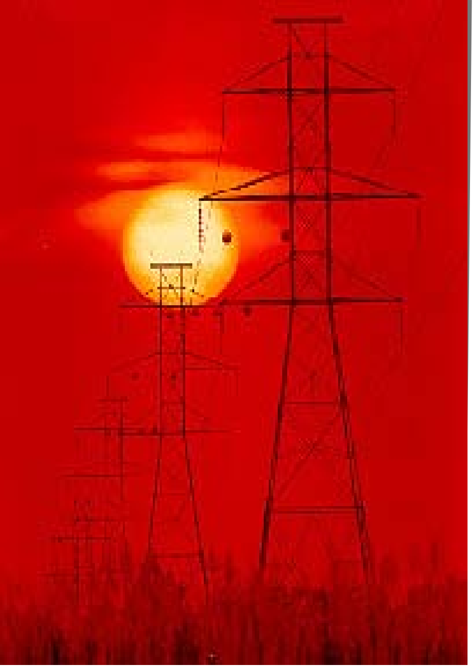
So, What's Holding Up the Standards Process?

- Separate industries:
  - Utilities, DER vendors. and Customers with DER
- DER units are relatively new forms of electric energy
  - Separate industries: DER units are typically owned by customers, not by utilities
  - No long standing history of exchanging information
  - No de facto communication protocols or generally accepted data exchanges
- Some differences of opinion between DER vendors and utilities
  - For DER vendors, utilities are viewed as delaying DER interconnections to the distribution system
  - For utilities, DER vendors are making demands on power system operations that the distribution system was not designed for
- Therefore to bridge the different industries and help establish common ground:

Internationally accepted standards are even more critical to success!!

Win-Win Situation?

- Integration of DER into power systems can be a win-win situation, if …
  - Utilities, Customers, and DER vendors understand both the **benefits** and the **challenges**
  - Electric interconnection standards are adhered to, specifically the **IEEE P1547** series of standards
  - **Computer applications** are developed to assist utilities, customers, and vendors to achieve the promised benefits
- Communication information standards are developed
  - Not only to (passively) monitor the DER units
  - But also to **manage the power system with widespread DER**



IEC Communication Standards: IEC 61850 and IEC 61970 (CIM)

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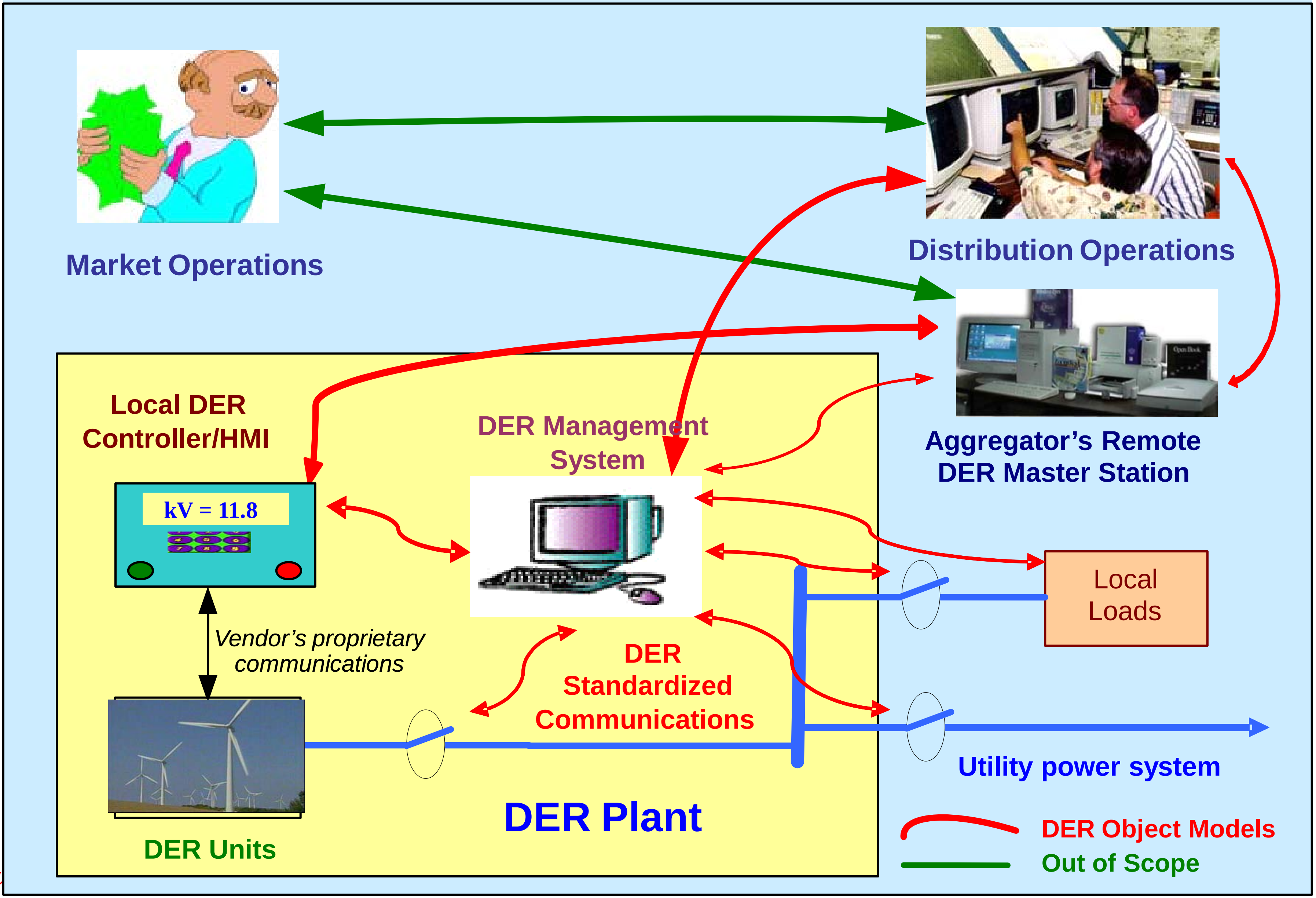
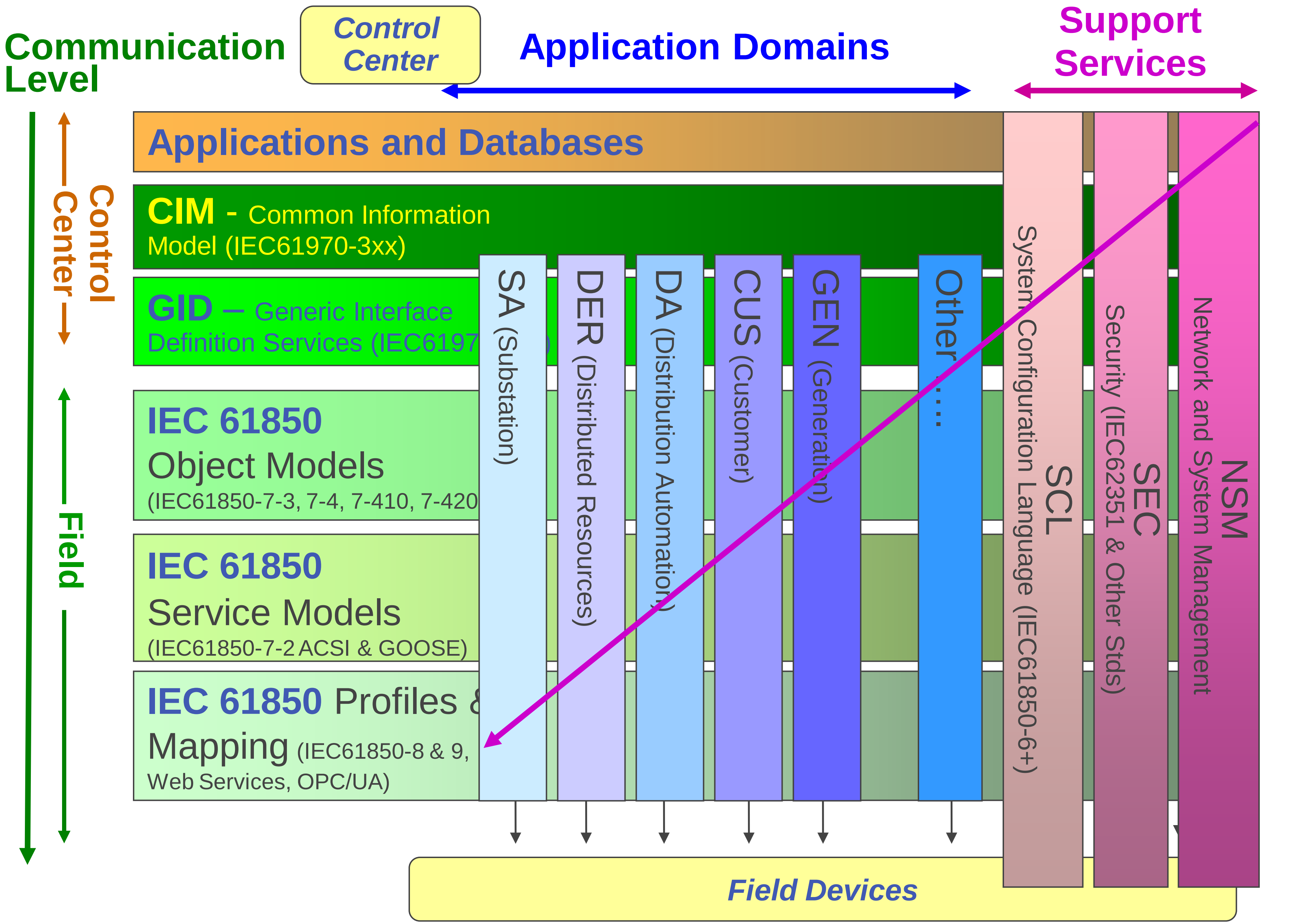
Scope of DER Information Exchanges

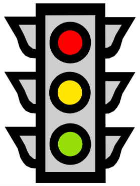


Xa

IEC 61850 Models and the Common Information (CIM) Model



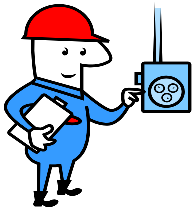
What Components are Involved in Interoperability? Similar to Any Language …



VERBS & GRAMMAR

Messaging & Security

Monitoring, Control,
Protocols, Networking



NOUNS

Data Management

Measurements, Data,
Calculations, Files, Databases

MEDIA

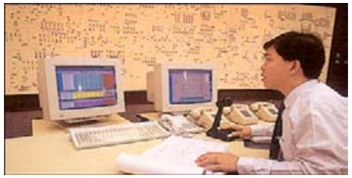
Communications Media

Fiber optics, Wireless, BPL,
Cellphone, Internet, LANs

USERS

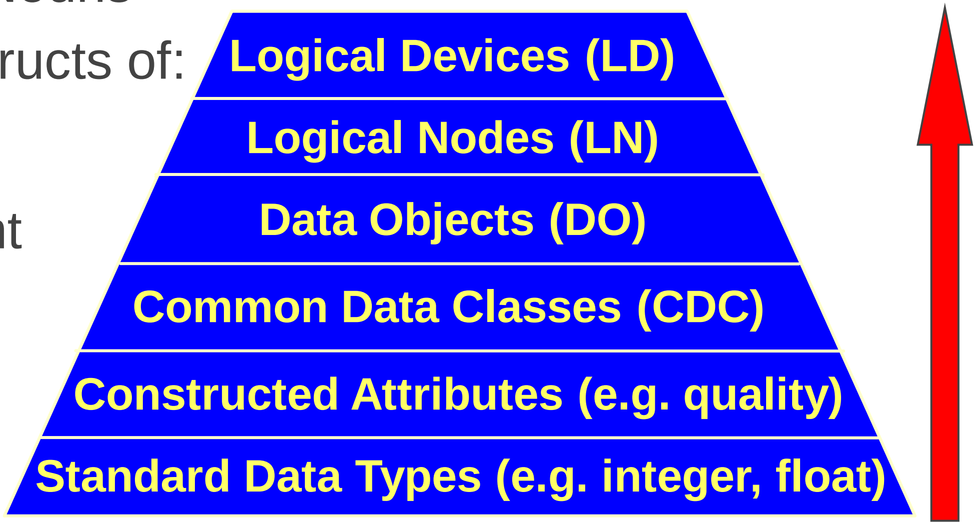
Computer Applications

Alarms, Analyzes ,
Displays, Stores data



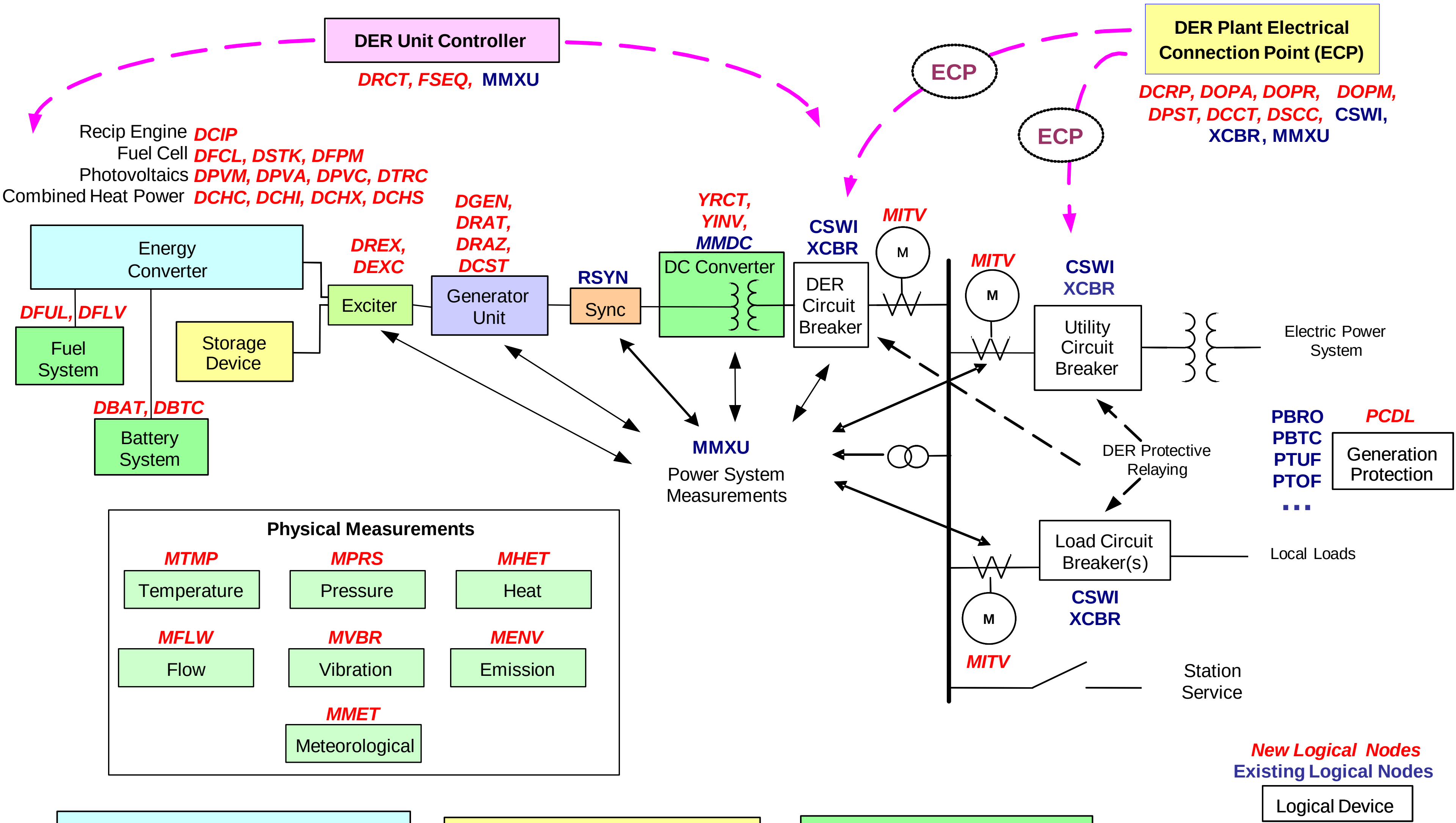
IEC 61850-7-420 for DER Models

- IEC 61850-7-420 for DER
  - Addresses only abstract “Nouns”
  - Uses the IEC 61850 constructs of:



- Covers:
  - General DER management
  - Photovoltaic systems
  - Fuel cells
  - Diesel generation
  - Combined heat and power
  - Wind power is handled separately (IEC 61400-25)
- IEC 61850-7-2, plus mappings, cover the “verbs”
  - Services define when and how to exchange messages
  - Mappings convert abstract standards to “bits and bytes”

Overview: Logical Devices and Logical Nodes for Distributed Energy Resource (DER) Systems



Energy Converter = Microturbines, Fuel Cell, Photovoltaic System, Wind turbines, Diesel Generators, Combustion Turbines

Storage Device = Battery, Pumped Hydro, Superconducting Magnetic Energy Storage, Flywheels, Micro - flywheels

Converter = DC to AC, frequency conversion, voltage level conversion

Auxiliaries = Battery, Fuel Cell

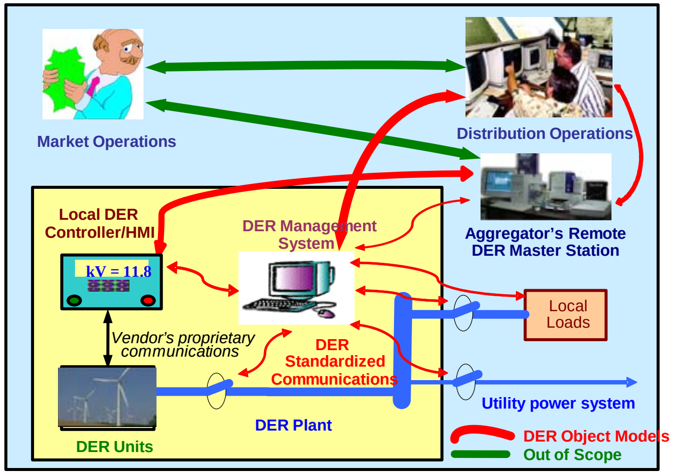
Example of (part of) DGEN Logical Node

<table>
<tr><td colspan="5">Status information</td></tr>
<tr><td>GnOpSt</td><td>INS</td><td>Generation operational state:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not operating</td></tr>
<tr><td>1</td><td>Operating</td></tr>
<tr><td>2</td><td>Starting up</td></tr>
<tr><td>3</td><td>Shutting down</td></tr>
<tr><td>4</td><td>At disconnect level</td></tr>
<tr><td>5</td><td>kW ramping</td></tr>
<tr><td>6</td><td>kVar ramping</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>GnSync</td><td>INS</td><td>Generator is synchronized to EPS, or not</td><td></td><td>O</td></tr>
<tr><td>ParlSt</td><td>SPS</td><td>Paralleling status:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>Paralleling</td></tr>
<tr><td>False</td><td>Standby</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>DroopV</td><td>SPS</td><td>Voltage droop status:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>Droop enabled</td></tr>
<tr><td>False</td><td>Droop not enabled</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>RampLod
Sw</td><td>SPS</td><td>Ramp Load/Unload Switch:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>Ramp load</td></tr>
<tr><td>False</td><td>Ramp unload</td></tr>
</table></td><td></td><td>O</td></tr>
</table>

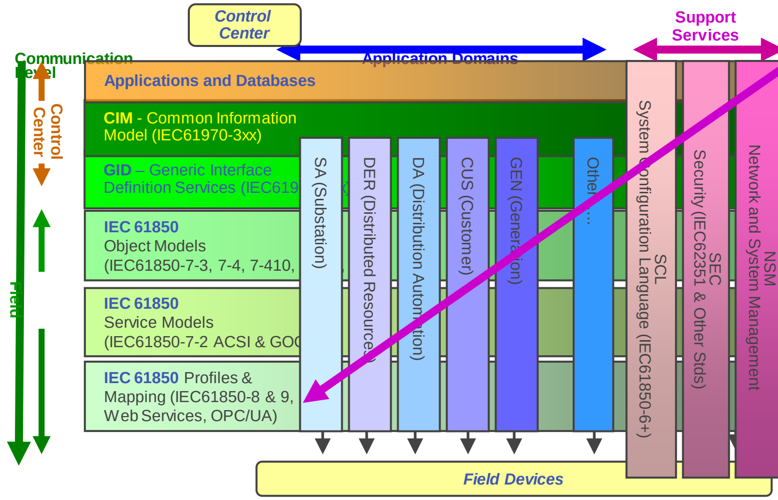
Next Steps

- Finalize IEC 61850-7-420 by mid-2008
- Address the "verbs" issues:
  - MMS-based?
  - Web services based?
  - Both, depending upon requirements?
- Conformance testing requirements
  - Pilot implementations
  - Interoperability testing
- Determine what DER aspects should be modeled in CIM
  - Distribution power system configurations with DER
  - Distribution Management Systems
- Undertake models of additional DER types
  - Energy storage?
  - Plug-in electric vehicles?
  - Biomass?
  - ??

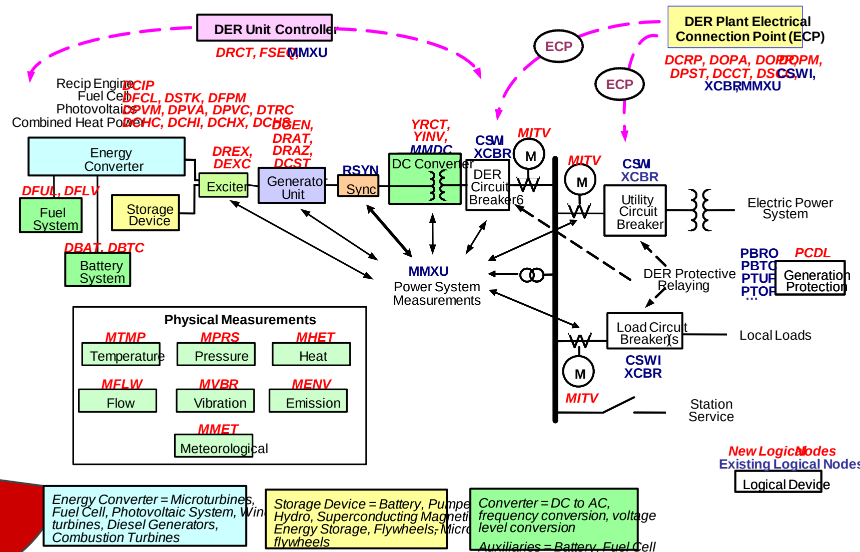
Questions?



Market Operations
Distribution Operations
Aggregator's Remote DER Master Station
Local DER Controller/HMI
kV = 11.8
DER Management System
Local Loads
Vendor's proprietary communications
DER Standardized Communications
Utility power system
DER Plant
DER Units
DER Object Models
Out of Scope



Control Center
Application Domains
Support Services
Communication Level
Control Center
Field
Applications and Databases
CIM - Common Information Model (IEC61970-3xx)
GID – Generic Interface Definition Services (IEC619
IEC 61850 Object Models (IEC61850-7-3, 7-4, 7-410,
IEC 61850 Service Models (IEC61850-7-2 ACSI & GOO
IEC 61850 Profiles & Mapping (IEC61850-8 & 9, Web Services, OPC/UA)
SA (Substation)
DER (Distributed Resources)
DA (Distribution Automation)
CUS (Customer)
GEN (Generation)
Other …
SCL System Configuration Language (IEC61850-6+)
SEC Security (IEC62351 & Other Stds)
NSM Network and System Management
Field Devices



DER Unit Controller
DRCT, FSEQ MMXU
DER Plant Electrical Connection Point (ECP)
DCRP, DOPA, DOPR, DOPM, DPST, DCCT, DSCC CSWI, XCBR MMXU
ECP
ECP
Recip Engine
Fuel Cell
Photovoltaics
Combined Heat Power
DCIP
DFCL, DSTK, DFPM
DPVM, DPVA, DPVC, DTRC
DCHC, DCHI, DCHX, DCHB
Energy Converter
DREX, DEXC
Exciter
DGEN, DRAT, DRAZ, DCST
Generator Unit
RSYN
Sync
YRCT, YINV, MMDC
DC Converter
CSWI XCBR
DER Circuit Breaker
MITV
CSWI XCBR
Utility Circuit Breaker
Electric Power System
DFUL, DFLV
Fuel System
Storage Device
DBAT, DBTC
Battery System
MMXU
Power System Measurements
DER Protective Relaying
PBRO PBTC PTUF PTOF
PCDL
Generation Protection
Load Circuit Breakers
CSWI XCBR
Local Loads
Station Service
Physical Measurements
MTMP
Temperature
MPRS
Pressure
MHET
Heat
MFLW
Flow
MVBR
Vibration
MENV
Emission
MMET
Meteorological
New Logical Nodes
Existing Logical Nodes
Logical Device
Energy Converter = Microturbines, Fuel Cell, Photovoltaic System, Wind turbines, Diesel Generators, Combustion Turbines
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