An Energy Internet Platform for Sensor-driven Transactive Energy Applications

Invited Talk

Professor Saifur Rahman
Director, Virginia Tech Advanced Research Inst., USA
President, IEEE Power & Energy Society 2018-2019

IEEE Southeast Asia Sections and Chapters, 03 June 2020
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.
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

But in the Energy Internet:

All transactions must be done in real-time
All network constraints must be met
Vision of the Future Grid

Supply: Efficient, Reliable, Compatible and Resilient

Equipment: Versatile, Self-healing

Customer: Flexible, Intelligent, Interactive and Accountable

Electricity Transmission

Electricity Production and Storage

Energy flow

Data flow

Business flow

Adapted from: SGCC
Mapping the Energy Internet into the Future Grid

Source: SGCC
Energy Transaction in a Future Power System

Future power system integrated with modern information technology

Source: SGCC
Future Power System: Pathway to Energy Internet

- Extensive & interconnected
- Smart & interactive
- Open & sharing
- Flexible & resilient
- Secure & controllable

Source: SGCC
Functions of the Energy Internet

- Strong & Smart grid
- CPS
- Ubiquitous eIoT
- Energy Internet

Grid business:
- Energy flow
- Info. flow
- Business flow

New business:
- Enterprise operation
- Grid operation
- Customer service
- Energy service
- Big data
- PV cloud
- Equipment
- EV internet
- Energy finance
- Energy internet
- Energy service
- Energy flow

Suppliers
End users
Internal user
Government & industrial bodies

© Saifur Rahman
Key Technologies of the Energy Internet

1. Intelligent sensor and terminals
2. Communication network architecture
3. IoT platform
4. Information security

Holographic perception
Ubiquitous connectivity
Integrated innovation

Efficient information transmission
Easy and flexible application
Comprehensive state perception

Source: SGCC
The ICT Framework

- Utility Wide Area Network
- Meter Data Management System
- Edge Routers (Collectors)
- Neighborhood Area Networks
- Smart Meters
- Home Area Networks

Source: P. Siano
Field Implementation

Control Devices
- Load control switches
- Smart thermostats
- Other controls integrated into EMS/EIS

Monitoring Systems
- EMS
  - Software
  - Custom database
  - Sensors & controls
- EIS
  - Software
  - Interval Meters
  - Data Gateways

Interval Meters
Customer

Communication Systems
- Land Line
- Radio
- Power
- Internet

Utility

Source: P. Siano

© Saifur Rahman
Basic Transactive Energy Process

- **OpenBidding**
  - 09Nov19-13:00
  - Sent @12:01

- **CloseBidding**
  - 09Nov19-13:00
  - Sent @12:59

- **Sell**
  - I have 6 kWh to sell between 13:00-14:00 @ 3 tokens/kWh

- **Buy**
  - I want to buy 5 kWh between 13:00-14:00 @ 4 tokens/kWh

- **DSO**
  - The Reserve Price between 13:00-14:00 @ 8 tokens/kWh

- **Buy**
  - I want to buy 5 kWh between 13:00-14:00 @ 4 tokens/kWh
Small Scale Realization of EI

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

Source: www.bemcontrols.com
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

Source: www.bemcontrols.com
Roof-top Solar Photovoltaics
Energy Transaction in a Microgrid

Prosumers

Homeowners

Consumers

DSO

TE Aggregator

Transactive Energy Controller

Microgrid

Blockchain network

Blockchain network
Active controllers enable customers to adjust their energy consumption depending to price changes.

Transactive controllers represent the most promising evolution for energy users aiming at participating in Local Energy Markets since they allow both prosumers and active users to make bids considering the real time price of electrical energy and their own energy requirements.
Application: Building Automation Platform

Open source software platform: [www.bemoss.org](http://www.bemoss.org)
WiseBldg is a commercial software platform, [www.bemcontrols.com](http://www.bemcontrols.com)
These signals enter the house through a **Home Gateway.**

*Source: P. Siano, Smart Grid Impact on Consumer Electronics Consumer Electronics Association (CEA), 2013*

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

Source: P. Siano
Energy Internet Value Proposition

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

- 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)

- 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

www.bemcontrols.com
IEEE President-elect Candidate 2020

Prof. Saifur Rahman

www.srahman.org

www.facebook.com/SRahmanPES

Past-President of IEEE Power & Energy Society
Past-Chair, IEEE Publication Services & Products Board

PES accomplishments:
    PES University
    IEEE PES Corporate Engagement Program
    PES Chapters’ Councils in China, India, Africa and Latin America