# The Importance of the Grid Edge to the Energy Transition

**KAY AIKIN**, Co-founder,
Chief Product Officer,
Dynamic Grid

**Dynamic Grid** provider of advanced DERMS platform and energy storage for utilities, buildings and microgrids

**Member of**

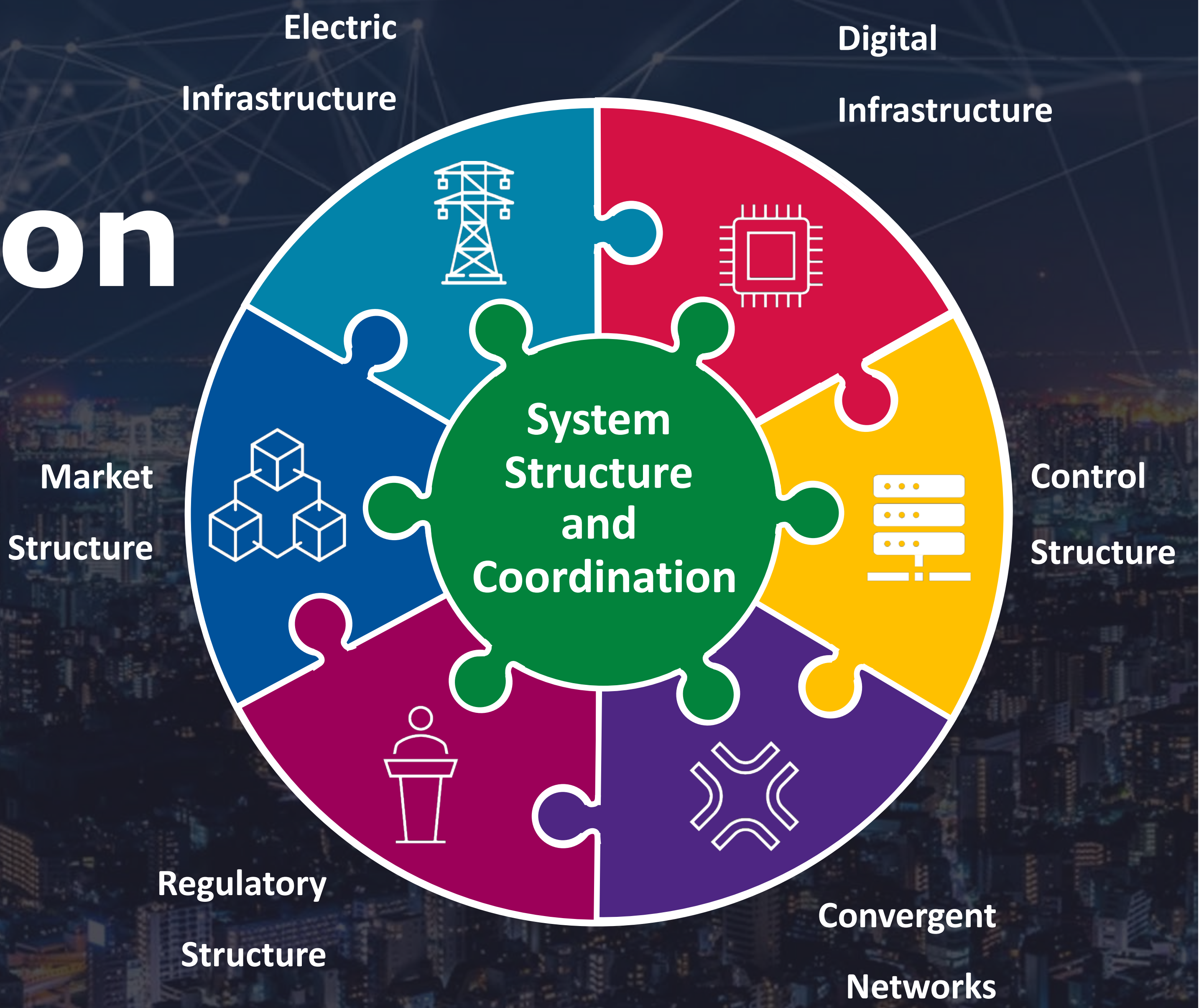
- GridWise Architecture Council
- IREC Customer Grid Edge
- Energy Services Interface Task Force
- SEPA Transactive Energy Working Group
- SEPA Grid Architecture Working Group
- SEPA Microgrids Working Group
- Maine Climate Council
- Maine Utility Regulatory Reform and Decarbonization Initiative

DYNAMIC GRID

# System Transformation

## How do we navigate the energy transition?

The electrical grid is the world's largest and most complex machine created by humans. It is a network of networks.



DYNAMIC GRID

# The Challenge

Regulatory solutions are happening too slowly

## Why Now?

Rapid growth in DER and Electrification.

## Who Cares?

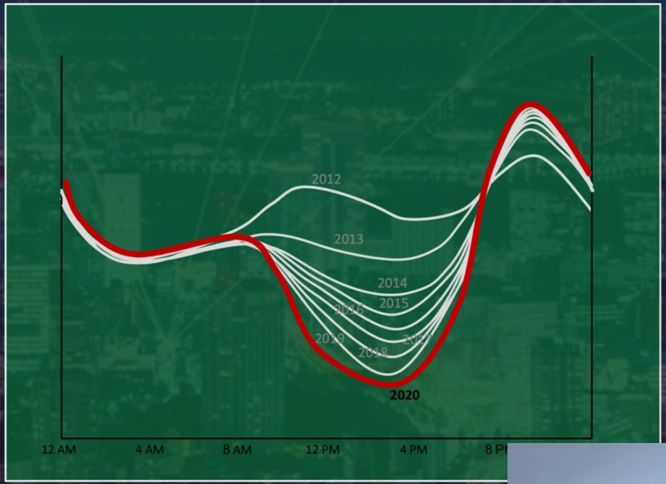
DER and Electrification creates new system dynamics

## Why it matters?

Need to speed the new solutions, or decarbonization will fail

DYNAMIC GRID

# Dynamics at the Edge




**Not just the duck curve . . .**

**but a brood of duckling curves**

## Managing dynamic change?

The grid is being confronted with new system dynamics across a range of domains:

- Increased temporal dynamics
- Increased locational dynamics
- Accelerating evolutional dynamics and,
- Accelerating technology and business dynamics

# The $10 Trillion Problem

Estimates from:
*Gupta etal, Spatial analysis of distribution grid capacity and costs to enable massive deployment of PV, electric mobility and electric heating, University of Geneva, and

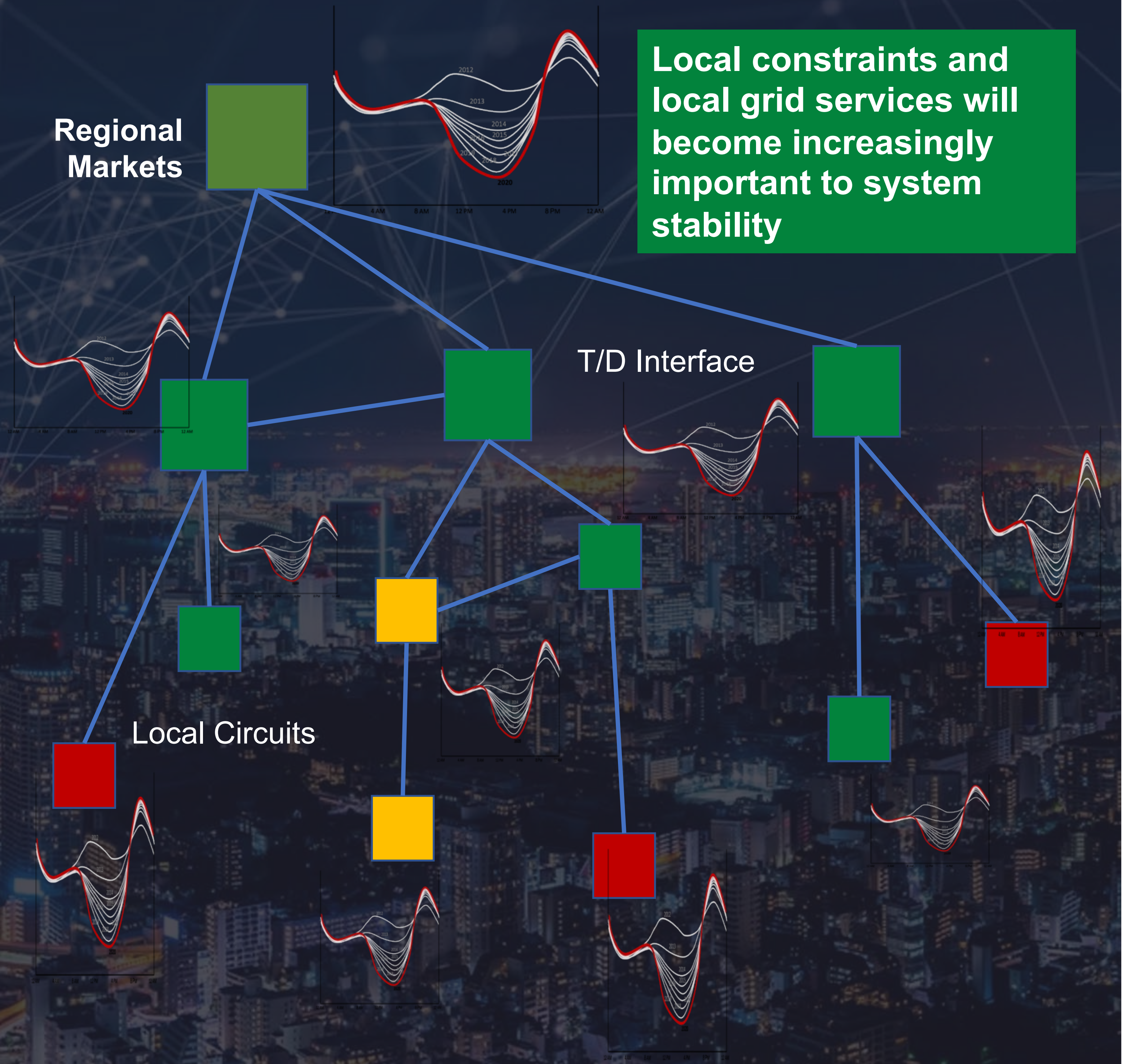
1898 Company (Burnes and McDonnel), Doug Houseman, Internal research

DYNAMIC GRID

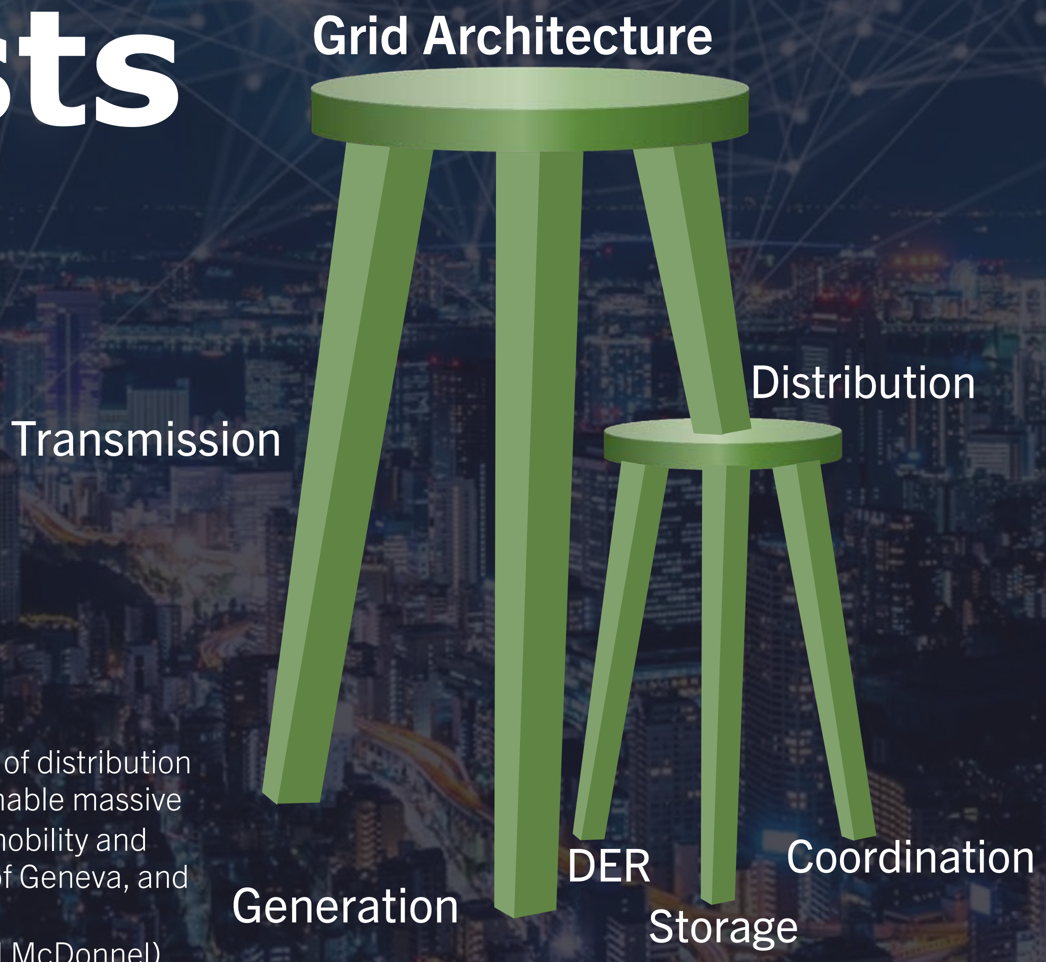
# Temporal and Locational Dynamics

Electrification will increase system load by 81% and peaks increase 2 to 3X:

- Increased winter peaking (in North) 3-6 am
- Increased summer peaking (in South) 3-7 pm
- Increased transportation peaking 6-9 pm



# Infrastructure Costs




## The 10 Trillion-dollar Challenge

The industry has not come to terms with the cost of distribution grid upgrades instead on focusing on generation, transmission and storage. Estimates of over 10 to 30 Trillion over the next 20 years in wires, poles and transformers have been suggested.

Estimates from:
*Gupta etal, Spatial analysis of distribution grid capacity and costs to enable massive deployment of PV, electric mobility and electric heating, University of Geneva, and

1898 Company (Burnes and McDonnel), Doug Houseman, Internal research

DYNAMIC GRID

# Slaying the Distribution Dragon

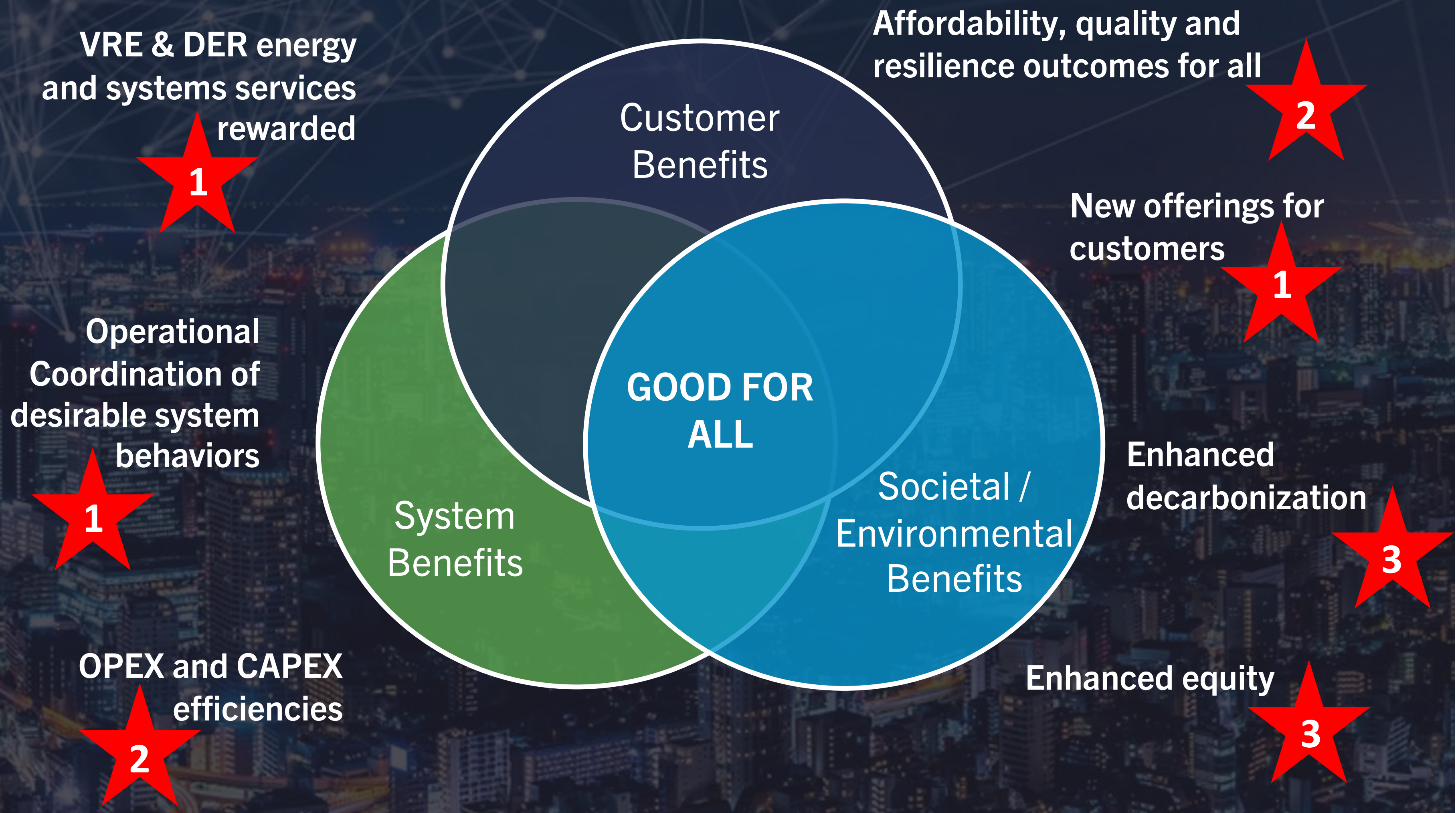
# Systems Architecture

Apply ’present forward’ + ‘future back’ systems thinking and analysis to evaluate grid expansion proposals so that the grid can function holistically.

DYNAMIC GRID

# Grid Architecture

Grid Architecture is critical for making key structural choices to enable a more intelligent, self-optimising power system for the 21st century



DYNAMIC GRID

# Operational Coordination

## Operational Coordination requires interaction between both markets and control structures

**Economists**

*"Get the market rules and prices right and everything will work fine"*

**✓ Solution:**

An ensemble of both market and control features is required

**Control Engineers**

*"Get the algorithms and standards right and everything will work fine"*

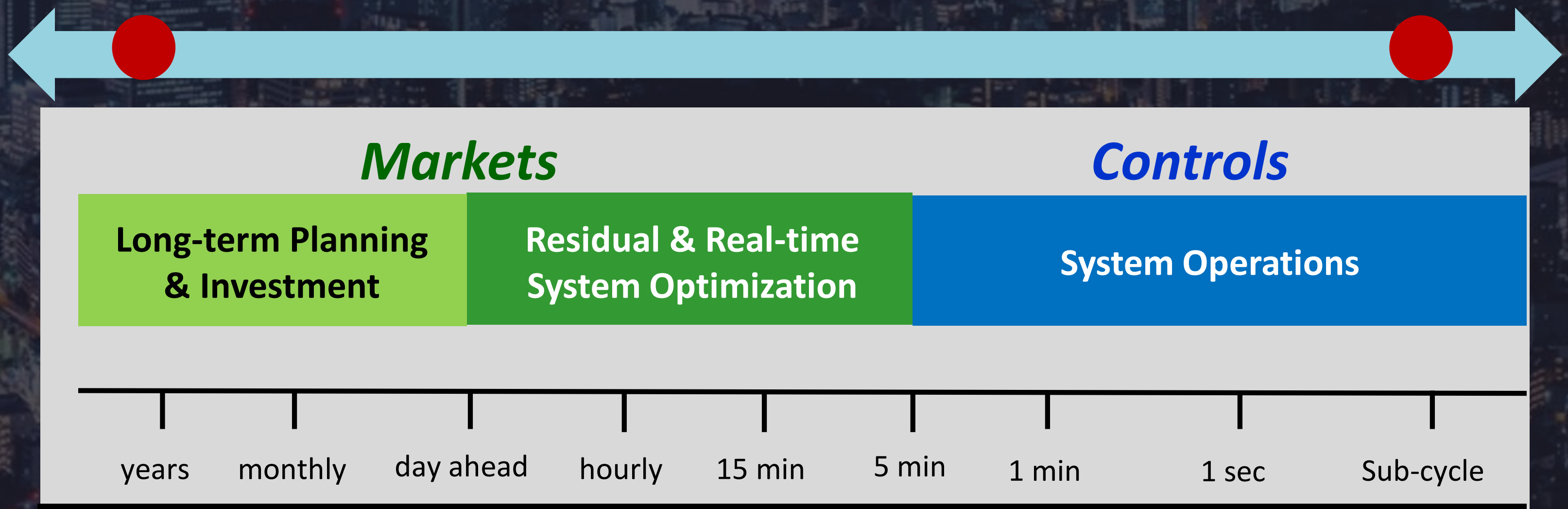
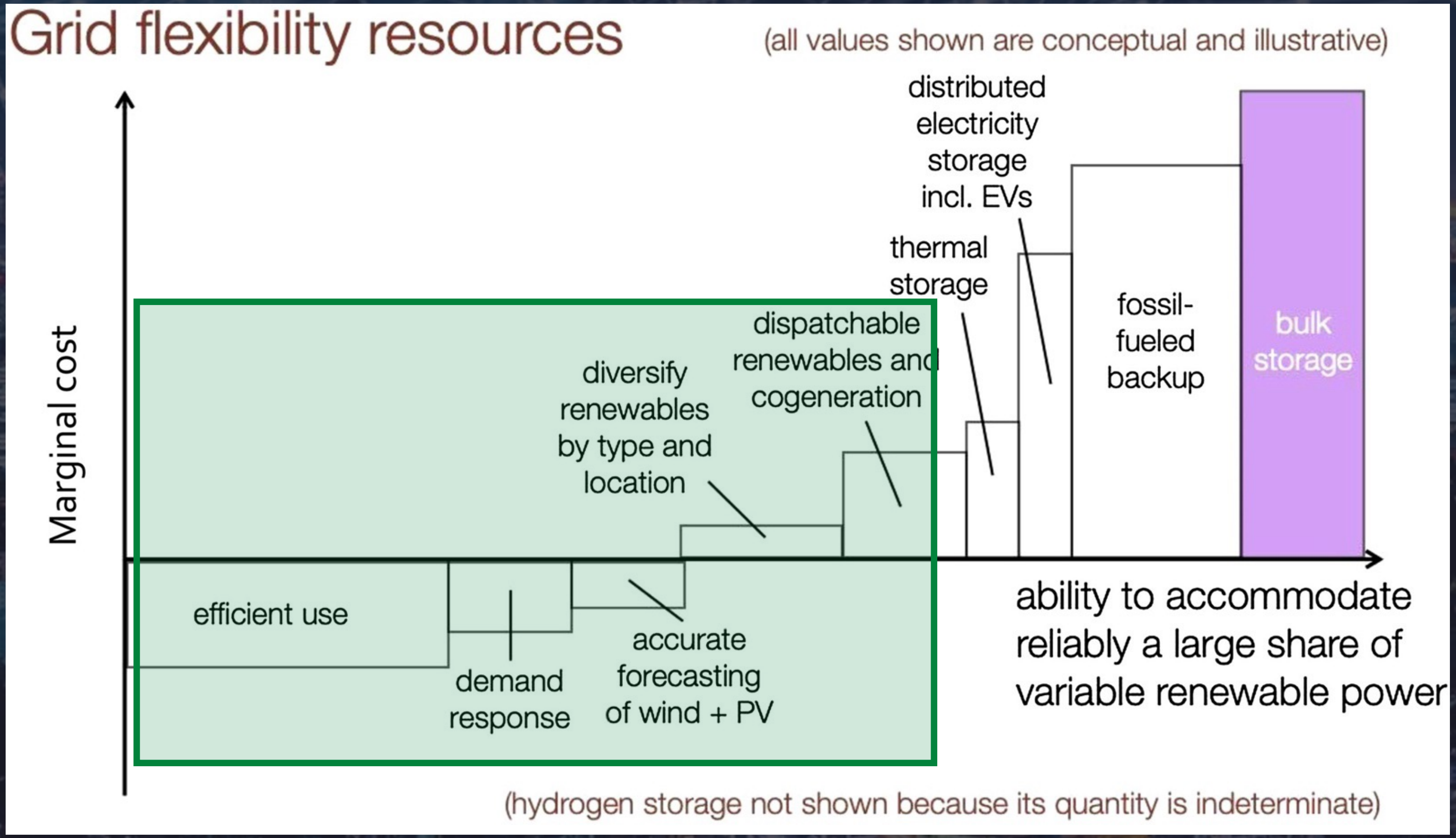



Image / Concept: Newport Consulting and Pacific Northwest National Laboratory (Adapted)

DYNAMIC GRID

# Resources




Source Amory Lovins as attributed by Faruqui, 2020

## Local Grid Flexibility

Local grid flexibility is the most affordable alternative to the temporal and locational dynamics on the distribution grid and the massive cost of new infrastructure.

DYNAMIC GRID

# Grid Flexibility

| | WITHOUT FLEXIBILITY | WITH FULL FLEXIBILITY | % CHANGE |
|---|---|---|---|
| AVERAGE ENERGY VALUE OF RENEWABLE GENERATION | $8.70/MWh | $11.82/MWh | 36% increase |
| ANNUAL PEAK NET LOAD | 58,441 MW | 44,354 MW | 24% decrease |
| AMOUNT OF ANNUAL CURTAILMENT | 42,405,742 MWh | 25,637,233 MWh | 40% decrease |
| AVERAGE MULTIHOUR NET-LOAD RAMP MAGNITUDE | 3,898 MW | 1,728 MW | 56% decrease |
| ANNUAL SYSTEM-WIDE CARBON DIOXIDE EMISSIONS | 31 million tons | 24 million tons | 23% decrease |

DYNAMIC GRID

# Grid Interactive Efficient Buildings

**EFFICIENT**

Persistent low energy use minimizes demand on grid resources and infrastructure

**CONNECTED**

Two-way communication with flexible technologies, the grid, and occupants

**SMART**

Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

**FLEXIBLE**

Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use

DYNAMIC GRID

# Shift Shed Shape

## Solution:

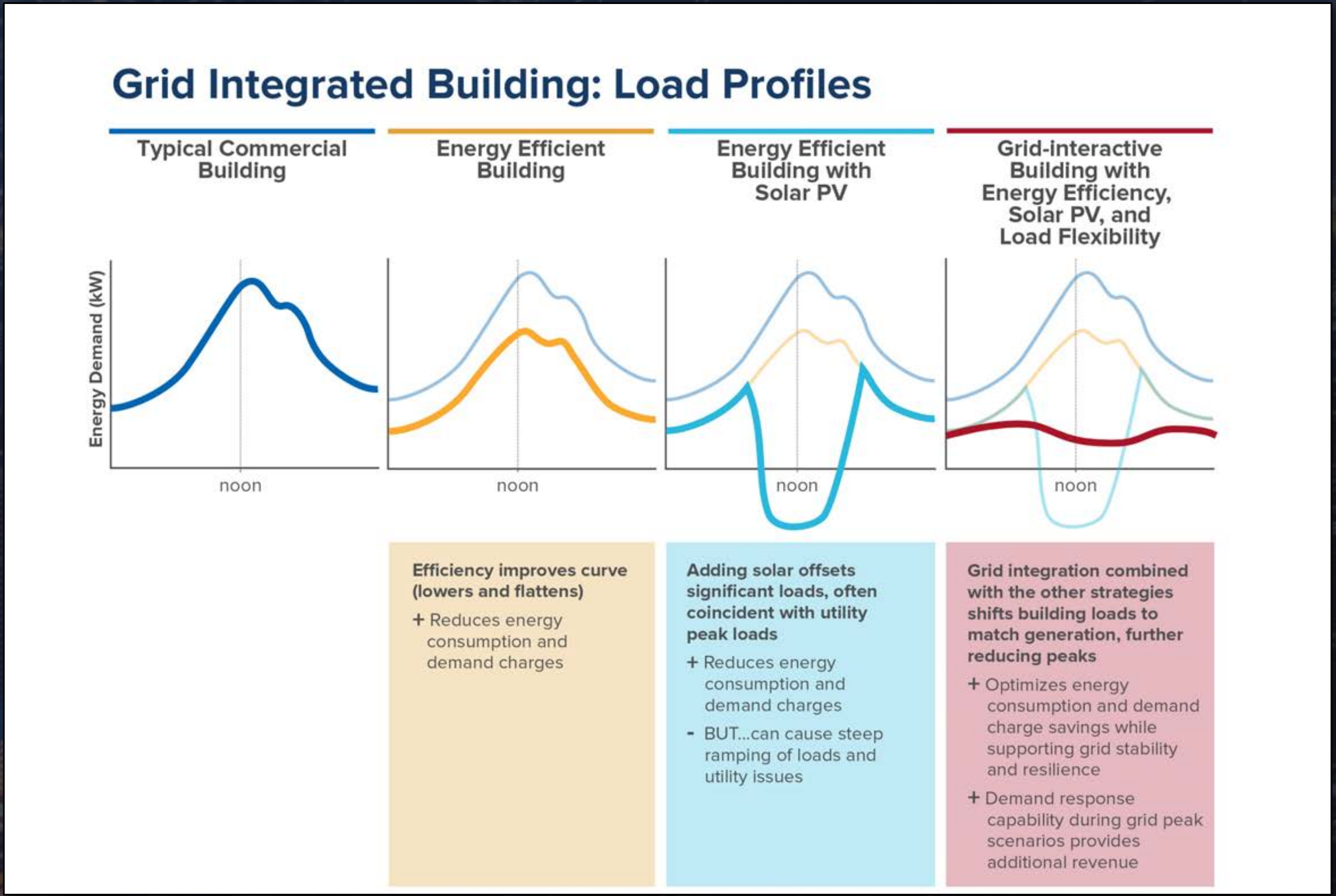
Reduce peak loads and ramping due to Distributed Energy Resources (DER) and Beneficial Electrification

Shift - Shed – **Shape** loads

## Opportunity:

Use load flexibility to manage DER

- Lower infrastructure needs
- Less storage
- Greater resource efficiency
- Increased decarbonization

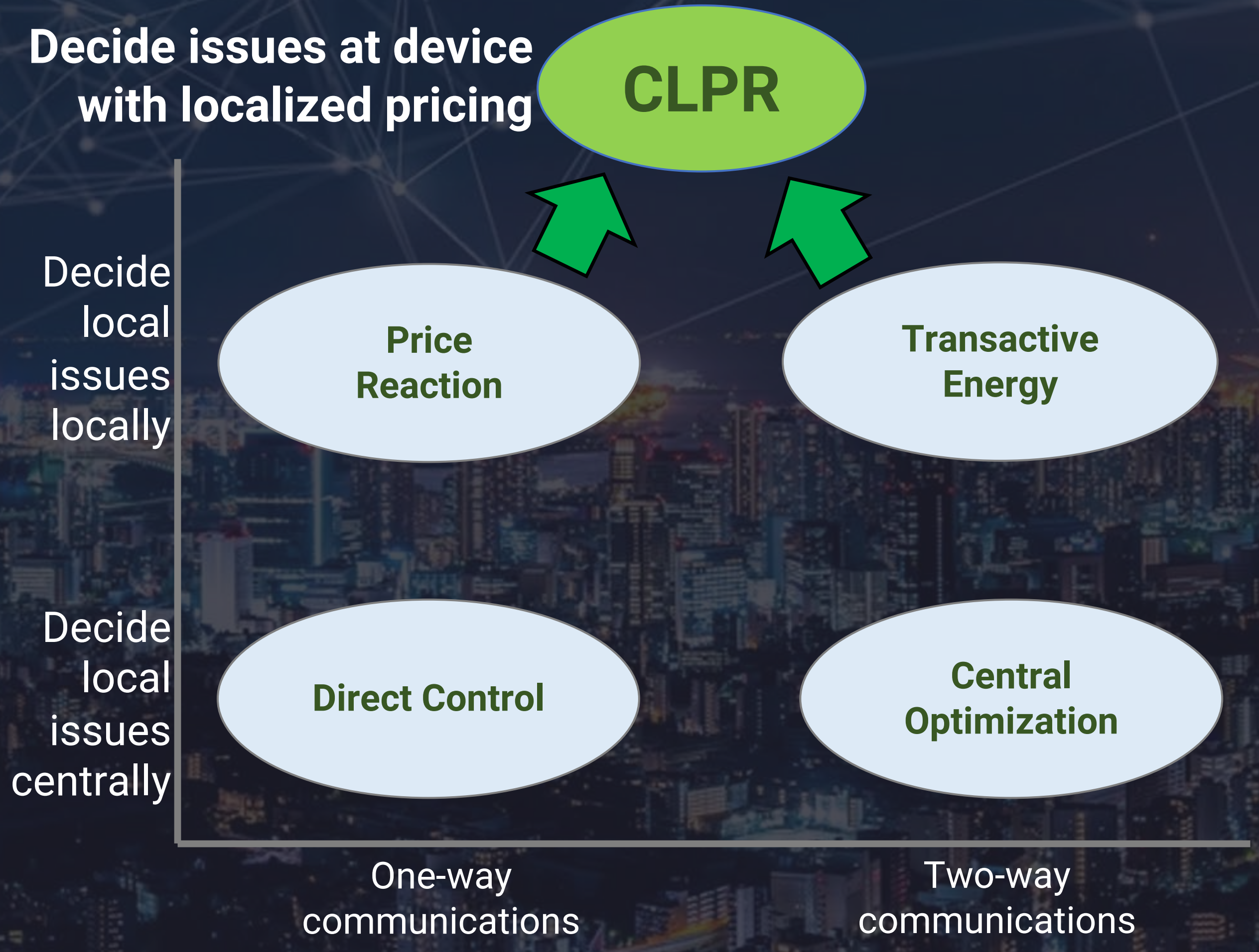


DYNAMIC GRID

# Coordination

- Direct (Top-Down) Control (DSM)
- Central Optimization (ISO-Bulk Power)
- Price Reaction Control
- Transactive Energy (TE) – Two way (method demonstrated)
- Dynamic Grid Transactive Energy – One-way coms with dynamic real-time interactions
  - –Autonomous devices (decisions at edge)
  - –Layered problem sub-optimization
  - –Gateways develop local dynamic pricing (Economic Dispatch Value-EDV) for reaction by edge devices, EDV is downward only to promote cyber-security and simplicity

## Coordination Methods



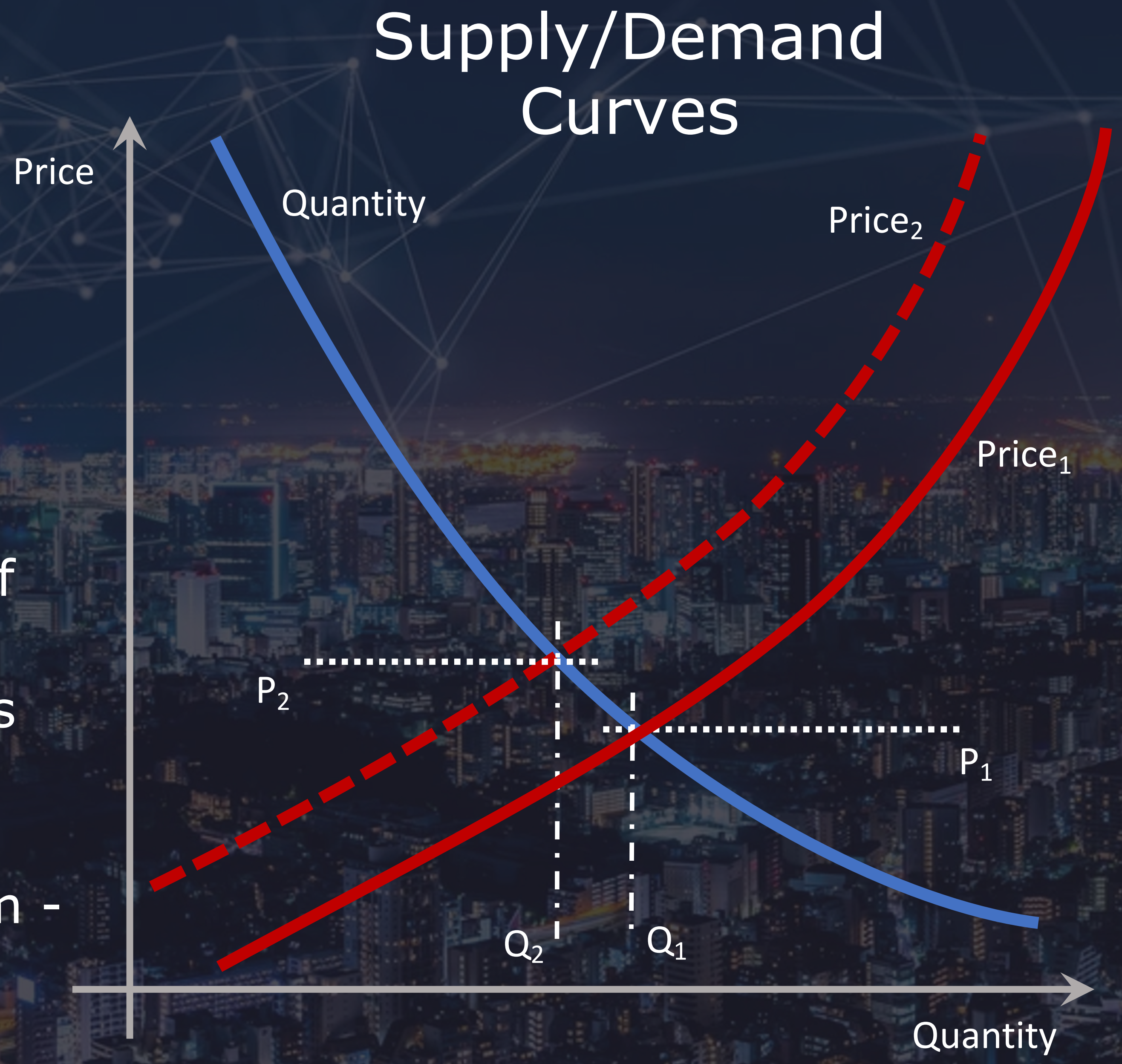

**Adapted From: IEEE Power and Energy Magazine** Volume: 14 Issue 3, A Society of Devices: Integrating Intelligent Distributed Resources with Transactive Energy, Koen Kok and Steve Widergren

DYNAMIC GRID

# Economics

## Competitive Equilibrium:

- Market clearing (two-way communication) is nearly impossible at scale and **cyber-insecure**
- **Law of many prices** rather than law of one price
- **Market Localization-** Each circuit sets their own price based upon past price, local environment and needs
- Neither side considers global equilibrium - resulting in **competitive equilibrium**.



DYNAMIC GRID

# Coordinated Local Price Reaction (CLPR)


Grid Challenges

- Voltage Constraints
- Thermal Constraints
- Undersized Transformers

DYNAMIC GRID

# CLPR

**INPUT:**
- LMP: Locational marginal price
- Local weather
- Local engineering limits (congestion etc.)
- State of Charge of utilityl energy storage (if installed)
- Other local parameters as required

Utility Gateway

Local System prediction

DRTP

**OUTPUT:**
Dynamic Real-Time Price (Coordination Signal) 0-24 hours

**INPUT:**
- DRTP
- Local weather
- Local engineering limits (congestion etc.)
- State of Charge of local energy storage (if installed)
- Other local parameters as required

Building Gateway or Microgrid

Local System prediction

DRTP

**OUTPUT:**
Dynamic Real-Time Price (Coordination Signal) 0-1 hour

**INPUT:**
- DRTP
- Equipment limits (duty cycle)
- Local state and control variables

Local Device Controller

Local Control Action

# aDERMS

## advanced Distributed Energy Resource Management System:

- Layered Architecture provides for separation of concerns and **resilience**
- Loosely coupled is communication **fault tolerant**
- One-way coordination/communication signal architecturally **cyber-secure**
- **Market localization-** Each circuit sets their own price based upon past price, local environment and engineering parameters.
- Local decision making provides for **privacy and local optimization**
- Neither side considers global equilibrium - resulting in **competitive equilibrium with equal competition and cooperation**.

DYNAMIC GRID

# More Information

Apply code ENER30 when ordering at website below for 30% discount off list price
https://www.elsevier.com/books/the-future-of-decentralized-electricity-distribution-networks/sioshansi/978-0-443-15591-8

## The Future of Grid-Interactive Efficient Buildings and Local Transactive Energy Markets Chapter 20 Kay Aikin

## The Future of Decentralized Electricity Distribution Networks