

Challenges in Energy Decarbonization: Building a Resilient Net-Zero Future

8th Annual IEA-EPRI Workshop

A Holistic Look at Electrification

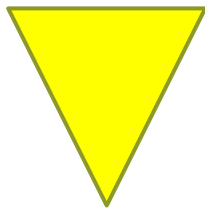
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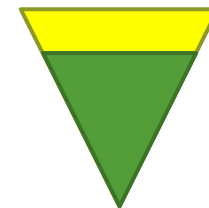


Answering a funnel question:

**How can I think about electrification
in holistic terms,**

**describing actionable programs
which contribute to
decarbonization?**

Complex systems and IoT



A **complex system** features a large number of interacting components, whose aggregate activity is nonlinear... and *difficult to predict*.

Energy, Water, Waste



Environment



Transportation

Economic & Social
Human Activity



(biological)

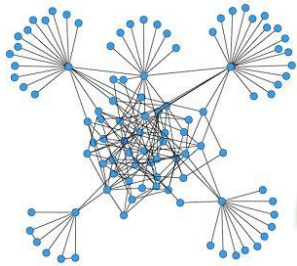
IoT delivers new opportunities to explore, simulate and inform by providing data from the edge

Holistic System Mapping

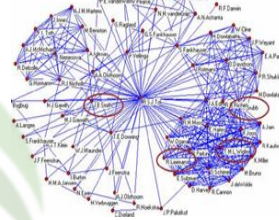


Characterized by comprehension of the parts of something as intimately interconnected and explicable by reference to the whole

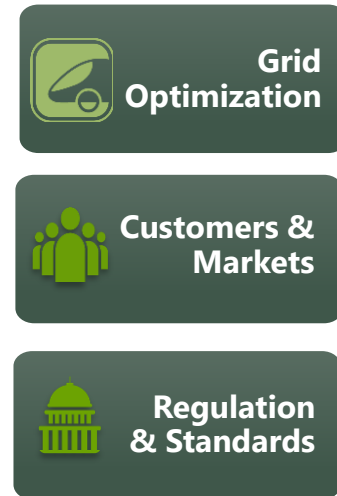
Energy, Water, Waste



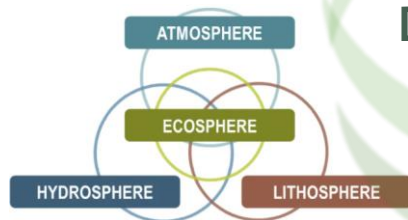
Economic & Social Human Activity



Industry Transformation



Optimized Decarbonization



Environment



Transportation

Electrification is an process which impacts many system relationships. Decarbonization success can be evaluated.

Regulation & Standards



ENERGY MANAGEMENT

Timing: NOW



Behind-the-meter Transparency, Customer Satisfaction



Local Energy Storage Interconnection



Safe Operation Practices



Data Privacy & Security



ELECTRIFICATION

Timing: EXPEDITE



Data Governance & Systems CIM



V2G and V2H Energy Storage Coordination



Energy Attribution



SYSTEM TRANSFORMATION

Timing: NEAR-TERM



IoT Reference Framework Architecture



Customer Energy Market Operation



Blockchain Interoperability Standards



INTERNET OF THINGS

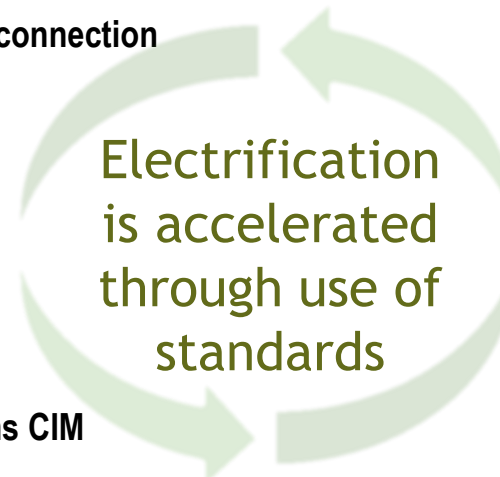
TIMING: EMERGING INNOVATIONS



Industrial IoT Communication Architecture



Multi-industry Communications, Data Privacy & Security Architecture



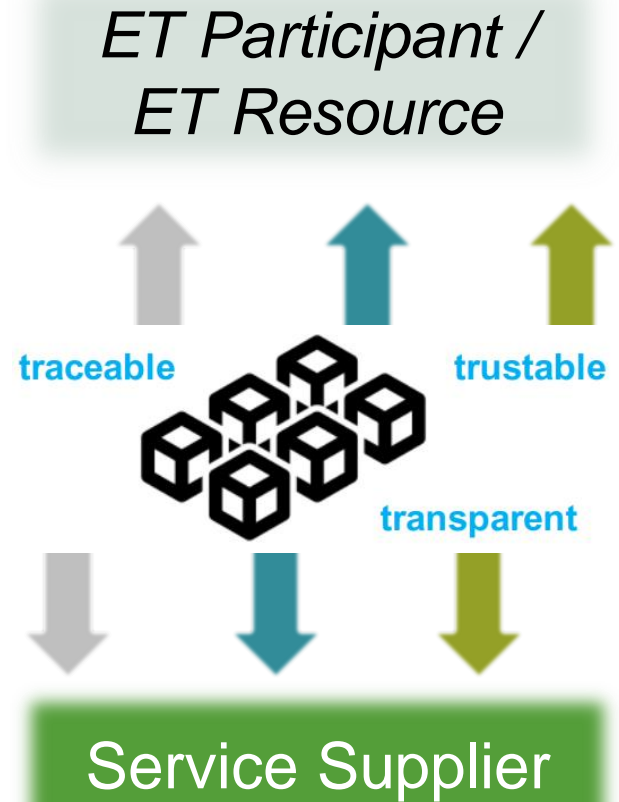
Electrification
is accelerated
through use of
standards

Activity in this system of possibility is driven by interaction between regulators, standards bodies, utilities and vendors

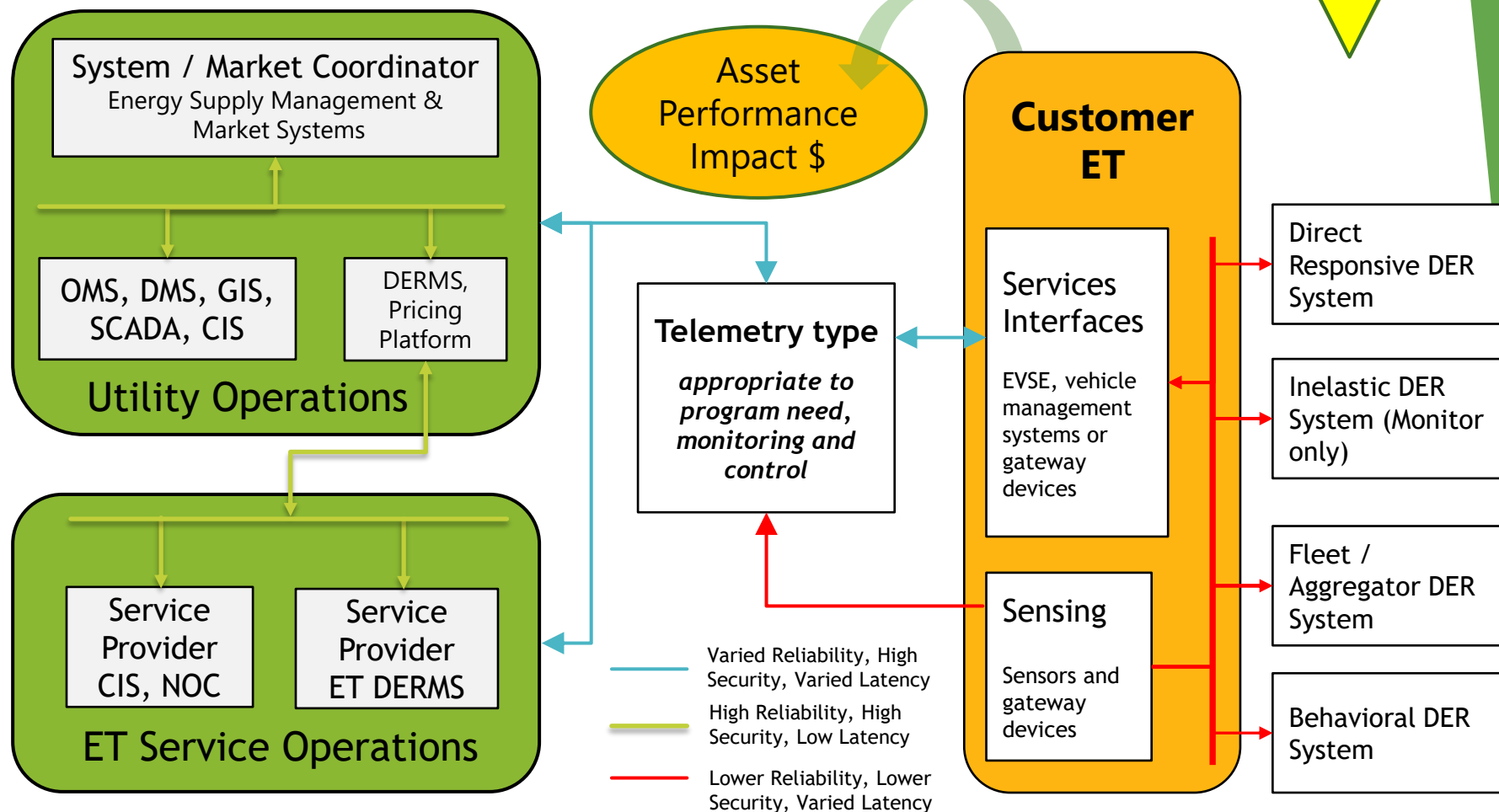
Blockchain Communications

Consider the energy system using market-based constructs for control & decisions with 3 key ledger components:

- **Information (data) exchange**
Time, prices, demand, supply, congestion, expected (future) conditions, constraints, environmental conditions, occupancy, location, managed transparency
- **Good / service exchange**
Control, management and scheduling, service plans and data, transparent assets
- **Financial exchange**
Measured elements, i.e., tokens, currency & value exchanges, smart contracts, settlement, immutable transactions, secure processing



Use Case – ESM & Electrification



Data reliability standards, security and latency management are critical to integration success

Special Thanks



IEA Technology Collaboration Programme

Global Observatory on P2P, Community Self-Consumption and Transactive Energy Models

<https://userstcp.org/task/peer-to-peer-energy-trading/>



IEEE Internet of Things

IEEE P2418.5 Blockchain for Energy

<https://blockchain.ieee.org/>



<https://www.comsoc.org/publications/magazines/ieee-internet-things-magazine>



Guidehouse – Energy

Energy, Sustainability & Infrastructure - Decarbonization

<https://guidehouse.com/capabilities/industries/energy-sustainability-infrastructure>