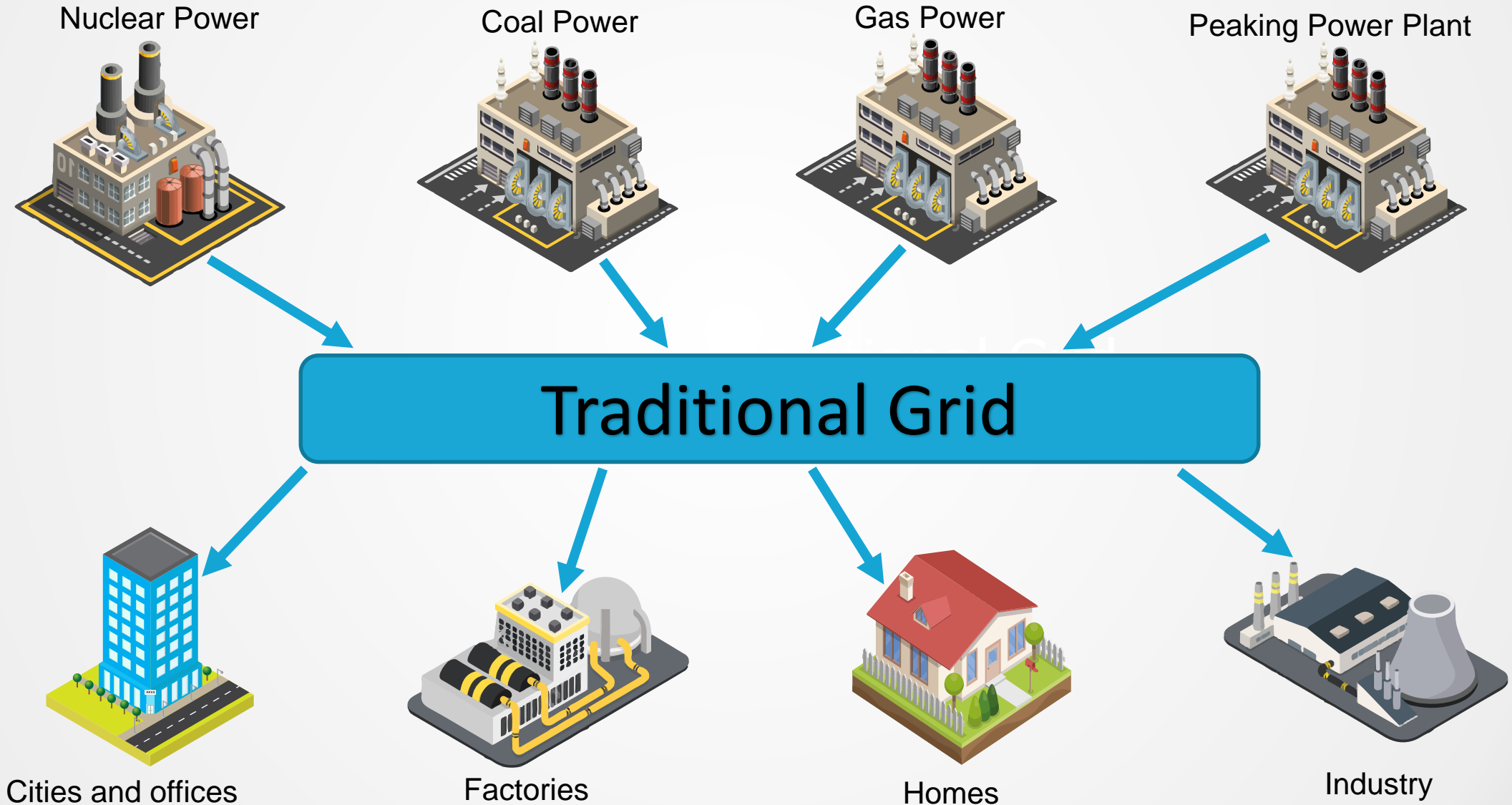


They Won't Build Grids Like They Used To

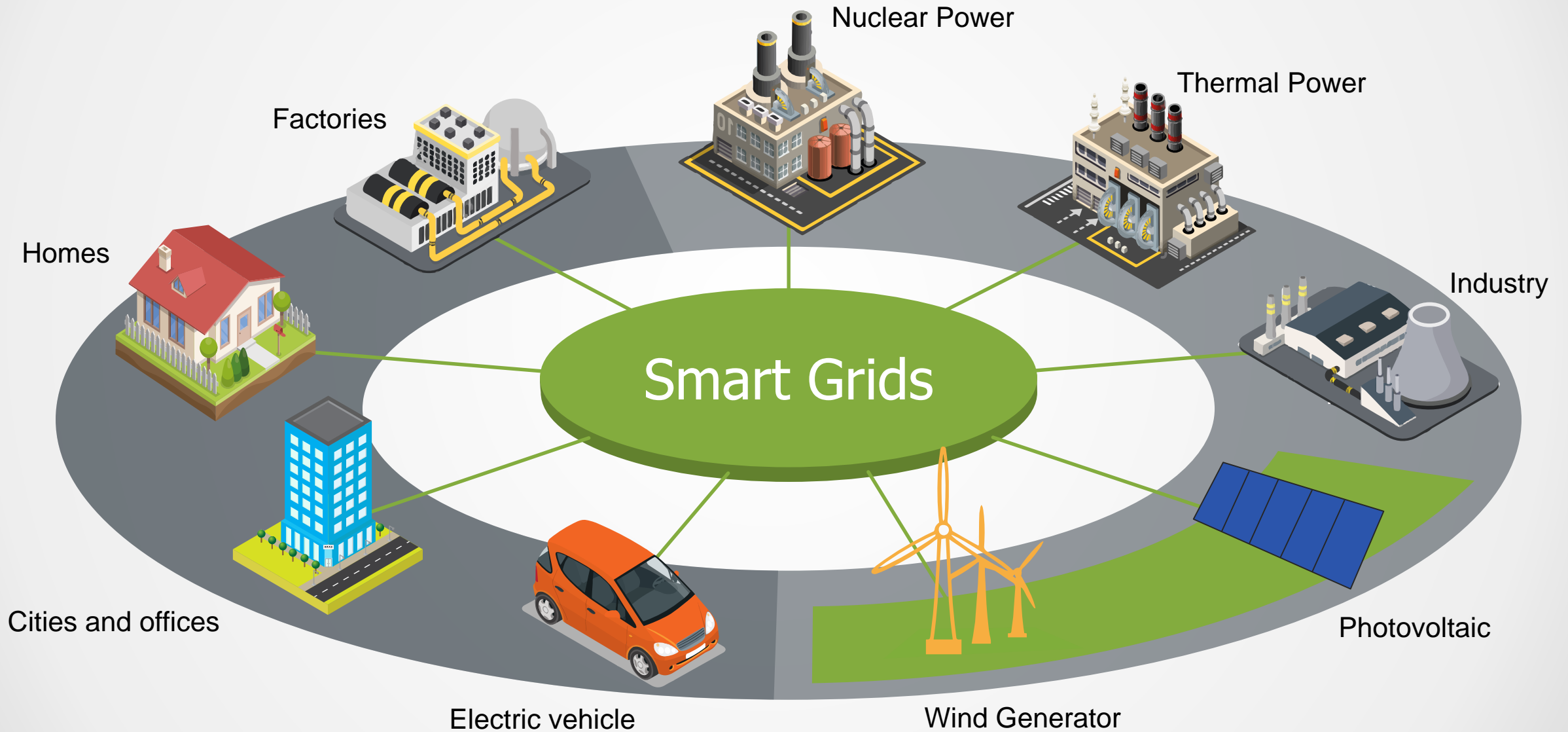


Kevin Suhanic
Executive Director of
Portfolio Strategy

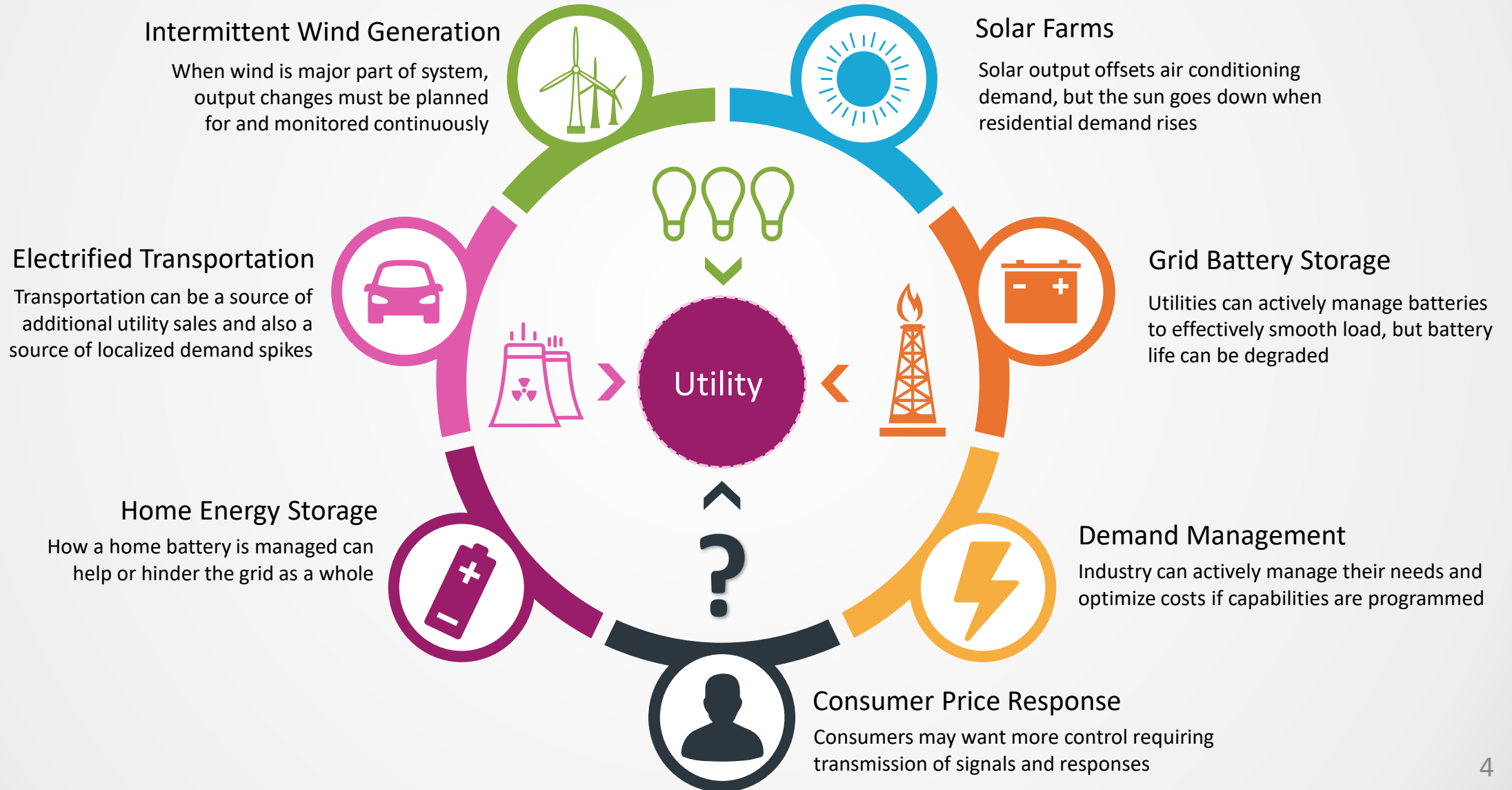
Traditional Grid Design



Future Grid Design



Future Grid Design



Future Grid Design

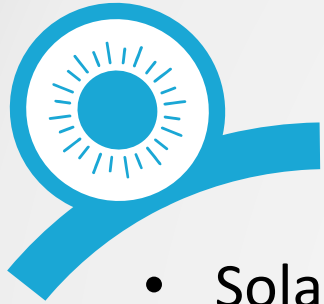


Intermittent Wind Generation

- Wind is an Abundant, Free Resource
 - Indiana and Illinois Have Great Combination of Wind Levels and Electric Transmission Infrastructure
- Not Dependable for a Given Hour
 - Spreading Development Over Larger Market Helps
- Forecasting is Key, Telemetering Good Data Critical
- Still Must Plan for Unexpected Drops
- Markets Also Plan For Over Generation and Wind Must Respond to Signals

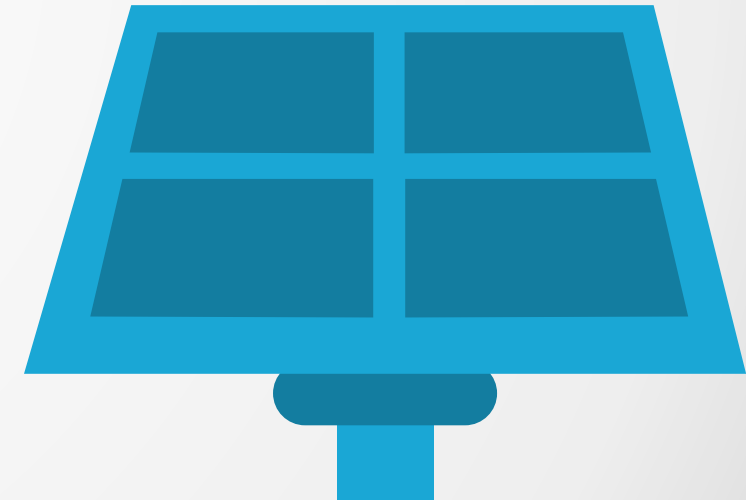


Future Grid Design



Solar Farms

- Solar Developments are The Hottest Projects Right Now
 - Mostly California and Desert Southwest
 - Utility Scale is Economic Now in Indiana and Illinois
- Rooftop Solar is not Far Behind
 - How do you Meter Customer With Rooftop Solar?
 - Rooftop Solar With Battery
 - Work Against Utility or For Utility
- Distribution Systems Built For Summer Peak
 - Do you need to Forecast Growth Differently?



Future Grid Design



Electric Vehicles

- Widespread Adoption Probably Still a Decade Away
 - Midwest Not Well Suited to Limited Range
 - Younger Demographics More Interested
- Increased Demand Helps Spread Utility Capital Costs
- Come Home From Work and Connect Charger
 - Not Ideal For Car Battery or Utility System
- Can the Car Battery be an Integrated Storage Resource
- What can iPhone Charging Schemes Teach Us?





Grid Battery Storage

- Technology Costs Decreasing
 - Much Like Solar, and Wind Before It
 - Li-Ion Now, Flow Batteries and Solid State in Future
- Critical Technology for High Renewable Adoption
- How to Optimize for Maximum Benefit
 - Immediate, Near, and Long-Term
 - What Algorithms Give us the Most Benefit
 - Industrial Process Control
 - Neural Networks and Machine Learning
 - New Approaches

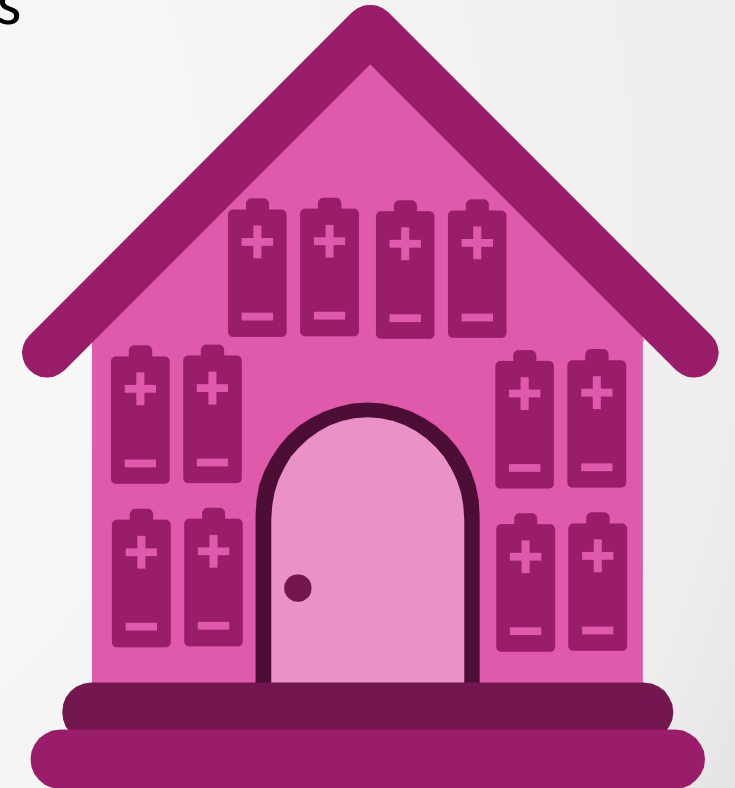


Future Grid Design

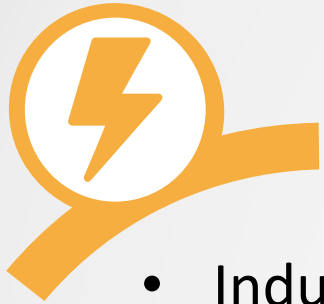


Home Energy Storage

- Tesla PowerWall, Others Included as Part of Solar Roofs
- Not Cost Competitive in Midwest
 - Grid Battery Costs Will Likely Come Down First
 - Some Folks Not Looking at Cost Only
- Suddenly a Predictable, Forecastable Load is Not So
 - How Does Homeowner Decide Best Plan
 - When to Charge
 - From Grid or Renewables?
 - Does the Utility Have a Role
- Micro Grid Could Mean Fewer Lines Needed



Future Grid Design



Demand Management

- Industrial and Commercial Customers Watch Energy Costs
- Typically Large Industrial Users Might be Offered a Demand Response Payment from Utility
 - Turn off High Energy Use Processed When Requested
 - Utility Tries to Predict, Usually Phone Call to User
- Current Products Hard to Match Payments to Savings
- Not Using Best Information Available
- Future Programs Would Control Breaker at Customer
 - Pay Based On Costs Avoided
 - Customer Could Set Different Breakpoints



Future Grid Design

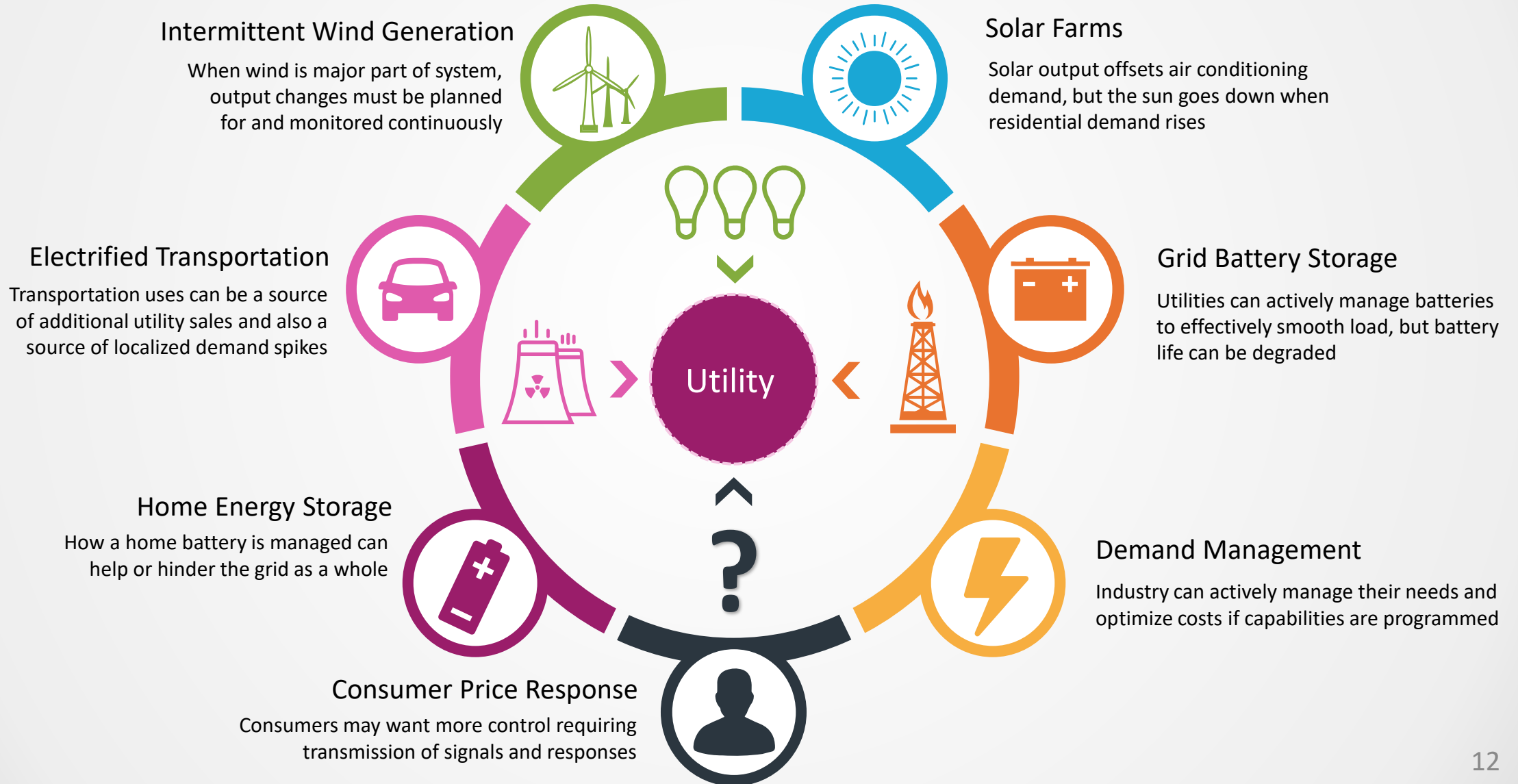


Consumer Response

- Much of These Changes “Push Down” Information
 - Real Time Pricing, Renewable/Battery Operation
- Benefit Realization Depends on User Behavior
 - Will You Wait to Charge Your Car if You Save Money
 - Will You Set Your Thermostat to a Wider Range for \$5?
- The Implementation Will Matter
 - Ease of Connectivity
 - Simplicity of Interaction
- The Smart Grid is Decentralized – But How Will Customers Use the Information?



Future Grid Design



Future Grid Design

The Challenges are Technical



- Implementing Systems That Allow Demand to be Variable
- Algorithms For Predicting and Responding to Changes in Renewable Output
- Communication Changes
 - Real Time
 - Bidirectional
 - Secure and Authenticated
- Models Must Change
 - Upgrading Equipment Not Only Option

The Challenges are Local