

# Integrated Energy Network and the Role of the Electric Sector in Support of a Low Carbon Future

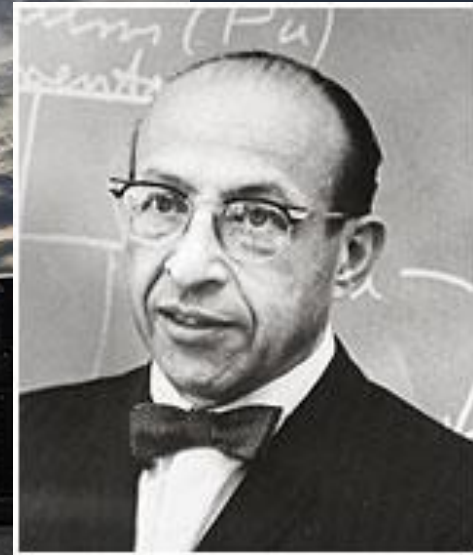


**Bill Gould**  
Director  
Strategic Analysis, Safety & Sustainability

**New York ISO**  
**Environmental Advisory Council**  
May 19, 2017

# EPRI – 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**

# Three Dimensions of EPRI's Value

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

## Thought Leadership



## Industry Expertise



## Collaborative Model





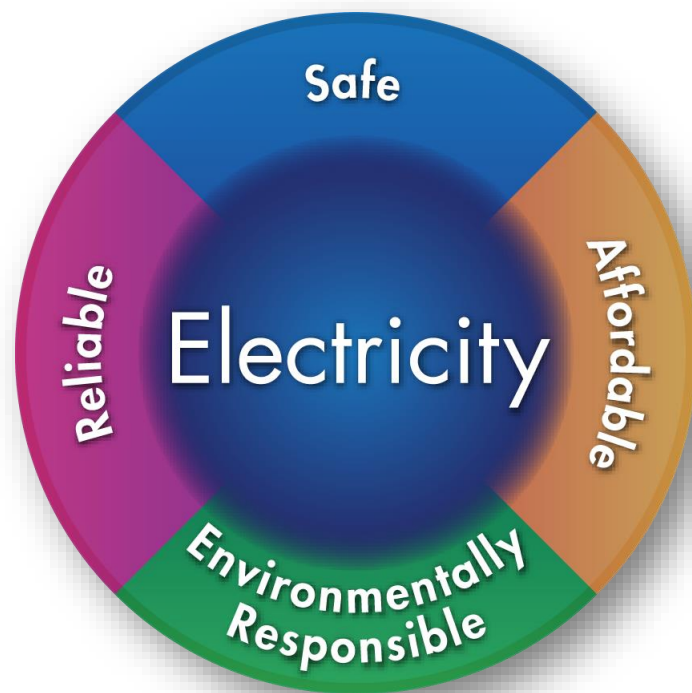
# Our Members...

- 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



# EPRI's Mission

Advancing ***safe, reliable, affordable, and environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation



# The Integrated Energy Network Builds upon Decades of EPRI Thought Leadership



## THE INTEGRATED ENERGY NETWORK





# The Energy System Today is Fragmented

Companies, products, business models, regulation



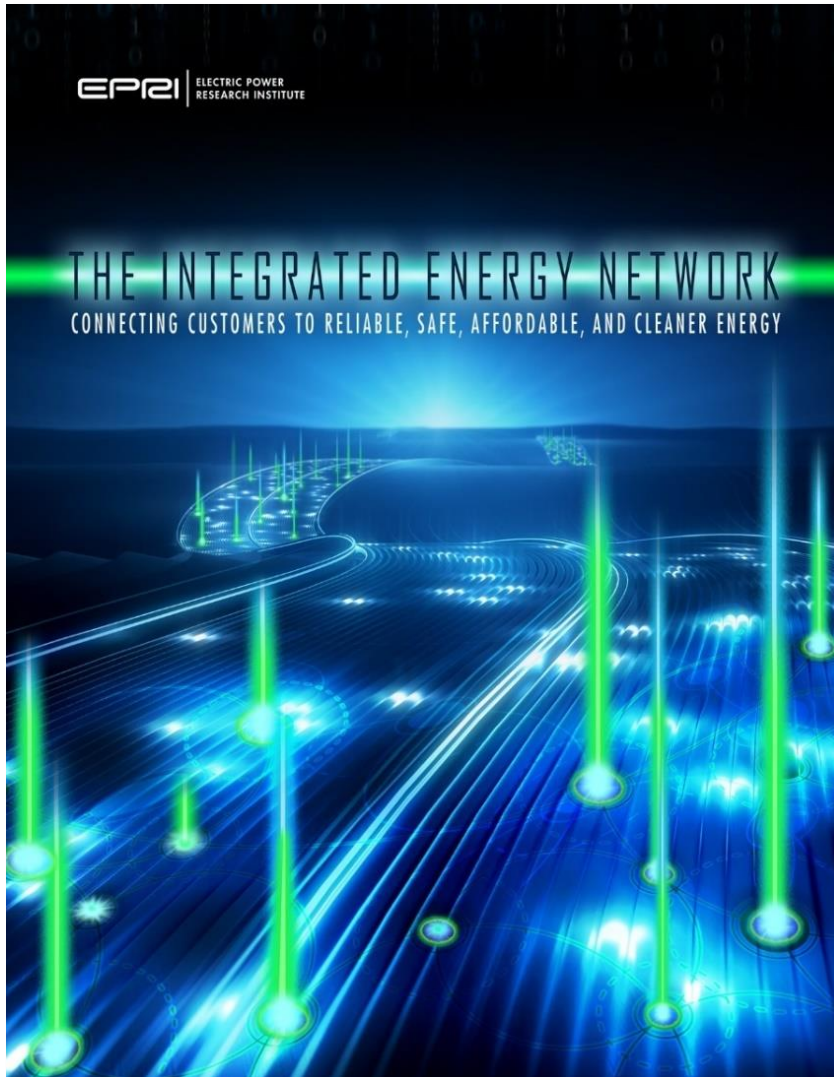


**Integration can Improve Reliability, Increase Efficiency,  
Create New Opportunities, and Expand Customer Choice**



# Integrated Energy Network

Connecting Customers to Reliable, Affordable, and Cleaner Energy



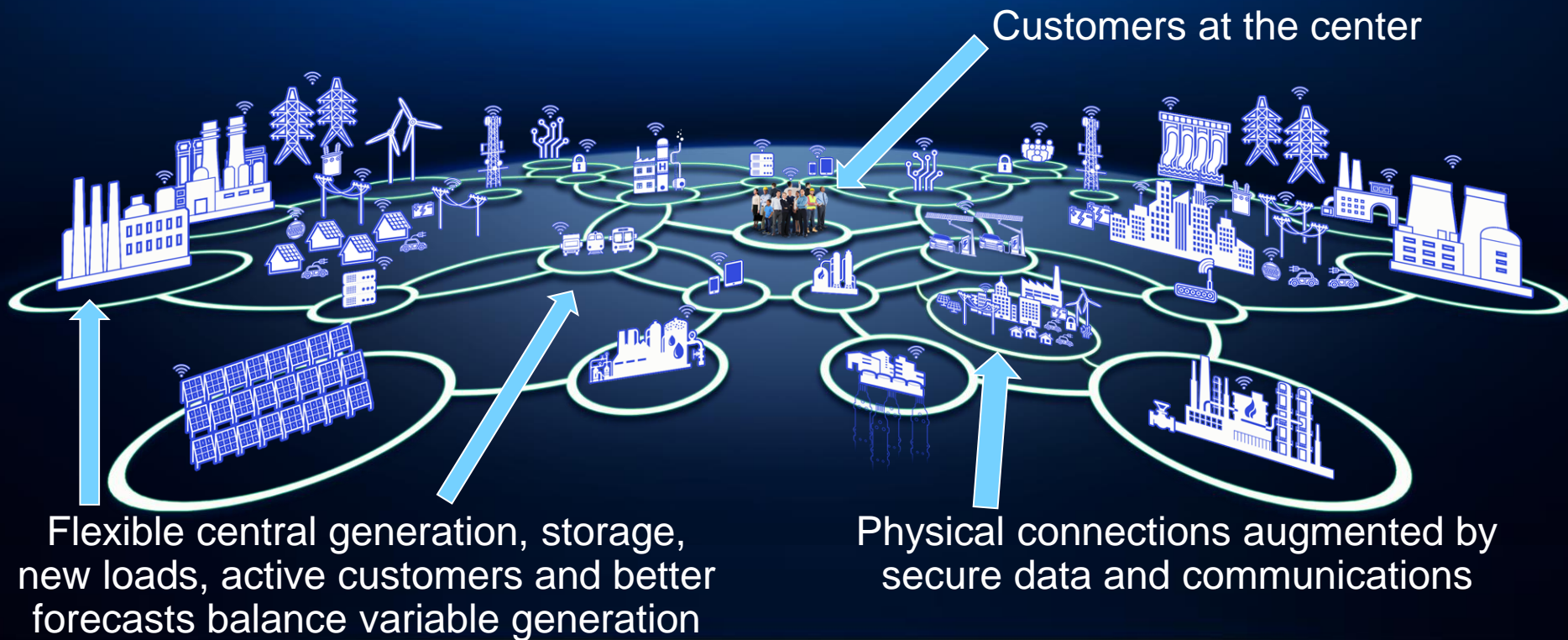
Published in February, this document provides an introduction to our thinking.

We welcome your engagement as we refine the concept and action plans!

**Available at:**

**<http://ien.epri.com>**

# Integrated Energy Network



**Energy and Natural Resource Systems are Integrated to Provide Reliable, Safe, Affordable, Cleaner Energy and Expanded Customer Choice**



# Why Do We Need an Integrated Energy Network?

- Improves Reliability
  - Integration enables quick assessment, containment, and rapid response
- Promotes economic efficiency, energy efficiency, and cleaner energy
  - Integration makes possible a wide array of efficient, affordable, cleaner energy options
- Expands customer choice and enhances value
  - Digitalization of energy provides both near-term and unforeseeable opportunities



# Governments and Companies are Taking Steps Towards the IEN... But are Only Scratching the Surface



**Integrated Thinking**

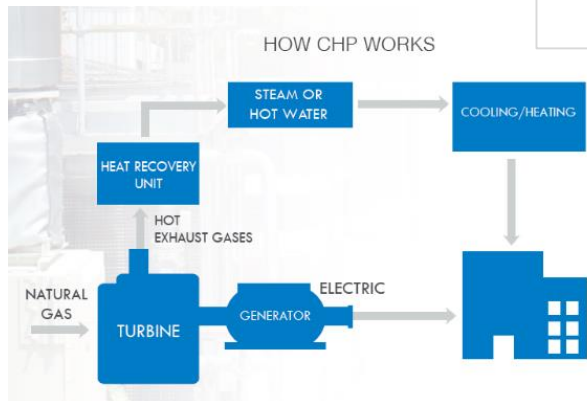


**Reforming the Energy Vision**

**Exploring Policy and Regulation**



**Investing in Infrastructure**



**Local Systems Integration**



**Testing Advanced Equipment**



# The IEN: Consumer, Producer and Delivery Perspectives

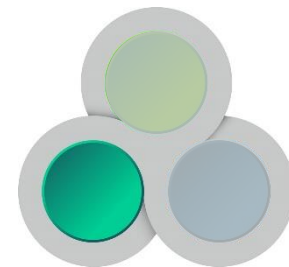


## ***Integrated Energy Network***

*Connecting Customers to Reliable,  
Safe, Affordable and Cleaner Energy*

**Cross-cutting Issues**

# Producing Cleaner Energy



**Renewables**



**Large-Scale Storage**



**Distributed Energy Resources**



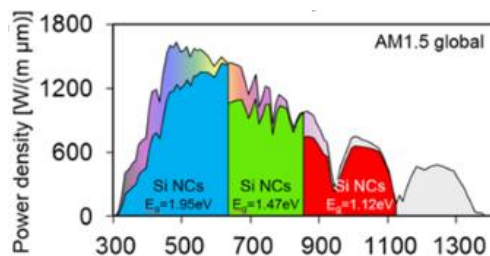
**Ultra Supercritical**



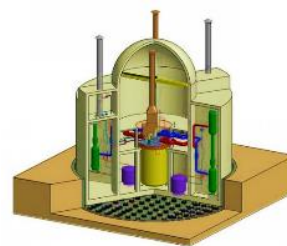
**Natural Gas**



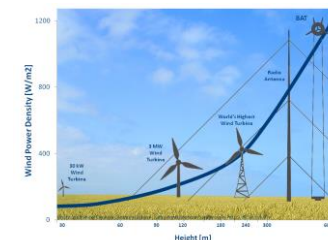
**Advanced Power Cycles**  
(e.g., Supercritical CO<sub>2</sub> Cycle)



**Gen III Photovoltaic (PV)**



**Generation IV Nuclear**  
(co-production – electricity, hydrogen steam)

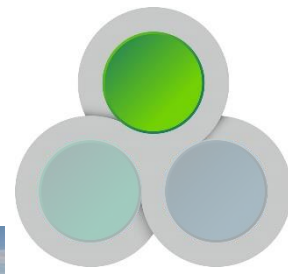


**High Altitude/Power Wind**

**Technology, policy, and regulatory innovation in the next decade can expand the options for the future**



# Using Cleaner Energy – Through Efficiency and Electrification



**Electric Vehicles**



**Advanced Energy Communities**



**Industrial Processes**



**Hydrogen and Biofuels**



**Heat Pumps**



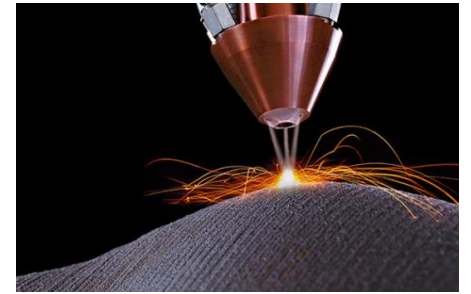
**Rail Electrification**



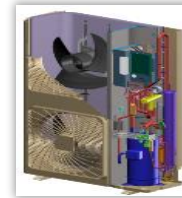
**Teleheating**



**Indoor Agriculture and Advanced Manufacturing**



# Using Cleaner Energy – A Customer's Perspective



Single-Family  
Home



Energy  
Efficiency  
Improvements



Heat Pump  
*Replaces Gas  
Furnace*



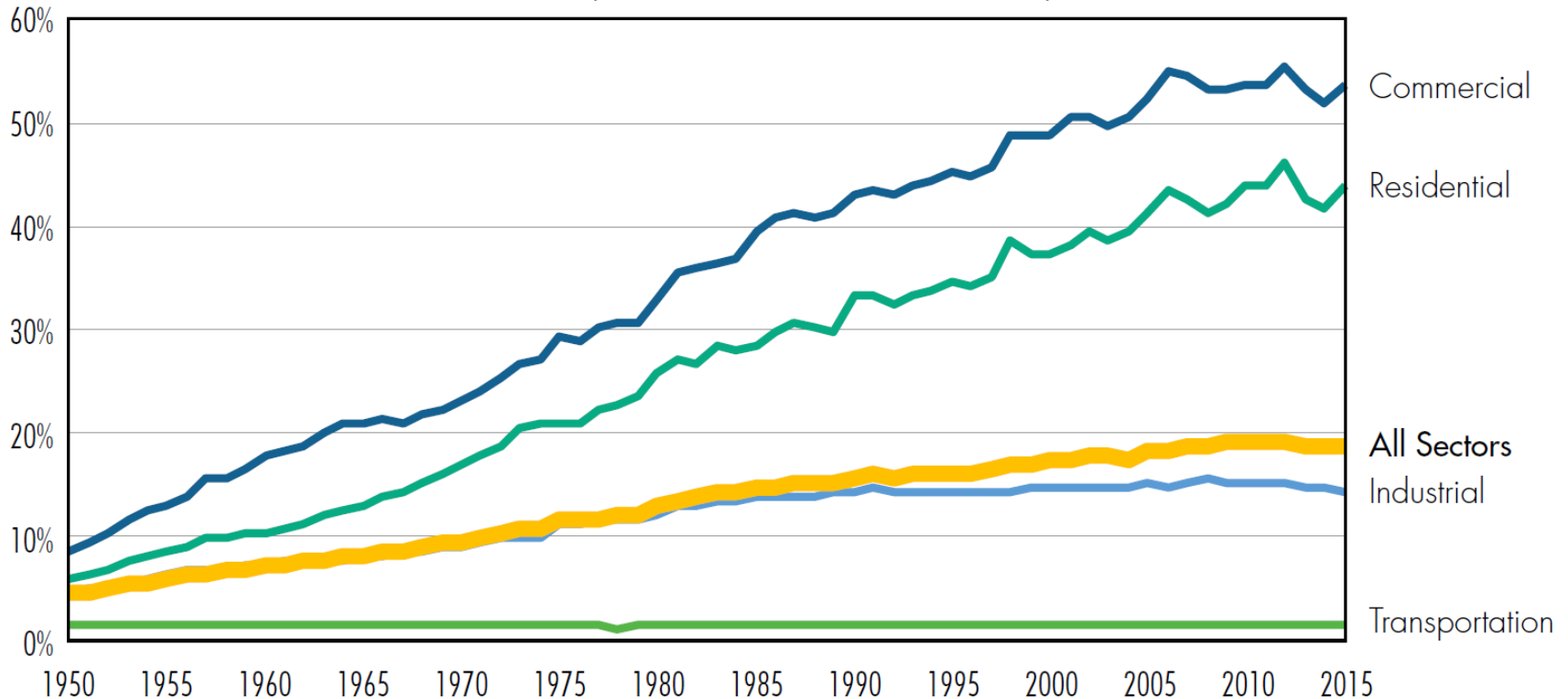
PHEV/EV  
*Replaces  
Mid-Size Car*

Electrification and efficiency are steps to  
reduced emissions you can take today

# Using Cleaner Energy: A Societal Perspective

## Electricity Use Has Grown Faster than Total Energy for More than A Century...What Happens Next?

ELECTRICITY'S SHARE OF TOTAL ENERGY CONSUMPTION, BY SECTOR  
1949-2015 (SOURCE: EIA AER 2016)



**Growth driven by efficiency, convenience, safety, and low cost**

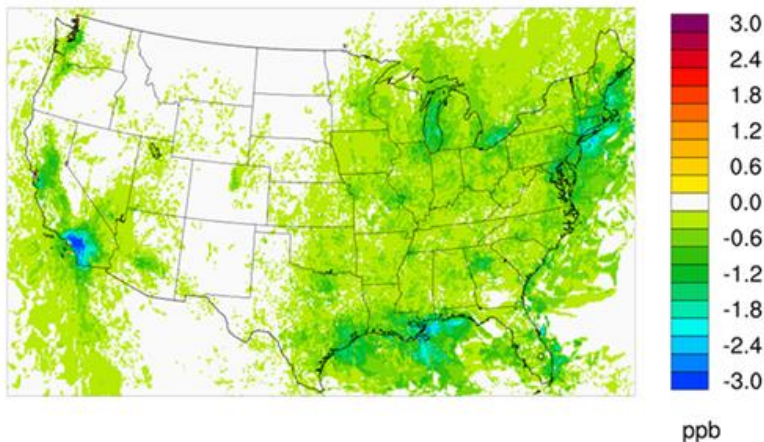
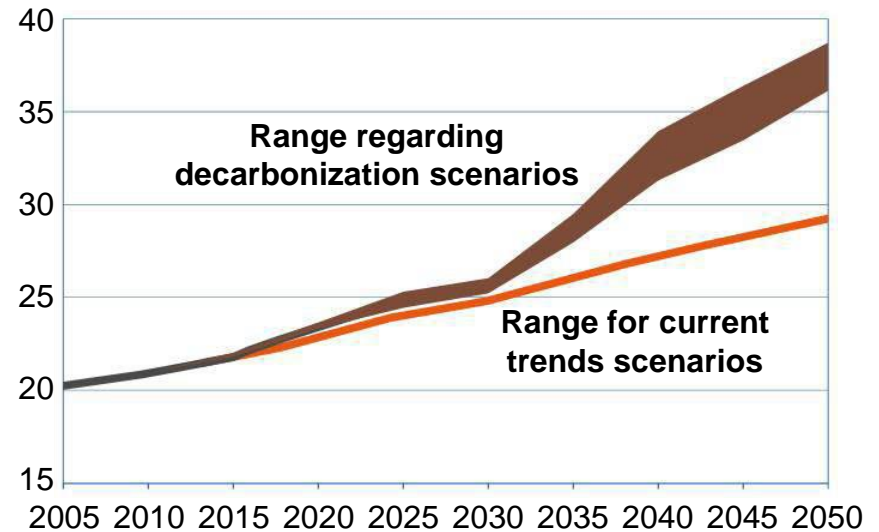


# Electricity's Share of Energy is Poised to Accelerate

## Efficient electrification can

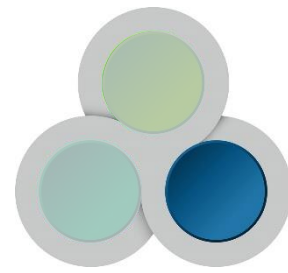
- Improve energy efficiency
- Reduce emissions
- Lower cost
- Improve productivity
- Enhance safety

EU Commission, Roadmap to a low-carbon economy



EPRI-NRDC, Reductions in ozone with electrification of transport

# Integrating Energy Resources



**Electricity, Gas, Water,  
Telecommunications, Customer Local  
Energy Networks**

**Improve comfort, convenience, choice, and control...cost-effectively**

# Integrated Grid Enables a Transition to Cleaner Electricity and Enables Integration of Energy

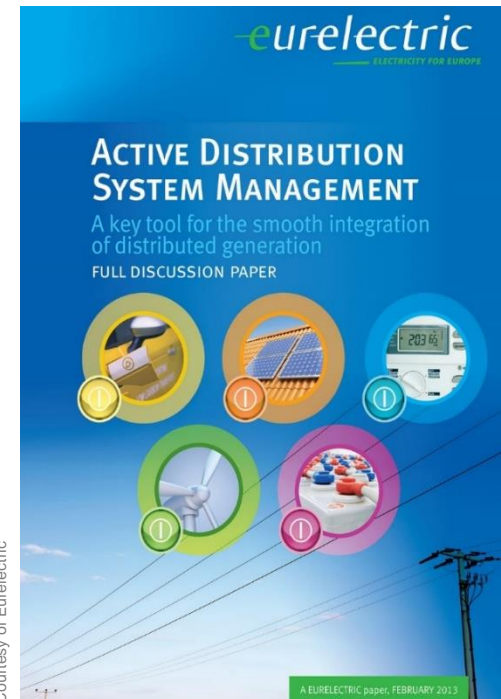
## Transmission



## Flexible Resources



## Smart Distribution

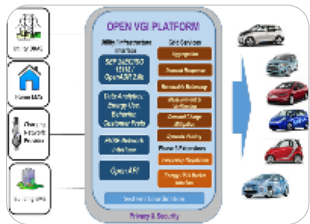




# Integrated Grid: Enables Electricity and Transportation Interface



- **National Charging Infrastructure Deployment**
  - >\$1B U.S. of utility-owned/operated infrastructure
  - Utility web portal data access and analytics, billing interface



- **Electricity Grid-to-Vehicle Interface**
  - Time-of-Use rates and Demand Response signals
  - EV batteries: grid optimization



- **High Power Fast Charging Infrastructure**
  - 150 kW / 350 kW leads to ~1.5 MW / 3.5 MW per “gas station”

# The IEN Supports Integration with Gas and Water Infrastructures



- **Natural Gas and Electricity**

- Pipeline and gas compression/electric generation station
- Electric/gas markets
- Power to gas (H<sub>2</sub>) and gas to power (fuel cell)



- **Water, Electricity and Energy**

- Water essential for electricity production and electricity essential for water transport
- Electricity essential for water treatment, e.g., desalination, waste
- Water end-uses could provide valuable thermal storage
- Electric technology advances reduce water use, e.g., cooling for generating facilities; electric end-uses for customers



**An integrated approach across energy and natural resources improves reliability, efficiency and productivity**

# Integrated Energy Network – Key Insights

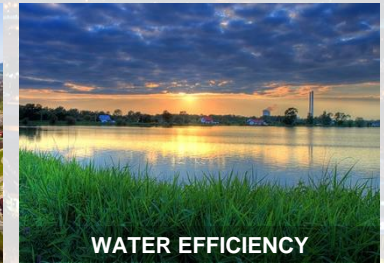
- The IEN requires rethinking energy
- Efficiency and electrification play essential roles in the future energy system
- Integrated (Electric) Grid enables the IEN
- Innovation is needed in technology, policy, regulation, business models and market designs to effect an efficient transformation
- Global collaboration in innovation necessary

THE INTEGRATED ENERGY NETWORK





# The Integrated Energy Network – Efficient Electrification



Economic and environmental factors will increasingly reward and drive the application of electric technologies to **boost energy efficiency and grid flexibility, increase productivity and improve product quality** while **supporting emissions reduction, water savings and safety.**



# Electrification Impacts – What If...?

PASSENGER  
VEHICLES

BUILDINGS

INDUSTRY

OTHER  
TRANSPORT

INCREASES ELECTRIC TO

**50%**

OF OVERALL ENERGY MIX  
(CURRENTLY 18%)

REDUCES CO<sub>2</sub> EMISSIONS

**70%**

FROM 5100 Mt TO 1600 Mt  
(SUPPLY 95% CARBON-FREE)

INCREASED  
PRODUCTIVITY

ENHANCED GRID  
FLEXIBILITY

IMPROVED HEALTH AND  
SAFETY

REDUCED WATER  
CONSUMPTION

# Efficient Electrification... National Assessment Project

Why National  
Assessment?

## *Request of Board Working Group to Understand...*

- Benefits/impact of expanded electrification to society, customers and utilities
- Impact to supply and demand side as well as natural gas markets
- Key industry drivers and role of policy/regulation

What Can I  
Expect?

## *Project Objectives...*

- Establish and address key research questions
- Broaden awareness of efficient electrification
- Capture peer-to-peer insights on strategies for efficient electrification

How Can I  
Apply the  
Results?

## *Value of Participating...*

- Understand the benefit/cost framework of pursuing efficient electrification for utilities, society and your customers
- Leverage results to inform policy and regulatory entities on value of efficient electrification



# Efficient Electrification... National Assessment Project

Who Should Participate?

## *Diversity of Participants is Key...*

- Strategic Planning, Integrated Resource Planning, Grid Op's, Regulatory Compliance and Customer facing utility employees are encouraged to join the collaborative
- NGO, and Academia perspective will be included

How Can I Be Involved?

## *Active Participation of Stakeholders is Critical...*

- Help define scenario's to assess
- Review key assumptions and results
- Support outreach to stakeholders and policymakers

When Can I Expect the Project Results?

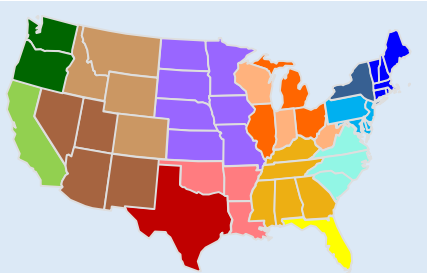
## *EPRI Sponsored Project...*

- Initial insights from project will be highlighted at EPRI's Summer Seminar – August 2017
- Final Report completed – December of 2017
- National assessment framework will support utility specific regional/service territory studies

# National Assessment Project Approach

## NATIONAL ELECTRIFICATION ASSESSMENT

2017



US-REGEN

### Technology Cost and Performance inputs

PDU: Electric technologies  
GEN: Fossil/renewables  
NUC: Nuclear power

### National Assessment of up to 50% Electrification by 2050

#### Estimates by Region, Nation for 2020, 2030, 2040, 2050

Energy demand by sector  
Electricity load shapes  
Electric capacity and generation  
Energy prices  
CO<sub>2</sub>, air emissions, other  
Drivers/barriers

## FOLLOW-ON STUDIES 2017+

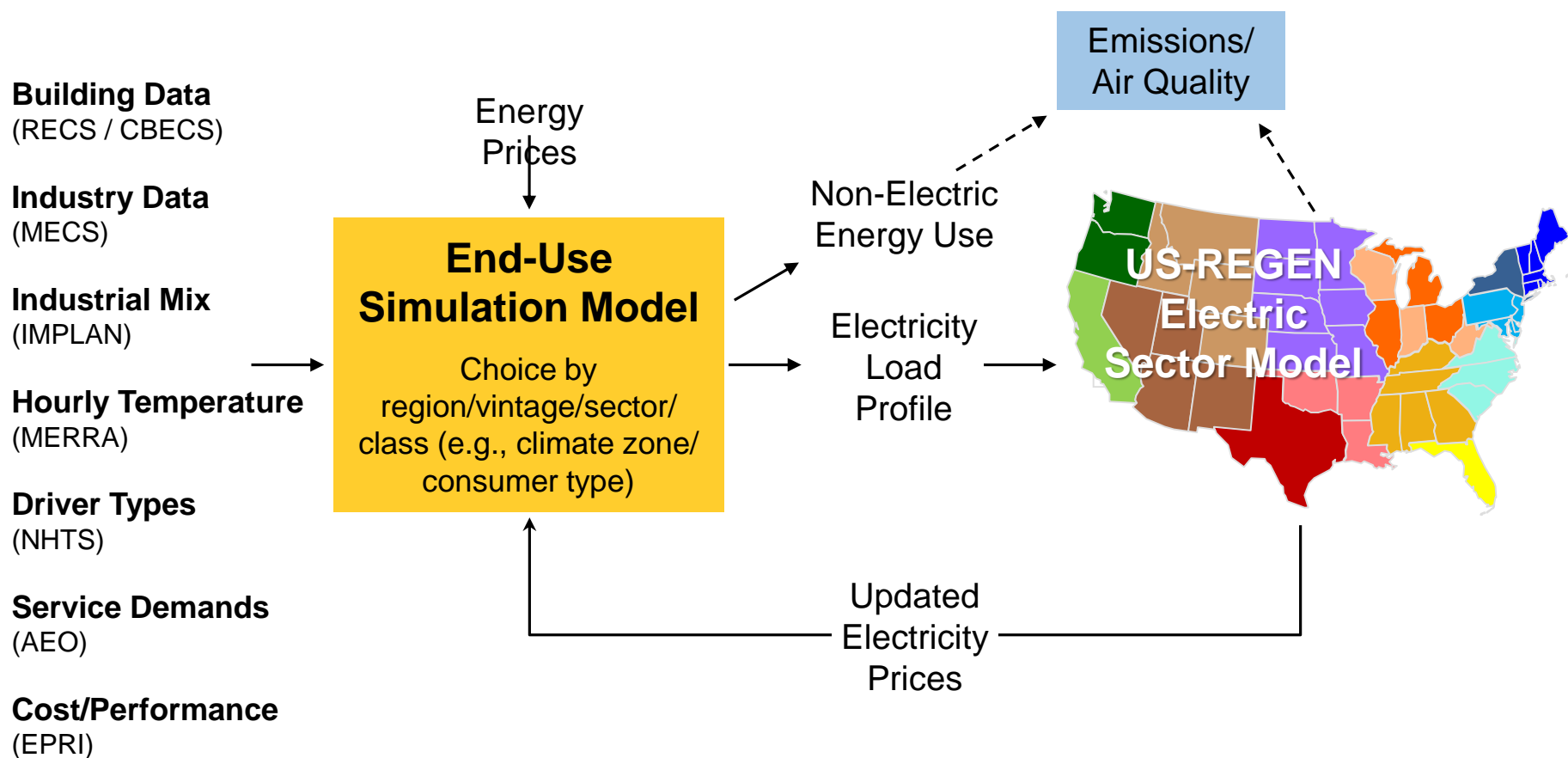
COMING SOON

### Company-Specific Electrification Strategy Studies

### Regional Policy, Air Quality and Water Resource

Member Advisory Group – Leadership, Technical, Business

# US-REGEN End-Use Model



RECS = Residential Energy Consumption Survey (from EIA)

CBECS = Commercial Buildings Energy Consumption Survey (from EIA)

MECS = Manufacturing Energy Consumption Survey (from EIA)

IMPLAN = Impact Analysis for Planning (state- and industry-level economic data)

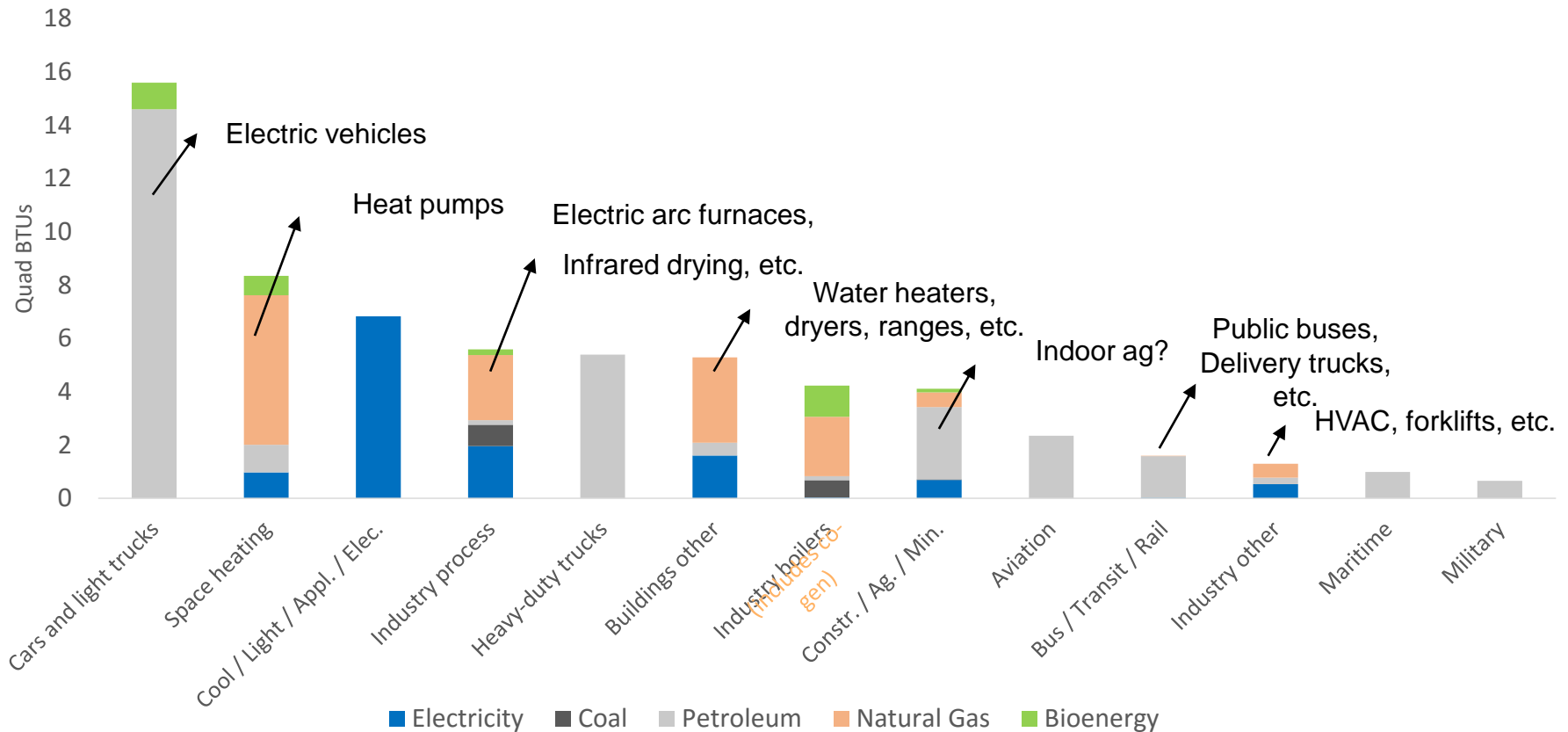
MERRA = Modern-Era Retrospective analysis for Research and Applications (gridded historical weather data from NASA)

NHTS = National Household Transportation Survey (US Department of Transportation)

AEO = Annual Energy Outlook (from EIA)



# Final Energy\* by Sector/End-Use/Fuel (2014)



\* Excludes upstream and midstream energy use, e.g., power generation, oil and gas extraction, refining, and pipelines

# Potential Drivers of Electrification

- Policy drivers (at federal, state, or local level)
  - Economy-wide carbon incentives
  - Sector-specific targets or mandates
  - Air quality regulations in non-attainment areas
- Non-policy drivers
  - Technological change (e.g., declining battery costs)
  - Fuel markets
  - New business models (e.g., autonomous vehicles, indoor agriculture)
  - Changing rate structures



# Electrification Prospects by Sector

## ■ Transportation

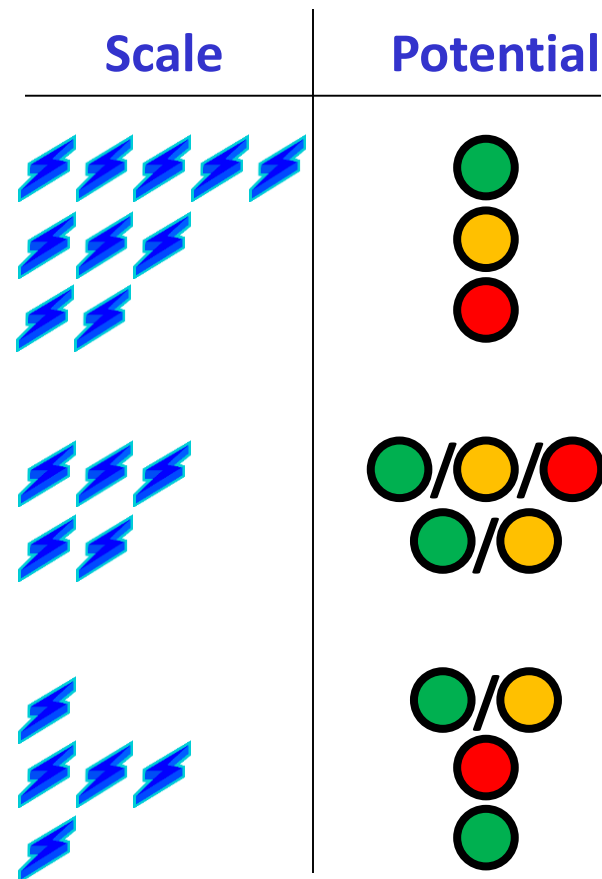
- Light duty vehicles
- Heavy duty road vehicles
- Other

## ■ Buildings

- Heat pumps for space heating
- Water heaters / dryers / ranges

## ■ Industry

- Specialized / low-heat process
- Boilers / high-heat process
- Facility energy use

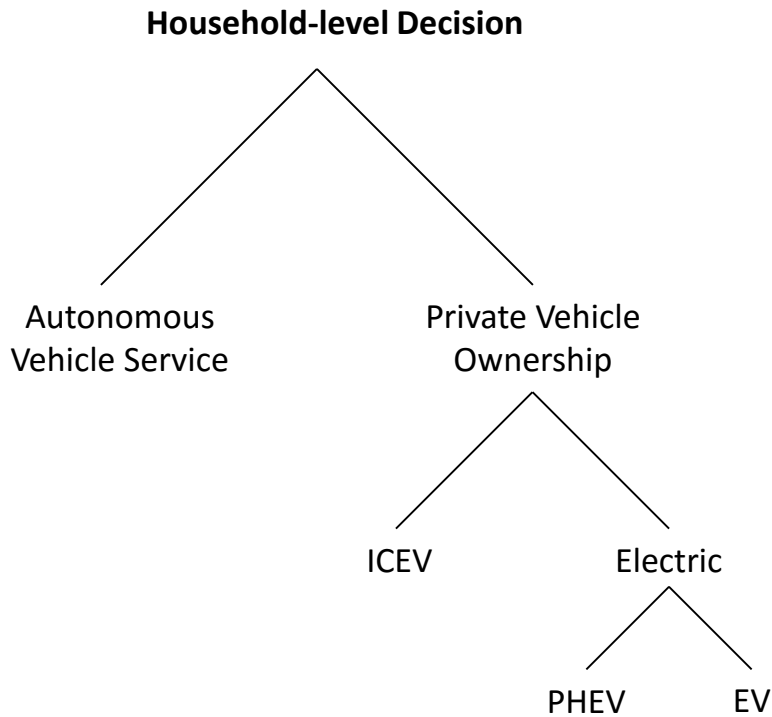




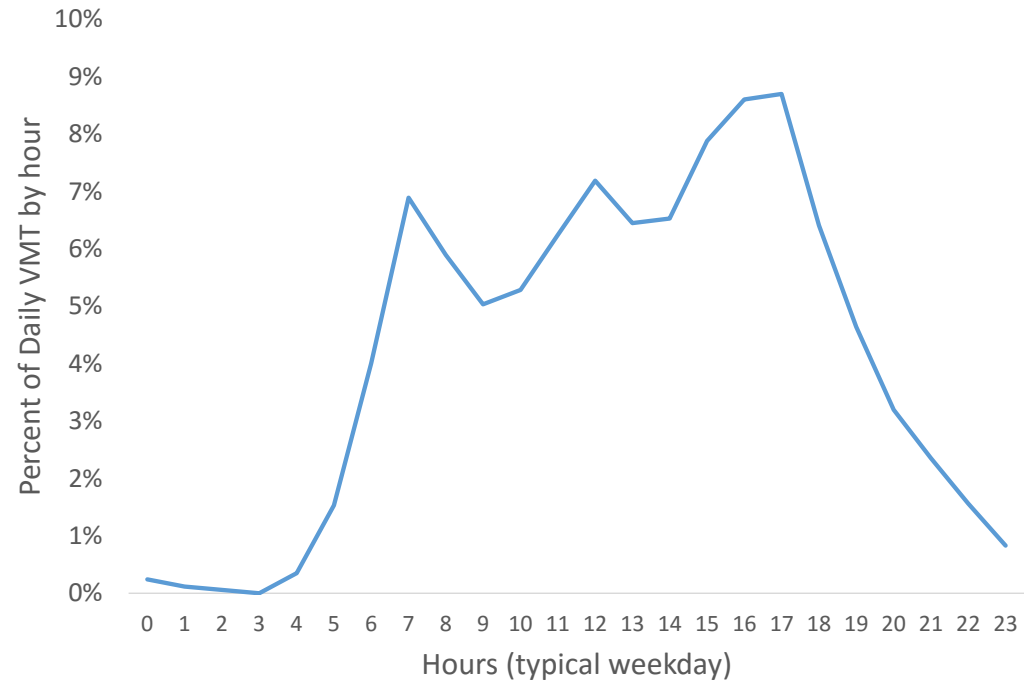
# Light-Duty Vehicles

- Currently EVs and PHEVs have a very small market share but may be on the cusp of much more widespread deployment
  - Technology is moving fast, especially battery costs
  - Autonomous vehicle service could change the landscape dramatically
- Significant customer heterogeneity
  - Urban / Suburban / Rural
  - Low / Medium / High annual mileage
  - Single / multiple car households
  - Attitude / Access to electric charging / ride service
- Model trade-offs including economic and non-economic factors

# Modeling Autonomous Vehicles



Typical weekday distribution of vehicle miles traveled  
(based on NHTS, 2009)

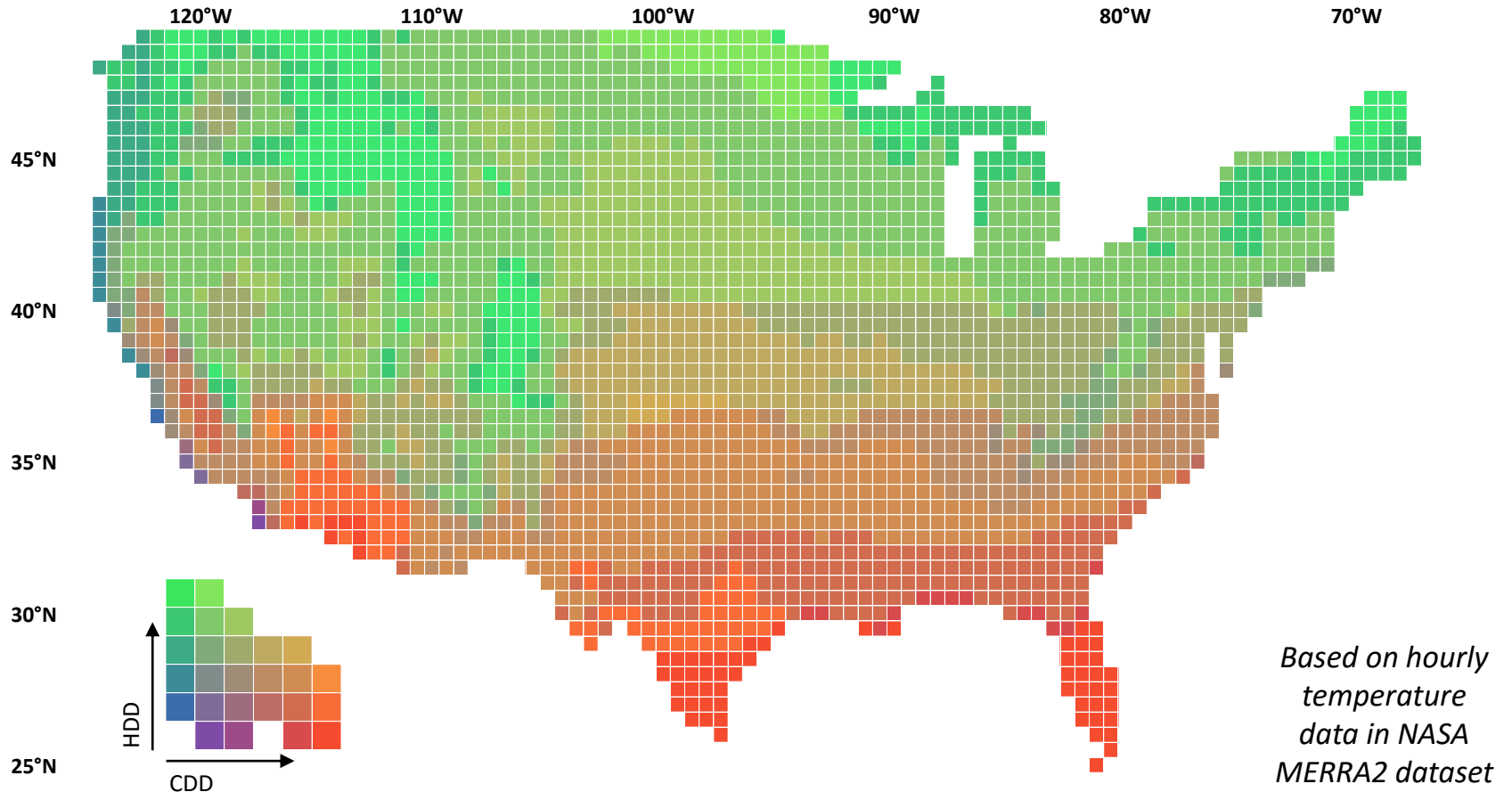


# Electric Heating in Buildings

- Currently about 1/3 of residential buildings in the US have electricity as the main heat source, according to EIA surveys
  - Concentrated in regions with mild climates / favorable relative fuel prices, e.g. Florida and Pacific NW
  - Higher shares in smaller housing units / recent vintages
  - 25% share of floorspace in commercial buildings
- New opportunities for air source heat pump (ASHP) technology
- We model the economic trade-offs for ASHP vs. conventional furnace (+ A/C) in each region / climate zone based on temperature profile and retail fuel prices

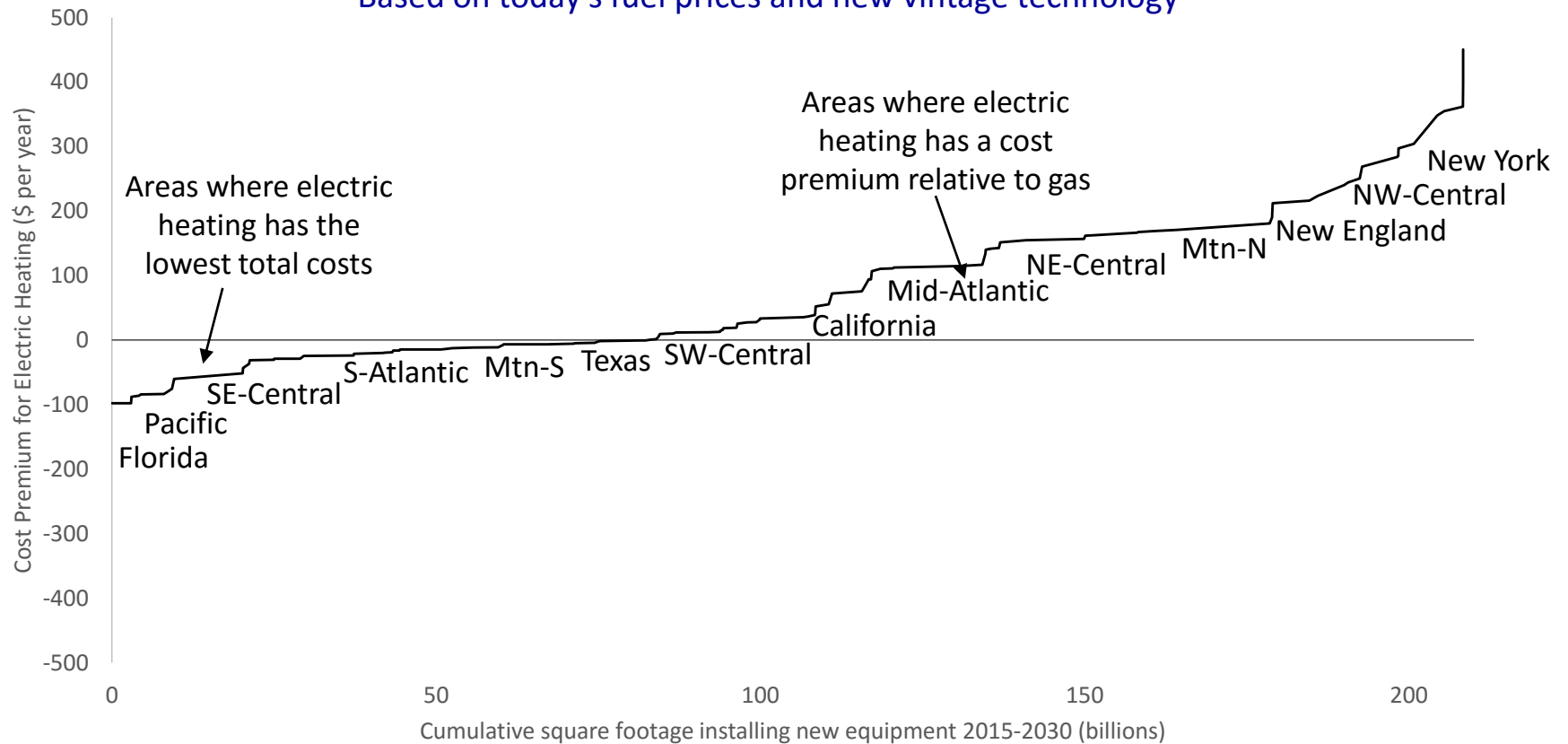


# Heating/Cooling Zones based on HDD × CDD



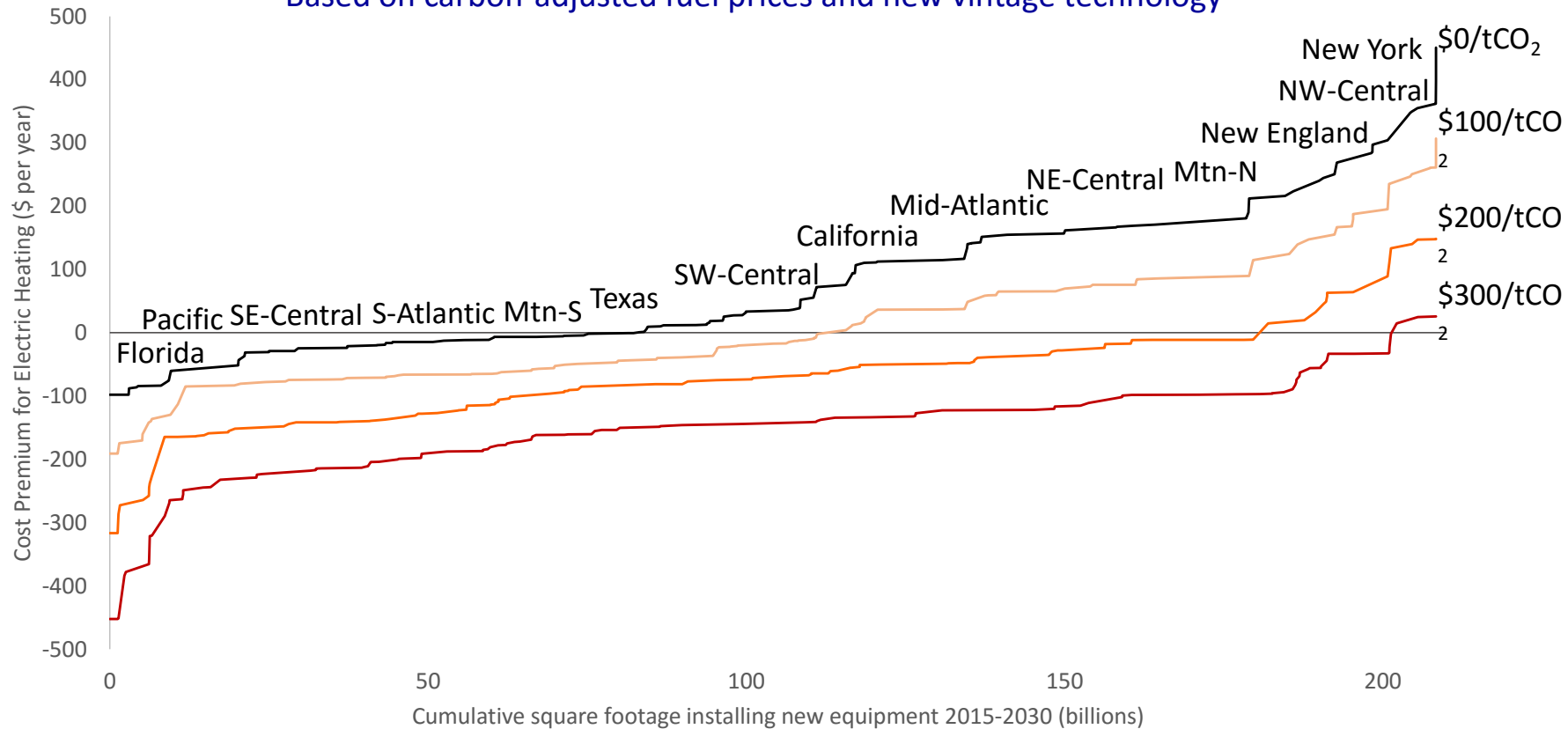
# Distribution across US of Electric Heating Cost Premium

Based on today's fuel prices and new vintage technology

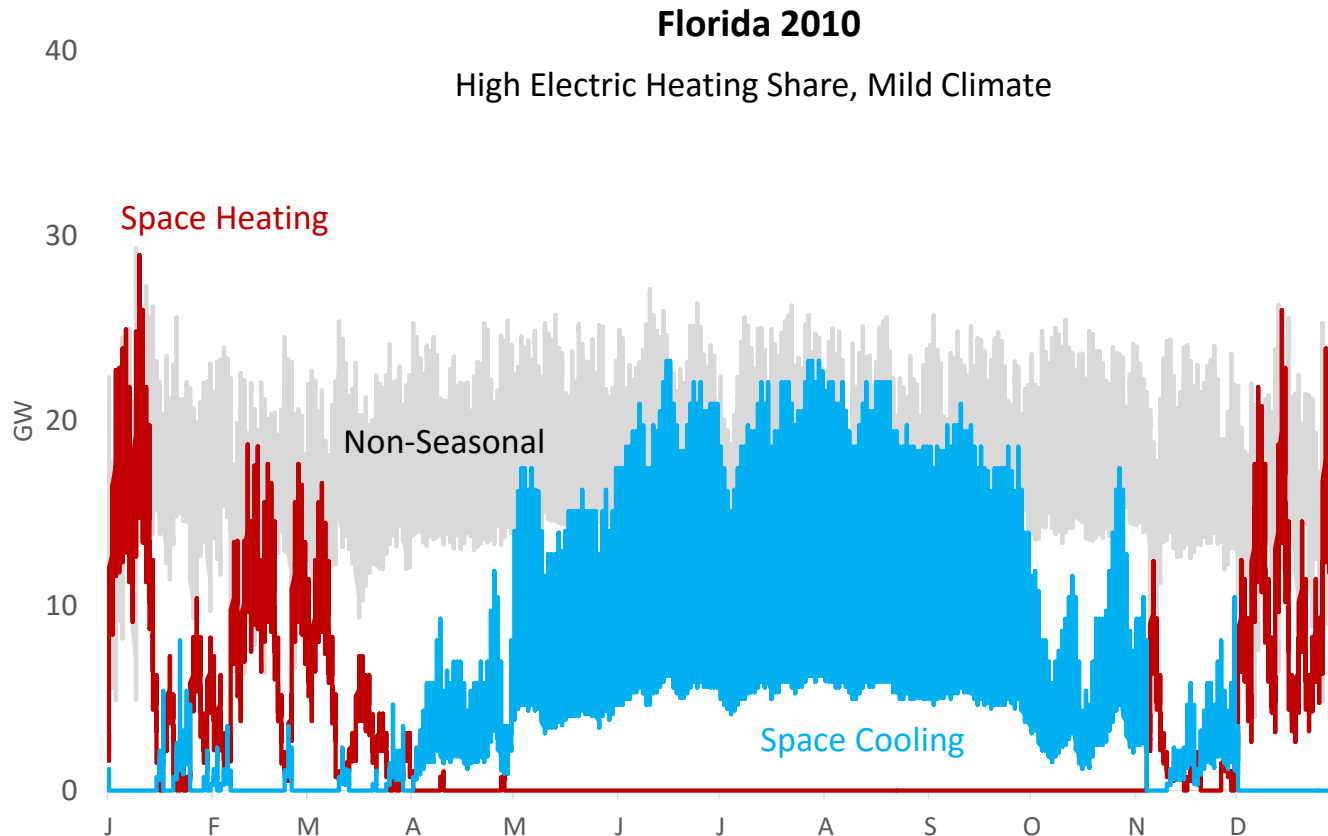


# Higher carbon prices → more electric heating in the money

Based on carbon-adjusted fuel prices and new vintage technology



# Effect of Electrification on Load Shapes

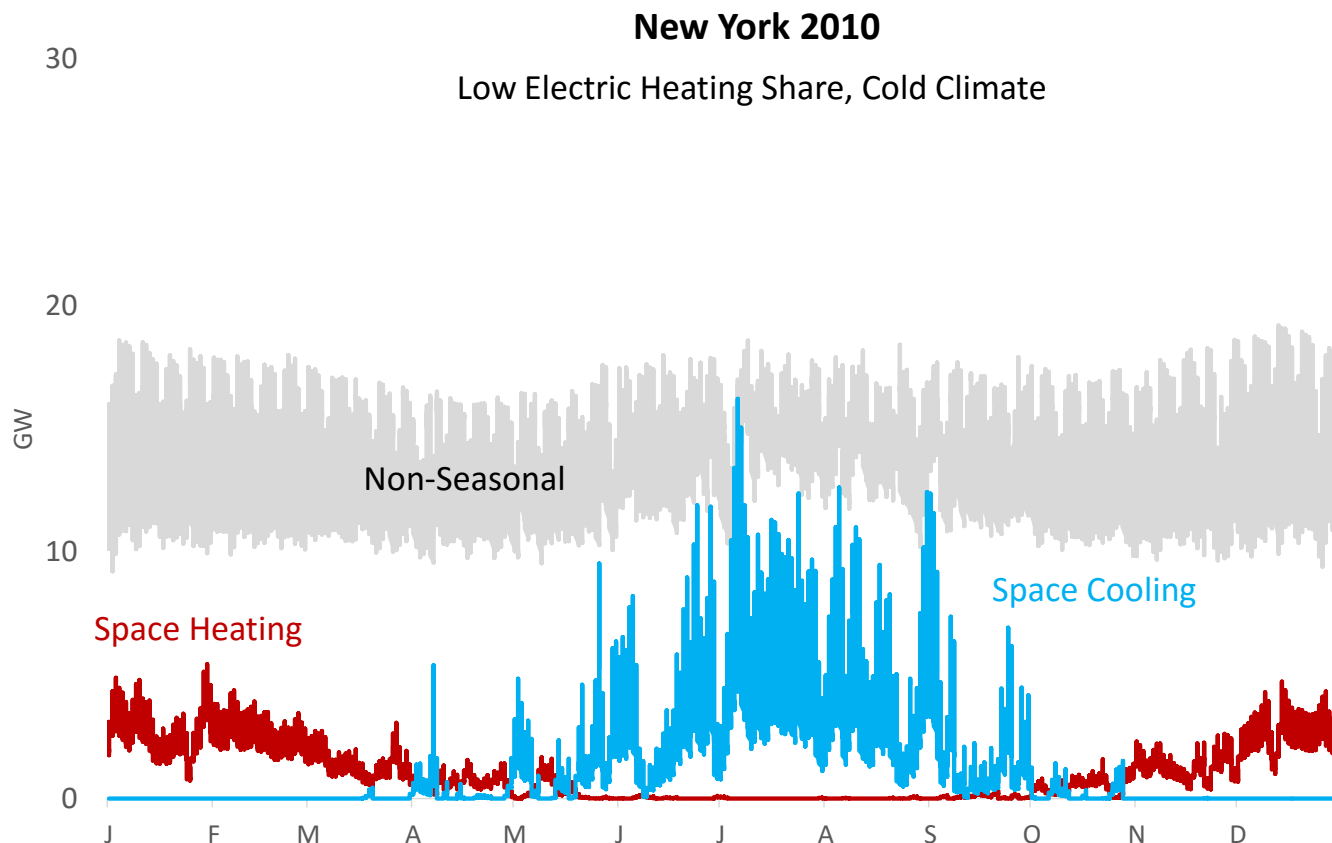


- As end-use mix changes, relative size of heating and cooling vs. non-seasonal loads will result in potentially very different aggregate profile / alignment with renewables
- New shapes will be introduced, in particular vehicle charging
- Result could improve or exacerbate generation asset utilization
- Better resource integration could allow more flexibility in demand response

*Preliminary: Subject to further calibration*



# Effect of Electrification on Load Shapes

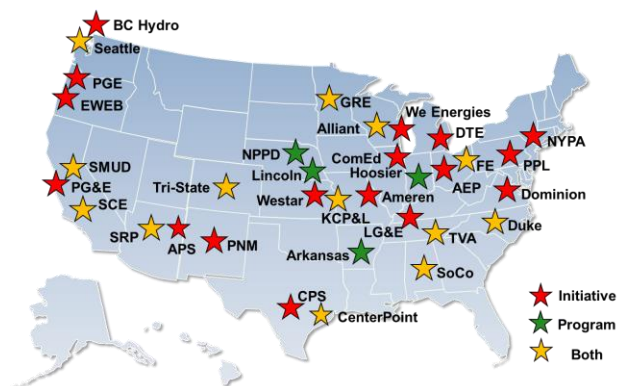


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# Key Action: How to Get Engaged Electrification Assessment and Policy/Regulation

- Assess what electric technologies make sense today
  - Contact: Allen Dennis
- Electrification National Assessment – What is the potential for electrification in the U.S. under alternative futures
  - Contact: Francisco de la Chesnaye
- Cooperative Activities:
  - International Energy Agency-EPRI workshops (past and planned)
  - NREL Power Up Study



# Integrated Energy Network: A Pathway to the Future

**More Reliable, Affordable Energy**

**Cleaner, More Diverse  
Energy Portfolio**

**Expanded Customer  
Choice, Dynamic and  
Individualized Engagement**

**Highly Connected  
Customer Energy  
Information**



**Reduced Environmental  
Footprint**

**Increased Efficient  
Energy Production and  
Customer End-Use**

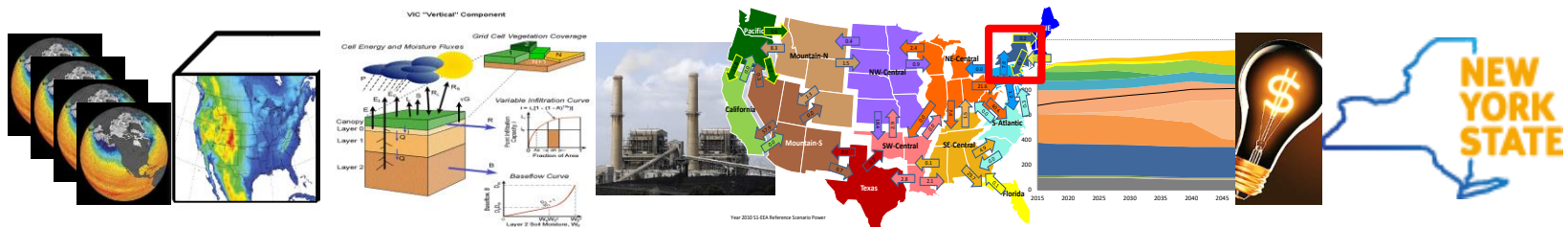
**Growing Energy-  
Water Interface**

**Innovative, Collaborative Thinking**

**What is Your Role in the IEN?**

# “Informing the resiliency of NY’s *electric system of the future* for operations in the *climate of the future*”

- Objective: Assess NYS electricity system performance, vulnerabilities, and adaptation strategies under a future climate, including costs and benefits at the system-level
- New 2-year EPRI-NYSERDA project “Climate Change Vulnerabilities of and Adaptation Strategies for NY’s Future Electric System”
- Develop new NY-focused REGEN to assess generation fleet given climate impact pathways (NYS ClimAID scenario inputs), environmental policies & socioeconomic trends
- Value: Help decision makers and planners design and operate system to be resilient to climate change and meet policy objectives at least cost



Project Approach: from climate drivers to NYS system impacts and costs





# Together...Shaping the Future of Electricity