Transactive Energy Framework for Bilateral Energy Imbalance Management

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Trade Secret

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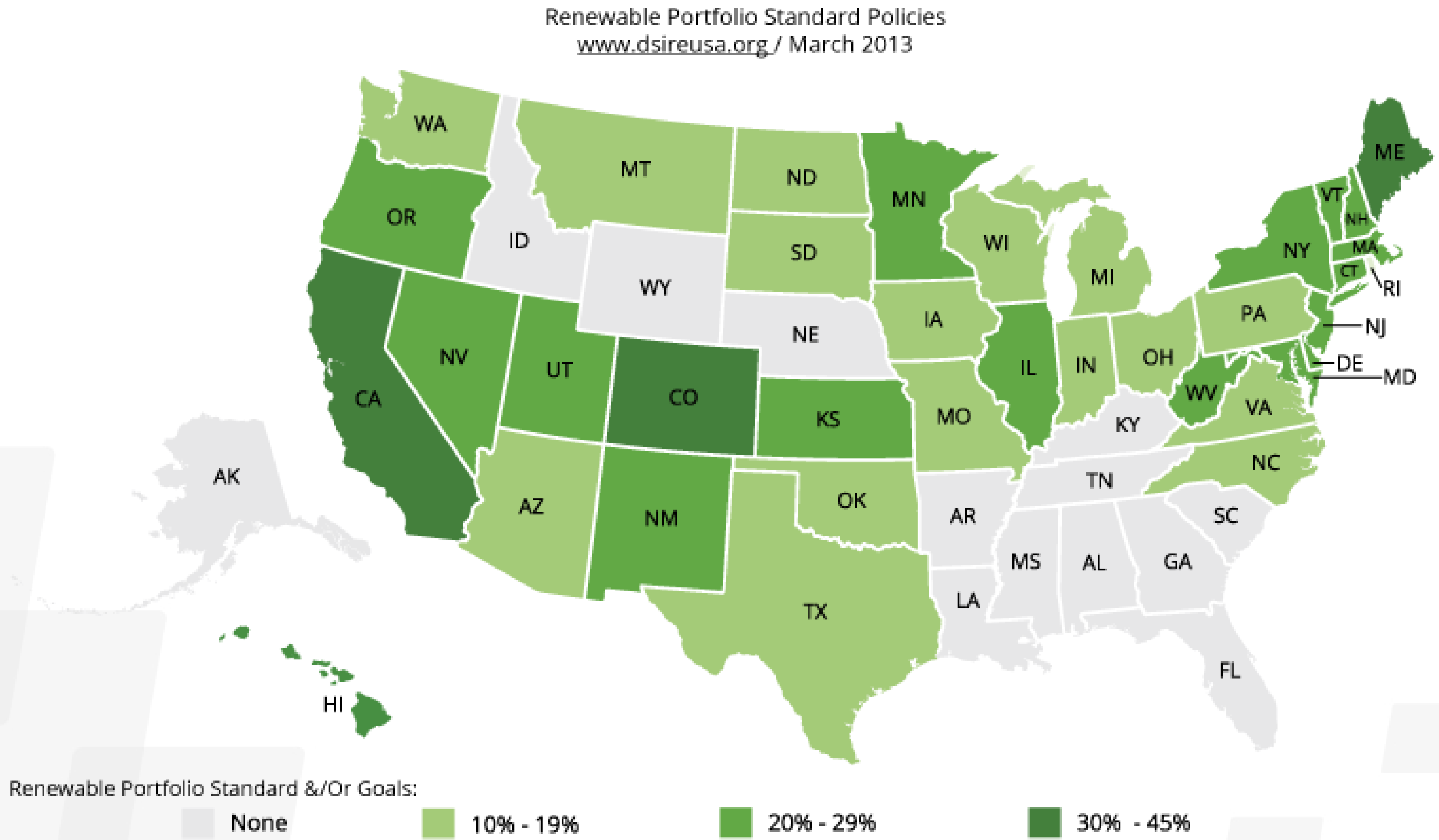
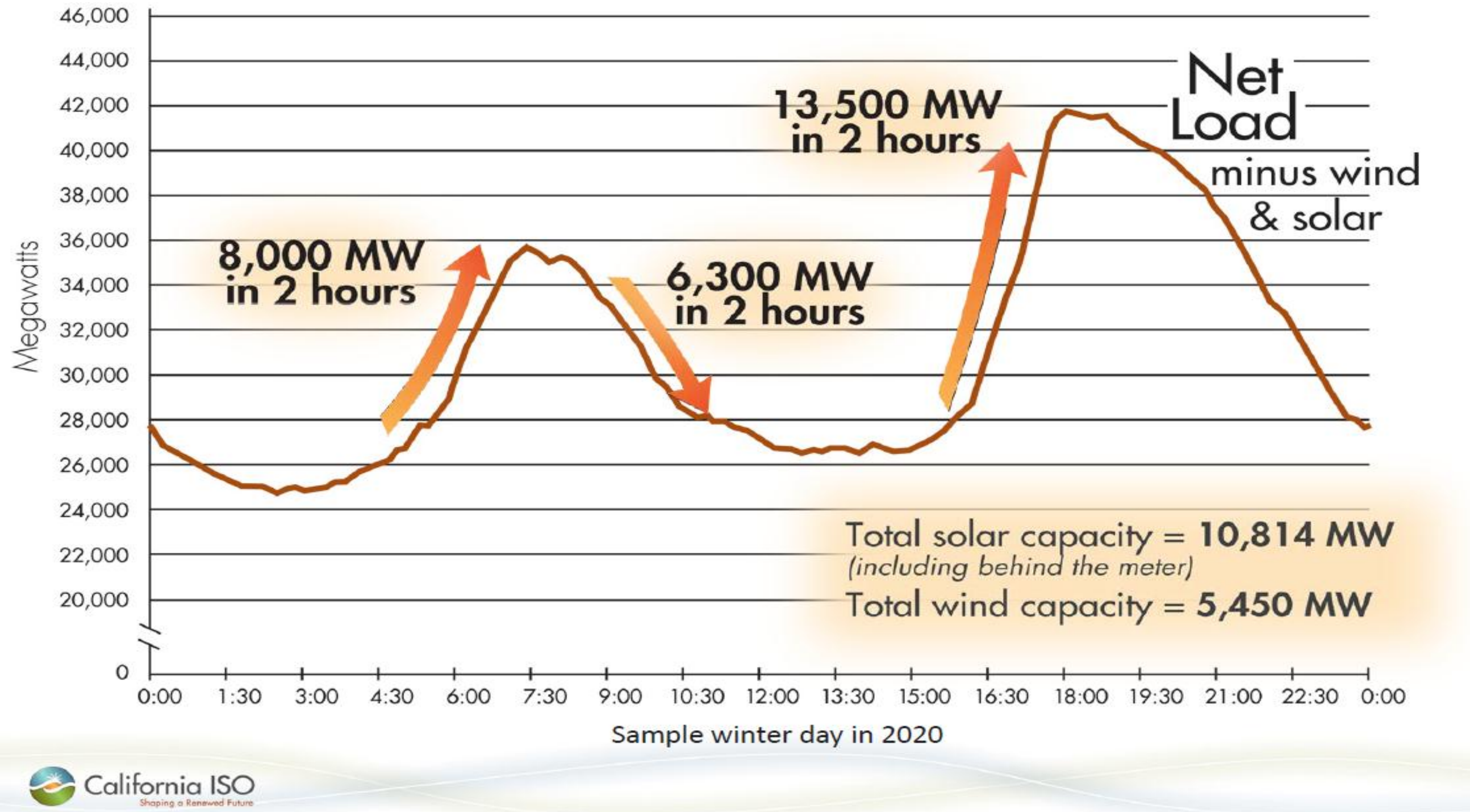
Topics

- Centralized vs Bilateral Energy Imbalance Market (EIM) Approaches
- Application of Transactive Energy Framework (TEF) to Bilateral EIM – Case Study
- Leveraging Existing Transactive Tools for Bilateral EIM

Renewable Portfolio Standards (RPS) Policies as of March 2013



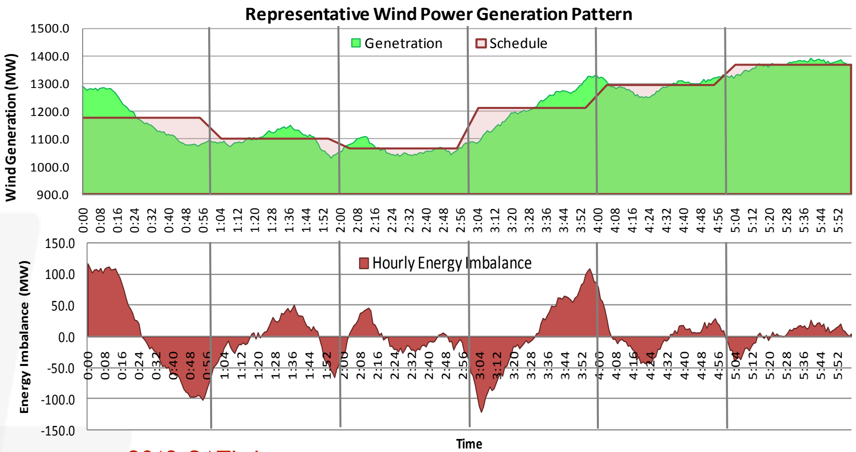
Expected Impact of 33% RPS on Net Load CAISO



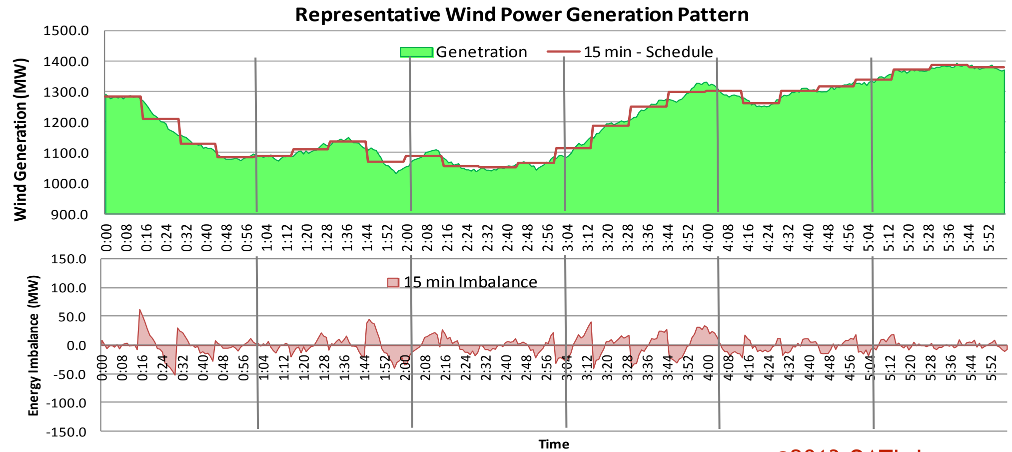
- Increased need for regulation capacity
- Increased need for ramp capability

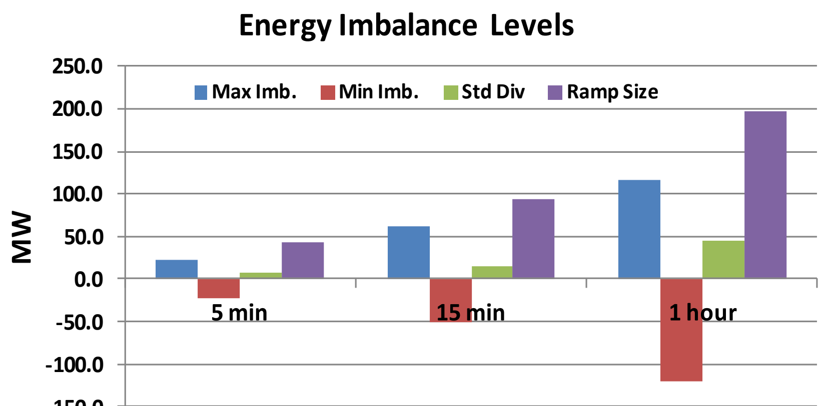
Impact of Sub-hourly Scheduling on Real-Time (RT) Balancing Energy Needs

Hourly Scheduling



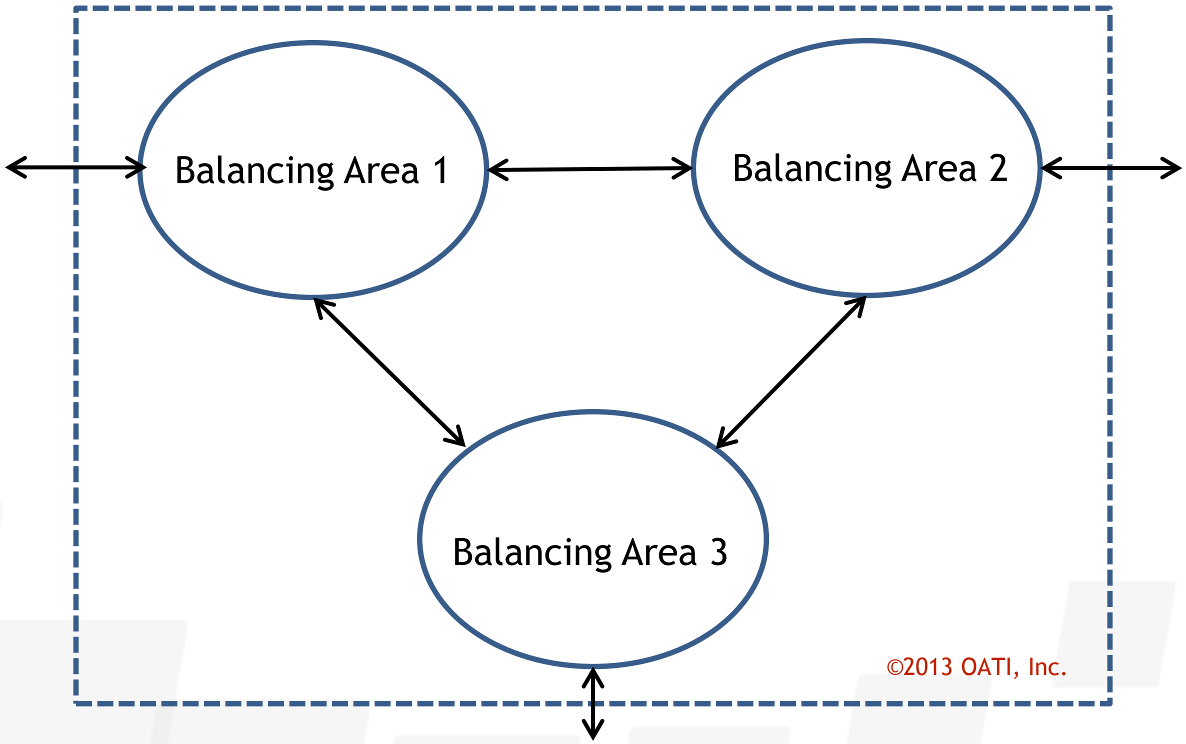
15 Minute Scheduling





EIMs

- Objective: Combine imbalances and share dispatchable resources among two or more Balancing Authority (BA) areas
- Time Resolution: 5-minute scheduling/dispatch
- Time Horizon: One or more 5-minute time intervals
- Dispatchable Resources: Conventional Generation, Dispatchable Demand Response, Dispatchable Storage



EIM Design

- Centralized EIM
  - *Single tariff*
  - *Centralized dispatch*
  - *Pooled transmission among participating BAs for RT use*
- Coordinated Decentralized EIM
  - *Multiple tariffs; coordinated rules for EIM*
  - *Transmission reservation*
  - *Centralized/hierarchical dispatch*
  - *Dynamic scheduling among participating BAs*
- Bilateral EIM
  - *Multiple tariffs*
  - *Transmission reservation*
  - *Automated bilateral bid matching*
  - *Dynamic scheduling*

Main Issues to Consider in EIM

- "Resource"-related Issues
  - *Resource bidding, commitment, scheduling, dispatch, pricing, and compensation*
  - *Resource qualification for EIM participation (required characteristics, admissible technologies, risks, and opportunities for participation of demand-side resources)*
- "Wires"-related Issues
  - *Avoid free-rider use of transmission in EIM*
  - *Compensate transmission owners for the use of transmission in EIM*
  - *Allocate cost of RT transmission usage based on cost causation*

Participation of Demand-side Assets in EIM

- Currently EIM designs are mostly based on participation of conventional resources
- No technical barriers exist for participation of demand-side resources in EIM
- Tools for bidding, scheduling, bid-matching, market-clearing, etc. exist
- Main impediments
  - *Non-uniform modeling and information exchange framework (to a large extent being addressed by the TEF)*
  - *Regulatory barriers (being addressed in various regulatory fora)*

Case Study Information

- Case study characteristics and objectives
  - *Motivated by a number of parallel activities in WECC related to the development of EIM*
  - *Initiated and funded by OATI in loose collaboration with several interested WECC BA operators*
  - *Primary objective: Demonstrate a novel approach to EIM based on Transactive Energy principles*
  - *The study is ongoing. Preliminary results*
    - Proper use of existing Energy Trading and Risk Management tools can expedite EIM
    - Case Study identifies desired enhancements of TEF to expand its application

Case Study Information (Continued)

- Transactive Energy Attributes
  - *Architecture: Both centralized and decentralized designs are considered and evaluated*
  - *Extents: The Transactive activities extend across two or more BA areas in the Western grid (WECC). Transacting entities include asset owners/operators of conventional and distributed generation, storage, Building Energy Management Systems, MicroGrids, Commercial and Industrial (C&I) prosumers, Residential prosumers, Distribution Utility operators, and Aggregators*

Case Study Information (Continued)

- Transactive Energy Attributes (Continued)
  - *Transactions: The commodities transacted include primarily energy (kWh/MWh), but may also include capacity (kW/MW), conventional reserves (Non-spinning, Spinning, Regulation), and new reserve products (Flexibility Reserves, Ramping, Load Following, etc.)*
  - *Transacting parties: Transacting parties may include human participants/actors or intelligent systems/nodes. Generally transactions with sub-hourly temporal granularity (e.g., 5 minutes) involve automated/intelligent systems*

Case Study Information (Continued)

- Transactive Energy Attributes (Continued)
  - *Temporal variability: The transaction time scales range from multi-day, multi-hour to sub-hourly (15 minute and 5 minute) temporal granularity*
  - *Interoperability: Where relevant, standards are used to facilitate interoperability*
  - *Value discovery mechanisms: The value discovery for forward (multi-day, multi-hour) transactions is effected either based on reference public prices (from organized markets or trading hubs) or through bilateral bid/ask mechanisms based on economic or engineering values. In sub-hourly time frame, automated clearing/bid-matching mechanisms are used (e.g., EIM automated dispatch/clearing) for value discovery*

Case Study Information (Continued)

- Transactive Energy Attributes (Continued)
  - *Value assignment: The bids and offers used in the transactions reflect objective value assignments for transacted products and services*
  - *Alignment of objectives: The premise of EIM is based on a win-win outcome for transacting parties by pooling imbalances across footprints and pooling different resources within the footprints to mitigate the cumulative imbalance*
  - *Stability Assurance: The system has been designed to ensure incentive-compatibility aligning economic objectives of the participating entities with security and stability of the physical grid. It is also designed with the stability of the market (EIM) as a primary objective*

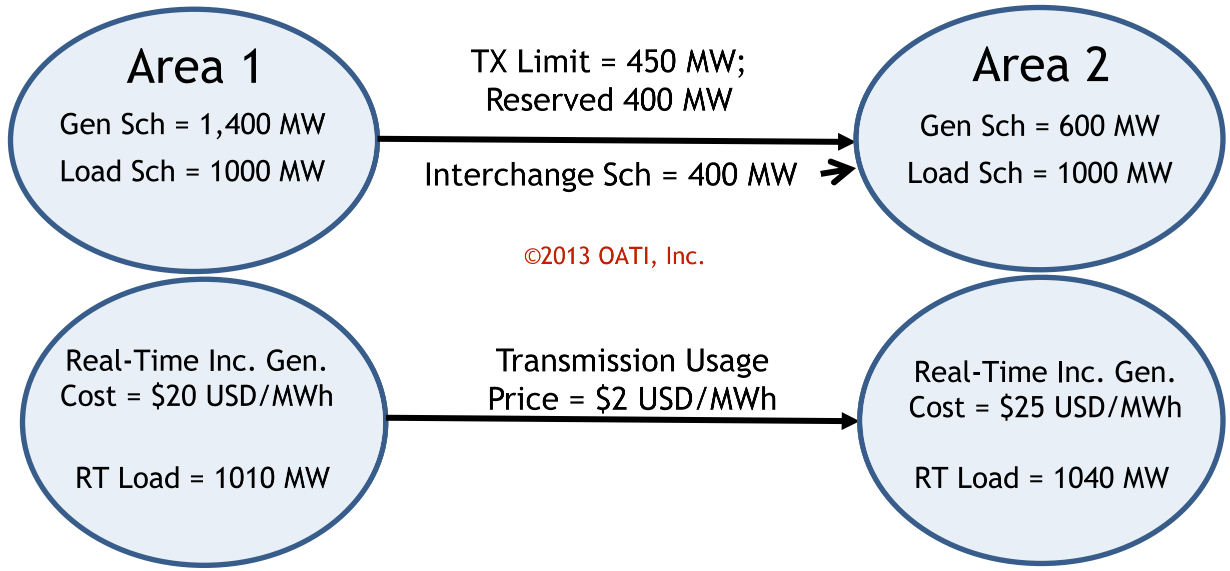
Case Study Information (Continued)

- Participating agencies and organizations: OATI has informal arrangements with some WECC entities; at this time, these discussions are ongoing
- References: OATI has made several presentations at EIM design meetings. OATI's contributions have been mainly to ensure distributed resources are included in EIM design

Preliminary Observations: Determination and Settlement of Transmission Usage in EIM

- Keep track of transmission reservation and transmission usage for EIM
- Compensate transmission owners based on incremental transmission usage for RT dispatch
- Allocate cost based on cost causation due to RT deviations
  - *Need to establish criteria to quantify responsibility for RT transmission use*
    - Rather straightforward in bilateral EIM
    - No unified accepted practice in Centralized EIM
  - *Need to deal with cases where different entities cause RT transmission use or relief*

Bilateral EIM - Example 1



Bid Ask Prices

- Area 1 Offer: 40 MW @ 21/MWh
- Area 2 Bid: 40 MW @ 23/MWh

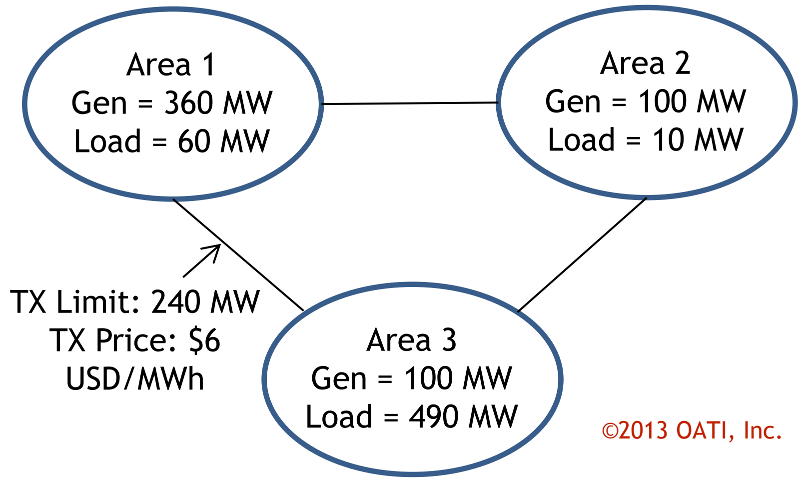
Result

- Incremental RT Generation Area 1: 50 MW
- Incremental RT Generation Area 2: 0 MW
- Incremental Line Flow: 40 MW

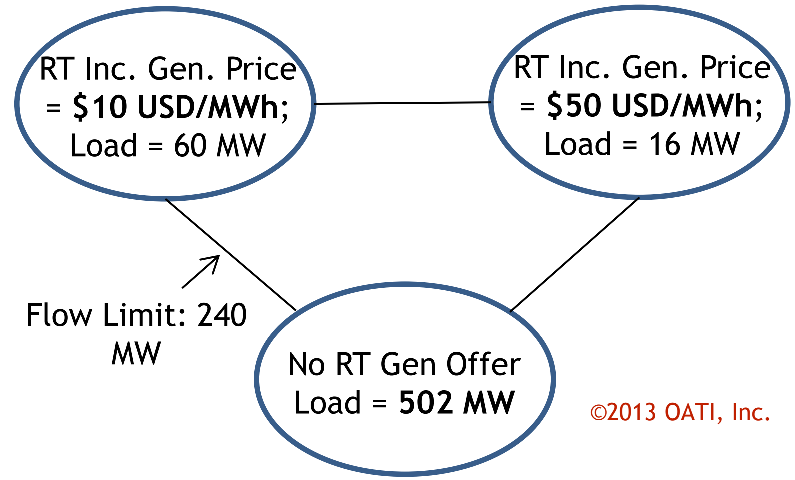
Compensating TX Owner for RT Usage

- TX Compensation: $2 USD*40 = $80 USD
- TX Cost Allocation Based on Cost Causation
  - *Area 1: $0 USD*
  - *Area 2: $80 USD*
- TX Cost Allocation Based on Net Load Deviation
  - *Area 1: $16 USD*
  - *Area 2: $64 USD*
- TX Cost Allocation Based on Load Ratio Share
  - *Area 1: $39.40 USD*
  - *Area 2: $40.60 USD*

Bilateral EIM Example 2: Impact of Meshed TX



Forward Schedules



RT Loads and Incremental Offers

- Assume lossless transmission lines with equal impedances
- Scheduled Flow on 240 MW line (2/3)*300+(1/3)*90 = 230 MW

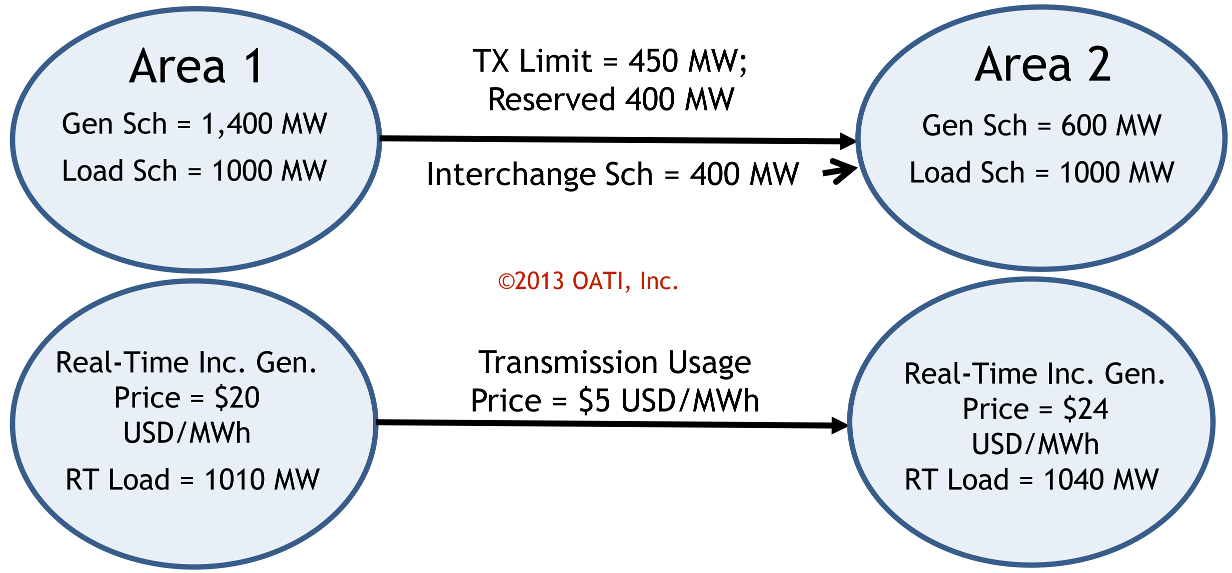
RT Bids and Offers

- Area 1 offer: 20 MW @ $35 USD/MWh
- Area 2 bid: 6 MW @ $40 USD/MWh
- Area 3 bid: 12 MW @ $45 USD/MWh

EIM Results

- Area 1 Inc. Gen = 18 MW
- Area 2 Inc. Gen = 0 MW
- Incremental flow on Constrained Line: (2/3)*12 + (1/3)*6 = 10 MW
- Payment to TX Owner for RT Use: $6 USD*10 = $60 USD
- TX Cost Allocation Based on Net Load Deviation
  - *Area 2: $20 USD*
  - *Area 3: $40 USD*
- TX Cost Allocation Based on Cost Causation
  - *Area 2: $6 USD*8 = $48 USD*
  - *Area 3: $6 USD*2 = $12 USD*

Coordinated Decentralized EIM
Example 1 – Ignoring TX Cost in RT Dispatch



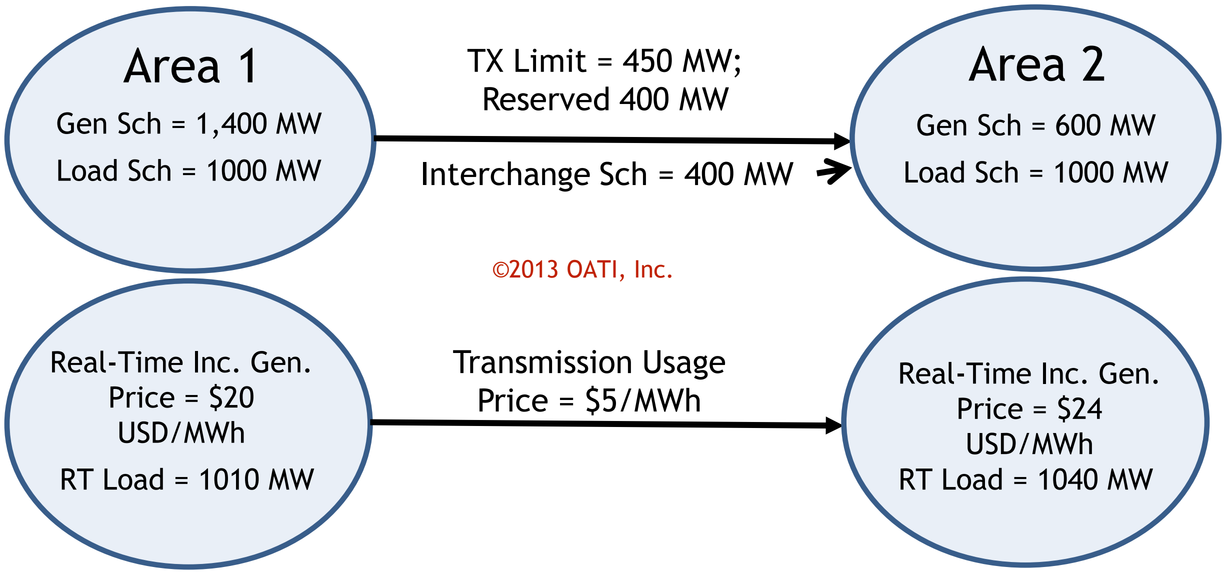
RT Dispatch Results
(Assuming Preserving Forward Gen. Schedules)

- Area 1 Inc. Gen: 50 MW
- Area 2 Inc. Gen: 0 MW
- Inc. Line Flow: 40 MW
- Area 1 LMPs: $20/MWh; Area 2 LMPs: $20/MWh
- Result: Either TX owner is not compensated, or (if TX usage charge is applied after the fact) Scheduling Entities have no control on RT dispatch charges.

Compensating TX Owner for RT Usage

- TX Compensation: $5*40 = $200
- TX Cost Allocation Based on RT Load Deviation
  - *Charge to Area 1: $40 for TX*
  - *Charge to Area 2: $160 for TX*
- TX Cost Allocation Based on RT Incremental TX Usage
  - *Charge to Area 1: $0 for TX*
  - *Charge to Area 2: $200 for TX*

Coordinated Decentralized EIM
Example 2 - Incorporating TX Cost in RT Dispatch



RT Dispatch Results

- Area 1 Inc. Gen: 10 MW
- Area 2 Inc. Gen: 40 MW
- Inc. Line Flow: 0 MW
- Area 1 LMP: $20 USD/MWh
- Area 2 LMP: $24 USD/MWh

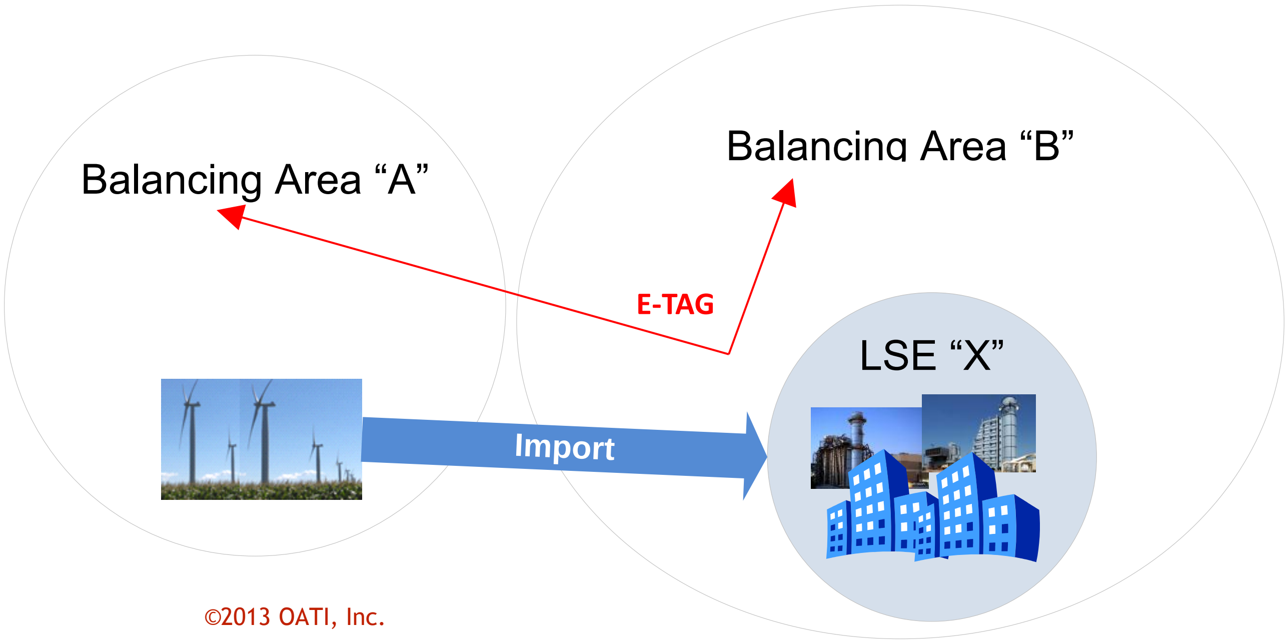
Compensating TX Owner for RT Usage

- TX Compensation: $0 USD
- Total Market Cost: $1,160 USD (instead of $1,200)
- Payment to Inc. Gen. 1: $20 USD*10 = $200 USD
- Payment to Inc. Gen. 2: $24 USD*40 = $960 USD
- Energy Charge to Load 1: $20 USD*10 = $200 USD
- Energy Charge to Load 2: $20 USD*40 = $960 USD
- Net Collection by Market Operator: $0 USD

Leveraging Existing Tools for Bilateral EIM

- Interchange Transaction Accelerator Platform (I-TAP)
  - *OATI webExchange*
  - *Provide bids/offers with 5-minute resolution for the next X intervals based on imbalance forecast*
  - *Accept and schedule using previously reserved transmission*
- Dynamic Scheduling System
  - *OATI webDynamic*
  - *Dynamically schedule cleared (matched) bids/offers within each 5-minute interval across BA boundaries*
- Enhancements underway to accommodate Bilateral EIM requirements
- Enhancements are compatible with TEF requirements

Scheduling Practice

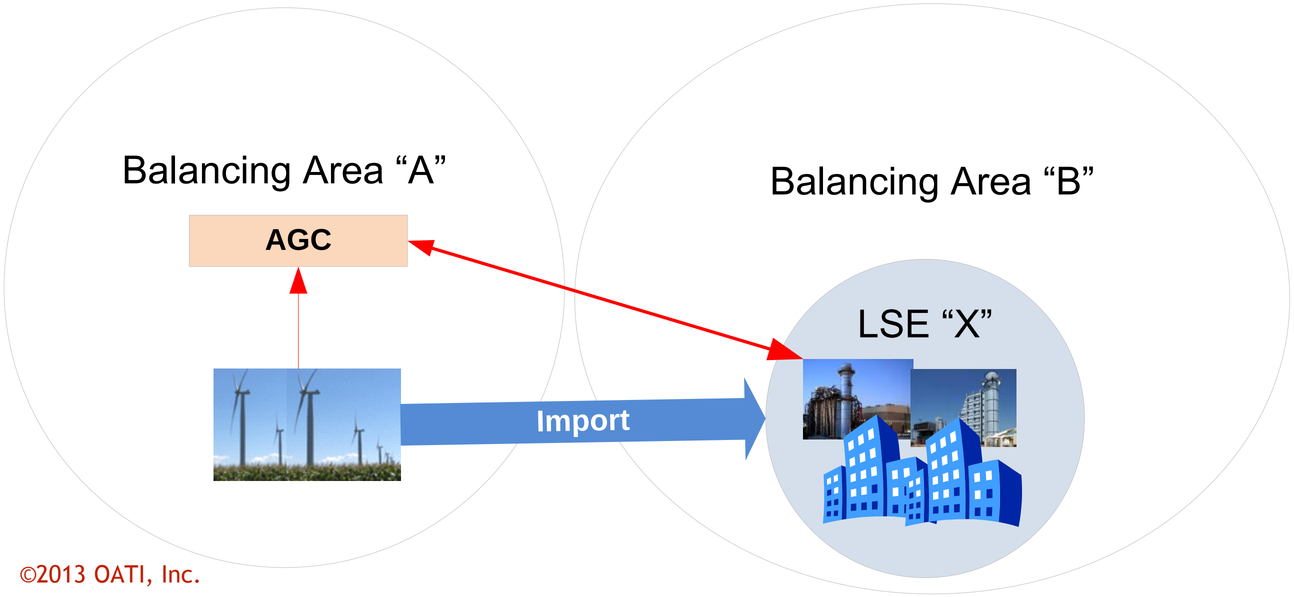


- LSE "X" needs to schedule wind imports from BA "A" through BA "B"
- The LSE will need a transmission reservation, and schedule the transaction with e-Tag, and receive approval from BA "A" and "B"
- From time-to-time, the LSE needs to adjust

Intra-Hour Scheduling: OATI webExchange

- Facilitate bilateral intra-hour (and longer) transactions through electronic platform that provides information, communications links, and user interfaces
- Provides all functionality needed to purchase, schedule, and tag energy
  - *Transmission Availability*
  - *Transmission Products*
  - *Price Discovery*
  - *Scheduling*

Dynamic Scheduling



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- Dynamic Scheduling allows an LSE or generator to move via telemetry some or all of its demand and/or generation output from its Host BA, and place it in another BA. The other BA can control the load and/or generation as though it was physically in that BA

OATI webDynamic

- webDynamic is a tool to establish dynamic schedules through standardized business practices and automated scheduling infrastructure
- RT data exchange (ICCP)
- Integration with webTag
  - *Scheduling practices*
  - *Tariff Provisions*
  - *Reporting*
- Expand Infrastructure
  - *Area Control Error (ACE) diversity*
  - *Regulation Services*
  - *Energy Imbalance Services*

Enhancements Underway

- webExchange
  - *Currently can accommodate different (MW, price) values for different 5-minute intervals in look forward horizon based on bilateral arrangements*
  - *Enhancement: Broadcast bids/offers to allow bid matching/clearing*
- webDynamic
  - *Currently webDynamic recognizes Dynamic Tags only on an hourly basis (if the start time is :00 min)*
  - *Enhancement: This restriction is being removed to allow sub-hourly dynamic tags*

Observations

- Incorporating transactive commodities in addition to "Energy" in TEF is important to extend its application
- TEF can easily be expanded to include derivative products such as Ancillary Services and Flexibility Reserves
- Inclusion of "wires usage" as a commodity with price (rather than embedded cost) in Transactive Energy Framework is highly desirable
- There are no technical impediments to bilateral EIM
- Bilateral EIM can be used as a Case Study for desired TEF enhancements

Thank You

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