Distribution Changes in WECC

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Presented to:
CREPC/SPSC/WIRAB

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Overview

Questions to Address

- What can be learned from Hawaii and California?
- When is it appropriate to address distribution changes?
- What to do now? What to do later?

Agenda

- WECC Examples of Distribution Changes
- Grid Modernization and DER
- DER is more than Solar
- California Distribution Resources Planning
- Smart Inverter Working Group Process and Results
- Distribution and the Smart Grid Architecture Model

Recommendations and Takeaways

- Address DER value and cost allocation early (now)
  - Value of Solar >>> Value of DER
  - Value + Cost Allocation to ratepayers
- Develop distribution roadmaps (now)
  - Incremental Steps: pilot > demonstration > scale
  - Manage technological obsolescence & target valuable areas
- Promote Standards and Interoperability (now)
  - Follow SIWG and updated IEEE 1547 DER
  - Support utility participation and training in standards
  - Ease cost recovery for testing, pilot, participation
- Add Distribution Resources Planning (?)
  - *When?:* Large $ T&D upgrades/replacement, DER/EV penetration, Large $ Grid Modernization
  - *Where?:* Identify feeders good fit for DER, pilots good for targeting
  - *Wait … for tools, CA dust to settle.*

British Columbia

- Solar: not now, DR target T&D

Washington

- DRP Proposed (HB 2045)
- Avista - Distribution Automation (DA)

Oregon

- DER Study in PGE IRP
- Dispatchable Standby Generation (DSG)

Colorado

- Wind more pressing concern
- Xcel Energy VVO & DMS Investment

Utah

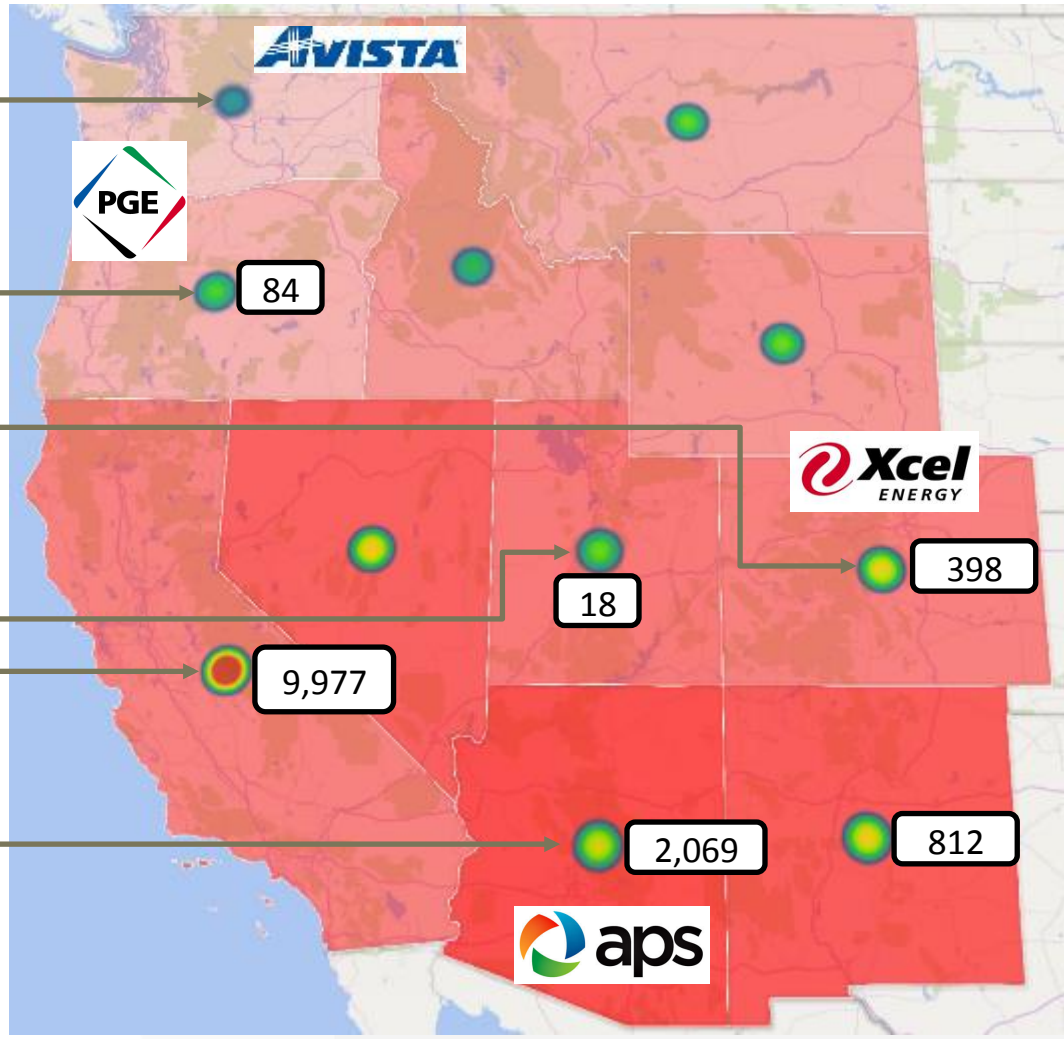
- Growth potential: QF and utility solar

California

- Distribution Resources Planning
- 12,000 MW DER Target
- Push for DER other than PV (ES)
- CA IOU Distribution Automation

Arizona

- Investor Owned Rooftop Solar Pilot
- APS VVO, DMS, & DA



WECC 2022 DER Forecast

DER	2022 DER WECC Estimate (GW)	Source
Solar	25	2013 E3 TEPPC study on High DG (Reference)
CHP	9	2013 E3 TEPPC study on High DG (Reference)
DR Load Following	2.6	2013 WIEB VER Integration
DR Other	4.7	2013 LBNL 6381, Incorporating Demand Response into Western Interconnection Transmission Planning
Energy Storage	1.8	AB2514 California 2020 mandate , plus 500 MW
Total	**43.4**	Peak WECC forecast 178,000 MW

http://www.westernenergyboard.org/sptsc/workgroups/dsmwg/highDSM/12-19-12WECCDGmr.pdf

Without Planning DER integration may be utility asset heavy

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Item	Violation Trigger	Total
Installed DG (MW)		902
Regulator	Feeder Reverse Flow	$308,000
LTC	Substation Transformer Reverse Flow	$1,642,000
Reconductoring	Exceed 50% Backbone Conductor/Cable	$75,588,700
Substation Transformer and Switchgear	Exceed 50% Capacity	$54,766,000
Distribution Transformer	Exceed 100% Loading, % GDML Linear Relationship to % Transformers Upgraded	$15,617,535
Poles and Secondary	Assumed 15% of Distribution Transformer Replacements need poles/secondary	$3,533,342
Grounding Transformers	Exceed 33% GDML (66% in model)	$43,045,200
Total		**$194,500,777**

With Planning, DER and supporting measures can find optimal solutions

System Operator	Interactive	Customer
Network reinforcement	Demand Response 2.0	Direct load control
Centralized voltage control	Locational Incentives	Power factor control
Static VAR compensators	On-demand reactive power	Direct voltage control
Central storage	On-demand curtailment	Local Storage
Network reconfiguration	Wide-area voltage control	Frequency-based curtailment
Utility owned DER	Community DER	Customer DER

Stakeholders

- Distribution Utility
- Utility Shareholders
- Regulators
- Ratepayers
- DER owners
- Economic Development
  - (politicians/business associations)
- Solar industry (175,000 employed)
- Cleantech Companies
- Third party DER, Retail energy providers
- Utility Distribution Equipment Vendors
- Concerned Citizens

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Evolving Distribution Systems:

California's Smart Inverter Working Group (SIWG), Distribution Resources Planning (DRP), and the WIEB/SPSC Report

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Topics

- Traditional Distribution System Planning
- What are the Issues and why is California undertaking Specific Activities?
- Distribution Resource Planning (DRP)
- Smart Inverter Working Group (SIWG)
- Recommendations from WIEB/SPSC Report

Background: Typical Distribution Planning

- Each distribution feeder is assessed separately
- Maximum load is determined for the next 3 to 5 to 10 years, based on load profiles and expected customer growth
- Additional capacity, maybe 50%, is added to ensure the feeder can handle reconfiguration scenarios
- Feeder equipment upgrades or additions are determined
- These distribution costs are either just the “cost of doing business” and/or are assessed by regulators for reasonableness

California's Situation with DER & Distribution Planning and Operations

- As part of achieving **33% renewables by 2020**, California Governor Jerry Brown called for 12,000 MW of DER, limit imports.
- Now the goal has been updated to ***50% renewables by 2030***
- DER systems are defined as distribution-connected **generation**, **energy storage**, and (sometimes) **controllable load**
- High penetrations of DER systems have the potential to provide **significant environmental and financial benefits** to California
- European experiences, including a 2003 blackout in Italy, have shown that DER systems must support the grid for both reliability and economic reasons
  - In particular, DER systems need to be able to **"ride-through" both frequency and voltage short-term anomalies**
  - **Europeans had to retrofit large numbers of DER systems** to add these critical capabilities – **a very expensive action**

Why Should Others Care about What is Happening in California?

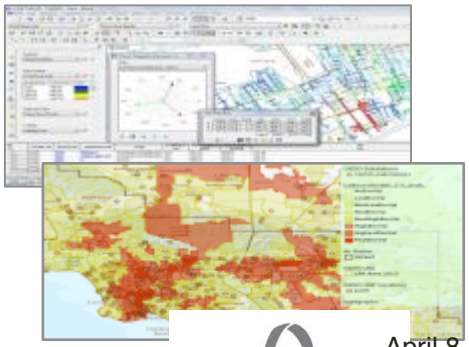
- Renewable energy portfolios (RPS) are incentivizing additional renewable energy, often at the distribution level
- DER systems in low penetrations are just negative load
- However, DER systems at higher penetrations can impact distribution operations both negatively and positively
- "Smart" DER technologies and grid modernization equipment are changing the nature of distribution planning and operations

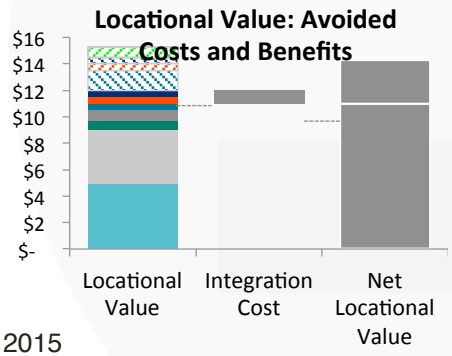
"***In the near future, utilities may no longer just supply electricity to customers, but may have to plan for, coordinate, and manage the flow of energy to, from, and between customers.***"

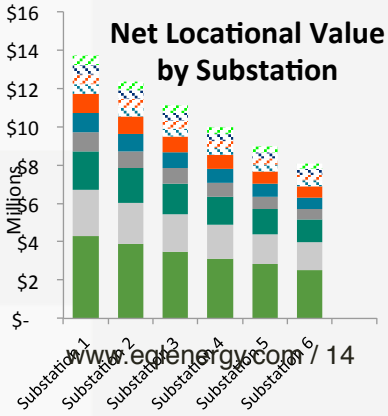
California's Distribution Resource Planning (DRP)

- Purpose is for distribution planning to **include DER** energy capacity, "smart" capabilities, energy efficiency, and market incentives during long-term distribution planning
- These factors would then be balanced against the **avoided costs** of ""traditional" distribution planning
- Process is to define a list of **mutually exclusive and collectively exhaustive (MECE)** categories of values

Identify DPA & Substations → **Perform Planning Analyses** → **Calculate Locational Net Value** → **Rank Substations by Locational Net Value**







Distribution Resources Planning Purposes (1)

- Identify optimal locations for Distributed Energy Resources
- Evaluate locational benefits of DERs based on:
  - Reductions versus increases in local generation capacity needs
  - Avoided costs versus increased investment for distribution infrastructure, safety benefits, reliability benefits
  - Any other savings or costs that DERs may provide to the grid or to ratepayers
- Integrated Capacity Analysis
- Propose or identify standard tariffs, contracts, or other mechanisms for deployment of cost-effective DERs that satisfy distribution planning objectives

Distribution Resources Planning Purpose (2)

- Propose cost-effective methods for **coordinating existing commission-approved programs, incentives, and tariffs** to maximize the locational benefits and minimize the incremental costs of DERs
- Identify **additional utility spending** necessary to integrate cost-effective DERs into distribution planning
- Identify possible **barriers to the deployment of DERs**, including:
  - **Safety** standards related to technology
  - **Reliability** requirements for the operation of the distribution circuit

Smart Inverter Working Group (SIWG)

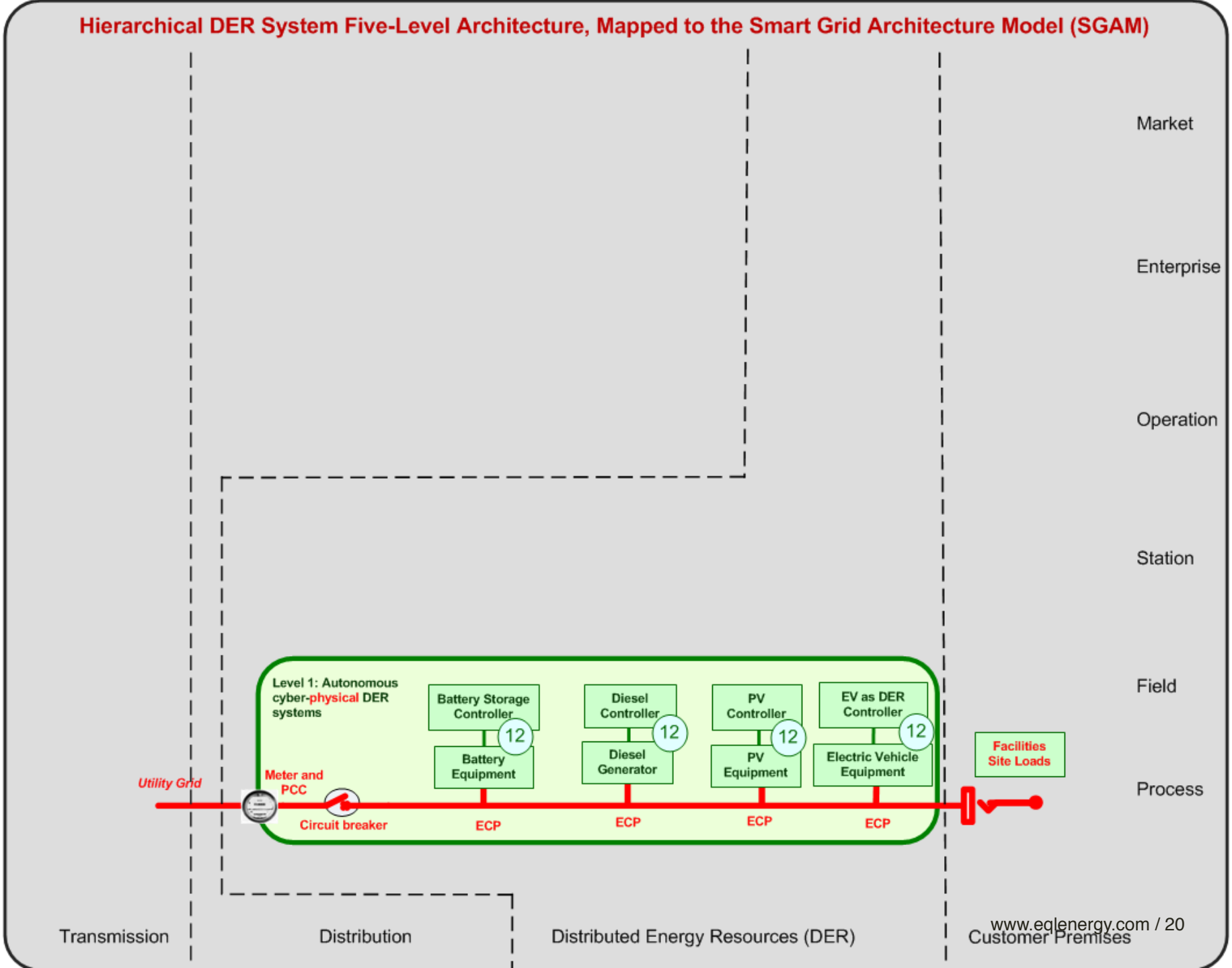
- California (CEC and CPUC) did not want to repeat the European scenario and initiated the ***Smart Inverter Working Group (SIWG)***
- The CPUC and the CEC staff convened the SIWG in January 2013 to:
  - Develop the default DER functionality requirements and establish an implementation plan for California
  - ***Update California's Rule 21 on DER interconnection requirements***
- The SIWG currently has ***over 250 participants*** from all major stakeholder groups, including utilities, DER manufacturers, integrators, customer groups, investors, and interested parties
  - After the first month of weekly calls, all stakeholders recognized the potential benefits of "smart inverters" and eagerly joined in the technical discussions
  - California's 3 IOUs have taken the lead in defining their requirements, while the DER manufacturers have determined what their products and technologies can achieve
  - Typical discussions are: "Should the timing be .2 or .3 seconds?"

SIWG Results To Date

- The SIWG developed a phased approach of recommendations to the CPUC:
  - **Phase 1**: Seven (7) critical autonomous functions – ***approved by CPUC in December 2014***
  - **Phase 2**: Communications capabilities for monitoring, updating settings, and control –***submitted to the CPUC in late February, 2015***
  - **Phase 3**: Additional DER functions – currently being discussed – ***open to all who want to address these technical DER capabilities***
- SIWG members now participating in a survey on the importance of about 40 DER functions

Phase 1: Seven Autonomous DER Functions – Focus on this slide

- SIWG Recommendations for ***Phase 1 Functions (now mandatory by mid 2016)***:
  - Support ***anti-islanding*** to trip off under extended anomalous conditions, coordinated with the following functions
  - Provide ***ride-through of low/high voltage*** excursions beyond normal limits
  - Provide ***ride-through of low/high frequency*** excursions beyond normal limits
  - Provide ***volt/var control*** through dynamic reactive power injection through autonomous responses to local voltage measurements
  - Define default and emergency ***ramp rates*** as well as high and low limits
  - Provide reactive power by a ***fixed power factor***
  - Reconnect by "***soft-start" methods*** (e.g. ramping and/or random time within a window)


Hierarchical DER System Five-Level Architecture, Mapped to the Smart Grid Architecture Model (SGAM)
Market
Enterprise
Operation
Station
Field
Process
Level 1: Autonomous cyber-physical DER systems
Battery Storage Controller
12
Battery Equipment
Diesel Controller
12
Diesel Generator
PV Controller
12
PV Equipment
EV as DER Controller
12
Electric Vehicle Equipment
Facilities Site Loads
Utility Grid
Meter and PCC
Circuit breaker
ECP
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Transmission
Distribution
Distributed Energy Resources (DER)
Customer Premises

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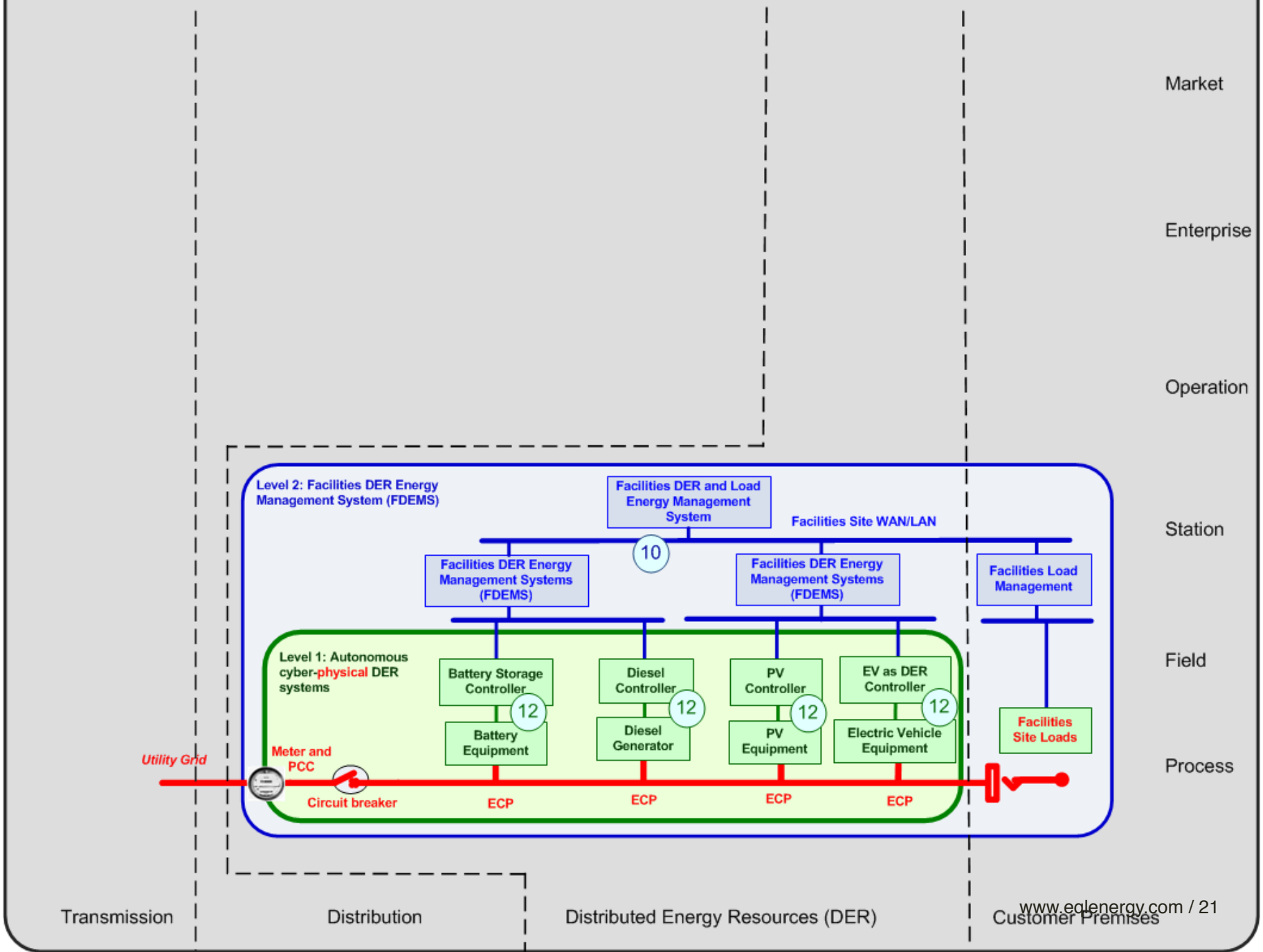

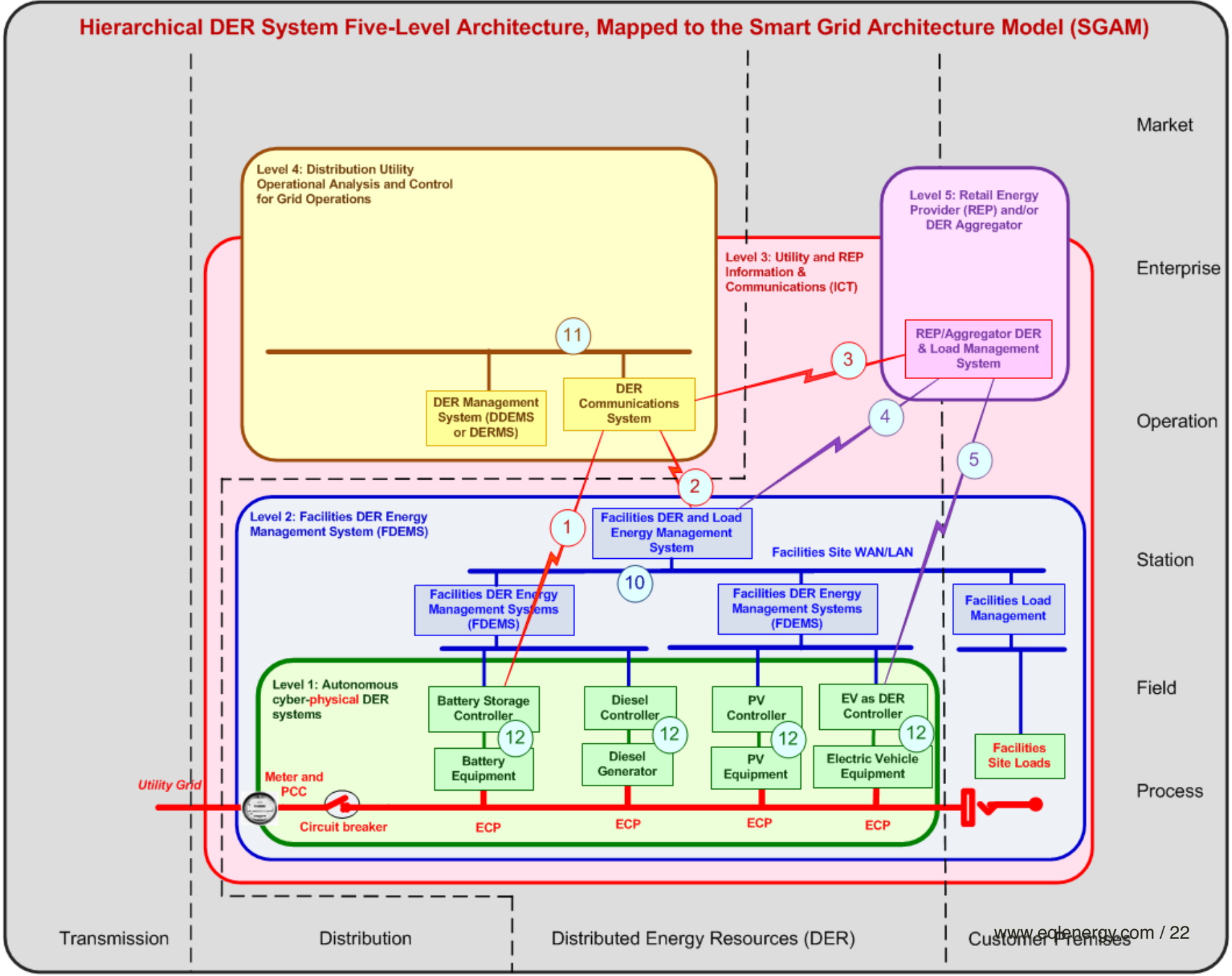
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Station
Field
Process
Level 4: Distribution Utility Operational Analysis and Control for Grid Operations
Level 5: Retail Energy Provider (REP) and/or DER Aggregator
Level 3: Utility and REP Information & Communications (ICT)
11
DER Management System (DDEMS or DERMS)
DER Communications System
3
REP/Aggregator DER & Load Management System
4
5
2
1
Level 2: Facilities DER Energy Management System (FDEMS)
Facilities DER and Load Energy Management System
Facilities Site WAN/LAN
10
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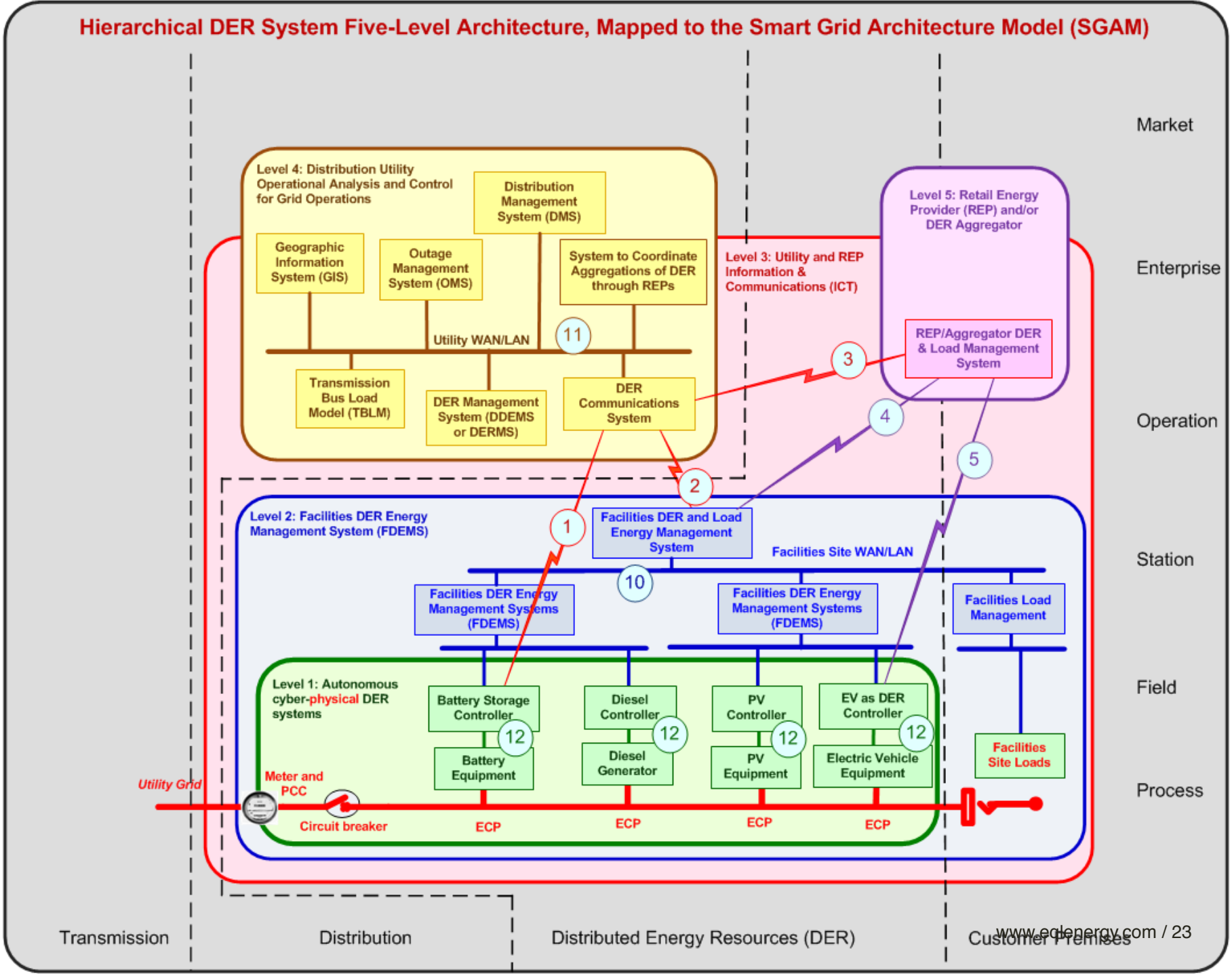
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Geographic Information System (GIS)
Outage Management System (OMS)
System to Coordinate Aggregations of DER through REPs
Utility WAN/LAN
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Transmission Bus Load Model (TBLM)
DER Management System (DDEMS or DERMS)
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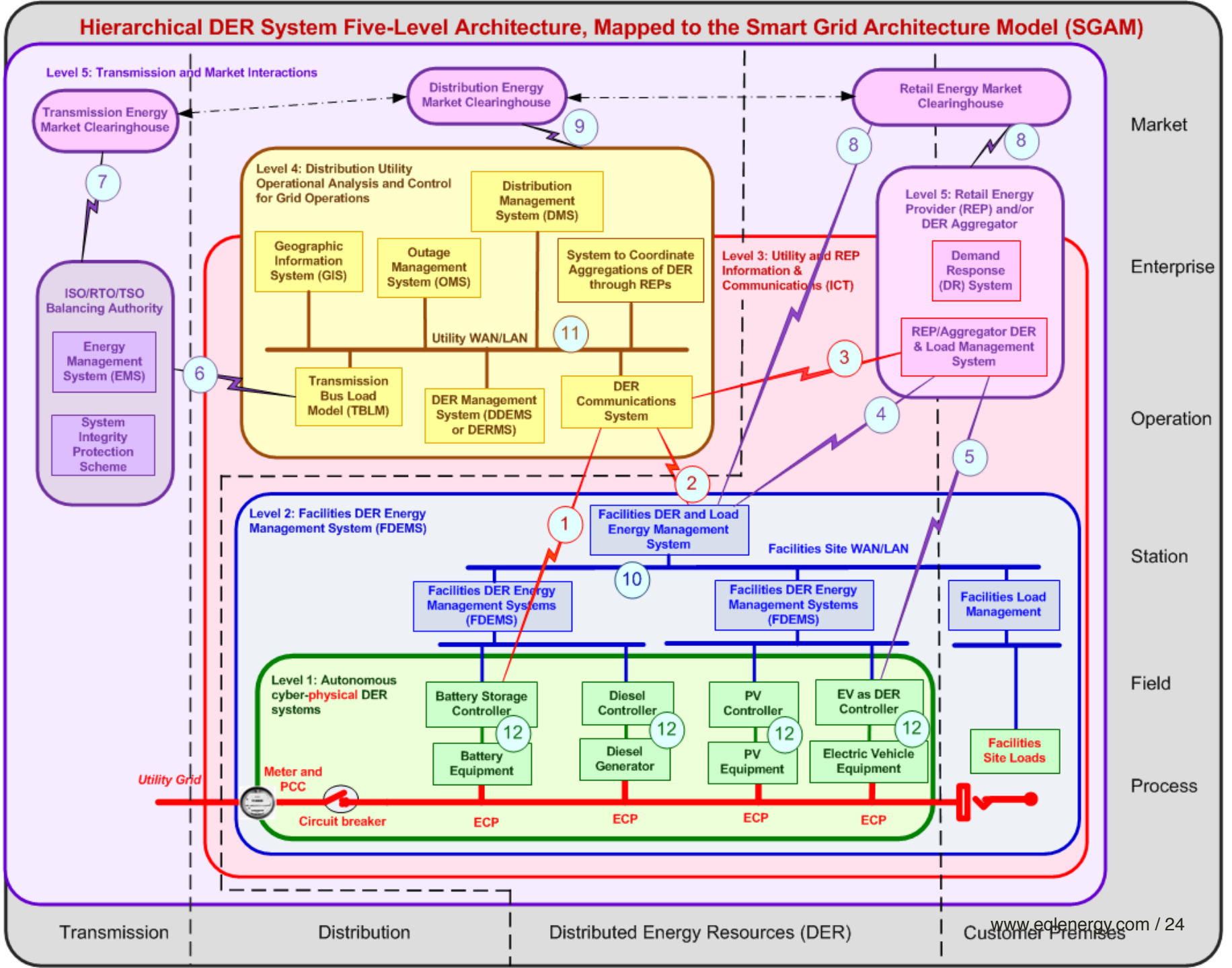
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Level 5: Transmission and Market Interactions
Transmission Energy Market Clearinghouse
Distribution Energy Market Clearinghouse
Retail Energy Market Clearinghouse
Market
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ISO/RTO/TSO Balancing Authority
Energy Management System (EMS)
System Integrity Protection Scheme
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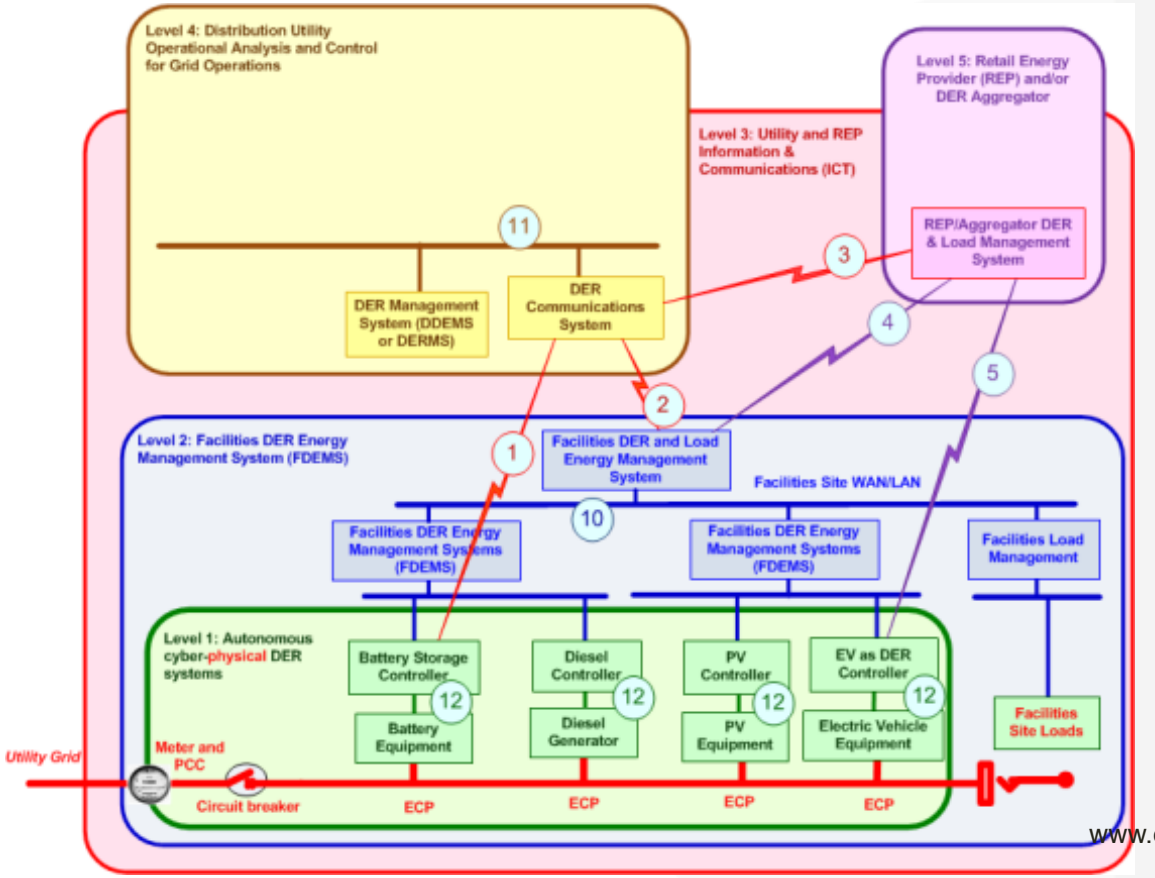
Scope of SIWG Phase 2

Communications between utilities and 3rd parties (red lightning bolts):

- ***(1) Utilities and individual DER Systems***
- ***(2) Utilities and Facility DER Energy Management Systems***
- ***(3) Utilities and Aggregators***



Current Status of SIWG Phase 2

- Decisions were made on initial recommendations for these and other communication issues
- Mandatory recommendations ruling through the CPUC:
  - **Recommended to be included in the CPUC Rule 21**
- Beneficial recommendations documents
  - Recommended to be included in each utility's "[Utility] Generation Interconnection Handbook" on requirements and options
  - Recommended to be included in a single "California IEEE 2030.5 Implementation Guide"
  - Recommended to be decided by mutual utility-DER owner/operator agreements on a utility basis or an installation basis
  - Recommended to be left up to vendor or market decisions

SIWG Phase 3 DER Functions

- Discussions on relative importance of **40 DER functions**, which need further technical resolutions, and which should be included in Rule 21.
- Some of Phase 3 functions include:
  - Provide status and measurements
  - Set actual real power output
  - Limit maximum real power output
  - Frequency-watt
  - Voltage-watt
  - Power-power factor
  - Schedule actual or maximum real power output
  - Frequency smoothing
  - Automatic Generation Control (AGC)

SIWG Efforts Spawned Updates to Standards

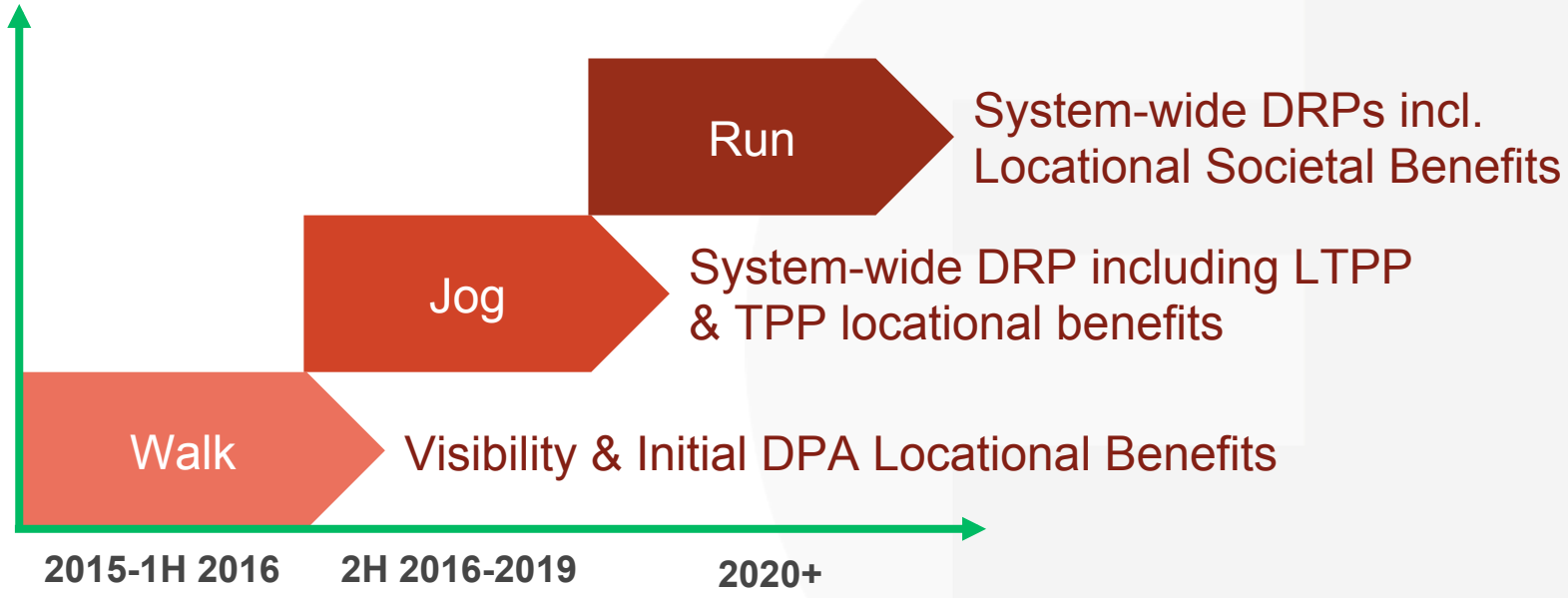
- This California SIWG process and other initiatives have triggered related efforts to update standards:
  - UL 1741, required for safety of DER installations, is developing a supplement to provide testing and certification for these functions, and is *almost* ready for ballot
  - IEEE 1547, which is used by most jurisdictions as the standard for DER interconnection requirements, was amended as IEEE1547a to permit these functions
  - ***IEEE 1547 is now being completely revised*** to cover these and a number of other functions
  - IEC 61850 Information Model is being updated
  - IEEE 2030.5 (Smart Energy Profile 2) communication protocol is being expanded
  - IEEE 1815 (DNP3) SCADA protocol is adding Profiles for DER

DRP Process: "More Than Smart (MTS)" Working Group

- Purpose:
  - **Provide an open, voluntary stakeholder forum** to discuss core issues
- Objectives:
  - Define common parameters for the development of distribution planning scenarios
  - Identify and define the integrated engineering-economic analysis required to conduct distribution planning in the context of AB 327 requirements
  - Identify the considerations to meet customers' needs and California's policy objectives.
  - Define the scope and parameters of an operational/DER market information exchange
  - Define distribution services associated with identified DER values, including performance requirements

Evolution of DRP Optimal Location Benefits Analysis

- What are the immediate benefit categories that can reasonably be evaluated within the next 3 months for the first DRP (July 1, 2015)?
- What are the next logical set (incl. data and tools needed) for system-wide DRPs?



DER Wholesale Value Components (1/2)

Objective is to define a list of **mutually exclusive and collectively exhaustive (MECE)** value categories

	Value Component	Definition
Wholesale	**WECC Bulk Power System Benefits**	Regional BPS benefits not reflected in System Energy Price or LMP
	CA System Energy Price (NEM 2.0)	Estimate of CA marginal wholesale system-wide value of energy
	Wholesale Energy	Reduced quantity of energy produced based on net load
	Resource Adequacy (NEM 2.0 modified)	Reduction in capacity required to meet Local RA and/or System RA reflecting changes in net load and/or local generation
	Flexible Capacity	Reduced need for resources for system balancing
	Wholesale Ancillary Services (NEM 2.0)	Reduced system operational requirements for electricity grid reliability including all existing and future CAISO ancillary services
	RPS Generation & Interconnection Costs (NEM 2.0)	Reduced RPS energy prices, integration costs, quantities of energy & capacity
	Transmission Capacity	Reduced need for system & local area transmission capacity
	Generation/DER Deliverability	Increased ability for generation and DER to deliver energy and other services into the wholesale market
	Transmission Congestion + Losses (NEM 2.0 modified)	Avoided locational transmission losses and congestion as determined by the difference between system marginal price and LMP nodal prices
	Wholesale Market Charges	LSE specific reduced wholesale market & transmission access

DER Distribution Value Components (2/2)

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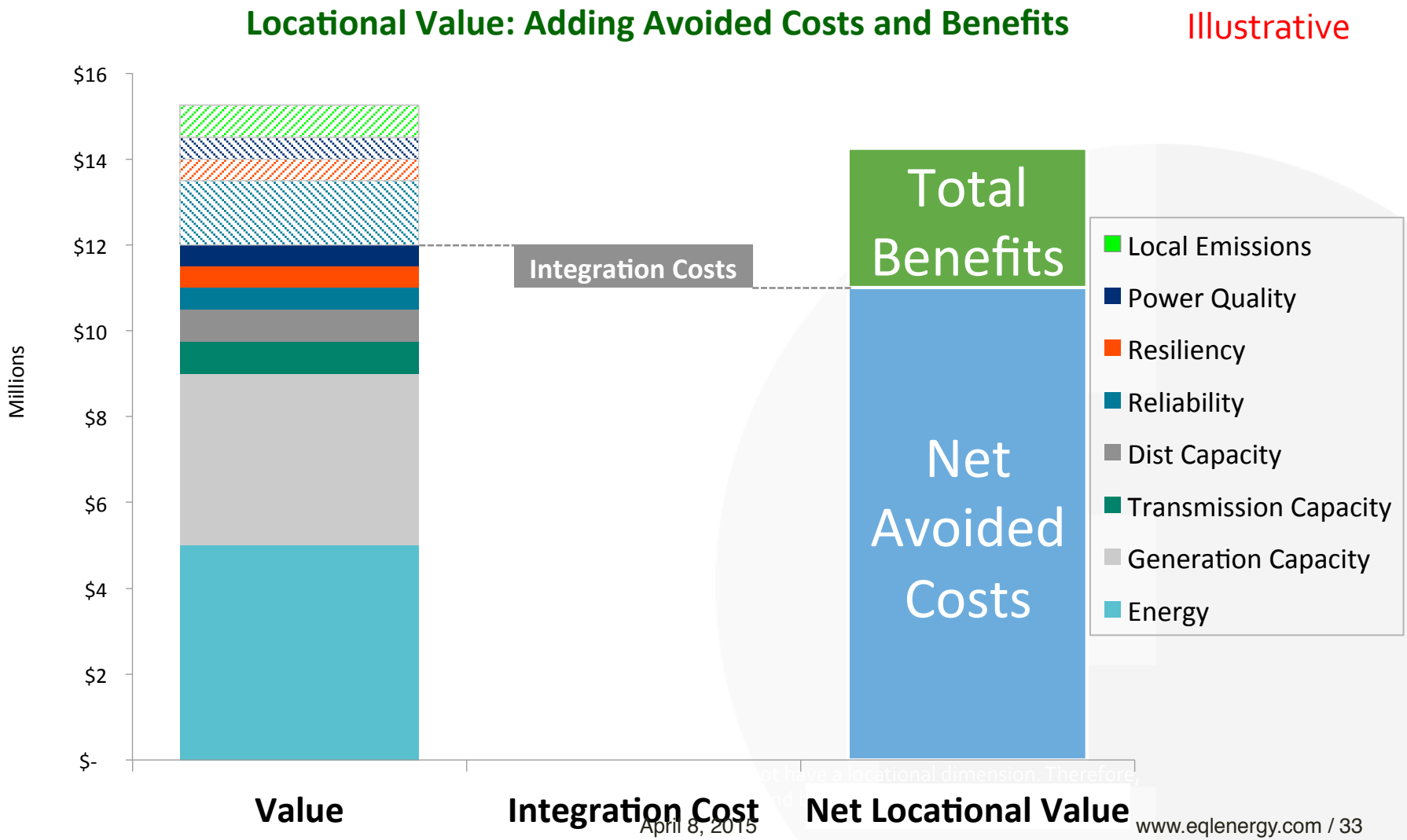
	Value Component	Definition
Distribution	**Subtransmission, Substation & Feeder Capacity (NEM 2.0 modified)**	Reduced need for local distribution system upgrades
	Distribution Losses (NEM 2.0)	Value of energy due to losses between wholesale transaction and distribution points of delivery
	Distribution Steady-State Voltage	Improved steady-state (generally >60 sec) voltage, voltage limit violation relief, reduced voltage variability, compensating reactive power
	Distribution Power Quality	Improved transient voltage and power quality, including momentary outages, voltage sags, surges, and harmonic compensation. *May also extend the life of distribution equipment*
	Distribution Reliability + Resiliency+ Security	Reduced frequency and duration of outages & ability to withstand and recover from external natural, physical and cyber threats
	Distribution Safety	Improved public safety and reduced potential for property damage
Customer & Societal	**Customer Choice**	Customer & societal value from robust market for customer alternatives
	CO_2 Emissions (NEM 2.0 modified)	Reductions in federal and/or state carbon dioxide emissions (CO_2) based on cap-and-trade allowance revenue or cost savings or compliance costs
	Criteria Pollutants	Reduction in local emissions in specific census tracts utilizing tools like CalEnviroScreen. Reduction in health costs associated with GHG emissions
	Energy Security	Reduced risks derived from greater supply diversity and less lumpiness
	Water Use	Synergies between DER and water management (electric-water nexus)
	Land Use	Environmental benefits & avoided property value decreases from DER deployment instead of large generation projects
	Economic Impact	State and/or local net economic impact (e.g., jobs, investment, GDP, tax income)

Locational Value: Assessment of DER by Adding Avoided Costs and Benefits



WIEB/SPSC Report: Essential Recommendations

- **Develop long term distribution planning roadmaps**
  - ✓ Use Open Stakeholder process for roadmap
  - ✓ Include if and when formal DRPs are necessary for which locations
  - ✓ Include risk assessments of technologies and reliability of resources
- **Do not re-invent what has already been achieved**
  - ✓ Use existing DRP costing methodology, as applicable
  - ✓ Follow SIWG technological requirements and IEEE 1547 standard
  - ✓ Use existing integration and communication standards for interoperability
- **Address cost allocation early**
  - ✓ Focus on “least regrets” solutions
  - ✓ Enhance market equitability (“fairness”) over time (not just the last DER)
  - ✓ Provide pricing and investment stability
  - ✓ Minimize technological obsolescence

Questions?

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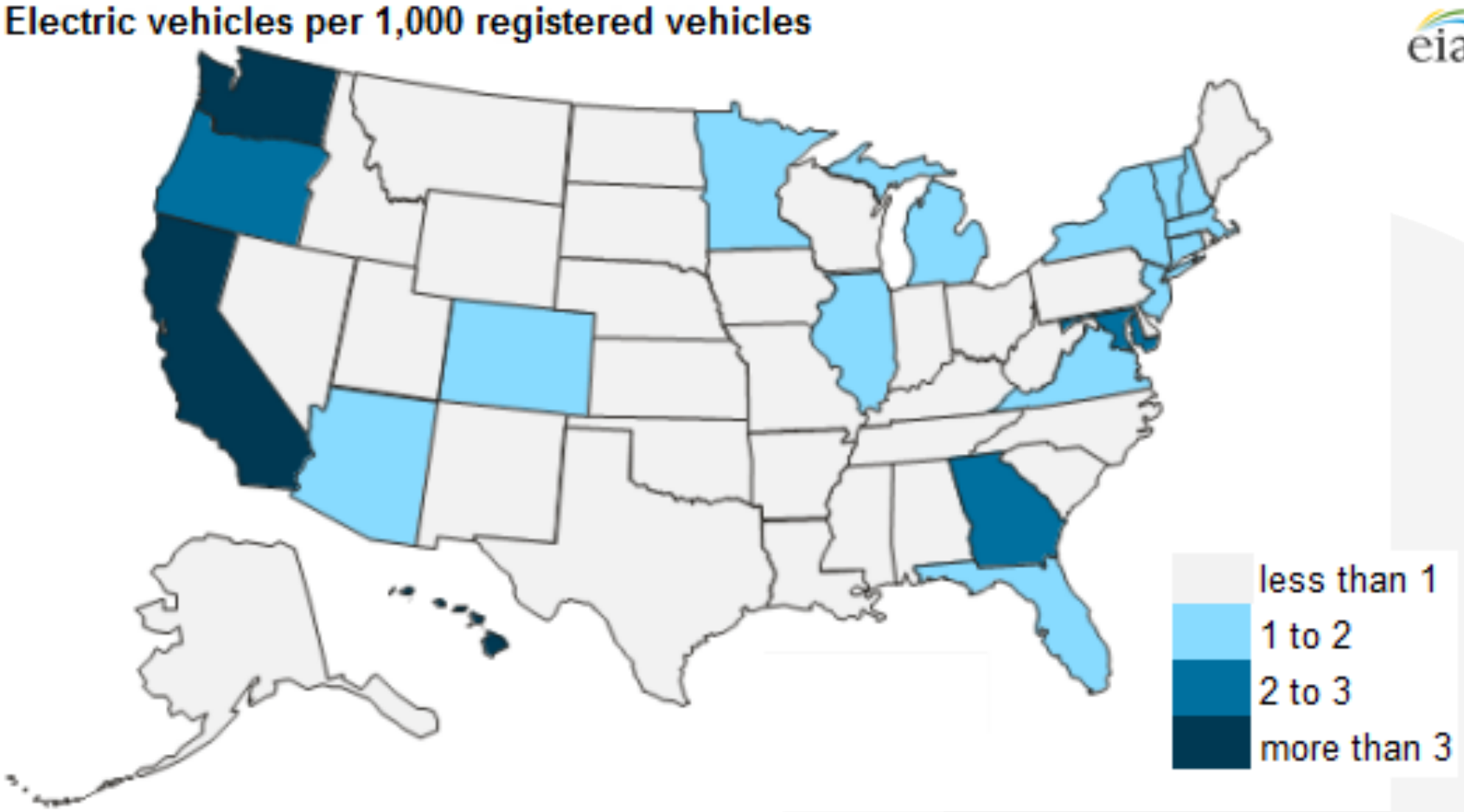
See draft web version of WIEB/SPSC report at

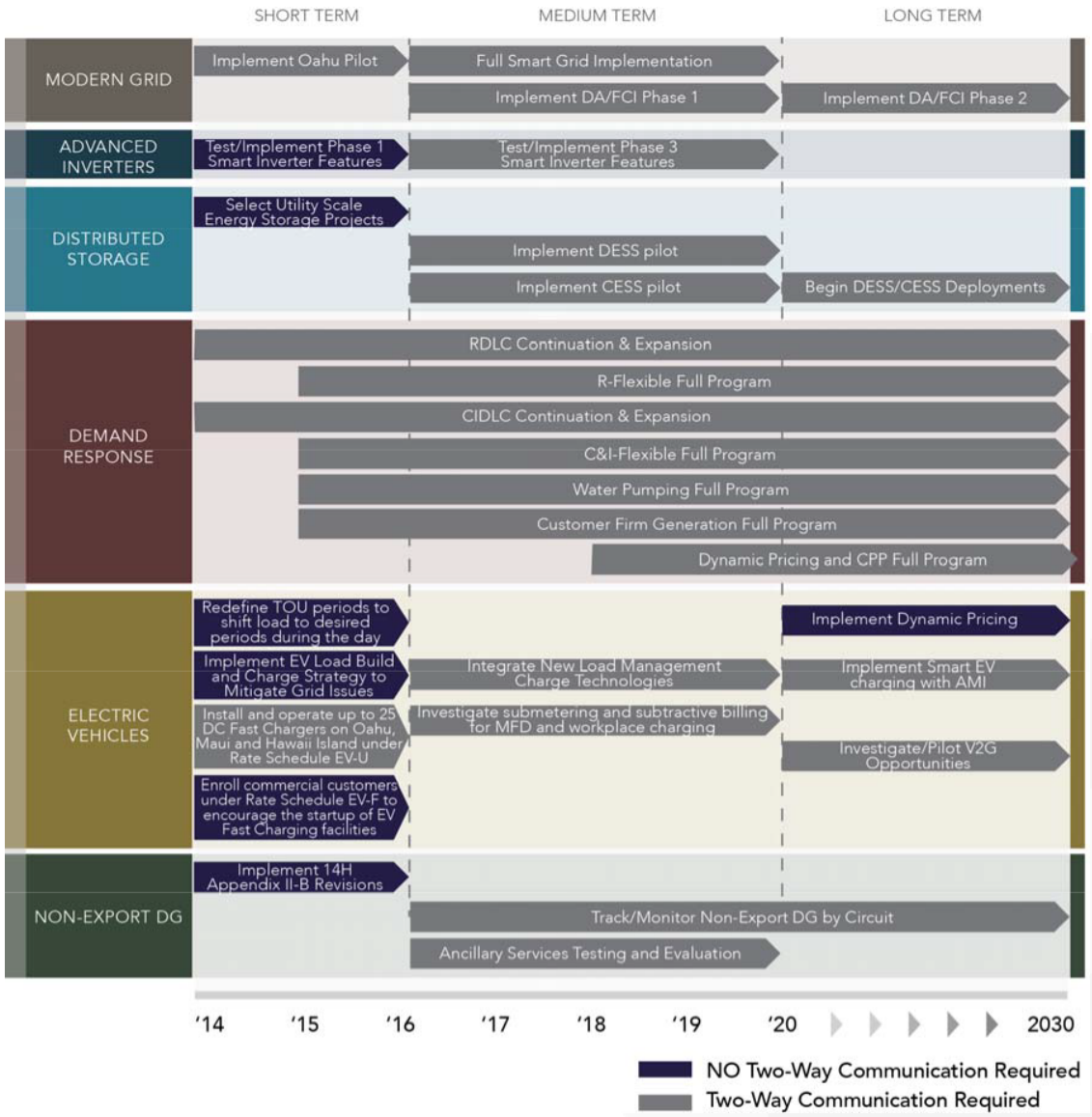
http://xanthus-consulting.com/WIEB/index.html

Extra Slides

Addressing EV Load Growth



Roadmaps


SHORT TERM
MEDIUM TERM
LONG TERM
MODERN GRID
Implement Oahu Pilot
Full Smart Grid Implementation
Implement DA/FCI Phase 1
Implement DA/FCI Phase 2
ADVANCED INVERTERS
Test/Implement Phase 1 Smart Inverter Features
Test/Implement Phase 3 Smart Inverter Features
DISTRIBUTED STORAGE
Select Utility Scale Energy Storage Projects
Implement DESS pilot
Implement CESS pilot
Begin DESS/CESS Deployments
DEMAND RESPONSE
RDLC Continuation & Expansion
R-Flexible Full Program
CIDLC Continuation & Expansion
C&I-Flexible Full Program
Water Pumping Full Program
Customer Firm Generation Full Program
Dynamic Pricing and CPP Full Program
ELECTRIC VEHICLES
Redefine TOU periods to shift load to desired periods during the day
Implement Dynamic Pricing
Implement EV Load Build and Charge Strategy to Mitigate Grid Issues
Integrate New Load Management Charge Technologies
Implement Smart EV charging with AMI
Install and operate up to 25 DC Fast Chargers on Oahu, Maui and Hawaii Island under Rate Schedule EV-U
Investigate submetering and subtractive billing for MFD and workplace charging
Investigate/Pilot V2G Opportunities
Enroll commercial customers under Rate Schedule EV-F to encourage the startup of EV Fast Charging facilities
NON-EXPORT DG
Implement 14H Appendix II-B Revisions
Track/Monitor Non-Export DG by Circuit
Ancillary Services Testing and Evaluation
'14
'15
'16
'17
'18
'19
'20
2030
NO Two-Way Communication Required
Two-Way Communication Required