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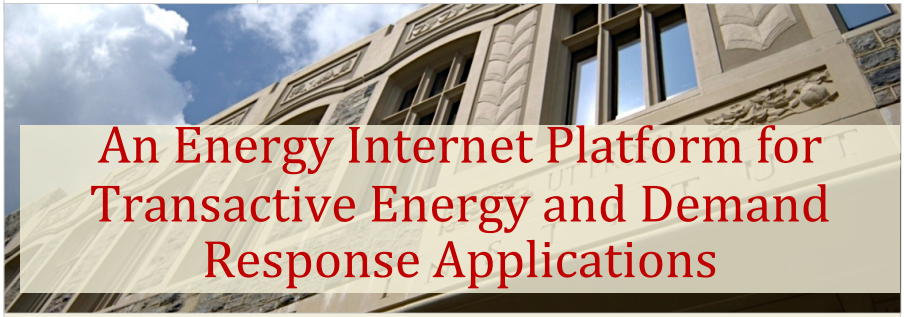

An Energy Internet Platform for Transactive Energy and Demand Response Applications

Keynote Speech

Professor Saifur Rahman
Director, Virginia Tech Advanced Research Inst., USA
President, IEEE Power & Energy Society

IEEE EI2 Conf., Changsha, China, 09 November 2019

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Dr. Rahman with ARI students @ IEEE-ISGT 2014
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An Energy Internet Platform for Transactive Energy and Demand Response Applications
Keynote Speech
Professor Saifur Rahman
IEEE EIz Conf., Changsha, China, 09 November 2019
Innovations in Power & Energy Society
Smart Grid for Integration of Renewables
Invited Talk
Saifur Rahman, PhD
President, IEEE Power & Energy Society
Professor, ECE Department, Virginia Tech
PES Distinguished Lecture, Honolulu, Hawaii, 25 October 2019
IEEE
Keynote Speech
The Smart City Building Blocks and Their Synergy with Smart Villages
Saifur Rahman
IEEE Smart City Conference
Casablanca, Morocco, 19 October 2019
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Helping to Make Smarter Cities a Reality
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AN OPEN-ARCHITECTURE PLATFORM FOR IOT SENSOR INTEGRATION IN SMART BUILDINGS
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Keynote Speech
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The Building Blocks
Saifur Rahman
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What is the Energy Internet ?

The Internet allows information to flow to anyone from anywhere.

The Energy Internet is a vast network that will allow efficient distribution of electricity to anyone and from anywhere.

EI will utilize smart sensors, ICT technologies and algorithms to facilitate power supply in real-time, enhance storage applications, and integrate renewable energy into the grid.

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Mission of the Energy Internet

Energy Internet is an online marketplace that transacts in energy (One-to-One, One-to-Many and Many-to-One)

O-to-O: Between individual users for bilateral transactions
O-to-M: One electric utility sells to Many customers
M-to-O: Many customers sell to One electric utility

淘宝网 Taobao.com

amazon

But in the Energy Internet:

All transactions must be done in real-time
All network constraints must be met

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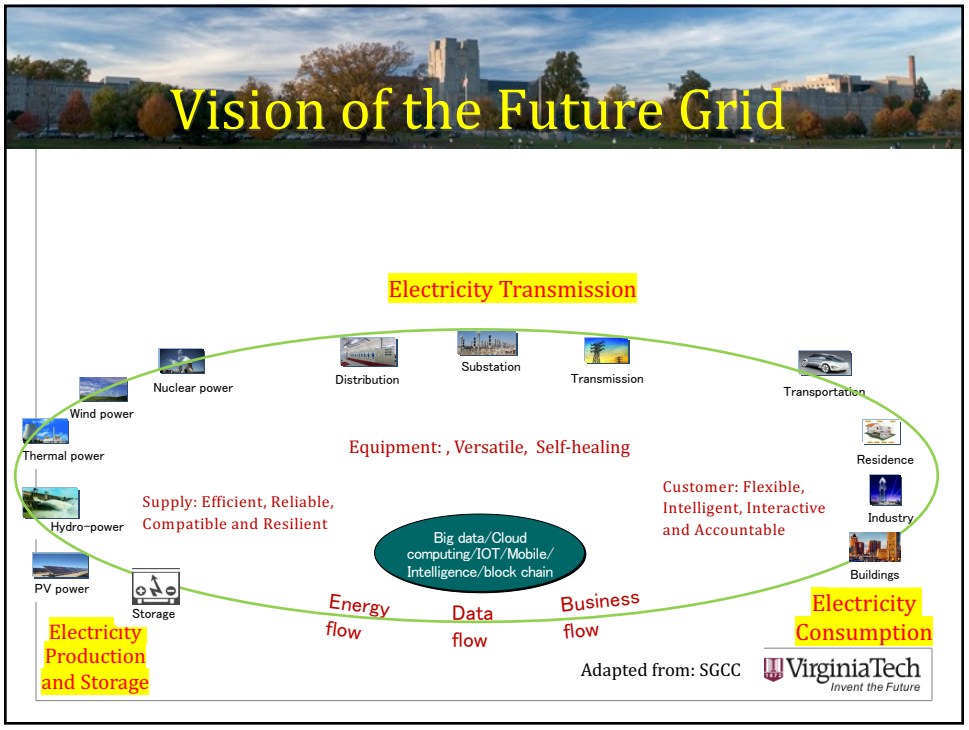
Vision of the Future Grid
Electricity Transmission
Nuclear power
Distribution
Substation
Transmission
Transportation
Wind power
Thermal power
Equipment: , Versatile, Self-healing
Residence
Hydro-power
Supply: Efficient, Reliable, Compatible and Resilient
Customer: Flexible, Intelligent, Interactive and Accountable
Industry
Big data/Cloud computing/IOT/Mobile/ Intelligence/block chain
PV power
Buildings
Storage
Energy flow
Data flow
Business flow
Electricity Consumption
Electricity Production and Storage
Adapted from: SGCC
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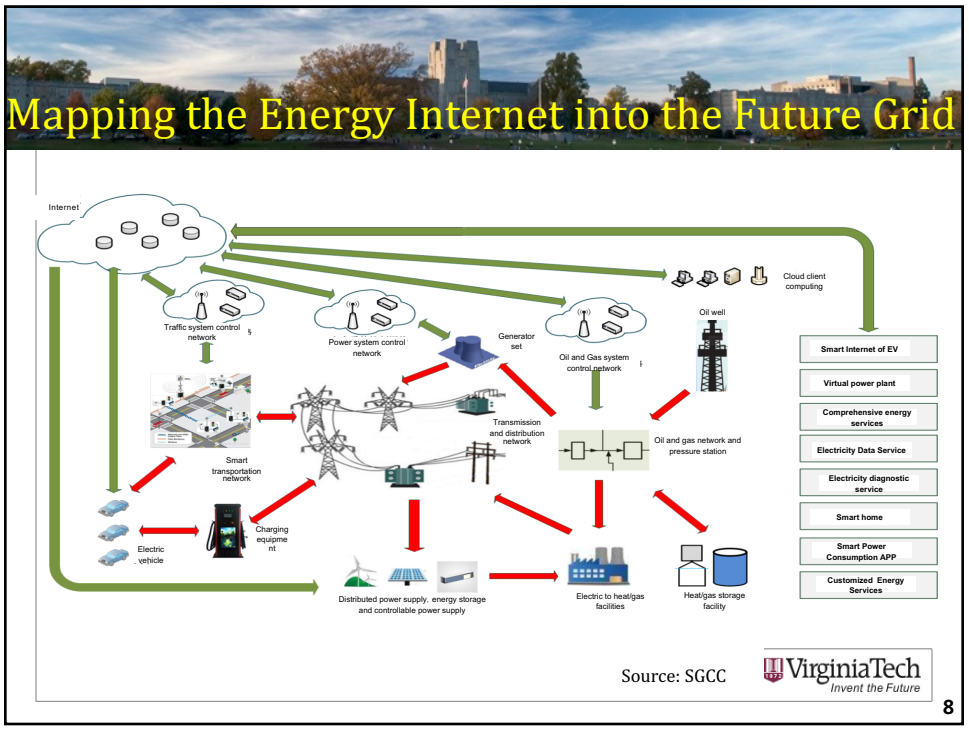
Mapping the Energy Internet into the Future Grid
Internet
Cloud client computing
Traffic system control network
Power system control network
Generator set
Oil and Gas system control network
Oil well
Smart transportation network
Transmission and distribution network
Oil and gas network and pressure station
Smart Internet of EV
Virtual power plant
Comprehensive energy services
Electricity Data Service
Electricity diagnostic service
Smart home
Smart Power Consumption APP
Customized Energy Services
Charging equipment
Electric vehicle
Distributed power supply, energy storage and controllable power supply
Electric to heat/gas facilities
Heat/gas storage facility
Source: SGCC
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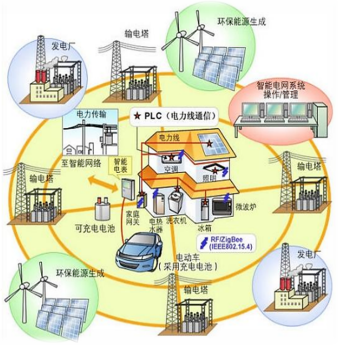
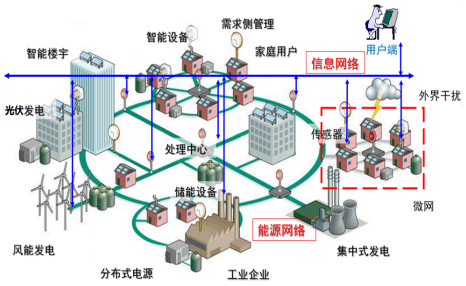
Energy Transaction in a Future Power System



Future power system



Future power system integrated with modern information technology

Source: SGCC

9

Future Power System: Pathway to Energy Internet

22

Source: SGCC

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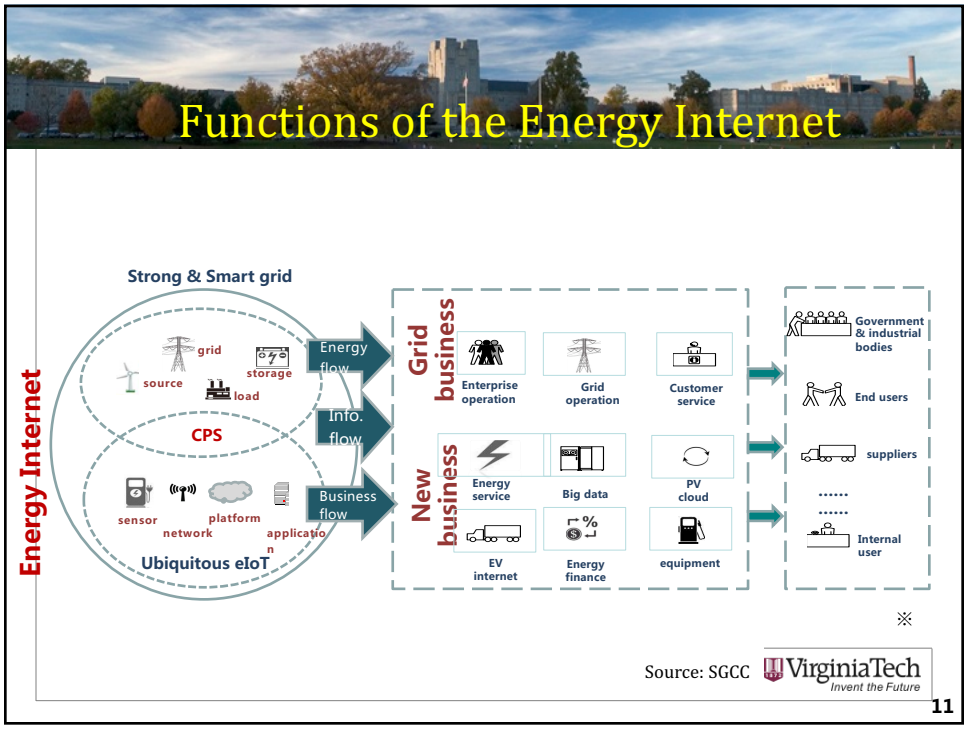
Functions of the Energy Internet
Energy Internet
Strong & Smart grid
grid
storage
source
load
CPS
sensor
platform
network
application
Ubiquitous eIoT
Energy flow
Info. flow
Business flow
Grid business
Enterprise operation
Grid operation
Customer service
New business
Energy service
Big data
PV cloud
EV internet
Energy finance
equipment
Government & industrial bodies
End users
suppliers
Internal user
※
Source: SGCC
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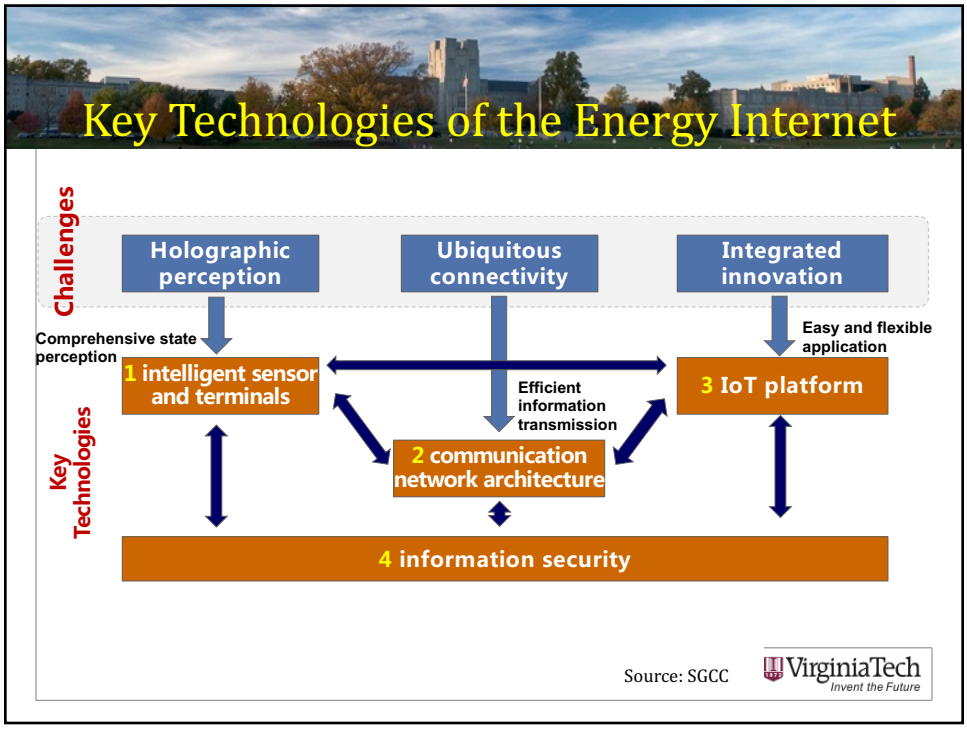
Key Technologies of the Energy Internet
Challenges
Holographic perception
Ubiquitous connectivity
Integrated innovation
Comprehensive state perception
Easy and flexible application
1 intelligent sensor and terminals
Efficient information transmission
3 IoT platform
2 communication network architecture
4 information security
Source: SGCC
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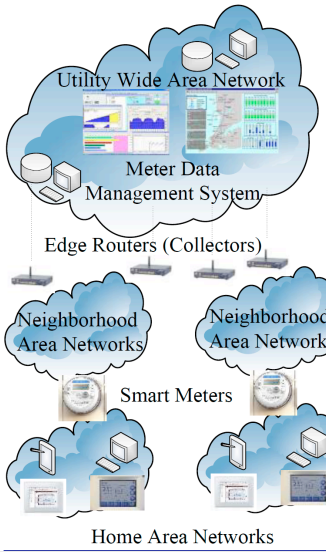
The ICT Framework



13 Source: P. Siano

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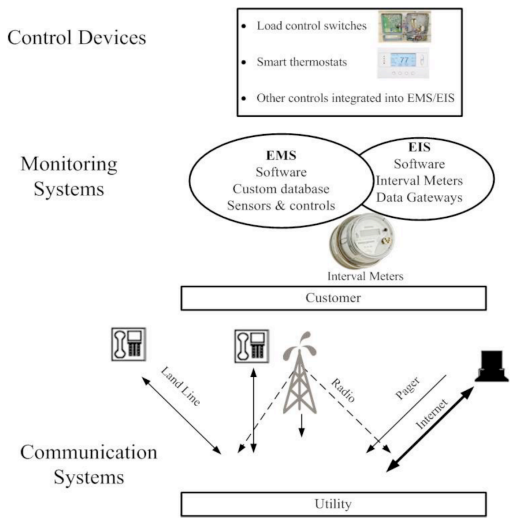
Field Implementation



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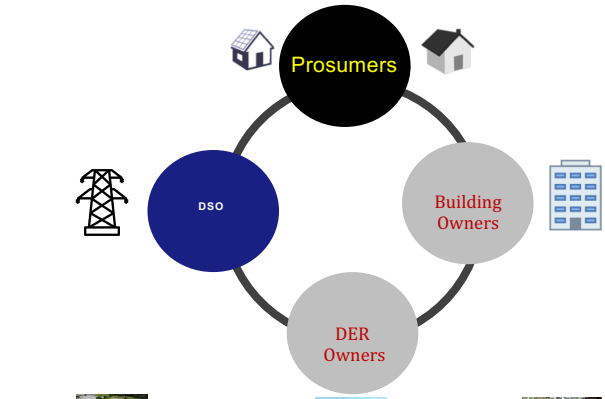
Participants




Community battery storage


Distribution-scale solar PV


Energy stored in EVs

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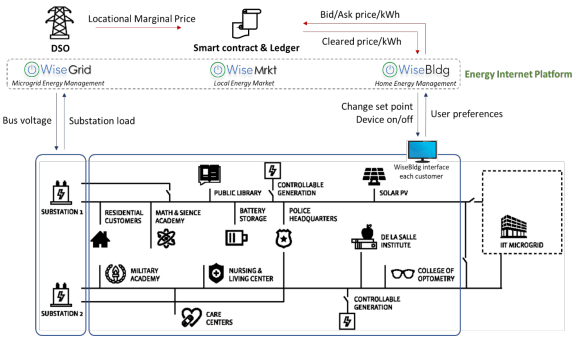
Transactive Energy in a Microgrid

Focus: Top develop & pilot an Energy Internet platform that provides higher efficiency, cost reduction, and energy insights for both utilities and end-customers by leveraging

1) Existing IoT/smart devices in homes
2) Blockchain/distributed ledger/related technology to execute smart contracts and maintain records of all transactions



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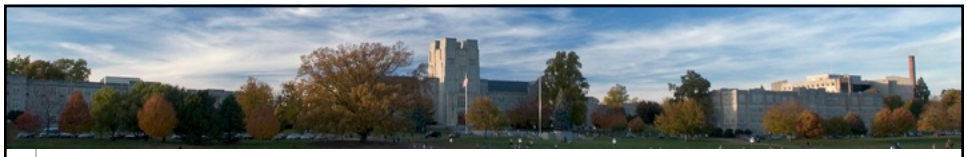

Demand Response
An Element of the Energy Internet

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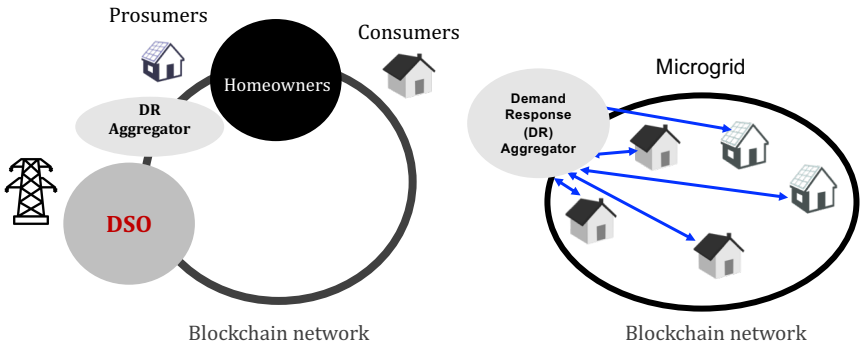
Energy Transaction and Demand Response



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Demand Response

The aim of Demand Response (DR) is to make the load an active participant in balancing electricity supply and demand around the clock via side-by-side competition with supply-side resources.

DR allows loads curtailment in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is at risk (using direct control by the utility or ancillary services markets).

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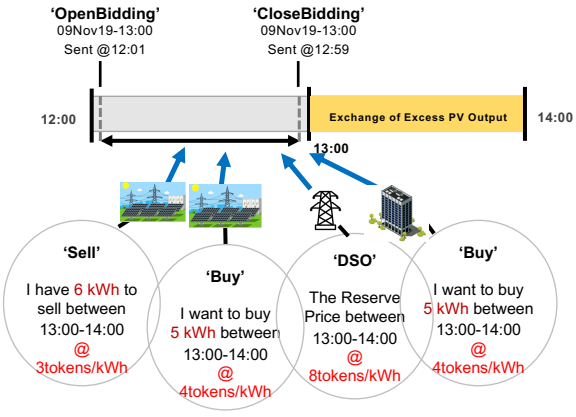
Basic Transactive Energy Process



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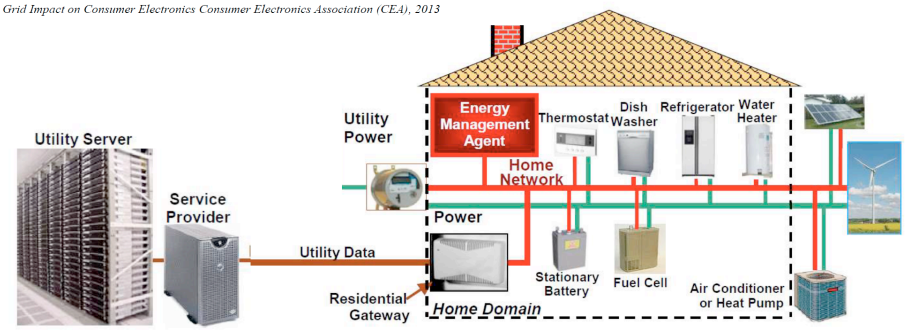
Home Energy Management System

These signals enter the house through a **Home Gateway**.

Smart Grid Impact on Consumer Electronics Consumer Electronics Association (CEA), 2013



Distributed Load Control with an Energy Management System (via Utility or Aggregators)

21 Source: P. Siano

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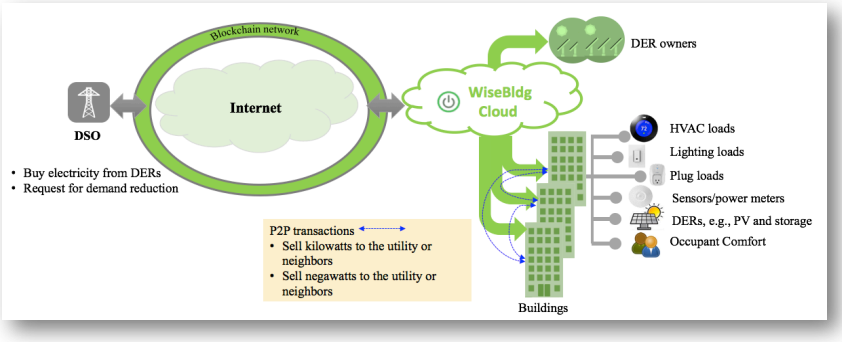
Building Automation Platform



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Small Scale Realization of EI

WiseBldg / WiseGrid

PV Trading | DR Trading | Data Analytics

WiseMrkt

- ★ Control/user interface
- ★ Intelligent control mechanisms
- ★ Energy insights
- ★ Historical data
- ★ Current status
- ★ Locational data
- ★ Immutable data

Source: www.bemcontrols.com

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Energy Internet Value Proposition

WiseBldg + WiseMrkt + WiseGrid = **The Energy Internet**

Building Energy Management

- **Commercial Open Architecture** Software Platform
- **Monitor and Control** energy systems (HVAC, lighting, plug loads)
- **Extendible to solar PV** systems in micro-grid environments.
- **Help buildings participate** in Demand Response programs through OpenADR

Local Energy Market

- **Immutable, secure record** of P2P and Negawatt trading transactions
- **Proprietary bidding algorithms** to maximize participants' utility from trading
- **Automated transactions** governed by smart contracts executed in near real-time (1 hour ahead)

Microgrid Energy Management

- **Monitor and Control** energy resources in Microgrid (battery storage, PVs, other DERs)
- **Create programs and involve customers** in the energy consumption, generation, and management process
- **Demand Response**
- **Data analytics & energy insights** applicable to local communities

Homeowners, utilities, microgrids and other **distributed energy resource** owners can:

- **Transact** on a trusted common platform
- **Fully integrate** building control into P2P and negawatt trading contexts
- **Harness the value of demand response initiatives** and microgrid-level PV production while **maintaining comfort of individual** buildings

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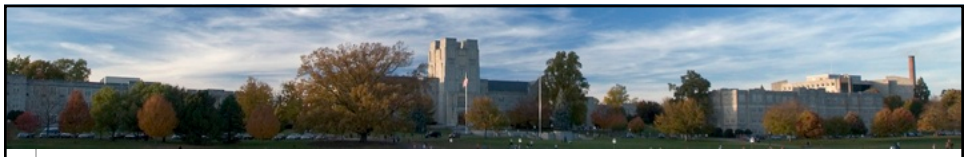
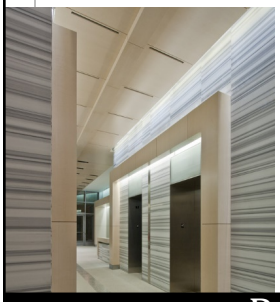
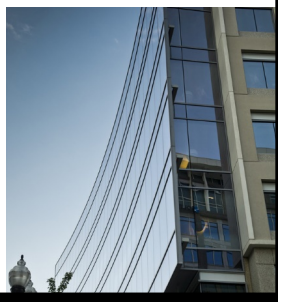


Thank You





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