

PRESENTATION OF FINDINGS

SWE Demand Response Potential Report

04/08/2015

Presented by the Statewide Evaluation Team:

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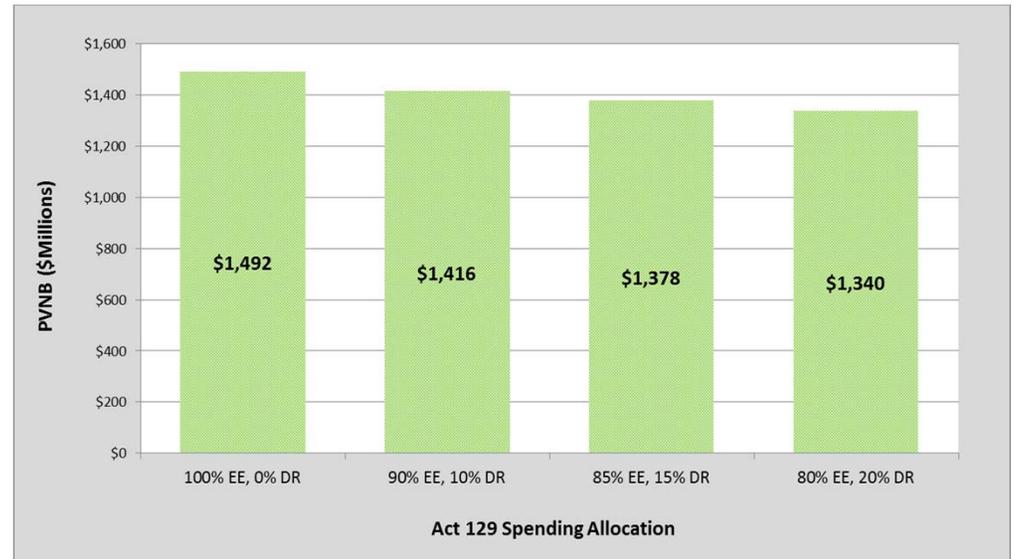

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HOW TO ALLOCATE ACT 129 FUNDS TO EE AND DR?

- Present Value of Net Benefits (TRC Benefits – TRC Costs)
- 4 Scenarios
 - 100% EE, 0% DR
 - 90% EE, 10% DR
 - 85% EE, 15% DR (Phase I split)
 - 80% EE, 20% DR



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TWO PJM SCENARIOS (15% ACT 129 DR SPEND)

Business as Usual at PJM

EDC	Average Annual Potential Savings (MW)	TRC
Duquesne	51	1.94
FE: Met-Ed	*50	1.90
FE: Penelec	*0	NA
FE: Penn Power	20	1.93
FE: WPP	76	1.94
PECO	199	1.69
PPL	*95	1.88
Statewide	492	1.82

Wholesale Changes (No PJM DR After 2017/2018)

EDC	Average Annual Potential Savings (MW)	TRC
Duquesne	51	1.94
FE: Met-Ed	73	1.90
FE: Penelec	68	1.92
FE: Penn Power	20	1.93
FE: WPP	76	1.94
PECO	199	1.69
PPL	222	1.88
Statewide	709	1.82



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PROGRAM DESIGN



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MOTIVATION

- The amount of load available to and attainable by a DR program depends on program design variables:
 - When will events be called?
 - What triggers an event? How many events per year will likely result from this trigger?
 - How long will they last?
 - What time of day will they begin?
- SWE Team needed a program design to estimate potential
- Top 100 Hours performance definition from Phase I was not cost-effective
- Data-driven approach to assess effectiveness of various program designs



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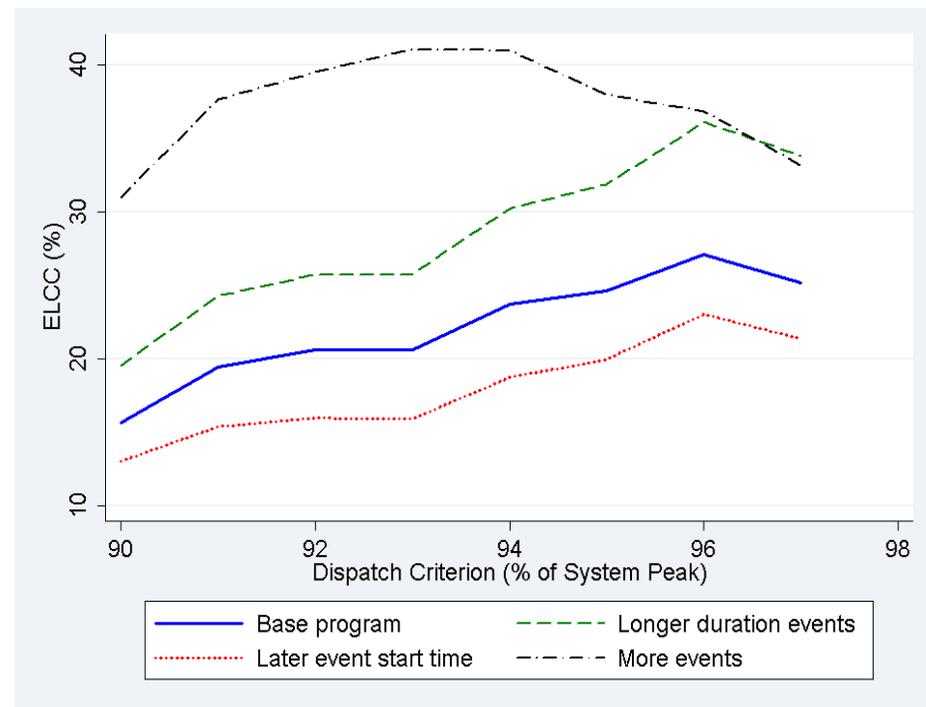
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PROGRAM DESIGN

- Effective Load Carrying Capacity (ELCC)
- $ELCC = \frac{\sum \text{Design Coincident } p90 \text{ load}}{\sum p90 \text{ load}}$
- Analysis conducted on RTO-level data
- System peak values taken from PJM load forecast reports
- Interplay between multiple design factors



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ELCC TRADEOFFS

ELCC(%)	5CP Captured (%)	Dispatch Criterion (%)	Event Start (Hour Ending)	Last Event Hour (Hour Ending)	Event Duration (hrs.)	Max No. Events	Average No. Events
27.1	57.5	96	15	18	4	6	4.1
26.4	55.0	96	16	19	4	6	4.1
25.3	55.0	96	14	17	4	6	4.1
25.2	55.0	97	15	18	4	6	3.4
24.6	52.5	95	15	18	4	6	4.4
24.3	50.0	97	16	19	4	6	3.4
24.2	62.5	96	16	18	3	8	4.6
24.2	55.0	97	14	17	4	6	3.4
24.2	60.0	94	16	18	3	8	5.8
23.8	62.5	94	15	17	3	8	5.8
23.7	65.0	96	15	17	3	8	4.6
23.7	50.0	94	15	18	4	6	4.6
23.6	50.0	95	16	19	4	6	4.4
23.4	60.0	95	16	18	3	8	5.3
23.1	62.5	95	15	17	3	8	5.3
23.0	52.5	96	17	20	4	6	4.1
22.9	50.0	95	14	17	4	6	4.4
22.6	57.5	96	17	19	3	8	4.6
22.6	47.5	94	16	19	4	6	4.6
22.0	47.5	94	14	17	4	6	4.6
21.9	52.5	94	17	19	3	8	5.8
21.9	60.0	97	15	17	3	8	3.6
21.6	10.0	96	14	16	3	8	4.6
21.6	70.0	93	16	17	2	12	8.6



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ELCC INTERPRETATION

- We selected a program design consisting of the following:
 - 24 total DR program hours
 - 96th percentile “trigger” of projected peak load for the delivery year
 - Event duration 4 hours
 - No more than 6 events
 - Event window is from 2 pm to 6 pm
- May result in zero events in a cool summer (2008, 2009)
- Could exhaust resources (n=19 in 2011)
- No uncertainty about which hours count



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ELCC CAVEATS

- The goal is to identify an effective program design
 - Subject to definition of “effective”
 - Multiple performance criteria require tradeoffs: 5CP vs. total load reduction
- This program design is used to estimate DR potential
 - The number of hours affects the incentive amount
 - **If the program design changes, DR potential changes**
- DR suppliers are likely to have preferences for non-incentive program attributes (frequency, duration, timing, etc.)



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KEY ASSUMPTIONS

- The goal is avoid costly generation capacity
- In PJM, DR is a supply-side resource (1:1)
- Act 129 DR
 - Actual load reductions during key hours lower PJM's forecast
 - Lower forecast = lower reliability requirements
 - 1:1 assumption is unproven
 - Econometric model
 - Observed loads can affect the forecast for multiple years
 - Study monetizes generation capacity using BRA values
- July 2, 2014 call with PJM



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T&D AVOIDED COSTS BY EDC

EDC	Average T&D Avoided Cost per kW-year for 2016	Average Transmission Only Avoided Cost per kW-year for 2016
Duquesne	\$40.88	\$40.88
FE: Met-Ed	\$40.98	\$14.77
FE: Penelec	\$40.98	\$14.77
FE: PennPower	\$40.98	\$14.77
FE: WPP	\$40.98	\$14.77
PECO	\$49.27	\$3.88
PPL	\$20.10	\$0.00



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RESIDENTIAL DIRECT LOAD CONTROL PROGRAM



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RESIDENTIAL DR SUMMARY

- Analysis focused on direct load control for four end uses:
 - residential central air conditioning systems
 - window air conditioners
 - electric water heaters
 - swimming pool pumps



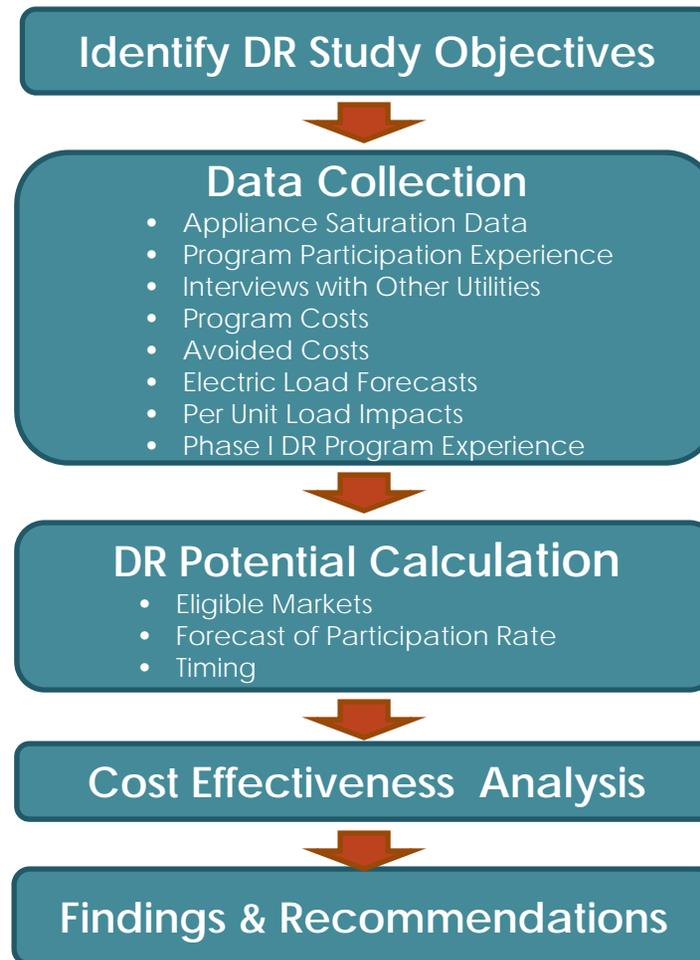
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Residential DR Potential Analysis



RESIDENTIAL DR BENEFITS AND COSTS

- Benefits
 - Avoided Generation
 - Avoided Transmission
 - Avoided Distribution
- Costs
 - Load control equipment
 - Central computer and software
 - Utility incentives to participants
 - Utility costs for program administration, marketing, data tracking and reporting, evaluation
 - Participant costs



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RESIDENTIAL DR – SWITCH FAILURE RATE

- Load control device, or switch failure rates were assumed at 3 percent per year.
- Source: PECO's benefit/cost analysis for the Company's A/C Smart Saver program –from PECO Phase II EE&C Plan filing



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RESIDENTIAL DR – OTHER INPUT DATA

Key Data for Residential DR Potential Study	Key Input Assumption
Cost of load control switch (equipment)	\$109
Installation cost per load control switch	\$91
Cost of central computer for load control	\$25,000
Useful life of load control equipment (years)	10
Maximum annual hours of load control	24
Annual \$ paid to each program participant (\$2016)	\$40
Annual participant cost (per unit, \$2016)	\$30
Annual rate of switch failure	3%
Avoided cost of generation capacity (\$2016)	\$43.38



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RESIDENTIAL DR ELIGIBLE MARKET

Name of EDC	Projected Total No. of PA EDC Residential Customers in 2016	Percent of EDC Residential Customers with Central Air Conditioning Systems from 2014 Baseline Study (%)	Eligible Market for Participation in Load Control Program for Residential Central A/C (No. of Residential Customers)	Actual Program Participation Rate Achieved During Phase I of Act 129 for Central A/C Load Control (%)	Forecast Program Participation Rate for Phase III	Total Number of Program Participants Forecast for a Phase III Residential Central A/C Control Program
TOTAL	4,987,101	63%	3,152,793	6.4%	12.50%	394,089



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RESIDENTIAL DR – PER UNIT LOAD IMPACTS

Key Data for Residential DR Potential Study	Duquesne Light Company	First Energy: Met-Ed	First Energy: Penn Elec	First Energy: Penn Power	First Energy: WPP	PECO	PPL
Per Unit Peak kW Reduction (at customer meter):							
Central A/C System	0.85	0.44	0.44	0.39	0.42	0.70	0.63
Electric Water Heater	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Room Air Conditioner	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Pool Pump	1.36	1.36	1.36	1.36	1.36	1.36	1.36



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TRC RESULTS – CENTRAL A/C CONTROL ONLY

EDC	Number of Program Participants	Average Annual Impact (MW at Generation Level)	Present Value of Program Benefits	Present Value of Program Costs	NPV of Benefits - NPV of Costs	Lifetime TRC Ratio
Duquesne	40,268	36.75	\$26,890,047	\$35,098,670	(\$8,208,624)	0.78
FE: Met-Ed	38,025	18.03	\$22,718,313	\$35,075,330	(\$12,357,017)	0.65
FE: Penelec	20,846	10.13	\$12,386,117	\$18,968,416	(\$6,582,299)	0.65
FE: PennPower	12,154	5.24	\$4,465,010	\$9,882,516	(\$5,417,506)	0.45
FE: WPP	51,133	23.71	\$30,301,372	\$47,164,543	(\$16,863,170)	0.64
PECO	108,049	82.20	\$68,684,924	\$65,334,434	\$3,350,490	1.05
PPL	80,072	55.46	\$48,813,983	\$64,151,543	(\$15,337,560)	0.76
Statewide	350,546	231.51	\$214,259,766	\$275,675,452	(\$61,415,686)	0.83



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TRC RESULTS – FOUR END USES CONTROLLED

EDC	Number of Program Participants	Average Annual Impact (MW at Generation Level)	Present Value of Program Benefits	Present Value of Program Costs	NPV of Benefits - NPV of Costs	Lifetime TRC Ratio
Duquesne	45,986	38.67	\$29,258,689	\$50,758,424	(\$21,499,735)	0.58
FE: Met Ed	52,475	22.62	\$29,582,690	\$47,927,900	(\$18,345,209)	0.62
FE: Penelec	15,802	5.88	\$6,302,159	\$13,203,170	(\$1,483,504)	0.48
FE: PennPower	55,410	25.16	\$31,683,691	\$50,703,963	(\$2,157,102)	0.62
FE: WPP	99,247	63.57	\$59,214,202	\$81,234,612	(\$22,020,410)	0.73
PECO	108,049	23.41	\$31,512,815	\$94,749,998	(\$63,237,183)	0.33
PPL	133,023	90.68	\$79,250,026	\$106,988,532	(\$31,088,995)	0.74
Statewide	459,201	269.98	\$266,804,271	\$445,566,598	(\$178,762,327)	0.60



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COMMERCIAL AND INDUSTRIAL PROGRAM



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LOAD CURTAILMENT ELIGIBILITY

- C&I Accounts:
 - Accounts with PLC > 75 kW
 - “Transparent DR” implicit to market structure
- Status quo is 2016 estimated PLC:
 - Segmented by business type
 - EDC’s provided 2012-2013 PLC estimates
- Economic Analysis
 - DR program incentive is equivalent to a price change
 - What is each segment’s price sensitivity?
 - Reservation Payment



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DR PRICE ELASTICITY

- Price-sensitivity of C&I customers
 - What do C&I customers forego to use electricity? (cost)
 - How much electricity would they forego in exchange for a DR payment?
- This is DR potential (supply of DR)
- Elasticity varies across segments
- Does not account for other preferences (i.e. frequency of DR)



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PRICE ELASTICITY EXAMPLE

- At \$0.09/kWh
 - Customer foregoes \$0.09 for each kWh consumed (P_0)
 - How much electricity would they forego in exchange for a DR payment?
- If segment represents 5 MW of EDC demand (Q_0):
 - With an elasticity value of -0.003 (ϵ):
 - Assume 24 DR program hours & incentive = \$25/kW ($P_1 = \$1.05/kWh$)
- After unit conversions, DR potential is :

$$\% \Delta Q = \% \Delta P * \epsilon \rightarrow -3.19\% \text{ of Electricity Demand;}$$
$$Q_1 = 4.84 \text{ MW or } 0.16 \text{ MW of DR}$$



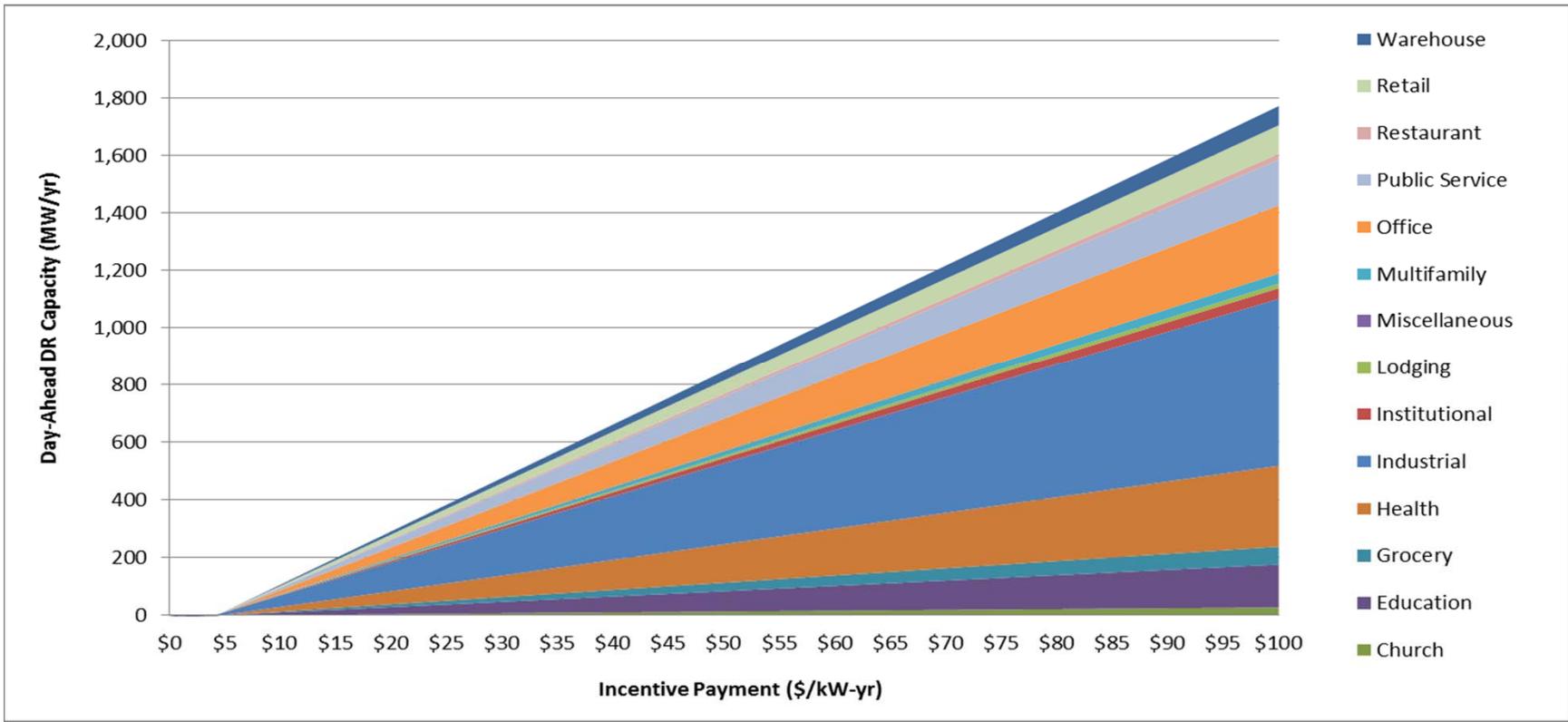
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DAY-AHEAD POTENTIAL (PECO)



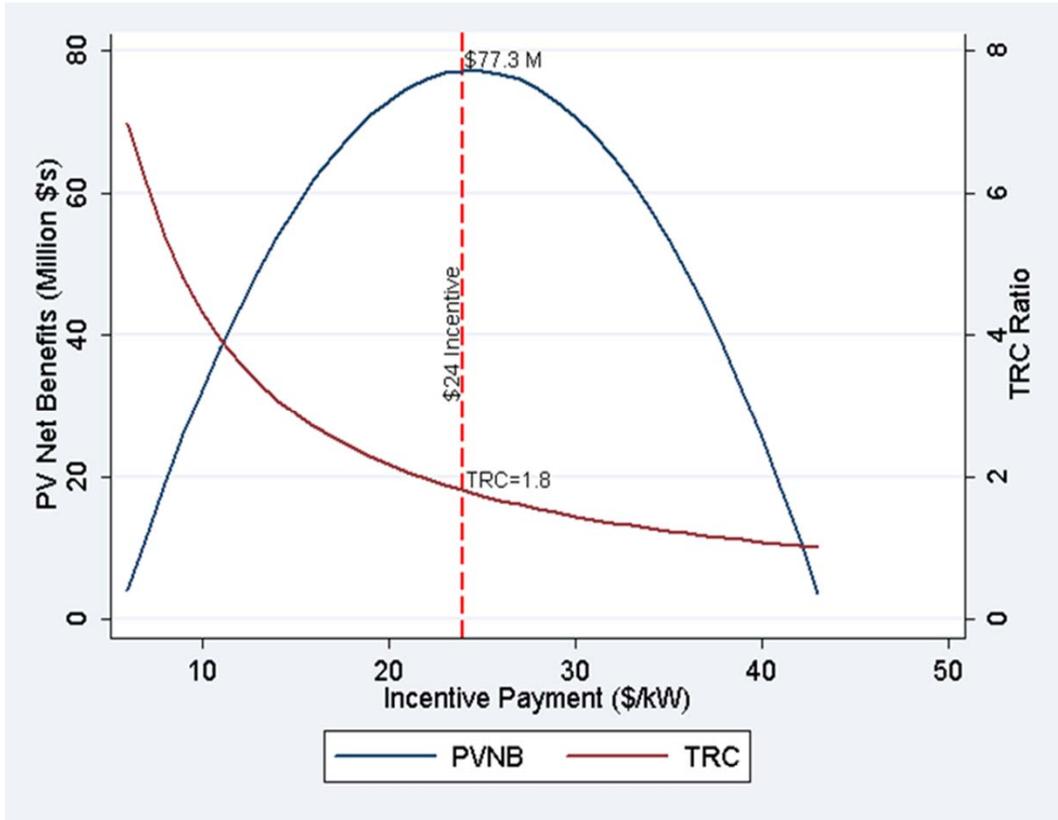
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DECISION CRITERION

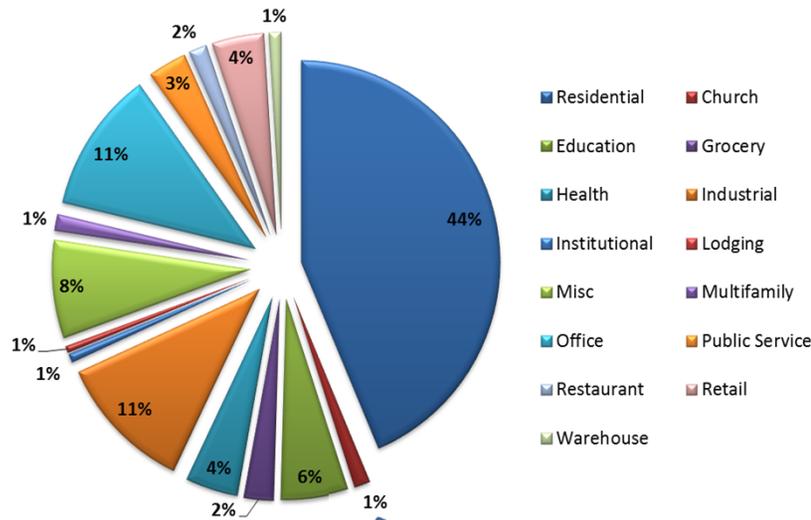


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MODELING

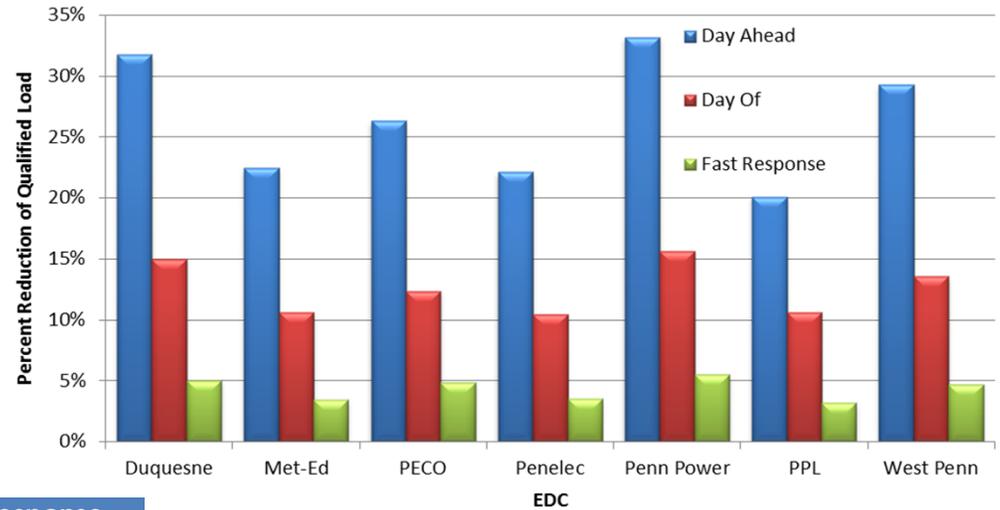


> 75 kW?

Elasticity by DR Market Type			
Segment	Day Ahead	Day Of	Fast Response
Church	0.021	0.007	0.002
Education	0.009	0.003	0.001
Grocery	0.010	0.009	0.001
Health	0.021	0.007	0.002
Industrial	0.013	0.007	0.003
Institutional	0.021	0.007	0.002
Lodging	0.010	0.005	0.002
Misc	0.011	0.006	0.006
Multifamily	0.011	0.006	0.006
Office	0.010	0.005	0.002
Public Service	0.021	0.007	0.002
Restaurant	0.010	0.005	0.002
Retail	0.010	0.009	0.001
Warehouse	0.036	0.045	0.003

POTENTIAL

- EDC potential varies by
 1. Market Composition
 2. Avoided Costs
 3. Notification



EDC	Day-Ahead	Day-Of	Fast Response
Duquesne	426	201	67
FE: Met-Ed	265	126	40
FE: Penelec	261	123	41
FE: Penn Power	122	58	20
FE: WPP	498	231	80
PECO	912	428	168
PPL	732	386	115
Statewide	3,216	1,552	532



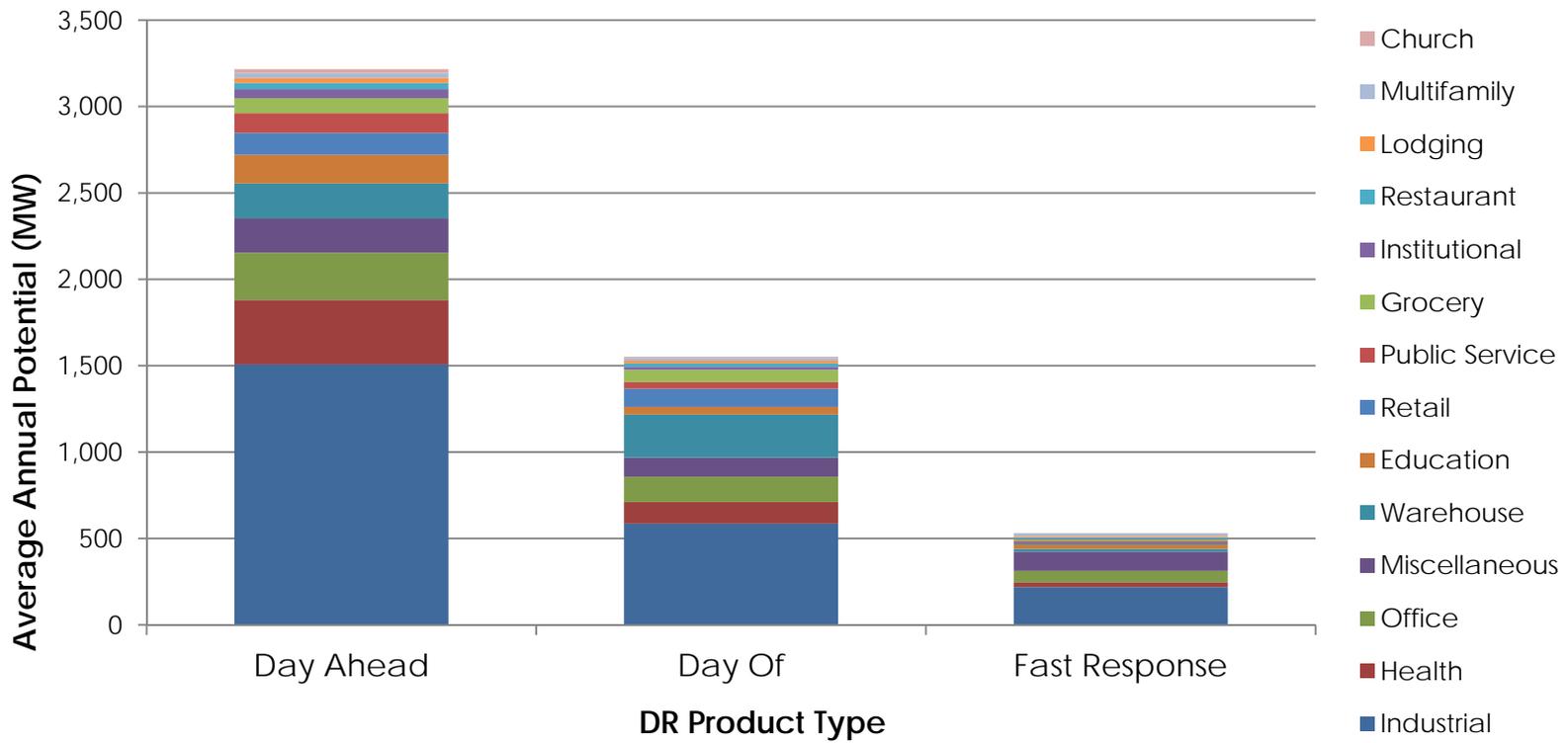
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C&I POTENTIAL BY SEGMENT



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INTERACTION WITH PJM PROGRAMS

- “Business as Usual” Scenario
 - Estimated future commitments subtracted

EDC	2016	2017	2018	2019	2020
Duquesne	319	324	323	321	318
FE: Met-Ed	50	52	51	49	48
FE: Penelec	(33)	(31)	(36)	(41)	(46)
FE: Penn Power	67	68	66	64	62
FE: WPP	153	157	154	155	155
PECO	494	499	488	474	460
PPL	93	99	94	95	95
Statewide	1,142	1,168	1,139	1,117	1,091

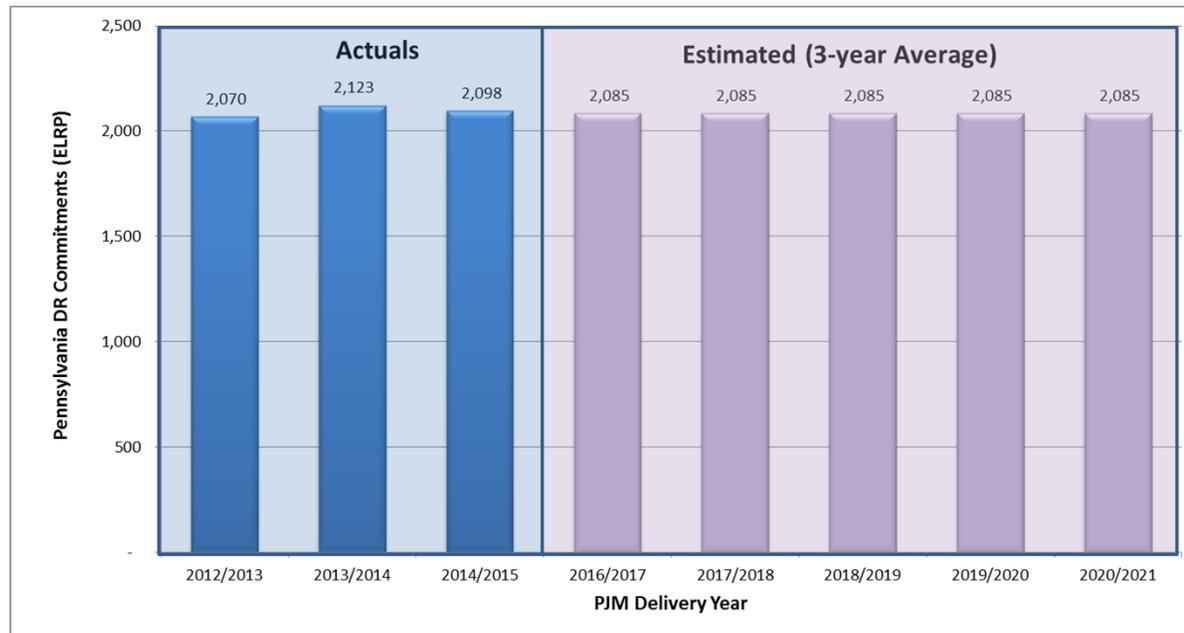
- “Wholesale Changes” Scenario
 - Current PJM commitments are subtracted (assume no PJM DR after 2017/2018)

EDC	2016	2017	2018	2019	2020
Duquesne	281	268	427	426	423
FE: Met-Ed	(48)	(32)	266	264	263
FE: Penelec	(166)	(90)	262	257	252
FE: Penn Power	(3)	53	123	121	119
FE: WPP	120	(10)	498	499	499
PECO	392	448	917	903	889
PPL	(269)	50	731	732	731
Statewide	306	687	3,224	3,202	3,175



ESTIMATED PHASE III COMMITMENTS

- DR commitments have dropped at incremental auctions
- 3-year average of committed MW



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SMALL AND MEDIUM ENTERPRISE DLC



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SMALL BUSINESS DLC ELIGIBILITY

- DLC Accounts
 - Customers >5 kW & ≤ 75 kW
- Status Quo is 2016 PLC
 - Segmented according to economic activity
 - EDCs provided 2012-2013 PLC estimates
- Economic analysis
 - Which customers have temperature-sensitive loads?
 - How much of that load is AC?
 - How many enrollees can the program reasonably attract?



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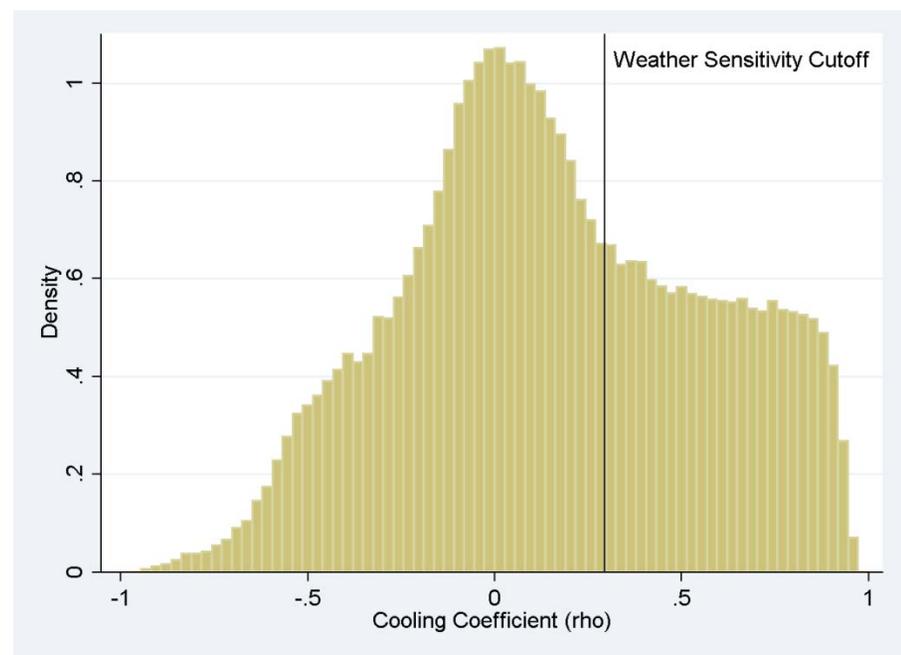
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WEATHER SENSITIVITY

- Correlate customer demand and temperature
- Identify cutoff
- Establish relationship between temp, humidity and demand
- Estimate load at peak conditions
- Estimate load at mild conditions
- Difference is AC



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ELIGIBLE LOAD

Day of Week	Accounts with PLC < 75 kW	Accounts with 5 kW < PLC < 75 kW	Weather Sensitive Accounts	Predicted kW (July 15-19, 2013)	Predicted kW at 60 Degrees (F)	AC Load (kW)	AC Load per Account (kW)
Monday	160,994	87,082	38,843	631,567	420,626	210,941	5.43
Tuesday	160,994	87,082	38,840	653,325	437,247	216,078	5.56
Wednesday	160,994	87,082	38,830	656,499	442,954	213,545	5.50
Thursday	160,994	87,082	38,823	678,485	441,639	236,847	6.10
Friday	160,994	87,082	38,821	672,774	429,338	243,436	6.27

- Approach consistent across EDCs
- Specifics modified for data provided by EDC
- PECO and FE based on peak vs. base demand
- DUQ estimate used parameters from other EDCs & available data



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DLC POTENTIAL

EDC	Total Qualified Accounts	Cumulative Sites	Cumulative Devices	Average Annual Impact (MW)	Lifetime TRC Ratio
Duquesne	10,529	471	829	0.56	0.76
FE: Met Ed	7,128	325	754	0.52	0.83
FE: Penelec	7,120	321	680	0.47	0.77
FE: Penn Power	2,446	113	258	0.17	0.45
FE: WPP	9,492	438	921	0.64	0.85
PECO	35,880	3,262	6,099	5.73	1.41
PPL	39,735	1,833	3,088	2.14	0.72
Statewide	112,330	6,763	12,629	10.23	0.97

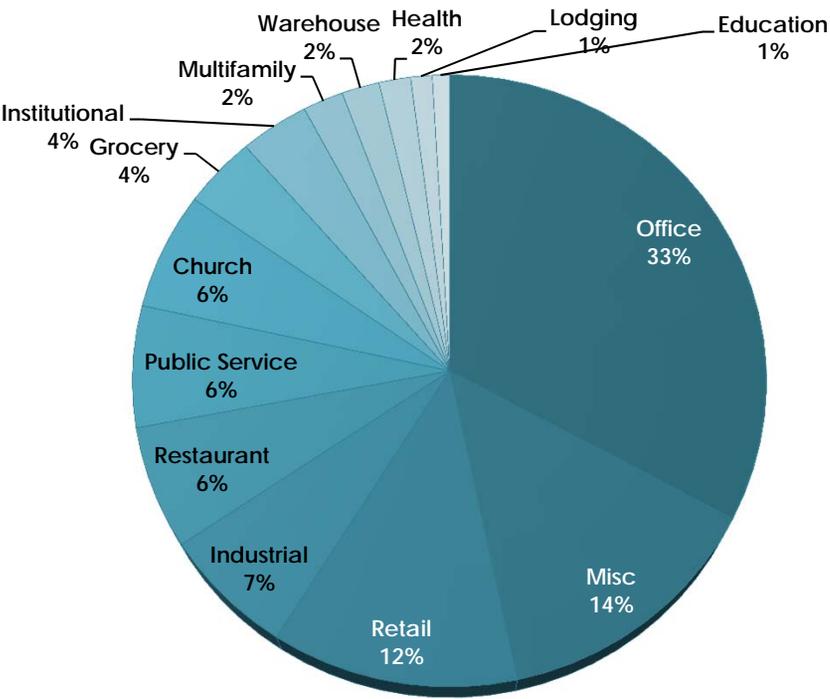


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DLC POTENTIAL BY SEGMENT



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PROGRAM POTENTIAL

Demand Response and EE + DR



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C&I DR ACQUISITION COST BY EDC

- Acquisition cost (\$/MW-year). All Load Curtailment for 6 EDCs

EDC	Load Curtailment Acquisition Cost (\$/MW-year)
Duquesne	\$57,976
FE: Met-Ed	\$51,210
FE: Penelec	\$50,782
FE: Penn Power	\$49,349
FE: WPP	\$46,203
PECO	\$58,893
PPL	\$41,622
Statewide Average	\$52,310



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PECO ACQUISITION COST

- Cost effective DR potential found in all 3 program types
- Weighted average acquisition cost

Program	Phase III MW	Phase III Cost	Acquisition Cost
Load Curtailment	2,414	\$142,167,801	\$58,893
Small Biz DLC	29	\$3,013,153	\$105,222
Residential DLC	392	\$36,960,776	\$94,300
Total	2,835	\$182,141,730	\$64,257



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DR POTENTIAL BY PJM SCENARIO AND FUNDING ALLOCATION

Business As Usual

EDC	5-Year DR Spending Ceiling	Average Annual Potential Savings (MW)	% of 2007-2008 Peak Demand	TRC
2016-2020 – 10% DR Spending				
Duquesne	\$9.8	34	1.3%	1.94
FE: Met-Ed	\$12.4	49	1.8%	1.90
FE: Penelec	\$11.5	0	0.0%	0.00
FE: Penn Power	\$3.3	13	1.4%	1.93
FE: WPP	\$11.8	51	1.5%	1.94
PECO	\$42.7	133	1.7%	1.69
PPL	\$30.8	95	1.4%	1.88
Statewide	\$122.3	375	1.4%	1.83
2016-2020 – 15% DR Spending				
Duquesne	\$14.7	51	2.0%	1.94
FE: Met-Ed	\$18.7	50	1.9%	1.90
FE: Penelec	\$17.2	0	0.0%	0.00
FE: Penn Power	\$5.0	20	2.1%	1.93
FE: WPP	\$17.7	76	2.2%	1.94
PECO	\$64.0	199	2.5%	1.69
PPL	\$46.1	95	1.4%	1.88
Statewide	\$183.4	492	1.9%	1.82
2016-2020 – 20% DR Spending				
Duquesne	\$19.5	67	2.7%	1.94
FE: Met-Ed	\$24.9	50	1.9%	1.90
FE: Penelec	\$23.0	0	0.0%	0.00
FE: Penn Power	\$6.7	27	2.8%	1.93
FE: WPP	\$23.6	102	2.9%	1.94
PECO	\$85.4	266	3.4%	1.69
PPL	\$61.5	95	1.4%	1.88
Statewide	\$244.5	607	2.3%	1.82

Wholesale Changes

EDC	5-Year DR Spending Ceiling	Average Annual Potential Savings (MW)	% of 2007-2008 Peak Demand	TRC
2016-2020 – 10% DR Spending				
Duquesne	\$9.8	34	1.3%	1.94
FE: Met-Ed	\$12.4	49	1.8%	1.90
FE: Penelec	\$11.5	45	1.9%	1.92
FE: Penn Power	\$3.3	13	1.4%	1.93
FE: WPP	\$11.8	51	1.5%	1.94
PECO	\$42.7	133	1.7%	1.69
PPL	\$30.8	148	2.2%	1.88
Statewide	\$122.3	473	1.8%	1.82
2016-2020 – 15% DR Spending				
Duquesne	\$14.7	51	2.0%	1.94
FE: Met-Ed	\$18.7	73	2.8%	1.90
FE: Penelec	\$17.2	68	2.8%	1.92
FE: Penn Power	\$5.0	20	2.1%	1.93
FE: WPP	\$17.7	76	2.2%	1.94
PECO	\$64.0	199	2.5%	1.69
PPL	\$46.1	222	3.4%	1.88
Statewide	\$183.4	709	2.7%	1.82
2016-2020 – 20% DR Spending				
Duquesne	\$19.5	67	2.7%	1.94
FE: Met-Ed	\$24.9	97	3.7%	1.90
FE: Penelec	\$23.0	90	3.8%	1.92
FE: Penn Power	\$6.7	27	2.8%	1.93
FE: WPP	\$23.6	102	2.9%	1.94
PECO	\$85.4	266	3.4%	1.69
PPL	\$61.5	296	4.5%	1.88
Statewide	\$244.5	945	3.6%	1.82

ENERGY EFFICIENCY VS. DEMAND RESPONSE

- ROI is very close given identical spending
- Stay mindful of PJM commitments
- More participant cost for EE
- Statewide TRC values go down as DR spending increases
 - DR wins for Penelec and PennPower
- Difference is certainly within margin of error for analysis

Scenario (EE/DR)	EDC	NPV Costs (EE + DR) \$Million	NPV Benefits (EE + DR) \$Million	Scenario PVNB \$Million	Scenario TRC
100/0	Duquesne	\$143.71	\$300.93	\$157.22	2.09
	FE: Met-Ed	\$168.93	\$325.03	\$156.10	1.92
	FE: Penelec	\$159.66	\$277.79	\$118.13	1.74
	FE: Penn Power	\$43.05	\$72.48	\$29.44	1.68
	FE: WPP	\$153.53	\$275.02	\$121.50	1.79
	PECO	\$600.11	\$1,162.94	\$562.83	1.94
	PPL	\$423.00	\$770.05	\$347.05	1.82
	Statewide	\$1,692	\$3,184	\$1,492	1.88
90/10	Duquesne	\$136.03	\$283.81	\$147.79	2.09
	FE: Met-Ed	\$160.55	\$308.65	\$148.11	1.92
	FE: Penelec	\$151.57	\$265.11	\$113.54	1.75
	FE: Penn Power	\$40.89	\$69.39	\$28.50	1.70
	FE: WPP	\$146.17	\$263.02	\$116.85	1.80
	PECO	\$575.00	\$1,105.62	\$530.62	1.92
	PPL	\$401.50	\$732.14	\$330.65	1.82
	Statewide	\$1,612	\$3,028	\$1,416	1.88
85/15	Duquesne	\$132.18	\$275.25	\$143.07	2.08
	FE: Met-Ed	\$156.35	\$300.46	\$144.11	1.92
	FE: Penelec	\$147.53	\$258.77	\$111.24	1.75
	FE: Penn Power	\$39.81	\$67.84	\$28.03	1.70
	FE: WPP	\$142.50	\$257.02	\$114.52	1.80
	PECO	\$562.45	\$1,076.97	\$514.51	1.91
	PPL	\$390.75	\$713.19	\$322.44	1.83
	Statewide	\$1,572	\$2,950	\$1,378	1.88
80/20	Duquesne	\$128.34	\$266.69	\$138.35	2.08
	FE: Met-Ed	\$152.16	\$292.28	\$140.12	1.92
	FE: Penelec	\$143.48	\$252.43	\$108.94	1.76
	FE: Penn Power	\$38.73	\$66.29	\$27.56	1.71
	FE: WPP	\$138.82	\$251.02	\$112.20	1.81
	PECO	\$549.90	\$1,048.31	\$498.41	1.91
	PPL	\$380.00	\$694.24	\$314.24	1.83
	Statewide	\$1,531	\$2,871	\$1,340	1.87

