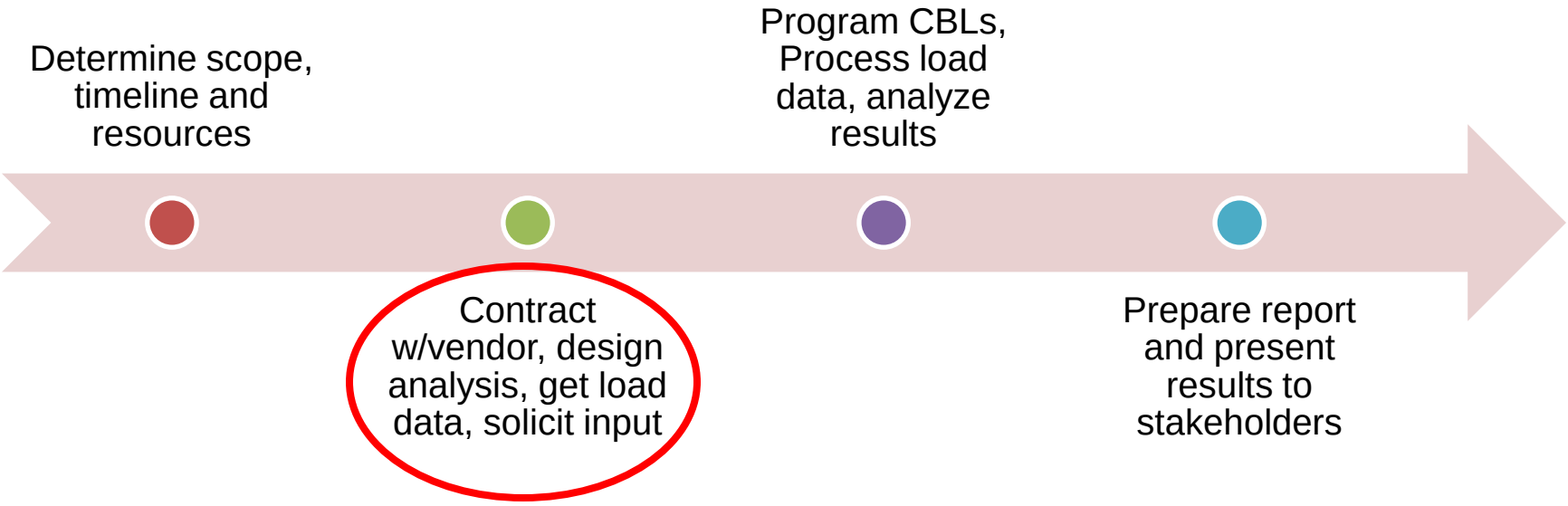
PJM Empirical Analysis of Demand Response Baseline Methods

LMTF

1/13/2011

- Primary Project Objectives:
  - Determine the accuracy and bias of a variety of CBL methods
  - Identify any obstacles to implementation associated with candidate baseline methods
  - Develop objective criteria to associate a customer load type with a specific CBL method

Project Timeline



Objective #1 – Evaluate Accuracy of Baseline Methods

1) Evaluate the accuracy and bias of current and proposed baseline methods for the Economic and Emergency Programs
2) Identify any obstacles to implementation associated with candidate baseline methods
3) Attempt to identify objective criteria for choice among multiple, accurate baseline methods

Proposed Baselines

- PJM economic CBL
  - High 4 of 5
  - with symmetric additive adjustment
  - with simple weather adjustment
  - with regression CBL
  - with alternative weather adjustment
- PJM emergency energy settlement

- PJM emergency GLD
  - Comparable Day (weather sensitive)
  - Comparable Day1 (non-weather sensitive)
  - Same Day1
- Regression Model(s)
  - ERCOT
  - Other (KEMA/PJM/MA)
- ISONE: standard CBL
- CAISO: standard CBL
- NYISO: economic CBL
  - High 5 of 10

Primary Focus

- Existing Emergency and Economic participants
  - Approximately 11,000 program participants will be used as the basis for the analysis
  - Continuous interval load data will need to be secured from participants

Secondary Focus

- EDC Load Research Data
  - Used to compare program participants to general EDC C&I population
  - PJM will solicit interval load data for C&I customers from selected EDC load research programs

Load Data Request

- Data Request
  - Request for **hourly data** was issued to market participants **Dec 17**
  - Hourly data requested to be delivered by **Jan 07**
  - Data requested for period June 2008 thru Sep 2010
  - Minimum data requirements necessary to accommodate regression baselines
- Some EDCs have indicated they need more time to compile the load data - this may impact overall timeline.
  - PJM working with EDCs to determine options to minimize impact.

Selected Test Periods

- Expect to use days from Oct 2009 through Sep 2010 that include:
  - Days for each season
  - High and low price days
  - Different days of the week (especially weekday vs. weekend days)
  - Morning and Afternoon hours

CBL evaluation metrics

- Statistical selection rules will be calculated at the account level during the likely event period
  - Bias
    - **Average Relative Error:** The average error divided by average load
  - Variability
    - **Error Ratio:** The standard deviation of the error divided the average load
  - Accuracy (reflecting both Bias and Variability)
    - **Relative RMSE:** Root mean square error divided by the average load

3 metrics will be used to determine performance of CBL methods for energy

Objective #2 – Identify Obstacle to Implementation

1) Evaluate the accuracy and bias of current and proposed baseline methods for the Economic and Emergency Programs
2) Identify any obstacles to implementation associated with candidate baseline methods
3) Attempt to identify objective criteria for choice among multiple, accurate baseline methods

Determine level of effort for different CBL methods

- Identify market participants involved in administration
  - CSP, EDC, LSE, Customer, PJM
- Identify key business processes that require significantly more effort for one baseline method vs. another
  - Data collection & maintenance
    - Regression may require multiple years of data which may need to be purchased
      - Load Data and Weather Data (temp, THI, etc.)
    - Average approach may only require 5 days of load data which does not need to be purchased
    - Need for full Meter Data Management system and associated maintenance
      - CSP may need to develop or purchase
  - CBL development and administration
    - Regression may require senior Load Research Analyst to develop and validate
    - Average approach may only require junior or mid-level analyst
  - Customer education
  - Reporting, transparency and auditing

Level of Complexity

Same Day
- Load prior and/or after event

Average
- Average load over a few days prior to event

Average w/Adjustment
- Average load over a few days prior to event with adjustment based on event day usage

Regression
- Year of historic load, weather and event data
- Multiple regression equations (e.g.: 25 – see appendix for ERCOT model description)
- Adjustments

Objective #3 – Objective Criteria for Selecting Baseline Method

1) Evaluate the accuracy and bias of current and proposed baseline methods for the Economic and Emergency Programs
2) Identify any obstacles to implementation associated with each baseline method
3) Attempt to identify objective criteria for choice among multiple, accurate baseline methods

- Determine if transparent customer segmentation will result in significantly better results
  - Customer segmentation must be reasonably transparent so market understands “which CBL” will go with “what type of customer”
  - Potential for:
    - Weather sensitive vs. non-weather sensitive
    - High variability of hourly load vs. Low variability of load
    - Customer Size - if significant difference in administrative cost
    - Energy vs. Capacity

- Analyze results segmented by:
  - Customer specifics:
    - Size
    - Segment (Commercial vs. Industrial)
    - Load variability
    - Load weather sensitivity
  - Time
    - Season
    - Time of day (morning vs. afternoon)
    - High vs. Low price days

Appendix

- CBL evaluation metrics – examples
- ERCOT regression method

- CBL evaluation metrics - examples

CBL evaluation metrics

		Baseline Hourly Loads (kW)						Actual Hourly Loads (kW)						Average Baseline kW	Average Actual kW
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)
														= average(a:f)	= average(g:l)
customer	**Date**	**1-2PM**	**2-3PM**	**3-4PM**	**4-5PM**	**5-6PM**	**6-7PM**	**1-2PM**	**2-3PM**	**3-4PM**	**4-5PM**	**5-6PM**	**6-7PM**		
1	18-Aug-09	508	520	517	506	488	461	492	494	500	502	502	481	500	495
2	18-Aug-09	83	82	72	53	47	35	64	59	38	47	5	5	62	36
3	18-Aug-09	349	342	287	267	237	196	326	322	313	301	294	222	280	296
4	18-Aug-09	3,482	3,468	3,843	3,606	3,556	3,445	3,771	3,761	3,730	4,023	3,487	3,361	3,567	3,689
5	18-Aug-09	439	445	446	416	425	404	383	382	383	381	387	391	429	385
6	18-Aug-09	386	397	394	370	229	194	353	386	375	312	235	178	328	307
7	18-Aug-09	92	92	92	93	92	92	82	85	83	85	84	86	92	84
8	18-Aug-09	3,204	3,229	3,257	3,208	3,185	3,115	2,964	2,964	2,961	2,386	2,833	2,770	3,200	2,813
9	18-Aug-09	660	625	568	532	493	482	613	583	566	551	535	499	560	558
10	18-Aug-09	6,397	6,377	6,322	6,308	6,411	6,343	7,165	7,098	7,047	6,918	6,799	6,820	6,360	6,975

Average Relative Error:
The average error divided by average load

		Average Baseline kW	Average Actual kW	Average Error (kW)	Error (%)
		(m)	(n)	(o)	(p)
Source		= average(a:f)	= average(g:l)	= (n - m)	= o / n
customer	**Date**				
1	18-Aug-09	500	495	(5)	-1%
2	18-Aug-09	62	36	(26)	-71%
3	18-Aug-09	280	296	17	6%
4	18-Aug-09	3,567	3,689	122	3%
5	18-Aug-09	429	385	(45)	-12%
6	18-Aug-09	328	307	(22)	-7%
7	18-Aug-09	92	84	(8)	-10%
8	18-Aug-09	3,200	2,813	(387)	-14%
9	18-Aug-09	560	558	(2)	0%
10	18-Aug-09	6,360	6,975	615	9%

10th percentile	-19%
Median	-4%
Mean	-10%
90th percentile	6%

Error Ratio:
The standard deviation of the error divided the average load

		Actual Hourly Error (kW)						Std Dev	Average Actual kW	Error Ratio
		(u)	(v)	(w)	(x)	(y)	(z)	(q)	(n)	(r)
								=stddev(u:z)	= average(g:l)	= q / n
customer	**Date**	**1-2PM**	**2-3PM**	**3-4PM**	**4-5PM**	**5-6PM**	**6-7PM**			
1	18-Aug-09	(16)	(26)	(17)	(4)	14	20	18	495	0.04
2	18-Aug-09	(19)	(23)	(34)	(6)	(42)	(30)	13	36	0.35
3	18-Aug-09	(23)	(20)	26	34	57	26	32	296	0.11
4	18-Aug-09	289	293	(113)	417	(69)	(84)	236	3,689	0.06
5	18-Aug-09	(56)	(63)	(63)	(35)	(38)	(13)	20	385	0.05
6	18-Aug-09	(33)	(11)	(19)	(58)	6	(16)	22	307	0.07
7	18-Aug-09	(10)	(7)	(9)	(8)	(8)	(6)	1	84	0.02
8	18-Aug-09	(240)	(265)	(296)	(822)	(352)	(345)	218	2,813	0.08
9	18-Aug-09	(47)	(42)	(2)	19	42	17	36	558	0.06
10	18-Aug-09	768	721	725	610	388	477	153	6,975	0.02

Median	0.06
Mean	0.09
90th percentile	0.13

Relative RMSE:
Root mean square error divided by the average load

		Actual Hourly Error (kW)						MSE	Average Actual kW	Relative RMSE
		(u)	(v)	(w)	(x)	(y)	(z)	(s)	(n)	(t)
								$\Sigma e^2/n$ (see note)	= average(g:l)	=SQRT(s)/(n)
customer	**Date**	**1-2PM**	**2-3PM**	**3-4PM**	**4-5PM**	**5-6PM**	**6-7PM**			
1	18-Aug-09	(16)	(26)	(17)	(4)	14	20	306	495	0.04
2	18-Aug-09	(19)	(23)	(34)	(6)	(42)	(30)	791	36	0.77
3	18-Aug-09	(23)	(20)	26	34	57	26	1,114	296	0.11
4	18-Aug-09	289	293	(113)	417	(69)	(84)	61,308	3,689	0.07
5	18-Aug-09	(56)	(63)	(63)	(35)	(38)	(13)	2,319	385	0.13
6	18-Aug-09	(33)	(11)	(19)	(58)	6	(16)	871	307	0.10
7	18-Aug-09	(10)	(7)	(9)	(8)	(8)	(6)	66	84	0.10
8	18-Aug-09	(240)	(265)	(296)	(822)	(352)	(345)	189,009	2,813	0.15
9	18-Aug-09	(47)	(42)	(2)	19	42	17	1,065	558	0.06
10	18-Aug-09	768	721	725	610	388	477	397,577	6,975	0.09

Note: (s) = (u)^2 + (v)^2 + (w)^2 + (x)^2 + (y)^2 + (z)^2 / (count of hours)

Median	0.10
Mean	0.16
90th percentile	0.22

ERCOT Regression Method

ERCOT Regression Model

- ERCOT's standard regression baseline model consists of:
  - One equation modeling daily energy (kWh_d), as a function of daily weather and calendar information, and
  - Twenty-four equations modeling the fractions of daily energy occurring in each hour ($Frac_{d,h}$), focused on factors affecting the distribution of loads throughout the day

- Daily energy model includes:
  - Calendar variables (day of week, holiday, weekday/weekend)
  - Weather variables (avg. temp, “degree-days” employing various cut-points, weather-based day types, daily temp gain)
  - Daylight variables (DST, daylight hours)
  - Interactions and lags

- Hourly equations include:
  - Calendar variables (day of week, holidays, season)
  - Weather variables (time-of-day temps, weather-based day types)
  - Daylight variables (Fraction of the hour that is dark—dawn and dusk hours only)
  - Interactions and lags

- Event-day adjustment
  - Applied to baseline to improve accuracy
  - Actual kWh summed across the 3 hours before event start-time
  - Same thing for baseline kWh
  - Adjustment factor is actual ÷ baseline
  - Unadjusted baseline kWh for each interval during the event is multiplied by the factor