The Transforming Global Energy Industry –

EPRI Integrated Energy Networks and Efficient Electrification Initiatives

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Club Español de la Energía

Today's Discussion

1. About EPRI
2. Integrated Energy Network
3.
4. Electrification Technology Initiatives
5. Other Considerations – Cyber Security

EPRI - Independent – Objective – Technically Based

BORN IN A BLACKOUT

Founded in 1972 as an independent, nonprofit center for public interest energy and environmental research

New York City, The Great Northeast Blackout, 1965

EPRI'S VALUE

To provide value to the public, our members, and the electricity sector

NonProfit

THOUGHT LEADERSHIP

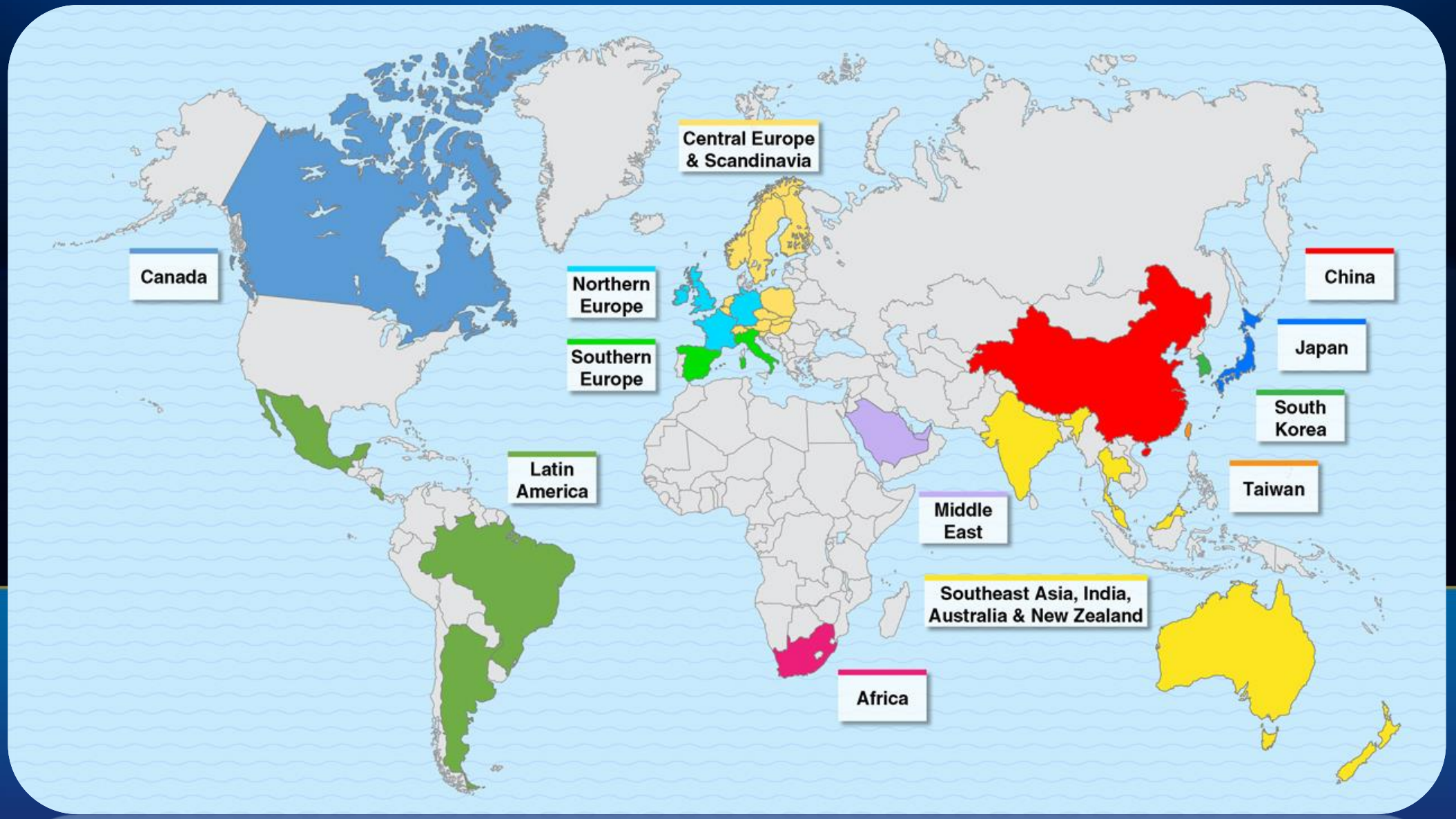
INDUSTRY EXPERTISE

COLLABORATIVE MODEL

OUR MEMBERS…

- 450+ participants in more than 30 countries
- EPRI members generate approximately 90% of the electricity in the United States
- International funding – nearly 25% of EPRI's research, development, and demonstrations

International Areas of EPRI's Engagement



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EPRI Global Research Areas

Power Delivery & Utilization

Transmission, Distribution, and Substations

Power Delivery & Utilization

Distributed Energy Resources and the Customer

Nuclear

Generation

Energy and Environment

Technology Innovation

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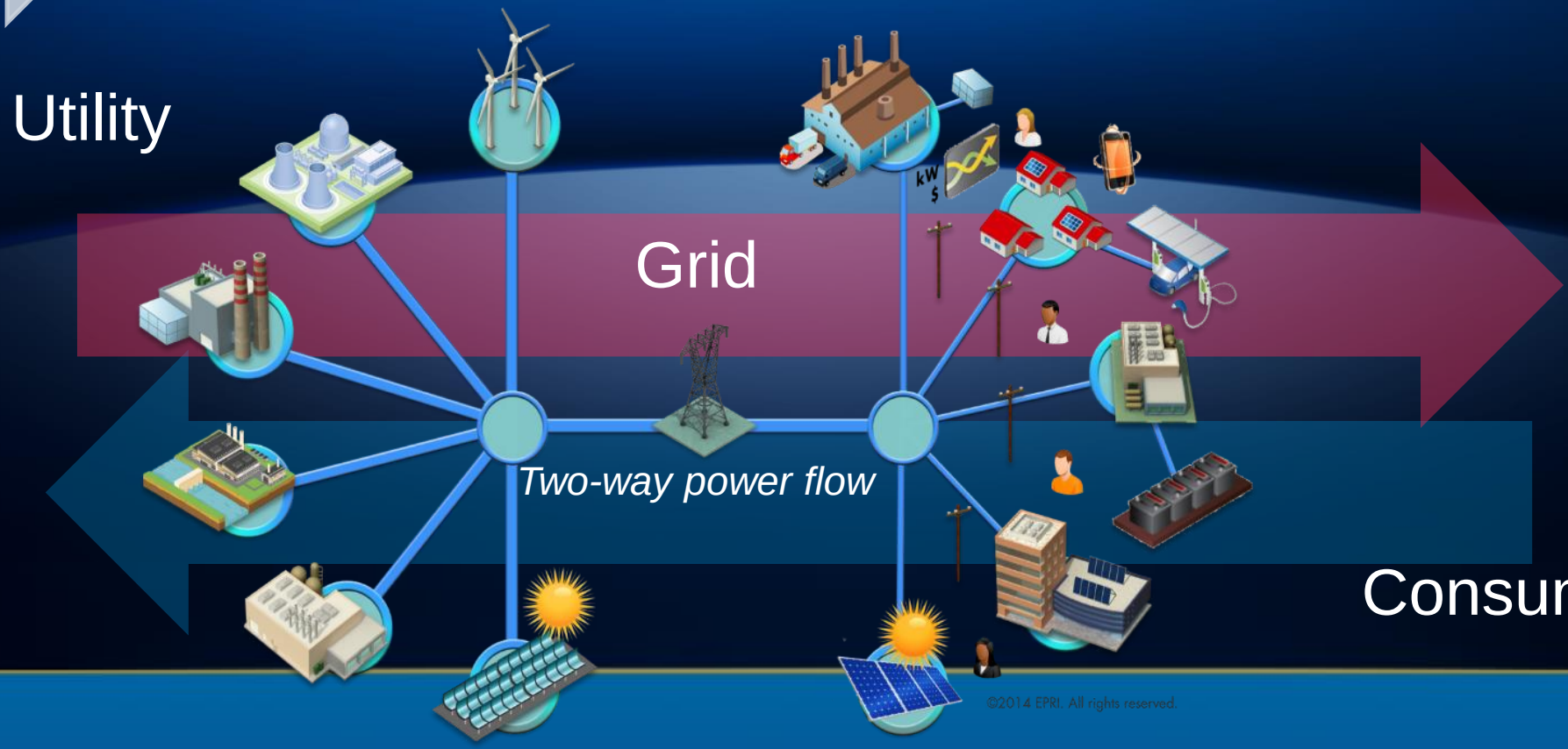
The Transforming Energy Network

- Integrated Grid
- Integrated Energy Network
- Efficient Electrification
- Shared Integrated Grid
- Data Analytics, AI, Cyber- OT

Integrated Grid

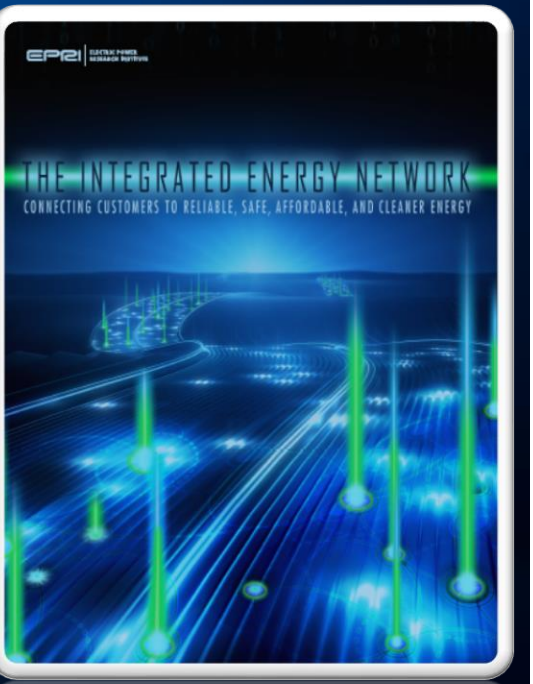
The Integrated Grid –
Integrating Distributed Energy Resources into Grid Operations and Planning



Enabling the full value of distributed resources and to serve all consumers at established standards of quality and reliability

Integrated Energy Network

Integrated Energy Network



Source: EPRI 3002009917
February 2017

Integration of Interdependent Energy Resources:

Improves Reliability, Resiliency, Efficiency, Productivity, Create New Opportunities, and Expand Customer Choice

The Customer

5 C's = Convenience, Comfort, Choice, Control and Cost-effective

Integrated Energy Network…

…Best Serves The Customer

Defines a pathway to the future which provides customers with the flexibility to use, produce and manage energy the way they want - while ensuring universal access to reliable, safe, affordable, cleaner energy.

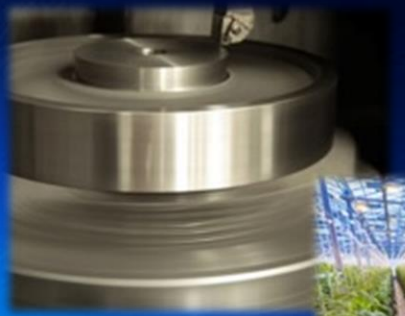
Efficient Electrification

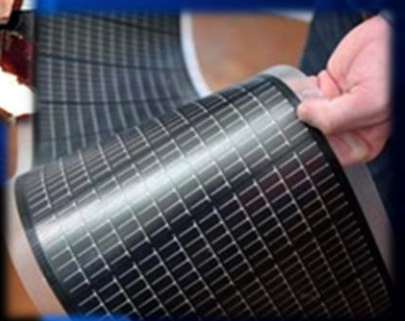
Energy Efficiency + Cleaner Electricity = Efficient Electrification

Mobility

Heating and Cooling

New Applications





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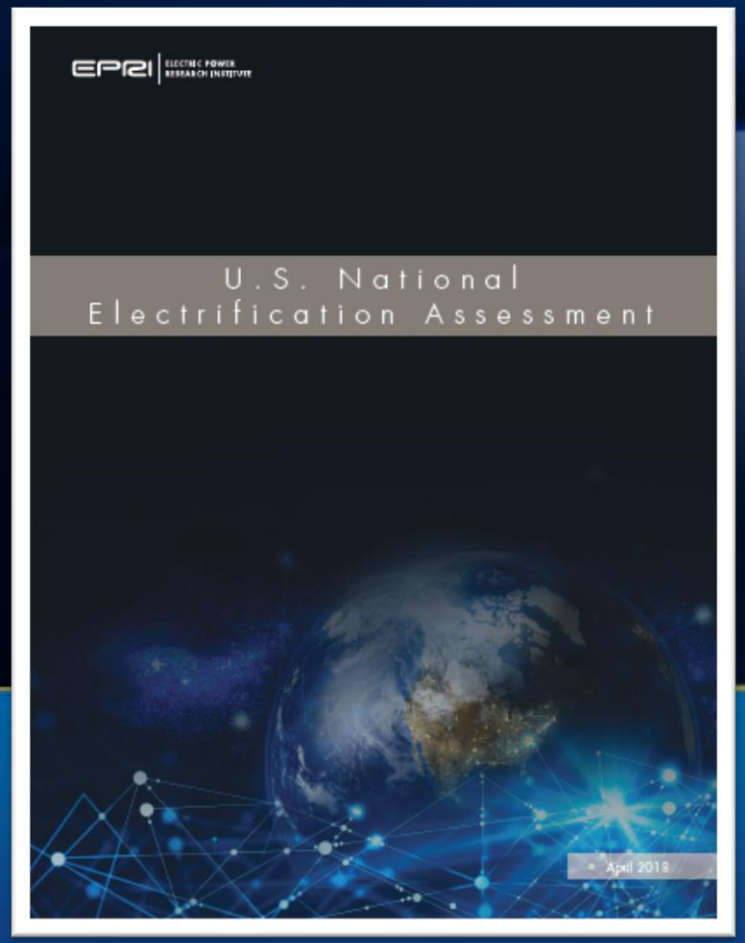
Efficient Electrification Assessments



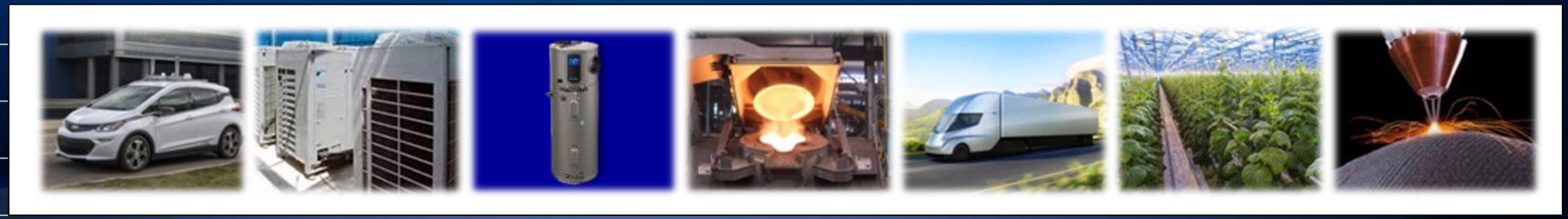
U.S. National Electrification Assessment (USNEA)

- Economy-wide assessment:
  - Residential, commercial, industrial and transport
- Customers have broad technology choices and control
- Customer decisions integrated with detailed electricity supply model

Just the beginning … much more to come

For more information on EPRI's Efficient Electrification Initiative:
https://www.epri.com/#/pages/sa/efficientelectrification

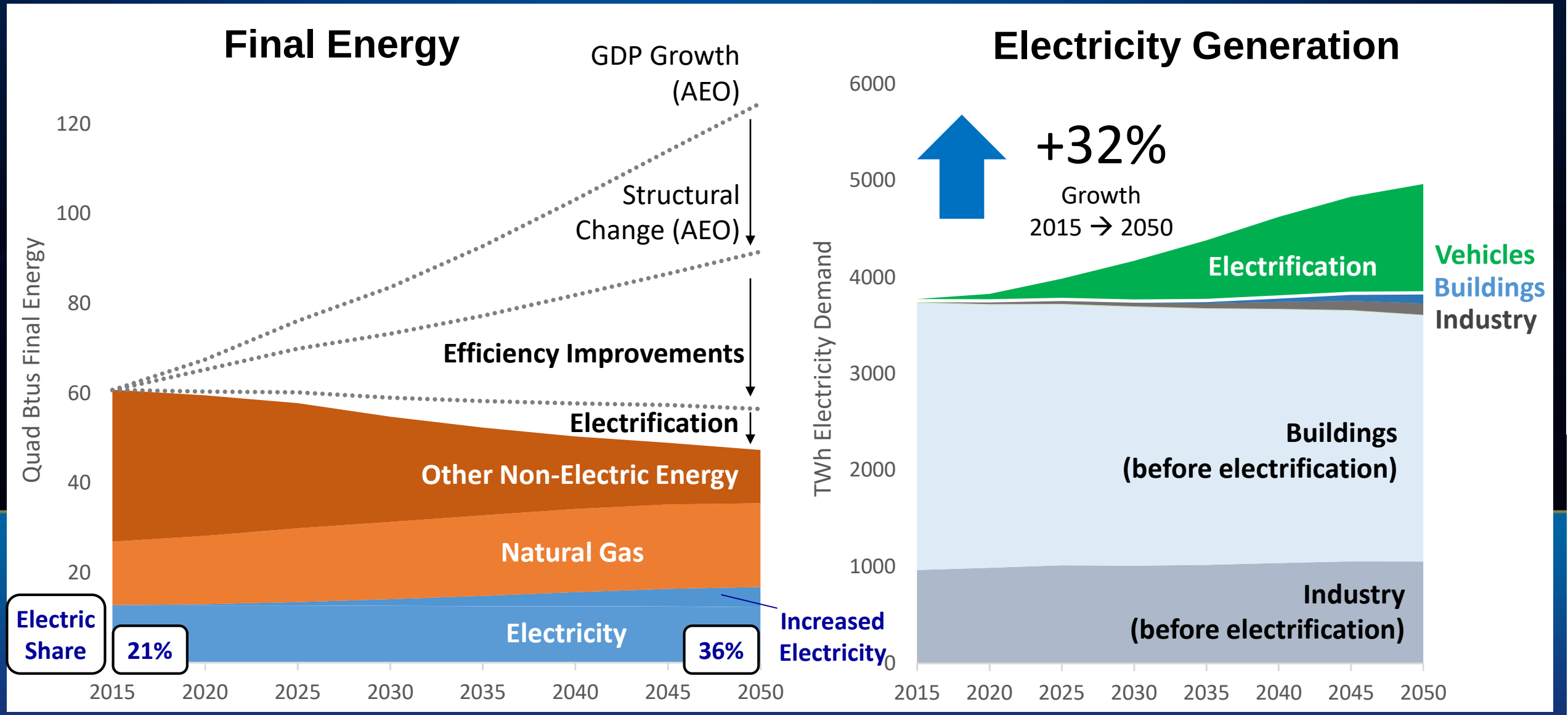
End-Use (Final) Energy Use By Sector



EPRI's US National Electrification Assessment Scenarios

CONSERVATIVE	Slower Technology Change	• AEO 2017 growth path for GDP and service demands, and primary fuel prices • EPRI assumptions for cost and performance of technologies and energy efficiency over time • Existing state-level policies and targets
REFERENCE	Reference Technology	
PROGRESSIVE	Reference Technology + Moderate Carbon Price	
TRANSFORMATION	Reference Technology + Stringent Carbon Price	

Efficient Electrification: Reference Scenario



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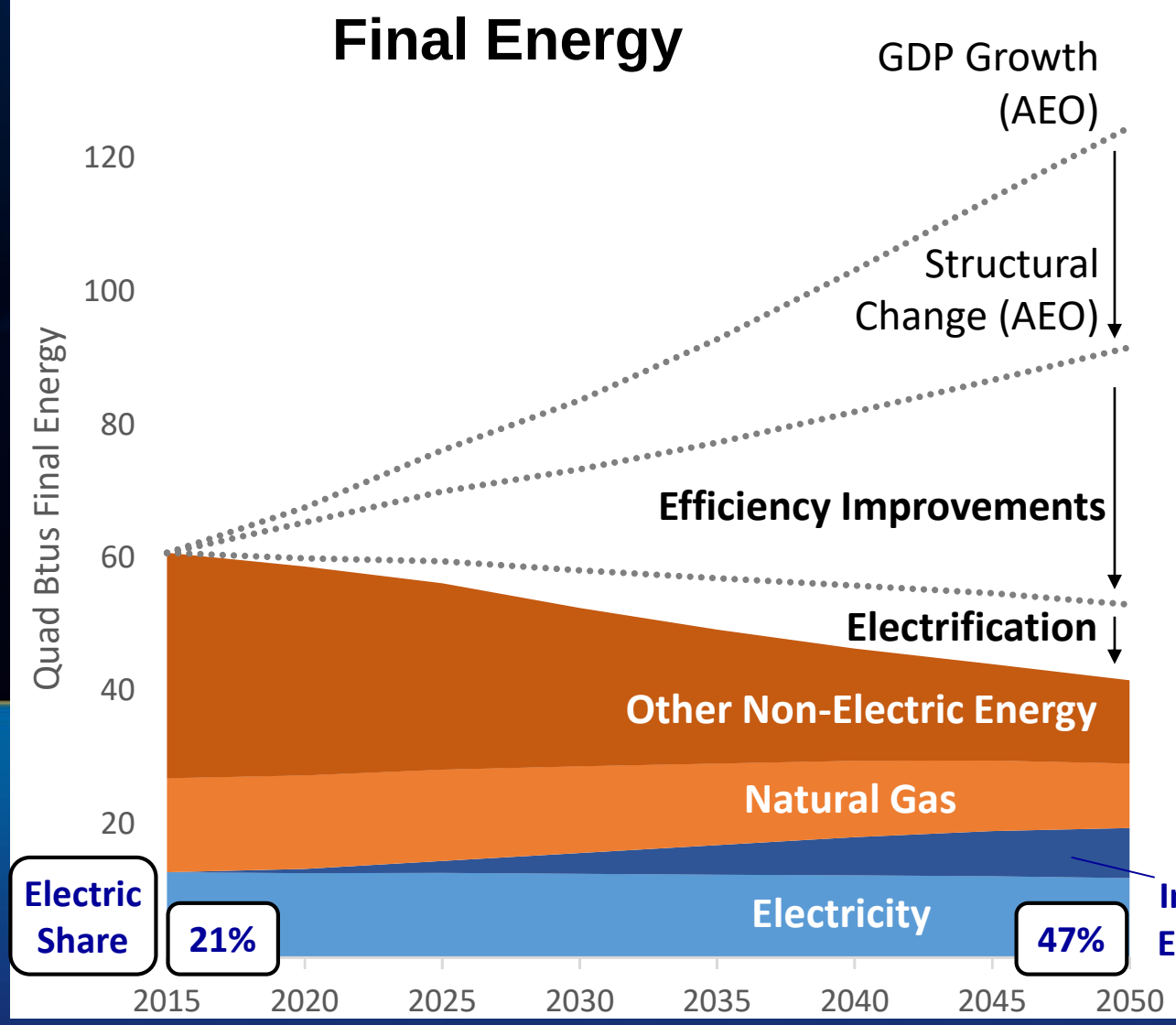
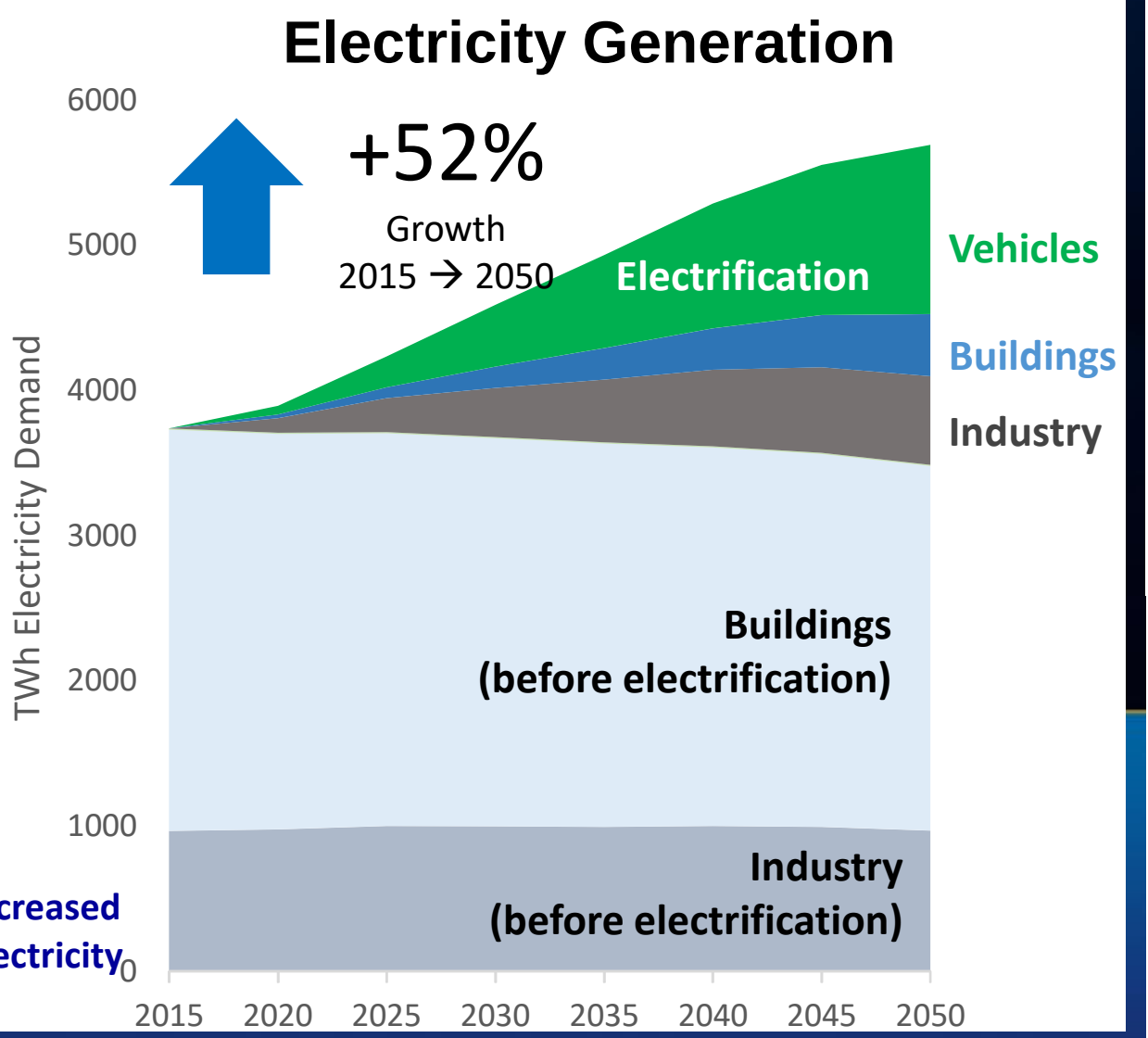
Efficient Electrification: Transformation (tight carbon target)





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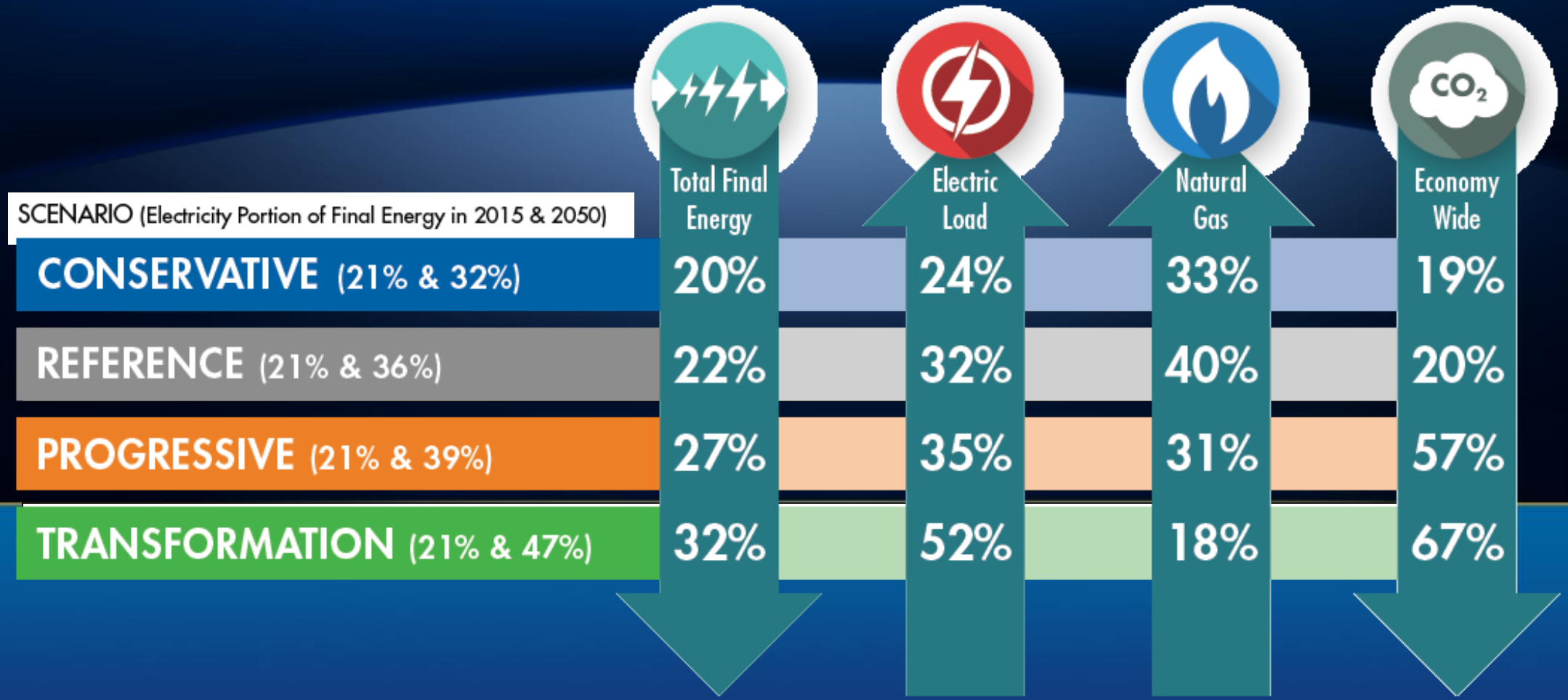
U.S. National Electrification Assessment (USNEA) – Results 2015-2050



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Efficient Electrification – "Sustainable" Opportunities

ELECTRIC VEHICLES

AIRPORT ELECTRIFICATION

PORT ELECTRIFICATION

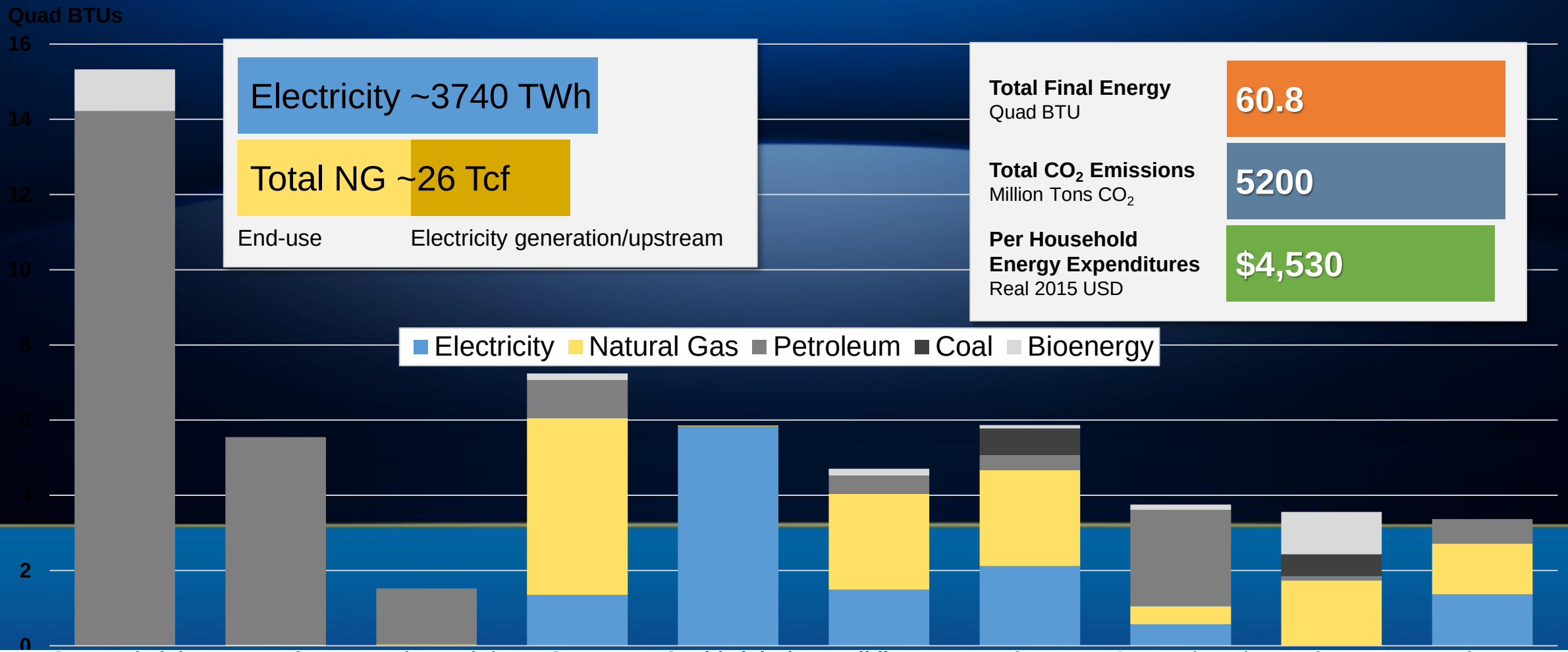
ADVANCED MANUFACTURING

INDOOR AGRICULTURE

RESIDENTIAL HEATING

Improve Productivity, Reduce Emissions, Reduce Cost and Is More Controllable

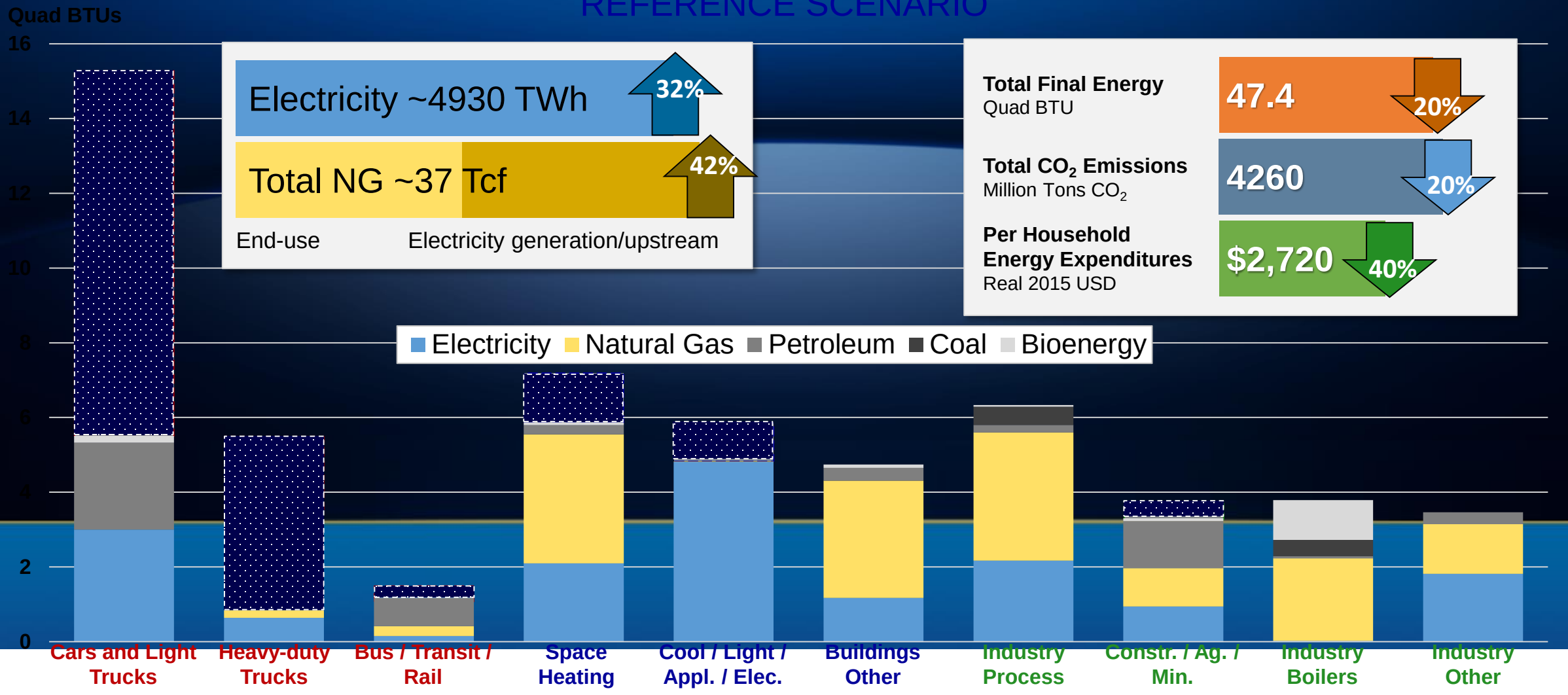
EPRI US Electrification Assessment – Use of Energy Today



** Final Energy, excludes upstream and midstream energy use, e.g., power generation, oil and gas extraction, refining, and pipelines*

US Electrification Assessment – Use of Energy 2015 - 2050

REFERENCE SCENARIO



** Final Energy, excludes upstream and midstream energy use, e.g., power generation, oil and gas extraction, refining, and pipelines*

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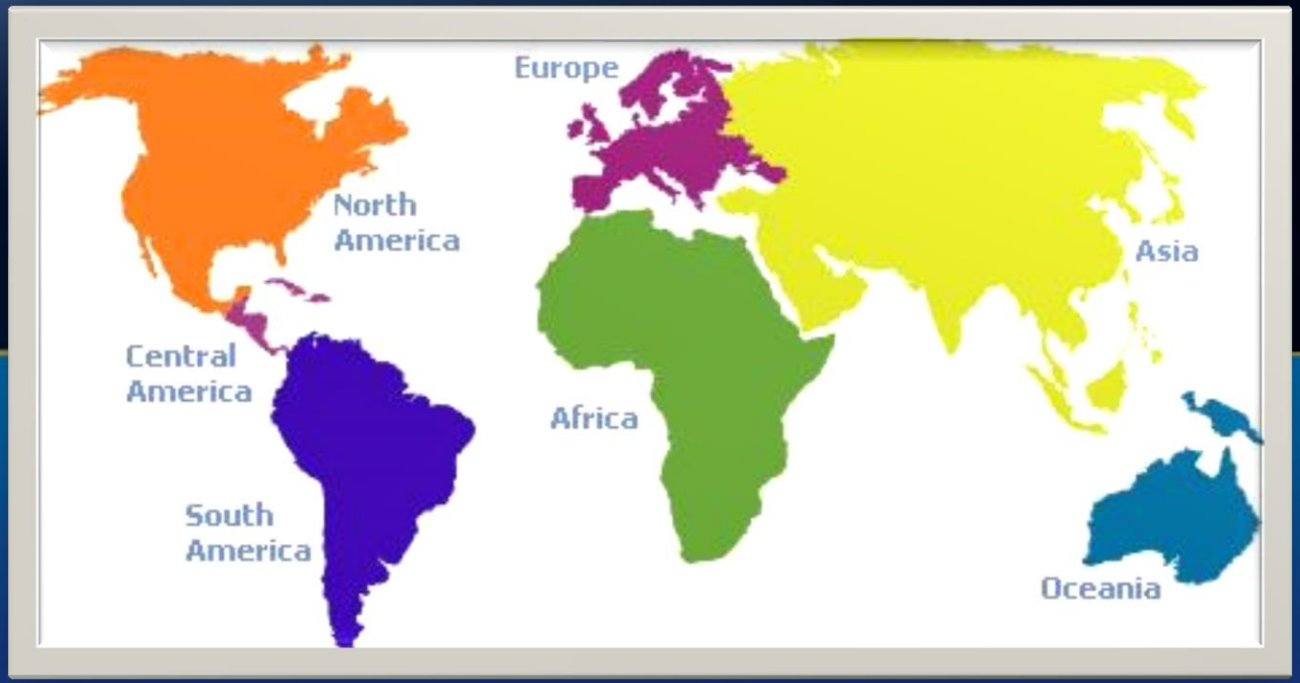
Local and Regional Differences Matter

Focus:

- **Local economics**
- **Local realities: building stock, access to charging, policies**
- **Implications of non-volumetric pricing**
- **Air quality**
- **Grid impacts**
- **Program implementation**



Shared Integrated Grid

Shared Integrated Grid – New Value Streams

Imagine a future when customers' energy assets become shared energy solutions that enhance grid reliability, resiliency, and value for all.

Customer Value Stream

Selection

Incentive

Seamless Integration

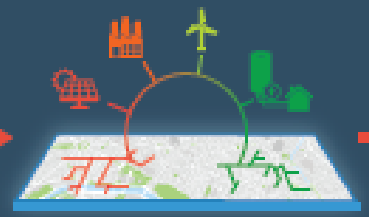
Direct Benefits

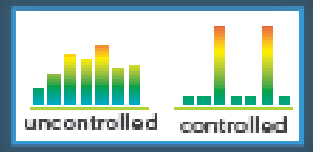
Network Operator Value Stream

Network Operator

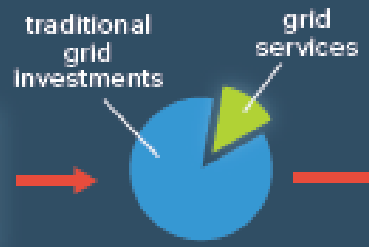
Bridging Customer Resources

Network Operator Platform





Grid Services from Customer Assets



New Type of Grid Investment

Societal benefits
The shared integrated grid delivers greater reliability, resiliency, and value for the grid and all customers.

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Shared Integrated Grid – Examples

MICROGRIDS

(Example) Campus pays to install the microgrid to increase resiliency and the utility invests in the interconnection to incorporate an asset that can support the overall distribution grid.

IMAGING ANALYSIS

(Example) Using AI to compare before and after images requiring a strong communications backbone. That same communication backbone could also be used for Smart Cities streetlights and other reliability benefits.

SOLAR ROOFTOPS

(Example) Smart Inverter provides limited power to the home and can also be resource to the grid – improving voltage support and hosting capacity.

Critical Trends – Data Analytics/Artificial Intelligence

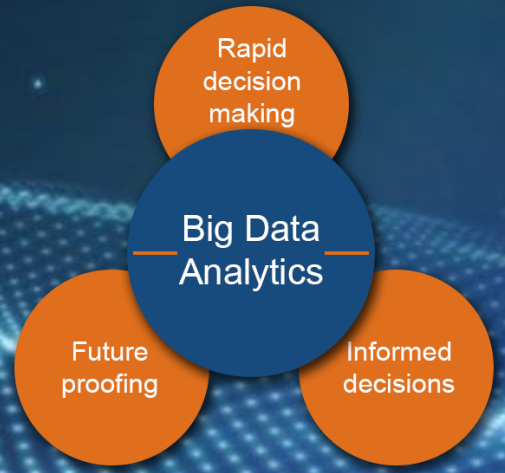
Data Analytics & Artificial Intelligence

SIGNPOSTS

1

Processing Power

2

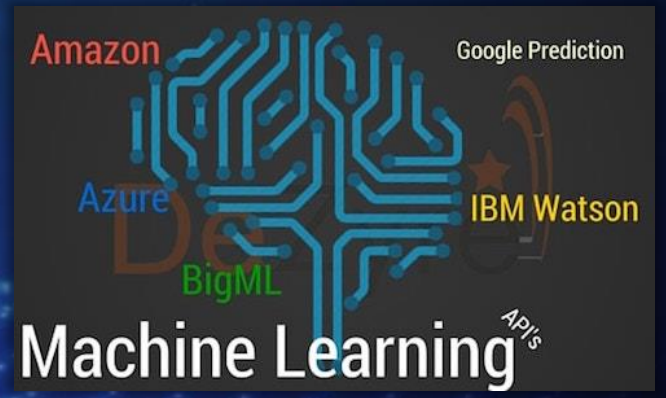


Big Data – Sensors and Internet of Things

3

Faster Wireless Communications

4



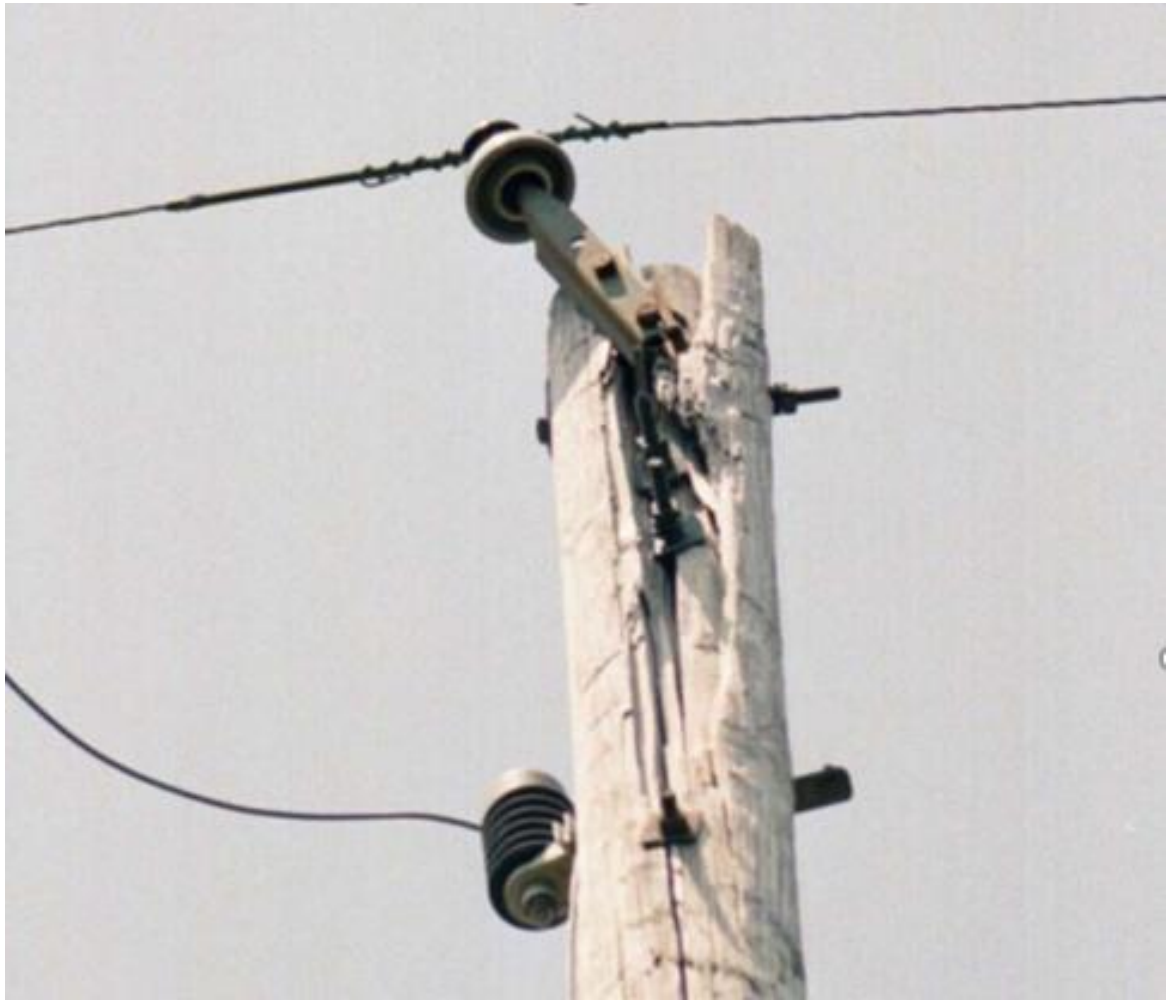
Mainstreaming of Analytics Platform

Training Data

Validating Data

Testing Data

Advanced Image Analytics

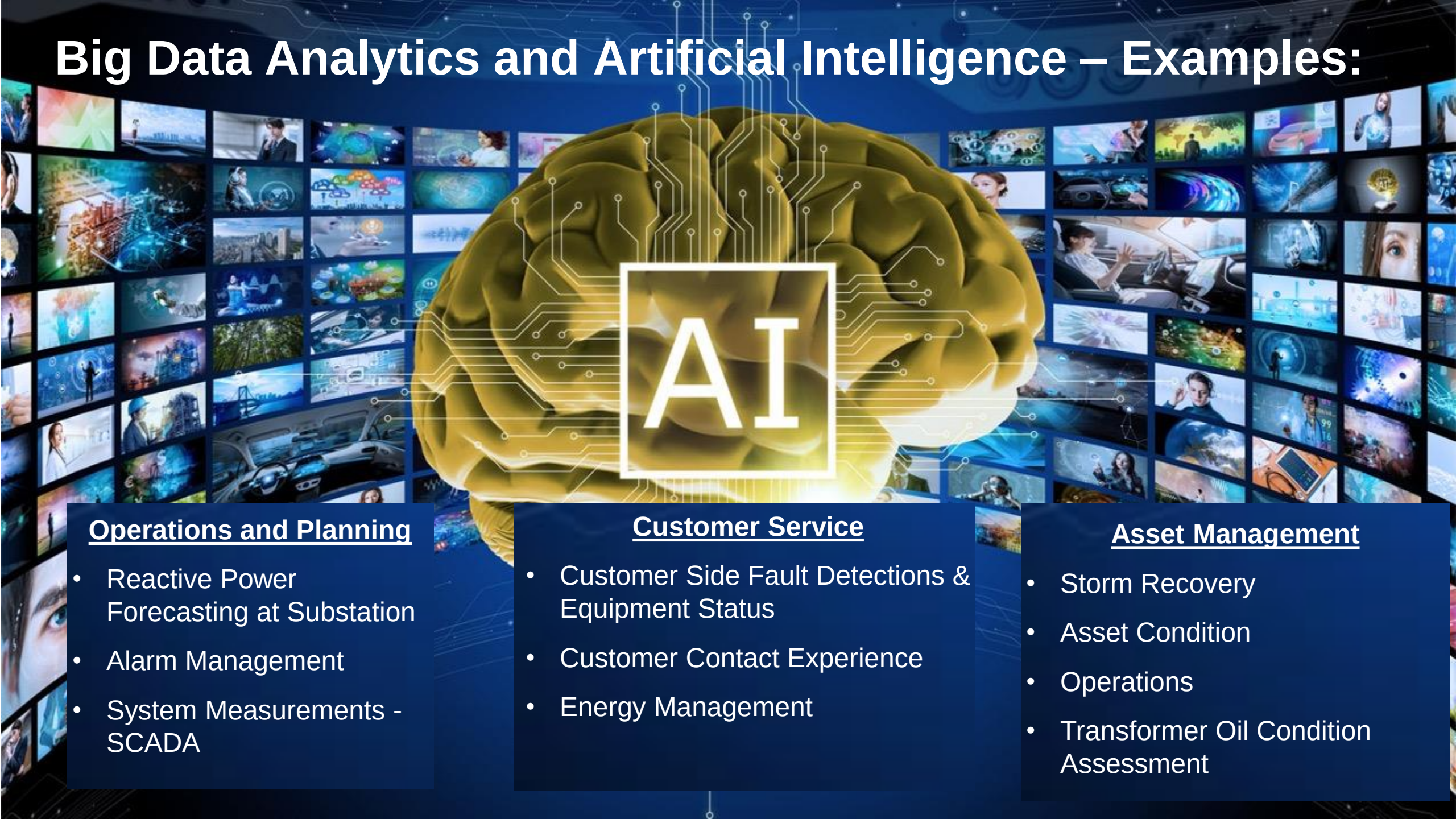


Deteriorated Wooden Pole Top

OR ?

Stop Light

Big Data Analytics and Artificial Intelligence – Examples:



Operations and Planning

- Reactive Power Forecasting at Substation
- Alarm Management
- System Measurements - SCADA

Customer Service

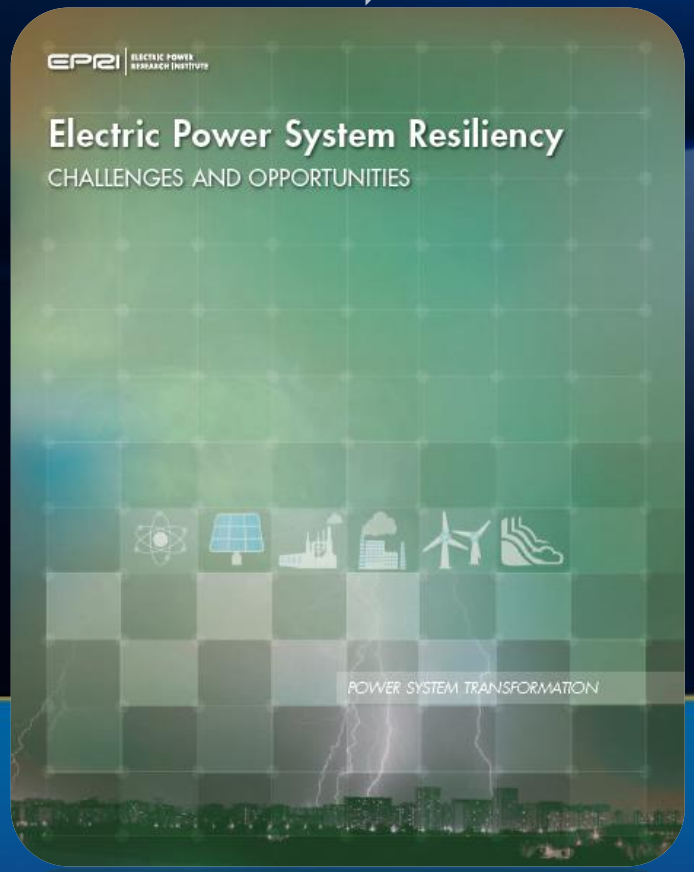
- Customer Side Fault Detections & Equipment Status
- Customer Contact Experience
- Energy Management

Asset Management

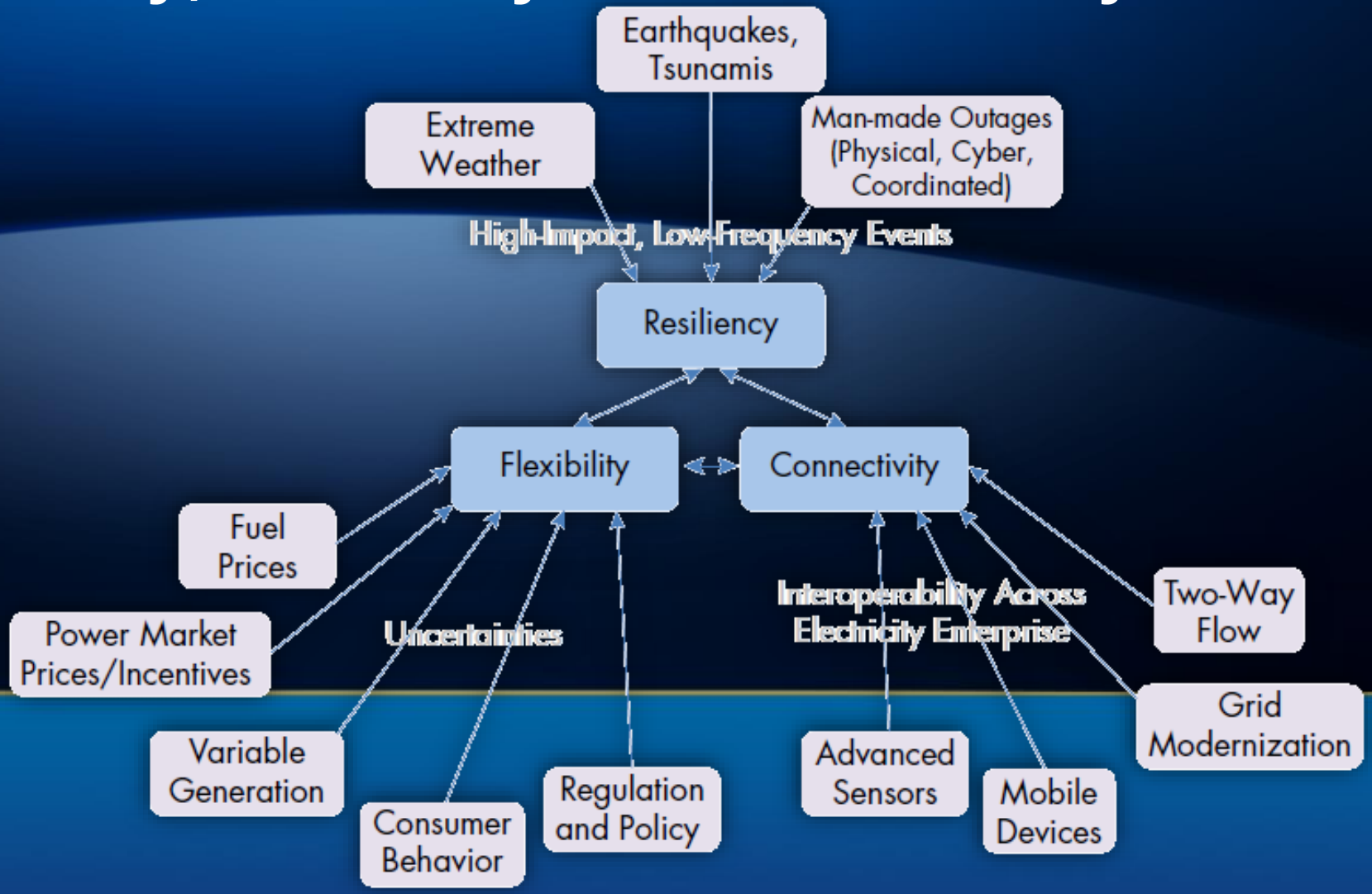
- Storm Recovery
- Asset Condition
- Operations
- Transformer Oil Condition Assessment

Grid Resilience- Cyber- OT

Resiliency, Flexibility and Connectivity



Source: EPRI 3002007376 February 2016



The Three Attributes of the Power System in a "No Regrets" Strategy

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EPRI R&D in Electric System Resilience Addresses:

(Examples of EPRI Work)

Manmade Hazards

EMP – High Altitude Electromagnetic Pulse

IEMI – Intentional Electromagnetic Interference

Today

Cyber Terrorism

Coordinated Physical Assault

Natural Hazards

Seismic Event – High Magnitude Earthquake

GMD Geomagnetic Disturbance (Severe Space Weather)

Hurricanes and Other Severe Weather Events

Hardening/ Prevention

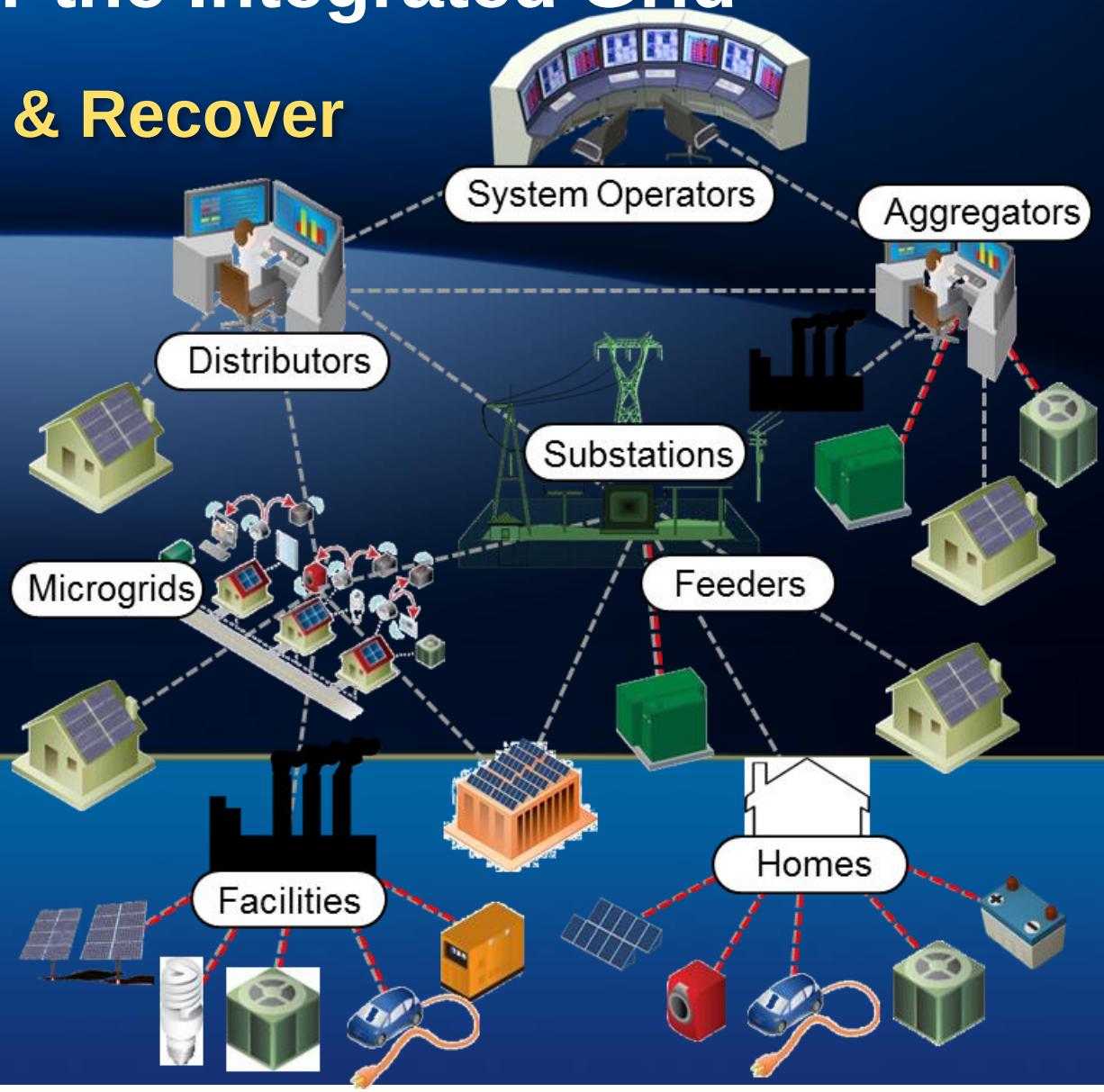
Response/ Recovery

Customer/ Community

Cyber Security Challenges for the Integrated Grid

- Protect - Detect - Respond & Recover

- Generation and storage assets may not be owned or operated by the utility
- Energy generation/consumption can be controlled by an aggregator
- Technology and business services are performed by third parties
- Operating increasingly complex, interconnected systems
- Dynamic governance relationships
- Cyber security vulnerabilities of deployed DER is unknown



The Integrated Grid is a Multi-Party Grid

Cyber Security Challenges for the Integrated Energy Network -
EPRI Focus: "Operations Technology (OT) Interfaces

Example: Smart Inverters:

- Secure Gateways
- Reactive Power Control
- Islanding Capability
- Aggregator Management

Third Party Equipment and Consumer Devices Vulnerabilities

Cybersecurity Threats to the Oil & Gas Industry

SAFEGUARD "ATTACK" SURFACES

Protecting Nuclear Plants from Cyber Attacks

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Engaging with Customers to Reliable, Resilient, Safe, Affordable and Clean Energy Systems

The Integrated Energy Network

Together…Shaping the Future of Electricity

Electrification of Airports (off-road)

- **Cost:** $31 million
- **Annual Savings**: $2.8 million in airline fuel costs
- **Emissions reduction**: 10,000 tons of greenhouse gas emissions - the equivalent of taking 1,900 cars off the road.

Port of Seattle
Seattle-Tacoma International Airport

Hartsfield-Jackson
Atlanta International Airport

Opportunity?

AIRGLADES INTERNATIONAL AIRPORT, LLC.
"Growers serving Growers"

Source: https://www.electricvehiclesresearch.com/articles/6385/sea-tac-airport-unveils-electrification-project

Electrification of Sea Ports

Electric Rubber Gantry Cranes Replace Diesel Cranes

$10 million saved annually

6 million gallons of diesel saved annually

85% reduction in crane operating costs

Georgia Port Authority's electrification efforts at Port of Savannah, are helping to reduce emissions, lower costs, and improve the efficiency of the port's operations

(Note: there is also an equal effort to use LNG at ports to reduce diesel fuel)

Advanced Manufacturing

Infrared and Induction Heating

(Replace Steam)

Additive Manufacturing

(e.g. 3-D printing for industrial parts)

Ultraviolet Curing

(Replaces Heat)

Heat Recovery Chillers

(Reduces water evaporation as a co-benefit)

Efficient Electrification, increases manufacturing productivity, reduces emissions and can be more cost effective

Indoor Agriculture: No Sun + No Soil = Healthy Food

ENERGY: The Biggest Cost of the Infrastructure is Energy: Lighting, Lumins, Climate Control and Pumps

90%

Reduces Water and Land Use by 90%