NREL Smart Grid Educational Series
March 9, 2016

- Secure & Reliable Grid Integration of DERs
- CAISO Communication via a RIG for IPPs

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DCSystems

RT|SES Real-Time Smart Energy Suite™

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- Douglass (Doug) Campbell
- President and CEO, DC Systems
- Technologist
- 35-year Industry Veteran

- A software company located in Redwood City, CA (Silicon Valley)
- 26-year history providing distributed intelligence monitor and control systems to the energy industry
- RT|SES Real-Time Smart Energy Suite
- Software solutions for Renewable Energy Control, Energy Storage, Grid Interconnection, Plant/Utility SCADA, Substations, and Enterprise Grid Service Bus

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The Changing Grid

A Radical Transformation

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The Grid: A Historical Perspective - 1990

- Vertically integrated silos
- Single vendor for SCADA, communication, RTUs
- Issues
  - Custom software, special for each utility
  - Legacy architecture from 1970s – 1980s
  - Relied on long careers of power system engineers

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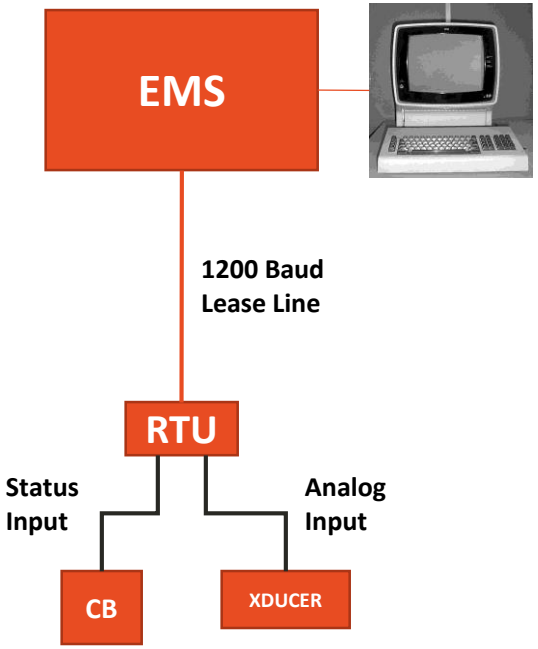
The Legacy Utility



The Grid Today

- Relatively small number of large power plants
- Transmission lines
- Substations
- Distribution lines
- Primarily unidirectional energy flow

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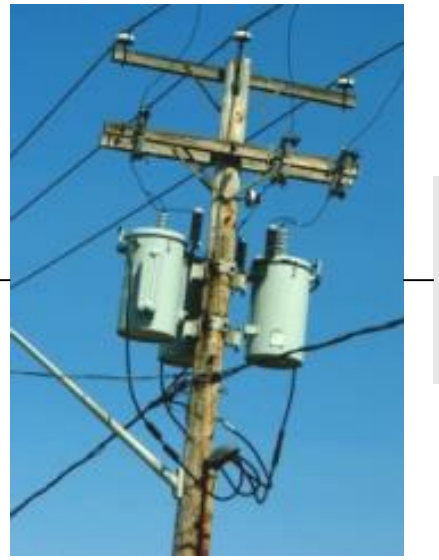
The Grid Today



Generation Transmission Distribution Consumption

ENERGY FLOW

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The Smart Grid

- Distributed generation
- Micro Grids
- Plug-in electric vehicles
- Energy storage
- Commercial and residential solar
- An interconnected “mesh”

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What is changing?

- Amount of data
- Timeliness of the data
- Location of data in the grid
- Acquire data using appropriate protocol
- Analyze the data in real-time
- Understand the business level content of the data
- Transport and feed data to other systems
- Act on the data at the right place at the right time

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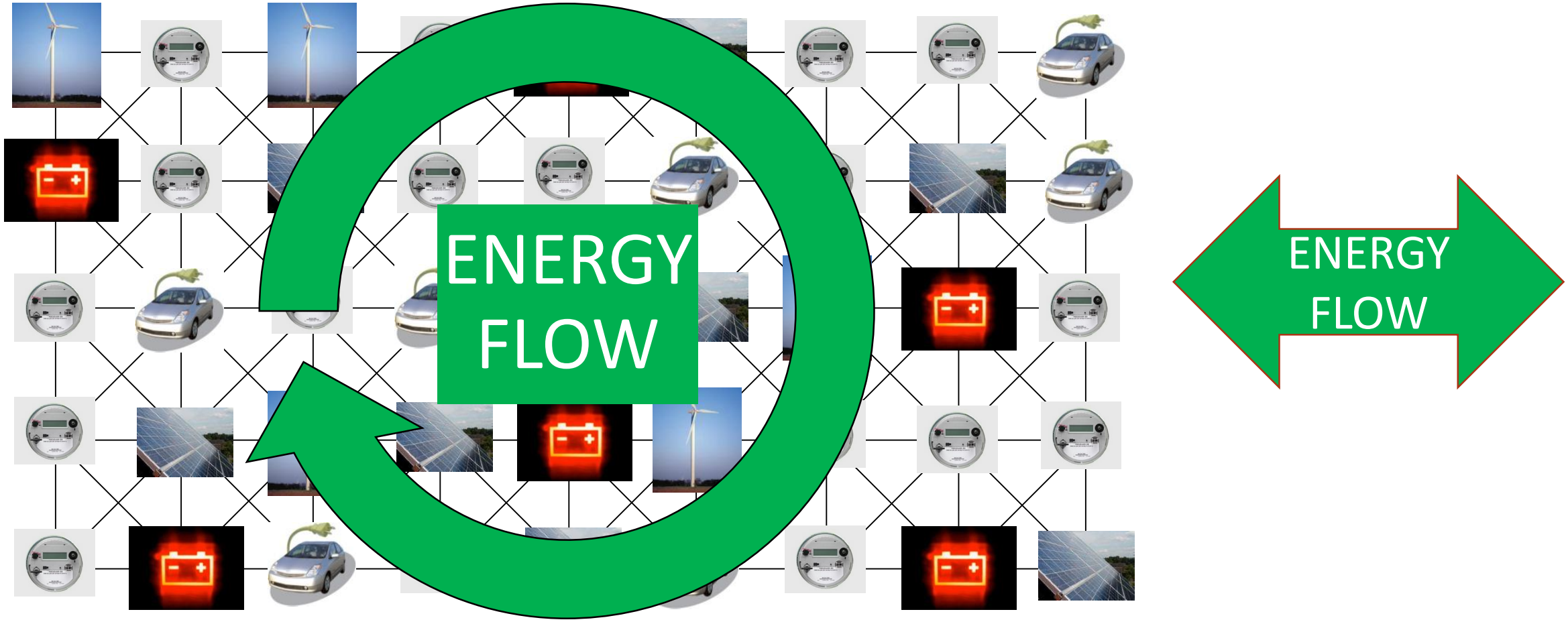
The Grid Tomorrow



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Connecting to the New Grid

Structure and Concepts for Reliable and Secure Interconnection

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The traditional centralized architecture approach will not work

Distributed Intelligence is the <u>only</u> Viable Architecture

- Tremendous increase in the volume of data
- Yesterday's systems were not designed to handle this amount of data
- Why the architecture must be distributed
  - Given the volume of data and the response time needed to control the dynamically changing grid, there is not enough time to transport the data to a central location, make a decision and return a control command.
  - Grid must be able to analyze data, make decisions, and take control action, *at multiple levels*, even when the communication lines are down.
  - Increasing amounts of renewable energy is being integrated at the medium and low voltage levels
    - The substation must now be empowered to make decisions for local load balancing
  - Security
    - By keeping the control broken down into individual, primarily isolated "nodes", the strategic importance of each unit of distributed data is less to a hacker than a large central repository.

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Viable Smart Grid Architecture

- Distributed Intelligence
  - Too much data to have all of it transported to a central location
  - Not enough time for round trip decision making
  - MicroGrids need to be able to operate during communication outages
  - Pass selected values and present operational results to central location
- Centralized Coordination
  - Overall decision making at a central location
  - Pass operational parameters to MicroGrids
- Centralized Configuration, Administration and Monitoring of distributed nodes

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New Grid Architecture

- Layered
- Distributed computing and data storage
- Standardized data interfaces (vendor agnostic)
- Needs to provide interoperability at the business process level, not just the semantic interface standard and lower layers
  - Across a single protocol – different vendors implement data on the protocol in different ways
  - Across protocols – acquire data using one protocol, pass to another system using a second protocol
  - Across data models – acquire data using one data model (e.g. 61850) and serve data to higher level systems using another (e.g. CIM)

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Challenges Facing Utilities/Owners/O&M

- Data integration and scalability
  - It's a multi-vendor world
  - Integrating best-in-breed technologies from multiple vendors, using multiple protocols and multiple data models
  - Scaling from pilot to production across an entire portfolio

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Challenges Facing Utilities/Owners/O&M

- Exponential amounts of new data
  - Cannot be controlled by a centralized system in real-time
  - Requires distributed intelligence
  - Local control with centralized coordination
- Same model applies to utilities, owners, and O&M companies

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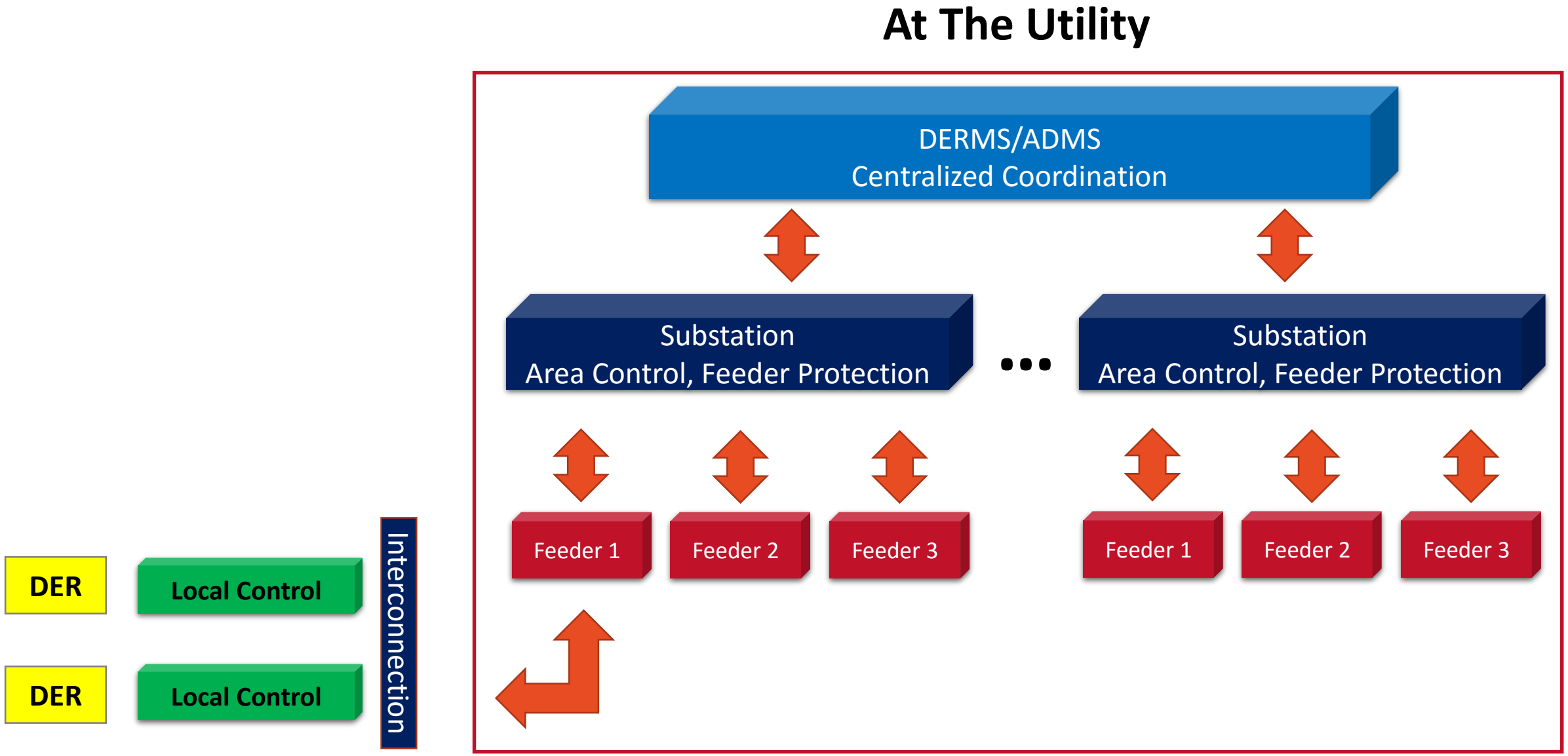
A Layered Approach



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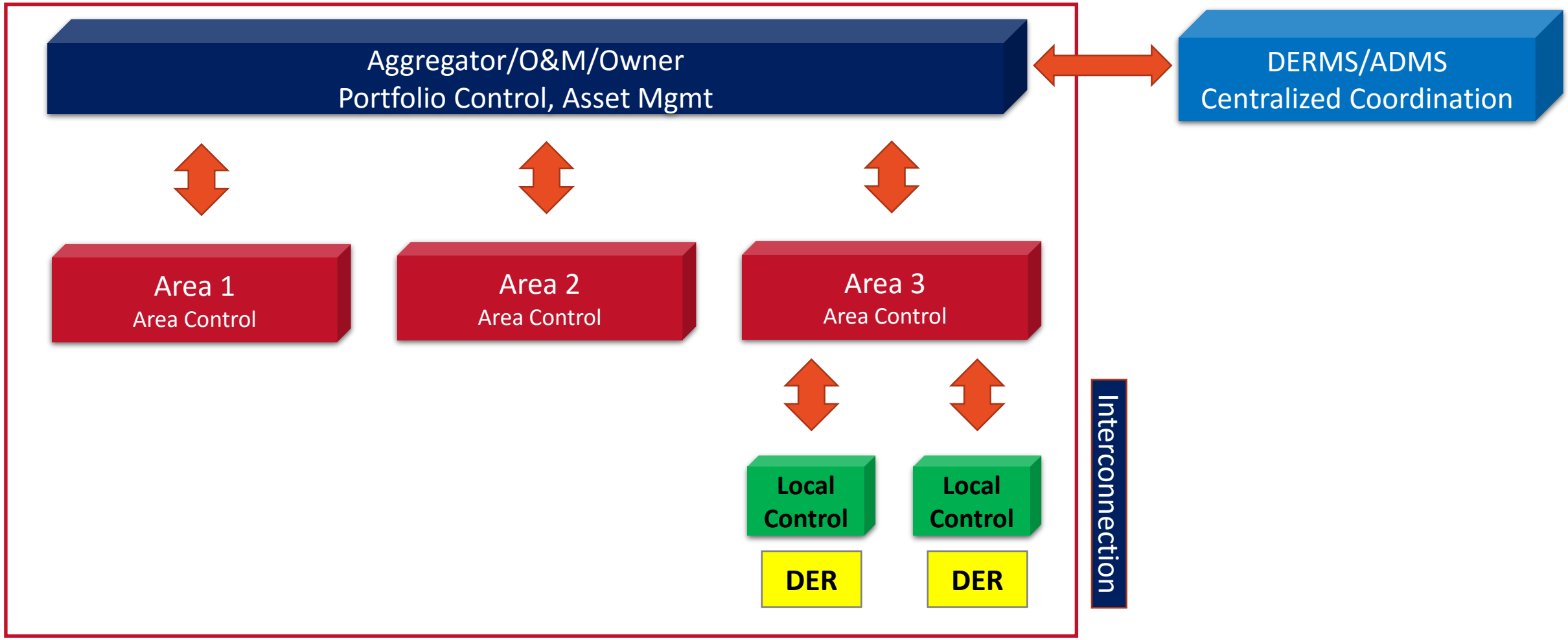
A Layered Approach

At The Aggregator/O&M/Owner



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Recommended Best Practices

- Take a hierarchical, multi-tier approach
  - Local controllers at each renewable energy/DER site
  - Area controllers for aggregation at substation or geographic area
  - Centralized interface to higher level systems (ADMS, DERMS, etc.)

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Recommended Best Practices

- Concentrate and reduce data at each level
  - Control at each local site
  - Pass <u>operational</u> <u>results</u> to Area Controllers
  - Perform aggregation at the area level
  - Pass <u>aggregation</u> <u>results</u> to central systems
  - Pass <u>operation</u> <u>parameters</u> from central to area/local levels

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Challenge

Integrate many different devices from different vendors, including energy storage

Control your plant in an economically optimized and regulatory compliant way

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RT|DECS Real-Time Distributed Energy Control System

- Utility-grade on-site control system
  - Device and vendor agnostic
  - Integrate inverters, trackers, met stations, soiling systems, string monitoring and energy storage
  - Interconnection substation data and control
  - HMI and alarming
  - Remote connectivity and alerting
  - Historian – Local with feed to central

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RT|DECS Real-Time Distributed Energy Control System

- Real-time control
  - Start-up/Shutdown
  - Ramping
  - VAR/pF control
  - Back-up generator control
  - Tracking system interface
  - Curtailment

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- Don’t lose money during curtailment!
  - Integrate energy storage
  - Charge batteries with excess output during curtailment
  - Extend plant output into evening hours
  - Be a solution for the “duck” curve

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RT|DECS Real-Time Distributed Energy Control System

- Participate in real-time energy markets
  - Market operation mode responds automatically to market awards from ISO
  - Provide ancillary services for frequency regulation and AGC
- Perform PV smoothing from energy storage

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MicroGrid Operational Modes

- Grid Interconnection
  - Provide services to the Grid – frequency regulation, voltage support, ancillary services and market operation
  - Primary focus is economics – the optimal time to release and consume power
  - How to best manage, utilize and optimize the DERs within the MG for optimal economic benefit.
  - For utility-owned MGs, this mode is about providing grid support and services needed to stabilize and run the grid as a whole

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MicroGrid Operational Modes

- Island
  - Use and manage the available resources within the MG to meet the load requirements on a second-to-second basis.
  - Load management, load shedding, optimization of the DERs to meet the load needs for the duration of the island event
  - Ideally be able to be islanded indefinitely, i.e. off the grid for as long as needed
  - Forced islanding is a potential control strategy from the utility perspective, i.e. demand response

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Security

Securing your overall system across devices and systems from multiple vendors

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Security Concepts

- Realize and understand your overall system
- Devices and systems from multiple vendors
- Step back and look at the entire realm
- Implement multiple security technologies on different parts of the system
- Use overlapping security areas/methods to create a gap-free security environment

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Security Concepts

- Recognize that intrusion prevention is a myth
- Identify physical/logical connections, transport mechanism and protocols
- Identify attack surfaces
- Install technologies to protect vulnerable areas
- Install technologies to detect intrusion
- Install technology to monitor/cleanse/defend protocol paths
- Eliminate gaps in protection

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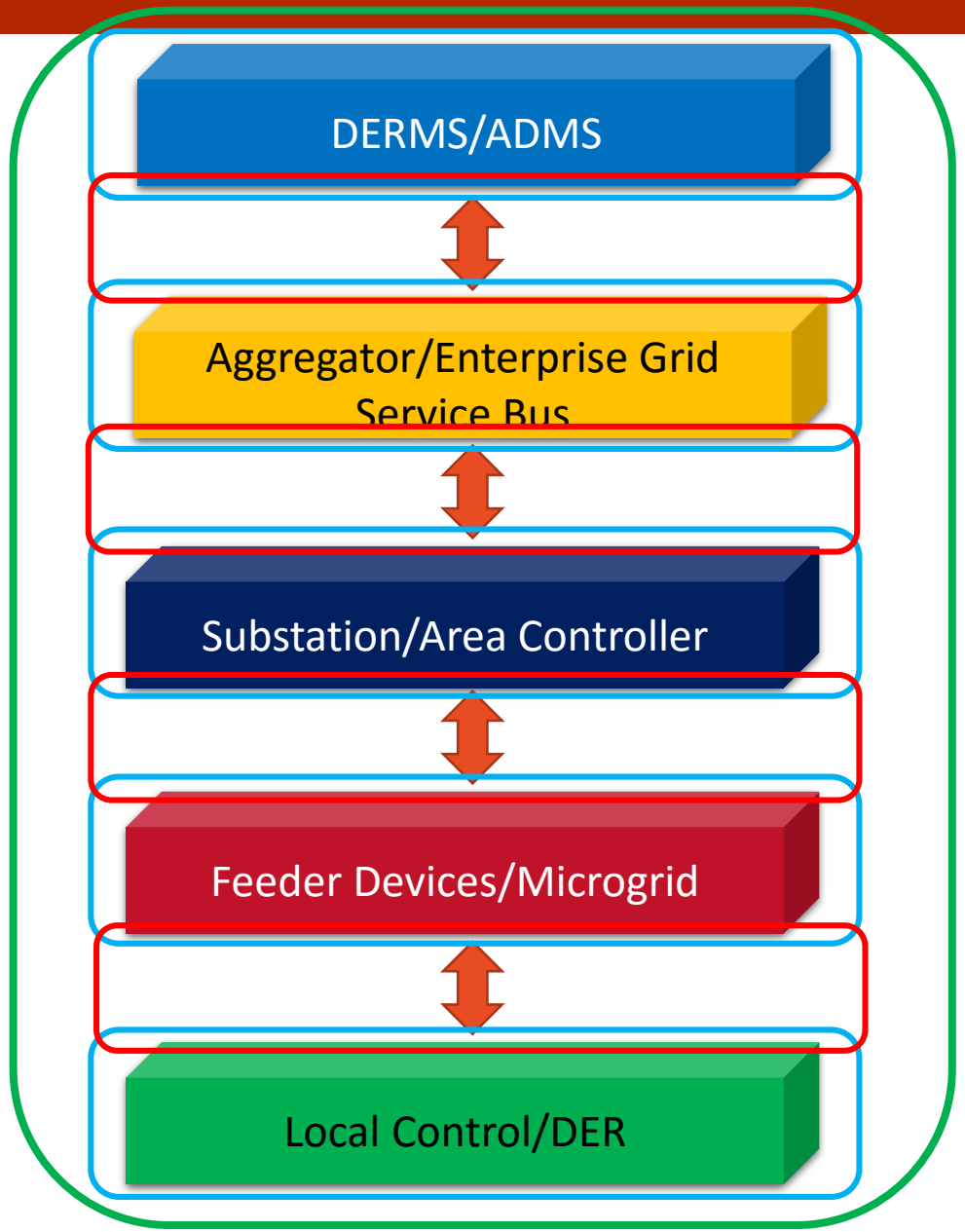
A Secure System

Secure Individual Systems

Create an Overall Secure System



Identify Attack Surfaces

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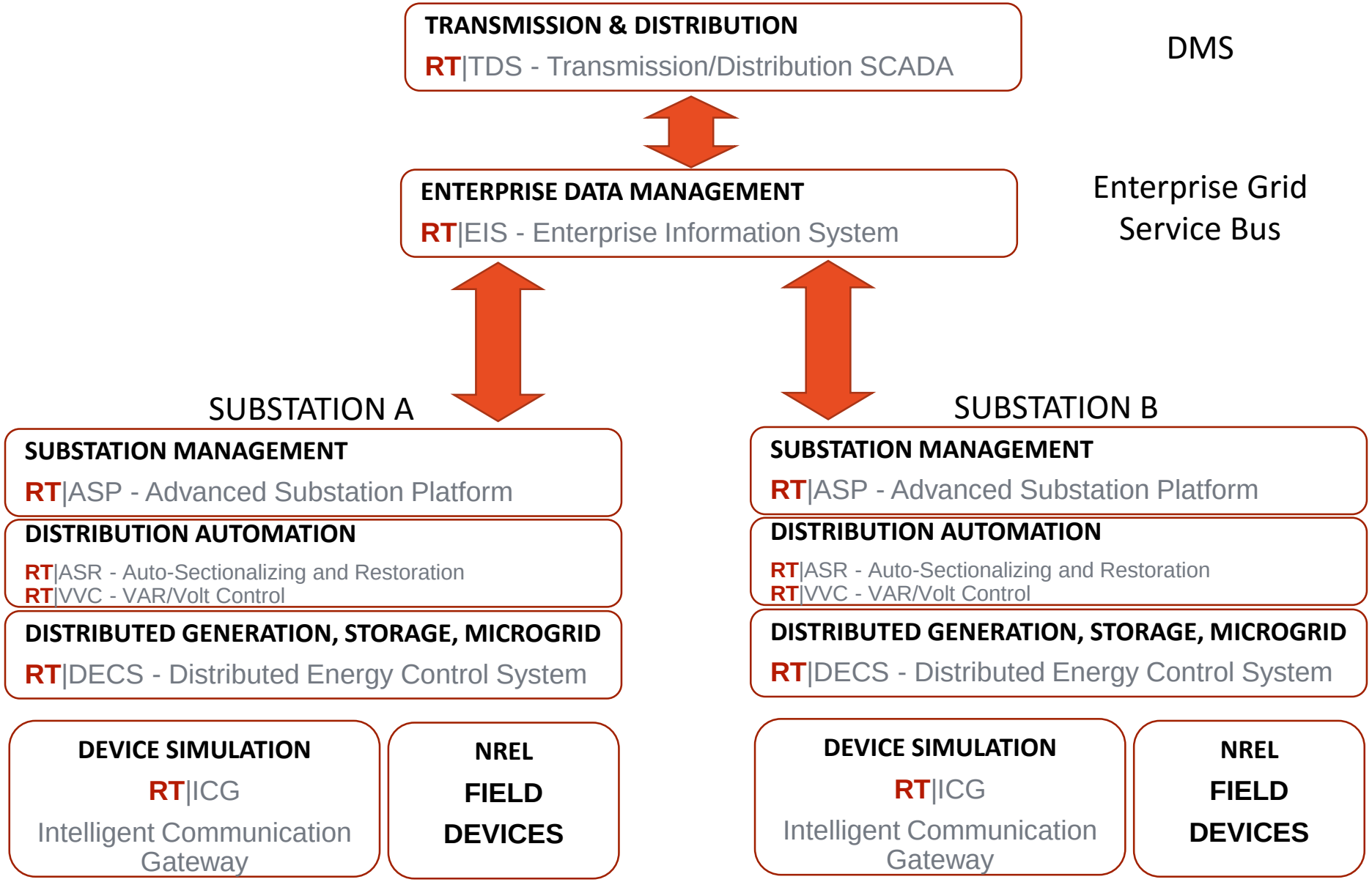
The NREL Test Bed



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Summary of Best Practices

- Use a modular solution with multiple distributed intelligence instances
- Acquire and merge data at source of data
- Enable localized decision making
- Use a solution with multi-vendor interoperability for legacy devices today and new devices tomorrow
- Be technology agnostic, vendor agnostic, protocol agnostic

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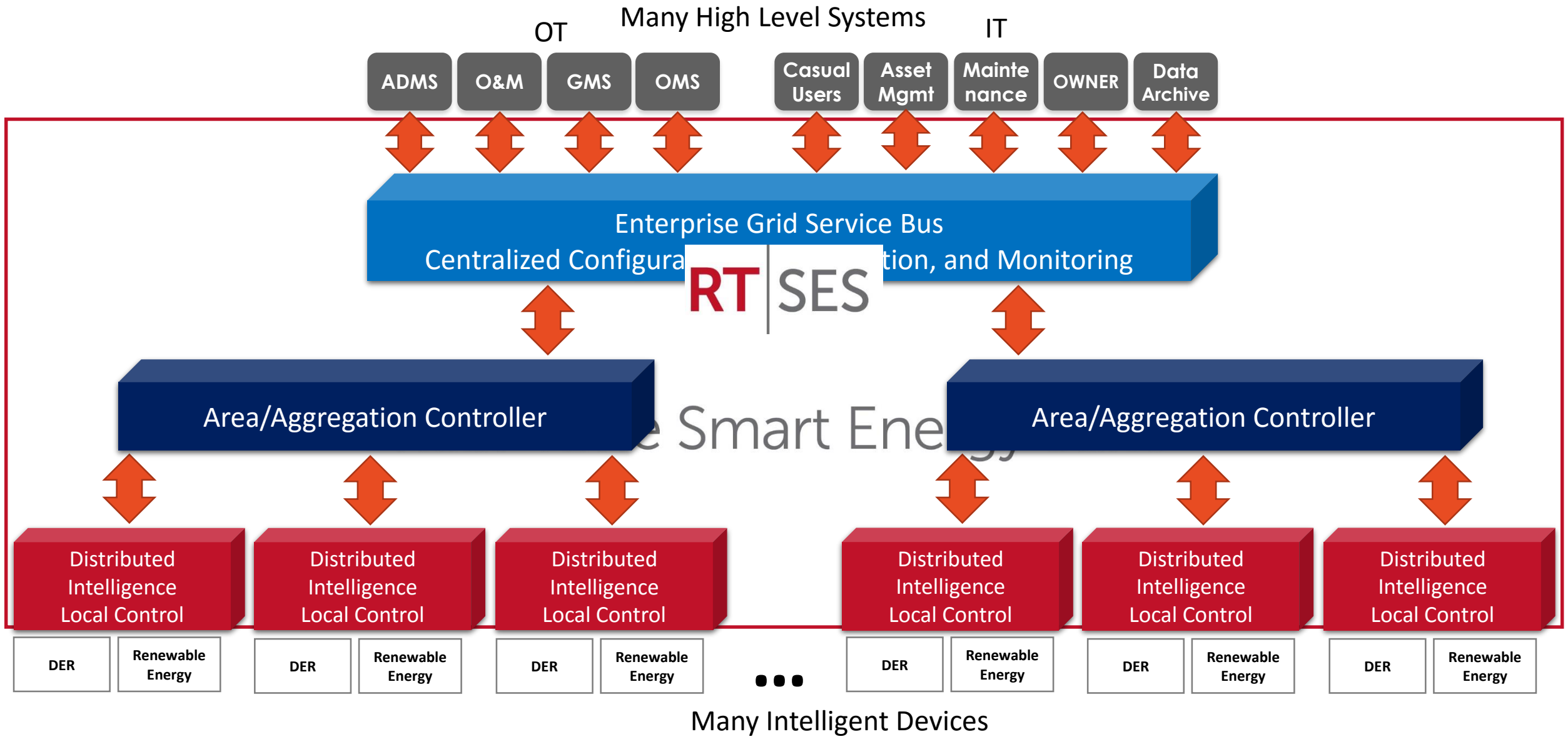
Elements of the New Grid



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California Independent System Operator Communication via a Remote Intelligent Gateway for Independent Power Producers

Requirements, Processes, Methods, and Procedures

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CAISO

- California Independent System Operator
  - Generation authority and marketplace for energy produced and/or sold in California

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Why Connect to CAISO?

- Part of PPA requirements
- Market participation
- Microgrid operation

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Plant/Aggregator Connection Requirements

- Traditional Fuel – 20MW
- Renewable – 1MW
- Distributed Energy Resource Provider (DERP) – 500KW

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Technical Requirements

- 4-second telemetry data
  - Interconnection, generation, met
  - Read by CAISO EMS systems
- Daily
  - Revenue interval data
  - Read by CAISO MDMS (MV-90) systems
- Provide data to multiple entities
  - CAISO
  - Interconnect Utility
  - Owner
  - O&M
  - Scheduling Coordinator

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Technical Requirements

- Interconnection grid protection – relays, etc.
- Grid isolation – CB or Disconnect

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Site Data

- Generator/Inverter/Turbine
- Weather station(s)
- Meters
- Communications
- Protocol translation

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Testing

- Site point-to-point
- “Mock” CAISO test
- CAISO RIG Acceptance Test (RAT)
- Meter revenue data

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Control

- AGC – From CAISO EMS systems
- Curtailment – via O&M system or automatically from CAISO Automated Dispatch System (ADS)

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Other Site Control Requirements

- Plant SCADA
  - Inverter – start/stop, output, VAR
  - Trackers
  - Turbine
  - Power Conversion Stations
  - String combiners
  - Power factor, VAR, Voltage

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Integration

- RIG can be combined with plant SCADA to create an integrated system
- Can be redundant

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The Interconnect Process

- Much more than just technology and data
- New Resource Implementation (NRI) process
  - Buckets for requirements at various stages
- Communication link to CAISO
  - CAISO Energy Control Network (ECN)
  - Direct T1, or VPN via Internet
- Documentation – Com Block Diagram, point lists, Single and 3-line diagrams
- Metering – Install, program, certify (CAISO certified meter inspector)
  - Same company cannot program and certify meter
- Testing

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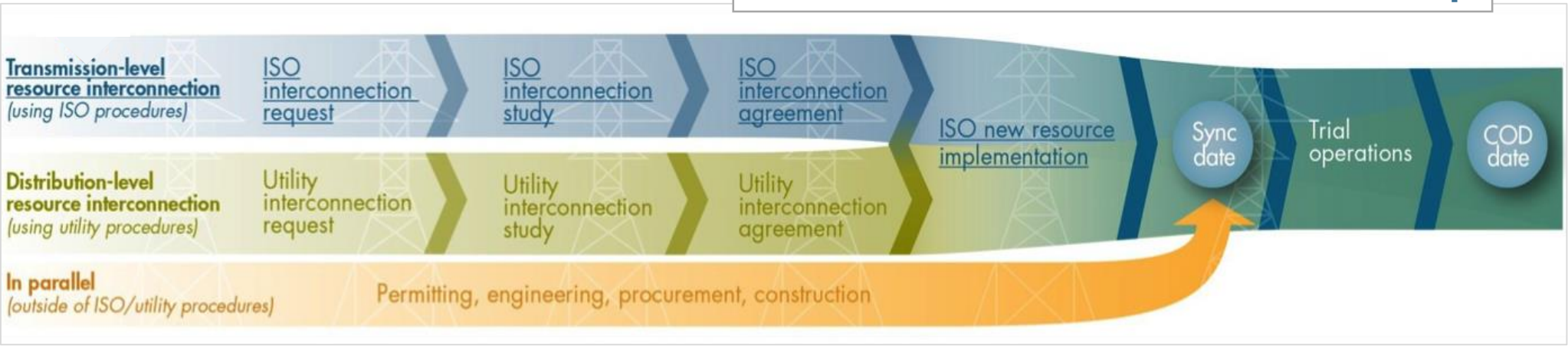
Challenge: Compliance

The Interconnection Process

Interconnecting with CAISO is a complex, high-stakes process:

- Compliance is necessary to access the market: reliable metering and telemetry are mission-critical; missing compliance deadlines means lost revenue
- CAISO keeps a rigid schedule for interconnecting new resources but regularly shifts requirements to serve an evolving market
- Integrating data from meters, plant control systems, turbines, inverters and met stations is technically complex
- Compliance does not end at project completion; CAISO certification must be renewed annually

CAISO Interconnection Process Map



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Summary of Best Practices

- Engage the help of a company that has experience in the process
- Procure and install a utility-grade system
- Be prepared for a 6 to 9 month process (possibly longer)
- Consider integrating plant SCADA and RIG
- Choose a vendor with a background in utility systems, as well as SCADA and telemetry

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Thank You!

Questions?

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