Northwest **Power** and **Conservation** Council

March 7, 2017

MEMORANDUM

TO: **Council members**

FROM: **John Ollis, Ben Kujala**

SUBJECT: **Primer on Electricity Markets**

BACKGROUND:

Presenter: John Ollis and Ben Kujala

Summary: This presentation will be a primer on wholesale power markets with a discussion of scheduling generation and transmission, the difference between physical and financial contracts over different timeframes, contrasted with the physics of the power system.

Relevance: In the February Power Committee, Staff presented a "Primer on the Physics of the Power System." This presentation is meant to supplement the physics presentation to provide the Committee more context on the current state of the regional wholesale power market, and contrast how power is marketed to how the system is physically operated.

Workplan: C.4.1 Prepare for 8th Plan

Background: The regional power system load serving entities (LSE) can utilize the wholesale power market to ensure their contracted or generated supply of electricity can instantaneously meet their customers demand (load-resource balance). Markets exist for LSE to buy the right to future power when they forecast a deficit (short), or sell future power when they are forecast a surplus (long). An LSE may be short for the day but long on

851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348
www.nwcouncil.org

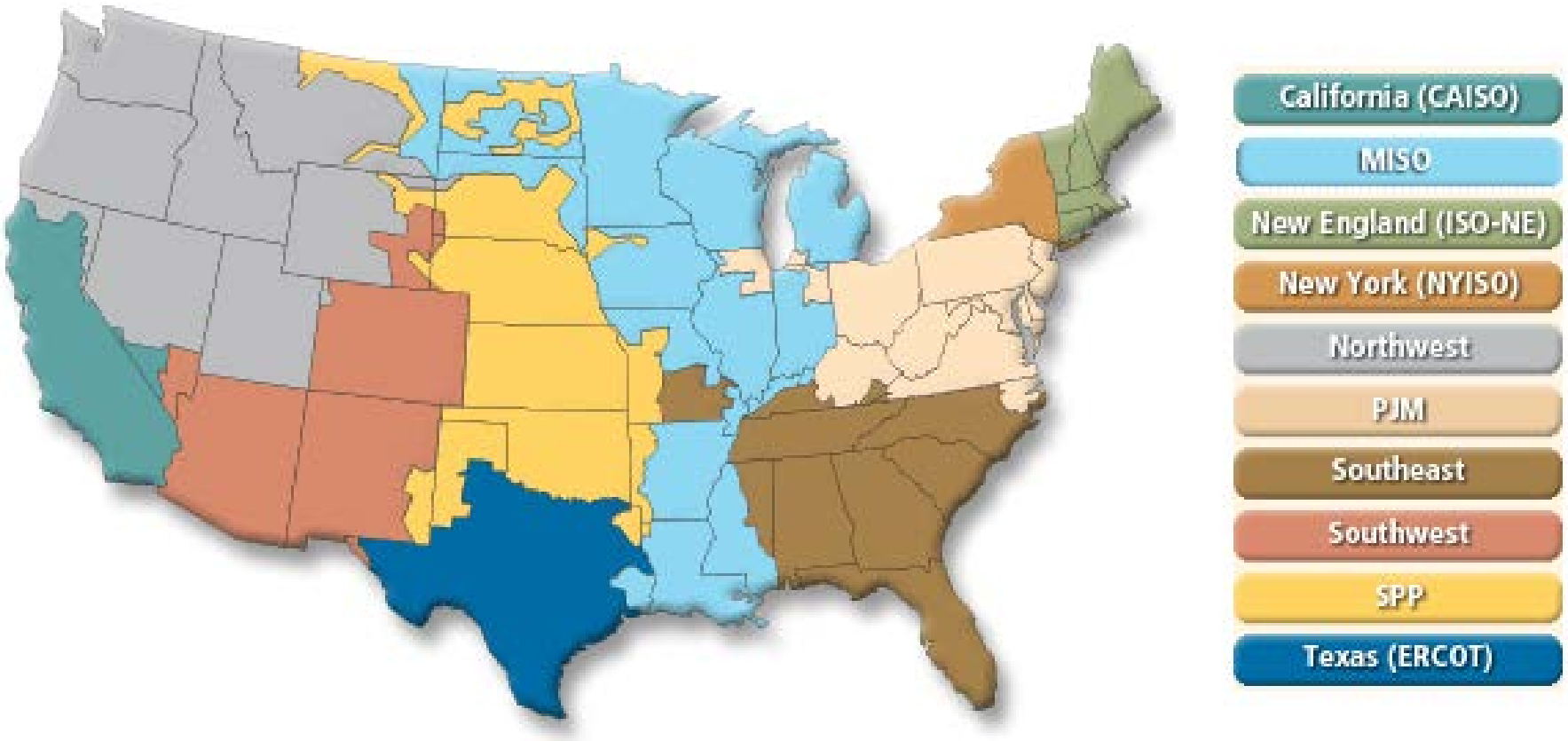
Steve Crow
Executive Director

503-222-5161
800-452-5161
Fax: 503-820-2370

average over the whole month, or any other combination of short or long position depending on the LSE's load-resource balance over time. In addition, since the capability to store power is uncommon, power markets provide load serving entities a way to maintain load-resource balance. To meet this load-resource balance using a supply and demand that fluctuate instantaneously requires cascading load-resource forecasts and market schedules of decreasing granularity.

Any physical power market transaction includes schedule of future generation being bought, or sold, and its nominal transmission path. A bilateral contract is a generation or transmission schedule between two parties. The Pacific Northwest market entities for the most part engage in bilateral contracts for future generation and transmission rights over all timeframes (including short-term deals in the day-ahead and spot markets). Many of these bilateral transactions on future power generation couple financial hedges with a "day of" spot market physical power purchase or sale, and together these two deals, function the same as a physical forward power purchase. This opens the market to not just those who seek to meet load or generate electricity, but those who want to take a financial position. These deals allow entities to deal with price risk separately from loss-of-load risk and up the liquidity of the market.

Per the aspects and variety of contracts indicated above, LSE are not the only market participants in the region. Market players include, but are not limited to the following: independent power producers, investor owned utilities, public utilities and cooperatives, power marketing agencies (BPA), transmission providers and financial institutions. While the Pacific Northwest region trades mostly bilaterally, most US wholesale electricity markets are organized on at least a short-term basis. An organized market require participants to bid generation in to, or ask for power from, an independent entity who clears the market by paying the bidders and charging the askers. Organized markets, like an Independent System Operator (ISO), or Regional Transmission Organization (RTO), theoretically, plan for adequacy for their footprint and ensure efficient market dispatch over varying timeframes. In the Pacific Northwest region, entities like the Columbia Grid and Northern Tier Transmission Group (coordinate on long-term transmission needs) and members of the Northwest Power Pool (participate in reserve sharing) fulfill some of those adequacy roles taken on by an organized market. However, for short-term purchases in the region, no independent market entity coordinates efficient dispatch of all regional resources as in an organized market.



Primer on Electricity Markets

John Ollis and Ben Kujala

February 14, 2017

Wholesale Power Markets

- Demand: Load Serving Entities
  - Entity granted authority by local or state law, regulation or franchise to serve electric retail load by generating or engaging in wholesale energy transactions.
- Supply: Wholesale Power Marketers
  - Independent Power Producers
  - Investor Owned Utilities
  - Public Utilities
  - Financial Institutions

Future Right to Generation

- Generation of power is instantaneous and meets load according to the laws of physics.

- Coordinating future power and transmission ahead of time facilitates enough power generation and transmission capability to meet forecasted demand.
  - Interchange scheduling
  - Balancing reserves

Interchange Scheduling

- Electronic Tagging (e-tag)
  1. All Control Areas involved
  2. MW amount of the schedule
  3. Starting and ending times of schedule
  4. Point of receipt/delivery
  5. Terms of interruption and reserve responsibility
  6. Ramp duration (usually 20 minutes)
  7. Effective Time (usually on the hour)
- Must be implemented 10 minutes before ramp (usually 20 minutes before the hour)

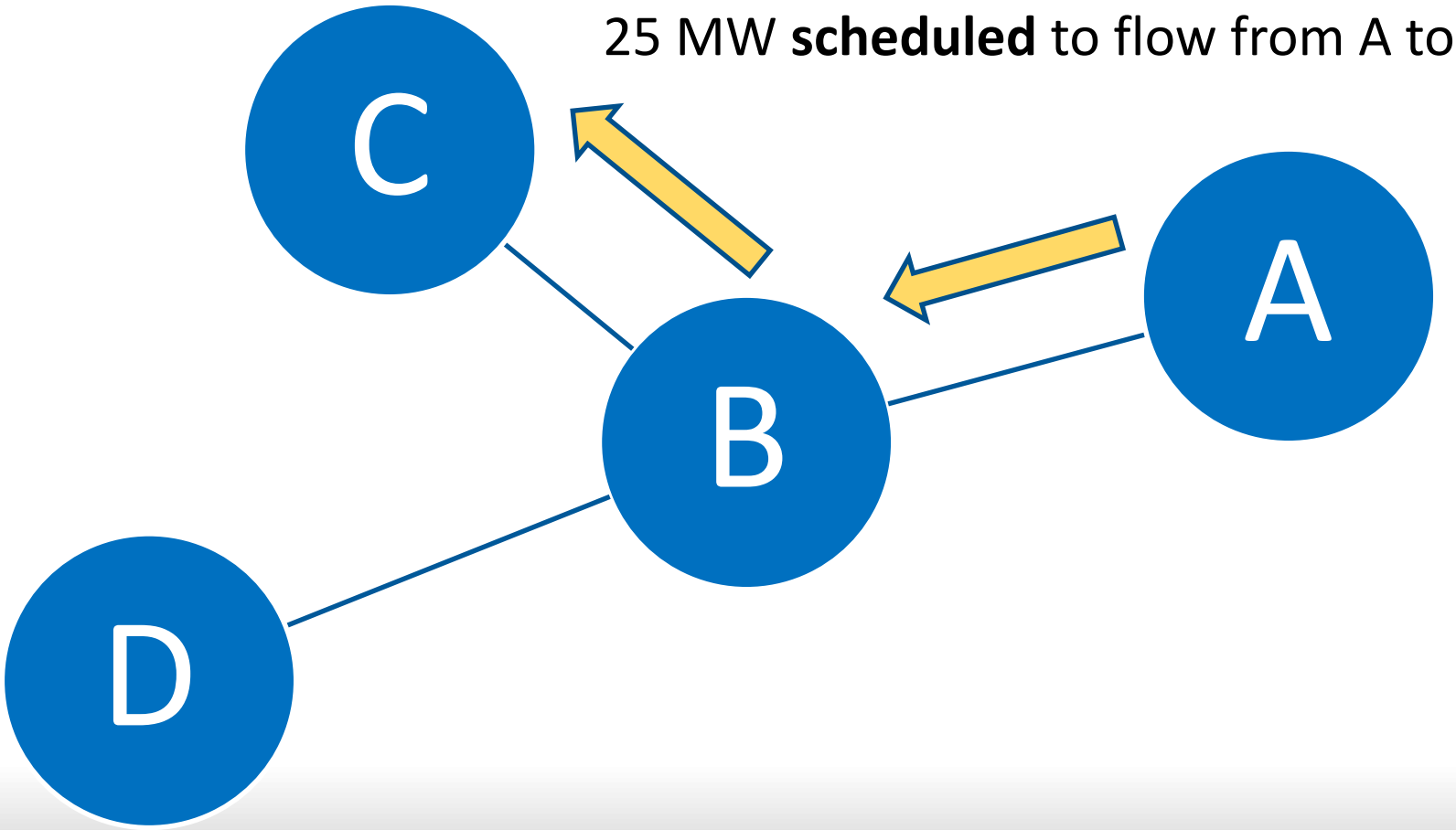
Transmission Path

- A transmission path may consist of one or more parallel transmission elements.
- The transfer capability of the transmission path is the maximum amount of actual power that can flow over the path without violating reliability criteria.
- To schedule power from the Control Area (CA) containing the generation to the CA of delivery rights to use transmission service on the path connecting the CAs must be obtained.

Scheduling Example

- E-tag for one hour ending 11 am (HE 1100)
  1. Some generator in A, B intermediary, some delivery point in C
  2. 25 MW scheduled
  3. Schedule time (HE 1000 to HE 1100)
  4. Delivered to Control Area C
  5. Terms of interruption and reserve responsibility
  6. Ramp 20 minutes from 9:50 am to 10:10 am
  7. Effective Time 10:00 am
- Transmission service for 25 MW is obtained from control areas A, B and C to the point of delivery.

Hour ending 1100

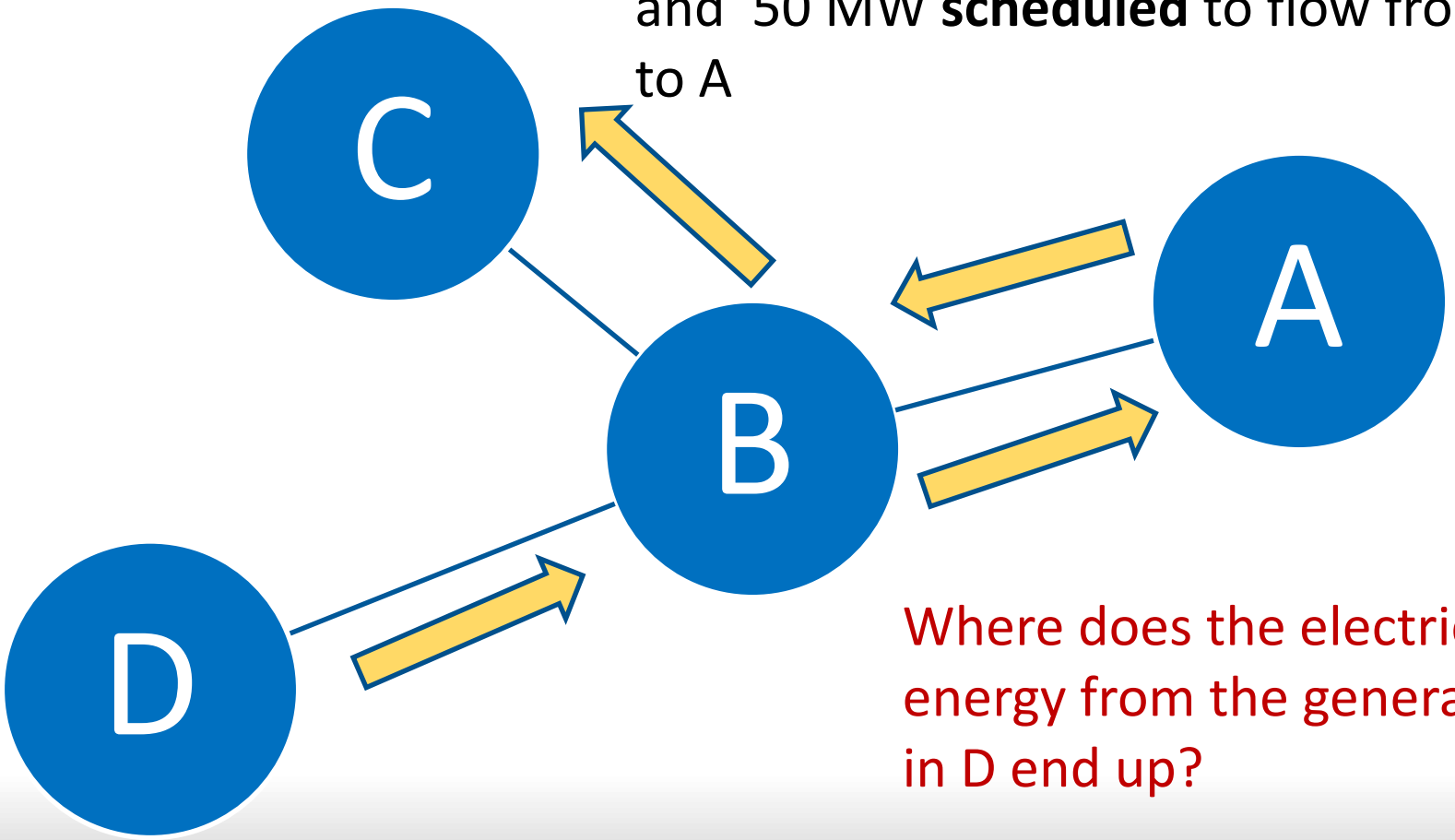


Another transaction

- E-tag for one hour ending 11 am (HE 1100)
  1. Some generator in D, B intermediary, some delivery point in A
  2. 50 MW scheduled
  3. Schedule time (HE 1000 to HE 1100)
  4. Delivered to Control Area A
  5. Terms of interruption and reserve responsibility
  6. Ramp 20 minutes from 9:50 am to 10:10 am
  7. Effective Time 10:00 am
- Transmission service for 50 MW is obtained from control areas D, B and A to the point of delivery.

Hour ending 1100

25 MW **scheduled** to flow from A to C, and 50 MW **scheduled** to flow from D to A



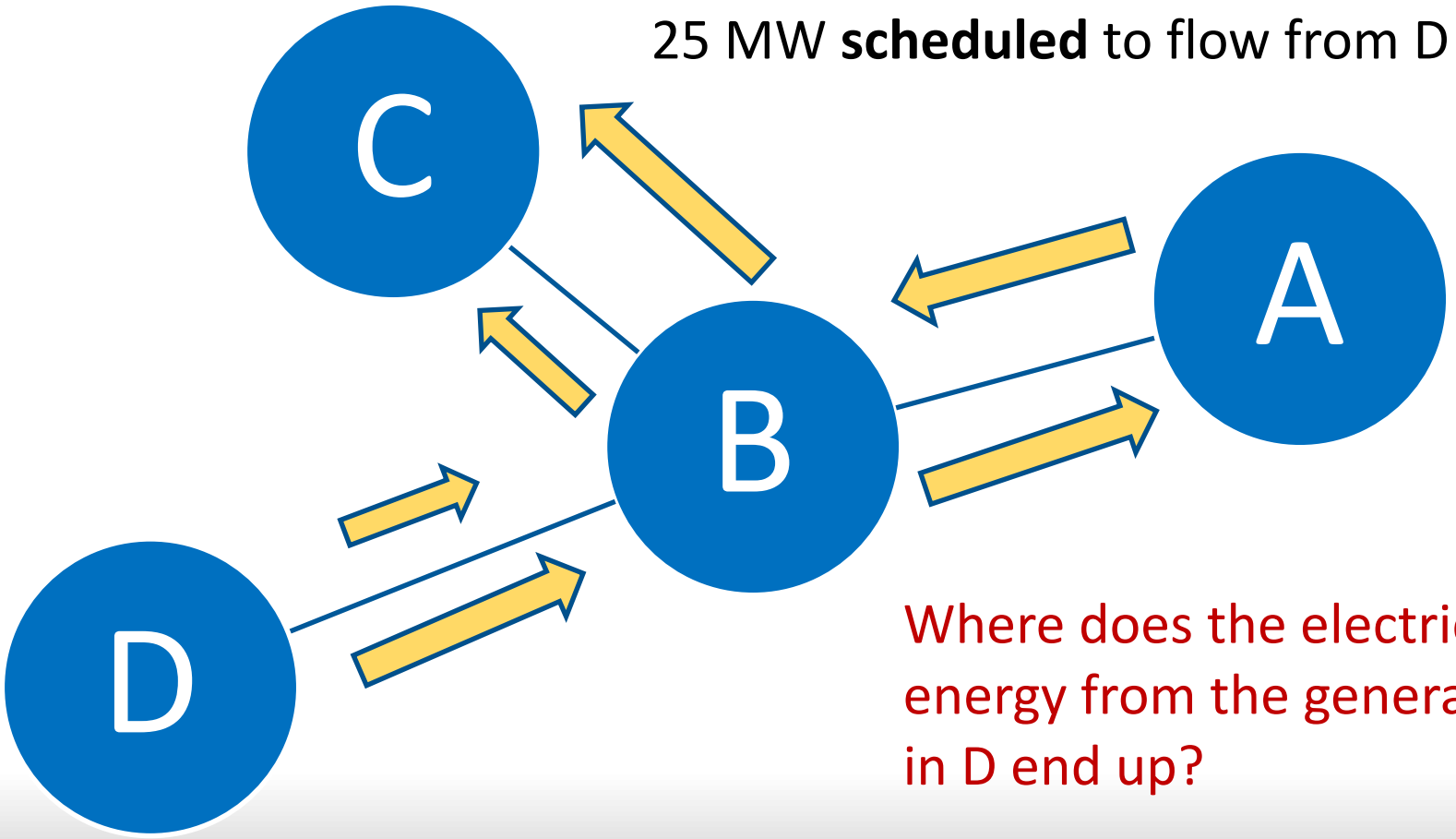
Where does the electrical energy from the generator in D end up?

Yet another transaction

- E-tag for one hour ending 11 am (HE 1100)
  1. Some generator in D, B intermediary, some delivery point in C
  2. 25 MW scheduled
  3. Schedule time (HE 1000 to HE 1100)
  4. Delivered to Control Area C
  5. Terms of interruption and reserve responsibility
  6. Ramp 20 minutes from 9:50 am to 10:10 am
  7. Effective Time 10:00 am
- Transmission service for 25 MW is obtained from control areas D, B and C to the point of delivery.

Hour ending 1100

25 MW **scheduled** to flow from A to C,
50 MW **scheduled** to flow from D to A,
25 MW **scheduled** to flow from D to C



Where does the electrical energy from the generator in D end up?

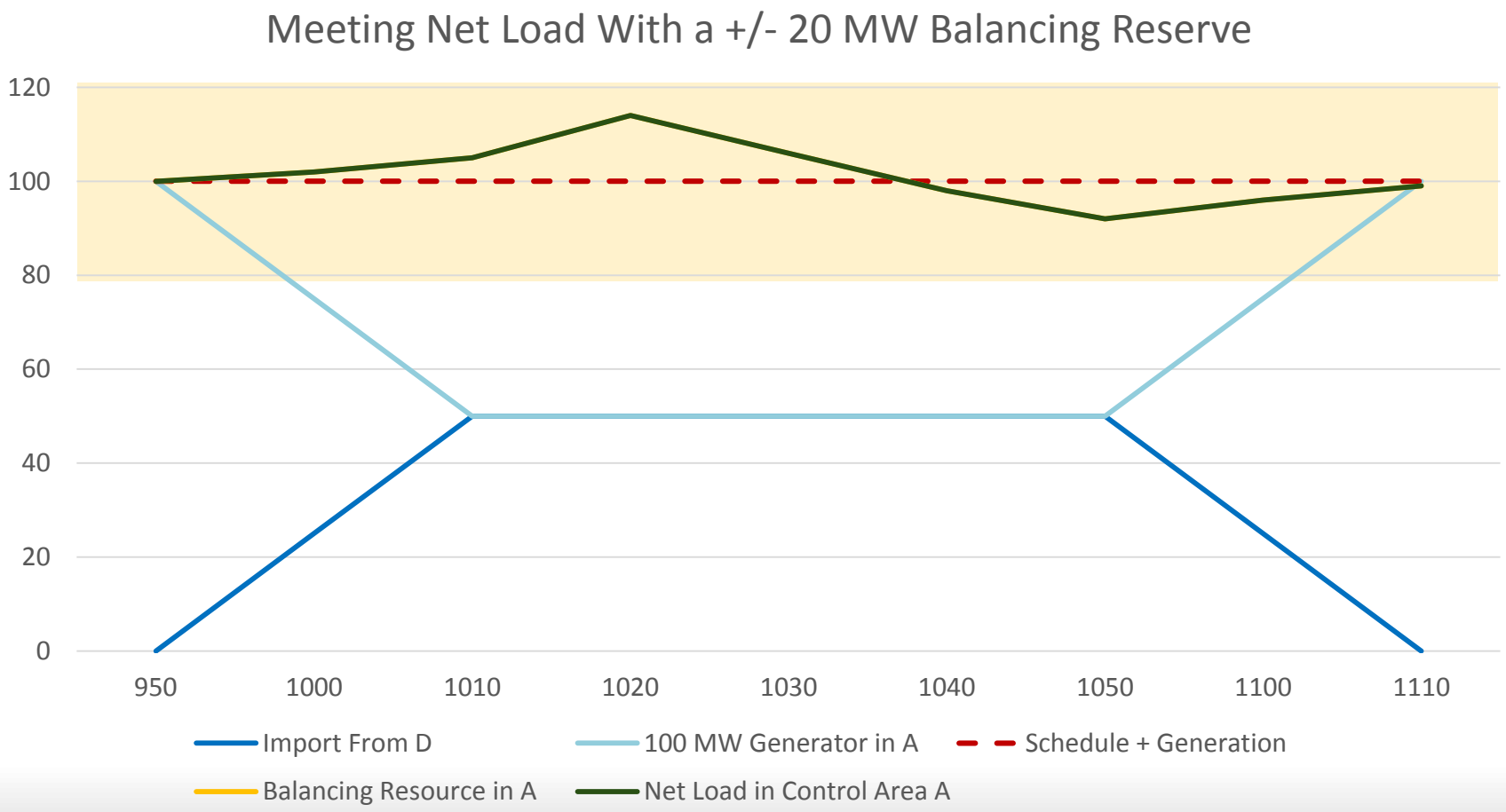
What happened in HE 1100?

- Control area A is a net importer (25 MW)
- Control area B is an intermediary (for 25 to 100 MW depending on the path)
- Control area C is a net importer (50 MW)
- Control area D is a net exporter (75 MW)

Balancing Reserves (pre-EIM)

- Inside the scheduling time period (1 hour) the market is not available.
- LSE's and variable energy resource schedulers must often contract for balancing services and/or hold back reserve capacity to account for intra-schedule variability to alleviate any supply and demand differences.

Load Resource Balance



Regional Wholesale Power Markets

Pacific Northwest markets are primarily made up of *bilateral* transactions.

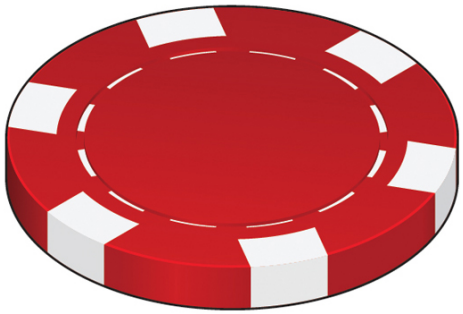
- Two parties transact one or more of the following:

1. Future right to generation (physical power)
2. Future transmission rights (transmission service on a path)
3. Fixed or index price (financial or “swap”)

Forward Power Contracts

Forward Contract Lengths

1. Long-Term:(5 to 20 years)
   - Power Purchase Agreements
   - Usually in Integrated Resource Plans
2. Term and/or Mid-Term (1 to 5 years)
   - Often for hedging financial risk
3. Current Year
   - Seasonal
   - Balance of Month
   - Preschedule
   - Real-Time



Power Price Hedging

- Most wholesale power market transactions are financial (more liquidity from banks).
- Fixed for floating swap
  - Trade a fixed price of the underlying for an index (floating) price.
  - Financial fixed contract matched with index/spot purchase of power gives purchaser a virtual forward contract on power (locks in power price).

Fixed for Floating Swap Example

Utility hedges for price risk

Buy 25 MW a few months ahead of time for hour ending 2100 on 3/14/17 hour 10 am to 11 am at $20 per MWh in early March, from Bank X

Utility buys physical power on spot market.

At 9:20 pm on 3/14/17, buy 25 MW of power at $28 per MWh from a power producer for the 10 pm to 11 pm.

Utility gets 25 MWh * 20 $ per MWh = $500 at and the bank gets 25 MWh * 23 $ per MWH = $575 which translates into a $75 loss for the bank.

This transaction is like if the utility made a physical power purchase a few months ahead for $20 per MWh.

Increases Liquidity of Financial Market

- Disaggregation of price and physical power delivery increases liquidity.
- Banks and financial institutions don't want physical power, but want to make financial bets on the price of power.
- Utilities want to hedge price volatility for customers.
- Financial liquidity concerns are exchanged adequate physical supply concerns.

Seems like a good job for A.I., right?

- Forecast error in demand net expected supply can be mitigated by scheduling techniques and holding reserves.
  - Blackouts can be prevented by good planning and skilled schedulers.
- Organized markets supposedly make adequacy a non-issue, and operational efficiency/good bidding leads to financial success

Organized Market: CAISO

- Day-Ahead Market
  - Participants submit schedules and bids
  - Bid in supply clears bid in demand
  - Procure reserves: regulation, spin and non-spin reserves
  - Residual unit commitment for reliability, not enough bid in supply to meet bid in demand.
  - Open seven days before until closing at 10 am the day before trade date.
  - All supply bids get paid Location Marginal Pricing made up of the following:
    1. System marginal cost for energy (all accepted bids get paid)
    2. Marginal cost of congestion and/or losses

Real-time: CAISO

- The real-time market includes a fifteen minute market and real-time economic dispatch every five minutes.
- The day-ahead market results make up almost all of the energy used in real-time.
- Additional needs are made up by residual committed units and supplemental bids, if necessary.
- Real-time market opens by 1:00 pm the day prior to the trade day and closes 75 minutes before the trade hour.

Organized Market Summary:CAISO

- Economics and reliability are handled by ISO
- Bidding strategy for day-ahead and real-time market handled by market entity.
- Longer term transactions are still bilateral.
- For more information on CAISO market structure:

http://www.caiso.com/CBT/Real-TimeMarketOverview_CBT/presentation.html

Organized versus Bilateral Markets – High level

- Both bilateral and organized markets use forecasting and energy scheduling to limit the amount of demand that is unplanned.
  - Longer term deals are bilateral in both.
- Balancing reserves cover the demand that is unplanned.
- Independent market operators coordinate efficient dispatch.
- Reserve sharing groups and long-term transmission coordination substitute for market operator adequacy planning.

Review of life on the trading floor

Scheduling transactions up to the hour...

- **Long-term, mid-term, term and balance of month trading**
- **Preschedule trading**
  - Trading for the next day
  - Mostly on-peak and off peak blocks of power
  - 25 MW increments
  - Change position per risk appetite
- **Real-time trading**
  - 24 hours to 30 minutes before scheduling time period
  - Less liquidity, more volatile pricing
- **Dispatch**
  - Scheduled generation and balancing reserves ensure power supply meets demand instantaneously.