
U.S. DEPARTMENT OF
ENERGY
Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY
Building Technology Office
2017 BTO FOA KICK-OFF
901 D Street SW, Suite 100
Washington, DC 20024

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Building Technology Office

# Building Technologies and the Enernet

**Brian T. Patterson**
President
EMerge Alliance

EMerge ALLIANCE

IEC

U.S. Green Building Council MEMBER

SEIA Solar Energy Industries Association

Smart Electric Power Alliance

PHIUS Passive House Institute US

CABA Continental Automated Buildings Association

NFPA MEMBER


The EMerge Alliance is the world's largest professional organization dedicated to advancing standards for direct current technology. It is an open industry association of collaborating commercial, government and academic organizations developing standards covering hybrid AC/DC microgrids used in commercial and residential buildings and campuses. EMerge standards facilitate the achievement of greater energy efficiency, safety, resiliency, and sustainability while maximizing the potential to use of clean, renewable on-site energy.

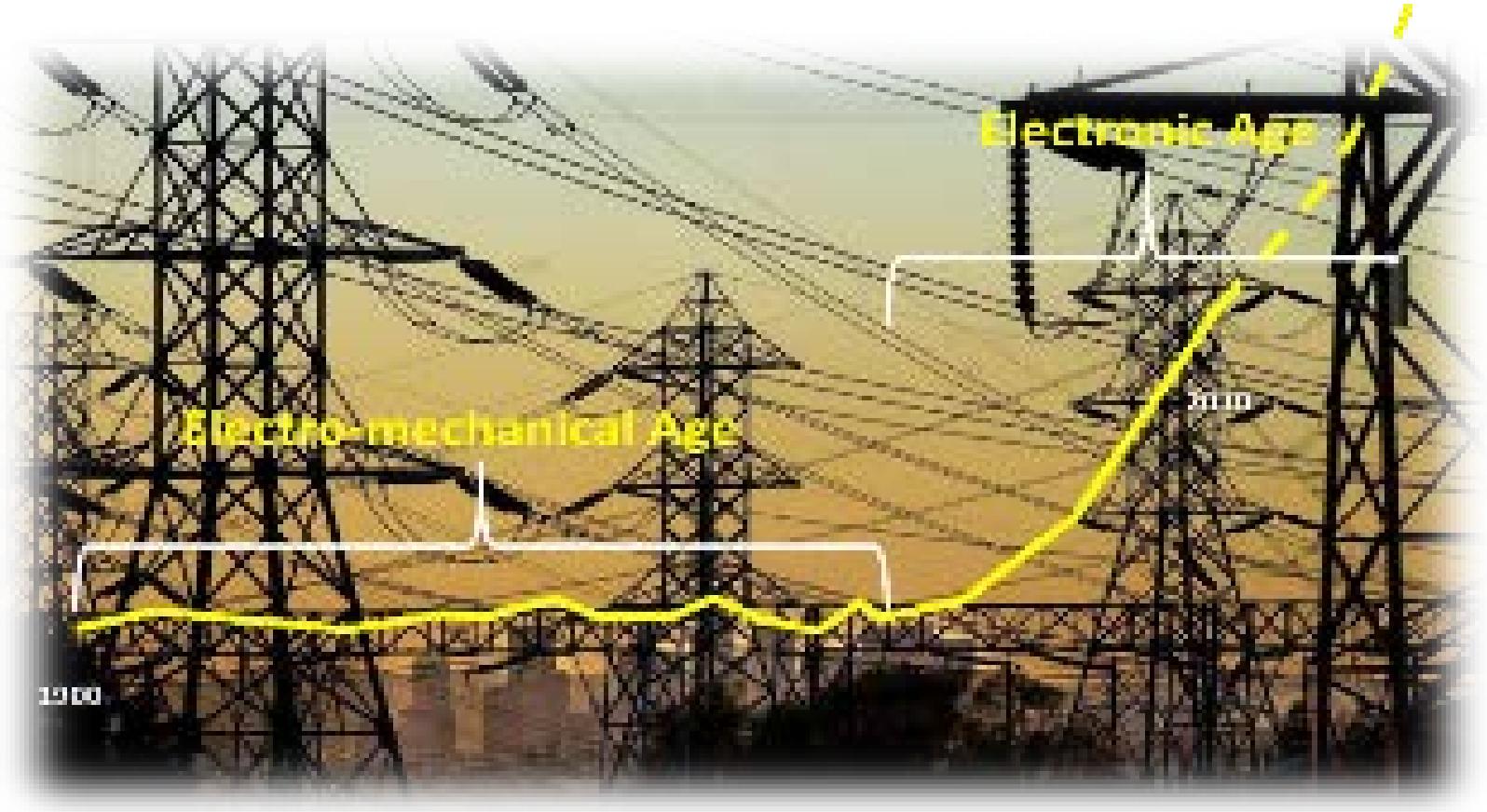
**http://www.emergealliance.org**

# 235,000 People Came Looking for the Future




AWESOME!!!

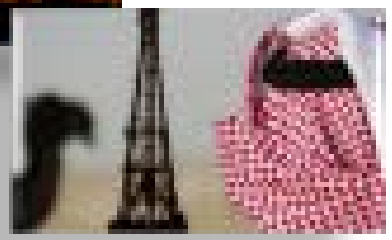
Merge ALLIANCE

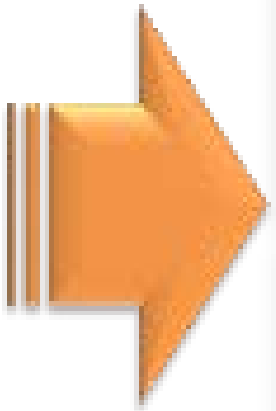



# Increasing Use of Electricity

**Despite Conservation Efforts – Use Grows at Double-Digit Rates**







## Over Dependency on Fossil Fuel Sources

**Coal & Oil issues are leading to Increased Reliance on NG & Nuclear**

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# Resistance to Expanding Centralized Infrastructure

There are real & perceived problems with using public domains


# Growing Problem of Resiliency

There's no easy answers for the existing grid

# Large and Growing Underserved Population

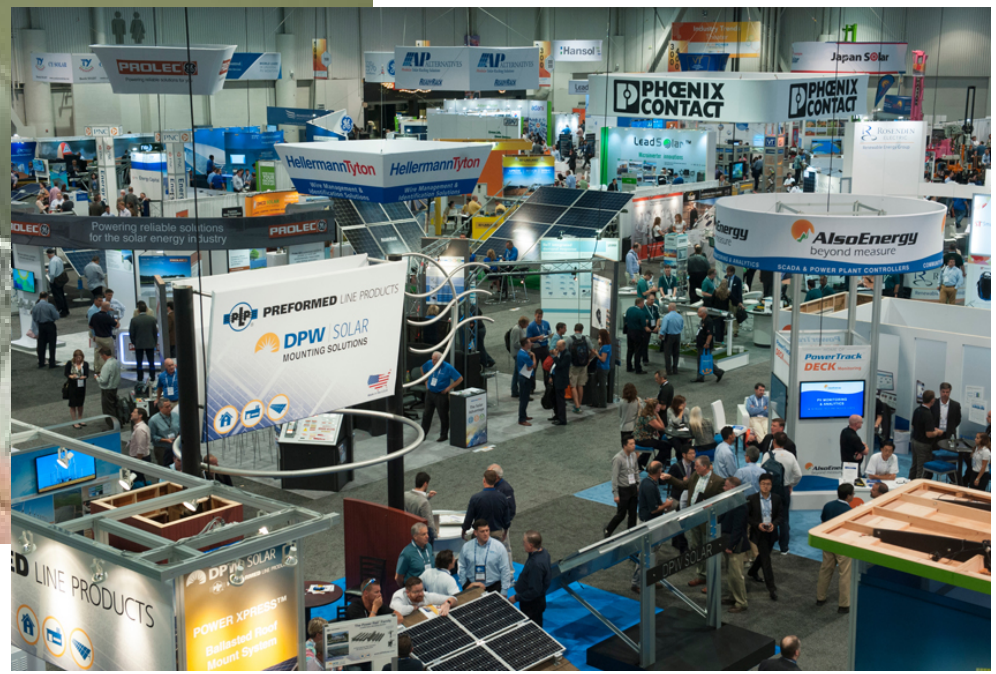
**Approximately 1/3 of the World's Population Has No Electricity**

eMerge ALLIANCE

# How to make money?

Entrepreneurial
Willing to learn
Passionate
Work Smart

Lucky
Deep Pockets
Count Cards
Own a Casino



# Wealth

↓

# Wellbeing

↓

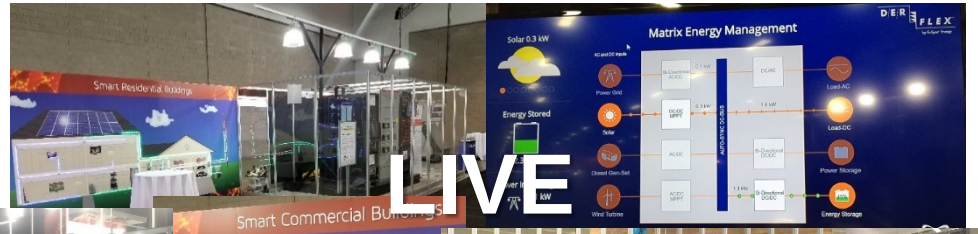
# Sustainability

North America
Smart Energy Week

SOLAR POWER INTERNATIONAL

SMART ENERGY MICROGRID MARKETPLACE

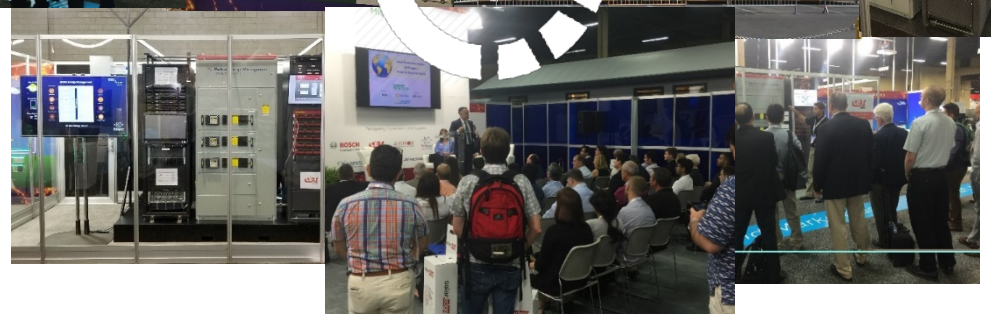
ESI ENERGY STORAGE INTERNATIONAL

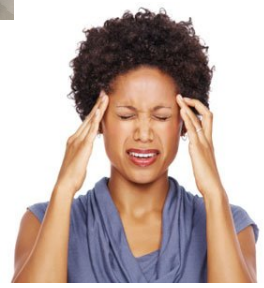



LIVE

CES®

GREENBUILD ABX2017
TOGETHER IN BOSTON
THANK YOU FOR MAKING THIS YEAR'S EVENT A SUCCESS





Top 100 Tradeshows - *Best Technology Integration Award*

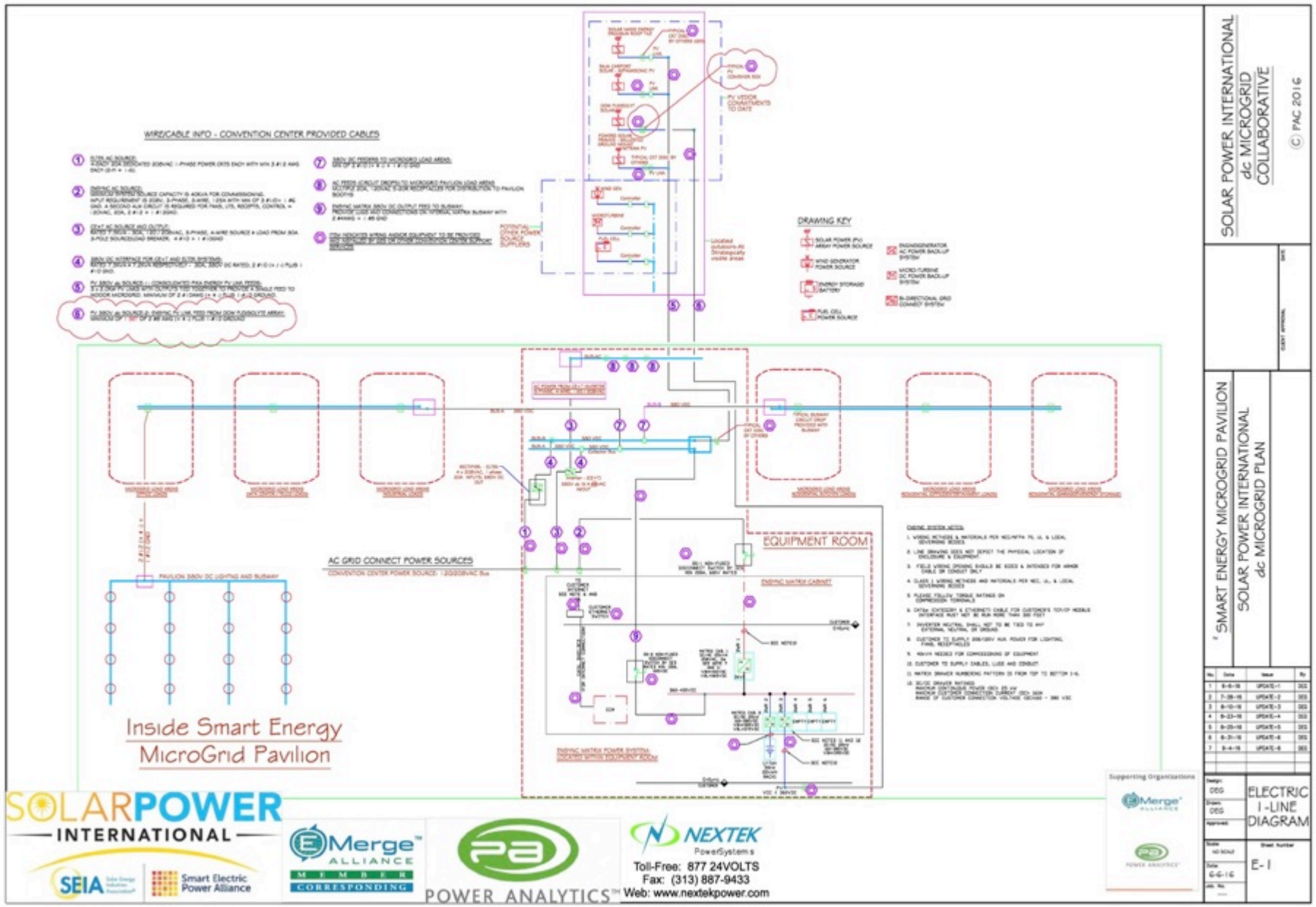
USGBC-GBCI/PEER Microgrid Performance Evaluation Demonstration – *Platinum Capability*

Solar Energy Trade Shows
SETS. The Standard in Solar Energy Events.

Merge ALLIANCE

# Demonstration Site

# Demonstration Site



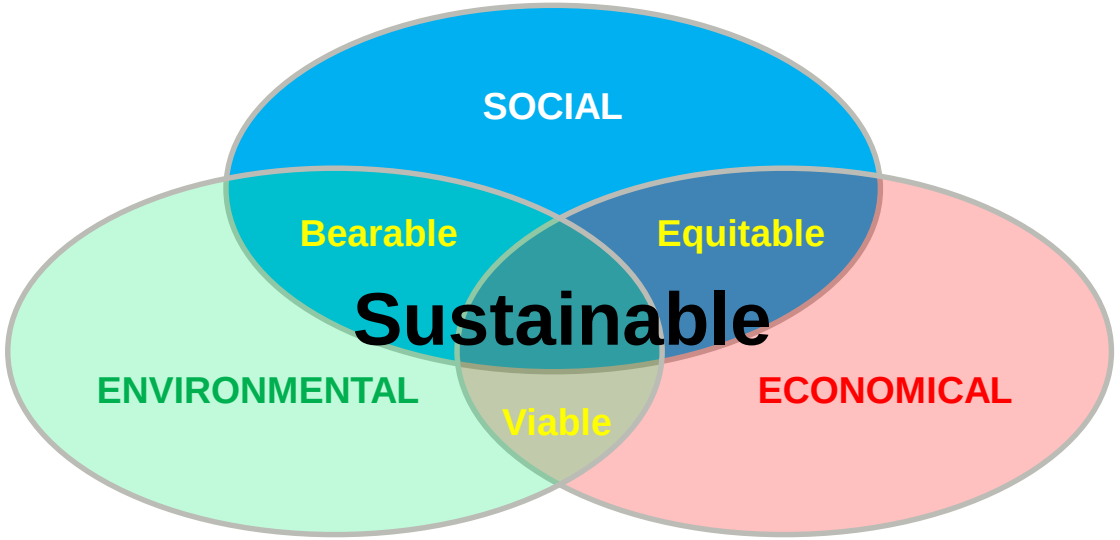
Women in Solar
Women in Green
Women in Energy


World Economic Council

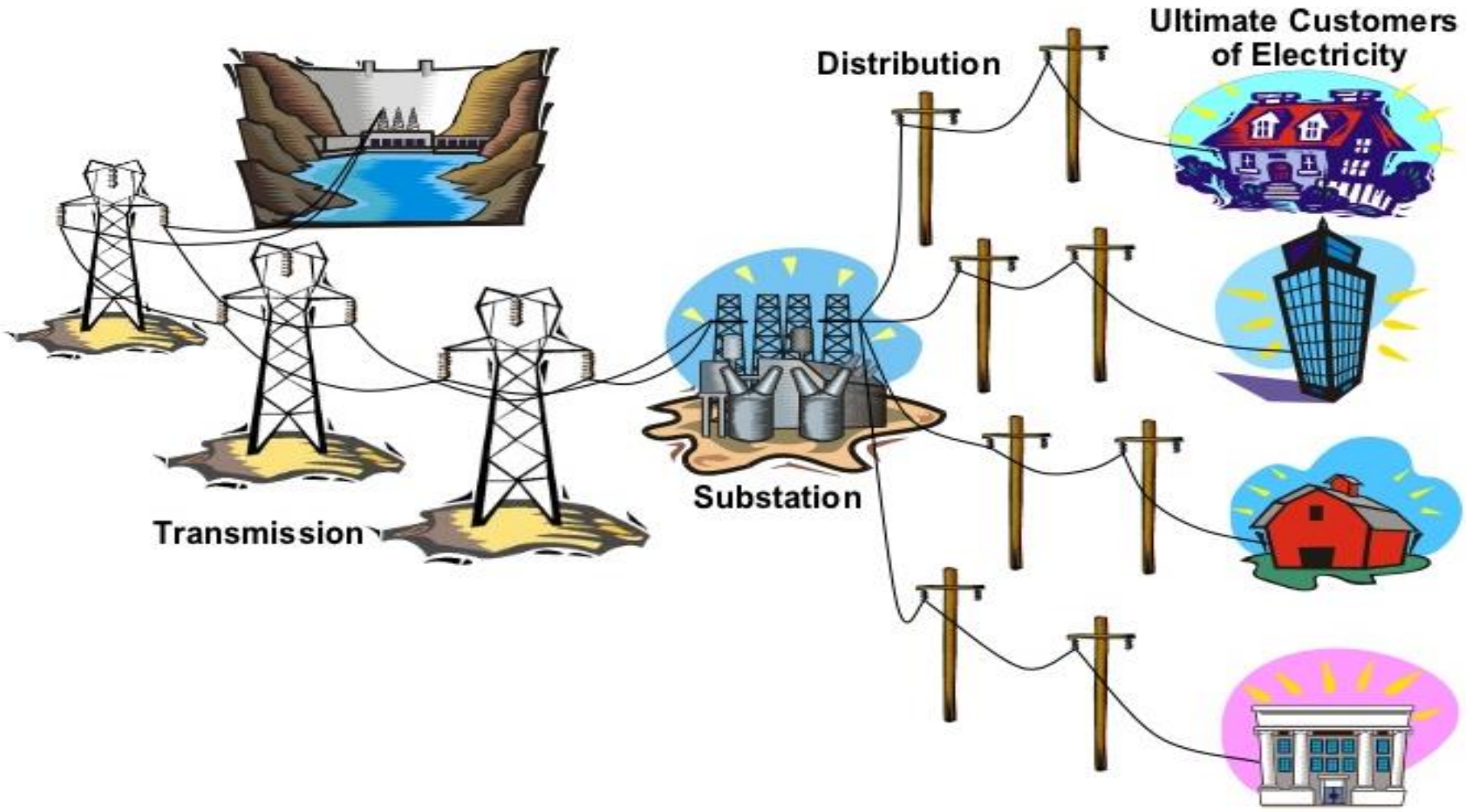
IEEE 2030.10
IEC SyC WG3
Electricity Access

“What we do with electricity can ~~X~~ will change the fate of the world.”

# We need an apolitical solution that is…




# After 100+ Years of Historic Success…



# The Electrical Energy Labyrinth…

Renewable Energy Sources (RES)
Solar (PV) – Wind - Fuel Cells
Micro-turbines - Combined Heat & Power
Distributed Energy Resources (DER)
Clean Energy
Energy Storage

**New Solutions ?**

Smart Grid
Eminent Domain
Synchronization
Frequency Control
Voltage Maintenance
Reactive Power (VARs)
Spinning Reserves
Peaking Turbines

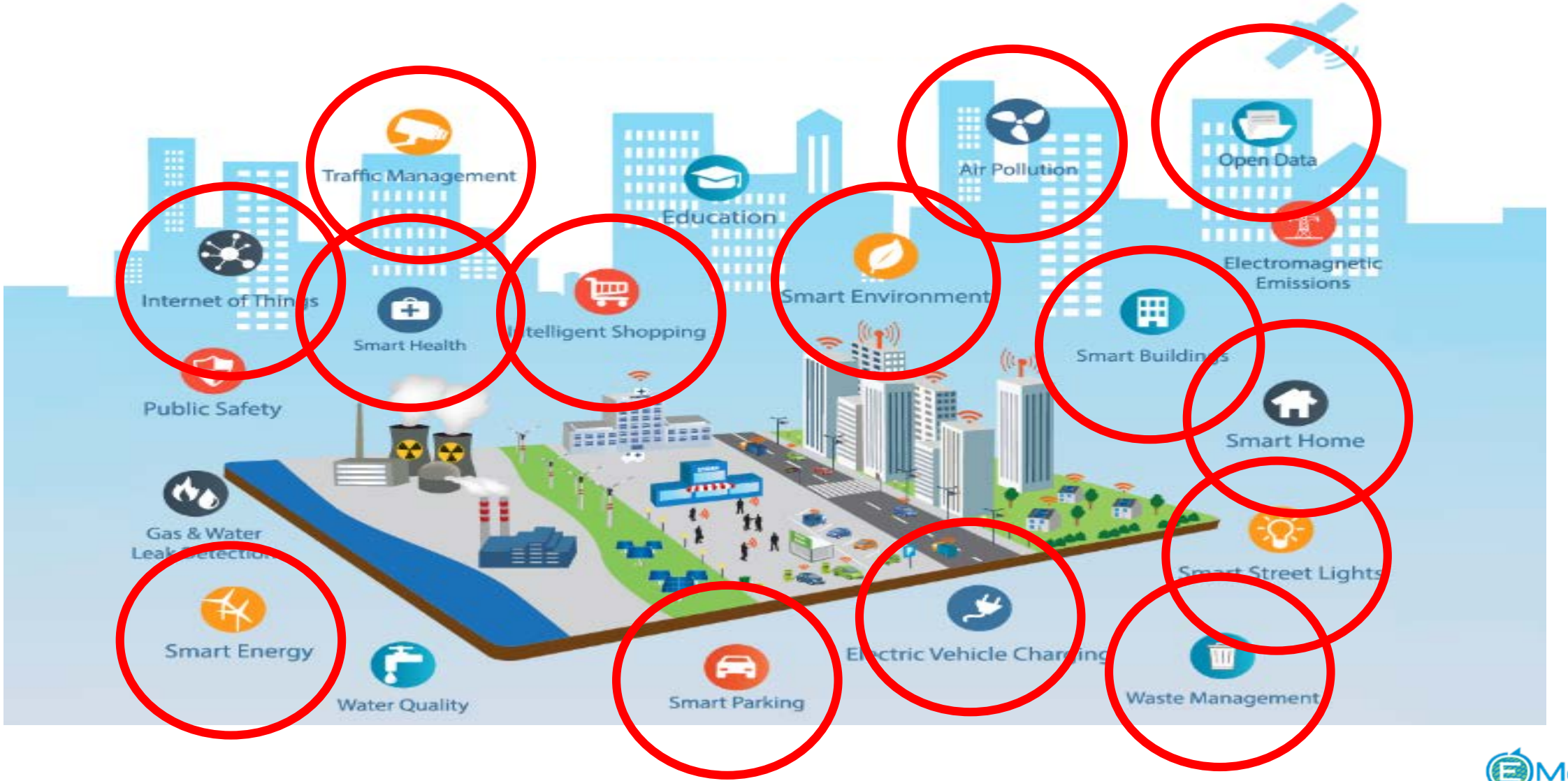
SSL - Efficiency
Smart Controls
Digital Devices – IoT
AC/DC Power Conversion
Fast Charge Electric Vehicles
Smart Buildings
Zero Net Energy (ZNE)

Power System Resiliency
Electro-Magnetic Pulses
Brownouts-Blackouts
Terrorism
Extreme Weather
Power Quality
Linear Dynamic Failure

Remote Power Access
Off-grid
Islanding
Microgrids
Load Shifting
Demand Response
Net Metering


Don’t get lost in the weeds…

# Wanted: A Smart World



# Enter the Disrupters…

Electricity Storage

Power Electronics

Electric Vehicles

Big Data Analytics

Internet of Things

Economical Clean Renewable Energy



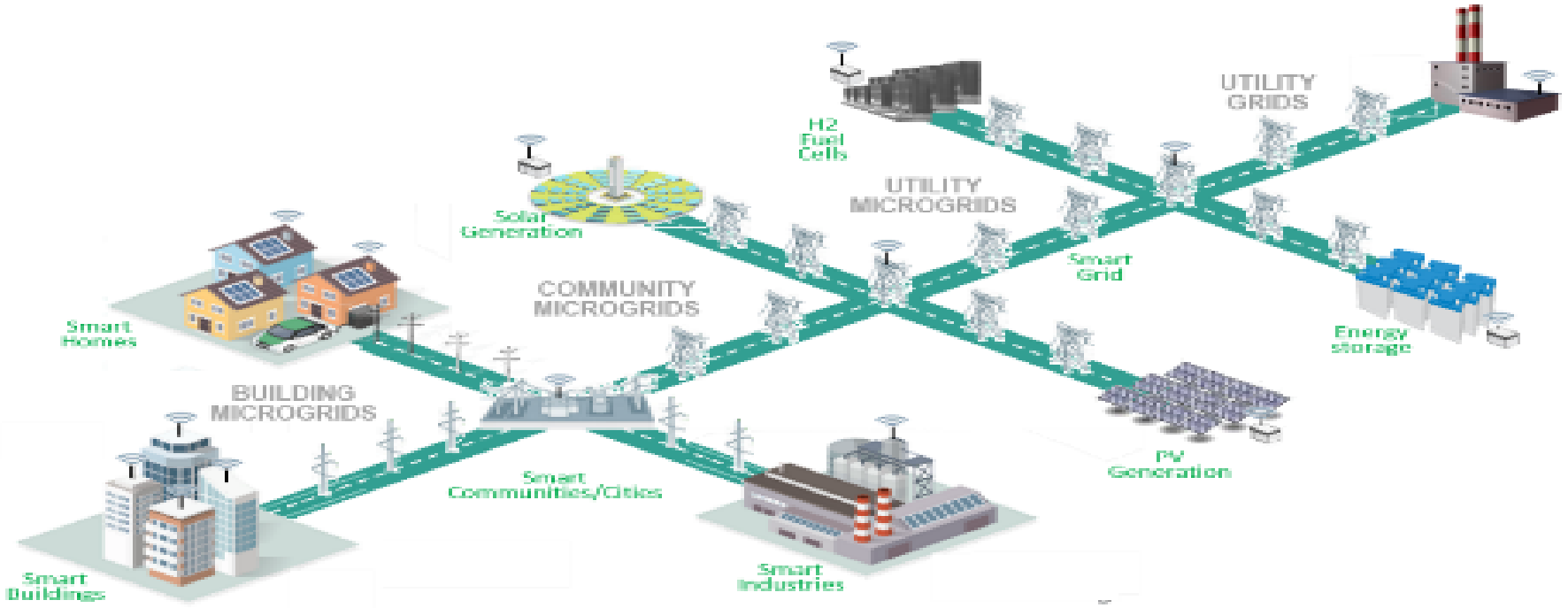
# New Age of Electricity

# Powered With Smart Energy

…smart meters, smart appliances, renewable energy resources, and energy efficient resources in an integrated, highly articulated, flexible, efficient and resilient infrastructure.

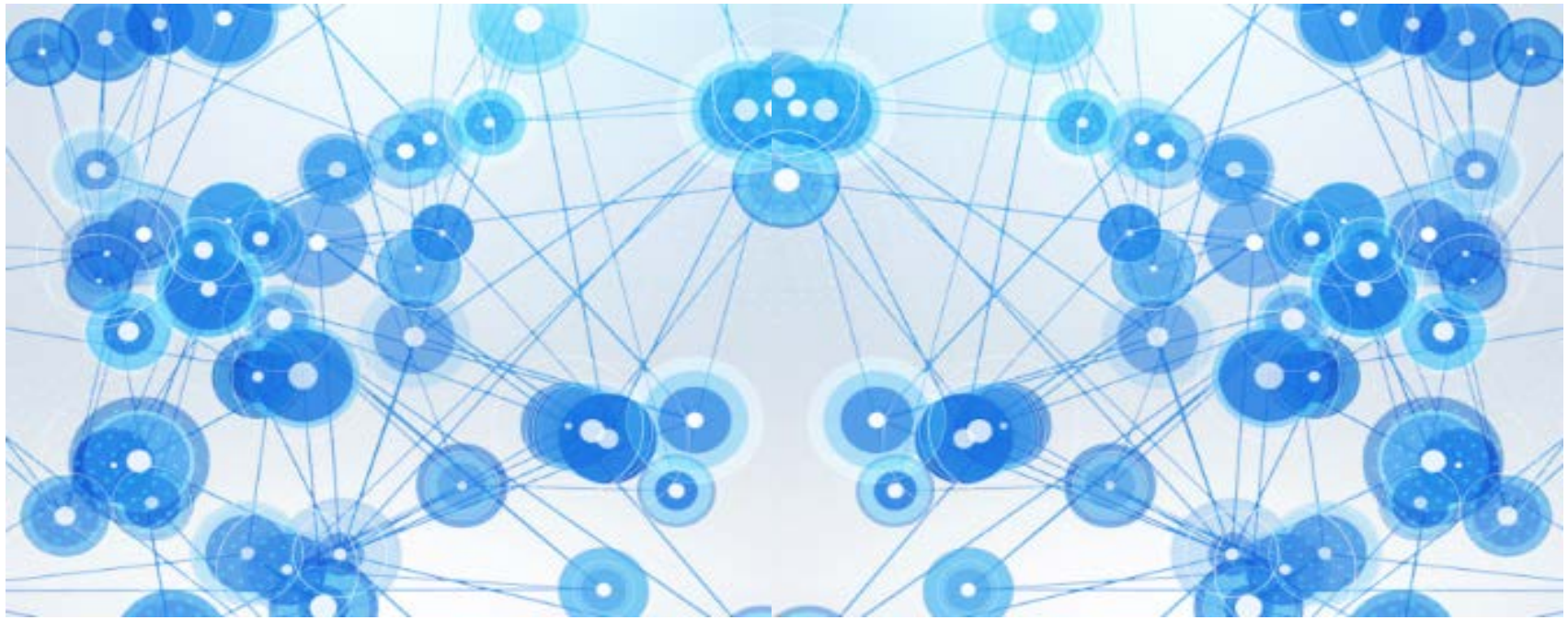
# Facilitated by an Enernet:

## Doing for electricity what the Internet did for information



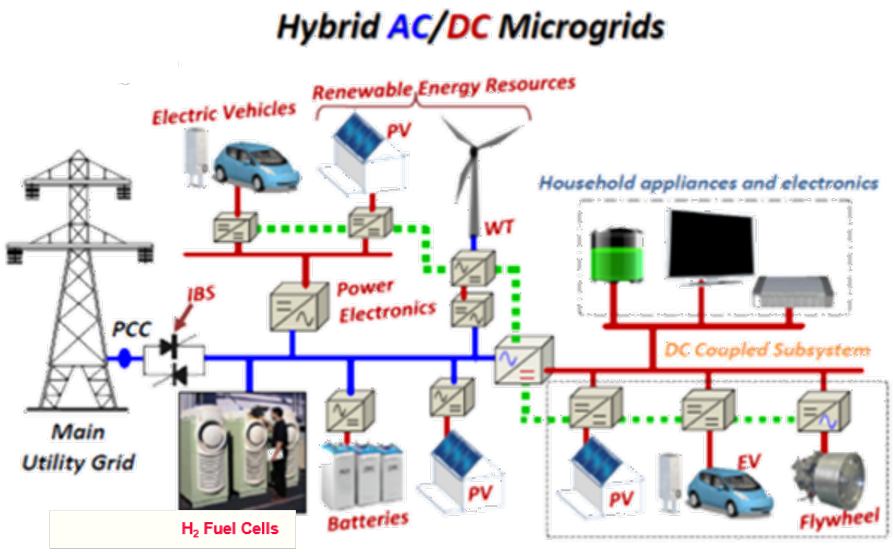
# Using Transactive Energy Control

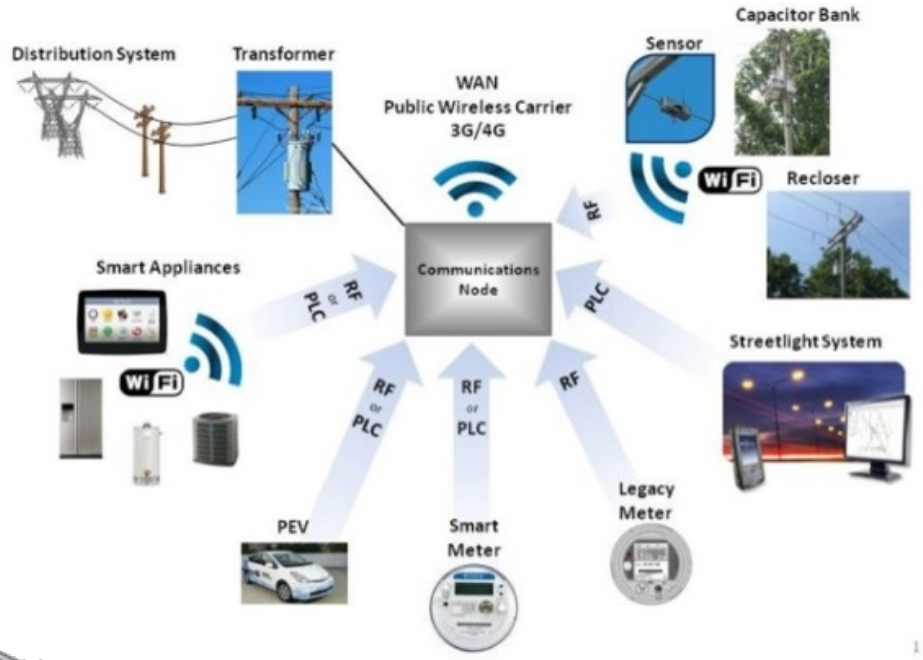
## Facilitated by Modern Information Technology

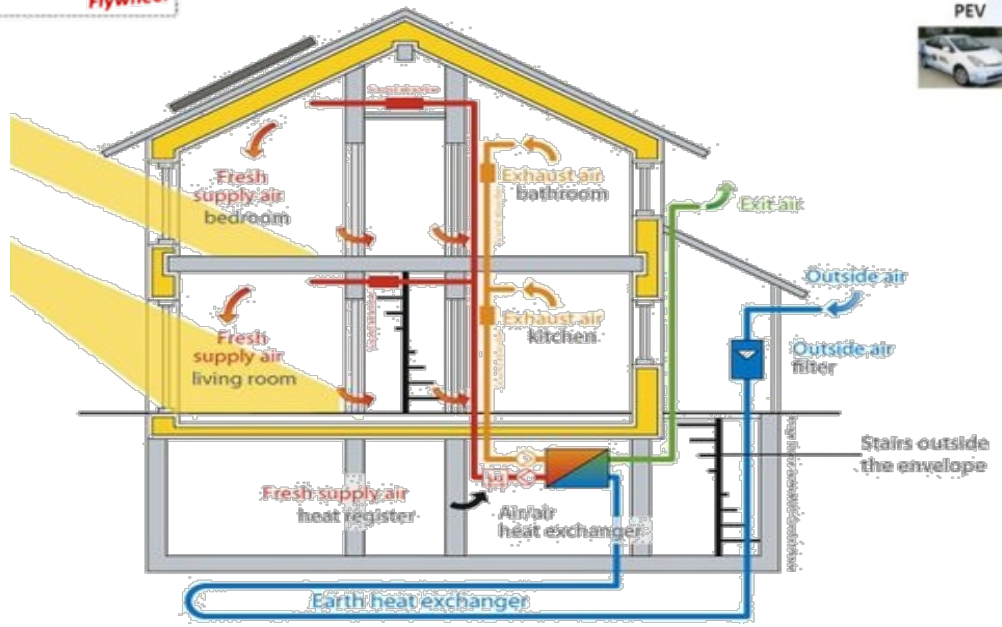


# Requiring new technology & new business models…

# And the integration of the best available technologies

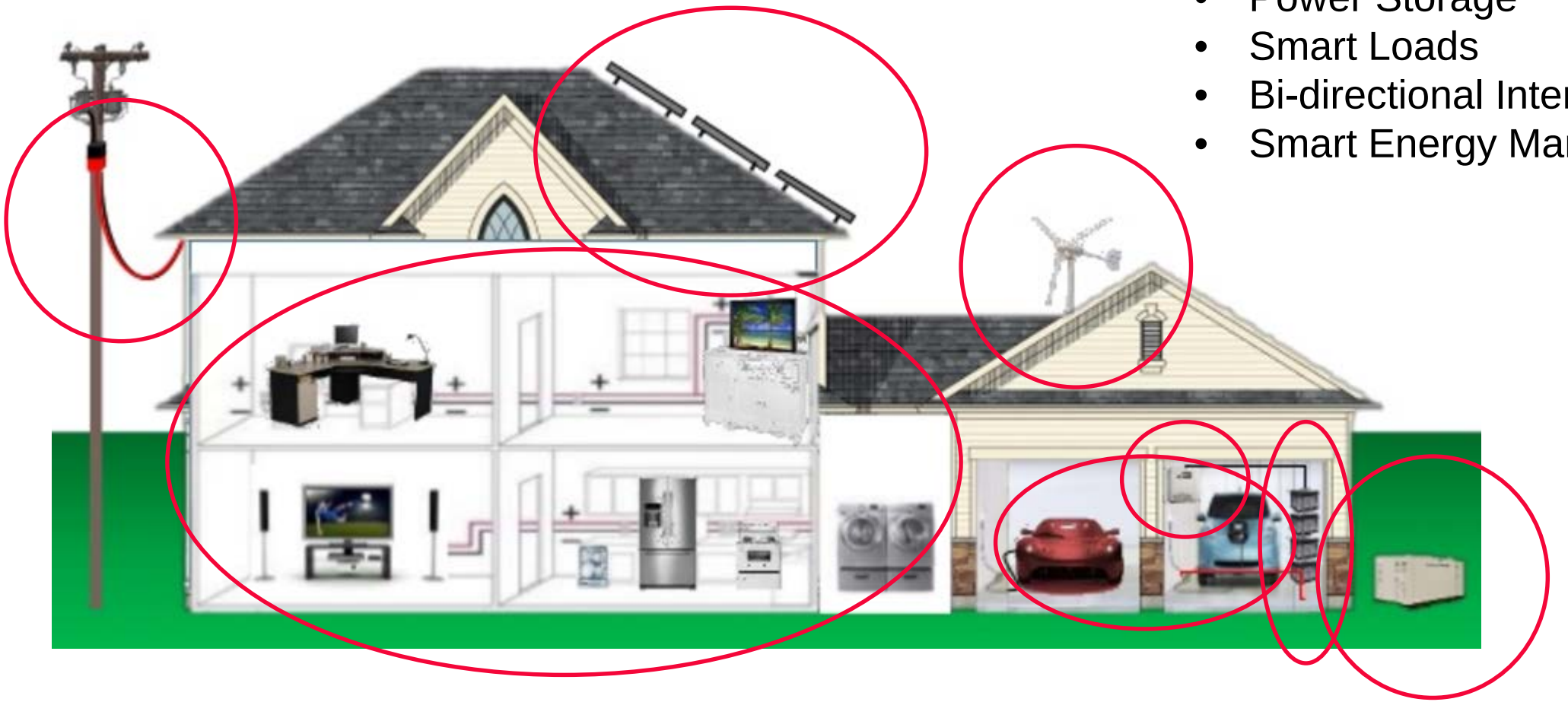


# Key New Technologies …

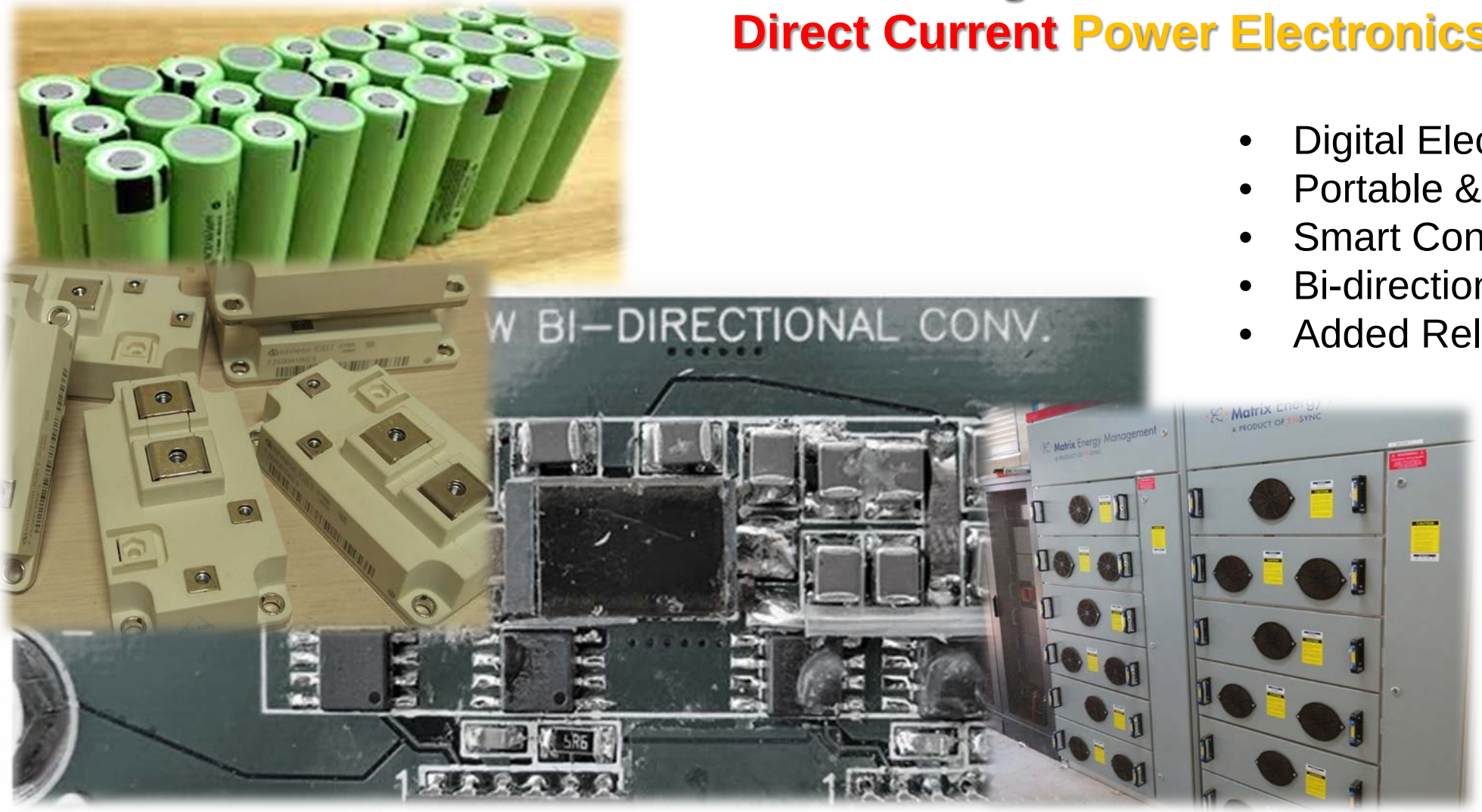
## Building Level Microgrids



- Local Power Generation
- Power Storage
- Smart Loads
- Bi-directional Interconnection
- Smart Energy Management

# Key New Technologies …

## A greater use of
## Direct Current Power Electronics…




- Digital Electronics
- Portable & Fixed Loads
- Smart Controls
- Bi-directional Integration
- Added Reliability & Safety

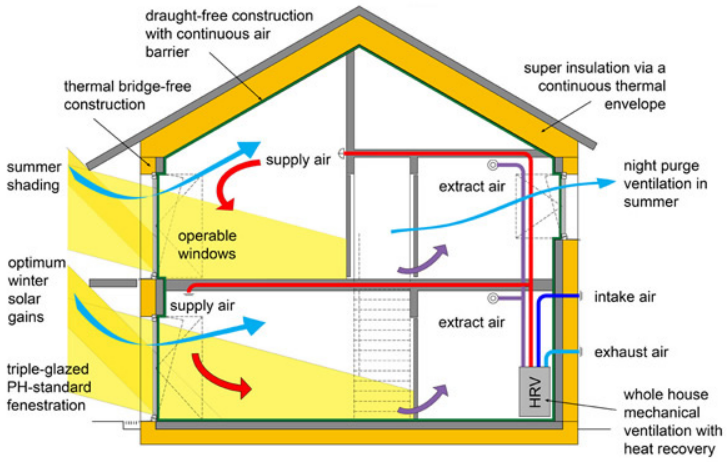
# Key New Technologies …

## An expanded array of
## New Sources and Efficient End-use Devices…

- High Efficiency Electronic Lighting & Appliances
- Portable (battery stored) & Fixed (line connected) Loads
- Smart Controls – Power/Signal Integration
- Bi-directional Integration
- Integration of CHP & CHCP
- Added Reliability & Safety

# Key New Technologies …

## Passive Envelope and Active House Design Integration

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Ideal Home of the Future

# Microgrids Require Power Conversions

| Electric Function | AC Microgrid | Hybrid DC Microgrid |
|---|---|---|
| **Power Sources** *(Solar / Wind / Fuel Cell / CHP/ grid)* | AC + DC ⎓∿ to AC | DC + AC ∿⎓ to DC |
| **Power Storage** *(Battery / Thermal Electric)* | IN: DC + AC ∿⎓ DC + DC<br>OUT: DC ⎓∿ to AC | IN: DC<br>OUT: DC |
| **Distribution/Wiring** *(Conduit / Wiring / Circuit Protection)* | AC + DC ⎓∿ to AC | DC |
| **Loads/Devices/Outlets** *(Lighting / Motors / Pumps / IT Security / Appliances / Desktop)* | AC + AC ∿⎓ to DC | DC + DC ⎓∿ to AC |
| **Controls/Monitoring** *(Wired / Wireless)* | AC ∿⎓ to DC | DC |
| *Total Frequency Conversion Points* | 6 | 2 |

**Notes:**

- Frequency conversions are generally much less efficient than simple voltage conversions
- Conversion efficiency is almost always better at higher voltages and currents
- Wire Size favors DC at equivalent voltages

# Optimizing Power Conversion via the Greater Use of DC can result in Double-Digit Efficiency Increases

**Power supply technology scenarios**

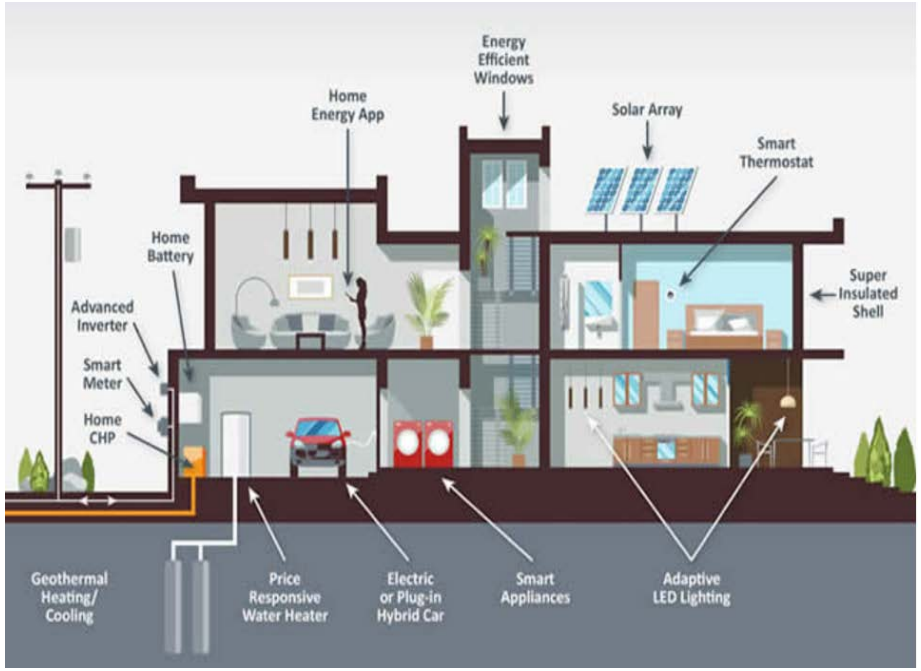
| | Low-voltage power supply system technology development | | | | High & low-voltage power supply system technology development | | | |
|---|---|---|---|---|---|---|---|---|
| | L: Low-voltage DC | L+: Low-voltage DC + More efficient AC/DC conversion | LC1: Low-voltage DC + "visualization" of power use | LC2: Low-voltage DC + "auto control" of power use | H: High & low-voltage DC | H+: High & low-voltage DC + More efficient AC/DC conversion | HC1: High & low-voltage DC + "visualization" of power use | HC2: High & low-voltage DC + "auto control" of power use |
| Immediate | 3.2% | - | - | - | 6.9% | - | - | - |
| Short Term | 1.8% | 1.8% | 2.2% | 2.4% | 10.6% | 11.7% | 20.1% | 23.5% |
| Long Term | 2.9% | 3.0% | 4.1% | 4.5% | 12.8% | 13.4% | 22.4% | 25.9% |

Source: Arthur D. Little Report to IEC SG4, September 2011

# New Building Level Business Models …

## Services ⟵ Key Drivers ⟶ Apps

- Pwr. Sys. Design & Installation
- Sys. Ops., Mgmt. & Service
- Energy Intell, Optm. & Mgmt.
- Virtual Power Plants
- Community Microgrids
- Intg. Pwr.,Comm., & Security
- Preemptive Maintenance
- Transactive Pwr. Mgmt.
  - Consumer Retail
  - Retail to Distributor
  - Distributor to Wholesale
  - Bulk Prod. to Wholesale



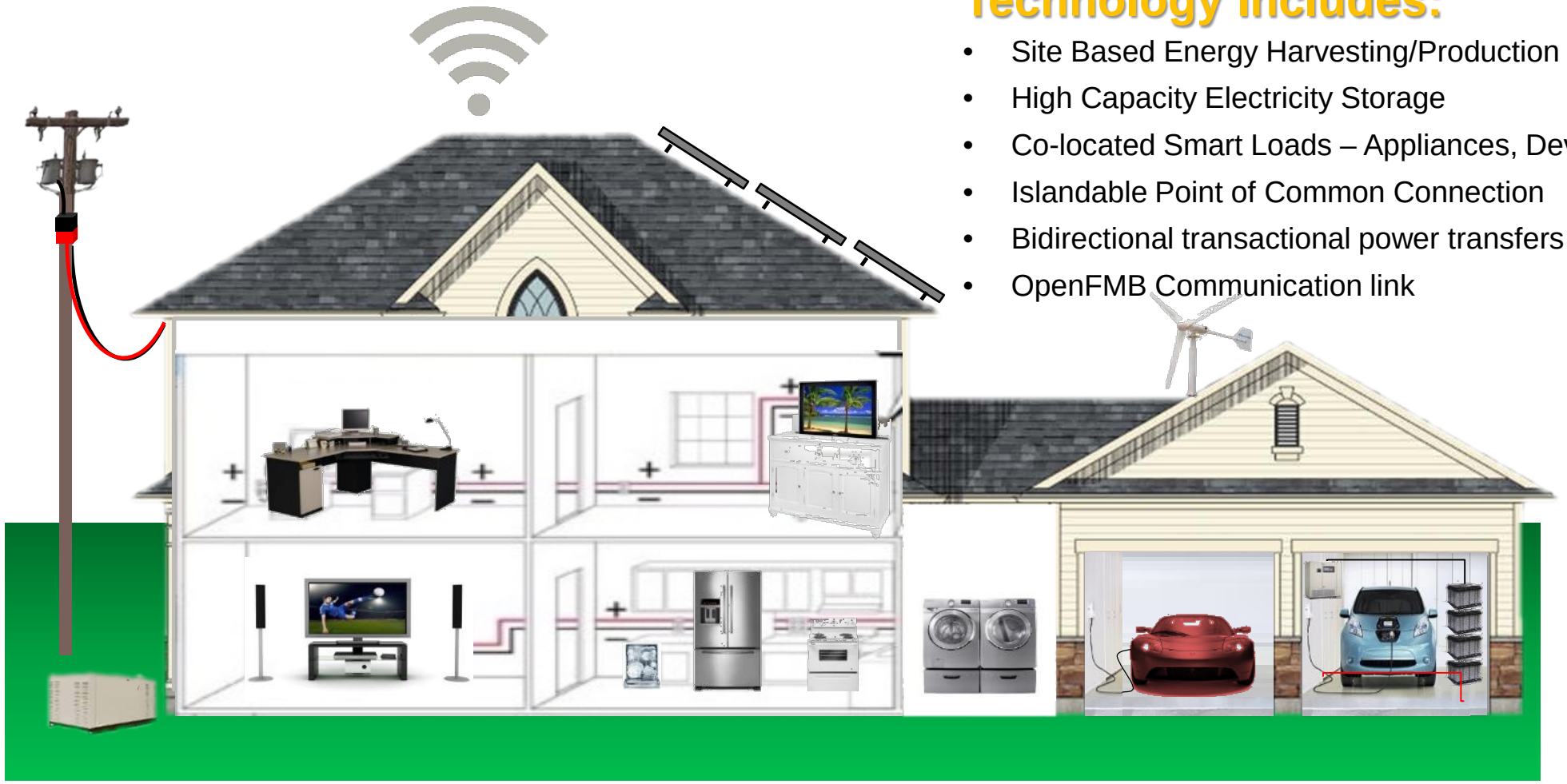

- Smart Building/Home
- Renewable Energy Prod.
- Power Storage
- Electric Vehicle Charging
- Electro-active Environments
- Augmented Reality
- Dist. Sys. Support
  - VARs
  - Peak Demand
  - Freq. Maint.
  - Fault Resilience

# Electro-active Smart Energy Integration…

## Consumer Drivers:

- Personal Power System – Energy Independence
- Desire to “Go Green”
- Operate on or off grid(s)
- Under the owner’s total control
- Conducts power transactions by choice
- Resilient high quality power
- Compatible with modern smart device technology

# Passive Design, IoP, IoT, & Direct Current are converging…

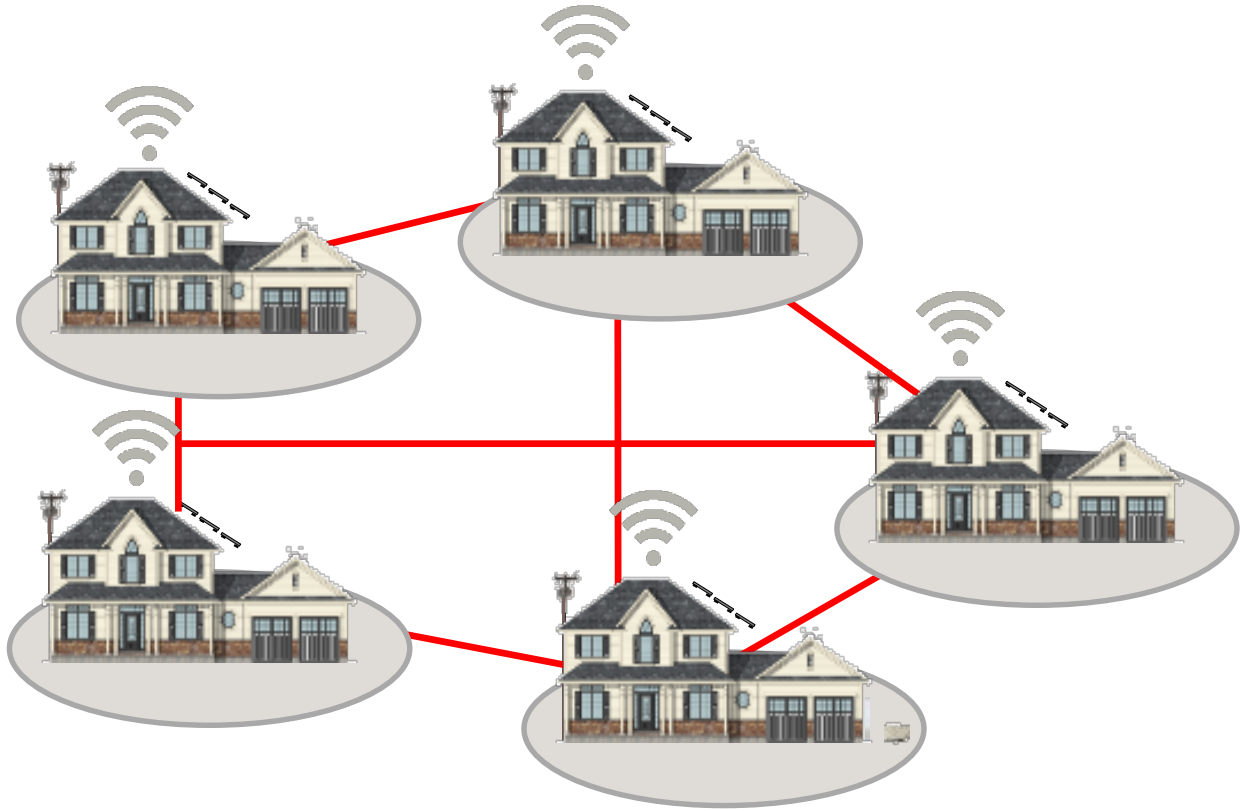


## Technology Includes:

- Site Based Energy Harvesting/Production
- High Capacity Electricity Storage
- Co-located Smart Loads – Appliances, Devices
- Islandable Point of Common Connection
- Bidirectional transactional power transfers
- OpenFMB Communication link

# Smart Homes Ener-connected into Smart Communities …

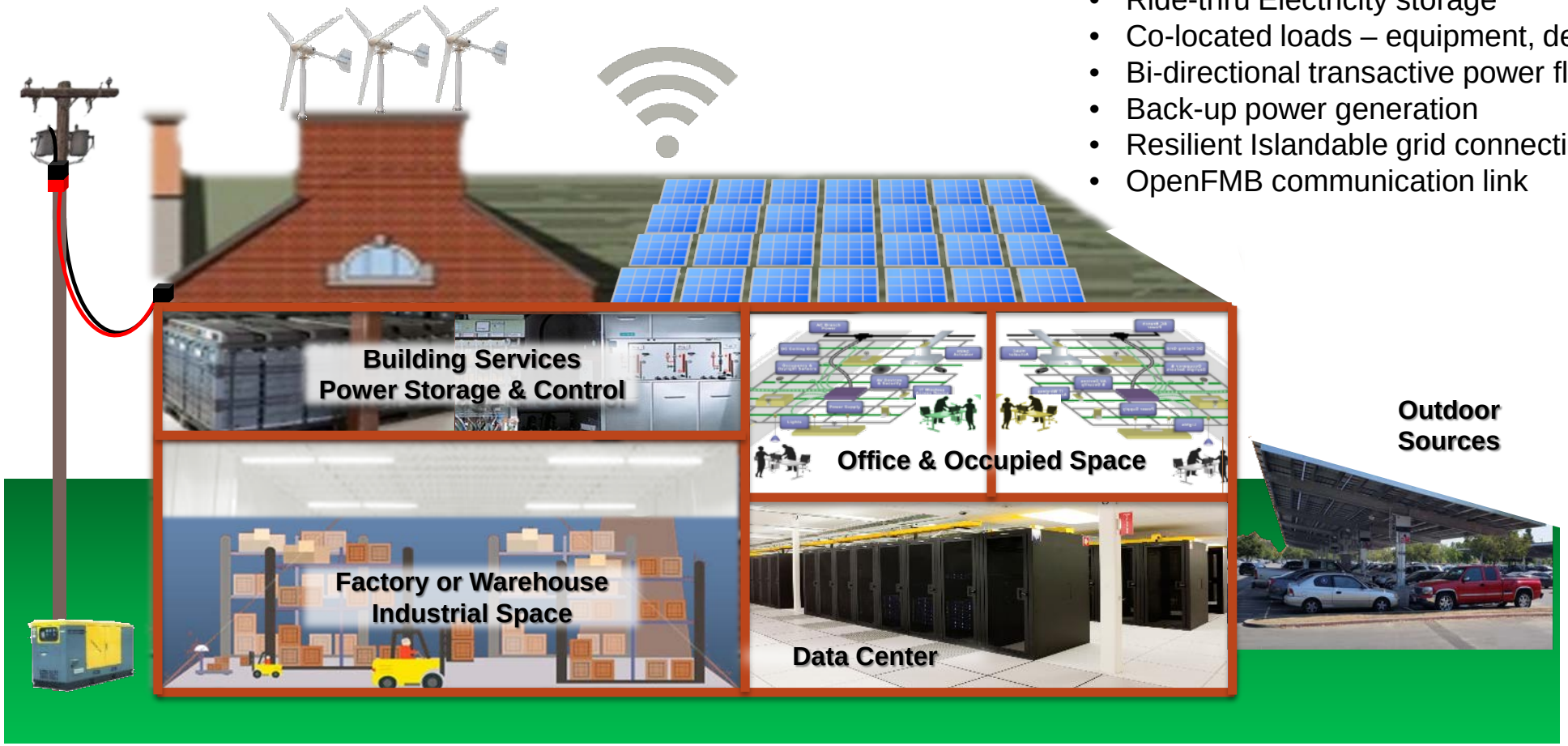
## Community Microgrids



# Smart Buildings with enterprise microgrids…

## Technology Includes:

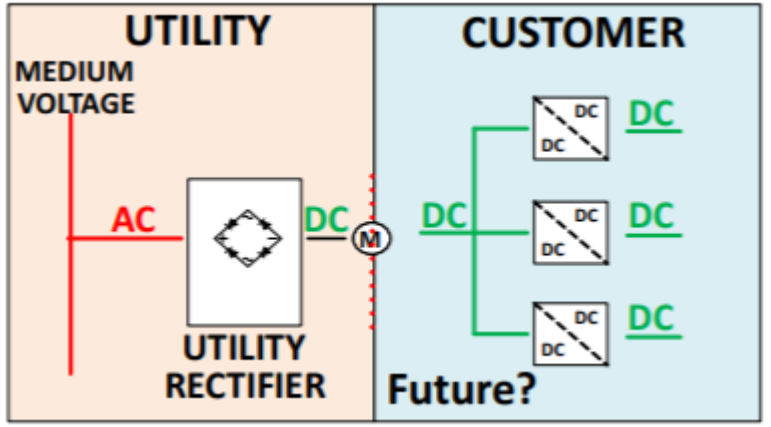
- Site based energy harvesting/production
- Ride-thru Electricity storage
- Co-located loads – equipment, devices
- Bi-directional transactive power flow
- Back-up power generation
- Resilient Islandable grid connection
- OpenFMB communication link



# Fast Vehicle Charging Stations:
# Direct Current as a Utility Supplied Service

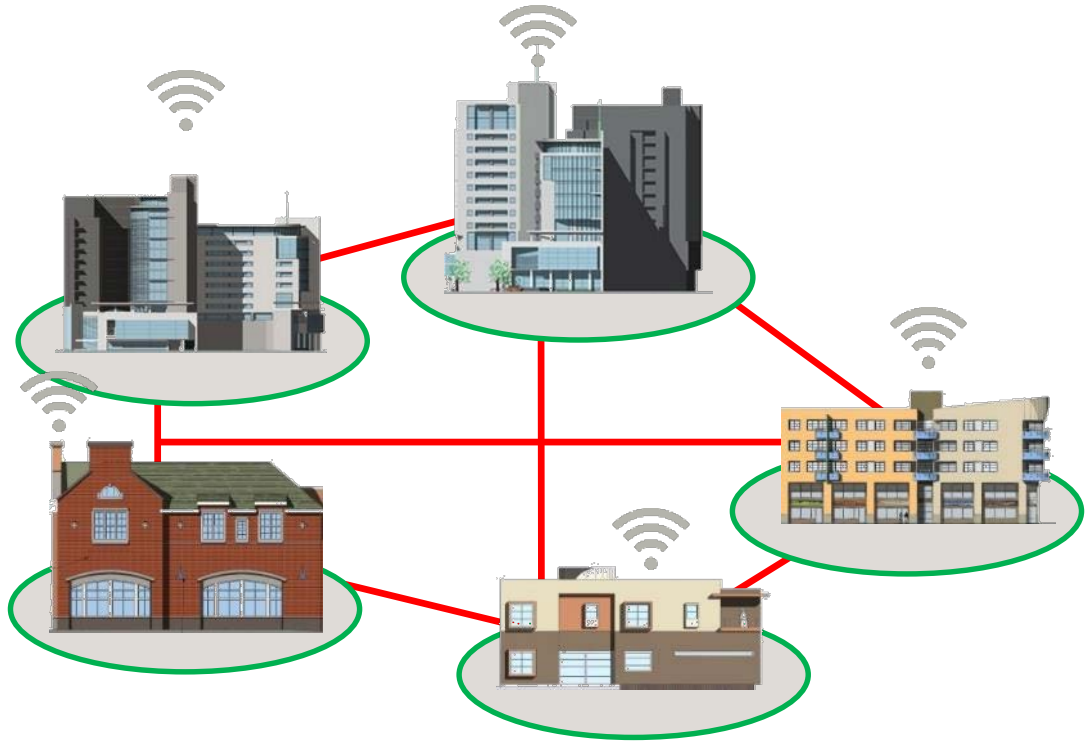

## Technology Includes:

- DC as a Service (DCaaS)
- Bulk/Reserve Storage
- Co-located Production
- Bi-directional Flow
- integration of Renewables
- Provide Grid Service
- Resilient Grid Connection
- Open communication Links



# Ener-connected into Smart Cities

## Commercial Campus Microgrids

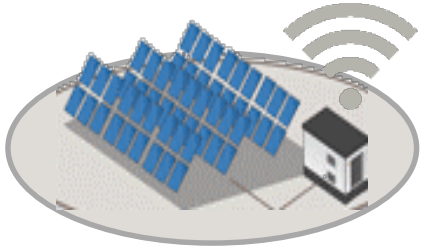


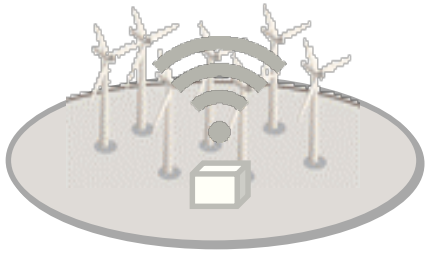
# Utility Scale microgrids can take many forms…

## Medium and High Voltage DC is being increasingly used in grid support strategies

H2 Fuel Cell Peaking Plants

Solar Farms



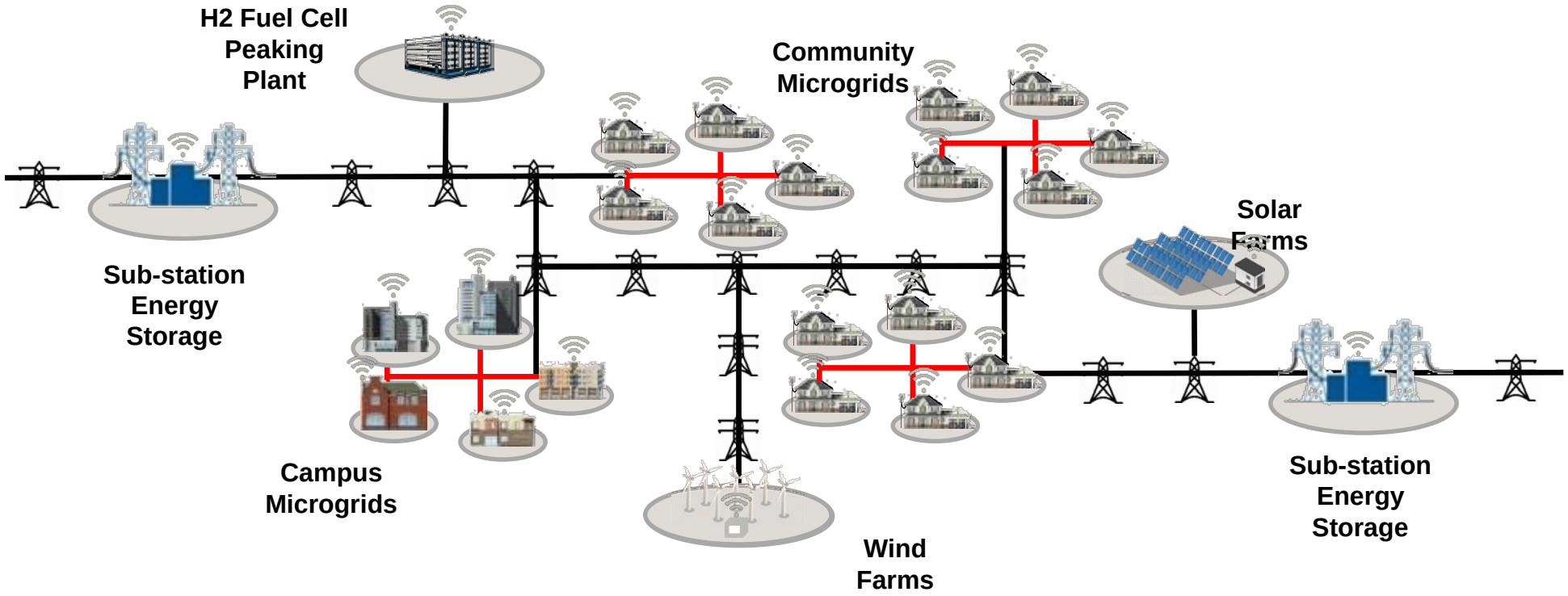


Wind Farms

Sub-station Power Storage

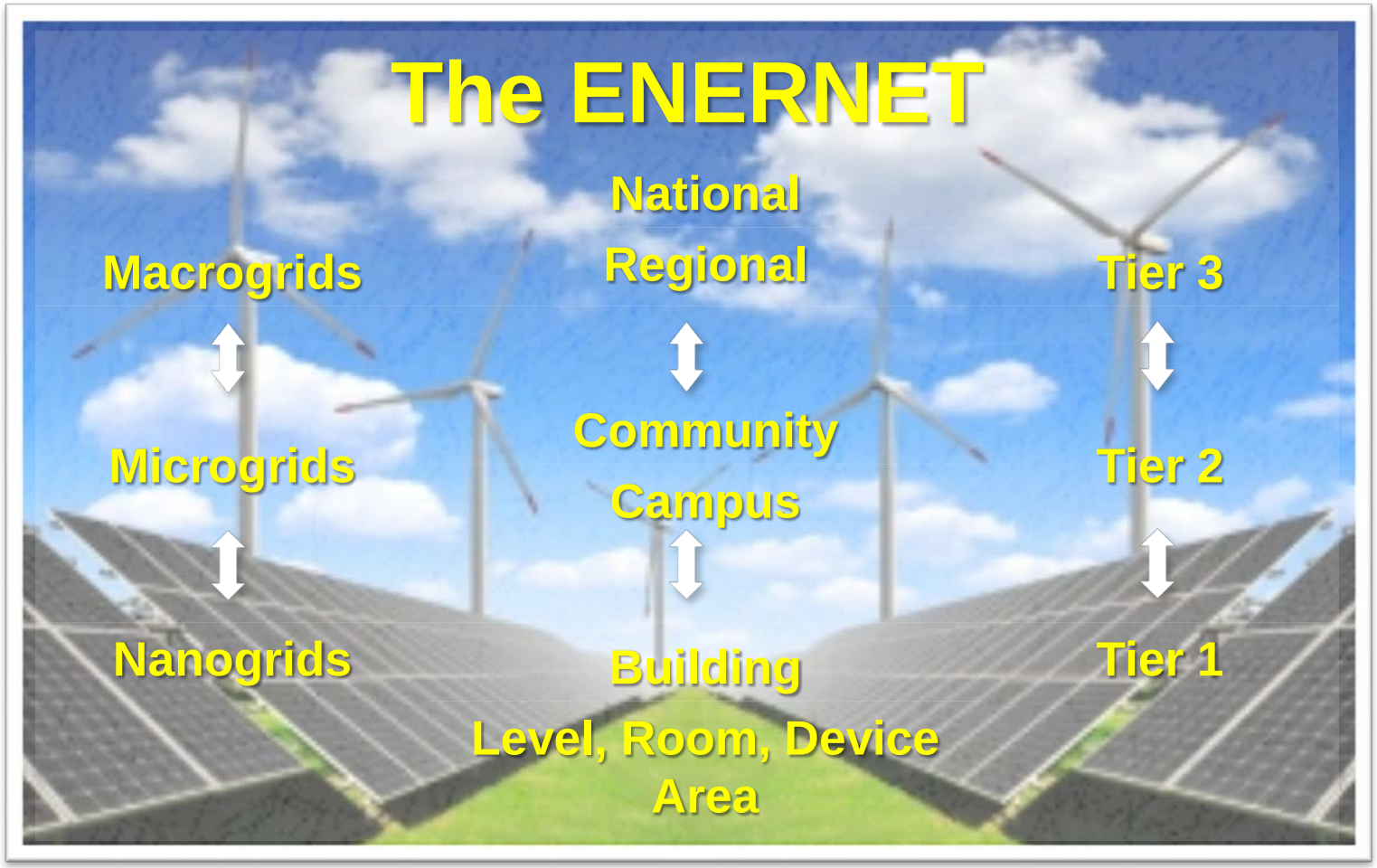
# ...to enable an interconnected grid of grids infrastructure...

## Controlled in tiers of Transactive Energy domains



# …of non-synchronous nanogrids, microgrids & macrogrids…

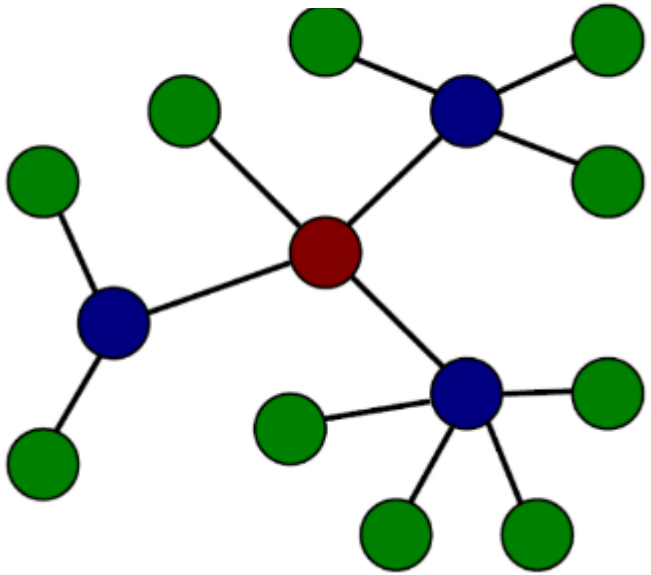
## Organized in a Tiered Framework



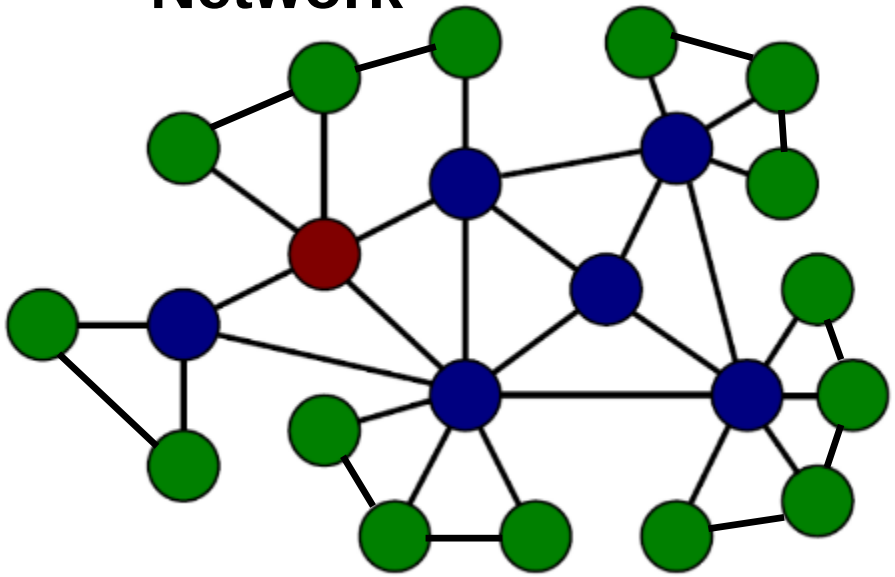
# …in an integrated mesh topology…

## Transforming Traditional Power Grids

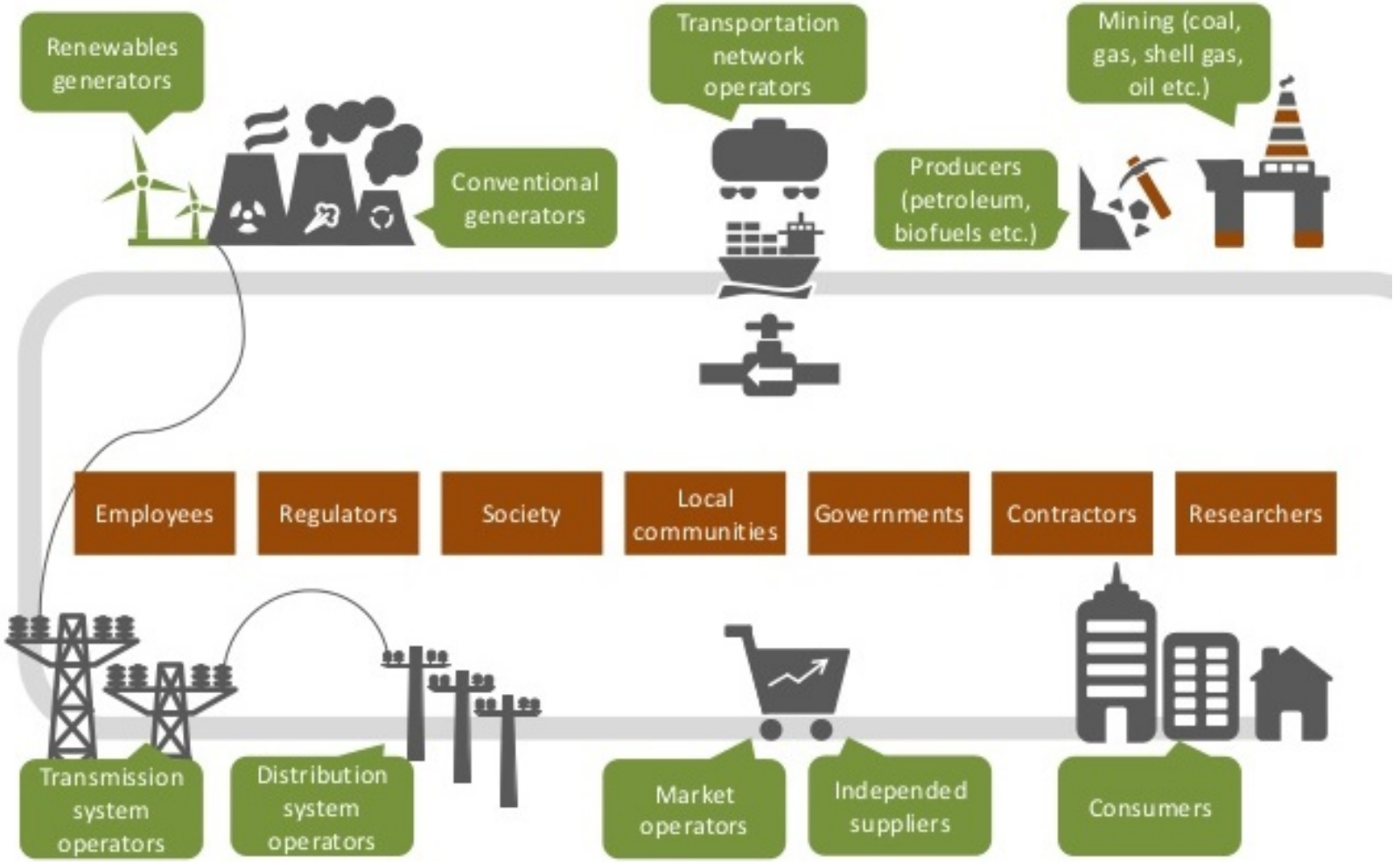
**Cluster Tree Network**



**Integrated Mesh Network**

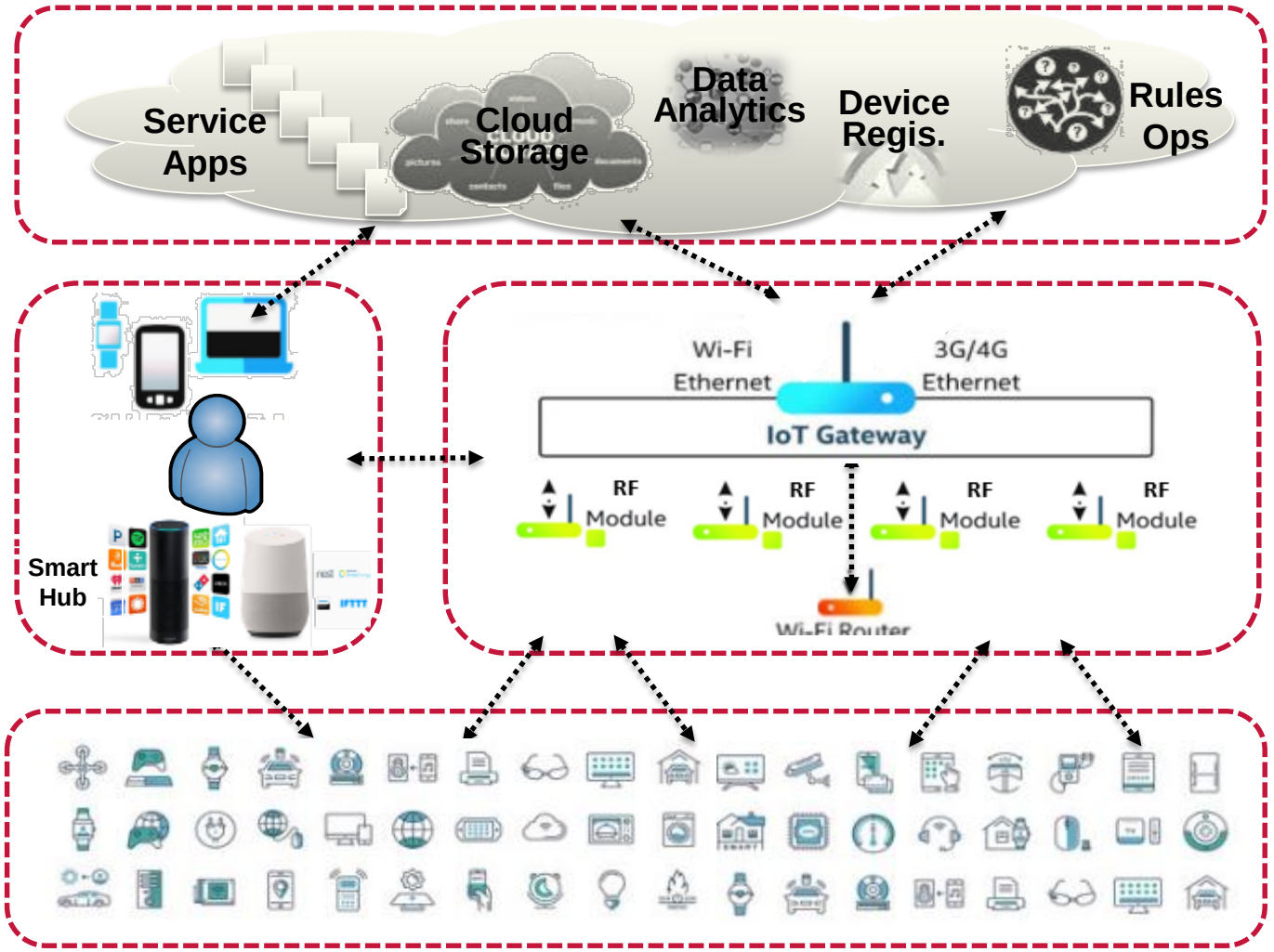


# …operated by a enormously expanded stakeholder base…




Source: University of Leicester

# …where the distributed ‘SMARTS’ come from the IoT…




**IoT Cloud Layer** (thousands of actors)

**User Interface Layer**

**IoT Gateway Layer** (millions of actors)

**IoT Device Layer** (billions of actors)

# Smart Building Communications

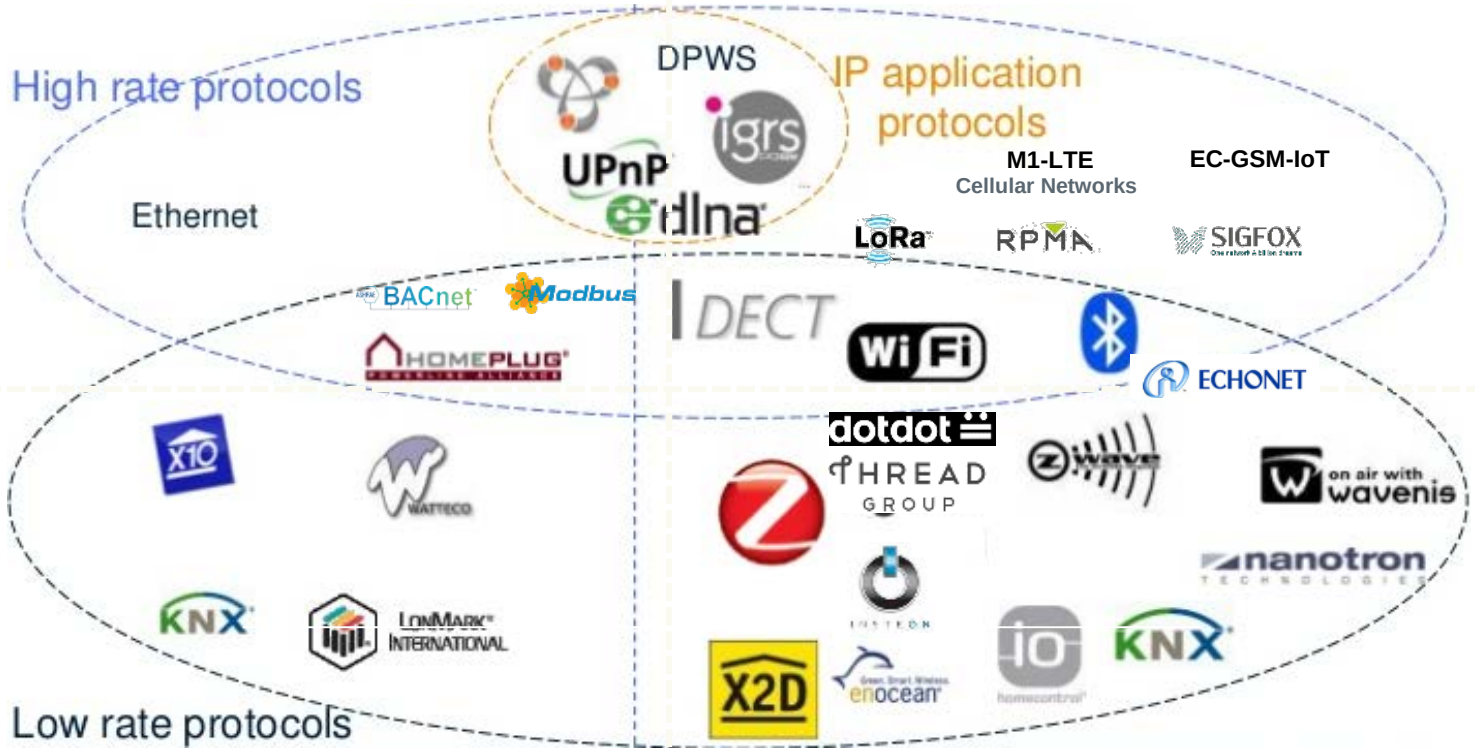
## Protocol Overview

**Wired**
Wire, Fiber Optic, Power Line Carrier

**Wireless**
Radio Frequency Communications

High Bandwidth

Low Bandwidth




**Note:** These are the major so-called "open" protocols – meaning anyone who is licensed can use them. There are many others that are similar in function but are proprietary and only used by a specific company and/or its selected agents.

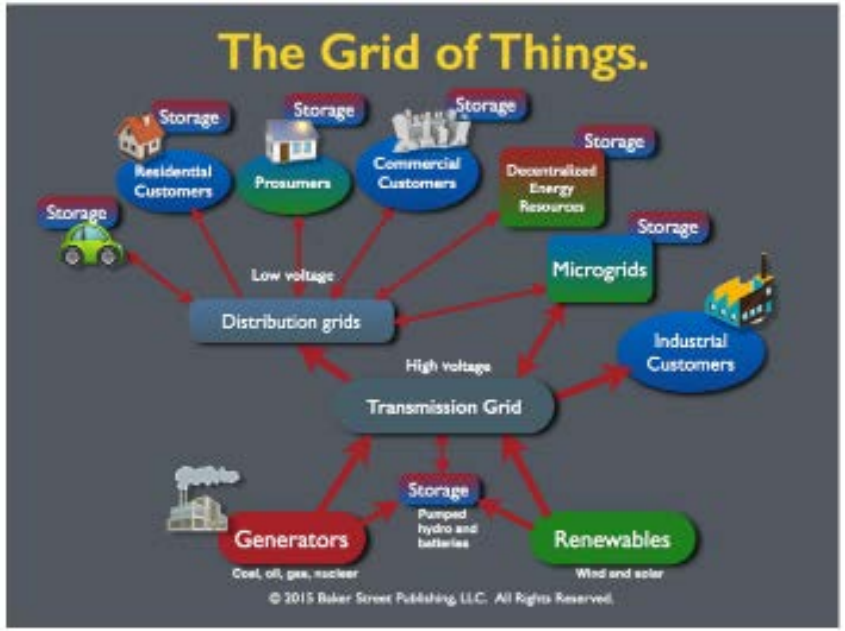
# …facilitating a new set of energy solutions…

## Key virtues learned from the Internet




| | |
|---|---|
| 1 | Presumption of Access Equality of Each Entity |
| 2 | Bottom-Up Public Structure |
| 3 | Strength of 'Weak' Transactive Cooperation |
| 4 | Self Organizing + Self Healing = Resilient |

# …utilizing a transactive power management framework…

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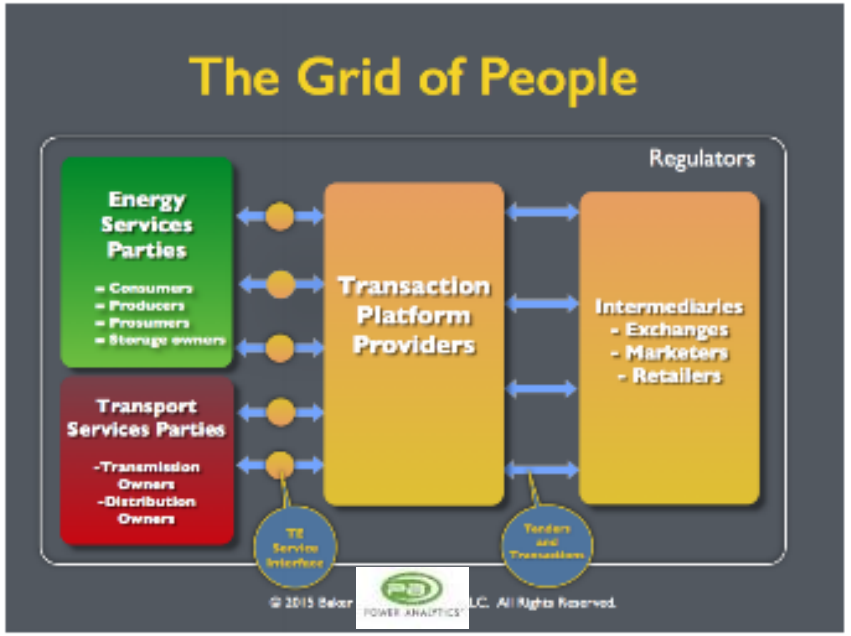



Public Utilities

+

Cloud Based Service Providers

+

Local Service Providers

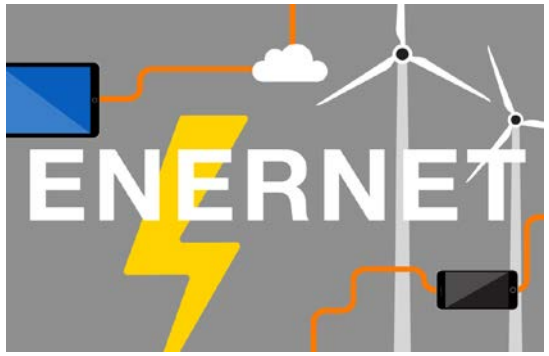
+

Prosumers

# Internet of Things + Enernet of Power

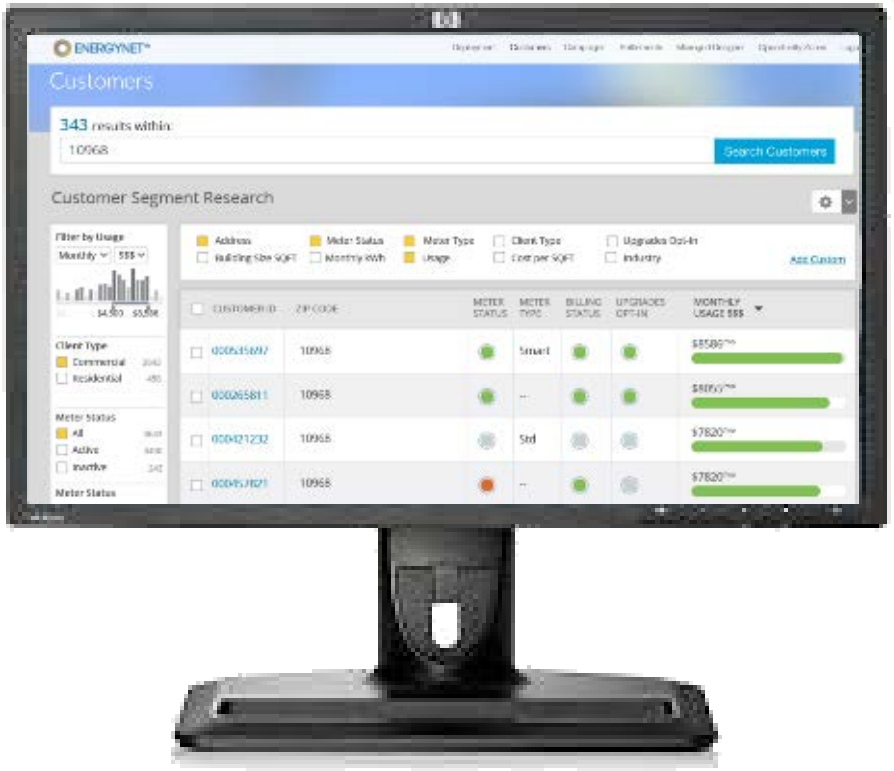
## System Capabilities


- Dispatching Assets
- Forecasting Utilization
- Simulation & Modeling
- Market Management
- Optimizing loads
- Integration Optimizers
- Control Storage
- DR Management
- Integration with Utility DMS
- Power Flow Control
- Data Exchange
- Smart Meter Data
- Limiting Spinning Reserves
- Monitoring Equipment
- Managing Outages
- Self-Healing Switching
- Support of Customer-Facing Applications



# Internet of Things + Enernet of Power

## Business Process Support



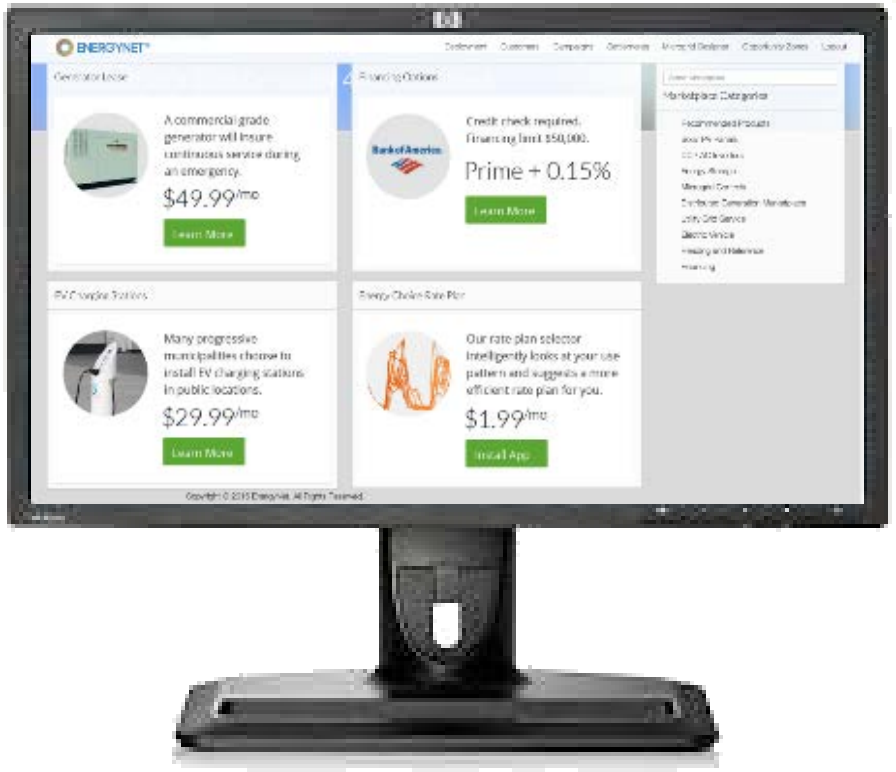

*Customer Segmentation Research*


*Energy Campaign Management*

# Internet of Things + Enernet of Power

## Prosumer Support


*Consumer Engagement Data*




*Consumer Sales Solicitations*

# Internet of Things + Enernet of Power

## Operational Process Support


*One-Line Visualizations*

*Real-Time Operations*

*Real-Time Dashboards*

# Internet of Things + Enernet of Power

## Impact on Utilities

- Lead the transition to Transactive Energy
- Provide and manage intermediary grid services
- Employ forward management of retail contracts
- Oversee down-stream regulatory requirements

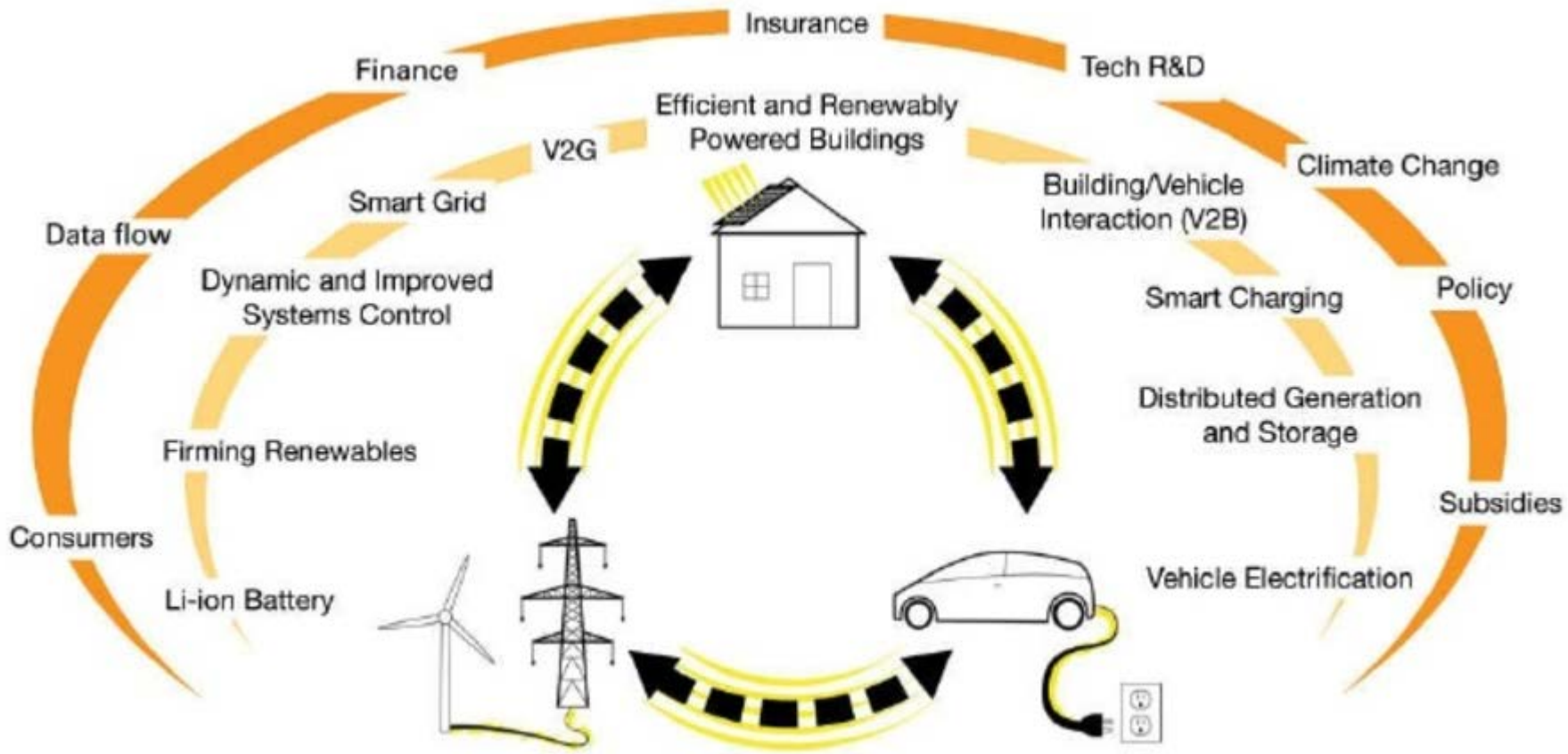
# Internet of Things + Enernet of Power

## Impact on Independent Energy Industry

- Create robust Renewable Energy value chain.
  - Independent Power Producers will transact peer-to-peer, up & down the supply chain.

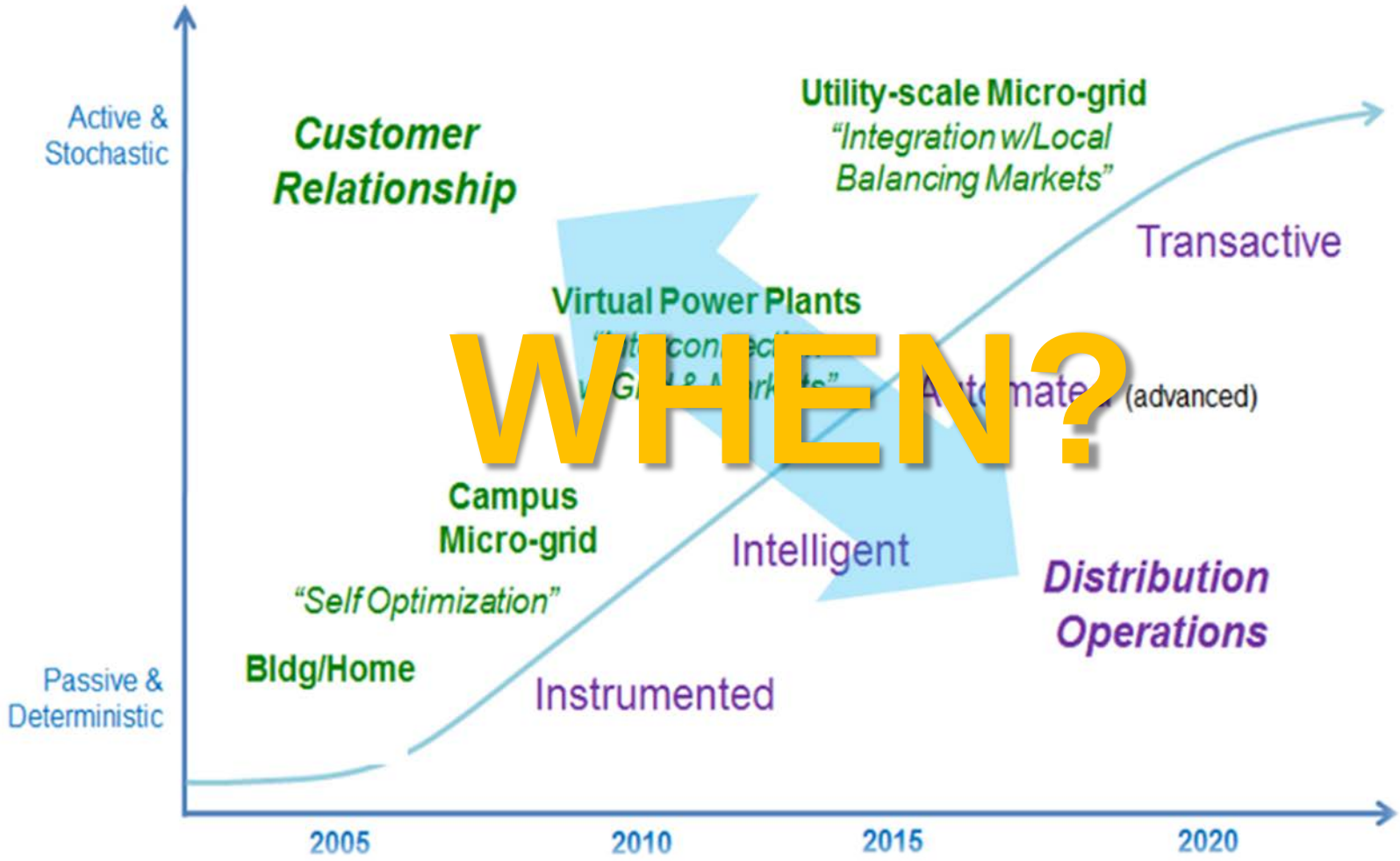
  - Storage Owners will transact peer-to-peer, up & down and provide specialized grid and microgrid support.

# Developing the Net Zero+ Smart Energy Marketplace



# Predicting the Future

## Transactive Power Management Framework Timing



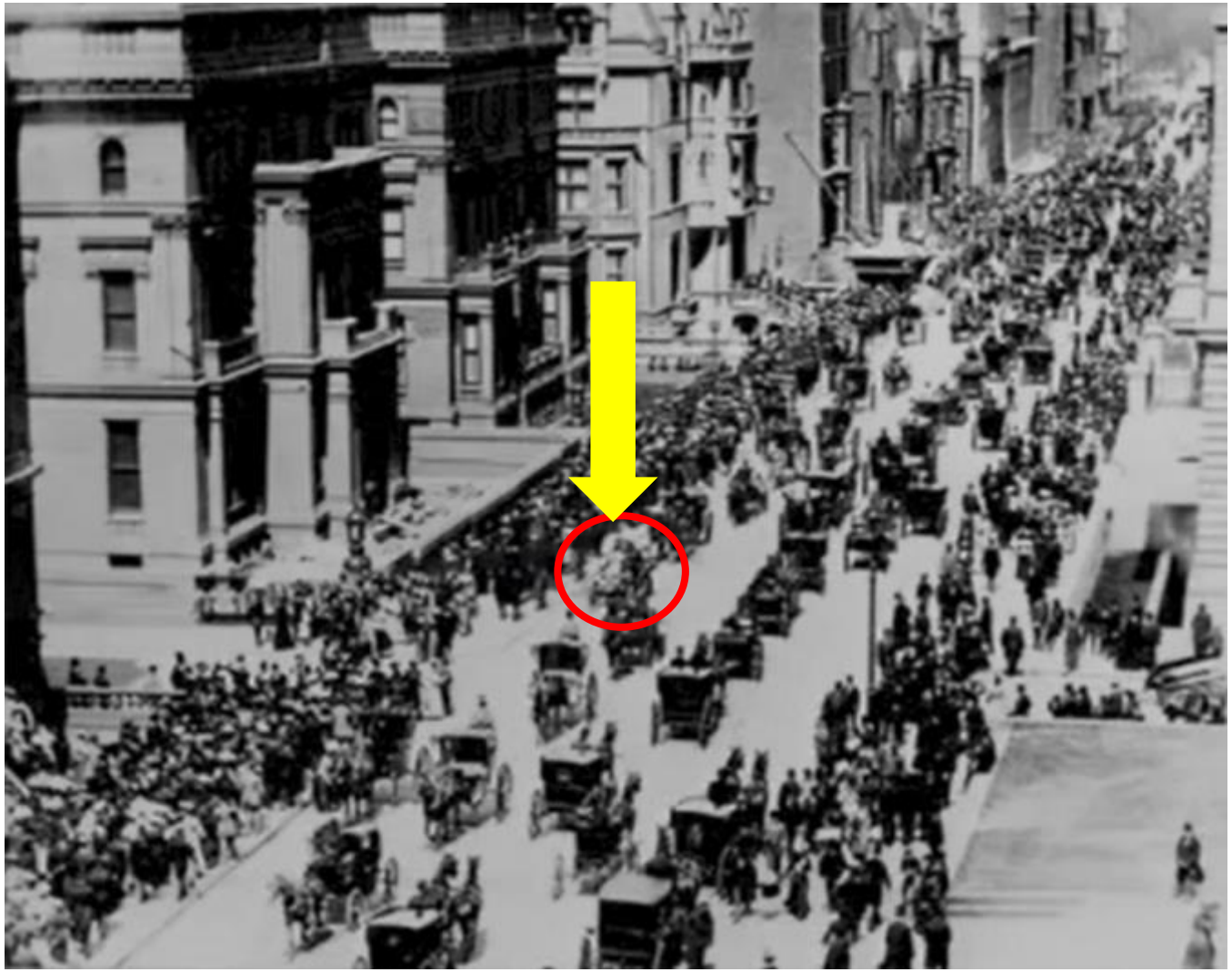
# 5th Ave. New York City – circa 1900

Where is the Car?

Source: Clean Disruption – Tony Seba

# 5th Ave. New York City – circa 1900

Where is the Car?



Source: Clean Disruption – Tony Seba

# 5th Ave. New York City – circa 1910

Where is the Horse?

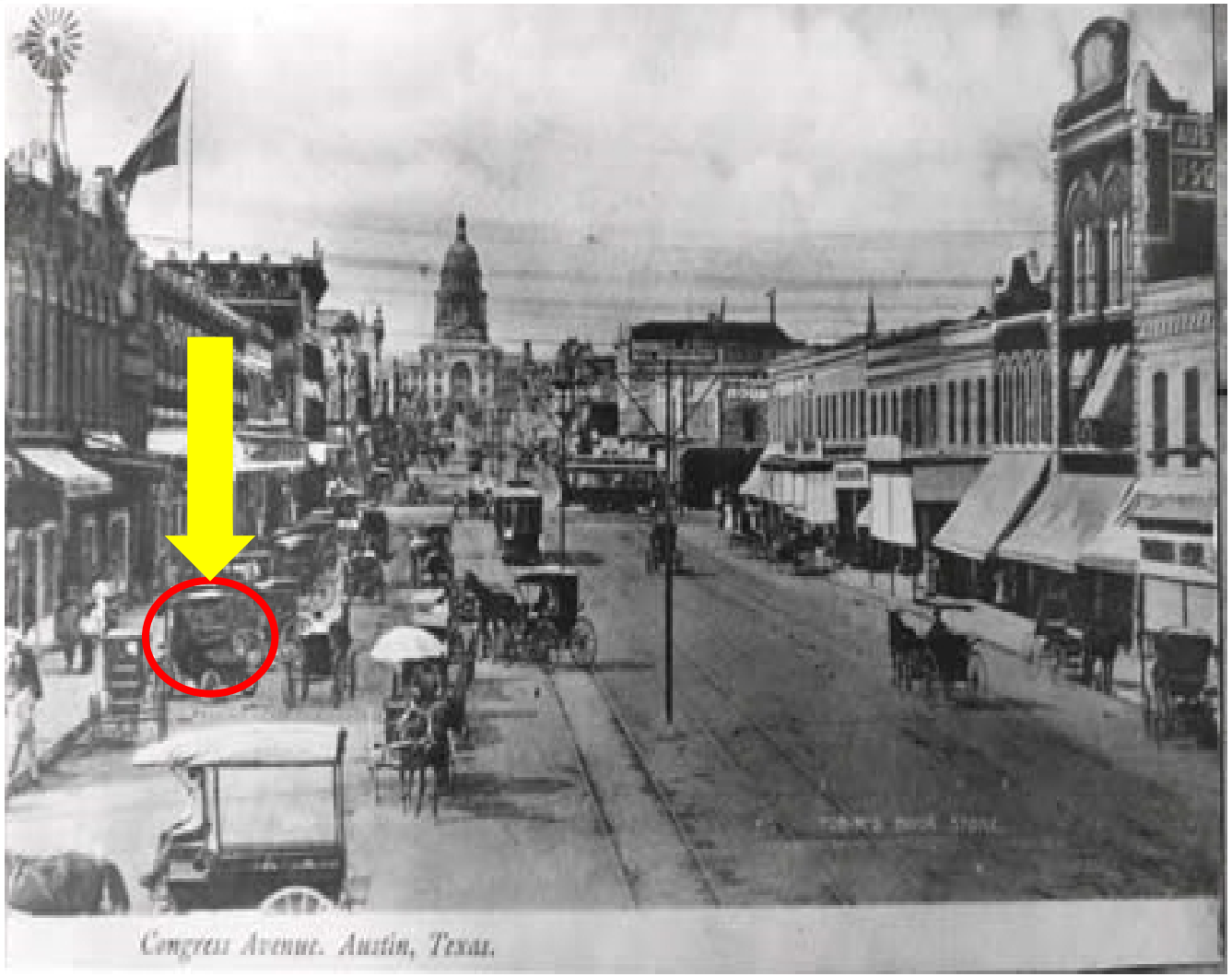

Source: Clean Disruption – Tony Seba

# Congress Ave. Austin Texas - circa 1900

Where is the Car?

# Congress Ave. Austin Texas - circa 1900

Where is the Car?



# Congress Ave, Austin Texas - circa 1910

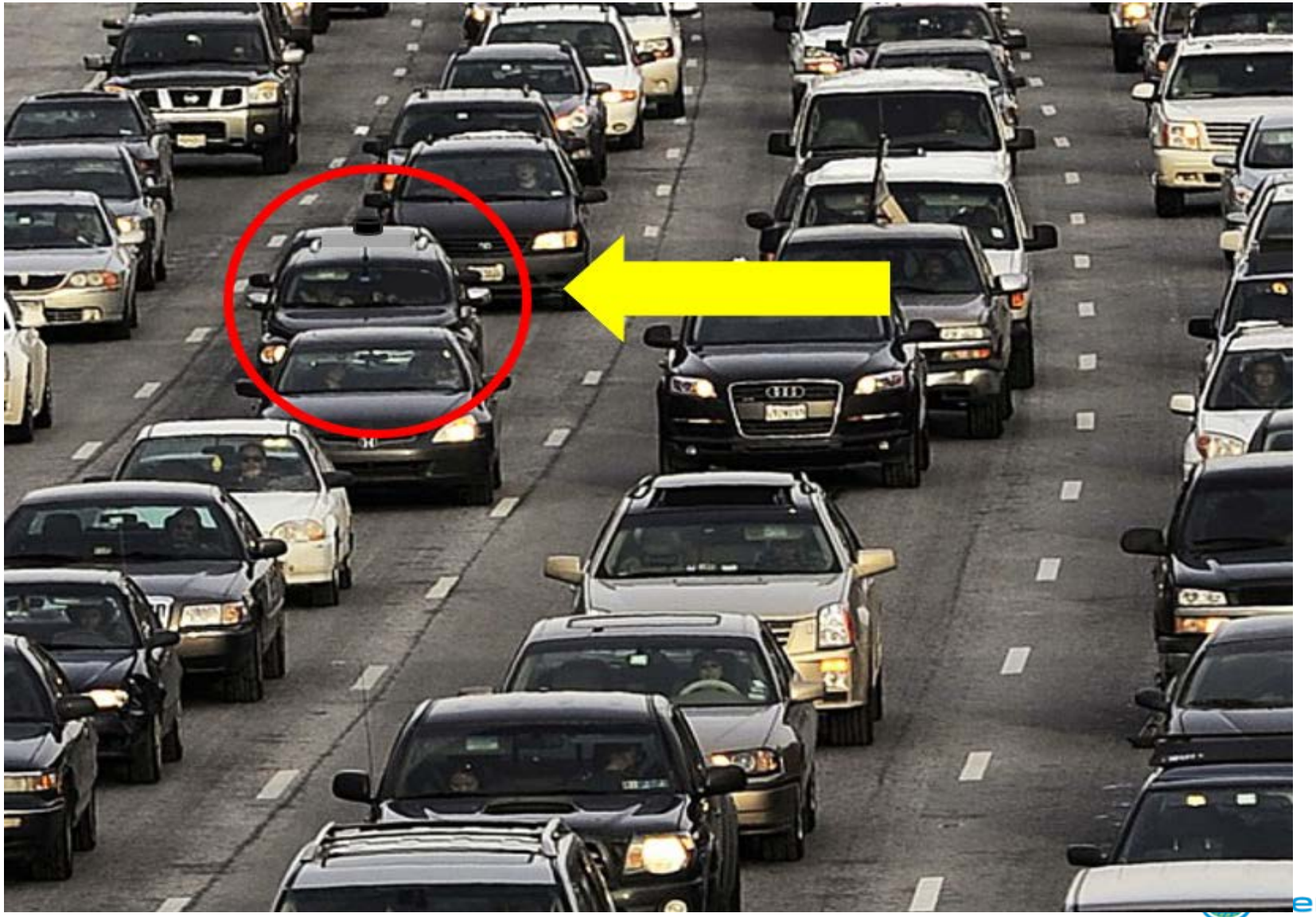
Where is the Horse?

# Congress Ave, Austin Texas - circa 1910

Where is the Horse?

# Washington DC – circa 2017

Where is the Self Driving Electric Vehicle?



# Washington DC – circa 2027

Where is the combustion engine driver operated car?

# US Roadmap to a Transactive Enernet


**Introduction 2011-2015**

- Development of Transactive Energy vision, standards and pilot demonstrations.

**Expansion 2013-2020**

- Deployments of Transactive Energy on portions of the grid where value is high, and there is regulatory and participant support.

**Hybrid 2015-2030**

- Widespread deployment of Transactive Energy within some regions with interfaces to existing operations and markets as needed.

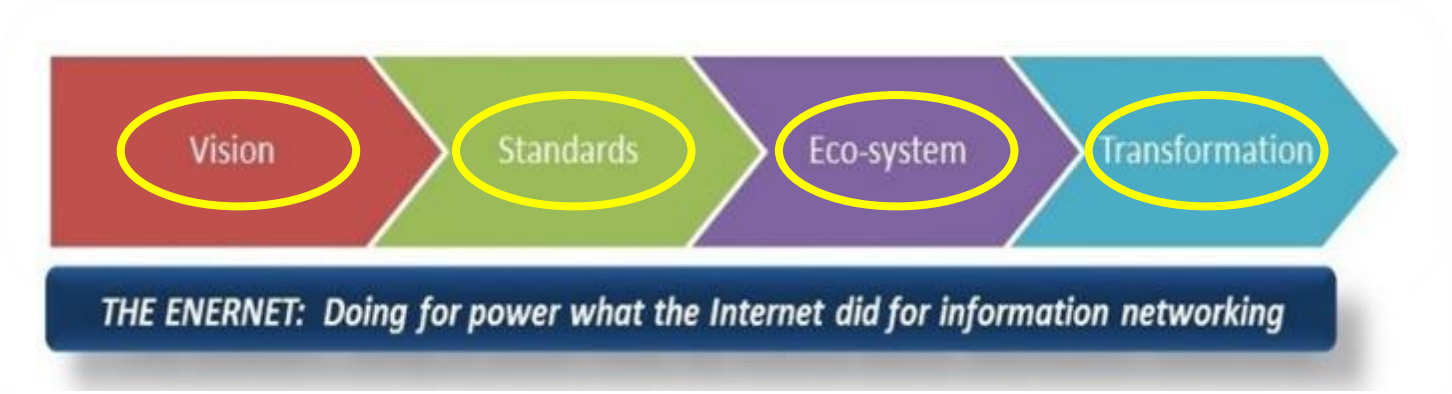
**Mature 2020-2050**

- Near full deployment of Transactive Energy within many regions.

Draft work product of the Gridwise Architecture Council (GWAC) Transactive Energy Workshop - www.gridwiseac.org

# The ENERNET

**Flexible, clean, efficient, resilient, affordable and sustainable energy & information infrastructure**




**Involving a greater integration of the best available technologies:**

**EFFICIENT PASSIVE BUILDING DESIGN**

**&**

**ACTIVE HYBRID AC/DC MICROGRID ARCHITECTURES**

**converging with the Internet of People &Things**

# (not so) **Secrete Formula for Success:**

**Things:**
**Innovate + Integrate**

**People:**
**Collaborate + Network**

**"What we do with electricity**
**<u>will</u> change the fate of the world."**

# Acknowledgment

I would like to acknowledge the contribution of resources and information provided by the EMerge Alliance and its membership.

**http://www.emergealliance.org**

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Building Technology Office

# Building Technologies and the Enernet

## Thank You!
## Questions?

EMerge® ALLIANCE

http://www.emergealliance.org