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Implementing Interoperable Transactive Energy with NIST Project/SGIP Standards



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About William Cox

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- Consulting Software Architect
 - Complex systems, eCommerce, due diligence, ...
- Specializing in Smart Grid architecture and information definitions



Outline

- NIST Framework and Roadmap
- Transactive Energy Semantics and Dimensions
- Business Goals
- End-to-end from pairwise relationships
- Implementing Transactive Energy
- Standards for Transactive Energy
- Energy Ecologies and Natural Gas
- Conclusions and References



NIST Framework and Roadmap



- Support for Transactive Energy
 - Standards from the Priority Action Plans
 - Common interoperable information models
- Cross-cutting model for price and product definition ([PAP03](#))
- Cross-cutting schedule communication ([PAP04](#))
- DR and DER interactions ([PAP09](#))
 - Included transactive interfaces based on PAP03



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Transactive Energy & Price Semantics

- From Nominal to Real transactive prices
 - Nominal or fiat prices
 - Someone else’s price
 - Related to price I pay
 - My price
 - My price that I have chosen transactively (product, time, price)






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Semantic Questions about Price

Dimension	Question
Transactable prices	Can I buy or sell?
Actual prices	What do I pay?
Fiat prices	Who made the prices up and why?
Actionable	Is action appropriate using the price?
Time	Historic/Present/Future?
Indicative	Is the abstracted information on direction only?
Certainty	How certain is the price?
Real?	Can I compute economic value with this price or is it abstracted?



Source: Sastry, Cox, Considine, [The Semantics of Price...](#), Grid-Interop 2012

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Transaction Types



- From price-taker to participant in current/ forward transactions
 - Price-taker
 - Price-taker aware of price and its real time changes
 - Price-taker aware of (estimated) forward price
 - Transactive
 - Participant in current markets (buy/sell)
 - Participant in forward markets (buy-sell)

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Supplier and Consumer Goals



- Suppliers' and consumers' business goals differ
- Transactive approach enables choice
- Actions for supplier and consumer
- Businesses manage cost of factors of production
 - Respond to what you get
 - Hedge against future increases
 - Smooth variability

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Implementing Transactive Energy



- Interactions are Service-Oriented, & allow
 - High scalability
 - High reliability
 - Fault resilience
 - Appropriate security for each interaction
 - Appropriate reliability for each interaction
 - Open entry, open participation

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Standards for Transactive Energy

- Energy product definition and price
 - NIST PAP03 Common Price and Product Definition
 - OASIS Energy Market Information Exchange (EMIX)
 - See Catalog of Standards entry and specification
 - Schedules, prices, currency, factoring of common information
 - Express Power Products today
 - Express transport and effects (congestion, loss, ...)
 - Express natural gas, thermal, ... in the same framework

Standards for Transactive Energy (2)

- NIST PAP09 DR, DER, included Transactive Services
- OASIS Energy Interoperation
 - See References
 - Interoperable DR, DER Services (SOA)
 - Evolved from OpenADR 1 and ISO-RTO Council DR work
 - Base for OpenADR 2 profiles
 - Transactive services (SOA)
 - EiTender—make or tender and offer
 - EiTransaction—accept an offer, creating a transaction
 - EiDelivery—confirm delivery
 - EiQuote—describe a price quote (non-transactable)



Standards for Transactive Energy (3)

- NIST PAP04 Common Schedule
 - Time is critical to energy and facility schedules
- WS-Calendar connects and interoperates with business and personal schedules
 - IETF iCalendar with OASIS WS-Calendar Extensions
 - See References
 - Schedules, time bindings
 - Compact notation and factoring of common values



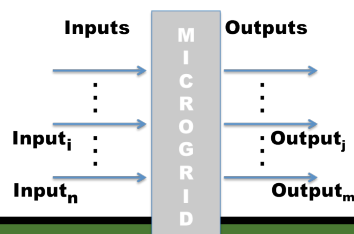
Energy Ecologies and Natural Gas

- Transactive energy supports economic and technical choice:
 - Different energy/commodity sources for electricity generation
 - Different energy/commodity sources for production and comfort
 - Local choices, depending on availability of
 - Merchant sources, technology, equipment, ...
- Energy Ecologies provide a decision framework



Energy Ecology at the Node

- Each available input
 - Has a price and product definition (including time)
 - May have EMIX source warrants
- Each possible output
 - Has a price and product definition (including time)
 - May have EMIX source warrants



Source: Cox, Considine, [Energy Ecologies](#), Grid-Interop 2012



Conclusions

- One size doesn't fit all
 - Different markets, scale, security, reliability, technologies at each level in the graph
- Micromarkets limit cost, increase flexibility
- Transactive Energy must include transactions
- Market participant business goals differ
- Economic and technology frameworks help decision making (Energy Ecologies)



References (1)

- Price and Product Definition
 - [OASIS Energy Market Information Exchange](#) (EMIX)
- Services and interaction
 - [OASIS Energy Interoperation](#)
 - [OpenADR2 Profiles](#) of Energy Interoperation
- Schedule
 - [WS-Calendar](#) extensions to iCalendar
 - PIM (abstract model) for WS-Calendar [in progress](#)



References (2)

- Selected papers (most are linked from [here](#))
 - [Automated Transactive Energy](#) (Cazalet [Grid-Interop 2011](#))
 - [Energy, Micromarkets, and Microgrids](#) (Cox [Grid-Interop 2011](#))
 - [Applying Energy Interoperation and EMIX to DR and Transactive Energy \(slides\)](#) (Holmberg [Grid-Interop 2012](#))



References (3)

- [Energy Ecologies](#) (Cox, Considine, [Grid-Interop 2012](#))
- Microgrids as Fundamental Structure for Smart Grids (Considine, Cox, Cazalet, [Grid-Interop 2012](#) Best Paper) (link pending at <http://www.gridwiseac.org/> "Historical Proceedings)

