Demand Response Triggers Project: Overview and Update on Results

September 15, 2009

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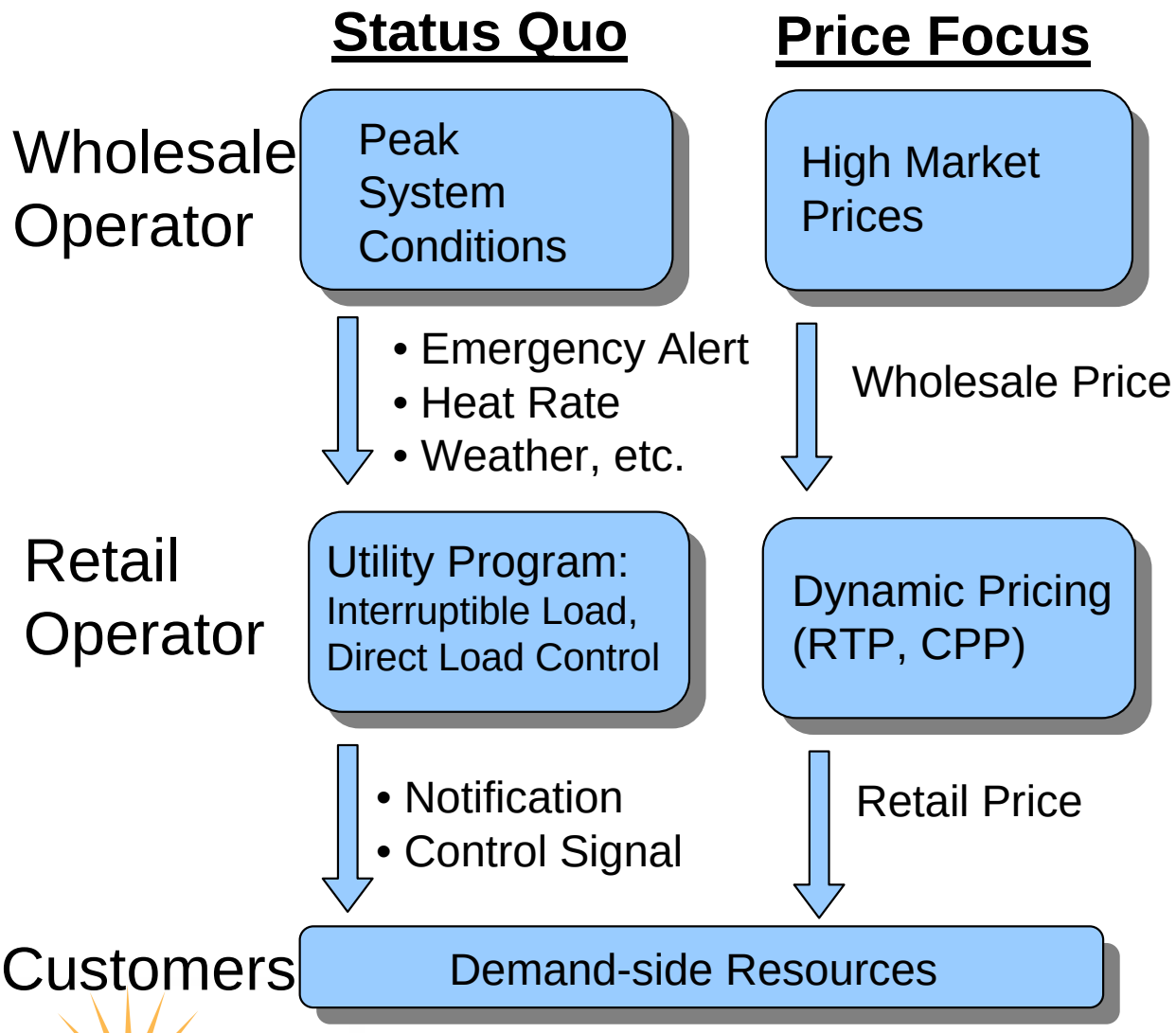
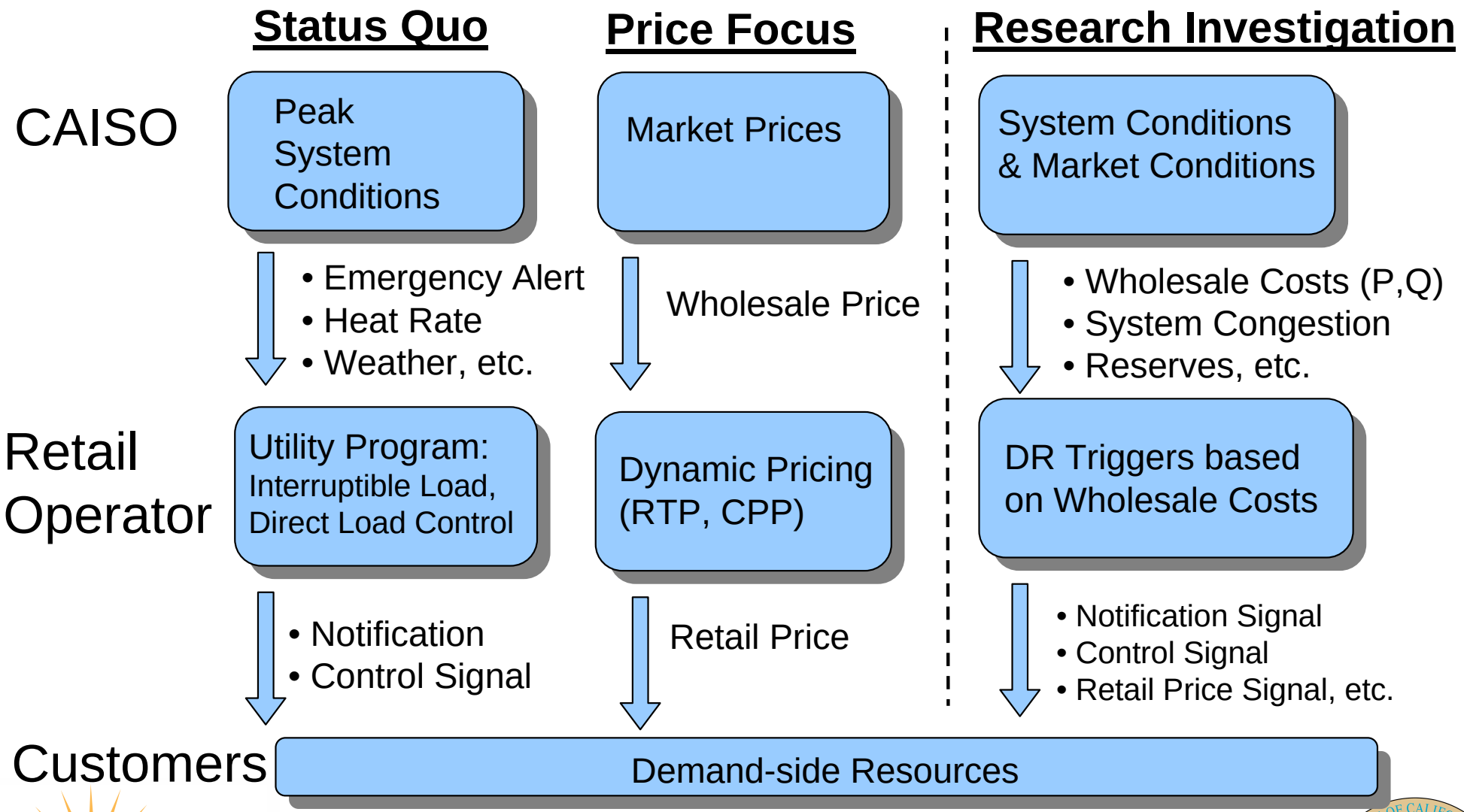
Electric Power Research Institute

Background: Status Quo



Retail markets (the demand-side) largely disconnected from wholesale markets

Background: Research Investigation



Retail load aware of the financial impact of wholesale markets in time to trigger DR to mitigate wholesale costs

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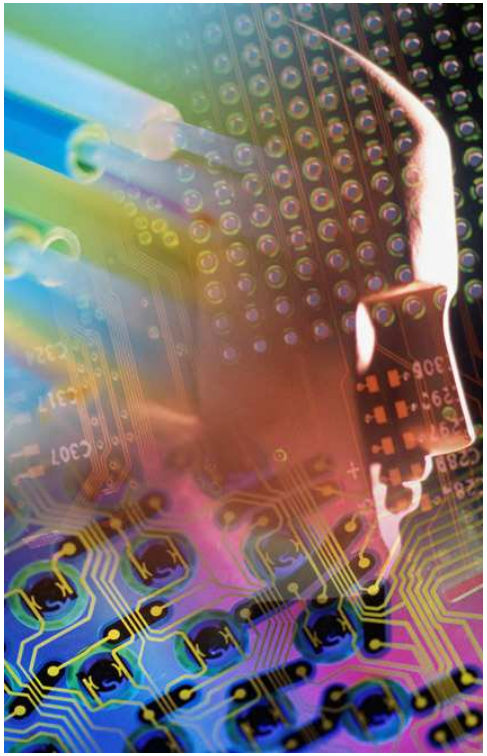
Project Tasks

- Trigger Methodology Development
- Information Technology Specification
- Proof-of-Concept Demonstration
- Reporting and Publication



Specify, develop, and demonstrate a method for energy retailers to trigger demand response in a fashion that financially links retail with wholesale electricity markets

Collaborative Team

Project Team:

Southern California Edison — An Edison International Company

EPRI — Electric Power Research Institute

ECCO International Inc. — Energy Consulting

\+ Consultants

Other Contributors:

PG&E

California ISO — Your Link to Power — 10 Year Anniversary 1998–2008

Department of Water Resources — State of California

SDGE — Sempra Energy utility

PIER — Public Interest Energy Research — "Research Powers the Future"

State of California — Energy Commission

Project Status

Analyze and Prioritize Charge Codes

- Identified Charge Codes sensitive to Demand Response
- Industry outreach
- Aggregated settlements to identify significant charge codes
- Prioritized charge codes (pre-MRTU and MRTU equivalents)

Develop Trigger Methodology and Specify Requirements:

Devise Trigger Methodology

Assumptions & Data Availability

Requirements Specification

Assess Potential Benefits

- Devise method for assessing DR impact on wholesale settlements
- Document assumptions
- Investigate input data availability
- Draft specification for envisioned tool to support short-term procurement personnel beyond status quo
- Vet with market participants to finalize and prioritize requirements

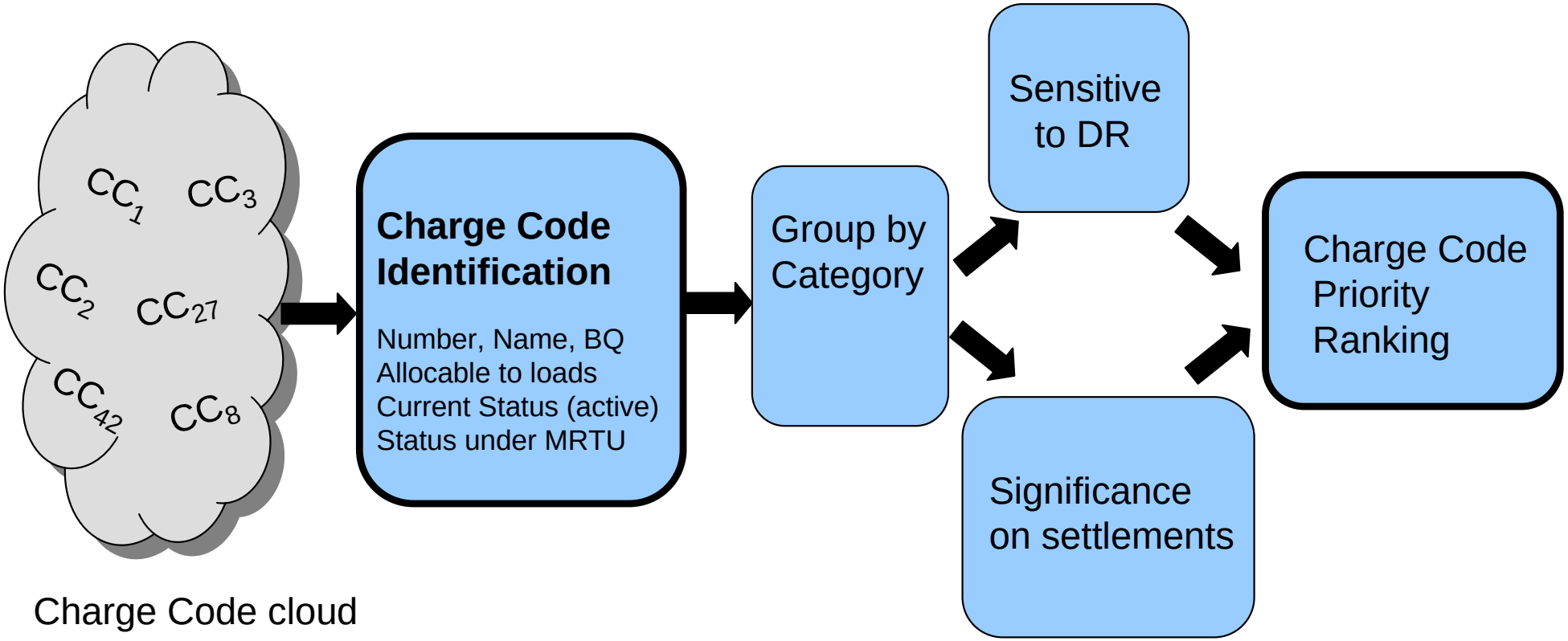
Develop and Demonstrate Prototype

- Develop prototype of Day-ahead and Day-of screens
- Limited function proof-of-concept prototype demonstration

Publish Report

- Summarize findings in report and gather feedback
- Final Edits
- Publication

Charge Code and Data Analyses



Priority Ranking: Top Charge Codes

- 16 Priority Charge Codes continued or were replaced under MRTU

* MD02 Charge Code Number	MD02 Charge Code Name	MRTU Charge Code Number	MRTU Charge Code Name	Priority
2	Day Ahead Non-Spinning Reserve due SC	6200	Day Ahead Non Spinning Reserve	1
52	Hour Ahead Non-Spinning Reserve due SC	6250	HASP Non-Spinning Reserve	1
111	Spinning Reserve due ISO	6194	Spinning Reserve Obligation Settlement	1
112	Non-Spinning Reserve due ISO	6294	Non-Spinning Reserve Obligation Settlement	1
115	Regulation Up Due ISO	6594	Regulation Up Obligation Settlement	1
116	Regulation Down Due ISO	6694	Regulation Down Obligation Settlement	1
372	High Voltage Access Charge due ISO	372	High Voltage Access Charge Allocation	2
550	FERC Fee	550	FERC Fee Settlement due Monthly	2
1401	Imbalance Energy Offset	6477	Real Time Imbalance Energy Offset	3
4401	Instructed Energy	6470	Real Time Instructed Imbalance Energy Settlement	1
4406	Unaccounted for Energy	6474	Real Time Unaccounted for Energy Settlement	1
4407	Uninstructed Energy	6475	Real Time Uninstructed Imbalance Energy Settlement	1
4487	Allocation of Excess Cost for Instructed Energy	6486	Real Time Excess Cost for Instructed Energy Allocation	3
4501	GMC-Core Reliability Services Non-Coincident Peak	4501	Core Reliability Services - CRS Peak Demand	2
4505	GMC-Energy Transmission Services Net Energy	4505	Energy Transmission Services - Net Energy	2
4534	GMC-Market Usage Ancillary Services	4534	Market Usage - Awarded AS	2

Highest priority for proof-of-concept are Ancillary Service and Imbalance Energy Charge Codes

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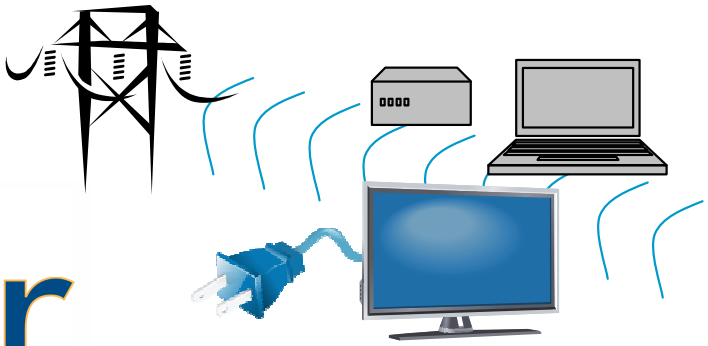
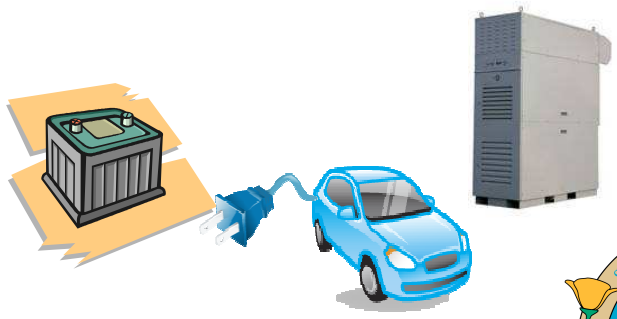
What is meant by Demand Response?

Dynamic change in electricity usage coordinated with system or market conditions

- Facilitated through **demand response programs** designed to coordinate electricity usage with power system or market needs

- Utilizes **demand-side resources**
  - on the end-use side of the meter
  - can be relied on to respond in coordinated fashion
  - distributed generation, storage, dispatchable load, etc.





Approach for Developing Trigger Methodology

- Step1: Start with highest priority CCs and work down
- Step 2: Document CC formulations and identify input data
  - Understand billable quantity and Price as a function of Load
  - Charge = Price(Load) * BillableQuantity(Load)
- Step 3: Analyze CCs by impact of change in load on charge
  - Derive ΔCharge/ΔLoad "change in charge with respect to a change in load"
  - Identify assumptions
- Step 4: Analyze availability of input data
  - Timeframe available (operational timeframe desired)
  - Source of input data (systems) and accessibility by market participants
- Step 5: Devise method of estimating data unavailable in operational timeframes
  - Historical data (e.g., from settlements or other input sources)
  - Fixed fees/prices by FERC/CAISO
- Step 6: Summarize trigger method for a collection of charge codes
  - Simplify calculations (e.g. , treat charges in groups or compute impact by similar BQ)
  - Summarize assumptions

Derivation of Trigger Impact Based on Ancillary Service Charge Group

Let $Charge_{ASGroup} = Charge_{Spin} + Charge_{NSpin} + Charge_{RegUp} + Charge_{RegDown} + Charge_{GMCMktUsageAS}$.

Then

$$\frac{\Delta Charge_{ASGroup}}{\Delta Load} = \frac{\Delta Charge_{Spin}}{\Delta Load} + \frac{\Delta Charge_{NSpin}}{\Delta Load} + \frac{\Delta Charge_{RegUp}}{\Delta Load} + \frac{\Delta Charge_{RegDown}}{\Delta Load} + \frac{\Delta Charge_{GMCMktUsageAS}}{\Delta Load}.$$

Since $\frac{\partial\left(\sum_i C_i(L)\right)}{\partial L} = \sum_i \frac{\partial C_i(L)}{\partial L}$ "The derivative of a sum is the sum of the derivatives"

Example of Derived Trigger Impact on "Regulation Up/Down due ISO" (CC115 / 116)

- Assumptions
  - Variables assumed to be independent of demand response

    For 115: *RegUpRate, EffectiveSelfProvidedRegUp, RegUpReqDA, RegUpReqHA, TotalEffSelfProvRegUp*

    For 116: *RegDownRate, EffectiveSelfProvidedRegDown, RegDownReqDA, RegDownReqHA, TotalEffSelfProvRegDown*

  - The change in *TotalLoad* due to a change in an SC's *Load* is negligibly small.

- Results

$$\frac{\Delta Charge_{115}}{\Delta Load} \approx \frac{RegUpRate * (RegUpReqDA + RegUpReqHA + TotalEffSe\ lfProvRegU\ p)}{TotalLoad}$$

$$\frac{\Delta Charge_{116}}{\Delta Load} \approx \frac{RegDownRat\ e * (RegDownReq\ DA + RegDownReq\ HA + TotalEffSe\ lfProvRegD\ own)}{TotalLoad}$$

where $Rate_{product} = \frac{(PayTotalDA_{product} + PayTotalHA_{product})}{ReqDA_{product} + ReqHA_{product}}$

Analyzed Availability of Input Data:

Variables	System or SC Quantity	Data Availability & Timeframe	Example	For ΔCC Spin	For ΔCC Nspin	For ΔCC RegUp	For ΔCC RegDown
Metered Load	SC	per SC	500.00 MW	Yes	Yes	Yes	Yes
Total System Load	System	HE+1, RT, CAISO	25,000.00 MW			Yes	Yes
Firm Exports	SC	HE+1, SC	100.00 MW	Yes	Yes		
Firm Imports	SC	HE+1, SC	400.00 MW	Yes	Yes		
Hydro Gen	SC	HE+1, SC	50.00 MW	Yes	Yes		
Total Base Operating Reserve Requirement	System	HE+1, CAISO	240.50 MW	Yes	Yes		
Total Effective Self Provided MW	System	HE+1, CAISO	25.00 MW	Yes	Yes	Yes	Yes
Product PayTotalDA	System	T-1, CAISO	$600	Yes	Yes	Yes	Yes
Product Pay Total HA	System	HE-1, CAISO	$65	Yes	Yes	Yes	Yes
Product Req HA MW	System	HE-1, CAISO	150.00 MW	Yes	Yes	Yes	Yes
Product Req DA MW	System	T-1, CAISO	25.00 MW	Yes	Yes	Yes	Yes
Product Rate	System	HE-1, T-1, CAISO	3.80 $/MW	Yes	Yes	Yes	Yes

Potential Benefit: Triggering during Top Priced Intervals

(1/1/08-11/30/08)

Date	Hour	Delta_Reg Down_Charge / Delta_Load	(RegUpReq+ TotSelfProv)/ TotLoad	Delta_Reg Up_Charge / Delta_Load	(SpinReq+Tot SelfProv)/Tot BaseOpResReq	Delta_Spin_Charge / Delta_Load	(NspinReq+TotSelf Prov)/Tot BaseOpResReq	Delta_NonSpin_Charge / Delta_Load	Factor	Delta_CC4534_Charge / Detla_Load	Delta_AS_ChargeGroup / Delta_Load	Top 24 Interval?	Value of Trigger (during Top 24 Intervals)
11/29/2008	9	0.0161141	0.01842748	0.2029347	0.499996724	0.1359373	0.499997	0.043107	0.07	0.06415398	0.462247617		
11/29/2008	10	0.0223867	0.0159364	0.1289674	0.49999364	0.1264277	0.499994	0.047099	0.07	0.06398327	0.388863739		
11/29/2008	11	0.0243477	0.01600547	0.2162329	0.5	0.0688265	0.5	0.045584	0.07	0.06400516	0.418996277		
11/29/2008	12	0.0225561	0.01510108	0.1867445	0.499993693	0.0874563	0.499994	0.044751	0.07	0.06393366	0.405441715		
11/29/2008	13	0.013915	0.01537605	0.1902084	0.5	0.073834	0.5	0.047107	0.07	0.06395566	0.389019734		
11/29/2008	14	0.015273	0.01619876	0.2188293	0.500006376	0.0670259	0.500006	0.047737	0.07	0.0640236	0.412888523		
11/29/2008	15	0.0185965	0.01585847	0.1961673	0.500003209	0.0687013	0.500003	0.0462	0.07	0.06399026	0.393655761		
11/29/2008	16	0.024604	0.0157945	0.1953655	0.499993612	0.0687622	0.499994	0.045359	0.07	0.06399006	0.398081005		
11/29/2008	17	0.0180779	0.01420142	0.1756979	0.500002887	0.073109	0.500003	0.051021	0.07	0.06388138	0.381787465		
11/29/2008	18	0.0080859	0.01438266	0.4162167	0.499997131	0.3232901	0.499997	0.051828	0.07	0.06382445	0.863244693		
11/29/2008	19	0.0081658	0.0141992	0.3749168	0.499994157	0.3307369	0.499994	0.051347	0.07	0.06381351	0.828980204		
11/29/2008	20	0.0086262	0.01731128	0.3371634	0.5	0.0954718	0.5	0.051167	0.07	0.06401522	0.556443228		
11/29/2008	21	0.026365	0.01416703	0.3167917	0.500003265	0.2898097	0.500003	0.049983	0.07	0.06390814	0.746857835		
11/29/2008	22	0.0601742	0.0158289	0.5144441	0.500006748	0.2744363	0.500007	0.048585	0.07	0.06409938	0.961738551		
11/29/2008	23	0.0215956	0.01556682	0.3915481	0.499996546	0.2971299	0.499997	0.049981	0.07	0.06407699	0.824331242		
11/29/2008	24	0.0528538	0.01686871	0.3543364	0.500003661	0.0829144	0.500004	0.03756	0.07	0.06420038	0.591864811		
11/30/2008	1	0.0173174	0.01814851	0.2929192	0.5	0.0732441	0.5	0.028727	0.07	0.06406149	0.476269298		0
11/30/2008	2	0.0184223	0.01860145	0.3002541	0.5	0.0275087	0.5	0.027982	0.07	0.06408877	0.438255453		0
11/30/2008	3	0.0231514	0.01863784	0.3007715	0.5	0.0275823	0.5	0.027953	0.07	0.06409466	0.443552517		0
11/30/2008	4	0.0289464	0.01860963	0.3002646	0.5	0.0275943	0.5	0.027952	0.07	0.06411914	0.448876931		0
11/30/2008	5	0.0286196	0.01841132	0.2971728	0.500007604	0.0275284	0.500008	0.028035	0.07	0.06410611	0.445461699		0
11/30/2008	6	0.0243934	0.0178338	0.2878573	0.499996344	0.0276945	0.499996	0.02819	0.07	0.06408334	0.432218738		0
11/30/2008	7	0.0401997	0.01929217	0.4543499	0.49999635	0.2737025	0.499996	0.036176	0.07	0.06420474	0.868633125		0
11/30/2008	8	0.0687394	0.01738759	0.2151141	0.499989471	0.0732315	0.499989	0.036112	0.07	0.06421992	0.457416615		0
11/30/2008	9	0.0460403	0.01633918	0.2697519	0.5	0.0730557	0.5	0.04266	0.07	0.06405478	0.49556307		0
11/30/2008	10	0.0285098	0.01584338	0.2991313	0.499996777	0.0715785	0.499997	0.044345	0.07	0.06394406	0.507509121		0
11/30/2008	11	0.0445404	0.01591222	0.3799558	0.499996816	0.0698725	0.499997	0.046341	0.07	0.06401083	0.604720537		0
11/30/2008	12	0.0595576	0.01527507	0.4417376	0.499996845	0.0728219	0.499997	0.046939	0.07	0.06400436	0.685060122		0
11/30/2008	13	0.0568312	0.01488242	0.4461265	0.499996847	0.0742054	0.499997	0.047466	0.07	0.06400261	0.688631832		0
11/30/2008	14	0.0571641	0.01487505	0.4494084	0.5	0.0742215	0.5	0.04796	0.07	0.06400252	0.692755995		0
11/30/2008	15	0.074458	0.0148763	0.3375215	0.500003211	0.0742101	0.500003	0.048311	0.07	0.06404029	0.598541121		0
11/30/2008	16	0.0475144	0.01477266	0.3368189	0.499996835	0.0741975	0.499997	0.048679	0.07	0.06402567	0.571235613		0
11/30/2008	17	0.0327491	0.01760865	0.2440432	0.499997084	0.2084063	0.499997	0.052347	0.07	0.06412072	0.601666709		0
11/30/2008	18	0.0066153	0.01718603	0.3561132	0.499991209	0.2130438	0.499991	0.046019	0.07	0.06395204	0.685742915		0
11/30/2008	19	0.0032526	0.01517627	0.4797026	0.499997045	0.256356	0.499997	0.046021	0.07	0.06380145	0.849134082		0
11/30/2008	20	0.0162344	0.01505155	0.3424057	0.500003006	0.250628	0.500003	0.045357	0.07	0.06385536	0.71848079		0
11/30/2008	21	0.0178264	0.01516274	0.5541564	0.499990831	0.2321718	0.499991	0.053173	0.07	0.06386946	0.921196905		0
11/30/2008	22	0.0106962	0.01438235	0.5276437	0.500003159	0.2621757	0.500003	0.048922	0.07	0.06378262	0.913219834		0
11/30/2008	23	0.0310788	0.01596061	0.3621086	0.499996649	0.0742245	0.499997	0.047553	0.07	0.06396044	0.578925181		0
11/30/2008	24	0.0548768	0.01784529	0.3951278	0.49999633	0.0717247	0.499996	0.046471	0.07	0.06418625	0.632386606		0
													2,155

15.5151525
15.69150878
16.3107934
16.32150501
16.59660689
17.1071083
17.65775665
18.09549313
18.47529603
19.09316355
20.33608731
21.1108606
21.11828318
22.25749953
23.85866343
24.63045605
25.16193539
26.91920874
27.37883259
28.58108561

1MW operating reserve from DR can capture $1000's in avoided Ancillary Service Charges during top 317 hours

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Trigger Impact based on Imbalance Energy Charge

- Documented settlement charge formula for each priority Imbalance energy charge code
  - "Uninstructed Energy due SC" (CC6475, CC4407)
- Took derivative of charge formula with respect to load

$$\frac{\Delta Charge_{4407}}{\Delta Load} = -P_{ex-post} \qquad \frac{\Delta Charge_{6475}}{\Delta Load} = -\lambda_{Avg}$$

- Determined data available in operational timeframes
  - RT LMP from CAISO
  - RT LMP Forecasts from third parties

Potential Benefit: Triggering during Top Priced Intervals
(1/1/08-1/31/09)

Algorithm 1: Trigger DR during top hours
(when imbalance energy prices exceed threshold)

Location	No. of Top Hrs	with Prices Above ($/MWh)	No. Dates top hours occur across	Trigger impact during top hours ($/MW)
NP15	100	244	58	$30,551
NP15	93	250	55	$28,827
NP15	78	260	47	$25,007
NP15	68	270	42	$22,368
NP15	55	280	36	$18,786
NP15	54	290	35	$18,504
NP15	49	300	33	$17,029
NP15	43	310	29	$15,206
SP15	100	235	56	$27,271
SP15	83	250	49	$25,792
SP15	71	260	42	$22,737
SP15	62	270	38	$20,366
SP15	51	280	32	$17,332
SP15	50	290	31	$17,050
SP15	43	300	27	$14,984
SP15	38	310	24	$13,469

Algorithm 2: Trigger DR during top hours
(when imbalance energy prices exceed threshold but only on days with multiple top hours)

Location	No. Top Hours	with Prices Above ($/MWh)	No. Days with multiple top hours	No. Top Intervals on these days	Trigger Impact during top intervals on these days ($/MW)
NP15	117	230	29	84	$25,557
NP15	93	250	24	60	$19,492
NP15	78	260	20	52	$17,125
SP15	105	230	24	71	$21,683
SP15	83	250	19	[illegible]	$16,902
SP15	71	260	[illegible]	46	$15,211

1MW DR can capture $10,000's in avoided imbalance energy charges during peak priced hours (for imbalance energy) on top two dozen or so days.

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Requirements Specification: Guiding Principles

- Objective of decision support tool: Use DR for short-term procurement economics
  - decision support tool to determine impact of triggering DR on wholesale settlements
  - information for short-term procurement personnel to determine whether in the money
- Basic functions: Get data, do calculations, create report
  - Show current state and what amount of DR have available to inform the decision
- Specification: Specify Wish List of functions and then prioritize
- Prototype: Get something built quickly and then add more later

Day-Ahead Screen

Day-Ahead | Day-of | Configure | Scenario

Charge Category

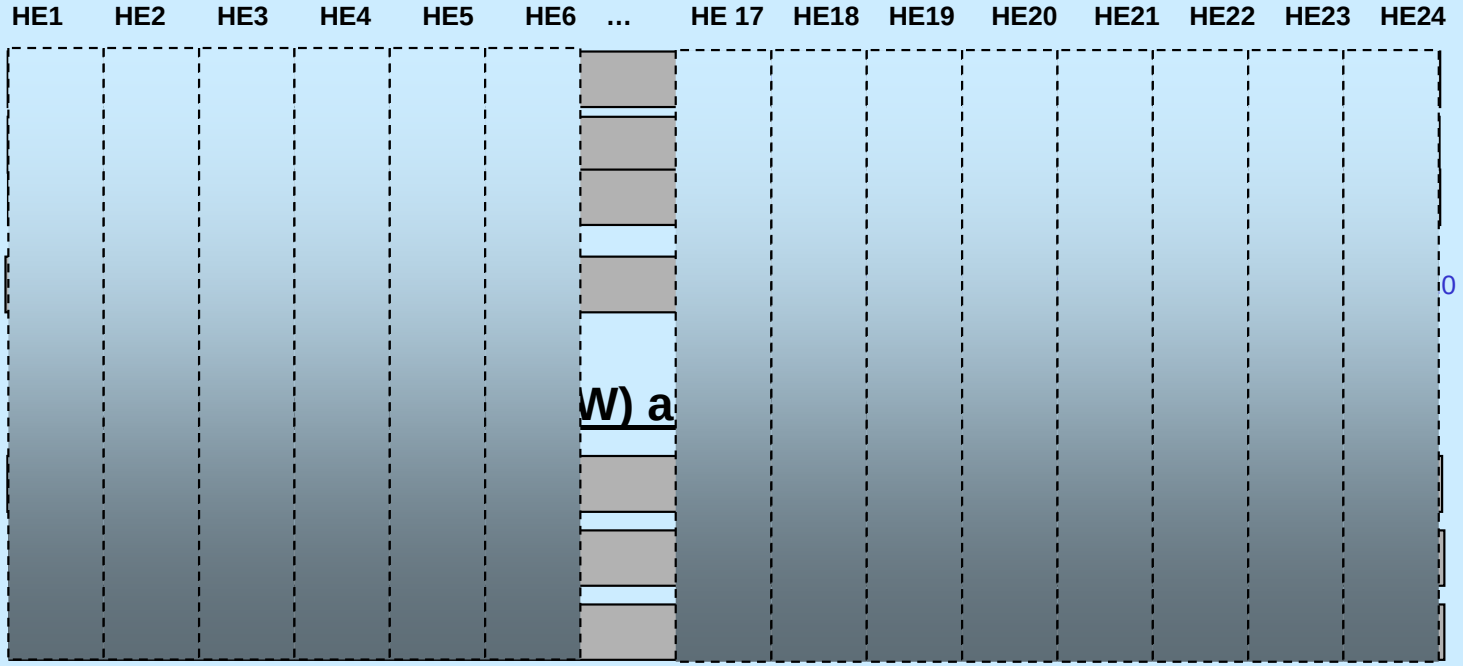
Imbalance Energy

Ancillary Service

GMC

Total Impact

Hourly Trigger Impact



Resource Name

- [x] PeakC Res1
- [x] CBP Res2
- [x] DBP Res3

Check to show DR Program resources

Select: Location

CAISO_Sys

Pull-down menu to select location to estimate trigger impact

Select: Mode

Latest MRTU Data [ ]

Hourly Forecasts [x]

Update

Performs on-demand 1) trigger impact calculation using latest available DA data. Can export interval-by-interval details to Excel.

Next Steps

- Develop proof-of-concept for participant feedback
- Capture feedback
  - Identification of useful information to present (e.g., Screen design)
  - Operational constraints, timeframes and supporting functions, etc.
- Develop full implementation plan
  - Beyond limited function proof-of-concept prototype
  - Include trigger impact calculations for other priority charge codes
- Final report and publication

Together…Shaping the Future of Electricity

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