Energy Management by Distributed Sociotechnical Systems

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VISION:

What is the "Sustainable Energy Pathway" that embraces the overarching theme of sustainability, and integrates scientific knowledge & technological innovation, as well as environmental, societal, & economic aspects, into the proposed activities to explore the vision?

- The fundamental question to be addressed:
  - Is there a benefit to a socio-technical energy system in terms of costs and/or environmental impact?
  - Can people be an enabler of a socio-technical energy system? or
  - Will they just walk away?

- To construct these systems and answer these questions requires a **Science of Sustainability.**

Integrates the three E's of Sustainability, Environmental, Economic, and Equity/social justice with Energy

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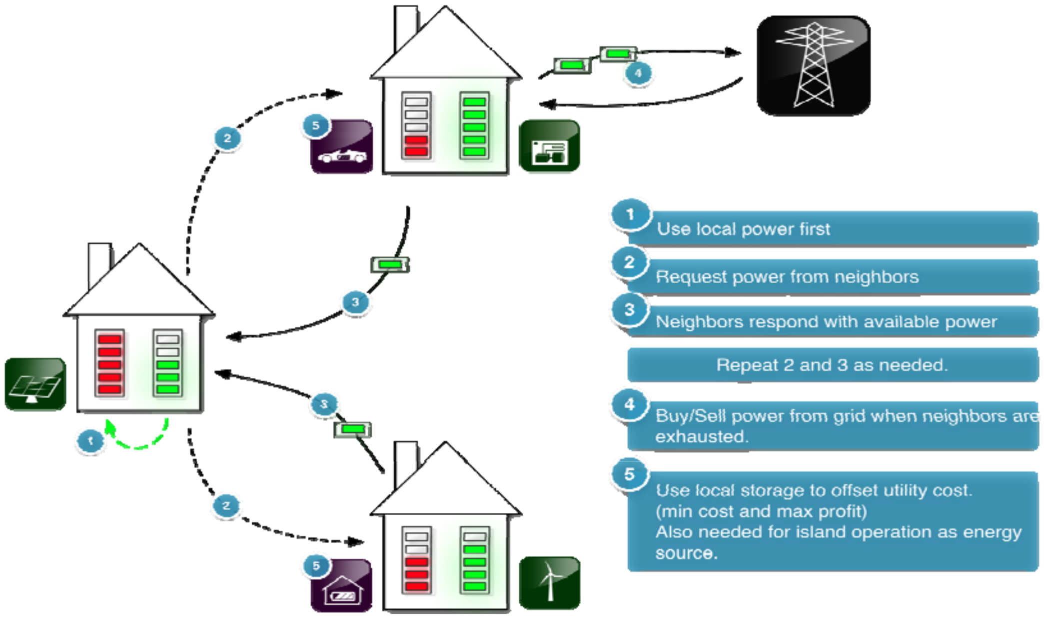
Scientific Basis

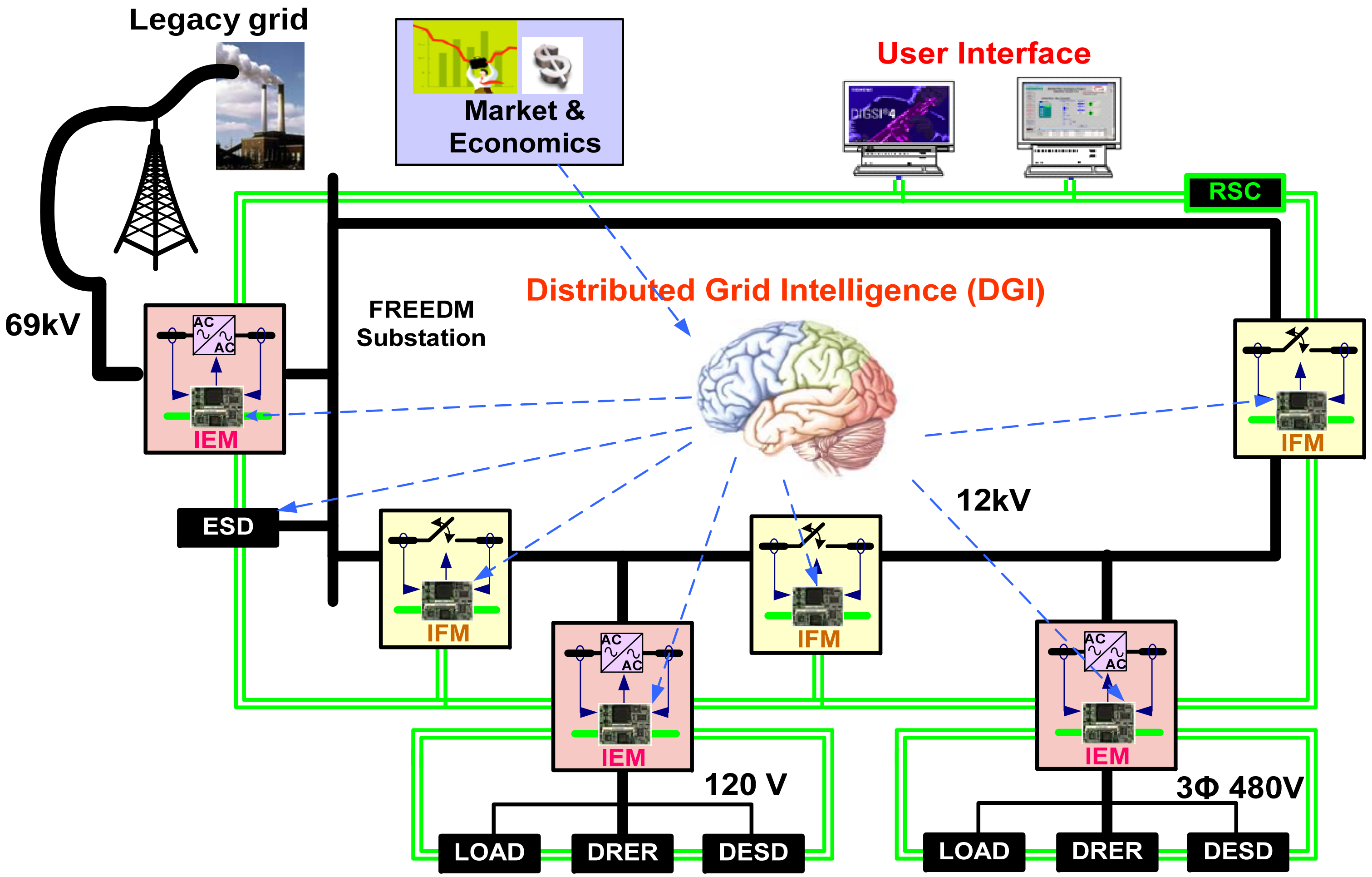
- Science
  - o Fundamentals of information sharing,
  - o Smart grid technology and economics,
  - o Human-centered environmental control, and
  - o Consumer acceptance.



Human factors	Microclimate Control	Macroclimate
Clothing	Thermal quality	Max. Power generation
Activity	Lighting quality	Energy storage
Individual preference	Air quality (Ventilation)	Energy export strategy
Occupancy		Power Gen. prediction
Behaviors		

Cyber-Physical System

FREEDM – Future Renewable Electric Energy Delivery and Management



IEM: Intelligent Energy Management **IFM**: Intelligent Fault Management

DRER: Distributed Renewable Energy Resource **DESD**: Distributed Energy Storage Device

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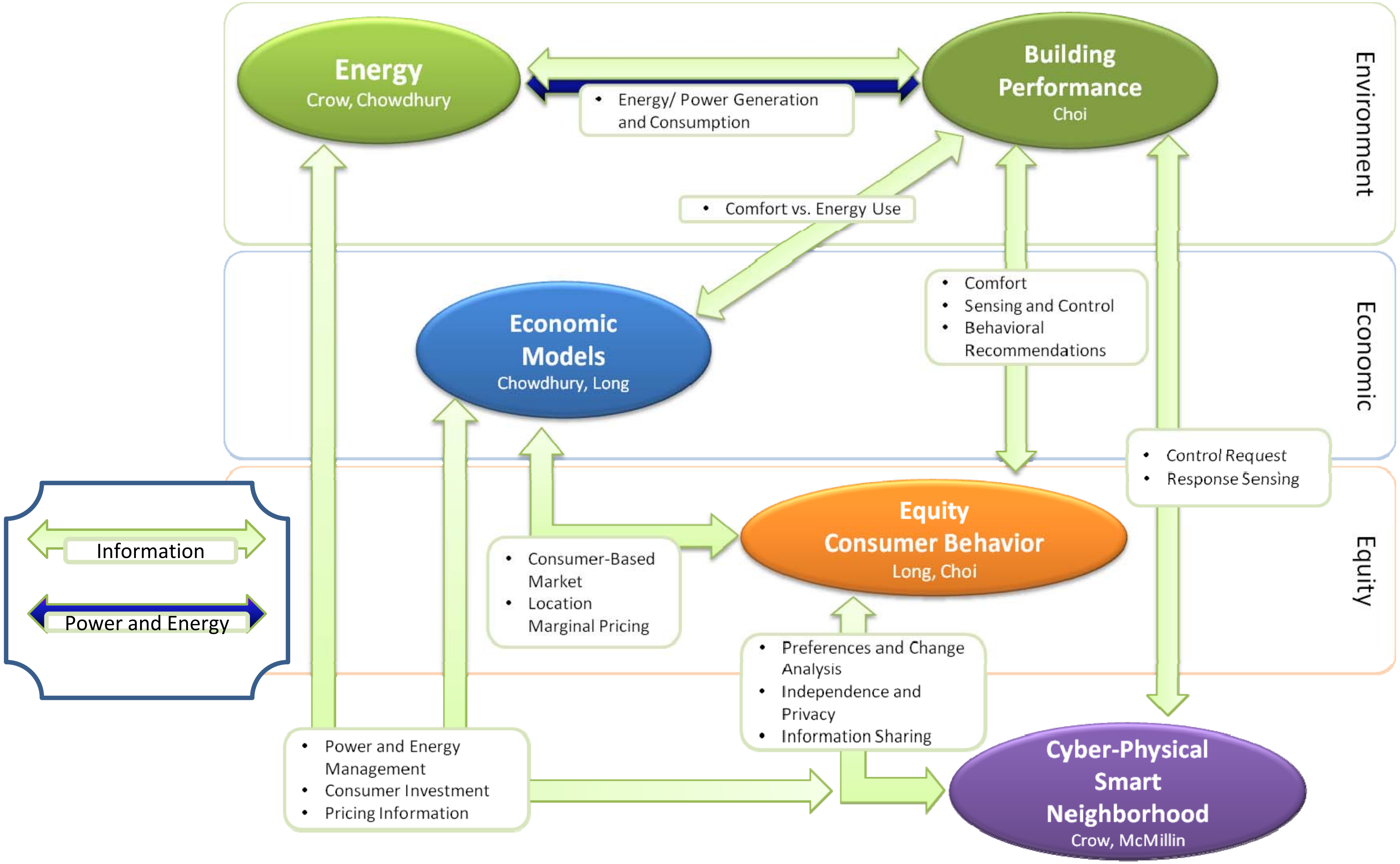
Schematic of "Sustainable Energy Pathway"

The Smart Grid Sociotechnical Neighborhood Information Flow Ontology



Equity/Consumer Behavior interfaced with Building Performance

	Item	Semantics	Format
Need	Sensing	❖ Semantics of Usage	• Equation based comfort level • Satisfaction
		❖ Aesthetics	•Indirect Feedback
	Behavioral Recommendations	❖ Semantics	•User Interface
Provide	Control	❖ Comfort Request	• Heating •Cooling l •Lighting •Natural ventilation
		❖ Active vs. Passive	•User Interface •Control Messages
	Occupancy	❖Detection and Prediction	

Equity/Consumer Behavior with economic models

	Item	Semantics	Format
Need	Costs	❖ From Utility	•From Utility
	Levelized models	❖ Fixed Cost	•Design
		❖ Fixed Comfort	•Design
	Demand Elasticity	❖ Quantity and time of day	
	Price Elasticity	❖ $ and time of day	
Provid	Policy Influence	❖ Global	
		❖ Local (individual)	

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Equity/Consumer Behavior interface with cyber-physical smart neighborhood

	Item	Semantics	Format
Need	Information sharing about the community	❖Semantics of Usage	❖Usage patterns observed/ communicated
Provide	Preference and change analysis	❖Semantics of Opinions	❖Messages, Questionnaires
	Independence and privacy	❖Semantics of Information	❖Observations
	Various levels of interactions	❖Semantics of Communication	❖Conversations ❖Cyber Information Share

Economic Model interface with cyber-physical smart neighborhood

Need	Pricing	❖D-LMP Models ❖Utility Prices	❖Digital Communication
Provide	Market Rules	❖Constraints	❖Logical Rules
	Privacy	❖Semantics of Information	❖Observations

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BUILDING PERFORMANCE WITH CYBER-PHYSICAL SMART NEIGHBORHOOD

Need	Sensing Input	❖Real Time Behavior ❖Local Climate	❖Temperature, Humidity, Light, Wind readings
Provi	Control	❖Operations	❖Ventilation Commands

Building Performance with energy

Need	Generation	❖Power Flow	• Watt-hours
Provide	Consumption	❖ Power Flow	• Watt-hours

Integration:

What is the synergistic, systems approach by which the team will address the science and engineering challenges?

- Define a **system model** that includes semantic inter-relationships (an ontology)of an energy neighborhood and quantify building occupant behavior and motivation as an energy consumer
- Develop **information flow models** to unify various facets and stakeholders
- Assess **privacy, information sharing, economics, building performance, and consumer behavior** to determine potential energy efficiencies
- Define metrics for success

Collaboration:

What is the management plan for the multi-disciplinary team to accomplish the research and education plans?

- Fundamentally different **technical and management approach**
- **Formal models of information flow** are the “glue” that tie together the disparate actors within the system and will formally indicate the effectiveness and limitations of the sociotechnical system.
- Team members **provide and integrate individual sciences** within the information flow model.

Intellectual Merit:

What unique, creative and transformative concepts will be pursued? How important are the proposed activities to advance the state-of-the art?

- Scientific integration of technological, economic, and social actors into a sociotechnical community.
- Common semantic basis for study
- Science of Energy Sustainability

Broader Impact :

How well does the activity advance discovery and understanding while promoting, teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups at all levels (faculty, students and postdoctoral researchers)?

Key to NSF's vision is addressing the enablers and stressors of sustainable energy.

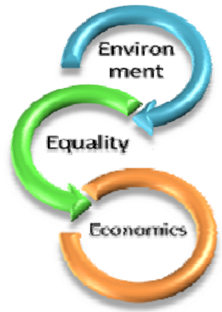
Enablers

1. Perceived critical need
2. Distributed cyber management/smart house technology,
3. Engagement models

Risks and Stressors

1. Lack of resilience of sociotechnical systems,
2. Loss of personal control
3. Lack of consumers' understanding of economics of green energy systems and behavioral contribution to sustainability.

Societal Nexus of Sustainable Energy



Workforce Development

- Integrate: social science to engineering and computer science.
- Perspective: The faculty and student participants in this project will gain a unique perspective on the societal nexus of sustainable energy.
- Dissemination: of this perspective is key through novel coursework (cross disciplinary), graduate certificate programs, and validation.
- Participation and Outreach: Validation through the S&T solar village and the FREEDM ERC systems will be used for societal outreach to the general public
- Provide informed decision making to policy makers
- Social Justice
- Societal Need: Model to increase STEM participation – social justice, making society a better place to live.

FREEDM systems center

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