

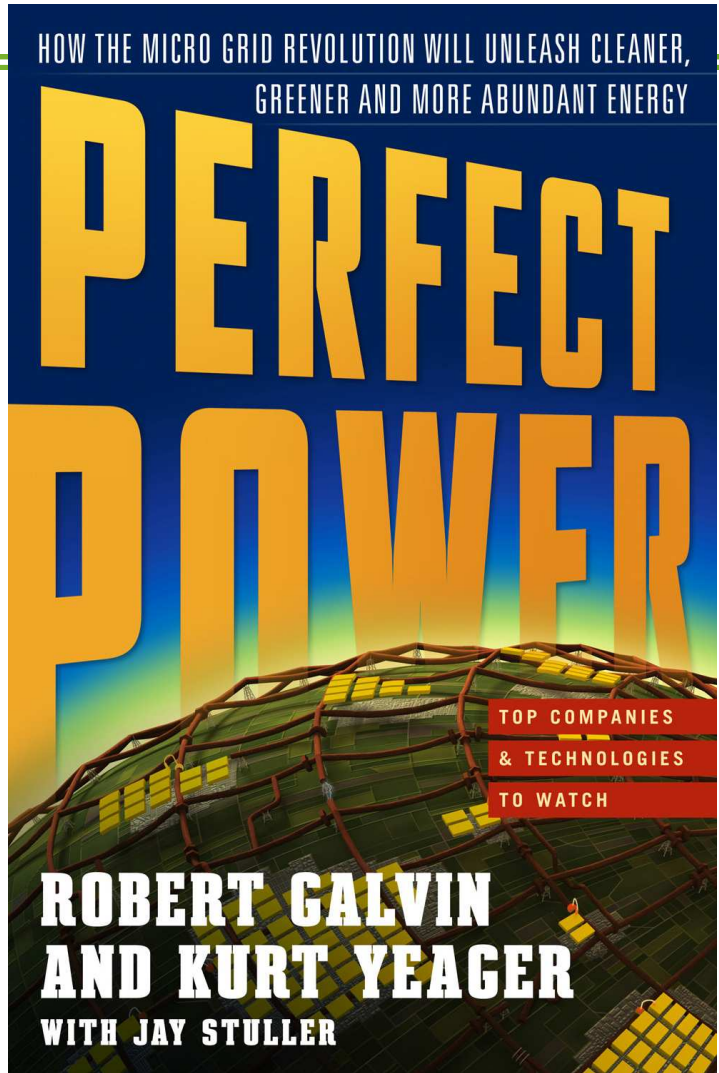


# **THE SMART MICROGRID REVOLUTION**

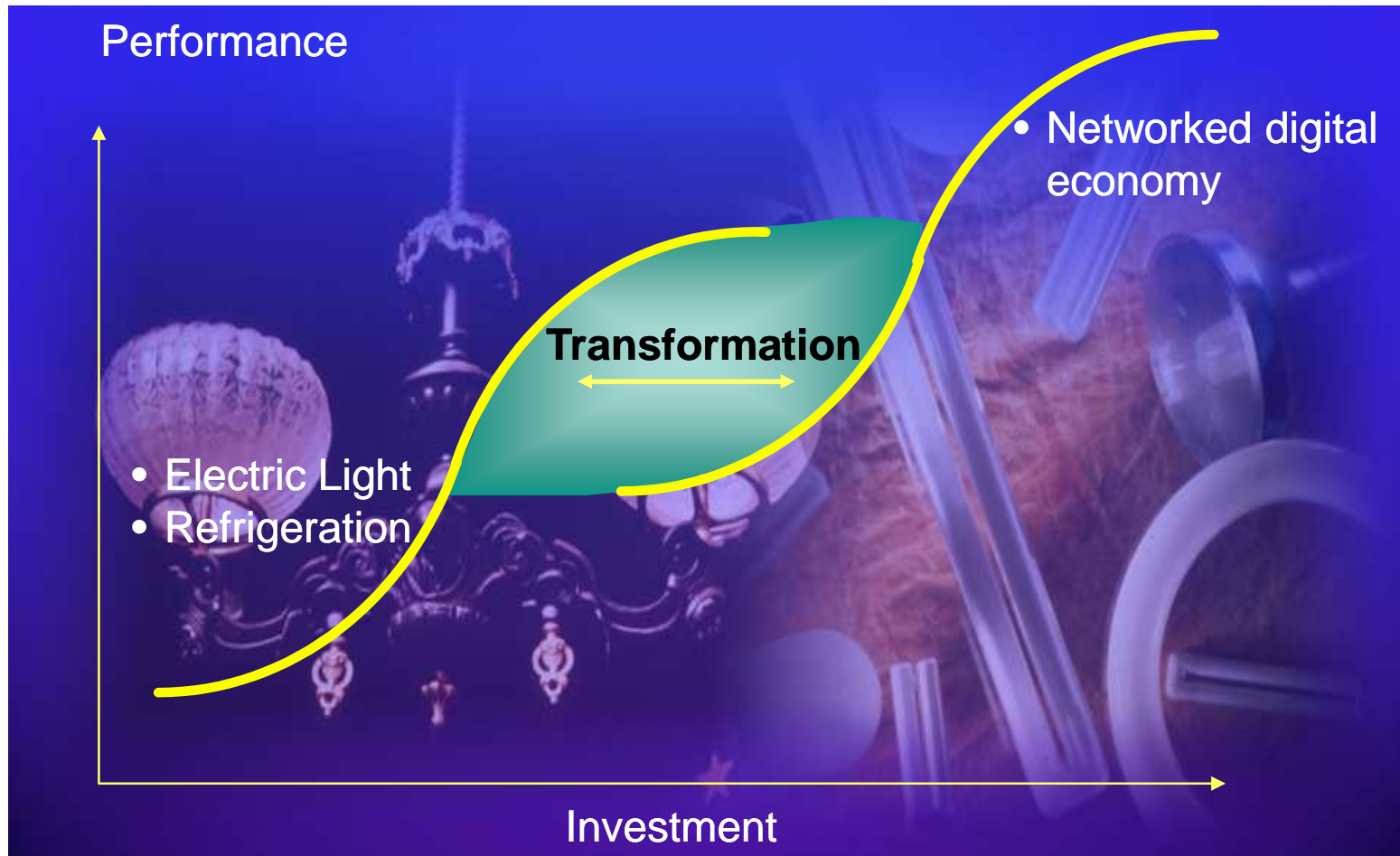
**Kurt Yeager**

**10/14/08**

**[www.galvinpower.org](http://www.galvinpower.org)**



# Breaking the Limits on Electricity Value



# The Power System That Evolved in Late 19<sup>th</sup> Century to Provide Power to the Newly Invented Light Bulbs .....



**1879 - Thomas Edison Developed a “Practical Light Bulb”**



**Line crew of Niagara Falls Power Co. in 1895**

# ..... has Remained Essentially the Same as it Powers the Essential Services and the Digital Revolution in the 21st Century



**August 29, 2005:** Power poles are pushed over in a flooded street after Hurricane Katrina

- Powers the critical pumps that takes water out from New Orleans and makes drinking water in a water treatment plant
- Powers the communication towers and central telephone stations that are essential for the communication infrastructure
- Powers the essential life saving services in a hospital
- Powers the continuous process industries that are the life blood of an industrial society
- Powers the computers, servers and routers that enable the digital revolution

# Challenges

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- **Demand Growth** — quality and quantity
- **Climate Change** — efficiency and renewables
- **Cost** — fuel and capital costs have doubled
- **Energy Security** — vulnerability and dependence

# Meet Sad Socket

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**You'd be sad, too, if you had to power digital-age businesses on 1950s technology**

# Value Lost to the U.S. Economy (\$ billion per year)

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- **Unreliability – 150**
- **Inefficiency – 100**
- **Productivity Penalty – 1,000+**

**Annual Cost to Correct – 25**

# Transforming the Electricity Grid for the 21<sup>st</sup> Century

**Electronically control the power system**

**Integrate electricity & communications**

**Transform meter into a two-way consumer services gateway**

**Incorporate Renewable & Distributed Resources**

**Reintroduce Direct Current (DC) Circuits/Microgrids**

**Enable smart, efficient end uses**



# Enabling Technologies

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**Power Electronics**

**Internet-Based Communications**

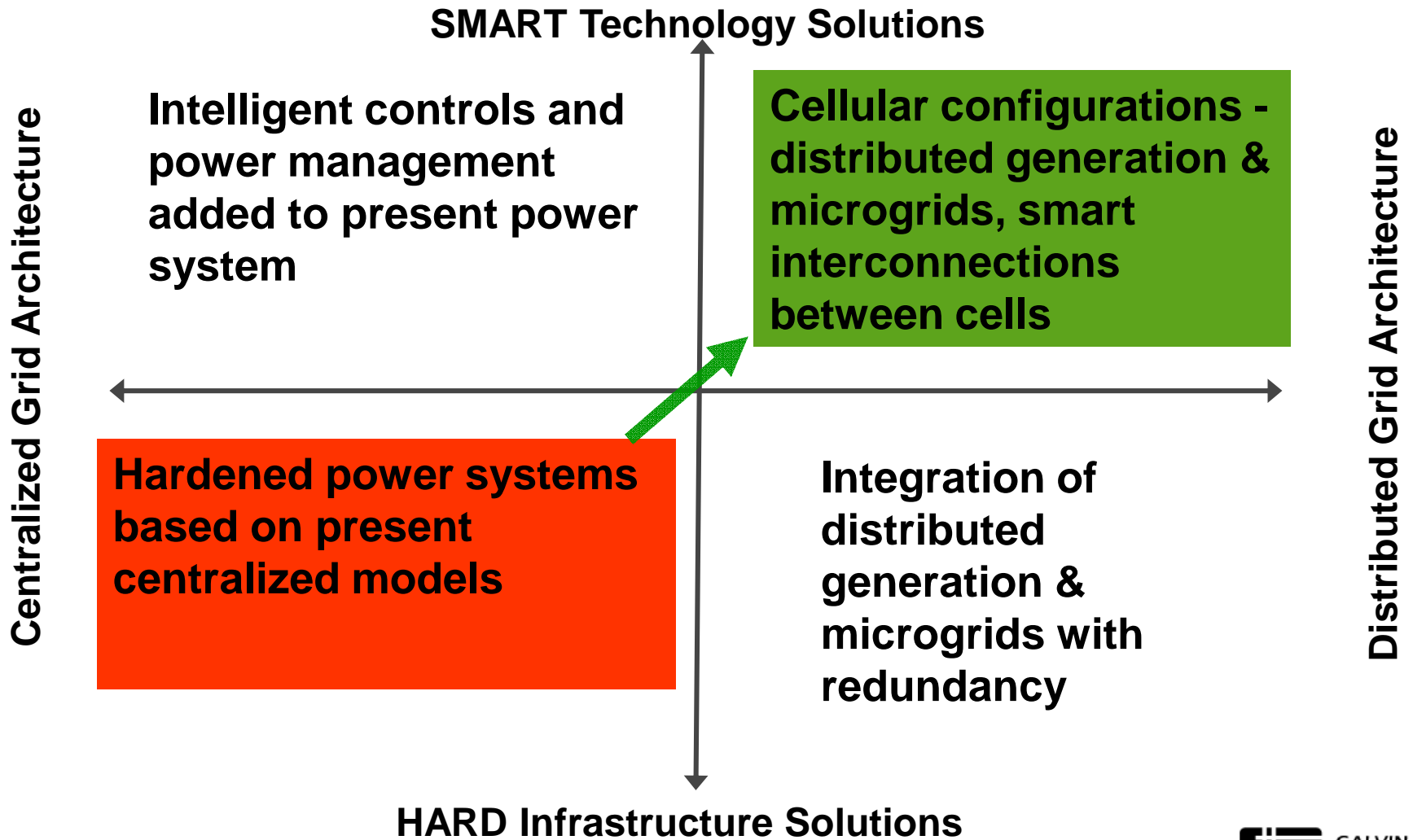
**Advanced Nanosensors**

**Wireless Power Distribution**

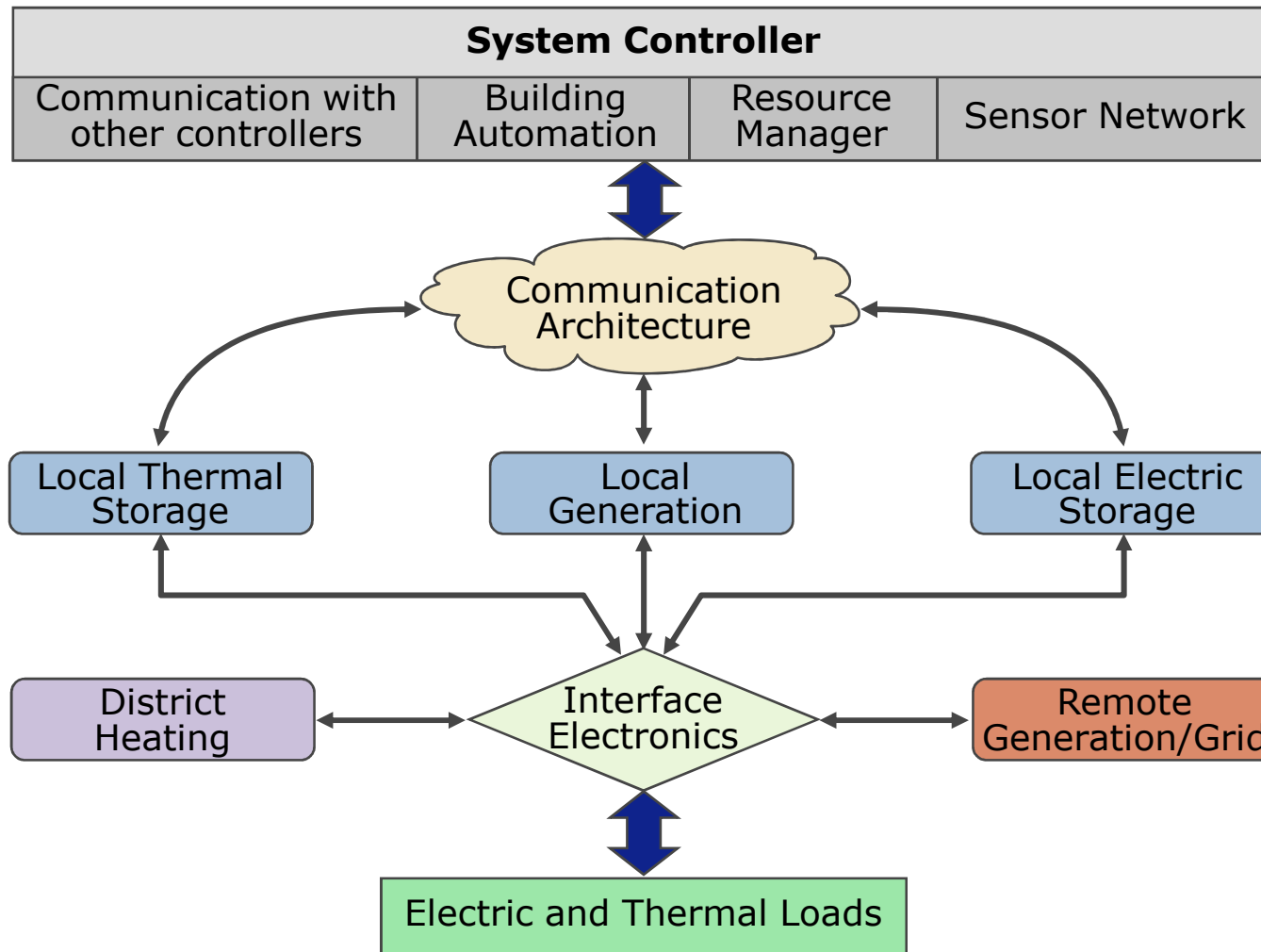
**Distributed Photovoltaics & Storage**

**Zero Energy Building Systems**

# Conceptual Framework for Alternatives



# Distributed Microgrid Power Systems



# Key Characteristics of Smart Microgrids

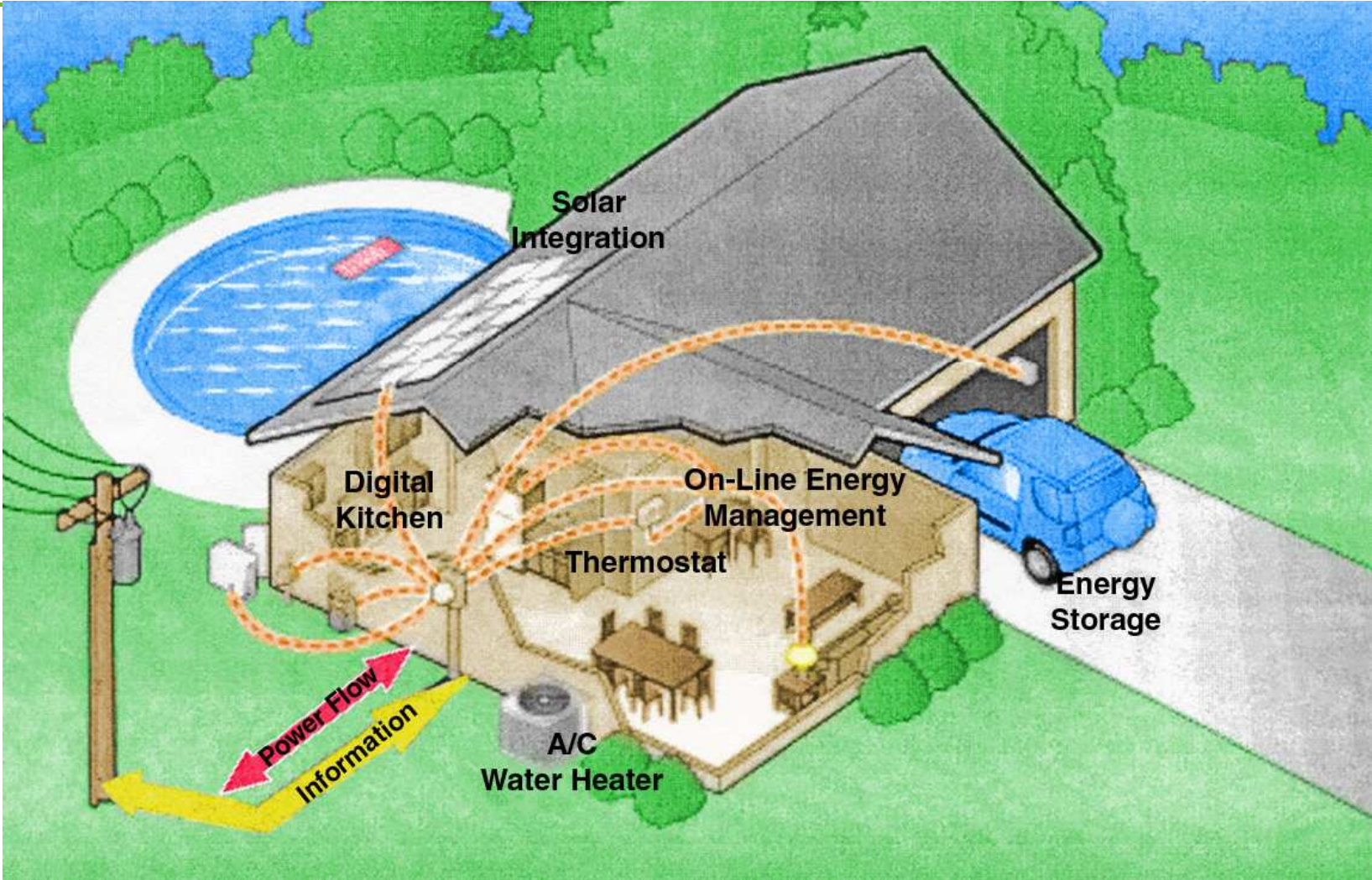
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- Self-healing.** Grid Rapidly Detect, Analyze, Respond and Restore.
- Empowers and Incorporates the Consumer.** Ability to Incorporate Consumer Equipment and Behavior in Grid Design and Operation.
- Tolerant of Attack.** Grid Mitigates and Resilient to Physical and Cyber Attacks.
- Provides Power Quality Needed by 21<sup>st</sup> Century Users.** Grid Provides Quality Power Consistent with Consumer and Industry Needs.
- Accommodates Wide Variety of Supply and Demand.** Grid Accommodates Variety of Resources (Including DR, CHP, Wind, PV).
- Fully Enables Maturing Electricity Markets.** Allows for and is Supported by Competitive Markets.

# The Grid Transformation Result

<b><u>20<sup>th</sup> Century</u></b>	<b><u>21<sup>st</sup> Century</u></b>
<b>Analog/Electromechanical</b>	<b>Digital</b>
<b>Totally Centralized</b>	<b>Accommodate Decentralized</b>
<b>Radial Topology</b>	<b>Network Topology</b>
<b>Manual Restoration</b>	<b>Self-Healing</b>
<b>Average Priced</b>	<b>Real-Time Priced</b>
<b>Commodity-Based</b>	<b>Service-Based</b>
<b>No Consumer Choice</b>	<b>Many Consumer Choices</b>

# Microgrid System Integration at the Consumer Level



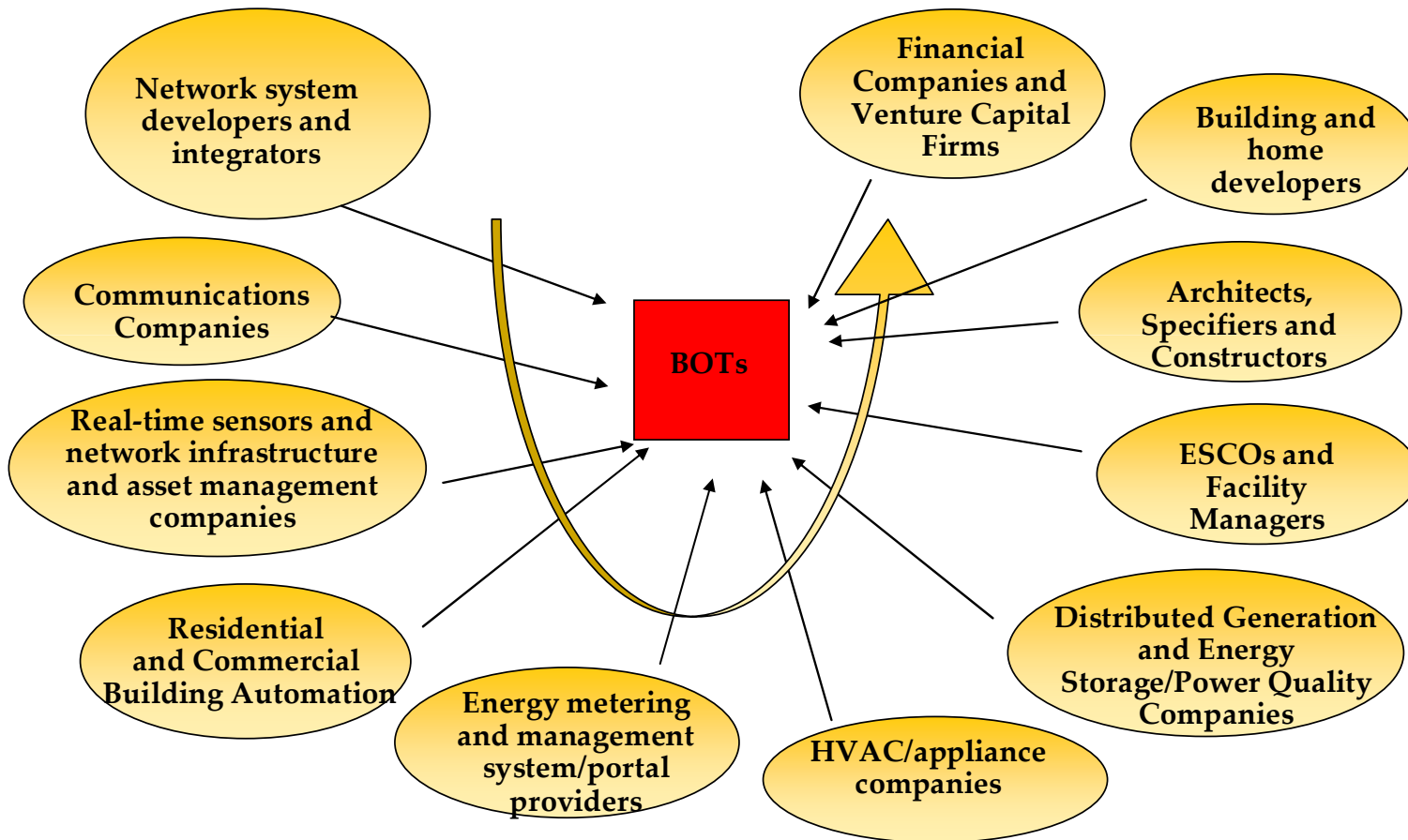
# Smart Microgrid Costs per Residential Rate Payer

<u>Technology</u>	<u>Installed Cost</u>
<b>1. Integrated Communications</b>	<b>\$40</b>
<b>2. Automatic Sensing &amp; Measurement</b>	<b>\$30</b>
<b>3. Distribution Automation</b>	<b>\$120</b>
<b>4. Substation Automation</b>	<b>\$200</b>
<b>5. Circuit Loops &amp; Smart Switches</b>	<b>\$500</b>
<b>6. Distributed Energy &amp; Storage</b>	<b>\$500</b>
<b>7. Smart Consumer Portal Meters</b>	<b><u>\$200</u></b>
<b>Approximate Total</b>	<b>\$1,600</b>
<b>ANNUALIZED CAPITAL COST (10 YRS)</b>	<b>\$200/Yr.</b>
<b>ANNUAL O&amp;M COST</b>	<b>\$25</b>

# Benefits Per Residential Rate Payer

<u>Category</u>	<u>Net Present Value/Yr.</u>
<b>1. Improved Reliability</b>	<b>\$250</b>
<b>2. Electricity Consumption Savings</b>	<b>\$100 +</b>
<b>3. Time of Use Savings, Shifting Peak Demand</b>	<b>\$75 +</b>
<b>4. Avoided Capacity Costs</b>	<b>\$120</b>
<b>5. Job Creation &amp; Increased Income</b>	<b>\$300 +</b>
<b>6. Reduced Power Distribution &amp; Competition Losses</b>	<b>\$25</b>
<b>Approximate Total</b>	<b>\$870 +/Yr.</b>
<b>Longer Term Potential</b>	
• <b>Households Become Electricity Suppliers</b>	<b>1,000 +</b>
• <b>CO<sub>2</sub> Emissions Reduction (15¢ / kWh)</b>	<b>300 +</b>
• <b>Energy &amp; Homeland Security</b>	<b>priceless</b>

## Many new Entrants and Type of Players



# Constraints to Transformation

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- **Lack of Consumer Knowledge**
- **Obsolete Cost/Benefit Accounting rules**
- **Dysfunctional Building Design & Construction Processes**
- **Utility and Regulatory Resistance**
- **New Entrant Barriers – Discriminatory Rules & Tariffs**

**CONCLUSION – These constraints will be overcome by cost and quality pressures.**

# Public Buy-in Checklist

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- **Demonstrate real savings & benefits**
- **Emphasize choice & opportunity**
- **Keep it simple & consistent**
- **“Fly the green flag”**

# Principles of a New Electricity Constitution

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- **Compensate Utilities Based on their Reliability, Efficiency and Customer Service Quality**
- **Enable Municipalities to Access & Invest in Their Electricity Distribution Infrastructure**
- **Eliminate Utility Restrictions on Smart Microgrids**
- **Provide all Consumers with Time-of-Use Electricity Rates & Incentives**
- **Require Fundamentally Higher Distribution Reliability Standards**
- **Establish Truly Competitive Retail Electricity Service Markets**

# GOAL

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“The perfect power system will ensure absolute and universal availability of energy in the quantity and quality necessary to meet every consumer’s needs. It is a system that never fails the consumer.”

Bob Galvin  
2005

