Economic Transmission Expansion Planning

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ABB Acquires Ventyx - Overview

- **Transaction**
  - ABB Group closed acquisition of Ventyx on June 1, 2010.
  - Ventyx is a leading global software provider to energy, utility, and other asset-intensive businesses, offering asset management, mobile workforce management, energy commercial operations and energy analytics solutions.
  - ABB is a leader in power and automation technologies that enable utility and industry customers to improve their performance while lowering environmental impact.
- **Transaction enhances ABB Energy and Utility industry software systems leadership**
  - Ventyx will be combined with ABB Power System's network management business.
- **ABB GridView & Ventyx PROMOD IV**
  - "Best of Both Worlds" approach to integration and solution development.
  - Combined capabilities produce the most in-depth solutions and expertise available.

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Market Planning Models for Transmission Analysis

Capacity Investment — MarketPower, Strategist

New unit construction, economic retirements, conversions & retrofits

Security-Constrained Unit Commitment — PROMOD IV, GridView

Unit generation & cost curves, area interchange, DC tie flows, PAR settings

(Optimal) Power Flow — PowerWorld, PSS/E, PSLF

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Software Requirements

- **Reliability tests for new projects requires detailed powerflow analysis for future "snapshots" of system conditions (peak, low-load, etc.) with assumed generation and net interchange schedules.**
- **Economic analysis requires market simulation and production cost calculations over a broad period, ideally a full 8760 hours for one or more years.**
- **Unit commitment and dispatch should be optimized to meet hourly load and ancillary service requirements, while respecting generation operating constraints and transmission topology and flowgate limits (referred to as Security Constrained Unit Commitment, or SCUC).**

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Software Requirements (cont'd)

- A widely accepted methodology is a DC Optimal Power Flow, which ignores voltage and reactive flow issues, but can be modified to account for marginal transmission losses.
- Net Scheduled Interchange between areas/markets should be dynamically determined based on economics, subject to hurdle rates representing tariffs or market inefficiencies.
- Locational Marginal Pricing (LMP) should be calculated for load zones and generation buses for screening and estimating import/export costs (even for non-LMP markets).
- Transmission line and flowgate loading should be calculated, along with congestion information such as frequency and costs.

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Database Requirements

- Starts with the base powerflow case(s) used for reliability analysis (and other purposes).
- Flowgate definitions should be synched up with the powerflow case, including interface limits, nomograms, and any contingencies.
- Load should be mapped into areas with an hourly load forecast, which may be a historical shape adjusted for a peak and energy forecast.
- Ancillary service requirements should be set on a regional basis.
- Hurdle rates for interchange between markets should be established (may be the basis for different scenarios).

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Database Requirements: Generation

- **Every generator in the powerflow case should be mapped into a generator database which includes the following:**
  - Constraints
    - Minimum & Maximum Capacity (with seasonal profile)
    - Minimum Runtime & Downtime
    - Ramp Up & Down Limits
    - Ancillary Services Contribution
  - Outages
    - Planned Maintenance Requirements
    - Forced Outage Rate & Mean Time to Repair
  - Costs
    - Heat Rates with Fuel Types and Delivered Fuel Price Forecasts
    - Emission Rates with Allowance Price Forecasts
    - Startup Fuel Requirements and Additional Costs
    - Variable O&M
- **Most of these will use category assumptions that apply across several units**

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Database Requirements: Capacity Expansion

- **Interconnection queue and previously approved transmission projects**
- **State (and federal) Renewable Portfolio Standards (RPS)**
- **Locational Capacity Market Requirements**
- **Use of Strategist or MarketPower**
  - MarketPower: Regional or national market-based expansion based on equilibrium of capacity and zonal energy prices
  - Strategist: State- or utility-level least cost expansion plan using return on rate base

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Benchmarking

- **Key Metrics:**
  - Generation by type
    - Capacity Factor
    - Number of Starts
    - Hours Online
  - Transmission Flowgates
    - Hourly Flow Distribution
    - % Hours Congested
  - Market Prices
    - Market Heat Rates
    - Seasonal and On Peak/Off Peak Differentials
    - Regional Differentials
    - Hourly Price Distribution

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Screening Potential Projects: Flowgate Congestion Frequency & Costs

Pivot Cube - Annual Flowgate

File Help

Over All ...

Date: (All)

RunId: (All)

Year: (All)

FromBusKvRating: (All)

FromPoolName: (All)

ToBusKvRating: (All)

ToPoolName: (All)

omPowerFlowAre: (All)

oPowerFlowArea: (All)

Graph: Display, Options...

Column: Data Item (All), UOM (All)

Constraint	SensitivityHoursAtMax: (HOURS)	SensitivityTotalAtMax: (K$)
92INTERFACE TOT 2A	7,271.00	-121.65
94INTERFACE BONANZA WEST	6,406.00	-91.46
64094SLVR PK 64096SLVR PS 1	5,601.00	-56.92
66INTERFACE ALBERTA - BRITISH CO	4,879.00	-48.60
2NOMO Combined_4a_4b	2,525.00	-39.36
64025CAL SUB 64023CAL S PS 1	7,903.00	-35.37
125INTERFACE MIDPOINT - SUMMER	5,539.00	-34.01
26061RINALDI 26094SYLMARLA 1	803.00	-17.37
20118ROA-230 20103WIS-230 1	173.00	-16.25
181INTERFACE WYOMING TO UTAH	6,622.00	-15.53
177INTERFACE NW to Canada East BC	5,120.00	-13.60
30790PANOCHE 30825MCMULLN1	28.00	-11.62
60240MIDPOINT 60385ROCKY PK	1,915.00	-10.14
86INTERFACE PACIFICORP_PG&E 115	4,178.00	-9.47
24728INYO 24730INYO PS 1	1,783.00	-9.29
15021PALOVRDE 15061RUDD 1	465.00	-8.99
9NOMO JohnDyPDCI 1EVENT	3,272.00	-8.89
123INTERFACE Z6-COI	2,514.00	-8.78
99INTERFACE TOT 4B 1EVENT	1,026.00	-6.62
91INTERFACE TOT 1A	852.00	-6.15
96INTERFACE TOT 2C	2,445.00	-4.50

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Screening Potential Projects: LMP Decomposition

Pivot Cube - Decomp

File Help

Over All ...

Year: (All)

UOM: (All)

RunId: (All)

Month: (All)

Date: (All)

BusName: (All)

Data Item: (All)

BusNumber: (All)

Graph: Display Options...

Column: Areas (All)

Constraint	PG&E_BAY	PG&E_VLY	SANDIEGO	SIERRA	SOCALIF	SW WYO	UT N	UT S	WAPA L_C
60240MIDPOINT 60385ROCKY PK 1	-0.16	-0.15	0.11	-0.05	0.09	-0.07	-0.02	0.12	0.00
62062RIMROCK 62061RMRK PHA 1	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	-0.00
62082BILINGS 62045BLGS PHA 1	0.00	0.00	-0.00	0.00	-0.00	-0.00	0.00	0.00	0.00
63002CRSOVRUM 63001CROS PHA 1		0.00		-0.00		0.00	-0.00	-0.00	0.00
64017BRDRTNPS 64018BRDRTWN 1	0.01	0.01	-0.01	-0.20	-0.01	0.02	0.01	0.00	-0.00
64025CAL SUB 64023CAL S PS 1	0.02	0.03	-0.02	-0.35	-0.02	0.02	0.01	0.01	-0.00
64053FT CHUR 64048FT CH PS 1	0.01	0.01	-0.01	-0.50	-0.01	-0.02	-0.04	-0.06	-0.00
64094SLVR PK 64096SLVR PS 1	-0.01	-0.01	0.00	-0.13	0.02	0.00	-0.00	-0.00	-0.00
66INTERFACE ALBERTA - BRITISH CO									
78INTERFACE IDAHO - SIERRA	-0.00	-0.00	0.00	-0.03	0.00	0.00	0.00	-0.00	0.00
79INTERFACE BORAH WEST	0.00	0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00
7NOMO JohnDyCOI 1EVENT 1	0.05	0.05	-0.04	0.07	-0.03	-0.01	0.01	0.03	-0.00
80150IH500 26199UPLND500 1	0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	-0.00	0.00
81INTERFACE BRIDGER WEST	0.00	0.00	-0.00	0.01	-0.00	-0.02	-0.00	0.00	0.00
82INTERFACE PATH C 1EVENT	-0.00	-0.00	0.00	-0.03	0.00	-0.00	0.06	0.03	0.00
84INTERFACE SOUTHWEST OF FOUR CO	-0.00	-0.00	0.00	0.01	0.00	0.00	0.00	-0.00	-0.00
86INTERFACE PACIFICORP_PG&E 115	0.00	0.00	-0.00	-0.00	-0.00			0.00	
89INTERFACE INTERMOUNTAIN - MONA	0.00	0.00	-0.00	0.01	-0.00	-0.00	-0.00	-0.00	-0.00
90INTERFACE INTERMOUNTAIN - GOND				0.00				0.00	
91INTERFACE TOT 1A 1EVENT	0.00	0.00	-0.00	0.04	-0.00	0.05	0.06	0.06	0.00
92INTERFACE TOT 2A 1EVENT	-0.14	-0.13	0.13	1.55	0.07	0.74	1.08	1.40	0.01
93INTERFACE PAVANT INTRMTN - GON	-0.05	-0.05	0.04	-1.88	0.02	0.08	0.27	0.46	0.00
94INTERFACE BONANZA WEST	0.03	0.02	-0.03	0.88	-0.01	0.15	1.23	1.34	0.01

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Defining the Change Case(s)

- All parameters associated, including new buses, transformers, re-conductered lines, etc. (should already be part of a revised powerflow case)

- Changes to existing path ratings, and adding any new flowgates or contingencies

Assessing Benefits and Costs

- **WECC Benefit (entire footprint):**
  - Δ Total Production Costs
- **Regional / LMP Market:**
  - Interchange Costs between markets/regions may be based on split savings, buyer's LMP, or seller's LMP
  - Market Benefit (such as CAISO): Δ Area Production Costs + Δ Import Cost - Δ Export Revenue
- **Market Participants:**
  - Interchange within a market is based on LMP, with allocations of congestion through CRR/FTR mechanisms
  - Participant Benefit (such as PG&E): Δ Company Production Costs + Δ Demand Cost - Δ Generator Revenue - Δ Hedged Congestion

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Participant Benefit Example

BEFORE		MW	Cost $	Avg Cost	Value	LMP
Company A	Generation	2,200	$ 57,200	$ 26.00	$ 66,000	$ 30.00
	Load	1,900	$ 4,513	$ 2.38	$ 60,800	$ 32.00
Company B	Generation	1,500	$ 52,500	$ 35.00	$ 60,000	$ 40.00
	Load	2,100	$ 4,988	$ 2.38	$ 86,100	$ 41.00
Total	Generation	3,700	$ 109,700	$ 29.65	$ 126,000	
	Load	4,000			$ 146,900	
	Net Interchange	(300)			$ (11,400)	$ 38.00
	Congestion				$ 9,500	
AFTER						
Company A	Generation	2,450	$ 64,925	$ 26.50	$ 85,750	$ 35.00
	Load	1,900	$ 1,579	$ 0.83	$ 67,450	$ 35.50
Company B	Generation	1,000	$ 30,000	$ 30.00	$ 36,000	$ 36.00
	Load	2,100	$ 1,746	$ 0.83	$ 77,700	$ 37.00
Total	Generation	3,450	$ 94,925	$ 27.51	$ 121,750	
	Load	4,000			$ 145,150	
	Net Interchange	(550)			$ (20,075)	$ 36.50
	Congestion				$ 3,325	

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Participant Benefit Example

CHANGE		MW	Cost $	Avg Cost	Value	LMP
Company A	Generation	250	$ 7,725	$ 30.90	$ 19,750	$ 5.00
	Load	-	$ (2,933)		$ 6,650	$ 5.00
Company B	Generation	(500)	$ (22,500)	$ 45.00	$ (24,000)	$ (4.00)
	Load	-	$ (3,242)		$ (8,400)	$ (4.00)
Total	Generation	(250)	$ (14,775)		$ (4,250)	
	Load	-			$ (1,750)	
	Net Interchange	(250)			$ (8,675)	
	Congestion				$ (6,175)	

	Company A	Company B	Total
Production Costs	$ (7,725)	$ 22,500	$ 14,775
Demand Cost	$ (6,650)	$ 8,400	$ 1,750
Generator Revenue	$ (19,750)	$ 24,000	$ 4,250
Hedged Congestion	$ 2,933	$ 3,242	$ 6,175
TOTAL BENEFIT	$ 2,442	$ 3,658	$ 6,100

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