KyPSC Case No. 2024-00197
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VERIFICATION

STATE OF NORTH CAROLINA)
) **SS:**
COUNTY OF MECKLENBURG)

The undersigned, John D. Swez, Managing Director, Trading and Dispatch, being duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of his knowledge, information and belief.

John D. Swez, Affiant

Subscribed and sworn to before me by John D. Swez on this 16th day of January, 2025.

NOTARY PUBLIC

My Commission Expires:

SHAMELL M WILSON
My Comm. Expires July 06, 2026

VERIFICATION

STATE OF KENTUCKY)
) **SS:**
COUNTY OF JEFFERSON)

The undersigned, Dan Sympson, General & Regulatory Strategy Director, being duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of his knowledge, information and belief.

Dan Sympson, Affiant

Subscribed and sworn to before me by Dan Sympson on this 3rd day of January, 2025.

Anne L. Foye
NOTARY PUBLIC

My Commission Expires: 6-12-2025

ANNE L FOYE
Notary Public - State at Large
Kentucky
My Commission Expires June 12, 2025
Notary ID KYNP29156

VERIFICATION

STATE OF NORTH CAROLINA)
) **SS:**
COUNTY OF MECKLENBURG)

The undersigned, Tim Duff, GM Customer Solutions Regulatory Enablement, being duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of his knowledge, information and belief.

Tim Duff, Affiant

Subscribed and sworn to before me by Tim Duff on this 6th day of January, 202~~4~~5

NOTARY PUBLIC

Renee B Crawford
NOTARY PUBLIC
Mecklenburg County
North Carolina
My Commission Expires 06/13/2029

My Commission Expires: 06/13/2029

VERIFICATION

STATE OF OHIO)
) **SS:**
COUNTY OF HAMILTON)

The undersigned, Sarah Lawler, VP Rates & Regulatory Strategy, being duly sworn, deposes and says that she has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of her knowledge, information and belief.

Sarah Lawler Affiant

Subscribed and sworn to before me by Sarah Lawler on this 13TH day of JANUARY 202~~4~~5

ADELE M. FRISCH, NOTARY PUBLIC
COMM. EXP. JANUARY 5, 2029

Adele M. Frisch
NOTARY PUBLIC

My Commission Expires: 1/5/2029

VERIFICATION

STATE OF OHIO)
) **SS:**
COUNTY OF HAMILTON)

The undersigned, J. Michael Geers, Manager of the EHS Energy Transition Group, being duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of his knowledge, information and belief.

J. Michael Geers
J. Michael Geers Affiant

Subscribed and sworn to before me by J. Michael Geers on this 16th day of January, 2025.

NOTARY PUBLIC

My Commission Expires:

ROCCO O. D'ASCENZO
ATTORNEY AT LAW
Notary Public, State of Ohio
My Commission Has No Expiration
Section 147.03 R.C.

VERIFICATION

STATE OF NORTH CAROLINA)
) **SS:**
COUNTY OF MECKLENBURG)

The undersigned, Matt Kalemba, Vice President Integrated Resource Planning, being duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of his knowledge, information and belief.

Matt Kalemba Affiant

Subscribed and sworn to before me by Matt Kalemba on this 16 day of January 202~~4~~. 5 SL

Sheila Lemoine
NOTARY PUBLIC

My Commission Expires: July 21, 2029

SHEILA LEMOINE
Notary Public, North Carolina
Lincoln County
My Commission Expires
July 21, 2029

VERIFICATION

STATE OF Texas)
COUNTY OF Collin) **SS:**
)

The undersigned, Ibrar Khera, Lead Load Forecasting Analyst, being duly sworn, deposes and says that he has personal knowledge of the matters set forth in the foregoing post hearing data requests, and that the answers contained therein are true and correct to the best of his knowledge, information and belief.

Ibrar Khera Affiant

Subscribed and sworn to before me by Ibrar Khera on this 13th day of January, ~~2024.~~ 2025

Sharon M Young
NOTARY PUBLIC

My Commission Expires: ~~2/8/28~~ smy
8/2/28

SHARON M. YOUNG
Notary Public, State of Texas
Comm. Expires 08-02-2028
Notary ID 126034380

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

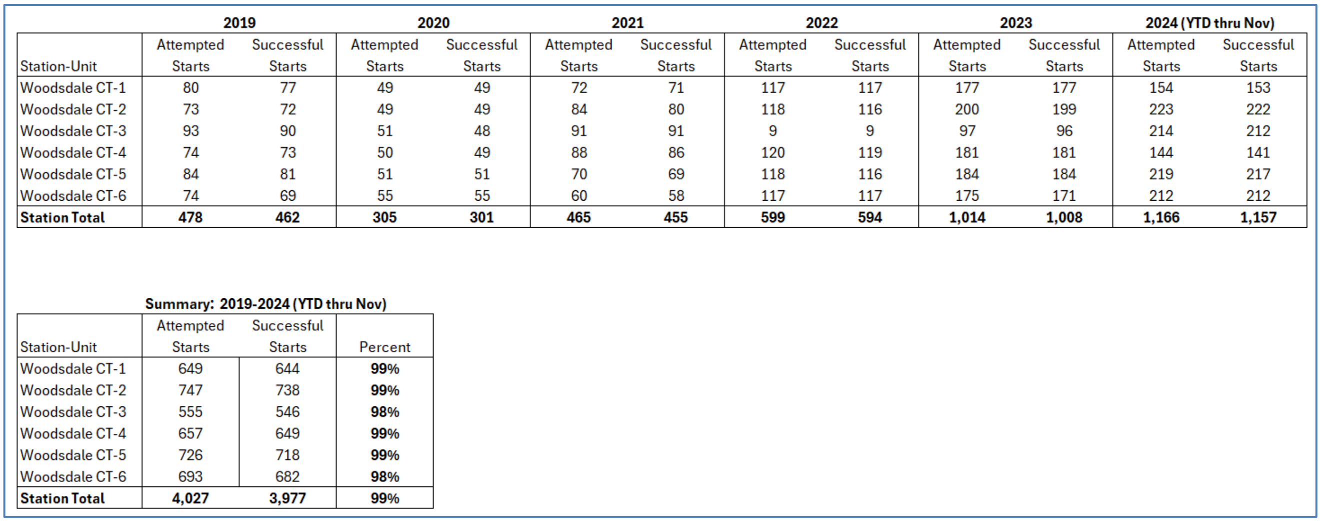
STAFF-PHDR-01-001

REQUEST:

Identify all startup failures or other issues that have occurred at Woodsdale Station resulting in a derate or outage for the years 2019 through November 2024, by month. Include in the response the issue, identify whether it resulted in a derate or an outage and provide the length of outage.

RESPONSE:

Please see STAFF-PHDR-01-001 Attachment for a listing of all startup failures that occurred at Woodsdale Station between 2019 and November 2024. Additionally, see below for a summary of the startups at Woodsdale station for the same period. Note that the station had a 99% successful startup rate over this period, with 3,977 successful startups out of 4,027 attempted startups.



	2019		2020		2021		2022		2023		2024 (YTD thru Nov)	
Station-Unit	Attempted Starts	Successful Starts	Attempted Starts	Successful Starts	Attempted Starts	Successful Starts	Attempted Starts	Successful Starts	Attempted Starts	Successful Starts	Attempted Starts	Successful Starts
Woodsdale CT-1	80	77	49	49	72	71	117	117	177	177	154	153
Woodsdale CT-2	73	72	49	49	84	80	118	116	200	199	223	222
Woodsdale CT-3	93	90	51	48	91	91	9	9	97	96	214	212
Woodsdale CT-4	74	73	50	49	88	86	120	119	181	181	144	141
Woodsdale CT-5	84	81	51	51	70	69	118	116	184	184	219	217
Woodsdale CT-6	74	69	55	55	60	58	117	117	175	171	212	212
Station Total	**478**	**462**	**305**	**301**	**465**	**455**	**599**	**594**	**1,014**	**1,008**	**1,166**	**1,157**

Summary: 2019-2024 (YTD thru Nov)

Station-Unit	Attempted Starts	Successful Starts	Percent
Woodsdale CT-1	649	644	**99%**
Woodsdale CT-2	747	738	**99%**
Woodsdale CT-3	555	546	**98%**
Woodsdale CT-4	657	649	**99%**
Woodsdale CT-5	726	718	**99%**
Woodsdale CT-6	693	682	**98%**
Station Total	**4,027**	**3,977**	**99%**

PERSON RESPONSIBLE: John Swez

Unit	Primary Fuel Type	Event Start	Event End	Event Type	Event Duration Hours	Equiv MWh Lost	Derate	Cause Code	Cause Description	Event Description
Woodsdale CT-3	Natural Gas	1/30/2019	1/30/2019	SF	3.92	368.17	93.99	5130	Starting system (including motor)	Starting device failure
Woodsdale CT-1	Natural Gas	1/30/2019	2/2/2019	SF	75.93	7,137.73	94.00	5130	Starting system (including motor)	starting breaker failed to open
Woodsdale CT-3	Natural Gas	3/27/2019	3/27/2019	SF	1.50	141.00	94.00	3621	Unit auxiliaries transformer	RAT Transformer 13 Tripped while starting
Woodsdale CT-4	Natural Gas	3/27/2019	3/27/2019	SF	1.50	141.00	94.00	3621	Unit auxiliaries transformer	RAT Transformer 13 Tripped while starting
Woodsdale CT-6	Natural Gas	6/19/2019	6/19/2019	SF	4.95	465.30	94.00	5050	Ignition system	FLAME OUT
Woodsdale CT-5	Natural Gas	6/26/2019	6/26/2019	SF	0.87	81.47	93.97	5041	Fuel piping and valves	Air supply to 2nd stage reg off
Woodsdale CT-6	Natural Gas	6/26/2019	6/26/2019	SF	0.43	40.73	94.06	5041	Fuel piping and valves	MAIN GAS SHUT OFF VALVE BREAKER TRIPPED
Woodsdale CT-1	Natural Gas	7/13/2019	7/13/2019	SF	0.33	31.33	94.08	5050	Ignition system	Trip on flame out
Woodsdale CT-6	Natural Gas	7/29/2019	7/29/2019	SF	0.72	67.37	93.96	5150	Turning gear and motor	Jacking Oil Pump Failure
Woodsdale CT-1	Natural Gas	9/9/2019	9/9/2019	SF	0.93	87.73	94.03	5041	Fuel piping and valves	Gas valve went closed
Woodsdale CT-5	Natural Gas	10/19/2019	10/19/2019	SF	1.00	94.00	94.00	5130	Starting system (including motor)	Remote start-breaker did not close.
Woodsdale CT-5	Natural Gas	11/13/2019	11/15/2019	SF	56.97	5,354.87	94.00	4810	Generator output breaker	SF6 Gas in Gen Breaker low
Woodsdale CT-6	Natural Gas	12/12/2019	12/12/2019	SF	1.98	186.43	94.01	9130	Lack of fuel: Physical failures of fuel supply or delivery/transportation of fuel	Main gas reg. not working
Woodsdale CT-3	Natural Gas	12/12/2019	12/12/2019	SF	1.90	178.60	94.00	9130	Lack of fuel: Physical failures of fuel supply or delivery/transportation of fuel	Shut down 0648, gas reg not working
Woodsdale CT-2	Natural Gas	12/12/2019	12/12/2019	SF	1.87	175.47	93.99	9130	Lack of fuel: Physical failures of fuel supply or delivery/transportation of fuel	Main NG regulator failed
Woodsdale CT-6	Natural Gas	12/20/2019	12/20/2019	SF	1.00	94.00	94.00	5150	Turning gear and motor	High level in fuel/water pump
Woodsdale CT-3	Natural Gas	7/3/2020	7/3/2020	SF	2.07	194.27	93.99	4700	Generator voltage control	Remote start. AVR fault unit did not start.
Woodsdale CT-4	Natural Gas	8/14/2020	8/14/2020	SF	1.77	166.07	93.98	4720	Generator synchronization equipment	Sync control issue
Woodsdale CT-3	Natural Gas	12/7/2020	12/7/2020	SF	0.53	50.13	94.05	5130	Starting system (including motor)	Undervoltage Relay for Starting Breaker failed.
Woodsdale CT-3	Natural Gas	12/8/2020	12/8/2020	SF	0.48	45.43	94.06	5130	Starting system (including motor)	Undervoltage Relay for Starting Breaker failed. (Remote Start)
Woodsdale CT-2	Natural Gas	2/16/2021	2/16/2021	SF	0.40	37.60	94.00	5130	Starting system (including motor)	Unit tripped due to starting bkr. Reset/installed & reracked starting bkr.
Woodsdale CT-4	Natural Gas	2/17/2021	2/17/2021	SF	0.50	47.00	94.00	5050	Ignition system	Flame out 2200RPM
Woodsdale CT-4	Natural Gas	3/22/2021	3/22/2021	SF	8.60	808.40	94.00	5049	Other fuel system problems	Remote start, trip on burner cooling air
Woodsdale CT-2	Natural Gas	4/9/2021	4/22/2021	SF	329.52	30,974.57	94.00	5130	Starting system (including motor)	Switch over device for SFC failed-Arc-over when switchover device went to GT1
Woodsdale CT-1	Natural Gas	4/9/2021	4/13/2021	SF	118.20	11,110.80	94.00	5130	Starting system (including motor)	GT2 SFC Switch over device failed; GT1 out to repair switchover device
Woodsdale CT-2	Natural Gas	6/4/2021	6/4/2021	SF	0.73	68.93	94.04	5130	Starting system (including motor)	Syncronizer Failure
Woodsdale CT-5	Natural Gas	6/27/2021	6/27/2021	SF	0.95	89.30	94.00	4810	Generator output breaker	Gen Breaker SF6 Gas Low
Woodsdale CT-2	Natural Gas	8/17/2021	8/18/2021	SF	21.47	2,017.87	94.00	5120	Hydraulic oil system	Power Oil Breaker won`t close
Woodsdale CT-6	Natural Gas	10/18/2021	10/19/2021	SF	15.08	1,417.83	94.00	4720	Generator synchronization equipment	Failed start; Synchronizer blocked
Woodsdale CT-6	Natural Gas	11/5/2021	11/5/2021	SF	3.92	368.17	93.99	4720	Generator synchronization equipment	Synchronizer problem
Woodsdale CT-2	Natural Gas	1/7/2022	1/7/2022	SF	1.50	141.00	94.00	5130	Starting system (including motor)	Starting Breaker would not close.
Woodsdale CT-4	Natural Gas	1/23/2022	1/23/2022	SF	1.68	158.23	94.02	4720	Generator synchronization equipment	Gen Exciter Synchronizer blocked.
Woodsdale CT-2	Natural Gas	5/13/2022	5/13/2022	SF	2.67	250.67	93.99	5130	Starting system (including motor)	Starting Breaker Failure.
Woodsdale CT-5	Natural Gas	6/15/2022	6/16/2022	SF	22.75	2,138.50	94.00	5001	Inlet air vanes/nozzles	TRIP during start up; Variable Inlet Guide Vanes Problem.
Woodsdale CT-5	Natural Gas	10/13/2022	10/14/2022	SF	1.28	120.63	94.02	5250	Other controls and instrumentation problems	Flame out due to bad Thermocouple.
Woodsdale CT-6	Natural Gas	1/10/2023	1/10/2023	SF	0.43	40.73	94.06	5050	Ignition system	Start up trip during ignition
Woodsdale CT-6	Natural Gas	5/7/2023	5/7/2023	SF	0.73	68.93	94.04	5050	Ignition system	Start Fail; tripped on flame, RS at 0700, Load Desk didn't want to restart.
Woodsdale CT-3	Natural Gas	7/26/2023	7/26/2023	SF	2.58	242.83	94.01	5050	Ignition system	Would not light off; propane ignition pressure too high
Woodsdale CT-2	Natural Gas	10/10/2023	10/10/2023	SF	3.30	310.20	94.00	4750	Other generator controls and metering problems	Start up fail; AVR Fault
Woodsdale CT-6	Natural Gas	12/4/2023	12/7/2023	SF	76.22	7,164.37	94.00	4720	Generator synchronization equipment	Unit Sync. Not giving Close command to BKR
Woodsdale CT-6	Natural Gas	12/12/2023	12/12/2023	SF	2.83	266.33	94.01	4720	Generator synchronization equipment	Unit back Available After Sync work, 12/12/23 8:48
Woodsdale CT-4	Natural Gas	1/8/2024	1/8/2024	SF	3.05	286.70	94.00	3661	4000-7000 volt circuit breakers	Unit back available after FO breaker calibration
Woodsdale CT-1	Natural Gas	1/8/2024	1/8/2024	SF	3.00	282.00	94.00	3661	4000-7000 volt circuit breakers	Unit back available after FO breaker calibration
Woodsdale CT-3	Natural Gas	1/8/2024	1/8/2024	SF	3.00	282.00	94.00	3661	4000-7000 volt circuit breakers	Unit back available after FO breaker calibration
Woodsdale CT-4	Natural Gas	1/15/2024	1/15/2024	SF	8.53	802.13	94.00	3661	4000-7000 volt circuit breakers	Unit back available after ignition system trouble
Woodsdale CT-3	Natural Gas	1/15/2024	1/15/2024	SF	1.23	115.93	94.02	5050	Ignition system	Unit back available after ignition system trouble
Woodsdale CT-4	Natural Gas	1/30/2024	1/30/2024	SF	8.78	825.63	94.00	5042	Fuel nozzles/vanes	Replaced bad card on FO control valve.
Woodsdale CT-5	Natural Gas	4/23/2024	4/23/2024	SF	4.30	404.20	94.00	4810	Generator output breaker	Unit would not sync due to low SF6 gas pressure, raised gas pressure, test ran, return
Woodsdale CT-2	Natural Gas	5/19/2024	5/19/2024	SF	5.82	546.77	94.00	5130	Starting system (including motor)	SFC fail to start
Woodsdale CT-5	Natural Gas	11/5/2024	11/5/2024	SF	7.52	706.57	94.00	4720	Generator synchronization equipment	Generator breaker air pressure contact stuck open, reset.

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

STAFF-PHDR-01-002

REQUEST:

State the earliest year that a natural gas combined cycle (NGCC) unit could be constructed and placed in service.

RESPONSE:

Eight (8) years is the currently estimated time from the start of site selection to when a new NGCC is placed in service. With that understanding, the earliest year a NGCC could be placed in service, if started in the near term, is 2033.

PERSON RESPONSIBLE: Dan Sympson

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

STAFF-PHDR-01-003

REQUEST:

Provide a copy of Duke Kentucky's most recent demand side management (DSM) study.

RESPONSE:

Please see STAFF-PHDR-01-003 Attachment. Although the attachment contains a CONFIDENTIAL watermark, the Company is not requesting confidential treatment.

PERSON RESPONSIBLE: Tim Duff

Duke Energy Kentucky: Market Assessment and Action Plan for Electric DSM Programs

Prepared for:
Duke Energy
Cincinnati, Ohio

Prepared by:
Forefront Economics Inc.
H. Gil Peach & Associates LLC

with contributions from:
Mark E. Thompson
H. Gil Peach
Howard Reichmuth
John Mitchell

January 7, 2013

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EXECUTIVE OVERVIEW

This document presents a long-term Demand Side Management (DSM) Market Potential Study (MPS) and a five-year Action Plan for residential and non-residential electric customers in the Duke Energy Kentucky (DEK) service area.[1] The MPS and Action Plan was prepared by Forefront Economics Inc. and H. Gil Peach and Associates, LLC. Long-term DSM savings potential is assessed from both the technical and economic perspectives. The design, implementation and cost effectiveness of specific DSM programs are addressed in the five-year Action Plan. This study considers energy efficiency (EE) and demand response (DR) technologies and programs for saving energy and reducing demand. The impact of energy prices including rate changes are beyond the scope of this study.

This study is expected to help inform utility planners regarding the extent of DSM opportunities and to provide broadly defined approaches for acquiring savings over the short term. It is not meant to provide detailed specifications and work plans required for program implementation. Accordingly, this study provides part of the information to use in setting DSM savings goals or targets. Actual DSM goals or targets are best developed considering this study along with detailed program plans constructed with the participation of program managers and with the possible assistance of implementation contractors.

Overview of Findings

Key findings from the MPS are summarized in Table 1. All energy and demand data presented in this report are at the customer meter level (i.e., line losses are not included) unless otherwise stated.

Table 1. Usage and DSM Potential

	kWh (millions)	Percent of Total
Planning Year 20 (2032)		
Total Usage	4,791	100%
Technical Potential Savings - EE and Solar	1,543	32%
Technical Potential Savings - Energy Efficiency Only	1,276	27%
Economic Potential (@ $0.075/kWh)*	789	16%
Planning Year 5 (2017) – Annual Impact from Participants in Years 1 through 5		
Recommended DSM Programs (after 5 years) **	232	5.7%

* Refers to the energy savings that can be acquired with DSM for less cost than the cost of serving the load with traditional supply side resources.

** DSM savings shown as percent of Year 5 usage. Savings are incremental to savings already achieved through existing programs.

The technical potential including solar photovoltaic (PV) shows that if the energy saving technologies identified in this report were applied across all applicable customers, without regard to market or economic constraints, weather normalized annual electricity usage could be reduced by 32 percent. Excluding solar technologies, the technical

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[1] This project also includes a similar analysis and DSM Action Plan for Duke Energy Ohio (DEOH), the results of which are presented in a separate report. Both reports are structured the same to allow for ease of comparison between the two reports. All of the data presented in this report pertain to Duke Energy Kentucky unless otherwise stated.

potential is estimated at 27 percent of annual usage. A recent meta-analysis of potential studies found similar results for electric measures across all customer segments.[2]

Economic potential reflects the subset of technical potential that can be acquired for less than the avoided cost of supply. Avoided costs vary significantly depending on the nature of the served load, fuel costs, distribution charges and other costs. Economic potential is presented in the body of this report in the form of a DSM supply curve showing the economic potential depending on the level of avoided cost. System avoided costs are based on long run expectations regarding the cost of supply and are therefore less volatile than short-term energy prices. After reviewing long range system avoided cost estimates a value of $0.075 per kWh was selected to estimate the economic potential as shown in Table 1.[3] Using this level for avoided cost, we estimate that about 60 percent of the electric technical potential excluding solar PV is cost effective. We have included incremental measure costs and a rough estimate of DSM program delivery and administration expenses in our calculation of economic potential. More precise estimates of DSM acquisition costs are reflected in the five-year DSM Action Plan.

For reasons discussed in the section on economic potential, the marginal cost of acquiring additional customers into a program can be expected to rise as more and more customers from the target customer segment are treated by the program. Estimates of economic potential typically include a flat level of program delivery and overhead costs based on current understanding of program costs. Consequently, estimates of economic potential tend to overstate what is actually cost effective in the latter stages of customer adoption when costs are higher. This is also true of the estimate of economic potential in this report. While they have their limitations, estimates of technical and economic potential are still useful concepts for defining the relative magnitude of opportunities. Achievable potential energy savings, given specific program designs and annual participation targets refined from experience, provides the best estimate of how much energy efficiency might be actually delivered in any given year.

The approach used to develop the set of recommended DSM programs consisted of the following steps:

(1) Conduct a market assessment for determining electric usage and characteristics across customer groups.
(2) Review a comprehensive list of DSM technologies for saving energy.
(3) Consider the appropriateness of selected technologies for Duke's Kentucky service territory in terms of markets, cost effectiveness and accessibility to products.
(4) Group the highest potential technologies into logical sets for marketing and outreach.
(5) Design program strategies to promote the technologies based on industry best practices.
(6) Consider the cost effectiveness of the designed program, including costs to Duke and to participating customers.
(7) Describe a final set of recommended program designs that make the most sense for the utility and have a strong potential for delivering cost effective energy savings.

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[2] Chandler, Sharon and Marilyn Brown, Meta-Review of Efficiency Potential Studies and Their Implications for the South. Georgia Tech Working Paper #51, August 2009. Studies examined in the Meta-Analysis reported total technical potential ranging from 24% to 33%. It is not clear from the report if solar was included in these estimates.

[3] The levelized cost at which to determine economic potential was selected from the observed range of electric avoided cost for various customer classes and types of DSM program savings analyzed with DSMore. While useful for reporting purposes, using a single level of avoided cost to determine economic potential is somewhat arbitrary. Observing the full range of economic potential as shown on the supply curves presented in the Economic Potential section of this report provides greater insight into economic potential.

The process resulted in the following set of recommended programs. DEK will, of course, make the final selection of programs to be submitted for regulatory approval.

Program Number	Program Name	Cost Effective (TRC Test)	Recommended
1	C&I Tune-Ups	Yes	Yes
2	C&I Energy Efficient Products	Yes	Yes
3	C&I Custom	Yes	Yes
4	Res Energy Efficient Products	Yes	Yes
5	Res Energy Efficiency Education for Schools	Yes	Yes
6	Res Energy Assessment	Yes	Yes
7	Res Appliance Recycling	Yes	Yes
8	Res High Performance Homes	Yes	Yes
9	Res Home Reports	Yes	Yes
10	Res Neighborhoods	Yes	Yes
11	Res Low Income Weatherization	No	Yes
12	C&I Demand Response	Yes	Yes
13	Res Demand Response	Yes	Yes

Expected savings and program budgets are presented in Table 2. Program budgets are also presented on a cost per retail customer basis.

Table 2. Energy Savings and Annual Budget for Recommended Programs

Year	Cumulative kWh Savings (millions)	Cumulative MW Savings	Program Budget (millions $)	Cost per Retail Customer
2013	45	6	12.2	$86
2014	84	13	12.3	$85
2015	129	20	14.3	$99
2016	179	28	15.8	$107
2017	232	37	16.4	$111

After five years the recommended programs deliver cumulative savings of 232 million kWh, 5.7 percent of usage in that year and about 30 percent of total economic potential. These savings do not include savings that Duke Energy has previously achieved through DSM programs.

Overview of Approach

The purpose of this section is to provide an overview of the approach used in the preparation of this DSM Action Plan. Our approach is perhaps best described as three components, each building off of the last. These components are Market Assessment, DSM Potential, and DSM Programs.

Market Assessment

Market assessment provides the foundation layer of the analysis and supports the work of the other two components. The objective of the market assessment component is to describe customers and loads in sufficient detail to provide an understanding of energy usage by market segment. An important aspect of this project is that the market assessment was completed using a blend of internal Duke data, service territory specific secondary data, and detailed energy modeling. By blending internal utility data with secondary data sources, a much richer market assessment is possible. Key to the market assessment layer is a rigorous analysis of actual customer billing and hourly load data to construct electric usage models for each residential and non-residential segment.

DSM Potential

The DSM potential component of the analysis builds off of the market assessment and provides an estimate of technical potential and DSM supply curves showing the amount of DSM potential available at various costs per kWh. At this stage of the analysis the savings potential of several Energy Efficiency Measures (EEM) is assessed. EEM savings potential is constructed from the use of secondary information documenting the industry's experience with the technology adjusted for the market assessment and load modeling results specific to DEK. The process of blending internal and secondary information along with energy modeling to develop the market assessment and DSM potential estimates is shown in the figure below.

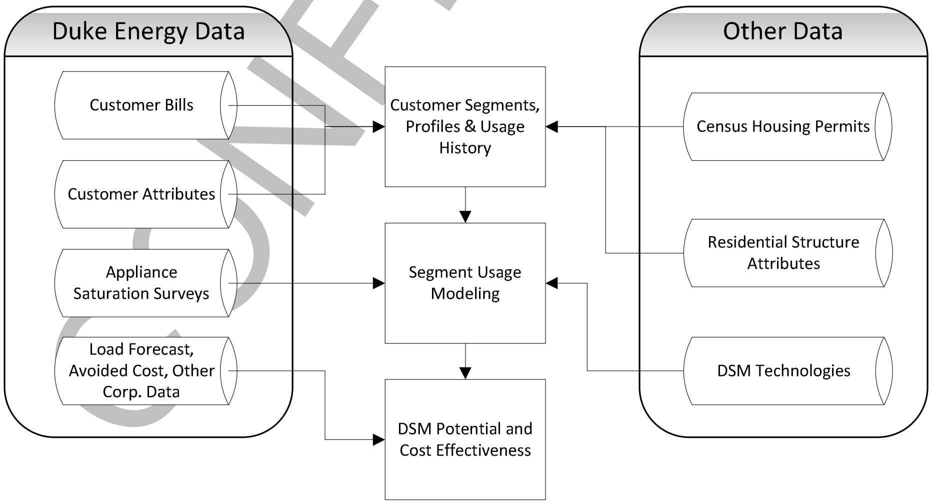

Figure 1. Overview of Market Assessment and DSM Potential Estimates

A significant benefit from this approach is that it results in end-use load profiles and DSM potential estimates by market segment that are based on customer characteristics and energy usage specific to DEK. Duke Energy Kentucky service territory specific data used to construct the analysis includes:

- Monthly energy bills for over 11,000 customer sites sampled from 21 market segments.[4]
- Customer attribute information from Duke CIS including housing type, initial service year and Standard Industrial Classification (SIC) code for non-residential customers.
- Residential Appliance Survey conducted in 2010 providing recent information on equipment and end-uses. DEK respondents were selected and analyzed separately from the broader survey.
- Hourly (8,760) load data for residential and non-residential Duke Energy rate classes. Hourly load data are not typically available for these types of projects and proved extremely valuable in our modeling efforts.
- Size of home (square feet) and vintage of construction (year built) were obtained from residential characteristics data licensed by Duke Energy.
- Long-term load forecast for Duke Energy Kentucky.

DSM Programs

DSM program design represents the final layer of the core analysis of this Action Plan. The program design process builds off of the prior two layers by mapping measures to programs through an analysis of industry practice and, where possible, best practices from other leading electricity and combined companies. This approach balances engineering and economic characteristics of specific end-use technologies with public policy and company objectives. The goals in this effort are, to the extent possible, to incorporate the specific environmental and market characteristics of the service territory, and to orient the programs toward both a technology optimum and a participation optimum. To be effective, these goals in program design and practical implementation will be implemented and optimized within Duke Energy's established marketing framework. Strategic change comes from working closely with customers and suppliers to jointly create program success. The result is a set of recommended programs that are optimized to meet the specific needs of DEK.

Organization of Report

The first three sections following this Overview present the findings of each of the three components or "layers" of analysis discussed above: Market Assessment, DSM Potential, and DSM Programs. The final two sections of the main report present program cost effectiveness results and evaluation plans. Several appendices following the main report provide additional documentation on various aspects of the analysis.

In this report the term Demand Side Management (DSM) refers to the planning and implementation of electric utility programs that influence customer uses of electricity in ways that will produce desired changes in the utility's load shape. As such, DSM includes traditional energy efficiency, conservation and load control programs. All energy usage numbers are 2011 weather normalized unless otherwise stated.

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[4] See Appendix E for details on the segmentation and sampling strategy used in this analysis.

MARKET ASSESSMENT

Energy efficiency planning needs to be based on a sound understanding of customer characteristics. The purpose of this section is to provide a foundation for the DSM planning and analysis presented in subsequent sections. We begin with a description of the DEK service territory in terms of households, businesses and customer data.[5] A description of the customer base precedes the presentation of energy usage models. These models are used to estimate the electric sales by end-uses; such as, space heating and cooling, water heating, lighting, process energy, appliances and miscellaneous plug loads. The detailed energy usage models also provide a basis for estimating the technical potential, energy savings and cost effectiveness of a wide variety of demand side measures and programs.

Electric energy usage estimates presented in this report are normalized to long-term weather conditions by applying the energy usage models adjusted to a typical or normal year. All energy use and end-use estimates in the report have been normalized to monthly temperature normals. Though the energy use estimates are for a normal year, the models were developed using actual usage and weather data from January 2011 through December 2011.

Overview of Market Sectors

The focus of this study is on nearly 140 thousand residential and non-residential retail customers in the DEK service territory. These customers account for almost 4 billion kWh annually, as shown in Table 3.

Table 3. DEK Customers and Weather Normalized Annual Usage by Sector – Year 2011

Sector	Customers	Annual Usage (million kWh)	Percent of Total	Use per Customer (kWh/year)
Residential	126,211	1,501	37.7%	11,892
Commercial	13,077	1,757	44.1%	134,366
Manufacturing	618	726	18.2%	1,174,316
Total	**139,906**	**3,984**	**100.0%**	**28,474**

Source: Unique premise counts and billing data from CIS extract (Jan 2011 – Dec 2011).

With 126,000 customers, the residential sector is far larger in terms of customer count than the non-residential sector. Although there are far fewer non-residential customers than residential, the average non-residential customer uses about 15 times more electricity than the average residential customer. The non-residential sector accounts for over 60 percent of the energy consumption considered in this study.

Monthly electric loads for all three sectors are shown in Figure 2. Monthly residential loads are by far the most seasonal and, like the non-residential segments, are highest during the summer months. Although not as seasonal as the residential sector, monthly commercial loads are highest in the summer and also increase in the winter months. By contrast, manufacturing loads are nearly constant across the months except for a small summer peak in July and August, coincident with the residential and commercial summer peak.

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[5] When using county-specific secondary data to describe the DEK service area, we have included the following 3 counties: Boone, Campbell, and Kenton.

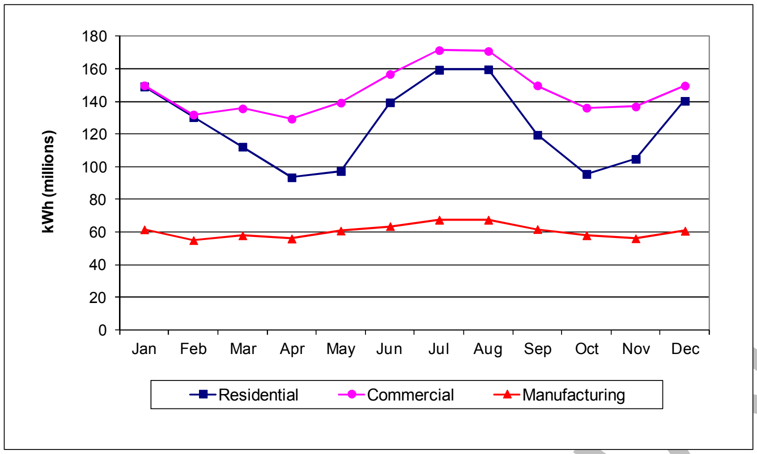

Figure 2. Total DEK Electric Sales by Sector

Detailed energy usage analysis by sector and end-use will be presented later in this section. An overview of monthly loads by end-use is presented here for the residential and non-residential sectors combined as an overview of the components of electric consumption. End-use models were estimated for each sector allowing loads to be disaggregated by major end-use. Monthly loads by end-use estimated from the models are shown in Figure 3.[6]

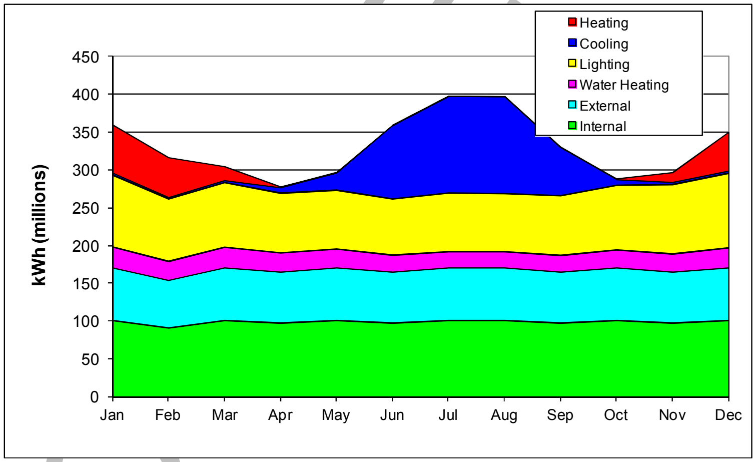

Figure 3. Total DEK Electric Sales by End-Use

Monthly shapes are characterized by a large base load with a prominent summer peak for cooling. Although lower than the summer peak, space heating contributes to a winter peak. Base loads include end-uses that are not highly weather dependent; such as, lighting, water heating, appliances and miscellaneous plug load uses. Annual data are shown for these same end-uses in Table 4. Base loads comprise 80 percent of total annual usage.

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[6] End-uses are described in Appendix A. Internal and external end-uses refer to uses that contribute to internal heat gains and those that do not, respectively, and are sector dependent as explained in Appendix A.

Table 4. DEK Total Annual Electric Use by End-Use

End-Use	Millions kWh	Percent
Heating	201	5%
Cooling	472	12%
Water Heating	282	7%
Lighting	1,007	25%
External	825	21%
Internal	1,196	30%
Total	**3,984**	**100%**

Source: Analysis of monthly usage

Energy and demand are both important considerations when planning DSM programs. A map of MW demand in all sectors by month and time of day is shown in Figure 4.

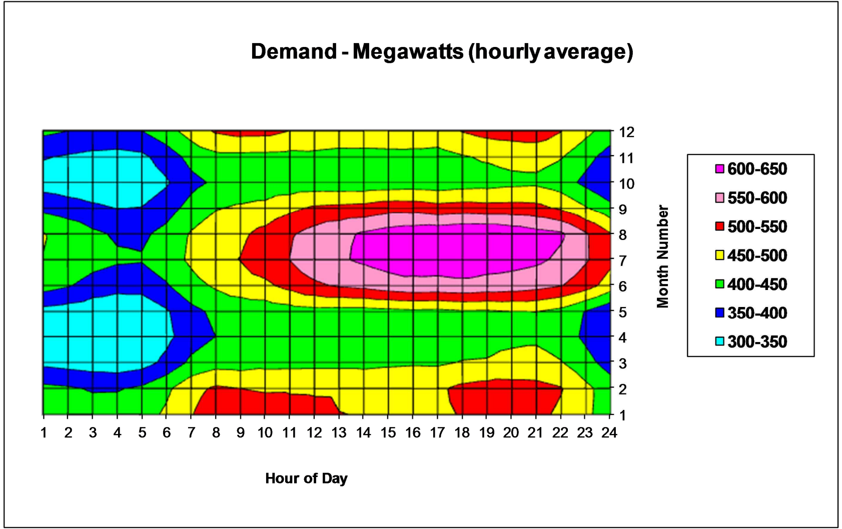

Figure 4. DEK Average Hourly Demand Map

Demand was modeled using several sources of information, including hourly load data provided for 2011. A detailed discussion of the methodology is presented in Appendix A. Demand is at its highest in July between 2 PM and 9 PM with high loads throughout the afternoon and early evening of the summer months. DSM technologies and programs with impact loads during these periods will save peak and energy. Demand is also high during the morning hours of 7 AM to 11 AM and, again, between 6 PM to 9 PM in December and January, driven by residential and commercial space heating.

Residential

The market assessment presented in this section begins with a high-level view of residential housing in the DEK service area, followed by a detailed analysis of residential electric loads. We used the following sources of information for the analysis presented in this section:

1. CIS Extract obtained from Duke Energy Kentucky, including monthly billing data.
2. The Duke Residential Appliance Saturation Survey (RASS), completed in 2010.
3. Residential attribute data licensed to Duke Energy.
4. Hourly load data for DEK rate classes.

Duke serves 126 thousand residential customers in Kentucky. A simple segmentation strategy based on type of structure and vintage of construction was used to describe and model residential energy usage. The housing type (single family and multifamily) and vintage of construction (existing and new), based on meter set date, were available from the Duke Energy customer information system (CIS). This segmentation approach captures the major differences in residential housing stocks that impact energy usage and DSM opportunities. The segments were also selected to better describe cost effective DSM opportunities which can vary significantly by type of housing and vintage of construction. Customer counts in each of the residential segments are shown in the table below.

Table 5. Residential Customers by Segment

	Single Family	**Multifamily**	**Total**
Existing Construction	85,229	38,704	123,933
New Construction	1,655	623	2,278
Total	**86,884**	**39,327**	**126,211**
Percent	69%	31%	100%

Source: Duke Energy CIS Data

Single family housing accounts for nearly 70 percent of all residential customers. Multifamily housing units including duplexes, condominiums and apartment buildings, make up over 30 percent of residential customers. These residential segments exhibit many differences that impact electric consumption and energy efficiency potential. These differences include size of unit, appliance penetration, building shell integrity and lifestyle attributes.

There are typically many important differences between older and newer homes that have large impacts on energy use and energy efficiency potential. Differences in the thermal integrity of the building shell and appliance penetration rates, for example, can lead to large differences in annual usage between older and newer homes. Existing construction is defined as all homes with meters installed prior to 2009. Current building practices are reflected in the new construction segment, defined as all customers connected in 2009 and 2010. It is important to have a group of homes that represent current construction practices to model and contrast the differences between existing and new housing stock.

New Construction Levels

Residential construction estimated from housing permit data for the DEK service area is shown in Figure 5. Data shown in Figure 5 are based on monthly permit data lagged to approximate the timing of construction and better align temporally with actual electric service installations. Single family and multifamily residential construction in the DEK service area fell sharply from around 3,500 dwellings annually to less than 1,500 following the crash of the U.S. housing market. In recent years the mix of new construction by housing type has averaged about 85 percent single family and 15 percent multifamily. The mix of construction can vary significantly from year to year.

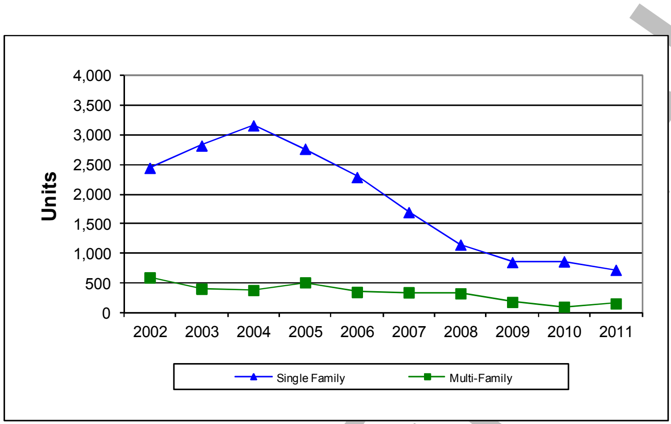

Figure 5. Residential Housing Units Permitted for Construction, DEK Service Area

Housing Stock Characteristics

Figure 6 through Figure 8 were derived from premise attribute information licensed by Duke Energy. These records provide valuable housing attribute details useful for understanding the nature of the housing stock and, therefore, the DSM opportunities. Since housing attribute information is typically derived from tax parcel data, its greatest accuracy and value comes from the information on single family. Multifamily attributes are not presented due to nonsensical patterns in the data, due most likely to the lack of correspondence between a multifamily dwelling and a tax assessor record.[7]

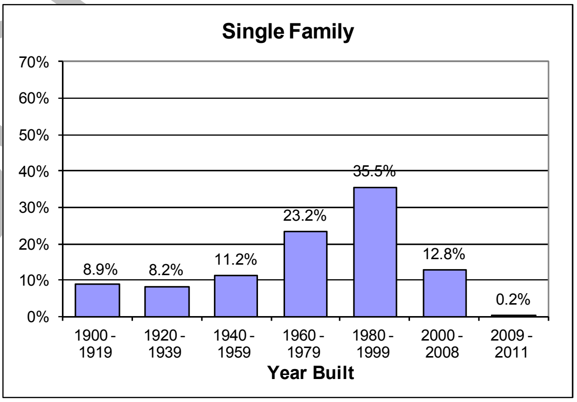

Figure 6. Percent of Dwellings by Year Built – Single Family

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[7] While useful for understanding the residential customer base, the multifamily modeling and usage analysis is not dependent on this descriptive information. Hence, the DSM potential estimates in this study are not affected in any significant way.

Nearly half of the single family housing stock was built after 1980.

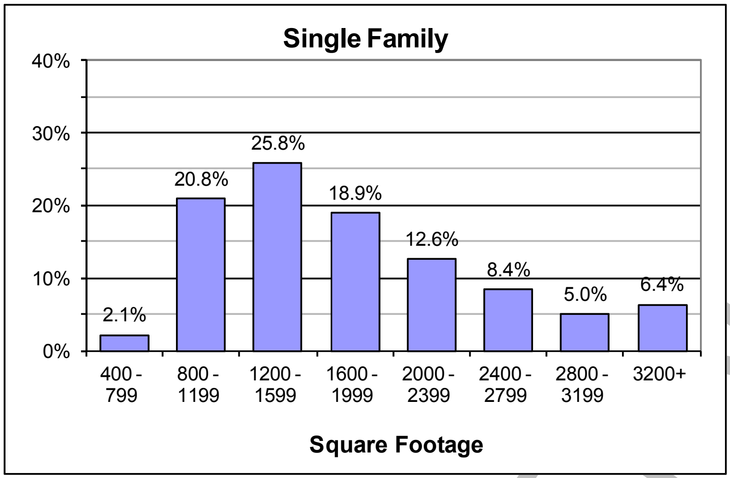

Figure 7. Percent of Dwellings by Square Feet – Single Family

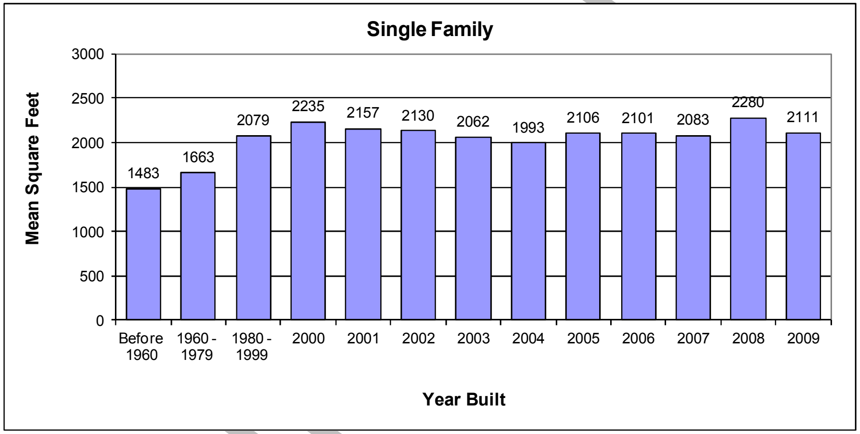

Figure 8. Dwelling Mean Square Feet by Year Built – Single Family

The average size of single family homes has fluctuated around 2,100 square feet since the 1980's.

Appliance Saturation Rates

Our analysis of customer usage took advantage of the Residential Appliance Saturation Survey (RASS) conducted by Duke in late 2010. Appliance saturation rates are important inputs to the segment usage models discussed later in this section. Sample sizes and results for major end-uses and appliances are shown in Table 6. Survey results are reported for segments with at least 30 respondents.

Table 6. Appliance and End-Use Installation Rates from Residential Survey

	Single Family		Multifamily	
	Existing	**New**	**Existing**	**New**
	n=107	**n=4**	**n=27**	**n=1**
Main Heat Fuel - Electric:	23%	NA	58%	NA
Standalone Forced Air Furnace	7%	NA	12%	NA
Heat Pump with Forced Air Furnace	17%	NA	31%	NA
Standalone Heat Pump	0%	NA	8%	NA
Other	0%	NA	8%	NA
Main Heat Fuel - Gas/Other:	77%	NA	42%	NA
Standalone Forced Air Furnace	66%	NA	35%	NA
Heat Pump with Forced Air Furnace	3%	NA	0%	NA
Standalone heat Pump	0%	NA	0%	NA
Other	8%	NA	8%	NA
Used for Cooling:				
Central Air Conditioner	74%	NA	58%	NA
Heat Pump	20%	NA	29%	NA
Window Unit	6%	NA	13%	NA
None	0%	NA	0%	NA
Electric Water Heat	43%	NA	64%	NA
Electric Oven	87%	NA	74%	NA
Electric Range	85%	NA	86%	NA
Electric Clothes Dryer	93%	NA	82%	NA
Dishwasher	82%	NA	70%	NA
Clothes Washer	100%	NA	84%	NA

Source: Residential Appliance Saturation Survey (2010)

In order to provide a sufficiently large number of respondents in all segments, homes built in 2006 and after were classified as new construction for the purpose of summarizing RASS results. Still, this designation did not provide for a sufficient number of completed surveys in the New Single Family and New Multifamily segments.

Electricity Usage Analysis

Monthly billing data at the premise level was aggregated by the four residential customer segments used in this report. An end-use energy and demand model was then estimated using the aggregated billing data, residential survey results, detailed hourly load profiles and weather data. Model assumptions were refined to provide the best empirical fit to the actual customer billing data. Table 7 below shows annual usage for each residential segment.

Table 7. Annual Usage by Residential Segment

Segment	Premises	Average Annual kWh per Premise	Total Usage (millions of kWh)
Existing			
Single Family	85,229	13,350	1,138
Multi Family	38,704	8,803	341
New Construction			
Single Family	1,655	10,633	18
Multi Family	623	7,545	5
Total Residential	**126,211**	**11,892**	**1,501**

Source: Energy model results using monthly billing data from Duke Energy CIS

Because of the large number of homes, the existing stock of single family homes is by far the largest segment, accounting for 75 percent of the residential sector's energy usage.

Monthly residential loads by major end-use are shown in Figure 9 and Table 8.

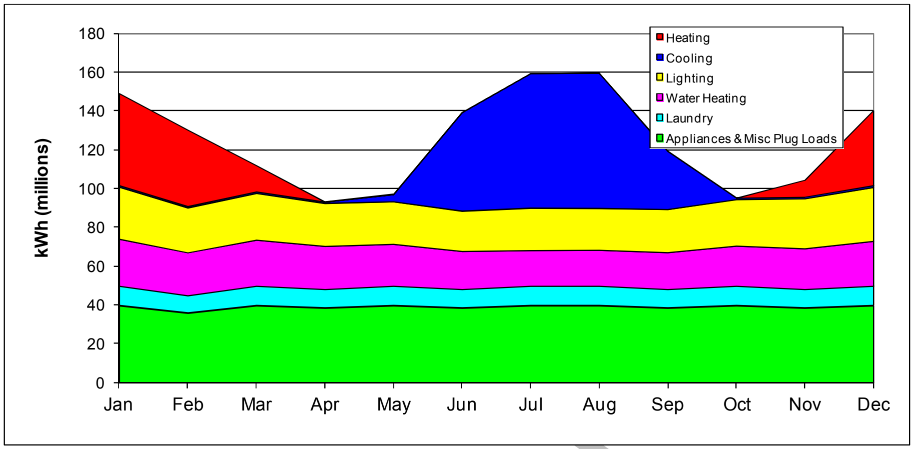

Figure 9. Monthly Residential Loads by End-Use

Table 8. Residential Sector Monthly Usage by End-Use

	Appliances & Misc Plug Load	**Laundry**	**Water Heating**	**Lighting**	**Cooling**	**Heating**	**Total**
	million kWh						
Jan	40	10	24	27	1	47	149
Feb	36	9	22	23	1	39	130
Mar	40	10	24	24	1	13	112
Apr	39	10	22	22	1	0	93
May	40	10	22	22	4	0	97
Jun	39	10	20	21	51	0	139
Jul	40	10	18	22	69	0	159
Aug	40	10	19	21	70	0	160
Sep	39	10	19	22	30	0	120
Oct	40	10	21	24	1	0	96
Nov	39	10	21	26	1	9	105
Dec	40	10	23	28	1	38	140
Annual	**471**	**119**	**254**	**280**	**230**	**147**	**1,501**
Percent	31%	8%	17%	19%	15%	10%	100%

Appliances and miscellaneous plug load is the largest single end-use, accounting for nearly a third of all annual residential usage. Taken together with the other base load end-uses (water heating, laundry and lighting), base loads account for 75 percent of all residential usage. Space cooling and heating account for 25 percent of annual energy usage but contribute significantly to the seasonal peak. Cooling, for example, is responsible for over 40 percent of all July residential kWh consumption. Charts showing the monthly usage by end-use for each of the residential segments are provided in Appendix F.

Non-Residential

The non-residential market is far less homogenous than residential. There are a greater number of basic customer types (segments) and the variation in size of building is much larger in commercial. For these reasons it is useful to describe the non-residential sector not only in terms of number of businesses but also in terms of square footage. Analysis of DSM opportunities in the non-residential segment also benefits from an understanding of the square footage of commercial and industrial space in the service territory. In this section we present the results of analysis to estimate commercial building customer electricity usage by end-use.

Customer Description

Non-residential customer data were segmented using the same SIC code classification scheme used to describe the business data acquired for the service territory. Number of premises and annual usage is shown by segment in Table 9. The number of premises was found to include many non-building types of electrical services (e.g. billboards and railroad controls). To better approximate the number of actual buildings, the data in Table 9 only includes premises with at least 3,000 kWh of annual usage.[8]

Table 9. Number of Premises and Annual Usage by Segment

Segment	CIS Premises	Average Annual kWh per Premise	Total Usage (millions of kWh)	Percent of C&I Loads
Grocery	269	445,536	120	4.8%
Hospitals	20	3,042,096	61	2.5%
Lodging	112	496,836	56	2.2%
Office	5,522	135,798	750	30.2%
Other	215	38,053	8	0.3%
Other Health	557	95,811	53	2.1%
Restaurants	804	165,285	133	5.4%
Retail	1,259	153,419	193	7.8%
Schools	336	507,233	170	6.9%
Wholesale & Warehouse	552	320,773	177	7.1%
Ag, Mining, Util., & Const.	565	58,438	33	1.3%
Small Loads	2,866	972	3	0.1%
Total Commercial	**13,077**	**134,366**	**1,757**	**70.8%**
Total Manufacturing	**618**	**1,174,316**	**726**	**29.2%**
Total Non-Residential	**13,695**	**181,295**	**2,483**	**100.0%**
Source: Energy model results using monthly billing data from CIS.				

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[8] Although arbitrary, this level of usage was thought to effectively screen non-building premises such as billboards and switching equipment. These small commercial load "premises" are grouped in a separate segment.

Commercial Load Analysis

Annual energy usage by segment has already been presented in Table 9. Commercial energy usage by end-use is shown in Figure 10. Commercial load is characterized by a large percentage of base load with a prominent summer cooling peak.

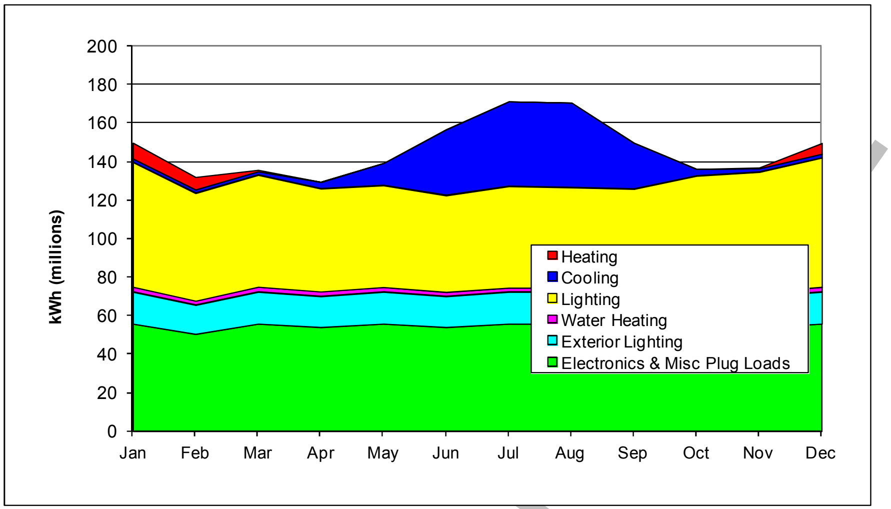

Figure 10. Monthly Commercial Usage by End-Use

Monthly load charts by end-use for each commercial segment are shown in Appendix F.

Table 10. Commercial Sector Monthly Usage by End-Use

	Electronics & Misc Plug Load	Exterior Lighting	Water Heating	Lighting	Cooling	Heating	Total
	million kWh						
Jan	56	17	3	65	2	8	150
Feb	50	15	2	56	2	7	132
Mar	56	17	3	58	2	1	136
Apr	54	16	2	54	3	0	129
May	56	17	2	53	11	0	139
Jun	54	16	2	50	34	0	157
Jul	56	17	2	53	44	0	171
Aug	56	17	2	52	44	0	171
Sep	54	16	2	54	24	0	150
Oct	56	17	2	58	3	0	136
Nov	54	16	2	62	2	0	137
Dec	56	17	2	67	2	6	150
Annual	**656**	**199**	**27**	**682**	**172**	**22**	**1,757**
Percent	37%	11%	2%	39%	10%	1%	100%

Electronics and miscellaneous plug load and lighting make up three-fourths of annual kWh usage in the commercial sector. While cooling load accounts for a quarter of summer usage, it only makes up 10 percent of annual kWh usage.

Manufacturing Load Analysis

Energy sales to manufacturing customers came to 726 million kWh (unadjusted) in 2011, representing nearly a one-fifth of total retail sales. As shown in Table 11, manufacturing customers cover a wide range of industries.

Table 11. Manufacturing Customers and Unadjusted 2011 Loads

SIC - Industry Name	Customers	Use Per Customer (MWh)	Total Usage (MWh)	Percent of Total
20-Food and Kindred Products	41	3,776	154,807	21%
22-Textile Mill Products	4	4,926	19,704	3%
23-Apparel and Other Textile Products	12	69	827	0%
24-Lumber and Wood Products	9	78	703	0%
25-Furniture and Fixtures	7	257	1,797	0%
26-Paper and Allied Products	14	1,395	19,533	3%
27-Printing and Publishing	80	628	50,268	7%
28-Chemicals and Allied Products	33	807	26,640	4%
29-Petroleum and Coal Products	10	295	2,947	0%
30-Rubber and Miscellaneous Plastics Products	17	8,553	145,396	20%
32-Stone, Clay, Glass and Concrete Products	21	2,571	53,998	7%
33-Primary Metal Industries	17	1,958	33,282	5%
34-Fabricated Metal Products	46	378	17,385	2%
35-Industrial Machinery and Equipment	96	575	55,216	8%
36-Electrical and Electronic Equipment	92	61	5,646	1%
37-Transportation Equipment	34	3,576	121,586	17%
38-Instruments and Related Products	17	553	9,399	1%
39-Misc Manufacturing Industries	68	100	6,784	1%
Total Manufacturing	**618**	**1,175**	**725,917**	**100%**

Food Products, Rubber and Plastic, and Transportation Equipment are the largest industries in terms of energy sales in the DEK service area. Together these industries account for nearly 60 percent of annual sales to manufacturing.

Total manufacturing loads are shown by month in Figure 11. Manufacturing loads are characterized by large process-related consumption that is not highly correlated with weather. Still, there is a noticeable summer cooling load that adds to the coincident summer peak.

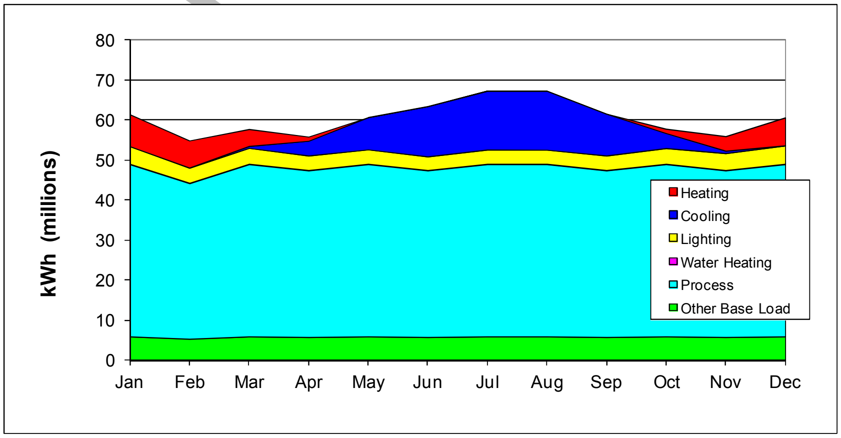

Figure 11. Monthly Manufacturing Usage by End-Use

Additional load shapes by end-use are provided in Appendix F for the following manufacturing segments: Primary Metals, Chemicals, Transportation Equipment, Food Products and Other Manufacturing.

Table 12. Manufacturing Sector Monthly Usage by End-Use

	Other Base Load	**Process**	**Water Heating**	**Lighting**	**Cooling**	**Heating**	**Total**
	million kWh						
Jan	6	43	0.2	4	0	8	61
Feb	5	39	0.1	4	0	7	55
Mar	6	43	0.2	4	1	4	58
Apr	6	42	0.1	4	4	1	56
May	6	43	0.1	4	8	0	61
Jun	6	42	0.1	3	13	0	64
Jul	6	43	0.1	4	15	0	67
Aug	6	43	0.1	3	15	0	67
Sep	6	42	0.1	4	10	0	62
Oct	6	43	0.1	4	4	1	58
Nov	6	42	0.1	4	1	4	56
Dec	6	43	0.2	5	0	7	61
Annual	**69**	**508**	**1.7**	**46**	**70**	**32**	**726**
Percent	9%	70%	0%	6%	10%	4%	100%

Other base load and process end-uses account for nearly 80 percent of annual manufacturing usage and are nearly constant across months.

ENERGY EFFICIENCY MEASURES AND POTENTIAL SAVINGS

In this section we present our estimates of the energy savings potential in the DEK service area. This work builds off of the energy modeling results presented in Appendix A by applying energy efficiency technologies to the model parameters. These technologies, referred to as Energy Efficiency Measures (EEMs), cause a reduction in the load profiles of the end-uses presented in the prior section. In this section we derive estimates of technical and economic potential.

Technical Potential

Technical potential refers to the amount of energy efficiency that could be obtained if all EEMs were adopted without regard to costs. This level of savings represents the upper limit of energy efficiency opportunity. Our estimate of technical potential assumes that all customers in each sector use the most efficient available electric technology for each end-use. The base to which the technical potential is referenced is electric energy use in the test year, 2011, normalized to long-term average temperatures. This base is fundamental to any estimate of technical potential. In principle the base represents the current practice including all codes and standards currently in place. However, in this technical potential estimate, the standards in place include a phase out of most incandescent light bulbs in the 2011 to 2016 time period. When it is complete, sometime after 2016, this phase out of incandescent lighting is expected to lead to reasonably significant energy reductions of the order of 2 to 4 percent for the residential sector and 3 to 5 percent for the commercial sector.

The test year, 2011, does not include the full physical effects of this mandated more efficient lighting because the switch to the more efficient lighting has just begun and is nowhere near complete. Therefore, the technical potential as referenced to the 2011 base will slightly overstate the future savings due to lighting improvements since the 2011 base year uses more energy for lighting than it is expected to in the near future, based on current standards. Therefore, the lighting savings component of the technical potential reported here has been de-rated to represent the savings potential relative to the more efficient lighting situation that will prevail in the near future when the full effects of the new lighting standards are realized. This is not a large change in the full scheme of things, but it is necessary in order to align the technical potential model to the utility forecast which includes the effects of the current lighting standards.

This lighting efficiency change is the only efficiency change that is being specially treated in this technical potential estimate. It is probable that there will be other future energy efficiency codes and standards, but these future efficiency improvements are currently not specifically known. If future standards come into effect, they will be considered as contributing fully to the technical potential. Likewise, there will probably be other spontaneous efficiency improvements in various commercial and industrial sectors, but these improvements are speculative at the current time. So in the interest of keeping this analysis reasonably simple, the end-use energy efficiency in all twenty four analysis sectors is assumed to remain constant; this is commonly referred to as a "frozen efficiency" analysis.

Conspicuously, this technical potential estimate does not include changes in energy use in response to changes in energy costs: price elasticity effects. The focus of this analysis is on the savings due to physical measures that reduce energy use without diminishing comfort factors. We recognize that there can be significant energy use changes due to energy price changes, but these price elasticity related changes are not considered as being part of the technical potential.

We have restricted our analysis to technologies meeting existing electric end-uses more efficiently. The technical potential derived in this analysis does not consider fuel switching technologies, but there are significant interactions between electric efficiencies and gas usage. In particular, envelope or equipment efficiencies intended to reduce cooling energy will also often reduce the use of gas for space heating. Interior lighting efficiencies and appliance efficiencies can actually increase the use of gas for space heating.

The technical potential is derived by applying all the efficiency measures at once in the energy model, so that interactions between measures are properly accounted for. For estimating the total technical potential, all the measures are applied as a package. In developing technical potential, we apply several EEMs at the same time, such as, the replacement of electric furnaces by heat pumps, leak tested ducts, improved lighting, and hot water flow reduction. The result of applying all these EEMs is shown in Figure 12. This figure is used to illustrate the derivation of technical potential and shows the energy use patterns for customers with electric furnaces that upgrade to a heat pump.

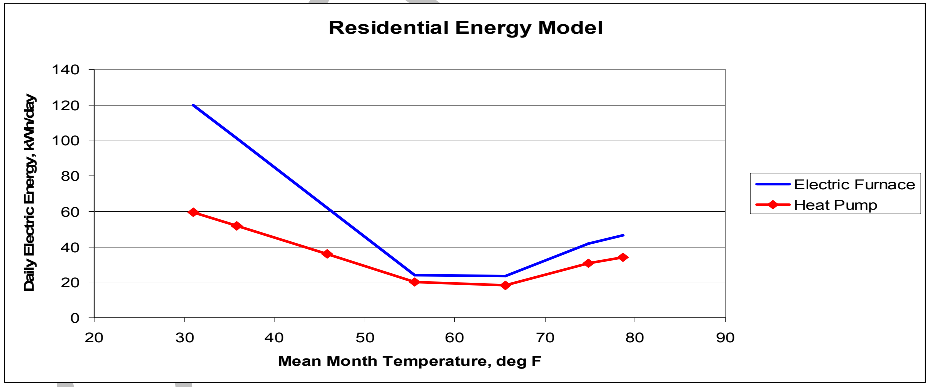

Figure 12. Residential Technical Potential Models

Figure 12 shows model results for two space heating options for an average building in the residential sector. In an energy use model of this sort, the lines specify the average daily electric usage given a particular average monthly outdoor temperature. The model can then be changed to represent physical changes to the building. Typically these models will be used to estimate the normal annual energy use by evaluating the model at each of the average monthly temperatures in a normal year.

In this illustration, the blue line is the current building energy performance model of a residential customer with an electric furnace. It shows a minimum electric energy use of about 23 kWh per day when the mean month temperature is in the 55-65°F range. In this temperature range, the building is neither heating nor cooling so this minimum is taken as the base load usage including lights, electronics, refrigeration, and all other electricity uses. As it gets colder, the electric usage for heating increases to about 120 kWh per day when it is on average 30°F outside. As the monthly temperature increases in the summer, the energy usage for cooling increases until it is about 50 kWh per day when the average monthly temperature is 80°F.

The red line shows what happens as the electric furnace is replaced by a heat pump and more efficient showerheads, lighting, and appliances are used. This more efficient building shows a lower base load energy use due to the efficient showerheads and more efficient lights and appliances. In addition, it shows significantly lower temperature sensitivity due to a more efficient space heating and cooling. In this example, the initial electric energy use of 20,600 kWh per year is reduced to 12,500 kWh per year. As is evident in Figure 12, most of the savings are associated with the improved heating efficiency.

There is a well developed community of interest and capability directed at residential space heat and water heating efficiency. In most retrofit programs, heating efficiency is approached in the same treatment from its three logical avenues: better thermal conversion and distribution efficiency, lower thermal and infiltration losses, and better controls. The water heating savings potential is made up of savings from lower flow fixtures, lower tank standby losses, and improved water heating efficiency from hot water heat pumps and solar water heat. One of the largest components of residential potential is the use of a higher thermal conversion efficiency afforded by efficient heat pumps and air conditioners coupled to a leak tested duct system. The next largest component is lighting savings followed closely by the improved thermal shell of the structure and water heating savings.

Non-residential buildings have more complex controls than typical residential applications. Usually, there will be a boiler. Often there will be a designated energy manager. This type of situation has been the focus of energy management contractors because there are large enough energy flows to create significant dollar savings. The largest elements of savings for this group are associated with improved lighting efficiency and improved controls and motors for manufacturing customers. The thermal integrity of the shell in this group is subject to improvement especially with respect to infiltration.

Figure 13 shows the effect of applying maximum reasonable improvements to every residential and non-residential building. This reasonably aggressive application of efficiency technology leads to the technical potential shown in Table 13 below. The technical potential line shows base case energy usage after applying energy efficiency measures. When solar is included, residential technical potential includes application of solar technologies with solar water heat on half the buildings and a 2 kW solar electric array on one-third of the buildings. Non-residential technical potential includes installation of 50 kW solar electric arrays on fifteen percent of buildings.

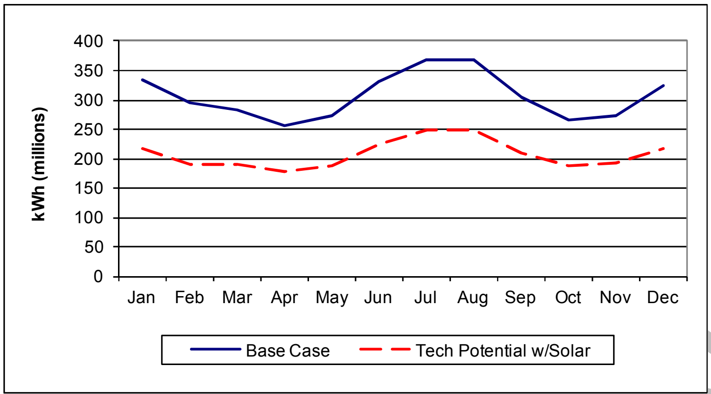

Figure 13. Technical Potential with Solar by Month (2012)

It should be noted that solar electric technology is technically fully mature. In principle, it could be maximally applied without regard for cost to create a technical potential savings of 100 percent. While this argument is technically accurate, we have resisted carrying the argument this far. Nevertheless, the solar potential noted here reflects an aggressive solar deployment.

For an electric utility the second aspect of the technical potential pertains to changes in demand proceeding from the efficiency measures. In general, changes in demand will vary from hour-to-hour and month-to-month. We have estimated an hourly demand curve for the average day of each month for the base case and for the technical potential case. Figure 14 shows the hourly demand curves for July and Figure 15 shows January to illustrate cooling and heating demand, respectively.

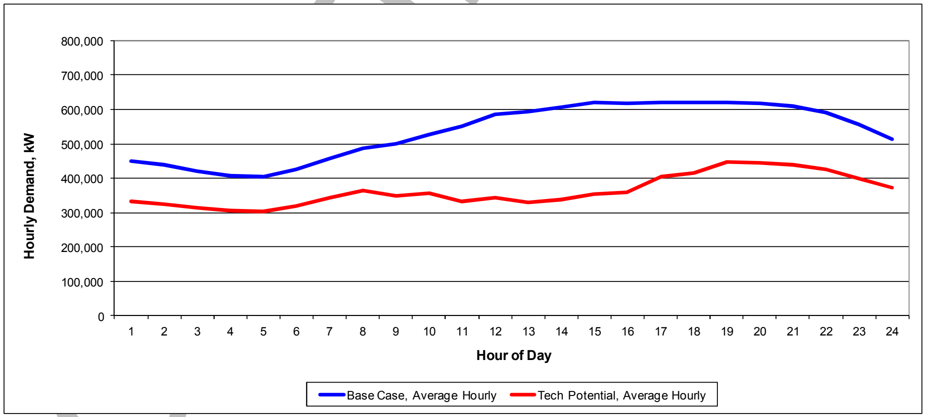

Figure 14. Technical Potential with Solar for Demand Reduction – July

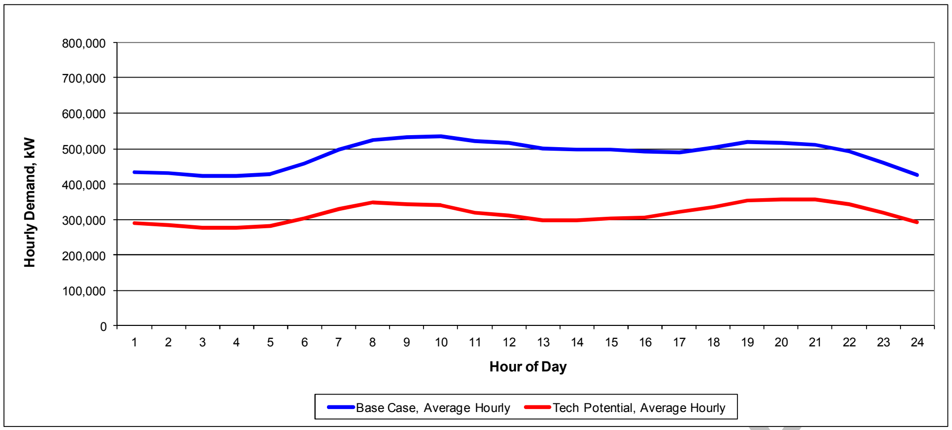

Figure 15. Technical Potential with Solar for Demand Reduction – January

This is because winter heating savings are quite strong. A summary of the technical potential is presented in Table 13 which reports the total technical potential in terms of load at the meter after transmission and distribution losses. The technical potential estimates for demand savings are expressed for cases including and excluding the extensive solar photovoltaic (PV) which is included as technically achievable. The technical potential excluding PV still includes energy savings associated with solar hot water and solar passive space heating (solar siting). Our analysis of technical potential shows that it is technically possible to cut usage and demand significantly. However, these estimates are not realistic estimates of actual reductions because they are unconstrained by market, behavioral and budget considerations.

Table 13. Summary of Technical Potential Over 5, 10 and 20 Year Planning Horizons

	2012	2017	2022	2032
Base Case Electric Energy Usage (millions kWh)	3,677	4,097	4,333	4,791
Technical Potential – Including Solar PV (millions kWh)	1,187	1,318	1,392	1,543
Percent	32%	32%	32%	32%
Technical Potential – Excluding Solar PV (millions kWh)	981	1,089	1,151	1,276
Percent	27%	27%	27%	27%
Base Case Summer System Peak Load (MW)	730	814	861	956
Technical Potential - Including Solar PV (MW)	259	287	304	338
Percent	35%	35%	35%	35%
Technical Potential - Excluding Solar PV (MW)	215	239	253	281
Percent	29%	29%	29%	29%
Base Case Winter System Peak Load (MW)	554	617	653	725
Technical Potential - Including Solar PV (MW)	205	228	241	267
Percent	37%	37%	37%	37%
Technical Potential - Excluding Solar PV (MW)	193	214	226	252
Percent	35%	35%	35%	35%

It is important to understand the variation of technical potential with time. In Figure 16 base case energy usage is broken down between core usage, usage that remains after removing technical potential, and potential energy savings from energy efficient retrofits, energy efficient new construction, and solar. In this figure the retrofit potential, red, remains constant over time. The new construction potential, the green wedge, increases in proportion to the amount of new construction. The solar potential increases slightly with time as more treeless building sites are used. As later analysis will show, the solar potential is beyond the immediate cost effectiveness limit. But this category of potential is technically sound, very large, and homogenous. It may reasonably become cost effective within the 20-year planning window, and it is important to understand the role and size of this resource in the larger picture.

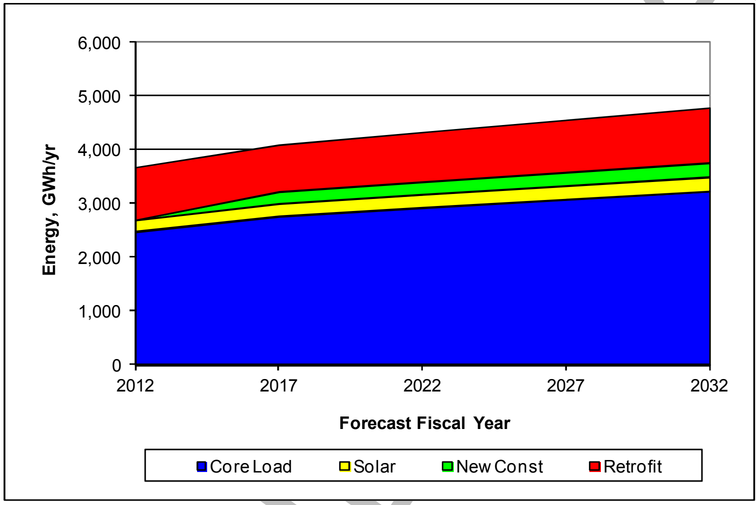

Figure 16. Technical Potential over Planning Horizon

Energy Efficiency Measure Assessment

In order to evaluate technologies for their potential in electric DSM programs it is necessary to compile detailed information at the EEM level of detail. An EEM is a device or action that causes a drop in energy usage. The objective of EEM assessment or screening is to determine the likely set of cost effective measures which can then be used to populate DSM programs that deliver savings through standalone or bundled EEMs. An important by-product of this screening is the information necessary to construct a DSM supply curve for determining economic potential. Measure savings and the associated energy efficiency supply curves are "gross" savings meaning they have not been adjusted for free riders.

Our list of EEMs and assumptions was developed through an integrated approach that combined an extensive review of industry literature, the detailed analysis of DEK loads described earlier, and our own expert opinion. These assumptions and sources are documented in the appendixes. The assumptions required to calculate EEM cost effectiveness are shown in Table 14 for residential and Table 15 for non-residential. Each of these tables uses a standard layout to present the assumptions used to calculate real levelized cost (RLC) per kWh. A discussion of the cost effectiveness approach used to evaluate EEMs follows these two tables.

Descriptions of the columns in Table 14 and Table 15 are presented below.

End-Uses	Unique EEM reference number.
EEM Description	Brief description of the EEM. See the appendixes for a more detailed description.
EEM Reference	Code to uniquely identify an EEM in this project.
Application	For residential measures only, describes the segment of residential sector where the EEM assumptions are applicable. For example, the same EEM may have different assumptions for single family and multifamily applications.
Annual kWh Savings	Annual kWh savings (gross) per customer site.
Incremental Cost	The incremental cost of installing the EEM at the typical customer site, including any incremental equipment and labor expenses. Note: "incremental" refers to the costs over and above what would have been expended for a standard efficiency measure. All costs are in 2012 dollars.
Annual O&M	Annual operation and maintenance (O&M) expenses over and above the O&M expenses incurred for standard efficiency measures. Most EEMs have zero incremental O&M expenses.
Measure Life	The average expected life of the measure.
Real Levelized Cost	The incremental cost and annual O&M expressed as a constant annual payment over the life of the measure and then divided by the annual savings. Real levelized cost provides a way of comparing EEMs with different attributes such as measure life on the same scale. No overhead or program cost is included at this point in the analysis.

Table 14. DSM Technology Assessment, Residential

End-Uses	EEM Description	EEM Reference	Application	Annual kWh Savings	Incremental Cost (dollars)	Annual O&M (dollars)	Measure Life (years)	Real Levelized Cost ($/kWh)
1. Customer-Sited Generation	Combined Heat Power, micro CHP	R-1	All	5,000	10,000	25	15	0.1994
2. Residential Space Conditioning	Elec Furnace to SEER 16 H Pump	R-2	Elec SF	8,000	3,750	100	15	0.0581
	Resist to SEER 16 Heat Pump	R-3	Elec SF	6,800	8,500	100	15	0.1362
	Elec Furnace to SEER 16 H Pump	R-4	Elec MF	6,471	2,813	100	15	0.0577
	Resist to SEER 16 Heat Pump	R-5	Elec MF	5,500	6,375	100	15	0.1308
	Refrig Charge/Duct Tune-Up	R-6	Elec	1,200	300	0	10	0.0326
	Refrig Charge/Duct Tune-Up	R-7	Gas	300	300	0	10	0.1303
	SEER 13 to SEER 16 Heat Pump	R-8	SF Elec New	800	643	0	20	0.0652
	SEER 13 to SEER 16 Heat Pump	R-9	MF Elec New	700	643	0	20	0.0745
	SEER 13 to SEER 16 CAC	R-10	SF Gas New	400	515	0	20	0.1044
	SEER 13 to SEER 16 CAC	R-11	MFGas New	350	515	0	20	0.1193
	Efficient Window AC	R-12	All	200	161	0	13	0.0863
	Cool Roofs	R-13	Elec	560	340	0	20	0.0493
	EE Windows	R-14	Elec	1,334	2,680	0	25	0.1444
	Programmable Thermostats	R-15	Elec	700	200	0	10	0.0372
	Ceiling Insulation (R6-R30)	R-16	Elec	1,800	1,200	0	25	0.0479
	Ceiling Insulation (R6-R30)	R-17	Gas	300	1,200	0	25	0.2875
	House Sealing using Blower Door	R-18	Elec	1,000	500	0	10	0.0652
	House Sealing using Blower Door	R-19	Gas	200	500	0	10	0.3258
	Ground Source Heat Pump	R-20	Elec	3,300	7,504	100	25	0.1938
	Wall Insulation (R3-R11)	R-21	Elec	2,100	1,700	0	25	0.0582
	Wall Insulation (R3-R11)	R-22	Gas	400	1,700	0	25	0.3055
	Solar Siting/Passive Design	R-23	New Elec	1,500	536	0	25	0.0257
	Energy Star Manufactured Home	R-24	New	5,000	2,500	0	25	0.0359
	Energy Star Construction	R-25a	New Elec	3,972	3,000	0	25	0.0543
	Major Remodel	R-25b	Elec	3,939	3,000	0	25	0.0547
	Window Film	R-26	Elec	400	125	0	5	0.0724
3. Load Management	Eliminate Old Appliances	R-27	All	1,150	180	0	5	0.0363
	Set Back HVAC with Ceiling Fan	R-28	All	250	86	0	10	0.0448
4. Residential Appliances	Energy Star Clothes Washers	R-29	All	400	116	0	18	0.0251
	Energy Star Dish Washers	R-30	All	75	54	0	10	0.0931
	Energy Star Refrigerators	R-31	All	91	60	0	18	0.0570
	Pool Pumps	R-32	All	640	180	0	10	0.0367
5. Residential Lighting	Efficient Residential Lighting	R-33	All	660	24	0	5	0.0084
	Daylighting Design	R-34	New Elec	750	536	0	25	0.0514
	Occupancy Controlled Outdoor Lighting	R-35	All	250	107	0	10	0.0559
	Residential Outdoor Lighting	R-36	All	1,000	500	0	15	0.0486
6. Water Heating	Tank Wrap, Pipe Wrap and Water Temp Setpoint	R-37	All	200	50	0	10	0.0326
	Low Flow Fixtures	R-38	All	600	27	0	10	0.0058
	Heat Pump Water Heaters	R-39	All	2,400	1,800	0	15	0.0729
	Tankless Water Heaters	R-40	All	400	850	0	18	0.1836
	Solar Water Heaters	R-41	All	2,900	6,000	21	25	0.1561
	Efficient Plumbing	R-42	New Elec	500	536	0	25	0.0771
7. Miscellaneous Technologies	Ductless Heat Pump	R-43	Elec	3,425	3,000	100	15	0.1143
	Drain HX	R-44	Elec	800	800	0	20	0.0811
	Smart Plug	R-45	All	250	40	0	10	0.0209
	Heat Pump Pool Heater	R-46	All	8,000	4,000	10	15	0.0498
	Customer Report	R-47	All	193	0	8	1	0.0415
	Solar PV	R-48	Elec	3,000	12,000	0	25	0.2875
	In Home Display	R-49	All	394	200	0	8	0.0790

Note: Dollar amounts are expressed in 2012 dollars.

Table 15. DSM Technology Assessment, Non-Residential

End-Uses	EEM Description	EEM Reference	Annual kWh Savings	Incremental Cost (dollars)	Annual O&M (dollars)	Measure Life (years)	Real Levelized Cost ($/kWh)
1. Customer-Sited Generation	Combined Heat and Power, CHP	C-1	2,000,000	300,000	75,000	25	0.0483
2. C&I Space Conditioning	Small HVAC Optimization and Repair	C-2	5,617	1,200	50	5	0.0584
	Commissioning - New	C-3	36,064	6,300	0	5	0.0405
	Re/Retro-Commissioning Lite	C-4	24,042	1,500	0	5	0.0145
	Low-e Windows 1500 ft2 New	C-5	15,000	4,500	0	25	0.0216
	Low-e Windows 1500 ft2 Replace	C-6	15,000	30,000	0	25	0.1438
	Premium New HVAC Equipment	C-7	12,021	5,571	250	15	0.0658
	Large HVAC Optimization and Repair	C-8	12,021	4,110	0	5	0.0793
	Window Film	C-9	832	260	0	5	0.0724
5. Design (new)	Integrated Building Design	C-10	60,106	20,364	0	25	0.0244
	Efficient Package Refrigeration	C-11	24,042	3,565	0	15	0.0144
6. Motors & Drives	Electronically Commutated Motors	C-12	9,617	3,211	0	15	0.0325
	Premium Motors	C-13	3,745	412	0	15	0.0107
	Variable Speed Drives, Controls and Motor Applications Tune-Up	C-14a	48,085	41,414	0	15	0.0837
	Single Application VSD	C-14b	1,200	200	0	15	0.0162
7. Power Distribution	Energy Star Transformers	C-15	3,606	292	0	18	0.0070
	Efficient AC/DC Power	C-16	3,606	268	0	5	0.0172
9. Lighting	Efficient/LED Outdoor Lighting	C-17	3,000	1,500	-50	20	0.0239
	New Efficient Lighting Equipment	C-18	19,234	5,059	0	18	0.0227
	Retrofit Efficient Lighting Equipment	C-19	19,234	6,323	0	18	0.0284
	LED Exit Signs	C-20	1,470	270	0	10	0.0239
	LED Traffic Lights (10)	C-21	5,000	2,000	-400	10	-0.0279
	Perimeter Daylighting	C-22	7,213	6,127	0	18	0.0734
10. Water Heating	Low Flow Fixtures	C-23	6,000	1,000	0	10	0.0217
	Solar Water Heaters	C-24	2,500	6,000	20	25	0.1805
	Heat Pump Water Heaters	C-25	2,000	2,000	20	18	0.0964
11. Cooking and Laundry	HE Food Prep and Holding	C-26	3,884	1,100	60	12	0.0476
	Energy Star Commercial Clothes Washer	C-27	1,845	1,041	20	10	0.0844
	Restaurant Commissioning Audit	C-28	19,234	1,419	0	5	0.0171
13. Other	Grocery Refrigeration Tune-Up and Improvements	C-29	14,425	2,734	0	5	0.0439
	Refrigeration Casework Improvements	C-30	12,021	3,967	10	10	0.0438
	VendingMiser®	C-31	1,000	215	0	10	0.0280
	Network Computer Power Management	C-32	4,808	338	0	2	0.0379
	Solar Electric	C-33	55,000	220,000	0	25	0.2875

Note: Dollar amounts are expressed in 2012 dollars.

Cost Effectiveness[9]

Cost effectiveness of each EEM is measured by the real levelized cost per kWh. Real levelized cost expresses the total incremental cost and any annual operation and maintenance expense as a constant annual payment over the life of the measure divided by annual savings.[10] The advantage of RLC is that it normalizes for differences in measure life and other EEM attributes to provide a means of comparing EEMs in terms of their relative cost effectiveness. As will be demonstrated in the next section, RLC also provides a convenient method for determining economic potential.

Assumptions on average annual savings, installed cost and measure life come from many sources, including the energy modeling work conducted as part of this project using segment-specific billing data for Duke Energy customers.[11] In other words, our annual savings estimates are linked and consistent with the modeled loads reported in the Market Assessment section of this report. Incremental cost for the EEM screening step includes the incremental costs of installing the measure. Depending on the measure, this could be simply the cost of the high efficiency measure over and above the standard efficiency option. In other cases installation labor and site modifications may also be required for the high efficiency model and, hence, would be included in incremental cost. At this stage of analysis (EEM screening), the costs do not include program administration, implementation and evaluation. Tax credits are also not considered at this stage of the analysis.

It should be pointed out that program design may have an impact on some of the EEM screening assumptions. An owner-installed delivery option, for example, may result in lower installed cost than a contractor installation but may also result in higher savings degradation rates, depending on the measure. Such tradeoffs are important program design considerations but beyond the scope of EEM analysis. For the purposes of this stage of analysis the EEM assumptions provide a reasonable starting point for our assessment of energy efficiency options.

Energy efficiency measures in Table 14 and Table 15 have been grouped by major end-use categories. Measures considered in the screening include combined heat and power (cogeneration) and solar electric. In principle these measures can provide very large energy savings, but they are usually not cost effective. They are included in this screening to keep a broad perspective in the analysis and to reach toward a more full understanding of the possibilities and physical limits of potential.

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[9] Two types of cost effectiveness analysis are presented in this report. This section deals only with technology assessment using levelized cost. More comprehensive analysis is required at the program level. See Appendix B for a discussion of each type of cost effectiveness analysis.

[10] The formula for this calculation is presented in Appendix B. A real discount rate of 5.13 percent was used based on the DEK weighted average cost of capital.

[11] The modeling is described in more detail in Appendix A and EEM assumptions are described in their respective appendixes.

Cost Effectiveness Rankings

The residential and non-residential measures are ranked by cost effectiveness in Table 16 and Table 17, respectively. Descriptions of the columns in these tables are presented below.

EEM Reference	Unique EEM reference number.
EEM Description	Brief description of the EEM. See appendixes for a more detailed description.
Application	For residential measures only, describes the segment of residential sector where the EEM assumptions are applicable. For example, the same EEM may have different assumptions for single family and multifamily applications.
Real Levelized Cost ($/kWh)	The incremental cost and annual O&M expressed as a constant annual payment over the life of the measure and then divided by the annual savings. Entries in the EEM ranking table are sorted from least cost (lowest RLC) to highest cost measures. No overhead or program cost is included at this point in the analysis.
Annual Savings per Site (kWh)	Annual kWh savings (gross) per customer site.
Potential Sites	An estimate of the potential number of customer sites that could have the EEM installed without regard to cost. See appendixes for more information on determining this estimate for each measure.
Potential Annual Savings (Measure and Cumulative) (million kWh)	Total annual energy savings potential in MWh derived by multiplying the annual savings per site by the number of potential sites.

It is apparent in Table 16 that many of the lower cost measures are retrofit measures and some efficient appliances (notably washers and lighting). Some measures with large technical potential are shown to have moderate to high cost (e.g. heat pump water heaters and solar water heaters).

Table 16. Ranked Measures, Residential

EEM Reference	EEM Description	Application	Real Levelized Cost ($/kWh)	Annual Savings per Site (kWh)	Potential Sites	Potential Annual Savings (million kWh)	
						Measure	Cumul-ative
R-38	Low Flow Fixtures	All	0.006	600	36,906	22.1	22
R-33	Efficient Residential Lighting	All	0.008	660	56,162	37.1	59
R-45	Smart Plug	All	0.021	250	24,069	6.0	65
R-29	Energy Star Clothes Washers	All	0.025	400	32,092	12.8	78
R-23	Solar Siting/Passive Design	New Elec	0.026	1500	9,628	14.4	93
R-6	Refrig Charge/Duct Tune-Up	Elec	0.033	1200	16,046	19.3	112
R-37	Tank Wrap, Pipe Wrap and Water Temp Setpoint	All	0.033	200	56,162	11.2	123
R-24	Energy Star Manufactured Home	New	0.036	5000	3,463	17.3	140
R-27	Eliminate Old Appliances	All	0.036	1150	16,046	18.5	159
R-32	Pool Pumps	All	0.037	640	20,136	12.9	172
R-15	Programmable Thermostats	Elec	0.037	700	16,046	11.2	183
R-47	Customer Report	All	0.041	193	40,115	7.7	191
R-28	Set Back HVAC with Ceiling Fan	All	0.045	250	28,766	7.2	198
R-16	Ceiling Insulation (R6-R30)	Elec	0.048	1800	8,023	14.4	212
R-36	Residential Outdoor Lighting	All	0.049	1000	4,814	4.8	217
R-13	Cool Roofs	Elec	0.049	560	19,255	10.8	228
R-46	Heat Pump Pool Heater	All	0.050	8000	1,605	12.8	241
R-34	Daylighting Design	New Elec	0.051	750	9,259	6.9	248
R-25a	Energy Star Construction	New Elec	0.054	3972	11,232	44.6	292
R-25b	Major Remodel	Elec	0.055	3939	6,418	25.3	318
R-35	Occupancy Controlled Outdoor Lighting	All	0.056	250	40,115	10.0	328
R-31	Energy Star Refrigerators	All	0.057	91	80,231	7.3	335
R-4	Elec Furnace to SEER 16 H Pump	Elec MF	0.058	6471	3,851	24.9	360
R-2	Elec Furnace to SEER 16 H Pump	Elec SF	0.058	8000	3,851	30.8	391
R-21	Wall Insulation (R3-R11)	Elec	0.058	2100	13,479	28.3	419
R-18	House Sealing using Blower Door	Elec	0.065	1000	10,270	10.3	429
R-8	SEER 13 to SEER 16 Heat Pump	SF Elec New	0.065	800	11,232	9.0	438
R-26	Window Film	Elec	0.072	400	1,605	0.6	439
R-39	Heat Pump Water Heaters	All	0.073	2400	24,069	57.8	497
R-9	SEER 13 to SEER 16 Heat Pump	MF Elec New	0.075	700	6,418	4.5	501
R-42	Efficient Plumbing	New Elec	0.077	500	3,209	1.6	503
R-49	In Home Display	All	0.079	394	3,209	1.3	504
R-44	Drain HX	Elec	0.081	800	16,046	12.8	517
R-12	Efficient Window AC	All	0.086	200	32,018	6.4	523
R-30	Energy Star Dish Washers	All	0.093	75	100,681	7.6	531
R-10	SEER 13 to SEER 16 CAC	SF Gas New	0.104	400	15,874	6.3	537
R-43	Ductless Heat Pump	Elec	0.114	3425	8,633	29.6	567
R-11	SEER 13 to SEER 16 CAC	MFGas New	0.119	350	8,023	2.8	569
R-7	Refrig Charge/Duct Tune-Up	Gas	0.130	300	16,046	4.8	574
R-5	Resist to SEER 16 Heat Pump	Elec MF	0.131	5500	2,407	13.2	587
R-3	Resist to SEER 16 Heat Pump	Elec SF	0.136	6800	2,407	16.4	604
R-14	EE Windows	Elec	0.144	1334	11,232	15.0	619
R-41	Solar Water Heaters	All	0.156	2900	24,069	69.8	689
R-40	Tankless Water Heaters	All	0.184	400	2,877	1.2	690
R-20	Ground Source Heat Pump	Elec	0.194	3300	4,814	15.9	706
R-1	Combined Heat Power, micro CHP	All	0.199	5000	160	0.8	706
R-48	Solar PV	Elec	0.288	3000	41,720	125.2	832
R-17	Ceiling Insulation (R6-R30)	Gas	0.288	300	32,092	9.6	841
R-22	Wall Insulation (R3-R11)	Gas	0.305	400	32,092	12.8	854
R-19	House Sealing using Blower Door	Gas	0.326	200	40,115	8.0	862
Note: Dollar amounts are expressed in 2012 dollars.							

Generally measures that pertain to efficient new construction are reasonably cost effective because EEMs can be installed at the time of construction with low incremental cost impacts.

The non-residential measures are ranked in Table 17 by cost effectiveness. Measures pertaining to building efficient new stock are generally cost effective. Also, measures associated with tuning and properly maintaining HVAC and refrigeration equipment are generally cost effective. Lighting, new design and commissioning are both cost effective and large. The highest cost measures are heat pump water heaters, solar water heat and solar photovoltaic.

Table 17. Ranked Measures, Non-Residential

EEM Reference	EEM Description	Real Levelized Cost ($/kWh)	Annual Savings Per Site (kWh)	Potential Sites	Potential Annual Savings (million kWh)	
					Measure	Cumulative
C-21	LED Traffic Lights (10)	-0.028	5,000	4,196	21.0	21
C-15	Energy Star Transformers	0.007	3,606	1,439	5.2	26
C-13	Premium Motors	0.011	3,745	839	3.1	29
C-11	Efficient Package Refrigeration	0.014	24,042	599	14.4	44
C-4	Re/Retro-Commissioning Lite	0.014	24,042	1,798	43.2	87
C-14b	Single Application VSD	0.016	1,200	1,798	2.2	89
C-28	Restaurant Commissioning Audit	0.017	19,234	360	6.9	96
C-16	Efficient AC/DC Power	0.017	3,606	2,997	10.8	107
C-5	Low-e Windows 1500 ft2 New	0.022	15,000	947	14.2	121
C-23	Low Flow Fixtures	0.022	6,000	912	5.5	127
C-18	New Efficient Lighting Equipment	0.023	19,234	2,997	57.6	184
C-17	Efficient/LED Outdoor Lighting	0.024	3,000	2,398	7.2	191
C-20	LED Exit Signs	0.024	1,470	4,196	6.2	198
C-10	Integrated Building Design	0.024	60,106	1,427	85.8	283
C-31	VendingMiser®	0.028	1,000	599	0.6	284
C-19	Retrofit Efficient Lighting Equipment	0.028	19,234	2,997	57.6	342
C-12	Electronically Commutated Motors	0.032	9,617	599	5.8	347
C-32	Network Computer Power Management	0.038	4,808	3,596	17.3	365
C-3	Commissioning - New	0.040	36,064	0	0.0	365
C-30	Refrigeration Casework Improvements	0.044	12,021	120	1.4	366
C-29	Grocery Refrigeration Tune-Up and Improvements	0.044	14,425	120	1.7	368
C-26	HE Food Prep and Holding	0.048	3,884	360	1.4	369
C-1	Combined Heat and Power, CHP	0.048	2,000,000	30	60.0	429
C-2	Small HVAC Optimization and Repair	0.058	5,617	2,398	13.5	443
C-7	Premium New HVAC Equipment	0.066	12,021	1,199	14.4	457
C-9	Window Film	0.072	832	120	0.1	457
C-22	Perimeter Daylighting	0.073	7,213	1,798	13.0	470
C-8	Large HVAC Optimization and Repair	0.079	12,021	669	8.0	478
C-14a	Variable Speed Drives, Controls and Motor Applications Tune-Up	0.084	48,085	1,199	57.6	536
C-27	Energy Star Commercial Clothes Washer	0.084	1,845	480	0.9	537
C-25	Heat Pump Water Heaters	0.096	2,000	719	1.4	538
C-6	Low-e Windows 1500 ft2 Replace	0.144	15,000	599	9.0	547
C-24	Solar Water Heaters	0.181	2,500	719	1.8	549
C-33	Solar Electric	0.288	55,000	2,398	131.9	681
Note: Dollar amounts are expressed in 2012 dollars.						

Economic Potential

Economic potential is defined as the total energy savings available at a specified long-term avoided cost of energy. Technologies with levelized costs that are lower than the avoided cost of energy are included in estimates of economic potential. A DSM supply curve provides a flexible framework for presenting economic potential that reflects the direct relationship between the long-term marginal cost of energy supply and energy efficiency potential. Unlike point estimates, DSM supply curves show the economic potential at several levels of marginal supply cost. The incremental cost of measures does not include program delivery and administration expenses that will be required to actually achieve energy savings. In order to provide a more realistic estimate of the economic potential, a 30 percent adder for program delivery expenses is added to incremental measure costs. Although the 30 percent adder is based on program budgets developed for other studies, it is meant as a rough estimate of the cost of actually acquiring the DSM resource. More refined estimates of program costs will be developed in the next section.

The DSM supply curve for residential is shown in Figure 17 which shows the cumulative kWh savings from all measures listed in Table 16 with a levelized cost less than the corresponding point on the graph. Two supply curves are presented, one that only includes the incremental measure cost and one with an adder for program delivery costs, as described above. Since the supply with program delivery costs is more realistic of actual costs, it will be used to estimate the economic potential for this study.

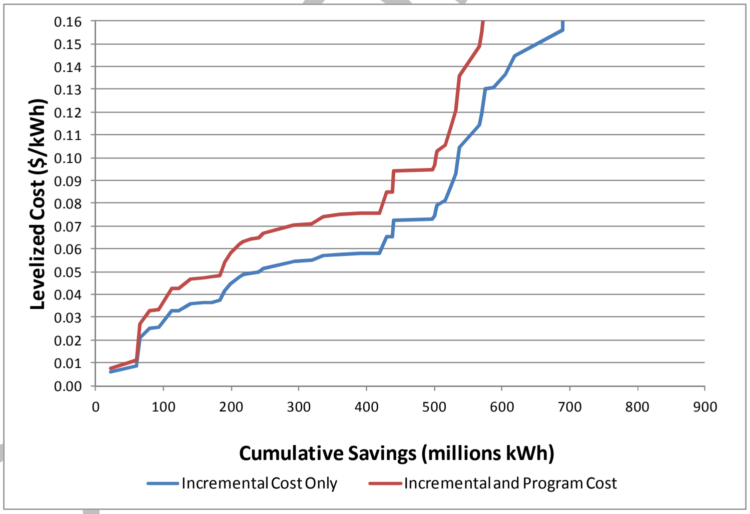

Figure 17. Residential DSM Supply Curve

Duke Energy's marginal cost of avoided supply depends on the load shape and longevity of savings.[12] Using $0.075 per kWh as an approximate marginal cost of supply, residential economic potential is estimated at 360 million kWh annually.

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[12] Marginal cost of supply varies by time of day and season and the amount of avoided peak load. Since different measures have different load shapes, they also have different marginal supply cost. When measures are grouped into programs, these

The DSM supply curve for non-residential is shown in Figure 18 and, like residential, represents an alternate format for the information in Table 17.

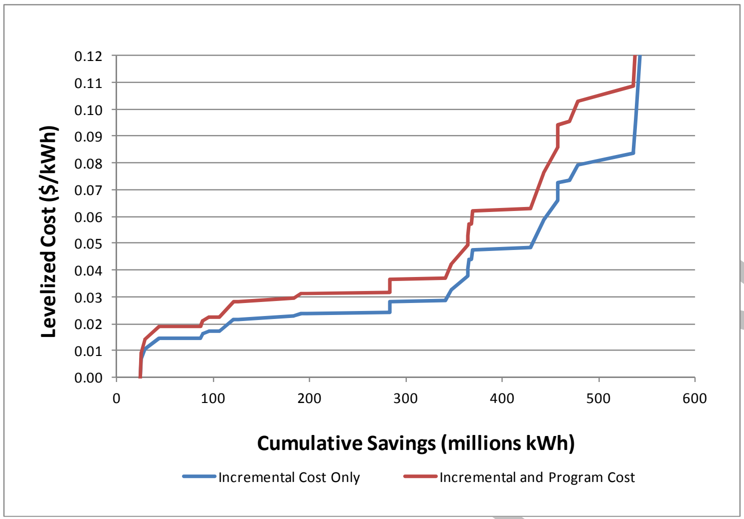

Figure 18. Non-Residential DSM Supply Curve

Figure 18 shows that much of the non-residential efficiency savings are available at levelized costs of less than $0.05 per kWh. Using an approximate marginal cost of supply of $0.075, we estimate annual economic potential in the non-residential sector to be 429 million kWh. Our estimate of total economic potential in both segments is 789 million kWh annually at $0.075 marginal cost of supply. Both the residential and non-residential DSM supply curves show a diminishing return as the levelized cost rises above $0.10 per kWh. Economic potential is shown at various points along the supply curve in Table 18.

Table 18. Economic Potential (millions of kWh) at Varying Levelized Costs

Levelized Cost ($/kWh)	Residential	Non-Residential	Total
0.050	183	365	547
0.060	198	368	566
0.070	248	429	677
0.075	360	429	789
0.080	419	443	862
0.090	438	457	895
0.100	501	470	971

Estimates of economic potential show which technologies are cost effective to install at a certain level of avoided cost given the installed incremental cost, program delivery costs and expected savings. One limitation of the approach is the application of one avoided cost to all measures. Differences in the shape of energy savings can lead to large differences in avoided costs between measures. This level of analysis is reflected in program cost

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differences are reflected in the breakeven marginal cost of energy supply for that program which represents the cost that the program must fall under in order to be cost effective.

effectiveness but is not considered at this stage of the analysis. For this reason the cost effectiveness of measures should be tested within the context of whole program designs when developing a program portfolio.

While useful for understanding the potential for cost effective energy efficiency, economic potential does not fully consider barriers to adoption that are encountered in the actual delivery of energy efficiency programs. Examples of adoption barriers are customer awareness of technologies, incentives and programs, customer acceptance of newer technologies over standard practices and delivery channel limitations. Some, though not all, of these barriers can be partially or fully overcome with greater program spending.

In the early stages of a new energy efficiency program these barriers may only be encountered at insignificant levels or not experienced at all. Initial program spending is adequate to make early participants aware of program opportunities. Early participants also tend to be more accepting of efficient technology. Also, the delivery channels are adequate for achieving the participation targets. As higher levels of participation are achieved, additional efforts are often required to make customers aware of program and technology features and to overcome skepticism concerning the adequacy of new technologies. Investments in the delivery channel such as training to increase the number of qualified trade allies may also be required.

What this means is that the marginal cost of acquiring additional customers into a program rises as more and more customers from the target customer segment are treated by the program. Estimates of economic potential typically include a flat level of program delivery and overhead costs based on current understanding of program costs. Consequently, estimates of economic potential tend to overstate what is actually cost effective in the latter stages of customer adoption. This is also true of the estimate of economic potential in this report. While they have their limitations, estimates of technical and economic potential are still useful concepts for defining the relative magnitude of opportunities. Achievable potential (energy savings given specific program designs and annual participation targets refined from experience) provides the best estimate of how much energy efficiency might be actually delivered in any given year. The achievable potential stemming from specific programs operated over a five-year period is presented in the next section of this report.

DSM PROGRAMS

Specific programs for acquiring economic potential identified in the previous section of this report are presented in this section. Program plans include estimates of participants, savings and costs and represent an "action plan" that provides an estimate of achievable DSM potential over five years (2013-2017). Programs proposed in this section of the report are designed to save kWh and to control electrical load (kW). Programs are designed as bundles of related energy savings measures and/or demand reduction measures. In program development the cost effectiveness of specific program designs was tested. A discussion of the cost effectiveness analysis and the results is presented in the next section of this report. The program designs presented below represent a viable and cost-effective portfolio for acquiring significant DSM savings over the next five years. The company will, of course, make the final selection of programs to be submitted for regulatory approval and implementation.[13]

Today, DSM programs are commonly managed with a small internal staff who are responsible for program delivery agents (program vendors) who then do most of the work to implement the programs. This work includes developing relationships essential to increase customer participation rates, to carry out the required day-to-day operations, and to perform the work of data entry for program tracking.[14] Within this management model, there will be a need to provide sufficient internal DSM staff that will insure that program controls are effective and that the responsibilities and lines of accountability of vendors to the company are kept crystal clear.

The following programs are oriented within current regulatory directives to capture cost-effective opportunities from the Energy Efficiency Measures (EEMs) identified earlier in this report. Each of the program plans presented in this section contains information on program design and participation, expected savings, tracking concerns, and implementation budgets. This information is organized as follows:

- Description of program design including measures and incentives. This description leads off each program plan.
- Rationale for the program. This is a brief description of the logic of the program.
- Participation and measures included in the program provides a discussion of the expected participants and energy savings. Number of participants and savings are shown in the Program Participation and Achievable Potential section beginning on page 63.
- Marketing Plans. A brief description of suggested marketing efforts specific to the program.[15]
- Program Tracking Considerations
- Budget Assumptions. Assumptions and considerations used to develop program budgets. Annual program spending estimates are presented in the Program Cost Effectiveness section beginning on page 66.

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[13] For programs ultimately selected and approved, full program designs are provided by implementation contractors for programs not run internally. Competing vendors propose full program designs in their bid package. The final program designs (the ones actually implemented) will be based on the planned design as approved by the Commission, the scope of work developed by Duke Energy, and the selected vendor's proposal.

[14] The program tracking system is usually best internal to the company rather than each vendor bringing their own system (so it will be consistent across programs) with a requirement for each vendor to enter the required detailed input.

[15] While marketing is addressed for each program, we recommend bundling the programs so that, from a customer perspective, there are fewer options. Although programs will be selected and evaluations performed on the individual programs, for customers, a simplified menu approach is more appropriate.

Note that in some of the program descriptions organizational or product names are given. These are not recommendations of specific groups or brands, but are included as links for developing further information.

Program Assumptions

In this section the essential characteristics of each program are presented. Each program is classified under one of three categories: Non-Residential, Residential or Demand Response. A description of each program follows this section. Assumptions for the three non-residential programs are presented in the table below.

Table 19. Non-Residential Program Assumptions

Program #	**1**	**2**	**3**
Program Name	**C&I Tune-Ups**	**C&I EE Products**	**C&I Custom**
Per Participant Savings & Costs:			
Annual Energy Savings (kWh)	14,754	31,035	44,563
Annual Coincident Peak Savings (kW)	2.3	2.8	6.2
Installed Incremental Cost	$1,566	$11,710	$8,574
Percent Paid by Utility	50%	50%	57%
Savings Life (years)	5.2	17.8	12.2
Net to Gross Ratio	0.95	0.70	0.70
Program Cost Assumptions:			
EE Staffing (Annual FTE)	1.3	0.5	1.0
Start Up (first year only)	$100,000	$0	$125,000
Variable Costs per Participant	$0	$150	$0
EM&V (percent of program costs)	8.0%	4.0%	7.0%

The program assumptions for the eight residential programs are summarized in the table below.

Table 20. Residential Program Assumptions

Program #	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Program Name	**Res EE Products**	**Res EE Ed for Schools**	**Res Energy Assess ment**	**Res Appliance Recycling**	**Res High Performance Homes**	**Res Home Reports**	**Res Neighbor hoods**	**Res Low Income Weatherization**
Per Participant Savings & Costs:								
Annual Energy Savings (kWh)	1,373	476	830	1,149	4,013	193	750	3,275
Annual Coincident Peak Savings (kW)	0.18	0.05	0.12	0.17	0.22	0.01	0.05	0.59
Installed Incremental Cost	$603	$43	$266	$0	$2,980	$0	$144	$1,417
Percent Paid by Utility	53%	100%	57%	NA	75%	NA	100%	100%
Savings Life (years)	12.7	8.9	14.0	5.0	25.0	1.0	7.1	15.9
Net to Gross Ratio	0.70	0.70	0.75	0.85	1.00	1.00	0.85	1.00
Program Cost Assumptions:								
EE Staffing (Annual FTE)	0.5	0.2	0.5	0.1	0.4	0.2	0.2	0.5
Start up (first year only)	$0	$0	$30,000	$20,000	$60,000	$0	$50,000	$20,000
Variable Costs per Participant	$15	$0	$50	$140	$500	$12	$50	$3,500
EM&V (percent of program costs)	4.0%	4.0%	5.0%	5.0%	5.0%	7.0%	5.0%	5.0%

The program assumptions for the two demand response programs, one commercial and one residential, are summarized in the table below.

Table 21. Demand Response Assumptions

Program #	**12**	**13**
Program Name	**C&I Demand Response**	**Res Demand Response**
Per Participant Savings & Costs:		
Annual Energy Savings (kWh)	0	0
Annual Coincident Peak Savings (kW)	204.39	1.10
Installed Incremental Cost	$3,350	$435
Percent Paid by Utility	100%	100%
Savings Life (years)	10.0	10.0
Net to Gross Ratio	1.00	1.00
Program Cost Assumptions:		
EE Staffing (Annual FTE)	0.5	0.5
Start Up (first year only)	$20,000	$30,000
Variable Costs per Participant	$126	$10
EM&V (percent of program costs)	4.0%	4.0%

Program 1. Commercial and Industrial Tune-Ups

This program targets commercial and institutional customers with a usage profile that indicates a possible high value from retro-commissioning. The program begins off-site with a scan of billing records using EZ Sim or other usage analysis software.[16] This screening process will select a pool of buildings for which it looks like retro-commissioning is highly likely to produce substantial energy savings. Building commissioning is a process that is associated with new buildings, and is a quality assurance process that is followed to facilitate new buildings performing as designed. Retrocommissioning applies a similar process to existing buildings. The goal is to insure that a building operates efficiently and effectively. The focus of this program is on insuring efficient operation, rather than on upgrading equipment. The program is designed to conduct a low-cost "tuning" of electricity related building systems. The tuning typically involves control systems such as energy management systems that may be improperly programmed, or controls that are out of calibration. When problems are identified and demonstrated, they may have major economic effects. When this type of problem exists, retro-commissioning resolves such problems at low cost.

The program will include schools, commercial and institutional buildings run by property managers and large chain stores (big box stores). There are four measures, each of which incorporates a set of opportunities for energy savings.

Table 22. Measures and Incentives – C&I Tune-Ups

Measures	Measure Number	Incentive
HVAC Optimization & Repair	C-2	50%
Retro Commissioning Lite	C-4	50%
Grocery Refrigeration Tune-Ups & Improvements	C-29	50%
Refrigeration Casework Improvements	C-30	50%

Rationale

The program offers incentives for participation. Most buildings have never been commissioned, so the commissioning of an existing building may be able to identify and correct high priority operating deficiencies and verify proper operations. The focus will typically be on energy-using equipment, lighting, and controls. Further, this program is designated as "retro-commissioning lite," since it will involve engagements of about $2,000 per building[17], rather than the $10,000 to $52,000 associated with full retro-commissioning.[18] The objective will be to find the best buildings for the program. These will be buildings with significant energy problems that can be easily detected and easily fixed.

Energy savings will be documented by engineering calculations and evaluated using usage analysis software such as EZ Sim. The persistence of energy savings will be tested in Program Year 5.

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[16] This prior screening using billing data is essential to the success of the pilot. See: http://www.ezsim.com/.

[17] This is per building. An individual project may have more than one building.

[18] See Haasl, Tudi &Terry Sharp, *A Practical Guide for Commissioning Existing Buildings*. Washington, DC: Office of Building Technology, State and Community Programs, US Department of Energy. Prepared by Portland Energy Conservation, Inc. and Oak Ridge National Laboratory, April 1999.

Participation

Participation has been projected to be relatively low with new participants each year and assessment of persistence in subsequent years. Participation estimates comes from NYSERDA's EnergySmart^{SM} Commercial Industrial Performance Program (CIPP) participation numbers, as presented in the 2007 Filing to the State Systems Benefits Committee. Because NYSERDA's program does not include smaller commercial facilities, average energy savings from the Wisconsin Focus on Energy (FOE) database have been used. Like the Duke program, the FOE program is open to both large and small commercial and institutional customers. This number represents the average per participant savings, which is driven up by the participation of several very large customers each year. Duke may not achieve the projected savings in Year 1 because we do not anticipate many large customers will participate in Year 1, but we do expect Duke to achieve the full projected savings by the end of the five-year period. We expect this to become a service supported by substantial customer interest once it has been in place for about three years. This will depend on demonstrating and communicating good savings results. In the right buildings, the program can yield substantial savings for not much cost so social marketing through "word of mouth" promotion should help to sustain and increase participation. However, for the first year or two, until the program catches on, participation can be expected to be low. The key feature in building support is successful pre-screening.

Marketing Plans

Duke will need to advertise this program during its initial stages, and, will also need to actively recruit ESCOs to work within its service territory. We recommend some general advertising within the business community, primarily in the form of brochures and mailings targeted to potential program participants. Duke also should work directly with business associations throughout its service territory, and contact its larger customers through Key Account representatives. The budget below provides for some general advertising at business events, as well as brochures and premiums. The incentive will be 50 percent.

Program Tracking

The program manager should collect, at a minimum, information about all customer electrical equipment, hours of operation, etc.

Budget Assumptions

The anticipated cost to Duke Energy for offering this program to customers involves budgets for:

- Cost for initial data gathering and screening to develop most likely buildings list.
- Duke Energy administrative costs to develop, advertise, oversee and monitor the program.
- A customer incentive to defray the cost of an energy audit for those customers that do not choose to work with ESCOs.
- Incentives for installing energy efficient equipment[19].

Costs to participating customers include the remainder of equipment costs.

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[19] Incentive amounts are based on the average incentive given in NYSERDA's EnergySmart^{SM} CIPP program, discounted to allow participation by smaller commercial customers. The average CIPP program participant receives $17,000 in incentives. This has been discounted here to $9,750.

Program 2. Commercial and Industrial Energy Efficient Products

The program targets non-residential customers eligible for electric prescriptive measures. These include commercial, industrial, for-profit, non-profit, schools, government and public and private agencies.

Rationale

Rebates are straightforward reimbursements of a portion of customer cost of specific rebated energy efficiency items. Many customers have concerns about the high first cost associated with some of the larger energy efficiency investments (e.g. HVAC systems or energy management systems). Duke Energy's proposed incentives will help remove that barrier.

Participation and Measures

Representative measures are shown in the table below. Measures may be added or deleted from the prescriptive list as information is gained during program planning and administration. The incentive level for these measures is 50 percent. Although we have not included an audit expense, the program could be run with or without a simple audit. Audit costs, if any, would also be incented at 50 percent with reimbursement of full cost for audits when measures are installed.

Table 23. Measures and Incentives – C&I EE Products

Measures	Measure Number	Incentive
Vending Miser	C-31	50%
Low Flow Fixtures	C-23	50%
New Efficient Lighting Equipment	C-18	50%
Retrofit Efficient Lighting Equipment	C-19	50%
LED Exit Signs	C-20	50%
LED Traffic Lights	C-21	50%
Efficient Outdoor Lighting	C-17	50%
Efficient Package Refrigeration	C-11	50%
Electronically Commutated Motors	C-12	50%
Premium Motors	C-13	50%
Energy Star Transformers	C-15	50%
Window Film	C-9	50%
Single Application VSD	C-14b	50%

An offering of energy efficient products is a traditional role that customers expect from utilities; and, we know that customers tend to trust utilities above other entities in this specialized area. We expect this program to easily communicate to customers and to have substantial participation from the first year given Duke Energy's prior achievements with this type of program. It is important to note that unlike most other programs, participants may return repeatedly to this program to purchase additional products.

Marketing Plans

This is a continuation of an in-place program type. We recommend some general advertising, primarily in the form of brochures and mailings targeted to potential program participants and Duke's website. Duke Energy should work directly with business associations and contact some customers through account representatives. The budget below provides for some general advertising at business events, as well as brochures and premiums. The incentive level for the program is 50 percent.

Program Tracking

The program manager should insure that the vendor managing this program has an excellent tracking system and provision should be made to gather in-service date and technical data about equipment being replaced as well as the energy savings measures that will replace old equipment. The vendor should track customer as well as orders so as to be able to produce reports on numbers of participants as well as on orders and quantities of materials ordered.

Budget Assumptions

The anticipated cost to Duke Energy for offering this program to customers involves budgets for:

- Administrative costs to develop, advertise, oversee and monitor the program.
- A customer incentive to defray the cost of an energy audit for those customers.
- Incentives for installing energy efficient equipment.

Costs to participating customers include the remainder of equipment and installation costs.

Program 3. Commercial and Industrial Custom

This program, due to its nature, should look at both the gas and electric energy savings potential. The program targets only commercial and industrial accounts. The program is designed to develop exceptionally productive energy savings opportunities customized for and in cooperation with the customer. Because it is structured to take on an industry perspective, both electric and natural gas measures will be included, though only electric energy savings is accounted for in this report. Each project will be specially designed. The program incorporates three sub-programs: small commercial and industrial, large commercial and industrial ("energy champions"), and new construction integrated building design beyond code. It is also expected to contain a small commercial LED lighting pilot and may contain other pilots.

The incentive will be the amount required to lower the customer payback to two years, up to a maximum of 50 percent of the incremental cost of the electric energy efficiency measures. Within this overall program framework, incentives may run to 100 percent of the electric energy efficiency costs for some included pilots, including a small commercial LED pilot (which will generally replace halogens, but is custom because some stores may have very different types of lighting). The remaining costs, which do not affect electricity savings but may result in natural gas savings and process improvements for more efficient production, will be the responsibility of the customer.

It is expected that projects will need to be carried out within narrow time windows as dictated by conditions specific to the customer's operations and that evaluation will be direct and simple electrical measurement, consisting primarily of short term instrumentation and spot metering. The hurdle rate for projects under this program will be set to insure only the most cost-effective projects are selected so as to insure cost recovery.

Rationale

Some commercial and industrial customers will offer special opportunities for energy savings, either brought to Duke Energy by the customer (or the customer's ESCO), or as identified by company account representatives and engineers. By providing a cost share in co-developing projects, plus a 50 percent "buy down" of incremental electric efficiency results, customer projects will be more likely to move forward.

Development will consist of an engineering study to isolate the cost and yield of high energy efficiency alternatives to standard practices and equipment. Experience will show whether a 50 percent buy down is enough to attract projects. If this percentage proves too low (based on response to the program) the percentage buy down will be raised. Experience with similar projects in the Northeast has led utilities to offer 75 to 90 percent buy downs in this program sector.

The Energy Champion approach for large industrials will require provision of substantial training and motivational work. Experienced engineering program delivery agents have this design available.

Models for this program are the Bonneville Power Administration Energy Smart Industrial Program[20]; the WPPI, SDG&E and Mid-American Large Bid Programs and the Xcel Energy Large Industrial Process Improvement Program. Sources for program philosophy are William McDonough & Michael Braungart, *Cradle to Cradle, Remaking the Way We Make Things* (New York: North Point Press, 2002) and Amory B. Lovins & Rocky Mountain Institute, *Reinventing Fire, Bold Business Solutions for the New Energy Era* (Vermont: Chelsea Green Publishing, 2011).

Participation and Measures

Measures are shown in the table below.

Table 24. Measures and Incentives – C&I Custom

Measures	Measure Number	Incentive
Customer Specified (Electric)	NA	Cost share of study to develop project proposal and 50% of energy efficiency improvements
Energy Champion (Large Industrial)	NA	
Integrated Building Design	C-10	

Because of the custom nature of the project, there will not be a large number of participants in any one year. Each participant, in this type of program, is special which makes tailoring to specific customers unique. In encouraging participation, it is important to recognize that standard baselines such as current practice for an industry or least cost alternative do not work for custom settings. Recognizing the unique baseline for each site, which will depend on the business operating procedures and on interactive equipment as much or more than on market factors should help in recruitment of participants.

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[20] http://www.businesswire.com/news/home/20121030006576/en/ConAgra-Foods-Lamb-Weston-Bonneville-Power-Honored

Marketing Plans

An example of this type of program is NSTAR Electric's Compressed Air Leak Detection and Remediation Program (www.compressedairchallenge.org and www.nstaronline.com/business/energy_efficiency). Also see Pacific Power's Energy FinAnswer and Energy FinAnswer Express programs, the WPPI, SDG&E and Mid-American Large Bid Programs and the Xcel Energy Large Industrial Process Improvement Program. It is expected that these will be high return projects in terms of savings achieved. The program approach is to "get out of the box" of conventional utility DSM programs to embrace programs that large customers may pursue for reasons of overall industrial efficiency. While both gas and electric energy will need to be analyzed, the Company would fund portions of these projects that produce electrical demand reductions and energy savings.

Program Tracking

Data requirements will vary with the specifications for each project. In some cases, utility billing meter information will provide a sufficient level of detail required to assess program impacts. In other cases, isolation of circuits and spot metering or other types of assessments may be required. In any case, the program manager should collect, at a minimum, information about all customer electrical equipment, hours of operation, etc. It is expected that evaluations will primarily take the form of short term instrumentation and spot metering with engineering review. Since these are custom projects, it will be particularly important to insure provisions are made to determine the kWh, therm, and/or kW condition that constitutes the baseline, and then measure the change due to the DSM improvements.

Budget Assumptions

The anticipated cost to Duke Energy for offering this program to customers involves budgets for:

- Administrative costs to develop, advertise, oversee and monitor the program.
- Up to 100 percent of engineering studies.
- A customer incentive of 50 percent to defray the cost and energy study and improvements (with some pilots at 100%).

Costs to participating customers include the remainder of energy study cost to develop project proposals, provision for staff involvement in developing and monitoring the project, and the remainder of equipment costs.

Program 4. Residential Energy Efficient Products

This is a continuation of a current programs type and will provide rebates to Duke Energy customers toward the purchase of CFLs, LEDs, and energy efficient appliances including ductless heat pumps, heat pump water heater, and selected consumer electronics. Cool roof and smart strips will also be included.

The dollar amount for the appliance incentive for this promotion is lower than might be expected based on industry experience in prior years. This is due in part to recent changes in the Energy Star program and the overall success of the Energy Star strategy as demonstrated by the gradual increase in energy efficiency of base case (non-Energy Star) equivalent products. Refrigerators may be included based on analysis as new Energy Star refrigerator standards go into effect. Currently some DSM administrators, such as the Energy Trust of Oregon, offer refrigerator rebates only on Consortium for Energy Efficiency (CEE) Tier 3 refrigerators. Rebates for energy efficient appliances should be set using Consortium for Energy Efficiency tiers.

Rationale

The appliance, lighting, and other residential products improve the product mix in favor of energy efficient technologies for the service territory by promoting the purchase and stocking of efficient replacement units. Appliance promotions are best developed on a national level with participation by utilities and governments. Energy Star has overcome all of the defects of the earlier local or regional promotional programs through a single national program structured to periodically advance program standards and regulate minimum efficiencies. At the same time, it is structured to work with regional marketing initiatives and local promotion.[21]

Participation and Measures

Representative measures are shown in the table below.

Table 25. Measures and Incentives – Residential Energy Efficient Products

Measures	Measure Number	Incentive
Efficient Residential Lighting	R-33	50%
Energy Star Clothes Washers	R-29	50%
Heat Pump Water Heaters	R-39	50%
Ductless Heat Pump	R-43	50%
Smart Plug	R-45	50%
Cool Roofs	R-13	50%
Pool Pumps	R-32	50%
Residential Outdoor Lighting	R-36	50%
Heat Pump Pool Heater	R-46	50%
Occupancy Controlled Outdoor Lighting	R-35	50%
Electric Furnace to SEER 16 Heat Pump, Single Family	R-2	50%
Electric Furnace to SEER 16 Heat Pump, Multifamily	R-4	50%

Because of Duke Energy's prior achievements with this type of program, large numbers of customers are expected to participate in this program from the beginning. The offer of energy efficient products is a long established role for utilities. Also, customers tend to trust utilities for information on energy efficiency. Communications with customers regarding offerings in this program is expected to proceed with ease. It is possible that participation will decrease over time as CFLs become the standard product in the lighting market. However, this possible decrease could be offset by the rapid developments in LED lighting and the continuing drop in LED costs.

Marketing Plans

Proposed marketing efforts focus on coordinated advertising with selected retail outlets, general media ads and bill stuffers. This type of program is best implemented using program implementation vendors. The program elements exist in nationally available programs for utilities to implement, and selection of a regional vendor will provide added value in the form of detailed program and technology knowledge and relationships. A basic assumption in

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[21] For an example of the history of the residential clothes washer initiative, see Shel Feldman Management Consulting, Research into Action incorporated, and Xenergy incorporated, *The Residential Clothes Washer Initiative, A Case Study of the Contributions of a Collaborative Effort to Transform the Market*, prepared for the Consortium for Energy Efficiency, June 2001.

the development of this program is that it is not so much the size of the rebate so much as the existence of a rebate and the skill in developing engaging promotions and long-term relationships with the appliance industry and dealers that will help move the more energy-efficient products.[22, 23]

The basic marketing goals for the appliance program elements come from the Consortium for Energy Efficiency and are provided below:[24]

- Consumers understand and value the benefits from energy-efficient features.
- Retail sales force is knowledgeable about Energy Star and considers it a meaningful distinction for making a sale.
- Rebate stickers are on appliances on retail sales floors.
- Manufacturers market and promote energy-efficient products and/or features.
- Energy efficiency, defined by Energy Star performance levels, becomes a standard feature or is available across all manufacturers' product lines.
- Energy Star represents the most energy efficient quality products available, but generally now serve as the base and the rebated appliance is typically a Tier 3 Consortium for Energy Efficiency retail appliance or a Top Ten™ level Energy Star appliance. Though we refer to the efficient alternative as Energy Star, we really mean Tier 3 or Top Ten™ appliances.

The Energy Star residential lighting promotion will parallel the Energy Star appliance promotion to reach residential customers through retail outlets. The lighting promotion provides direct incentives to consumers to facilitate their purchase of energy-efficient lights. The incentive is in the form of discounted pricing available for lighting products that carry the Energy Star logo. To the extent possible, all lighting supplies should be through up-market program relationships at the manufacturer or top level distributor.

This program is justified based on direct energy savings targets but also has a significant market transformation dimension. Generally, throughout the US, the Energy Star program has been affecting the types of lighting products available in stores:

- The relative amount of available lighting shelf space assigned to Energy Star lighting products is increasing dramatically in "big box" stores.
- The quality of CFL lighting has dramatically increased.
- The diversity of CFL styles and applications has greatly increased.
- There has been as sizable decrease in the cost of energy-efficient lighting, and with it an increase in store sponsored promotions featuring price discounts.
- At the same time, there is still variation in lighting quality between manufacturers and types of CFLs.
- LEDs are now available in a range of applications with lighting of high quality better pricing.

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[22] See the WECC paper on residential appliances at http://www.aceee.org/utility/ngbestprac/wecc.pdf. Note that this paper is for a natural gas clothes washer program, however "lessons learned" regarding relationships and promotion would apply across appliance programs.

[23] A review of rebates offered across the US indicates that most utilities are offering rebates from this kind of marketing and promotional perspective rather than from a direct resource acquisition perspective. See the Database of State Incentives for Renewables & Efficiency, (DSIRE), maintained by the North Carolina Solar Center for the Interstate Renewable Energy Council (IREC) funded by the U.S. Department of Energy (DSIRE) at http://www.dsireusa.org/.

[24] CEE's National Residential Home Appliance Market Transformation Strategic Plan, December 2000 (http://www.cee1.org/resid/seha/seha-plan.php3).

In this program, Duke Energy will be an active participant in the US Energy Star campaign. Through this participation, it is expected that the company will move more Energy Star products into retail stores, help make energy efficient lighting more affordable to its customers, and provide a continuing and responsible guidance and energy efficiency education message to customers.

Incentives may be implemented by coupons, in-store markdowns, or upstream manufacturer buy-downs. A coupon approach is more suitable for a service territory because it gives the program administrator direct control over where coupons are available and for which sales outlets.[25] The lighting promotion program is modeled after a set of promotional programs that is implemented by Energy Federation Incorporated. These programs are sponsored by Connecticut Light and Power, United Illuminating Company, the Cape Light Compact, National Grid, NSTAR Electric, and Western Massachusetts Electric.

Program Tracking

Data collection and documentation for program purposes and monthly/annual reporting will be included as features of the vendor program "package." Data estimation of the baseline market and market potential for the specific Energy Star appliances promoted should be refined as a part of the vendor services and developed for each product type. Data estimation of the baseline market and market potential for Energy Star bulbs and fixtures in the DEO service territory should be refined as a part of the vendor services and developed for each product type (for example, LED/CFL, type of LED/CFL, CFL pack, LED holiday lights). In addition, for the program evaluation, data collection to compute free-riders and spillover effects for computing Net-to-Gross ratios will need to be worked out prior to program implementation, and responsibilities for collecting data inputs will need to be carefully defined along with workable accountability relationships.

Budget Assumptions

As in the other programs, the anticipated cost to Duke Energy for offering this program to customers involves budgets for:

- Administrative costs to develop, advertise, oversee and monitor the program.
- Vendor services for the program vendor (assuming use of existing turnkey program elements).
- Incentives for the installation of approved measures as demonstrated through the provision of coupons collected and processed from the retail outlets.

The cost to participating customers is the customer's share of the cost (cost of product after the rebate). The target rebate is 50 percent.

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[25] An alternative or parallel approach is the "lighting catalog," which can be an extensive catalog of lighting options offered by a fulfillment vendor or a simple option for purchase of limited types of CFLs over the Duke Energy website. For customers not near a cooperating big box or local store, an Internet option is a valuable addition from a customer service perspective. At the same time, there is a 'trade off' since the market transformation dimension of this program is better met by working with existing supply channels and existing retail outlets.

Program 5. Residential Energy Efficiency Education for Schools

This program is a continuation of a current program type. The Company has invested considerable effort in the development and refinement of program for energy efficiency education in the schools. The program is available (at the Company's option) to public and private schools in the service territory for students in grades K-12. The goal is to educate students about energy. Each eligible student who completes a home energy audit receives a kit of energy efficiency measures for the home.

Rationale

Education programs have in the past largely been seen as a part of the public service role of utilities and have generally emphasized information about the science of electricity and safety around power lines or when using electricity. The current program emphasizes the problem of assessing opportunities to make a home more energy efficient, joined with an opportunity to install kit items.

Education programs are important even without immediate energy savings because the substantial payoff for these programs is in the knowledge gained by the students and the potential influence it will have in their ability to make smart energy choice of the life course. The assessed savings for this program come from the kit measures installed.

Participation and Measures

Measures are shown in the table below, and may be added or subtracted during the program based on experience.

Table 26. Measures and Incentives – Residential Energy Efficient Education for Schools

Measures – Kit Items	Measure Number	Incentive
Efficient Residential Lighting	R-33	100%
Low-Flow Fixtures	R-38	100%

Participation will be dependent on negotiation of access to schools and ability to work constructively through several levels of school administration as well as with teachers. This program now has a good start and is establishing a record that will make continued access easier. The actual installation of measures by students will require both motivation of students and development of enthusiasm for the program among teachers and parents.

Marketing Plans

This program is unusual because its success depends on considerable ongoing effort to work with school organizations at several levels in order to insure institutional support and to promote enthusiasm for the program among teachers and students.

Program Tracking

The program requires detailed reporting on school, classroom and student participation rates, allocation of kits, and documentation of kit items installed. All data requirements should be part of the program database maintained by the program vendor.

Budget Assumptions

Budget must take into account the costs of working with several levels within the schools.

Program 6. Residential Energy Assessment

The program is a continuation of a current program type. It includes two residential energy assessment options that are carried out remotely, by Internet or by means of a telephone interview. The third option is for an on-site audit (with direct installation of minor measures) plus an analysis. The remote audit program is the same for both the Internet and telephone, and works by linking to actual billing data for the residential account.

The remote Internet and telephone analysis options are open to all customers and free to all customers. However, the program will work best for electric heat customers and this is the focus of the remote audit program. In addition, for electric heat customers who complete the remote audit, Duke Energy will send a small kit of energy efficiency items. The savings in the remote elements of this program are computed based on the items in the kit, and no savings is assumed for the remote audit step.

As a more advanced option, the program will also offer an on-site audit for Duke Energy's electric heat customers for a $50 fee, as discussed below. During the audit, minor measures will be directly installed.

Rationale

The remote elements of this program are open to all residential customers at no charge to provide easy access to energy efficiency recommendations tailored to the home. Since it is conducted by Internet or telephone, it can fit in a customer’s schedule. The remote elements are an entry-level degree of customer engagement, providing a way for customers to begin to get direct information on what they can do to make their home more energy efficient.

For homes with electric heat, the separate program element for an on-site energy audit with direct install of minor measures provides the option of a higher level in-home audit for a small fee, refunded if audit recommendations are implemented. The on-site audit program element targets households in existing single family homes and condos and (with a different permission structure) for multifamily dwellings. The program includes an on-site audit and encourages households to save electricity through the installation of energy efficiency measures. The audit, for example, might recommend air sealing, insulation, and other measures.

The On-Site Audit with direct install program element will provide households with a walk-through examination of their home by a trained auditor/contractor using standard audit software for identifying existing conditions related to electric energy usage. The auditor will identify specific energy saving opportunities that could be installed by the contractor upon approval of a job scope by the customer. The auditor will convey energy saving tips during the walk-through, and attempt to be comprehensive in their assessment of opportunities. Customers will pay $50 of the audit cost, and have their audit cost credited to their bill if they proceed with installation of at least one of the recommended measures. The recommendations of the auditor are expected to be standard measures associated with whole house weatherization, such as ceiling insulation, wall insulation, air sealing, etc.

At the same time, during the walk-through audit, the auditor will install the measures in the Direct Install Kit at no cost to the customer and additional low-cost measures (see Table 27). At the conclusion of the site visit, customers will be provided with a check list of preliminary recommendations from the audit, to be followed within one week by a full report generated by the audit software.

Expected installation rates of 80 percent for CFL's, 60 percent for showerheads, and 75 percent for aerators were used to calculate program savings for the mailed kits. Savings from the on-site audit are only counted for measures installed at the time of the audit and recommended measures subsequently installed and rebated. There is a 50 percent incentive for recommended measures beyond those directly installed during the audit.

The package of direct install measures is modeled after Wisconsin's Home Performance with Energy Star program with emphasis on their E-Saver Kit component, which includes these measures plus a programmable thermostat, but only included one CFL.[26] Programmable thermostats have recently become controversial (see Appendix). To overcome problems with programmable thermostats, the program will focus on easy-to-read, easy-to-use equipment and provide customer education.[27]

This program element, in addition, will provide referral to the efficient products program and to the full Home Performance program.

Participation and Measures

Measures are shown in the table below, and may be added or subtracted during the program based on experience.

Table 27. Measures and Incentives – Residential Energy Assessment

Measures	Measure Number	Incentive
Measures – Remote Program Elements		
Efficient Residential Lighting	R-33	100%
Low Flow Fixtures	R-38	100%
Measures – On-Site Program Element		
All of Remote Program Elements plus:		
Wall Insulation	R-21	50%
Ceiling Insulation	R-16	50%
Refrigerator Charge/Duct Tune-Up	R-6	50%
House Sealing using Blower Door	R-18	50%
Tank Wrap, Pipe Wrap & Water Temp Setpoint	R-37	50%
Efficient Residential Lighting	R-33	100%
Low Flow Fixtures	R-38	100%

There is no cost in the remote program elements to participating customers for the remote audit and kit. There is a $50 fee for the on-site audit, however this is credited to the bill if at least one program recommended measure is installed (recommended measures will be supported by the company at a 50% rebate).

Participation in this program is expected to reflect general conditions in the residential consumer economy. We have experienced a rapid drop in household wealth, prolonged unemployment and forces that prevent a rise in consumer income. If the economy continues to slowly improve, participation in this program is expected to slowly

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[26] State of Wisconsin Department of Administration Focus on Energy Statewide Evaluation, Evaluation of the Home Performance with Energy STAR Whole House Component, April 24, 2003.

[27] A climate control Energy Star device replaces the old programmable thermostats. These devices have a built in utility control chip and provide a local override. The devices are becoming available now and should be universal by 2014.

increase from year to year. Most participants are expected to be remote only with the remainder receiving the on-site audit.

Marketing Plans

Duke Energy will need to actively market this program in customer communications, such as bill stuffers. Employees can also make customers aware of this program if they contact the company about energy efficiency or a need to lower bills. The remote program elements are low-involvement lead-in programs that will help develop prospects for other programs.

In developing the kit for the remote program elements, strategic attention should be placed on the kit as a marketing tool. First, insure that the kit items are attractively packaged and that the overall kit packaging is attractive. The focus should be on making the kits attractive and interesting as well as technical. Possibly some non-energy but useful health and safety items can be included, as well as helpful literature. Since many customers are more interested in "green" items to try to reduce carbon and save the planet, marketing staff should ask for suggestions and perhaps create a "green" theme. For the basic kit items, it is important to consider the value of paying a bit more for "higher end" better performing and better looking items. Again, the kit is part of the marketing and promotion of this program. The kits should also be available at cost from the company's website.

The on-site program element represents a step up in engagement and commitment for an on-site energy audit that can lead to full weatherization retrofit with a 50 percent level of support from the utility company.

Program Tracking

The program elements in this program (remote and on-site) are packaged programs provided by a vendor. All data requirements should be part of the program database.

Budget Assumptions

The anticipated cost to Duke Energy for offering this program to customers involves budgets for:

- Administrative costs to develop, advertise, oversee and monitor the program.
- Direct program costs, including a vendorized Internet/mail-in energy assessment program.
- Direct program costs for the audit/direct install vendor.

There is no cost in the remote program elements to participating customers for the remote audit and kit. There is a fifty dollar fee for the on-site audit, however this is credited to the bill if at least one program recommended measure is installed (recommended measures will be supported by the company at a 50% rebate).

Program 7. Residential Appliance Recycling

This is a continuation of a current program type. The recycling program improves the in-service technology mix for the service territory by removing energy hog appliances and deleting them from existence in an environmentally friendly way. Appliance recycling is available primarily through two national program vendors, both of which bring the necessary environmentally sound technologies and procedures to the program.

This program targets households with second refrigerators or freezers. The program will provide free refrigerator and or freezer pick up. The contractor will pick up, disable, and recycle the unit(s). Once Duke Energy receives verification that the refrigerator has been recycled, the customer will receive a $40 incentive. This number is based on the $30 to $50 incentives offered by other companies.[28] As a program option, old window AC units may also be picked up ($20 customer incentive) from homes in which a visit is scheduled to pick up a refrigerator or a freezer.

Rationale

This program targets residential customers with second refrigerators or freezers, preferably those older than 1993. The program is designed to take these inefficient older refrigerators off the market entirely, and to do so in an environmentally-sustainable manner. Duke Energy will pay a $40 incentive to each customer to help persuade them to get rid of the second refrigerator or freezer, and will also cover the cost associated with removing the refrigerator or freezer and recycling its components.

Participation and Measures

Measures are shown below.

Table 28. Measures and Incentives – Residential Appliance Recycling

Measures	Measure Number	Incentive
Eliminate Old Appliances	R-27	$40
Window AC Unit Recycling	(Optional, may be developed, discuss with vendor)	$20

Appliance recycling is a program that must be initially introduced since it represents a change in the flows of old appliances from pre-program market conditions. Once introduced, participation should grow due to pent up demand from customers and "word of mouth" communication among friends and relations. After about three years, it is likely that customers will begin to assume this program is the best way to deal with old appliances and participation is likely to grow more quickly before stabilizing and falling off in the years beyond the action plan.

Marketing Plans

This program will be marketed directly to consumers through bill inserts, direct mailing materials, and through refrigerator distributors. The program will need to mail information to customers on a regular schedule (twice a year basis, or more frequently as needed to produce the desired participation rates), and through point-of-purchase

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[28] Wisconsin Public Service offers a $50 incentive, but we believe Duke Energy's program will be successful with the lower incentive amount.

information at trade ally facilities. The two primary program vendors for this type of program are Appliance Recycling Centers of America, Inc. (ARCA)[29] and JACO Environmental, Inc. (JACO)[30].

Program Tracking

The program vendor will be required to supply a detailed database sufficient to demonstrate the age and condition of units picked up and also to demonstrate that the units are properly destroyed and recycled. In addition, the database should be sufficient to supply data necessary for program evaluation. Generally tracking for this program type begins with a photo of the refrigerator nameplate or attachment of an ID code sticker on pick-up, and tight tracking capability is required through disassembly to insure beyond question that there is never even a slight diversion of working units to the secondary market.

Budget Assumptions

The anticipated cost to Duke Energy includes:

- Administrative costs to develop, advertise, oversee and monitor the program.
- Incentive payments to customers of $40.
- Contractor payment.

There are no costs to participating customers.

Program 8. Residential High Performance Homes

This is an electricity energy saving, "beyond Energy Star" strategy for new residential construction for homes with electric heat (normally electric heat pumps). In the Energy Star program, there are many builder pathways (called Building Options Packages) to enable manufacturers to meet Energy Star criteria. Many Energy Star builders, in order to be sure of meeting the Energy Star criterion, now build beyond it. From a utility perspective, supporting "beyond Energy Star" homes is the only viable option to insure cost-effectiveness of this program element.

Energy Star homes are homes that are independently certified and are more efficient, comfortable and durable than standard homes constructed according to local building codes. Energy Star homes feature additional insulation, better windows, doors and bath ventilation and highly energy efficient appliances such as furnaces, AC units, heat pumps, and water heaters. These improvements beyond current practice typically cost home buyers a factor of two to three times the actual cost to builders for the energy efficiency improvements. For this reason, a builder incentive provides excellent leverage in an upstream program model that can provide something like two to three times the customer value for each dollar of upstream buy-down.

The incremental cost of $3,000 per home plus a $500 inspection fee in the illustrative measure package represents a generalized measure package.

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[29] Appliance Recycling Centers of America, Inc. (ARCA), 7400 Excelsior Blvd., Minneapolis, MN 55426 [952-930-9000] [www.arcainc.com].

[30] JACO Environmental, Inc. (JACO), 7115 Larimer Road, Everett, WA 98208 [425-290-6291] [www.jacoinc.net].

Rationale

The Energy Star Plus program element is necessary due to the overall success of the Energy Star concept. With the ongoing influence of Energy Star, baseline homes have become increasingly energy efficient, enough so that to mitigate the risk of not being cost-effective, program homes must be taken to a beyond Energy Star level of performance.

Two other certifications have been introduced into the home performance market. These are LEED and Passivehaus. The basic concept of the program is the "high performance" home. All such homes will be Energy Star Plus and some will also be LEED and Passivehaus certified. Duke should provide all three tracks. The ultimate goal is the "net zero ready" home, which, with the addition of Solar PV from the renewable energy program will become net zero or even slightly revenue positive for the household, selling net energy back to the utility. This end goal will not be met by most homes in the program, but they can all be oriented towards this track.

The basic philosophy for the program should incorporate net-zero concepts. These include an expected measure life for the new house of 150 years and a net-zero plan. The plan for each house will provide elements of energy savings in the original construction plus a set of steps which may be taken later to move towards net-zero. The key feature of the plan is to order elements so no work impedes the future steps. PV, since it is not a DSM measure is not included in this program but the goal is a house that is solar ready. A basic concept is the development of the customers as a repeat customer for additional increments or energy efficiency packages throughout the life of the structure.

Passive solar design and orientation reduce a home's heating and cooling costs and makes the home more comfortable. Better lighting and better internal temperature control are to be included.

Participation and Measures

Measures are shown below. We recommend a 75 percent incentive as realistic in the context of the current housing market to stimulate participation.

Table 29. Measures and Incentives – Residential High Performance Homes

Measures	Measure Number	Incentive
Energy Star Construction (beyond)	R-25a	75%
Energy Star Manufactured Home	R-24	75%
Major Remodel	R-25b	75%

Participation is limited since only the top income segments are likely to be fully and effectively in the market under current economic conditions. Much of the work to make a home net zero ready is beyond the utility contribution to costs and will need to be financed by the customer. However, it is possible to structure combinations of funding, including the mortgage, to be optimal for the homeowner. Over time, the real value of the fixed total of monthly mortgage payments for a year will decline significantly. In parallel the offset in decreased energy costs will move with inflation and with increases in energy rates. With work, it should be possible to create packages including some financing that permit a larger part of the market to participate. And, in any case, every new home can participate to a limited extent in that it can come with a net-zero or net-zero ready plan.

Marketing Plans

The financial incentive is provided directly to homebuilders to help offset the additional cost to build an Energy Star home. This gives the incentive a multiplier of between two and three. This program element is a vendor-delivered program requiring an experienced Energy Star program vendor. The program vendor provides all of the detailed knowledge and relationships to put the program in place with a restricted set of measures to reach savings levels significantly beyond Energy Star using a set of builder options packages. While the customer has higher first cost, the customer pays less for energy over the life of the home and on a life cycle basis comes out well ahead financially. The program vendor will also provide the established channels to national builders, establish relationships with local builders, and will come supplied with all manner of promotional materials.

To support dissemination of practical home information on good practices, we recommend Duke sponsor two demonstration homes in the state. While characterized as "high performance homes," they would also be certified as Energy Star Plus, high quality construction, LEED, and Passivhaus and so demonstrate the full range of available best practices for smaller (1600 square feet) new home. The homes would also be solar oriented and "PV ready" and promote the "net zero" and "net zero ready" design concepts.

Program Tracking

As Energy Star homes, Energy Star Plus homes are certified by BPI/HERS raters, and Duke Energy will need to work with the HERS raters and the program vendor to establish a workable data tracking system.

Budget Assumptions

The anticipated cost to Duke Energy for the beyond Energy Star program element involves costs for:

- Administrative costs to develop, oversee, and monitor the program. A vendor contract to market and deliver the new home program, including funding of BPI/HERS raters.
- Cooperative advertising budget as part of an inclusive marketing and promotional budget.
- Incentives to be paid to the builder.

Costs to participating customers include the customer's outlay for any remaining incremental cost of the Energy Star Plus home.

Program 9. Residential Home Reports

The Home Energy Comparison Report is a periodic comparative usage report that compares customers' energy use relative to similar residences in the same geographical area and which also gives customers specific energy savings recommendations to encourage energy saving behavior. The reports are typically mailed quarterly but the pattern may be altered by the program manager. The recommendations may be accompanied by coupons and links to other Company programs and to a website that promotes energy efficiency opportunities. The program has been tested as a pilot in South Carolina, where it was limited to individually metered, owner-occupied single family homes. The pilot showed approximately 2 percent overall energy savings for the pilot participants as compared to a control group of non-participants. According to the evaluation study, customers who reduced energy use tended to live in homes that had higher energy consumption and customers who increased energy use tended to live in homes with lower energy consumption compared with average homes. Based on pilot results, expansion to a full scale program will use information on homes that lowered use and homes that increased use for targeting and for testing messaging content to improve program performance.

Rationale

Customer Reports programs have emerged since 2007 and are being introduced by several utilities and other DSM administrators. They are often referred to as "behavioral" programs since the program theory is that careful messaging will influence energy savings behavior and because the first generation of these pilot programs studied only the messages and the net energy savings with respect to the control group. Only much more recently have the physical mechanisms causing energy savings been a subject of program research. Behavior, for example, may be as simple as changing energy use habits and patterns. Or it may be the purchase of an energy efficient appliance. It could be participation in one of the Company's other DSM programs. This program differs from all other DSM programs because it is not designed to provide meaningful savings to individual households. An average savings of 2 percent is well within the range of normal year to year variation in household energy use ("noise"), and the pattern of reduction for high use homes coupled with increase for low use homes is the typical pattern of regression to the mean. However, if the 2 percent savings can be shown to hold up over time as a contrast between a treatment group and a control group (with both groups determined by random assignment under control of a third-party evaluator rather than the Company or a program vendor or implementer) the result is meaningful and sizable at the system level on a one-year savings basis.

Participation and Measures

There is one measure, the Customer Report. However, the reports may be delivered with different frequencies, and messaging may be tested to achieve best results.

Table 30. Measures – Residential Home Reports

Measures	Measure Number
Customer Report	R-47

The knowledge base for messaging is similar to that for corporate communications and traditional marketing and promotion programs.

This program type is unique in that it presents no dollar cost that is apparent to customers and participation is assigned by the utility (with provision for opt-out) as a part of the program design. Duke has considerable experience with this program type so that participation levels will be set with reasonable certainty in advance, and participants may be replaced as necessary to compensate for opt-outs. As this program matures, different groups of customers may be targeted for participation.

Marketing Plans

Since the program content is marketing and promotion/corporate communications there is not a special marketing plan other than the actual Customer Reports. Instead, the program manager will determine which customers should be included and which excluded from the program (targeting). Then the total group eligible for the program will be split using random assignment conducted by the third party independent evaluator. This will provide a treatment group and a control group. The treatment group will receive the messaging; the control group will not. Possibly the program manager will decide to form more than one treatment and/or control group. In that case, the key feature is always random assignment from a pool of eligible customers to the various groups. Also, frequency of reports may be quarterly or varied.

Program Tracking

Data collection and documentation for program purposes and annual reporting will require a tracking system. This will require careful tracking of group members, attrition, and of messages and frequency. In addition, an effort will be conducted to determine the physical causes of energy savings and customer costs.

Budget Assumptions

Costs to participating customers will be customer's time and any incremental costs due to selection of energy-efficient appliances or home improvements. Company costs will be limited to the communications, the tracking system, and determining the actual customer costs.

Program 10. Residential Neighborhoods

This is a program type developed largely by Progress Energy in the Carolinas, now part of Duke Energy. Progress Energy's existing program is targeted primarily to households at or below 150 percent of poverty. The program involves identification of a specific neighborhood with approximately 60 percent low-income customers which is approached through local leaders and an organized effort to secure community participation.

The program provides a set of low-cost/no-cost energy saving measures plus a full set of air sealing to electrically heated homes in the neighborhood. This service will be provided to all electrically heated homes, including low-income and non low-income homes. Gas customers are provided with energy efficient lights (CFLs, LEDs and/or halogens). Though administered through a program delivery vendor, the program requires staff involvement in community meetings and events.

Rationale

The program concentrates services in a neighborhood blitz and with local recognition to minimize cost. It then moves on to another neighborhood. By concentrating on lower income neighborhoods and rural communities, the program serves mainly low-income customers. However, in keeping with the community approach all homes in the neighborhood are offered service.

Participation and Measures

Measures are shown in the table below.

Table 31. Measures and Incentives – Residential Neighborhoods

Measures	Measure Number	Incentive
Low Flow Fixtures	R-38	100%
House Sealing using Blower Door	R-18	100%
Tank Wrap, Pipe Wrap & Water Temp Setpoint	R-37	100%
Efficient Residential Lighting	R-33	100%

Participation is expected to begin with the selection of one or two neighborhoods, then be expanded to additional neighborhoods.

Marketing Plans

Marketing is approached through community social relations in a neighborhood application with the support of community leaders. Generally, a community meeting or community dinner will be included. Application will be in a house by house blitz.

Program Tracking

Data collection and documentation for program purposes and annual reporting will require a tracking system so that measures installed can be tracked by relevant household classification variables.

Budget Assumptions

The budget for this program will be refined with experience. In several ways, this is a social marketing program rather than a traditional marketing program in that it is community based. This means there will be overhead for working with local officials and community leaders and for community events such as a dinner.

Program 11. Residential Low Income Weatherization

This program contains two separate program elements, differentiated based on household income. The first program element is the Residential Low Income Program which will serve customers up to an including 200 percent of the Federal Poverty Level. It is modeled on the federal Weatherization Assistance Program (WAP). The second program element is to serve income limited households from 200 percent of the Federal Poverty Level to 300 percent or higher of the federal poverty level, depending on household structure, size, and income using the family budget method of accounting for income insufficiency.[31] It is modeled on the "Gap" programs now implemented by many US electric and gas utilities to assist households with income deficiencies, but which are technically above the cut off level for low income programs. The innovation is use of the family budget method for qualification.[32] The two program elements will be identical except for the income cut offs to determine eligibility.

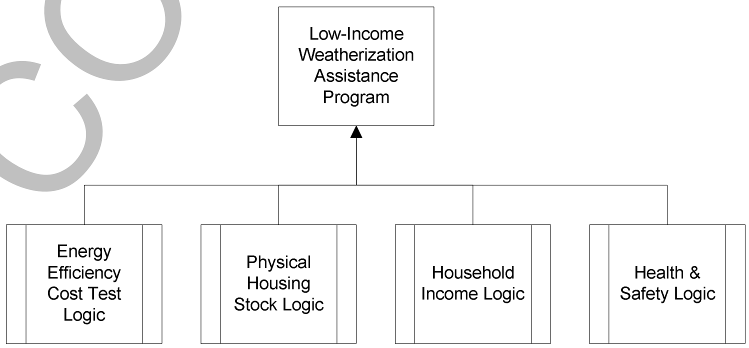
It is expected that the homes served by these program elements will be primarily single family owner-occupied homes and manufactured owner-occupied homes. However, and although the permission structure is different, and typically much less work can be done in a rental unit than in an owner-occupied home, we recommend that rules be developed for inclusion of apartments and rental units in this program. Services will be provided at no cost to the customer.

Rationale

Low-income programs are different from traditional DSM programs. They are a special case in that they attempt to cover four objectives:

- Like other DSM programs, a core objective is to provide energy savings (DSM savings).
- Unlike other DSM programs, a second core objective is to provide repairs necessary to install energy savings improvements in a part of the housing stock that is often old and substandard in comparison to middle and upper income housing.
- Provide DSM service to customers who otherwise could not obtain DSM improvements due to cost.
- Due to problems with low-income housing stock, address health and safety concerns.

Though cost tests are calculated, these programs are generally approved for equity or other reasons (for example in proportion to revenue share in the residential class generated by low income customers).



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[31] With the possibility of some homes with a higher percentage, depending on household structure and size using the income insufficiency tables.

[32] See: http://www.selfsufficiencystandard.org/docs/Ohio%20SSS%202011.pdf.

For these reasons, the prevailing practice in the area of low-income programs is not to focus solely on the "California tests" traditionally used in DSM program review.[33] Instead, commissions have been adopting different tests for low-income programs. For example, the DC Commission uses an "Expanded All Ratepayers Test" incorporating several "non-energy benefits" for low-income programs. In California, if the benefit-cost ratio on the Total Resource Cost (TRC) test is 0.8 or above, the California commission uses a "Modified Participant Test" and Utility Cost Test that includes "non-energy benefits" for screening measures for low-income programs. A measure is accepted into the program if it passes either test.[34] Thus, the TRC test result for the Southern California Edison Low-Income Energy Management Assistance Program was 0.63 for 2004 and 0.61 for 2005. Similarly, the TRC for Pacific Gas & Electric's Low-Income Energy Partners Program was 0.41 for 2004.

Participation and Measures

The types of weatherization measures to be offered are shown in the table below. This program is free to qualifying participants each year until funds are exhausted.

Table 32. Measures – Residential Low Income Weatherization

Measures	Measure Number
Low Flow Fixtures	R-38
Wall Insulation	R-21
Ceiling Insulation	R-16
Refrigerator Charge/Duct Tune-Up	R-6
House Sealing using Blower Door	R-18
Tank Wrap, Pipe Wrap & Water Temp Setpoint	R-37
Efficient Residential Lighting	R-33
Note: Measures above are illustrative. It is expected that the program will adopt the measure list of the state WAP program.	

For developing participation, the Low Income program limit of 200 percent of the Federal Poverty Level has been retained for the new program to facilitate compatibility and cost sharing with the state program.[35] However, consistent with the direction of current practice, the upper limit for the Moderate Income Weatherization Assistance Program is 300 percent of the federal poverty level or higher depending on analysis using the family budget method.

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[33] For low-income programs, program cost-effectiveness is a lesser issue, although still an important calculation. Due to their particular focus on the special needs of disadvantaged households, low-income energy efficiency programs are generally not held to the same cost-effectiveness criteria as utility energy-efficiency "resource" programs (i.e., they are not judged with a strict "total resource cost" test). More typically, the focus is on the magnitude of utility bill savings to participating customers, rather than the utility system avoided energy supply costs. Also, low-income programs often include broader "non-energy benefits" (NEBs) such as lowered credit and collection costs and avoided bad debt for the utility, and improved health and safety for customers. See: Kushler, Martin, Dan York & Patti Witte, "Meeting Essential Needs: The Results of a National Search for Exemplary Utility-Funded Low-Income Energy Efficiency Programs." Washington, DC: American Council for an Energy-Efficient Economy, Report Number U053, September 2005. For an update on approaches to low income programs please also see: Peach, H. Gil, "The TRC and Low Income", paper for the Low Income Subcommittee, Nevada Energy Collaborative, May 2012 https://dl.dropbox.com/u/12011114/The%20TRC%20and%20Low-Income.pdf).

[34] In addition, in California several measures are deemed for inclusion and are not cost tested.

[35] For methods and advantages of cost coordination, see Hill, Lawrence J. & Marilyn A. Brown, "Estimating the Cost-Effectiveness of Coordinated DSM Programs." *Evaluation Review*, Vol. 19 No. 2, April 1995, Pp. 181-196.

Since this program has no dollar cost to the customer, the level of actual participation each year will be set administratively by the Company.

Marketing Plans

Marketing for this program is expected to be coordinated with the state weatherization program, which already has outreach activity through the sub-grantee agencies. The number of program slots to be allocated to the Moderate Income program is expected to be a matter for continuing decision as economic conditions change. It is very important to have the capability to serve electrically heated homes above the 200 percent of poverty level since the federal poverty measurement system is systematically in error by a factor of two or more (depending on household size and structure). The situation of a home somewhat above the 200 percent cut off may easily be very difficult from an income insufficiency perspective. The assignment of slots between the Low Income and Moderate Income programs is likely to depend on circumstances that will develop and change. Care will need to be taken to try to insure that the programs are not over-subscribed in any given year.

The delivery contractor will be responsible for recruitment, taking into account referrals from Duke Energy. Proposed marketing efforts include the use of utility bill stuffers for customer education, and mention of the program in communications with customers regarding energy efficiency program options. Customer relations and collections staff will be trained to refer electric heat customers if they are within the income range and enquire about weatherization or experience payment problems.

Program Tracking

Data collection and documentation for program purposes and annual reporting will require a tracking system. The selected delivery contractor will be requested to carry out most of the data entry for this system.

Budget Assumptions

Costs to participating customers will be customer's time and permitting access to the home for improvements. The program should be coordinated with the state WAP program for program delivery and cost sharing.

Program 12. Commercial and Industrial Demand Response

This is a continuation of a current program type. One sub-program continues the current load curtailment program; the other adds a C&I AC cycling program component. For the ongoing curtailment program, the interruption period has been defined as six (6) hours to conform to PJM interconnection rules. The program is limited to load curtailment and the previously included local generation option is excluded. Duke currently offers several load curtailment options to large commercial and industrial customers. We recommend keeping these programs and gradually extending them. We do not assume the existence of a smart grid and while we recommend consideration of two-way meters for immediacy of certain verification, we assume a one-way signal with time of use meters for back-up recording. Direct load control is an important approach to peak reduction because it is low cost to the company and can be dispatched.

AC cycling is modeled on the current residential program but here applies to commercial customers. It extends peak reduction to a wider market of medium-sized commercial and small industrial customers with a load reduction program focused on air conditioners. We do not assume the existence of a smart grid and while we recommend consideration of two-way meters for immediacy of certain verification, we assume a one-way signal with the use of meters with memory that may be queried on-site as used in the Power Manager program.

Participation and Measures

Measures are shown below.

Table 33. Measures – C&I Demand Response

Measures
Load Control – AC Cycling
Load Control – Call Options

Duke has considerable experience with this program type so it is expected that participation goals and ramping rate can be set with high reliability. Since the service territory is limited, relatively small participation is expected throughout the program cycle.

Marketing Plans

The Marketing and Promotional Plan should include the following considerations. Include mention of the program in any communications with commercial and industrial customers regarding energy efficiency program options and on the Company website. Additional promotion may include bill inserts, recognition window stickers for participating businesses, and promotion using the Duke Energy website. The company has considerable experience enlisting large commercial and industrial customers. The small commercial class is not expected to be easy to enlist. Generally, these customers will be concerned about the effects of the cycling on clients (sales) and staff. It is expected that this program may cause a temperature fluctuation of about 2 degrees. If this can be communicated or demonstrated it may ease fears about effects on customers or production. The small commercial class is not assigned account representatives, so this will be a limiting factor in communications. The issue of owner-occupied versus tenant-occupied space will also be a challenge in promoting participation in this program. The marketing and promotion effort will give priority to owner-occupied facilities.

We recommend design of a marketing plan that draws from the theories of choice architecture so that communications are framed to position increased participation. Results from the recent evaluation of the corresponding residential sector Power Manager program suggest many residential customers are more aware of participant bill credits than of AC cycling events when called. If this turns out to be true for the small commercial sector, the program extension should work well.

Program Tracking

Direct load control is data intensive and load management data is precise. When load events are called either for capacity shortages or economic emergencies, the systems self-validate. Care needs to be taken to insure the collection of data elements sufficient to show the baseline condition at the time an event is called and the response to the call as a kW effect. The duration of each event for evaluation purposes should also last long enough to show the affected units back on line to demonstrate there are no unexpected rebound effects.

Budget Assumptions

The anticipated cost to Duke Energy for offering the medium/small commercial AC cycling component to customers involves budgets for a monthly participant incentive and payment when events are responded to.

Cost to the participants is to accept the temporary load control when incidents are called.

Program 13. Residential Demand Response

This program contains the existing residential AC cycling program and also includes the newly planned thermostat control program. The program is expected to be a precursor to the eventual system-wide implementation of these technologies. The company will have its own internal preferences as to meter types and brand(s). Generally these are digital meters with a one-way or two-way radio frequency or Internet communications capability. Generally, the required technology supports direct load control, a feature that allows automatic adjustments to central air conditioning units during periods of peak demand during summer months in exchange for price incentives on electric rates, and direct control of thermostats (HVAC) with local override.

In a dispatch program, a switch can be engaged to send a signal that directly reduces load. Direct load control is an important approach to peak reduction since it is low cost and is a dispatch program.

Rationale

Load (KW) constraints are one of the most costly events a utility encounters. During peak times when demand escalates and there is a problem with meeting demand with additional generation supply (either physically or at reasonable cost), the cost per kW to the company can escalate exponentially. For this reason, in these situations load control is essential to control costs and insure service.

Participation and Measures

Measures are shown below.

Table 34. Measures – Residential Demand Response

Measures
DLC – Residential AC
DLC – Climate Controller

Duke Energy has considerable experience with this program type so it is expected that participation goals and ramp rate can be set administratively with high reliability. We would expect participation to increase over the program cycle.

Marketing Plans

Marketing should take advantage of current concerns for mitigating climate problems by emphasizing a green marketing theme and can include the following elements:

- Proposed marketing efforts should include mention of the program in communications with customers regarding energy efficiency program options. These include bill inserts, recognition window stickers for participating homes, media coverage of how to manage electric bills, customer service representatives, and promotion using the Duke Energy website.
- Residential communications for the program can reach out to customers with high bill complaints and to customers with payment problems as well as to general promotion to customers concerned with keeping costs low and interested in mitigating global warming.

Program Tracking

Direct load control is data intensive and load management data is precise. When load events are called either for capacity shortages or as tests, the systems self-validate. Care needs to be taken to insure the collection of data elements sufficient to show the baseline condition at the time an event is called and the response to the call as a kW effect. The duration of each event for evaluation purposes should also last long enough to show the affected units back on line to demonstrate there are no unexpected effects.

Budget Assumptions

The anticipated cost to Duke for offering this program to customers involves budgets for:

- Participant incentives.
- Cost of equipment prorated to the DLC effort plus the cost of connecting the controlled equipment.

Cost to the participants is to accept the temporary load control when incidents are called.

Program Participation and Achievable Potential

The number of participants in each program was subjectively determined considering recent program history, the relevant customer population, elements of program design including incentive levels and the longer term need for energy efficiency savings. The projected number of "active" participants in each program was then calculated as the cumulative adoption less prior year participants past the end of the life of savings for that program. Since the action plan has a five year horizon, the Home Reports program with an assumed life of savings of one year is the only program for which prior year participants drop off in the estimation of cumulative program participation. It is also important to restate that this study does not include participants in Duke DSM programs prior to 2013 in our estimates of program participation. Incremental and active (cumulative) program participants are shown in Table 35 and Table 36.

Table 35. Incremental Participants by Program

Program	2013	2014	2015	2016	2017
C&I Tune-Ups	9	37	93	111	130
C&I EE Products	444	469	494	518	543
C&I Custom	147	196	246	295	344
Res EE Products	10,267	7,059	7,700	8,021	8,342
Res EE Ed for Schools	1,155	1,155	1,155	1,155	1,155
Res Energy Assessment	1,952	2,196	2,440	2,684	2,929
Res Appliance Recycling	770	1,155	1,540	1,925	1,925
Res High Performance Homes	35	49	49	49	49
Res Home Reports	36,330	36,330	36,330	36,330	36,330
Res Neighborhoods	173	347	347	347	347
Res Low Income Weatherization	173	347	554	693	693
C&I Demand Response	2	4	5	5	5
Res Demand Response	590	790	990	990	990

The number of active participants can fall over time since prior year participants past the end of the savings life are not counted as active.

Table 36. Active (Cumulative) Participants by Program

Program	2013	2014	2015	2016	2017
C&I Tune-Ups	9	46	139	251	380
C&I EE Products	444	913	1,407	1,925	2,468
C&I Custom	147	344	589	884	1,228
Res EE Products	10,267	17,326	25,026	33,047	41,389
Res EE Ed for Schools	1,155	2,310	3,465	4,620	5,775
Res Energy Assessment	1,952	4,149	6,589	9,274	12,202
Res Appliance Recycling	770	1,925	3,465	5,390	7,315
Res High Performance Homes	35	84	133	183	232
Res Home Reports	36,330	36,330	36,330	36,330	36,330
Res Neighborhoods	173	520	866	1,213	1,559
Res Low Income Weatherization	173	520	1,074	1,767	2,460
C&I Demand Response	2	6	11	16	21
Res Demand Response	590	1,380	2,370	3,360	4,350

Average savings per participant and the number of incremental and active participants in any given year are used to estimate incremental and cumulative program savings in that year. Incremental and cumulative energy and demand savings are presented in Table 37. Gross (before net-to-gross effects) and net achievable potential are shown by program and planning year in Table 37 below.

Energy (kWh) savings from DSM programs are nearly equally distributed between residential programs and non-residential programs. The Energy Efficiency Products programs for residential and non-residential customers account for the greatest share of total energy savings. The Custom program for non-residential customers is expected to become increasingly important in terms of the mix of savings, accounting for one-fourth of energy savings from incremental participants in 2017.

Demand savings are measured at coincident peak. The mix and pattern of change in kW savings follows closely with kWh savings.

Table 37. Achievable Energy and Demand Potential by Program and Year

Program	**Gross Savings**							**Net Savings**					
	2013	**2014**	**2015**	**2016**	**2017**	**Pct of Total**	**NTG Ratio**	**2013**	**2014**	**2015**	**2016**	**2017**	**Pct of Total**
Millions of kWh - Incremental													
C&I Tune-Ups	0.1	0.5	1.4	1.6	1.9	2%	0.95	0.1	0.5	1.3	1.6	1.8	3%
C&I EE Products	13.8	14.6	15.3	16.1	16.9	29%	0.70	9.7	10.2	10.7	11.3	11.8	27%
C&I Custom	6.6	8.8	10.9	13.1	15.3	21%	0.70	4.6	6.1	7.7	9.2	10.7	19%
Res EE Products	14.1	9.7	10.6	11.0	11.5	22%	0.70	9.9	6.8	7.4	7.7	8.0	20%
Res EE Ed for Schools	0.5	0.5	0.5	0.5	0.5	1%	0.70	0.4	0.4	0.4	0.4	0.4	1%
Res Energy Assessment	1.6	1.8	2.0	2.2	2.4	4%	0.75	1.2	1.4	1.5	1.7	1.8	4%
Res Appliance Recycling	0.9	1.3	1.8	2.2	2.2	3%	0.85	0.8	1.1	1.5	1.9	1.9	4%
Res High Performance Homes	0.1	0.2	0.2	0.2	0.2	0%	1.00	0.1	0.2	0.2	0.2	0.2	0%
Res Home Reports	7.0	7.0	7.0	7.0	7.0	13%	1.00	7.0	7.0	7.0	7.0	7.0	18%
Res Neighborhoods	0.1	0.3	0.3	0.3	0.3	0%	0.85	0.1	0.2	0.2	0.2	0.2	1%
Res Low Inc Weatherization	0.6	1.1	1.8	2.3	2.3	3%	1.00	0.6	1.1	1.8	2.3	2.3	4%
C&I Demand Response	0.0	0.0	0.0	0.0	0.0	0%	1.00	0.0	0.0	0.0	0.0	0.0	0%
Res Demand Response	0.0	0.0	0.0	0.0	0.0	0%	1.00	0.0	0.0	0.0	0.0	0.0	0%
Total	45.5	45.8	51.8	56.6	60.5	100%		34.4	35.1	39.7	43.4	46.1	100%
Millions of kWh - Cumulative													
	2013	**2014**	**2015**	**2016**	**2017**	**Pct of 2017**	**NTG Ratio**	**2013**	**2014**	**2015**	**2016**	**2017**	**Pct of 2017**
C&I Tune-Ups	0.1	0.7	2.1	3.7	5.6	2%	0.95	0.1	0.7	2.0	3.5	5.3	3%
C&I EE Products	13.8	28.3	43.7	59.7	76.6	33%	0.70	9.7	19.8	30.6	41.8	53.6	31%
C&I Custom	6.6	15.3	26.3	39.4	54.7	24%	0.70	4.6	10.7	18.4	27.6	38.3	22%
Res EE Products	14.1	23.8	34.4	45.4	56.8	24%	0.70	9.9	16.7	24.1	31.8	39.8	23%
Res EE Ed for Schools	0.5	1.1	1.6	2.2	2.7	1%	0.70	0.4	0.8	1.2	1.5	1.9	1%
Res Energy Assessment	1.6	3.4	5.5	7.7	10.1	4%	0.75	1.2	2.6	4.1	5.8	7.6	4%
Res Appliance Recycling	0.9	2.2	4.0	6.2	8.4	4%	0.85	0.8	1.9	3.4	5.3	7.1	4%
Res High Performance Homes	0.1	0.3	0.5	0.7	0.9	0%	1.00	0.1	0.3	0.5	0.7	0.9	1%
Res Home Reports	7.0	7.0	7.0	7.0	7.0	3%	1.00	7.0	7.0	7.0	7.0	7.0	4%
Res Neighborhoods	0.1	0.4	0.6	0.9	1.2	1%	0.85	0.1	0.3	0.6	0.8	1.0	1%
Res Low Inc Weatherization	0.6	1.7	3.5	5.8	8.1	3%	1.00	0.6	1.7	3.5	5.8	8.1	5%
C&I Demand Response	0.0	0.0	0.0	0.0	0.0	0%	1.00	0.0	0.0	0.0	0.0	0.0	0%
Res Demand Response	0.0	0.0	0.0	0.0	0.0	0%	1.00	0.0	0.0	0.0	0.0	0.0	0%
Total	45.5	84.3	129.1	178.7	232.2	100%		34.4	62.5	95.2	131.5	170.7	100%
MW - Incremental													
	2013	**2014**	**2015**	**2016**	**2017**	**Pct of Total**	**NTG Ratio**	**2013**	**2014**	**2015**	**2016**	**2017**	**Pct of Total**
C&I Tune-Ups	0.0	0.1	0.2	0.3	0.3	2%	0.95	0.0	0.1	0.2	0.2	0.3	0%
C&I EE Products	1.3	1.3	1.4	1.5	1.5	18%	0.70	0.9	0.9	1.0	1.0	1.1	1%
C&I Custom	0.9	1.2	1.5	1.8	2.1	19%	0.70	0.6	0.9	1.1	1.3	1.5	1%
Res EE Products	1.9	1.3	1.4	1.5	1.5	19%	0.70	1.3	0.9	1.0	1.0	1.1	1%
Res EE Ed for Schools	0.1	0.1	0.1	0.1	0.1	1%	0.70	0.0	0.0	0.0	0.0	0.0	0%
Res Energy Assessment	0.2	0.3	0.3	0.3	0.3	4%	0.75	0.2	0.2	0.2	0.2	0.3	0%
Res Appliance Recycling	0.1	0.2	0.3	0.3	0.3	3%	0.85	0.1	0.2	0.2	0.3	0.3	0%
Res High Performance Homes	0.0	0.0	0.0	0.0	0.0	0%	1.00	0.0	0.0	0.0	0.0	0.0	0%
Res Home Reports	0.5	0.5	0.5	0.5	0.5	7%	1.00	0.5	0.5	0.5	0.5	0.5	0%
Res Neighborhoods	0.0	0.0	0.0	0.0	0.0	0%	0.85	0.0	0.0	0.0	0.0	0.0	0%
Res Low Inc Weatherization	0.1	0.2	0.3	0.4	0.4	4%	1.00	0.1	0.2	0.3	0.4	0.4	0%
C&I Demand Response	0.4	0.8	1.0	1.0	1.0	11%	1.00	0.4	0.8	1.0	1.0	1.0	1%
Res Demand Response	0.6	0.9	1.1	1.1	1.1	12%	1.00	0.6	0.9	1.1	1.1	1.1	1%
Total	6.2	6.9	8.2	8.8	9.3	100%		4.9	5.6	6.7	7.2	7.6	4%
MW - Cumulative													
	2013	**2014**	**2015**	**2016**	**2017**	**Pct of 2017**	**NTG Ratio**	**2013**	**2014**	**2015**	**2016**	**2017**	**Pct of 2017**
C&I Tune-Ups	0.0	0.1	0.3	0.6	0.9	2%	0.95	0.0	0.1	0.3	0.5	0.8	0%
C&I EE Products	1.3	2.6	4.0	5.5	7.0	19%	0.70	0.9	1.8	2.8	3.8	4.9	3%
C&I Custom	0.9	2.1	3.7	5.5	7.6	20%	0.70	0.6	1.5	2.6	3.8	5.3	3%
Res EE Products	1.9	3.2	4.6	6.1	7.6	20%	0.70	1.3	2.2	3.2	4.2	5.3	3%
Res EE Ed for Schools	0.1	0.1	0.2	0.3	0.3	1%	0.70	0.0	0.1	0.1	0.2	0.2	0%
Res Energy Assessment	0.2	0.5	0.8	1.1	1.4	4%	0.75	0.2	0.4	0.6	0.8	1.1	1%
Res Appliance Recycling	0.1	0.3	0.6	0.9	1.3	3%	0.85	0.1	0.3	0.5	0.8	1.1	1%
Res High Performance Homes	0.0	0.0	0.0	0.0	0.1	0%	1.00	0.0	0.0	0.0	0.0	0.1	0%
Res Home Reports	0.5	0.5	0.5	0.5	0.5	1%	1.00	0.5	0.5	0.5	0.5	0.5	0%
Res Neighborhoods	0.0	0.0	0.0	0.1	0.1	0%	0.85	0.0	0.0	0.0	0.1	0.1	0%
Res Low Inc Weatherization	0.1	0.3	0.6	1.0	1.5	4%	1.00	0.1	0.3	0.6	1.0	1.5	1%
C&I Demand Response	0.4	1.2	2.2	3.3	4.3	12%	1.00	0.4	1.2	2.2	3.3	4.3	3%
Res Demand Response	0.6	1.5	2.6	3.7	4.8	13%	1.00	0.6	1.5	2.6	3.7	4.8	3%
Total	6.2	12.6	20.2	28.5	37.3	100%		4.9	10.0	16.2	22.9	29.9	18%
NTG (Net-To-Gross) Ratio is multiplied by gross savings to calculate net savings.													

PROGRAM COST EFFECTIVENESS

Program cost effectiveness analysis answers the question of would we be better off with the EE program compared to not having the program. The answer almost always depends on who is asking the question. In other words, better off from whose perspective? Standard DSM cost effectiveness analysis includes five perspectives. Four of which will be addressed in this report:

- Total Resource Cost (TRC)
- Participant
- Ratepayer Impact (RIM)
- Utility Cost (also known as Administrator Cost)

A detailed discussion of cost effectiveness methodology, including the standard tests listed above, is included in Appendix B. In this section, we present the results of the cost effectiveness analysis beginning with a discussion of assumptions. Cost effectiveness results are then presented for each perspective and EE program.

Expected Program Costs

Program spending includes the cost of incentives and other program specific expenses including evaluation. It also includes costs for fully-loaded program staffing, administration and indirect expenses that support the overall EE effort. Program spending over the 5 year action plan is shown in Table 38. Detailed program spending estimates are included in tables at the end of this section.

Table 38. Program Spending

	Planning Year				
	2013	**2014**	**2015**	**2016**	**2017**
EE Program Budget (millions $)	12.2	12.3	14.3	15.8	16.4
Incentives	62%	61%	60%	60%	61%
Program Admin and Delivery	22%	23%	26%	27%	26%
EM&V	4.2%	4.3%	4.4%	4.4%	4.5%
Indirect EE Spending	11.4%	11.4%	9.8%	8.9%	8.5%

Incentives are the largest cost category. Program administration and delivery are mostly comprised of payments to vendors for delivery-related services and to a lesser extent internal staffing. Evaluation measurement and verification costs are expected to average between four and five percent. Program spending includes indirect program expenses that support the overall EE effort. For example, program databases for tracking all programs are mostly in place but will require on-going development expenditures. Our estimates of these annual expenditures are shown in Table 39 below.

Table 39. Annual Indirect Program Expenses

Item	Amount
Information Technology and Systems	$ 150,000
Staff Development & Training	$ 280,000
Program R&D (includes pilots)	$ 550,000
Trade Organization Memberships	$ 120,000
DSM Marketing and Customer Awareness	$ 300,000
Total	**$1,400,000**

It is important to understand that actual expenditures will vary from planned expenditures in their timing and distribution between specific DSM programs. For this reason it is important for the program administrator to have flexibility in the administration of DSM program funding without having to obtain approval from the Public Utility Commission.

Miscellaneous Program Assumptions

Energy savings and demand expected from the programs are based on the designs and assumptions presented earlier in this report. Key assumptions affecting the annual savings and program cost effectiveness are shown in Table 19, Table 20 and Table 21. The savings life of each program is calculated from the life of individual measures within the program weighted by measure savings. The life of a program represents the duration of energy savings flowing from a participant in the program.

The net-to-gross ratio captures the effects of free-riders, participants in the program who would have installed the energy efficient measures without the program, and spillover effects, program induced savings happening outside of the program. A ratio of 1.0 means the net effect is the same as the gross effect. Ratios less than 1.0 imply a greater level of free-rider effects than spillover effects in the program. NTG ratios in this study vary by program ranging from 0.7 to 1.0. These assumptions are based on subjective professional opinion. Accurate estimates are beyond the scope of this study and involve specialized research that can cost several hundred-thousand dollars.

Avoided Costs

The avoided or marginal cost associated with a reduction in energy and demand is of primary importance when evaluating the cost effectiveness of DSM programs. These costs represent the value of avoided electric energy and demand. DEO's costs are the reduction in the cost of supply compared to what it would have been without the reduction in loads and include all incremental energy, transmission and distribution costs as well as the cost of avoided capacity. These costs were embedded in the DSMore cost effectiveness model supplied by Duke. Hourly savings load shapes developed by Forefront for each program were entered into the DSMore software for modeling program cost effectiveness.

Cost Effectiveness Results

In this section, the findings of the cost effectiveness analysis which provides a systematic comparison of the program benefits and costs discussed in previous sections are presented. Results are shown for the four perspectives mentioned at the beginning of this section.

The TRC perspective is the broadest of the cost effectiveness tests presented below. As the name implies, TRC shows the total cost of the resource relative to supply side resources. The Utility Cost Test only considers costs paid by the program administrator and generally results in a higher benefit-cost ratio than the TRC unless the utility pays for the full cost of installation. The Participant Test shows the economics of program participation from the participant's perspective and reflects benefits from lower bills and incentive payments. Elements of program design, such as incentive payments, can greatly impact participant economics. For most utility EE programs the lost revenue calculation in the RIM Test exceeds the avoided cost of supply causing the programs to fail the RIM Test.

From the TRC perspective, all programs, expect for the Residential Low Income Weatherization program, are cost effective.

Table 40. Cost Effectiveness Results – Benefit-Cost Ratios by Test

EE Program	**TRC**	**Utility Cost**	**Participant**	**RIM**
C&I Tune-Ups	1.7	2.1	4.0	0.8
C&I EE Products	2.8	3.8	3.0	0.9
C&I Custom	3.9	4.6	4.5	1.0
Res EE Products	2.0	2.6	2.5	0.8
Res EE Ed for Schools	4.0	3.2	NA	0.8
Res Energy Assessment	2.3	2.8	3.4	0.8
Res Appliance Recycling	2.7	2.2	NA	0.7
Res High Performance Homes	1.1	1.4	2.5	0.6
Res Home Reports	1.3	1.3	NA	0.5
Res Neighborhoods	1.3	1.2	NA	0.6
Res Low Income Weatherization	0.8	0.8	NA	0.5
C&I Demand Response	5.8	4.1	NA	1.8
Res Demand Response	2.3	1.4	NA	1.4

Indirect EE expenses, those costs not directly attributable to a specific EE program, are not included in the program-specific cost effectiveness analysis. They are included in the TRC for the overall EE portfolio (all programs) which produces an overall TRC benefit-cost ratio of 2.1.

Program Cost Details

Provided below are detailed program spending estimates included in various tables. The term 'incentives', as used in the Cost Effectiveness section of this report, refers to the installed incremental cost that is incurred by the utility.

Table 41. Total Program Costs

Program Number	Program	2013	2014	2015	2016	2017	Pct of 5 Yr Total	Incentives	Variable	Fixed	EM&V	Total
1	C&I Tune-Ups	255,180	170,177	217,562	233,357	249,152	2%	26%	0%	66%	8%	100%
2	C&I EE Products	2,832,013	2,986,396	3,140,778	3,295,161	3,449,543	22%	92%	2%	2%	4%	100%
3	C&I Custom	1,102,768	1,227,706	1,487,051	1,746,397	2,005,743	11%	80%	0%	13%	7%	100%
4	Res EE Products	3,635,925	2,516,300	2,740,225	2,852,187	2,964,150	21%	90%	4%	2%	4%	100%
5	Res EE Education for Schools	75,070	75,070	75,070	75,070	75,070	1%	66%	0%	30%	4%	100%
6	Res Energy Assessment	498,131	518,160	569,768	621,377	672,985	4%	64%	21%	10%	5%	100%
7	Res Appliance Recycling	177,691	229,588	302,540	375,490	375,490	2%	20%	70%	5%	5%	100%
8	Res High Performance Homes	205,581	185,056	185,056	185,056	185,056	1%	55%	12%	28%	5%	100%
9	Res Home Reports	490,708	490,708	490,708	490,708	490,708	3%	0%	89%	4%	7%	100%
10	Res Neighborhoods	109,486	92,236	92,236	92,236	92,236	1%	47%	16%	32%	5%	100%
11	Res Low Income Weatherization	971,528	1,847,266	2,923,416	3,640,850	3,640,850	18%	27%	66%	2%	5%	100%
12	C&I Demand Response	83,203	73,618	82,246	87,254	92,262	1%	30%	1%	66%	4%	100%
13	Res Demand Response	400,885	501,510	641,719	682,969	724,219	4%	85%	1%	10%	4%	100%
	Total Program Spending	**10,838,169**	**10,913,791**	**12,948,375**	**14,378,111**	**15,017,463**	**90%**	**67%**	**21%**	**6%**	**5%**	**100%**
	General EE Spending	**1,400,000**	**1,400,000**	**1,400,000**	**1,400,000**	**1,400,000**	**10%**					
	Total DSM Budget	**12,238,169**	**12,313,791**	**14,348,375**	**15,778,111**	**16,417,463**	**100%**					

Table 42. Incentives

Program	**2013**	**2014**	**2015**	**2016**	**2017**
C&I Tune-Ups	7,266	29,063	72,657	87,188	101,720
C&I EE Products	2,601,095	2,745,600	2,890,105	3,034,610	3,179,116
C&I Custom	723,575	964,766	1,205,958	1,447,149	1,688,341
Res EE Products	3,285,481	2,258,768	2,464,111	2,566,782	2,669,453
Res EE Education for Schools	49,667	49,667	49,667	49,667	49,667
Res Energy Assessment	294,607	331,433	368,259	405,085	441,911
Res Appliance Recycling	30,801	46,202	61,603	77,003	77,003
Res High Performance Homes	77,226	110,322	110,322	110,322	110,322
Res Home Reports	0	0	0	0	0
Res Neighborhoods	24,949	49,898	49,898	49,898	49,898
Res Low Income Weatherization	245,550	491,099	785,759	982,198	982,198
C&I Demand Response	8,623	19,169	27,327	32,134	36,942
Res Demand Response	297,950	422,550	555,150	594,750	634,350
Total	**7,646,789**	**7,518,538**	**8,640,815**	**9,436,788**	**10,020,921**

Table 43. Other Variable Costs (excluding EM&V)

Program	**2013**	**2014**	**2015**	**2016**	**2017**
C&I Tune-Ups	0	0	0	0	0
C&I EE Products	66,638	70,340	74,042	77,744	81,446
C&I Custom	0	0	0	0	0
Res EE Products	154,007	105,880	115,505	120,318	125,131
Res EE Education for Schools	0	0	0	0	0
Res Energy Assessment	97,617	109,819	122,021	134,223	146,425
Res Appliance Recycling	107,805	161,707	215,610	269,512	269,512
Res High Performance Homes	17,276	24,681	24,681	24,681	24,681
Res Home Reports	435,958	435,958	435,958	435,958	435,958
Res Neighborhoods	8,663	17,326	17,326	17,326	17,326
Res Low Income Weatherization	606,402	1,212,804	1,940,487	2,425,609	2,425,609
C&I Demand Response	252	504	630	630	630
Res Demand Response	5,900	7,900	9,900	9,900	9,900
Total	**1,500,518**	**2,146,919**	**2,956,160**	**3,515,901**	**3,536,618**

Table 44. Fixed Program Costs

Program	**2013**	**2014**	**2015**	**2016**	**2017**
C&I Tune-Ups	227,500	127,500	127,500	127,500	127,500
C&I EE Products	51,000	51,000	51,000	51,000	51,000
C&I Custom	302,000	177,000	177,000	177,000	177,000
Res EE Products	51,000	51,000	51,000	51,000	51,000
Res EE Education for Schools	22,400	22,400	22,400	22,400	22,400
Res Energy Assessment	81,000	51,000	51,000	51,000	51,000
Res Appliance Recycling	30,200	10,200	10,200	10,200	10,200
Res High Performance Homes	100,800	40,800	40,800	40,800	40,800
Res Home Reports	20,400	20,400	20,400	20,400	20,400
Res Neighborhoods	70,400	20,400	20,400	20,400	20,400
Res Low Income Weatherization	71,000	51,000	51,000	51,000	51,000
C&I Demand Response	71,000	51,000	51,000	51,000	51,000
Res Demand Response	81,000	51,000	51,000	51,000	51,000
Total	**1,179,700**	**724,700**	**724,700**	**724,700**	**724,700**

Table 45. EM&V Costs

Program	**2013**	**2014**	**2015**	**2016**	**2017**
C&I Tune-Ups	20,414	13,614	17,405	18,669	19,932
C&I EE Products	113,281	119,456	125,631	131,806	137,982
C&I Custom	77,194	85,939	104,094	122,248	140,402
Res EE Products	145,437	100,652	109,609	114,087	118,566
Res EE Education for Schools	3,003	3,003	3,003	3,003	3,003
Res Energy Assessment	24,907	25,908	28,488	31,069	33,649
Res Appliance Recycling	8,885	11,479	15,127	18,774	18,774
Res High Performance Homes	10,279	9,253	9,253	9,253	9,253
Res Home Reports	34,350	34,350	34,350	34,350	34,350
Res Neighborhoods	5,474	4,612	4,612	4,612	4,612
Res Low Income Weatherization	48,576	92,363	146,171	182,042	182,042
C&I Demand Response	3,328	2,945	3,290	3,490	3,690
Res Demand Response	16,035	20,060	25,669	27,319	28,969
Total	**511,162**	**523,634**	**626,700**	**700,722**	**735,224**

APPENDIX A. METHODOLOGY

At the root of most DSM analysis there is some form of energy usage model. The model that is often used in larger multi-utility DSM planning synthesizes estimates from demographics applied to engineering prototypes. This approach is easy to apply to individual measures and to small groups of measures where the result of all the measures is small relative to the total energy sales. But the simple synthesis approach becomes unstable where a large or comprehensive technical potential is contemplated because the simple sum may not include measure interactions, and can result in inflated (or seriously deflated) savings estimates. Also demographic information and market penetration information are more accurate applied to large regions, but lack precision when applied to smaller regions. Under this circumstance, the cumulative errors due to lack of precision can compound into large errors.

Therefore, in this case, where a technical potential will be derived from a maximum application of a wide variety of interacting measures and applied to a relatively small region, we have opted to approach the estimate with a "calibrated engineering model". With this approach we will true the models to the current actual energy sales by fitting a relatively simple algebraic model to the recorded energy use (and demand) and the associated average monthly temperatures. This approach has the strong advantage of starting the analysis from a verifiable energy use situation. Another significant advantage of this approach is that it is somewhat empirical, and the data fitting process will reveal large unusual energy use situations, if they exist. Finally, it is particularly important to be able to establish a reasonably bounded estimate of the aggregate energy under conditions representing the full technical potential, which requires the explicit treatment of measure interactions afforded by the engineering modeling approach.

Within conditioned spaces, heating and cooling energy will be influenced by lighting and other internal gains and by large scale refrigeration. This results in an interaction of energy savings measures. Another form of measure interaction is related to changes in thermal conversion efficiency. Whenever there is a load reduction measure, the net realized energy savings will also be dependent on an assumed thermal conversion efficiency. Where a thermal conversion efficiency is changed at the same time as a load reduction, the result is interactive, and it is important to consider the effect of both measures simultaneously. In this case, where a wide range of efficiency and load reduction measures will be applied, it is particularly important to be able to deal with measure interactions in an orderly way.

The model has been devised and structured with explicit variables to express in physical or engineering terms, the measures and treatments involved in attaining the full technical potential. This includes variables for conversion efficiency, load reductions and thermal and electrical solar energy measures. The model will also estimate the changes in peak demand associated with the applied efficiency measures. The following discussion will be in two parts: the first part for the energy model, and the second part for the demand model.

Energy Model

Nature of the Data

A brief review of the energy sales and the associated average temperature, as illustrated in Figure 19 and Figure 20, shows that the daily average energy use has a close relationship to temperature.

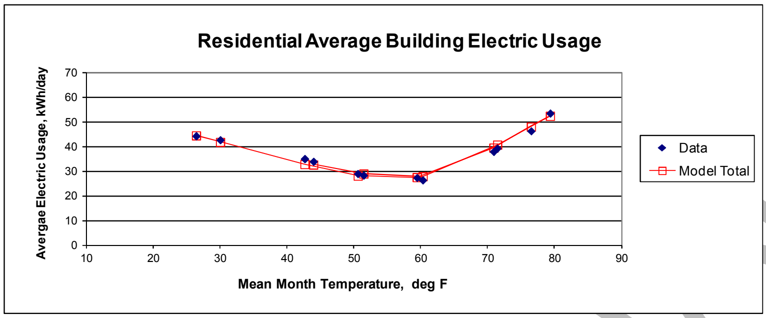

Figure 19. Average Monthly Electricity Usage - Existing Single Family

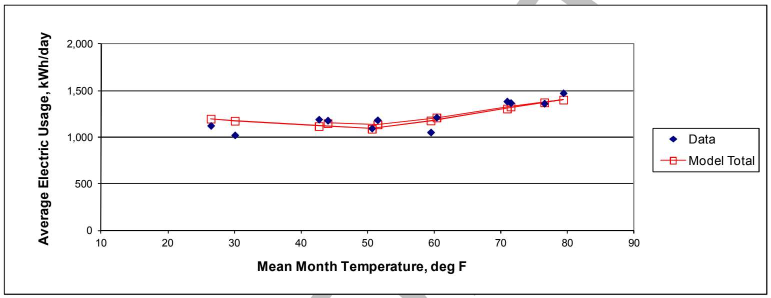

Figure 20. Average Monthly Electricity Usage – Grocery

Figure 19 was derived from a random sample of residential single family units older than four years. This model is intended to characterize the energy use in the largest portion of the residential sector. There are other similar models for the other segments of the residential sector. In general, these models of average performance fit quite closely with an R-square usually in excess of 95 percent. This figure shows clearly the increased energy use at higher temperatures for air conditioning. And it also shows increased average energy use at low temperatures for heating, mostly by customers with electric furnaces. Note that at average temperatures in the range of 55-65 deg F, there appears to be no heating or cooling. Energy use at these temperatures is mostly the residential base load: lights, plugs, hot water.

Figure 20 was derived from all the available billing histories of customers classified as Grocery. The model and the data fit quite closely here. The average grocery store shows an increased energy use with temperature associated with air conditioning and mostly with refrigeration. There appears to be little electric heating. In Figure 20 most of the energy use appears to be grocery base load, typically interior refrigeration, lights, and ventilation.

Energy Model Structure

For energy modeling purposes, customers were subdivided into segments as described in the Market Assessment section of this report. An engineering model was fitted to usage, appliance and end-use saturation levels, and temperature data. The models applied in each of the segments are all similar and represent six very fundamental end-uses:

- Space Heating
- Space Cooling
- Water Heating
- Lighting
- Internal Uses: Appliances, Electronics, Cooking, Dishwasher, Miscellaneous Plug Loads
- External Uses: Outdoor Lights, Washer, Dryer, Process Loads

Note that the fundamental end-uses distinguish between internal and external electric energy use. Internal uses contribute to internal heat gains while external uses do not contribute to internal gains. This distinction is for the purpose of estimating measure interactions between the heating and cooling end-uses and the electrical energy use within the conditioned space. Lighting and internal uses are assumed to occur within the conditioned envelope. Predominant internal and external uses differ by sector as shown below.

Predominant Internal and External End-Use by Sector		
Sector	**Internal**	**External**
Residential	Appliances and Misc Plug Load	Laundry
Commercial	Electronics and Misc Plug Load	Exterior Lighting
Industrial	Other Base Load	Process

Model Inputs

Some of these end-uses are dependent on weather variables. The heating and cooling end-uses depend on average monthly temperature; the hot water end-use depends on the average monthly inlet water temperature, and lighting depends slightly on calendar month and day length. The thermal and electrical solar energy benefits depend on the average monthly solar. The other end-uses are assumed constant from month to month. For weather dependent inputs the models use the inputs shown in Table 46.

Table 46. Weather Inputs to Modeling

End-Use	Inputs
Heating	Monthly average temperatures and long-term average month temperatures
Cooling	Monthly average temperatures and long-term average month temperatures
Hot Water	Monthly long-term average inlet water temperatures
Lighting	Seasonal lighting usage factors

Beyond the weather inputs are the inputs pertaining to the distribution and operation of the energy using systems, listed in Table 47 and Table 48 for residential and non-residential, respectively. These are the variables that are changed in the process of fitting a model to the data. It is noteworthy that relatively few model parameters are sufficient to specify a model that provides a good fit to the data. This is partly due to the fact that we are using usage and weather data aggregated from hundreds and, in some cases, thousands of sites.

The parameterization of this model is simple to provide transparency and for ease in review. It admittedly does not include many well known second order effects, such as variation of heating COP with temperature. However, the simple treatment of energy use in terms of first order effects is sufficient to the principal purposes here, which are: 1) to be able to true-up the model to the current energy use, and 2) to be able to estimate a physically reasonable energy use assuming conditions of full technical potential.

Table 47. Residential Energy Model Parameters

	Existing Housing		New Construction	
Model Input	**Single Family**	**Multifamily**	**Single Family**	**Multifamily**
Water Heat Saturation	43%	64%	30%	33%
Hot Water Use Gallons per Day	55	45	55	55
Tank Loss btu/degree hour	3	3	3	3
Hot Water Tank Set Temperature	130	130	130	130
Water Heating Efficiency	100%	100%	100%	100%
Space Heat Saturation	23%	58%	30%	33%
Space Heat Efficiency	1.10	2.00	1.68	1.93
Space Heat Set Temperature	55	55	60	60
Space Heat Use btu/degree hour	453	320	540	425
Lights kWh/day	8.23	3.88	6.30	4.00
Lights and Misc Saturation	100%	100%	100%	100%
Kitchen Use kWh/day	12.29	5.79	9.41	5.97
Kitchen Use Saturation	100%	100%	100%	100%
Washer, Dryer and External kWh/day	3.10	1.46	2.37	1.51
Washer, Dryer and External Saturation	100%	100%	100%	100%
Space Cooling Saturation	90%	85%	85%	50%
Space Cooling Set Temperature	63	63	66	66
Space Cooling Use btu/degree hour	453	320	540	425
Space Cooling Efficiency	2.45	2.45	3.50	3.00

Table 48. Non-Residential Energy Model Parameters

	Commercial												**Manufacturing**				
Model Input	**Grocery**	**Hospitals**	**Hotels**	**Office**	**Other**	**Health Srv**	**Eating/ Drinking**	**Retail**	**Schools**	**Warehouse**	**< 3000 kWh**	**AG Con**	**Chemicals**	**Food**	**Transportation**	**Other**	**Primary Metals**
Water Heat Saturation	40%	5%	10%	20%	20%	10%	10%	10%	15%	10%	0%	10%	1%	1%	1%	1%	5%
Hot Water Use (gallons/day)	230	9000	2550	80	100	375	430	500	675	75	60	500	5700	3300	3000	3500	260
Tank Loss (btu/degree hour)	15	40	4	4	4	4	4	4	40	4	4	4	150	4	150	4	4
Hot Water Tank Set Temperature	140	140	140	130	130	130	140	140	130	130	130	140	140	140	140	140	140
Water Heating Efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Space Heat Saturation	5%	1%	40%	10%	50%	5%	5%	0%	4%	3%	0%	0%	6%	0%	0%	10%	50%
Space Heat Efficiency	110%	110%	100%	75%	168%	85%	120%	150%	110%	150%	125%	150%	100%	100%	100%	100%	110%
Space Heat Set Temperature	62	60	62	55	56	60	65	66	62	45	60	60	55	63	55	63	60
Space Heat Use (btu/degree hour)	10000	22000	8000	3200	850	2000	1845	2750	18000	6000	10	2600	35000	6000	120000	20000	30000
Lights (kWh/day)	279.0	2698.8	595.9	180.0	27.9	88.2	86.1	255.2	531.6	438.7	2.5	77.2	147.9	804.2	759.5	144.8	383.0
Lights and Misc Saturation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Process Use (kWh/day)	597.79	3447.26	285.12	139.61	44.04	112.60	235.50	85.05	674.42	248.44	0.33	55.41	197.22	1072.25	1012.67	193.05	510.67
Process Use Saturation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Washer, Dryer and External (kWh/day)	222.42	1181.13	277.42	33.30	18.76	38.58	68.65	40.34	6.60	190.25	0.10	11.54	1454.53	7907.87	7468.42	1423.77	3766.17
Washer, Dryer and External Saturation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Space Cooling Saturation	100%	100%	95%	79%	75%	80%	85%	80%	70%	85%	0%	80%	23%	70%	20%	32%	20%
Space Cooling Set Temperature	50	46	65	64	60	65	55	55	55	57	67	65	40	40	40	51	70
Space Cooling Use (btu/degree hour)	10000	22000	8000	3200	850	2000	1845	2750	18000	6000	10	2600	35000	6000	120000	20000	30000
Space Cooling Efficiency	2.20	3.50	2.00	3.50	2.00	2.50	2.40	3.00	3.00	2.80	2.70	1.80	1.00	1.50	1.50	1.50	2.00

Separation into End-Uses

The total energy use is partitioned into the six fundamental end-uses by a combination of empirical discovery and engineering calculation, however simple.

The heating and cooling end-uses are empirically derived through the fitting of the model to the energy versus temperature slope in the usage and temperature data. The hot water end-use is explicitly calculated from water usage, inlet water temperature, and storage loss assumptions.

During weather neutral months such as April and May, these models empirically show the total building base load. But the models cannot go further and separate that total base load into its constituent end-uses: hot water, lighting, internal loads, and external loads.

The further separation of end-uses is done by removing the explicitly calculated hot water end-use and partitioning the remaining base load (lighting, internal loads, and external loads) on the basis of US national electric energy end-use splits. For the residential sector as a whole and for most of the commercial analysis categories there are published end-use splits on the average energy use for a full range of end-uses.

For this analysis appropriate items from the full range of end-uses are aggregated into the three fundamental end-uses used in this analysis: lighting, internal uses, and external uses. From these aggregated end-uses two ratios are developed, internal usage/lighting and external usage/lighting. These two ratios are then used in the models to maintain the appropriate relationships between lighting, internal uses, and external uses.

Usage Normalization

For planning purposes, usage data is normalized to the average 10-year temperatures for the service area. Figure 21 shows the actual temperatures in the test year and the long-term average temperatures.

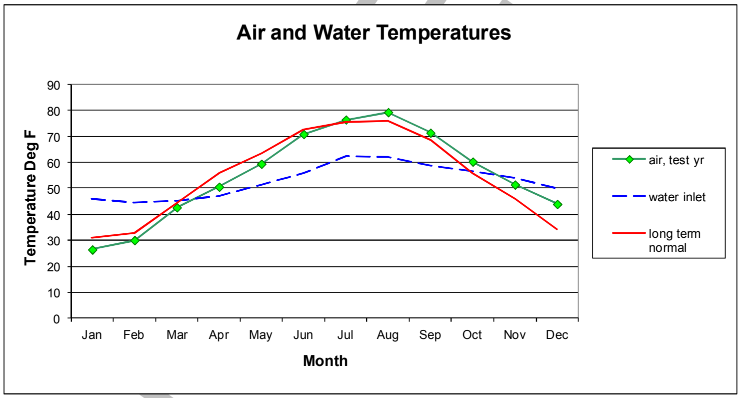

Figure 21. Air and Water Temperatures

In Figure 21, it is evident that the test year, green, will experience more heating and cooling, and will use more energy, than the 30-year average, red. The water temperature in Figure 21 refers to the ground water temperature which is used in the end-use models for water heating energy. In this case, the 30-year estimate of the groundwater temperature is assumed the same for the test year.

Perspectives on Energy

For perspective and review, the average daily energy use by end-use category and by month for each of the sixteen analysis categories is shown graphically at the end of this appendix.

Demand Model

Available Data

Duke made available hourly load data by rate class for 2010. This analysis proceeded from a load metered sample worked to an estimate of the total system load, and to the load of the principal customer sectors. Loads that we excluded from the analysis include the direct sales to municipalities and industrial transport.

This load analysis first derived the total residential and total non-residential coincident peak load for each hour of the peak day for each month for the analysis period, 2010. This analysis is the benchmark to which this demand model is trued up.

But first it is important to note that the energy model developed here estimates the average demand for a particular hour for each month. The average hourly demand from this model is quite different than the peak day hourly load for the same hour and month in the Duke Energy System Peak Day Load Analysis. They are almost as different as apples and oranges because the hourly demand is born of the monthly average and the peak hourly load comes from the monthly extreme and includes transmission and distribution losses. The initial analysis showed that the shape of the peak day load curves provided an opportunity to empirically modify and tune the timing of the predicted demand.

Demand Model

The demand model is driven by the energy model. For each end-use and for each month, the energy model estimates the average daily energy use, kWh/day. The demand model then takes the estimated daily energy use and distributes it among the twenty four hours of the day.

The objective of this demand model is to estimate the average distributed hourly demand for a large number of customers. The concept of distributed demand assumes that thousands of the same device, (stove water heater, computer, etc) will be turning on and off according to use at random times within the hour of interest. The contribution of any one of these devices is the full load power multiplied by the duty cycle for the hour. For example, if a 1400 watt toaster is on for one-tenth of the hour, the distributed demand is 1400 watts times 0.1 hours, or 140 watts. In essence, the distributed demand is the energy used in the hour.

The distribution from daily energy use to hourly is done by means of "demand distribution functions". The demand distribution function consists of twenty-four hourly demand factors that specify the fraction of the daily energy use that occurs in each hour. Figure 22 and Figure 23 show the hourly demand factors empirically derived from this analysis and applicable to the residential customers.

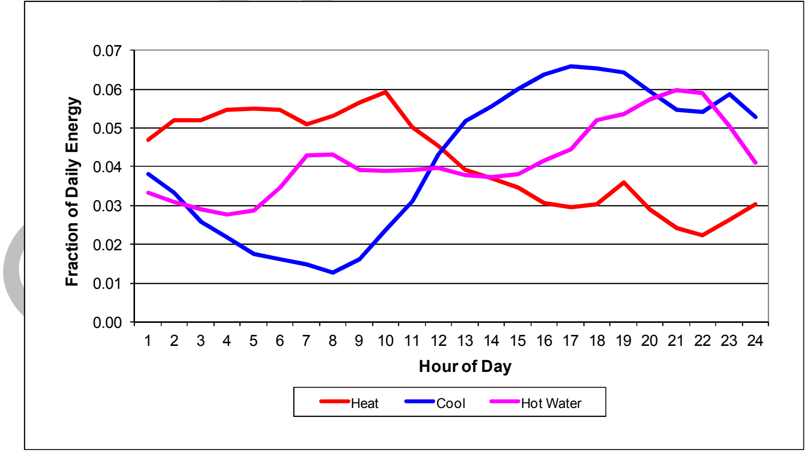

Figure 22. Residential Hourly Demand Factors for Heating, Cooling and Hot Water

Notice in Figure 22 that the cooling demand factor is greatest at about 4-5 PM when the cooling energy for each hour reaches about .073*daily average cooling energy. Similarly, the hourly demand factor for heating appear to be maximum at 1 AM when the hourly demand factor is .068 and the hourly heating energy is .068*daily average heating energy. Hot water demand is known to be bi-modal occurring in the morning and late evening.

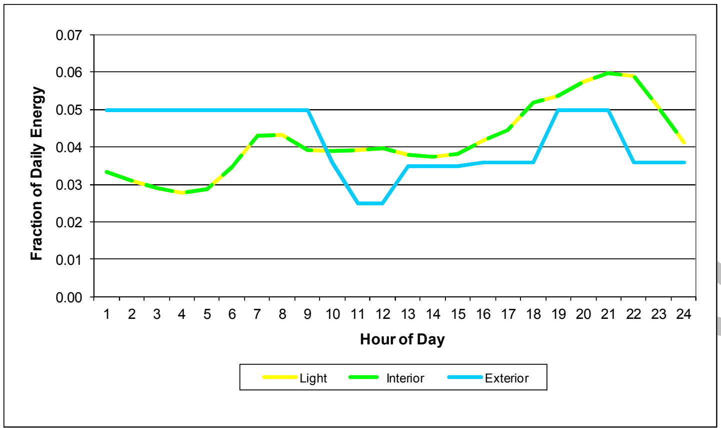

Figure 23. Residential Hourly Demand Factors for Lighting, Internal and External Loads

Notice in Figure 23 that the interior loads and lighting have the same hourly demand factor and work toward a daily peak at about 8PM. The exterior load here consists of washer and dryer activity and some exterior lighting. Washers and dryers are considered here to be external loads because most of the energy is discharged outside as in the case of dryers. Or because the load may occur in an attached space such as a basement or wash porch that is not directly part of the conditioned space, as in the case of washers.

In the model there is a set of hourly demand factors for each of the six end-uses for each of the 24 analysis categories. In principal quite a lot of unique demand specifics. But in practice the comparison of the modeled demand and the de-rated peak day load curves was done at a much aggregated level. For example the de-rated commercial peak day load was compared hour by hour to the sum of the demand estimated in the twelve commercial analysis categories. In this comparison, the data is not detailed enough to distinguish one commercial load from another. Therefore, there is a set of hourly demand factors for each of the six end-uses, and these are used in all twelve of the commercial analysis categories. The commercial hourly demand factors are shown in Figure 24 and Figure 25.

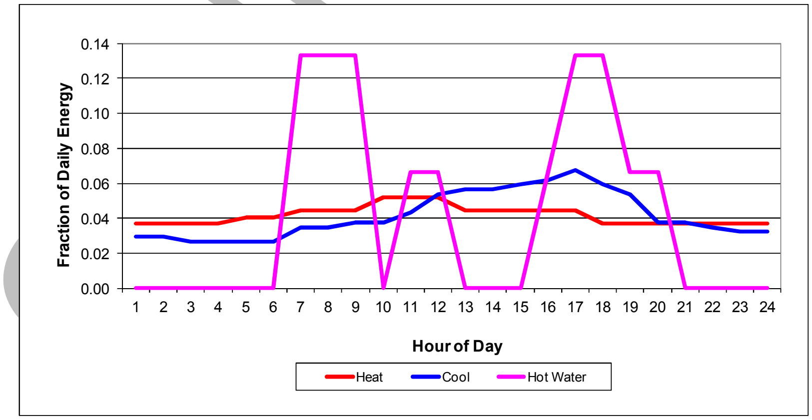

Figure 24. Commercial Hourly Demand Factors for Heating, Cooling and Hot Water

There is very little electric heating or water heating in the commercial sector, and the demand factors for these end-uses find minimal use. In Figure 24 the demand factors for cooling are the most important.

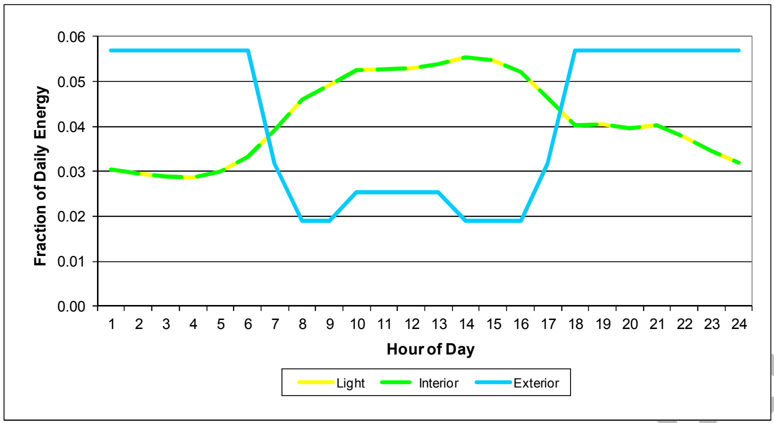

Figure 25. Commercial Hourly Demand Factors for Lighting, Internal and External Loads

In Figure 25, the hourly demand factors for the exterior loads express the fact that these loads are principally exterior lighting which is on at night. The hourly demand factors of principal importance are those for the lighting and interior loads which are assumed to be the same.

Truing the Demand Model

The demand model is ultimately trued against the coincident peak day. And ultimately, the truing process requires a temperature adjustment to simulate peak load instead of average demand conditions.

The first step in the demand true-up is to adjust the non-weather end-uses, lighting, internal loads, external loads, and hot water. The adjustment consists of modifying the hourly demand factors for these end-uses until the modeled sum of the non–weather end-uses is close to that observed from the load study. This comparison is best done when heating and cooling are at a minimum. Once the hourly demand factors are so adjusted they are then used to represent the non-weather load throughout the year and especially in the heating and cooling situations. Figure 26 shows a close comparison between the demand estimated by the model and the demand from the load study for the sum of the non-weather load.

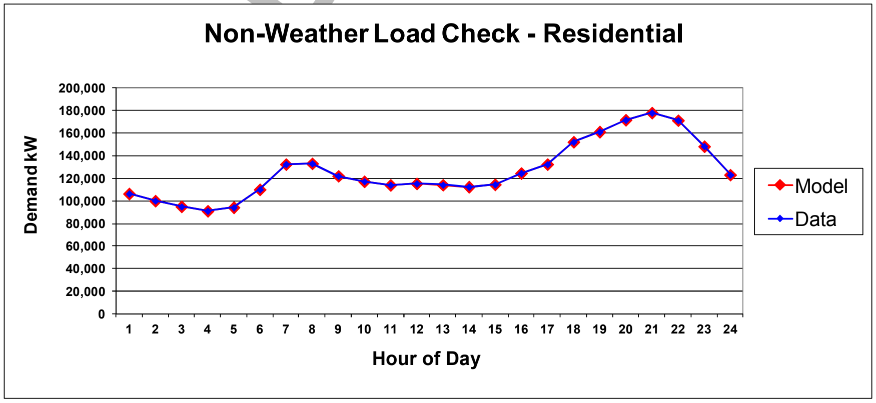

Figure 26. Base Load True-Up – Residential, October

The next step in the true-up is for cooling. In this case the model is compared to the load study for a maximum cooling month and the hourly load factors for each of the cooling months are adjusted for best fit between the model and load study. It has been found necessary to derive a different load factor curve for each cooling month because the actual dynamics of the cooling vary from month to month. For example cooling in May never carries over into the small hours of the morning as does cooling in August.

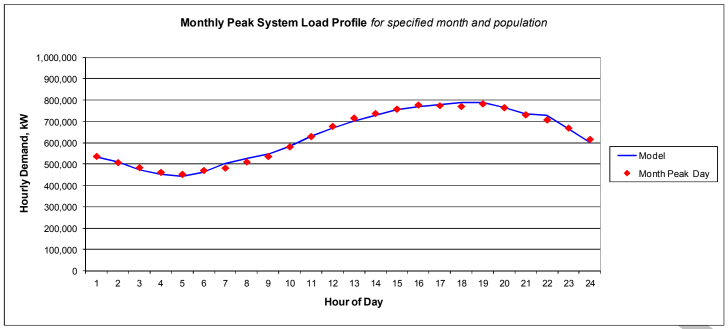

Figure 27. Cooling True-Up – All Customers, August

Figure 27 shows a close comparison between the demand estimated by the model and the demand from the load study after this cooling true-up step.

The final demand true-up step is for heating. In this case the model is compared to the load study for the heating months and a separate heating load factor curve is derived for each month from the best fit between the model and load study.

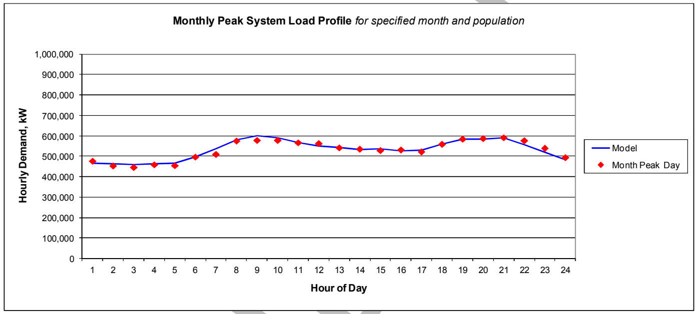

Figure 28. Heating True-Up – All Customers, December

Figure 28 shows a close comparison between the demand estimated by the model and the demand from the load study after this heating true up step. Through these true-up steps, the most significant hourly demand factors are derived and the demand model can now estimate the average daily demand versus hour for each month.

Estimating the Coincident Peak Day Load

There is a relationship between the coincident peak day load versus hour and the average day demand versus hour produced by this model. To estimate the coincident peak load, the energy model is driven by peak monthly temperatures instead of average monthly temperatures.

This model will estimate the change in average hourly demand for each month simulating any group of efficiency measures or all the measures used to express full technical potential. This month by month change in hourly average demand, at the hour of maximum system demand, will be reported as the demand impact. As such, this demand impact does not include effects of transmission and distribution losses that will often be in the financial analysis for both energy and demand. This analysis is carried out in terms of demand, and the final technical potential will be reported as an offset to the forecast energy at the meter.

Estimating the Technical Potential for Demand Savings

This model will also estimate the change in hourly demand for each month for peak, not average, conditions corresponding to any group of efficiency measures or all the measures used to express full technical potential. This month by month change in peak hourly demand, at the hour of maximum system demand, will be reported as the technical potential demand impact for each month. As such, this demand impact does not include effects of transmission and distribution losses.

Measure Savings

The screening relies on measure savings that are observable in real world billing histories. Thus the measure savings used in this screening are the net observable savings after and including the effects of take back, measure interactions, and background energy usage changes. Competent impact evaluations often report savings at the measure level.

Measure specific estimates are typically derived by regression from a billing analysis normalized for weather. This type of analysis often does not show “crossover savings,” that is, gas savings resulting from measures intended to produce electric savings. These crossover savings result from measures such as duct sealing, attic insulation, wall insulation, or house sealing which produce both gas heat and electric cooling savings. This highlights a cost effectiveness issue for this analysis: the true cost effectiveness of some measures will need to include the value of both the electric and gas savings.

Customer and Load Forecast

In order to better express the savings potential attributable to new construction, and to understand the magnitude of the technical potential relative to overall energy sales, we put the technical potential in the perspective of the current 20-year planning horizon. The technical potential model has been aligned to the base case utility forecast which does not include any energy efficiency efforts except those that would occur naturally such as the effects of product improvements or the effects of current building codes and standards, including the effects of the mandated retirement of incandescent lighting. The model is aligned to the utility forecast at four intervals in the 20-year planning horizon. This alignment is achieved by the use of scaling factors which drive the technical potential model to match the utility forecast at the desired years.

It should be noted that this technical potential is a strictly physical calculation based on the empirically derived energy usage of the average customers in 24 different categories. In estimating future energy use or savings it is assumed that these average energy uses do not change with time, commonly referred to as a “frozen efficiency” estimate. We recognize that in the real world energy decisions will often be based on more complex effects such as the response to energy costs, and the emergence and demise of various energy saving options with time. Therefore in the interest of simplicity and transparency our estimates do not include customer price elasticity, fuel switching, efficiency changes, or demographic trends. The estimates presented here over the 20 year planning horizon are essentially physical offsets to the official utility forecast which generally does include the more complex effects. The intention here is to present a reasonable physical estimate of technical potential accounting for redundancies, measure interactions, and time of season and day, and that is well bounded by the empirical evidence found in survey information and in the utility’s aggregate energy usage records. The technical potential estimated for 2011 will be used as a benchmark for evaluating DSM program objectives and performance.

The utility forecast for this analysis is the Duke Energy Spring 2012 forecast for Kentucky. This forecast includes a forecast of “before energy efficiency” and a forecast for after an assumed level of energy efficiency. We used the “before energy efficiency” forecast as the baseline reference for the technical potential. Derived in this manner, it should be clear that our 20 year estimate of technical potential relative to the utility forecast serves the purpose of providing a broad perspective of the technical potential vis-à-vis the utility planning horizon.

APPENDIX B. COST EFFECTIVENESS METHOLOGY

Cost effectiveness analysis refers to the systematic comparison of program benefits and costs using standardized measures of economic performance. In this report, cost effectiveness is discussed at both the technology level and the program level. The assumptions and approach used to calculate technology and program cost effectiveness are presented in this appendix. Much of the material in this section is taken from the *California Standard Practice Manual: Economic Analysis of Demand Side Management Programs and Projects, October 2001* (SPM 2001),[36] which has broad industry acceptance.

Technology Cost Effectiveness

It is desirable to consider some measure of a technology's cost effectiveness in the preliminary stages of program design. This allows program planners to subjectively tradeoff cost and other attributes of energy efficiency measures (EEM) when considering possible program designs. Cost effectiveness analysis is less precise at the technology screening stage because estimates of energy savings and costs at the measure level are subject to a great deal of variance due to interaction with other measures and actual program implementation. Still, measure cost effectiveness provides a useful metric for consideration along with the many other factors outlined in the Program Plans section of this report.

What is needed at the technology or measure level is a simple measure of cost effectiveness that does not require assumptions of avoided resource cost, rebates, program delivery cost and other program level details. Levelized Cost (LC) provides such a measure by expressing the cost of a measure in annual terms per unit of energy saved. This allows an easy way to compare and rank order the cost effectiveness of measures. The formula used for the LC calculations in this report is presented below:

LC=DCosts / DSavings

$$DCost = \sum_{t=1}^{N} \frac{IC_t + OM_t}{(1+d)^{t-1}} \qquad DSavings = \sum_{t=1}^{n} [(\Delta EN_t) \div (1+d)^{t-1}]$$

where:

LC = Levelized cost per unit of the total cost of the resource (dollars per kWh)
IC = Incremental cost of the measure or technology
OM = Annual operation and maintenance cost
DCost = Total discounted costs
DSavings = Total discounted load impacts
ΔENit = Reduction in net energy use in year t
N = Life of measure
d = Discount rate

Although not suited for fuel substitution and load building programs, LC provides an easily calculated way of comparing measures. Measure cost, savings, useful life, and discount rate are the only assumptions required for calculating LC. Real levelized cost refers to LC expressed in constant dollars (i.e., without inflation).

The formula used in Microsoft Excel to approximate LC is as follows:

LC = (OM-PMT(d,N,IC))/EN

where PMT is the payment function in Excel and the other terms are defined as above.

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[36] Prepared by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC). All formulas and discussion are based on the SPM 2001. Formulas have been modified to remove peak savings, multiple costing periods, and otherwise adapted to be relevant for use with this project.

For example, using a real discount rate of 6.6%, a measure life of 18, an incremental cost of $200, and annual savings of 100 kWh with no annual O&M, results in real levelized costs of $0.1931.[37]

Program Cost Effectiveness

The discussion of program cost effectiveness is meant to provide a general overview of the standard tests consistent with the calculations in the SPM (2001). Actual cost effectiveness analysis was run using DSMore software from Integral Analytics. DSMore returns benefit-cost rations and other results for the perspectives represented in the standard tests. Contact Integral Analytics (http://www.integralanalytics.com/) for information and documentation regarding DSMore software.

Many additional assumptions over and above those required for calculating EEM cost effectiveness must be made when calculating program cost effectiveness. Cost effectiveness of energy efficiency programs involves describing the economic impact of the program from the perspective of various groups. This analysis required detailed program budgets and design elements such as rebate levels and other program features. Perspectives, also called tests, presented in this report are listed in the table below along with the primary benefits and costs used to compute cost effectiveness.

Table 49. Benefits and Costs by Cost Effectiveness Test

Cost Effectiveness Test	Benefits	Costs
Utility Cost (also known as Administrator Cost)	Avoided energy costs (net)	Program expenses paid by utility including incentives
Participant	Reduced energy bill Incentive payments Tax credits Decreased O&M costs	EEM installation Increased O&M costs
Ratepayer Impact	Avoided energy costs (net)	Lost revenue (net) Program expenses
Total Resource Cost (TRC)	Avoided energy costs (net) Tax credits Decreased O&M costs	EEM installation Program expenses Increased O&M costs
Societal (variant of TRC)	TRC benefits plus non-energy benefits less tax credits	TRC costs plus non-energy costs

Reference to "net" indicates that the load used to measure the benefit or cost is net of free-riders. EEM installation includes all incremental costs to acquire and install an EEM. Program expenses include all costs related to delivery of the program and include staffing and overhead, advertising, incentive payments, administration fees, and monitoring and evaluation expenses.

Various measures of the economic impact are available for each perspective. The two primary measures we will use in this report are listed below:

- Net Present Value
- Benefit-Cost Ratio

In addition to the economic criteria listed above, other criteria may be unique to a given perspective. For example, simple payback of investment is often cited as an important criterion from the participant perspective. Each of the perspectives is discussed in detail below including the assumptions and formulas required to calculate the measures of economic impact. Each of the cost effectiveness tests are discussed below.

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[37] The values used in the example are not meant to represent actual assumptions. See the Energy Efficiency Measure Assessment section for specific assumptions, including the discount rate.

Utility Cost Test (also known as Administrator Cost Test)

The Utility Cost Test measures the cost of acquired energy savings considering only the costs paid by the utility. Benefits are similar to the TRC Test but costs are more narrowly defined. Its primary purpose is for assessing resource acquisition from the perspective of the utility. In this sense, it is similar to the Participant Test in that the test provides a measure of cost effectiveness from a single perspective that does not include all costs.

Benefits included in the calculation are the avoided cost of energy supply. Net loads are used for the purpose of calculating avoided cost of energy benefits. The costs include all program expenses including incentive payments for EEM installation.

Participant Test

This test compares the reduction in energy bills resulting from the program with any costs that might have been incurred by participants. Other benefits included in this test include incentive payments and tax credits. When calculating benefits, gross energy savings are used rather than reducing savings for free-riders.

The main value of the Participant Test is that it provides insight into how the program might be received by energy consumers. The incentive level required to achieve some minimum level of cost effectiveness, for example, can be useful in program design efforts. It should be noted, however, that consumer decision making is far more complex than reflected by the Participant Test. For this reason, the test should be used as one consideration of likely program acceptance and not an absolute indicator.

Ratepayer Impact Measure Test

The Ratepayer Impact Measure (RIM) Test measures the impacts to customer bills and rates due to changes in utility revenues and operating costs caused by the program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates will go up if revenues collected after program implementation is less than the total costs incurred by the utility for implementing the program. This test indicates the direction and relative magnitude of the expected change in customer rate levels.

The benefits calculated in the RIM Test are the savings from avoided supply costs. These avoided costs include the reduction in commodity and distribution costs over the life of the program.

The costs for this test are the lost revenues from reduced sales and all program costs incurred by the utility, including incentives paid to the participant. The program costs include initial and annual costs, such as the cost of equipment (either total cost for a new installation or net cost if done as a replacement), operation and maintenance, installation, program administration, and customer dropout and removal of equipment (less salvage value). The decreases in supply costs and lost revenues should be calculated using net savings.

Total Resource Cost Test

The Total Resource Cost Test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. Of all the tests, the TRC is the broadest measure of program cost effectiveness from the standpoint of energy acquisition. This makes the TRC Test useful for comparing supply and demand side resources.

The primary benefit in the TRC Test is the avoided cost of energy. Loads used in the avoided cost calculation are net of free-riders. Tax credits and reductions in annual O&M costs, if applicable, are also treated as a program benefit (or a reduction in costs). Costs used in the TRC calculations include all EEM installation costs, program related costs and any increased O&M costs no matter who pays them. Incentive payments are viewed as transfers between participants and ratepayers and are excluded from the TRC Test.

Societal Test

The Societal Test is the broadest of all of the perspectives and is considered a variant of the TRC. The primary difference between the two tests is that the Societal includes non-energy benefits and costs that are not part of the TRC. Another difference is the treatment of tax credits. While tax credits are counted as a benefit in the TRC test, they are considered a transfer payment between members of society and, hence, excluded from the Societal test.

APPENDIX C. RESIDENTIAL EEM DOCUMENTATION

The purpose of this appendix is to provide documentation of the assumptions used to screen the residential Energy Efficiency Measures (EEM) identified for consideration in this report. As such, this appendix supports, but does not list, the specific values for savings, measure life and incremental costs for measures used in this study. These specific values for residential measures are listed in Table 14 on page 25. Our assumptions are based on references cited throughout this section as well as the direct experience of our team with technologies in the field and actual EE program evaluations. While not all of the field and EE program experience can be cited in published works, published references are used to establish a reasonable range of assumptions. The point estimate used within that range is based on our professional opinion. The mapping of EEM to residential EE programs is shown in the table below. The value represents the percentage of participants installing the measure. Cells with no value mean the measure is not included in the program.

Table 50. Mapping of Electric EEM to Residential EE Programs

Program #			**4**	**5**	**6***	**7**	**8**	**9**	**10**	**11**
End-Uses	**EEM Description**	**EEM Ref #**	**Res EE Products**	**Res EE Ed for Schools**	**Res Energy Assessment**	**Res Appliance Recycling**	**Res High Performance Homes**	**Res Home Reports**	**Res Neighbor hoods**	**Res Low Income Weatherization**
Customer-Sited Generation	Combined Heat Power, micro CHP	R-1								
Residential Space Conditioning	Elec Furnace to SEER 16 H Pump	R-2	0.03							
	Resist to SEER 16 Heat Pump	R-3								
	Elec Furnace to SEER 16 H Pump	R-4	0.01							
	Resist to SEER 16 Heat Pump	R-5								
	Refrig Charge/Duct Tune-Up	R-6			0.06					0.40
	Refrig Charge/Duct Tune-Up	R-7								
	SEER 13 to SEER 16 Heat Pump	R-8								
	SEER 13 to SEER 16 Heat Pump	R-9								
	SEER 13 to SEER 16 CAC	R-10								
	SEER 13 to SEER 16 CAC	R-11								
	Efficient Window AC	R-12								
	Cool Roofs	R-13	0.04							
	EE Windows	R-14								
	Programmable Thermostats	R-15								
	Ceiling Insulation (R6-R30)	R-16			0.08					0.50
	Ceiling Insulation (R6-R30)	R-17								
	House Sealing using Blower Door	R-18			0.06				0.15	0.40
	House Sealing using Blower Door	R-19								
	Ground Source Heat Pump	R-20								
	Wall Insulation (R3-R11)	R-21			0.05					0.25
	Wall Insulation (R3-R11)	R-22								
	Solar Siting/Passive Design	R-23								
	Energy Star Manufactured Home	R-24					0.04			
	Energy Star Construction	R-25a					0.95			
	Major Remodel	R-25b					0.01			
	Window Film	R-26								
Load Management	Eliminate Old Appliances	R-27				1.00				
	Set Back HVAC with Ceiling Fan	R-28								
Residential Appliances	Energy Star Clothes Washers	R-29	0.20							
	Energy Star Dish Washers	R-30								
	Energy Star Refrigerators	R-31								
	Pool Pumps	R-32	0.02							
Residential Lighting	Efficient Residential Lighting	R-33	0.90	1.00 {0.80}	0.08 0.80 {0.80}				1.00	1.00
	Daylighting Design	R-34								
	Occupancy Controlled Outdoor Lighting	R-35	0.05							
	Residential Outdoor Lighting	R-36	0.02							
Water Heating	Tank Wrap, Pipe Wrap and Water Temp Setpoint	R-37			0.04				0.20	0.40
	Low Flow Fixtures	R-38		1.00 {0.50}	0.06 0.80 {0.55}				1.00 {0.20}	0.75
	Heat Pump Water Heaters	R-39	0.05							
	Tankless Water Heaters	R-40								
	Solar Water Heaters	R-41								
	Efficient Plumbing	R-42								
Miscellaneous Technologies	Ductless Heat Pump	R-43	0.08							
	Drain HX	R-44								
	Smart Plug	R-45	0.20							
	Heat Pump Pool Heater	R-46	0.01							
	Customer Report	R-47						1.00		
	Solar PV	R-48								
	In Home Display	R-49								

Values in the table represent the percentage of participants receiving the measure. A number in brackets represents the percentage of those who receive the measure that actually install the measure; for all other measures the install rate is 100% of those receiving the measure.

Cells with no value mean the measure is not included in the program.

* For this program the second value in a cell represents the remote delivery channel; all other values are for the direct install delivery channel.

Combined Heat/Power, Micro CHP (R-1)

This measure is a form of site generation. There are two general classes of combined heat and power. The first class is applied to large steady thermal loads, usually at an industrial scale. This first class has a high load factor and is very rare in a residential context. The second class of combined heat and power has a low load factor, typical of the highly seasonal heating load in the residential sector. This second class, referred to here as “micro CHP”, is considered here as a residential measure. In this context it is intended to apply to existing residential space heat and water heat loads. Electricity generated by CHP applied to an existing gas thermal load has a unique efficiency opportunity in terms of fuel use and in terms of carbon offset because the fuel use associated with the generated electricity is only the marginal increase in gas use. The CHP resource is strongly favored from the perspective of carbon calculations, and it also has significant benefit as summer capacity, and as local backup power. Notably, this resource is based on ultra clean and quiet combustion in sterling cycle engines or fuel cells, and it can potentially be readily sited anywhere in the service territory and used to balance distribution. System sizes range from about 1 kW to 8kW electrical output. For this estimate of technical potential an electrical output of 4 kW is assumed.

Measure Applicability

This measure is applicable to residences with gas space and water heat.

Incremental Cost

This measure is not currently a mature market item and costs reflect the demonstration nature of the resource.

Average Annual Expected Savings

The savings from this measure have not been widely measured but based on the available space and water heating load an electrical output of 5,000 kWh/yr is assumed. A greater annual output could easily be achieved, but only by generation with no useful thermal load which would be much less fuel efficient.

Expected Useful Life

This measure has an expected useful life typical of appliances, of 15 to 20 years.

Resistance Electric Space Heat to SEER 16 Heat Pump (R-2, R-3)

This measure is designed to save heating energy and cooling energy by replacing an existing central air conditioner/electric furnace (R-2) or existing interior resistance heat (R-3) by a SEER 16 heat pump. Most of the savings proceed from replacing resistance heating by a heat pump at more than twice the thermal efficiency. This measure has significant savings, but also significant costs because it involves replacing the whole heating and cooling system. For R-2 the existing ductwork is used; and for R-3 the replacement includes the new ductwork.

Measure Applicability

This measure is applicable to residential customers that use electric resistance heat.

Incremental Cost

This measure requires replacing the whole heating/cooling system sometimes including ducts. The cost of such a replacement is quite site specific, in the case of R-2 the cost does not include new ductwork, and in the case of R-3 the cost does include new ductwork. There are two contexts for such a replacement: 1) early retirement in order to achieve large heating savings, and 2) where the central AC needs to be replaced anyway, the most prudent thing would be to replace with a heat pump because of its significant heating savings. The costs for measure R-2 assume that the central AC needs to be replaced to code, SEER 13, and that the incremental costs only include the cost difference between an installed SEER 16 heat pump and a base case which is a SEER 13 central AC unit.

Average Annual Expected Savings

The average annual expected savings from this measure depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

The physical life of this measure is about 20 years, but if the application of this measure is in an early retirement context, as with R-2 and R-3, the life will be less than the full physical life.

Resistance Electric Space Heat to SEER 16 Heat Pump (R-4, R-5)

This measure is designed to save heating energy by replacing resistance heat by a SEER 16 heat pump. These measures are exactly parallel to R-2 and R-3, except that they apply to the smaller multifamily stock. For R-4 the existing ductwork is used; and for R-5 the replacement includes the new ductwork.

Measure Applicability

This measure is applicable to existing residential customers in multifamily residences that use resistance heat.

Incremental Cost

This measure physically involves replacing the entire air conditioning unit in R-4, and including new ductwork in R-5. It is assumed that the context of R-4 is a forced replacement of AC, and that the incremental cost is the difference between an installed SEER 16 heat pump and a base case consisting of an installed SEER13 air conditioner only.

Average Annual Expected Savings

The average annual expected savings from this measure depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

The physical life of this measure is about 20 years but if the application of this measure is in an early retirement context the life would be considerably less.

Refrigeration Charge and Duct Tune-Up (R-6, R-7)

This measure is designed to save electric energy by increasing the operating efficiency of the refrigerant system by insuring that it is properly charged. Measure R-6 is applied to an electrically heated residence where both heating and cooling savings will accrue. Measure R-7 is applied to a gas heated residence where only cooling savings will accrue. It is common in residential cooling or heat pump systems to have an incorrect amount of refrigerant charge because these systems are usually charged on-site during installation. This measure also leads to savings from finding and sealing duct leaks which increases the system distribution efficiency.[38]

Measure Applicability

This measure is applicable to most of the residential stock. Notably even new installations can benefit from this measure.

Incremental Cost

The incremental cost of this measure pays for a visit by a specially trained HVAC technician.

Average Annual Expected Savings

The average annual expected savings from this depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

This is essentially a tune-up measure with a limited lifetime.

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[38] While these measures are theoretically handled by different trades, in practice they are implemented by a specially trained HVAC technician. This combination is efficient from a cooling system perspective and also typically cost effective.

Upgrade Heat Pump Efficiency from SEER 13 to SEER 16 (R-8, R-9)

This measure is designed to encourage the installation of more efficient heat pump equipment. Rather than installing a heat pump with a SEER of 13, the homeowner is encouraged to install a more efficient heat pump with a SEER of 16. R-8 applies to an upgrade to a new all electric single family home, and R-9 applies to the upgrade to a new all electric multifamily unit.

Measure Applicability

This measure is applicable to new heat pump installations in all electric residences.

Incremental Cost

Incremental costs include only the increased cost of the SEER 16 unit relative to the SEER 13 code unit. There are no ductwork costs in the incremental cost as the ductwork is considered an existing part of the job.

Average Annual Expected Savings

The average annual expected savings from this measure depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

The DEER uses 18 years. The new equipment used here is assumed to last 20 years

Upgrade Central Air Conditioner from SEER 13 to SEER 16 (R-10, R-11)

This measure is designed to encourage the installation of more efficient central air conditioning equipment. Rather than installing a central air conditioner with a SEER of 13 the homeowner is encouraged to install a more efficient central air conditioner which has a SEER of 16.

Measure Applicability

This measure is applicable to new or replacement central air conditioner installations in gas heated residences.

Incremental Cost

Incremental costs include only the increased cost of the SEER 16 unit relative to the SEER 13 code unit. There are no ductwork costs in the incremental cost as the ductwork is considered an existing part of the job.

Average Annual Expected Savings

The average annual expected savings from this measure depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

The DEER uses 18 years. The new equipment used here is assumed to last 20 years

Efficient Window AC (R-12)

An efficient window or room air conditioner saves energy by slightly more efficient operation, and often by use of an internal timer to restrict operation to occupied periods. An equally important consideration in the selection of a room air conditioner is to avoid over-sizing the unit, in which case additional spaces may be unintentionally cooled.

Measure Applicability

This measure is applicable in the residential and small commercial sector where central air conditioning is not used.

Incremental Cost

The incremental cost of the more efficient unit will vary with the size of the unit.

Average Annual Expected Savings

The energy savings from this measure will vary considerably with the size of the unit, the particular application, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

This measure's expected lifetime ranges from 12 to 13 years.

Cool Roofs (R-13)

This measure is intended to save cooling energy by reducing the temperature in the attic through attic ventilation and through the use of optically reflective roofing materials. Recent improvements in roofing have led to roofing material in attractive architectural colors that can reflect solar gain almost as well as white or reflective roofs. This reflection of solar gain along with adequate attic ventilation can lower attic temperatures significantly thereby reducing heat gain to the home and also improving the distribution efficiency of any ductwork or distribution fans that are located in the attic space. Attic cooling lowers the thermal gain to the residence below, and it also improves the distribution efficiency of any attic duct work. At least half the cooling savings attributable to this measure proceed from the improved distribution efficiency, and therefore this measure is intended for application where there are attic ducts or distribution fans. This is essentially a site-built measure including the installation of roof vents and the installation of several hundred square feet of reflective material to the inside of the roof rafters.

Measure Applicability

This measure is considered applicable to all new roofing applications. It is especially effective for central air conditioning applications with distribution ductwork in the attic.

Incremental Cost

The incremental cost for this measure is taken to be the incremental cost of the Energy Star Qualified roofing which is reported to be currently $0.20/square foot, but which is expected eventually to be zero. All other roofing costs are required and ventilation is assumed to be unchanged by this measure.

Average Annual Expected Savings

The savings from this measure proceed from lowered cooling energy by reducing ceiling heat gain. According to DOE, ceiling heat gain accounts for 15-25 percent of the residential cooling load. The radiant barrier has been observed to reduce ceiling heat gain by 16-42 percent. The cool attic strategy also improves cooling distribution efficiency if the cooling ducts or fan unit is in the attic. Larger savings will be found in the extreme cases with poorly insulated air conditioning distribution located in the attic spaces. Generally, savings depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

This measure consists of reasonably durable material installed in an attic where degradation potential is reduced.

EE Windows (R-14)

This measure involves increasing window insulation from a U value of 1.1 BTU/sqft/hr deg F to a U value of 0.35. This measure saves both heating and cooling energy. In the case of gas-heated residences, the electric savings are for cooling only and are much less than the heating savings. So the cost effective application of this measure is to electric heated residences only.

Measure Applicability

This measure is considered applicable to a portion of the residential customers that heat with electricity.

Incremental Cost

DEER uses a value of $28/square foot of window area, and C&RD[39] uses a value of $16/square foot.

Average Annual Expected Savings

Savings from this measure are strongly dependent on the efficiency of the electric heat source and the square feet of windows replaced. The stock to which this measure is applied consists primarily of electric furnaces. Therefore the simulations assume the displacement of resistance heat. Savings due to this measure depend significantly on the size of the residence, temperature set points, and the thermal integrity of the shell.

Expected Useful Life

DEER cites a useful life of 20 years for this measure.

Programmable Thermostats (R-15)

Programmable thermostats save energy by lowering the average daily temperature of the inside of a building. Most of the energy savings is heating energy because the heating thermal load is much larger than the cooling load, but some energy savings in cooling energy will also be realized. Programmable thermostats are commonly sold for self-installation. But the installation has the following four important issues that need to be considered.

- Some thermostats are line voltage thermostats, and there is some shock hazard to the unaware.
- The first step in programming a thermostat is the system specification. Here the installer tells the thermostat what kind of a system it is controlling. The system type is selected from a list of about 30-50 different system types. This is a non-obvious choice.
- For system controls there are standard colored wires, but often hookups use non-standard wire. For the mechanically inclined this process is okay but for others it is daunting.
- Then, after it is installed successfully there is the issue of controlling it to get satisfactory results. Sometimes this needs a guiding hand.

The US EPA has phased out programmable thermostats from the Energy Star program. This phase out is related to recent evaluation studies that found insufficient savings of an Energy Star Programmable Thermostat as compared to a non-Energy Star thermostat to warrant the Energy Star designation. Proper installation and operation appear to be at the root of the lack of energy savings. We have chosen to leave these devices in our mix of EEMs and feel that with proper installation and setup the technology is sound. Our incremental cost includes the cost of installation over-and-above the off-the-shelf cost of programmable thermostats. Even with proper installation, there is an ongoing need for a design that is more user-friendly and easier to operate. Energy Star is replacing programmable thermostats with climate control devices that are required to have a communicating climate control feature or to support installation of a communications module. As the new units become widely available, this will open up new opportunities for utility thermostat control programs.

Measure Applicability

For this analysis one-half the electric heating situations are taken as good candidates for a new programmable thermostat.

Incremental Cost

Programmable thermostats cost retail in the range of $50-$100. A utility program may be able to purchase in bulk. It may be necessary to have a range of options which include at least line voltage and low voltage. DEER lists the incremental cost as $56.30 and the installed cost as $73.33 per unit. It is assumed here that thermostats will be installed as part of a site visit in a broader program which affects the installation labor costs. Some sites with line voltage thermostats may require more than one thermostat.

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[39] Northwest Power and Conservation Council's Conservation Resource Comments Database (C&RD), which is continually updated as new information becomes available.

Average Annual Expected Savings

Thermostat savings are best realized when the set back interval is of the order of 8 hours or longer, and the amount of savings depends on the number of degrees the thermostat is set back. The rule of thumb is 1 percent heating savings for every degree the thermostat is set back for at least 8 hours. We have discounted savings significantly in light of the previously referenced findings from evaluation studies.

Expected Useful Life

In principle, these thermostats can last in excess of 20 years, but the backup batteries have a finite life and the programming can be changed or confused, resulting in significantly shorter savings life.

Ceiling Insulation R6-R30 (R-16, R-17)

This measure involves increasing ceiling insulation from R6 to the R30 level. This measure saves both heating and cooling energy. In the case of gas-heated residences, the electric savings are for cooling only and are much less than the heating savings. So the cost effective application of this measure is to electric heated residences only.

Measure Applicability

This measure is considered applicable to a portion the residential customers that heat with electricity.

Incremental Cost

We assume a cost of $0.80/square foot of surface area and 1,000 square feet of surface area. DEER uses a value of $0.757/square foot of wall area. This job includes the cost of providing for adequate attic venting.

Average Annual Expected Savings

Savings from this measure are strongly dependent on the efficiency of the electric heat source, the thermal integrity of the shell, and temperature set points. The stock to which this measure is applied consists primarily of electric furnaces. Therefore the simulations assume the displacement of resistance heat.

Expected Useful Life

The DEER uses an effective useful life of 20 years.

House Sealing Using Blower Door (R-18, R-19)

This measure applies to residential electric-heated properties. It involves using blower door technology to pressurize the home. Once the house is pressurized, air leaks are identified and sealed with appropriate materials to decrease heat loss from the building envelope.

Measure Applicability

This measure is applicable to most of the residential stock.

Incremental Cost

The incremental cost of sending a technician to a home and performing a Blower Door test and sealing the identified leaks is about $500. The C&RD database lists $0.16 per 0.1 air change per square foot.

Average Annual Expected Savings

Expected savings depend on home size, temperature set points, and resident behavior.

Expected Useful Life

The life of the savings for this measure depends on the quality of the materials used especially for the gaskets for the windows and doors. DEER lists 13 years and C&RD lists 20.

Ground Source Heat Pump (R-20)

The ground source heat pump uses the ground as the energy source/sink in a heat pump cycle. This allows the ground source heat pump to operate with about twice the efficiency of a conventional air source heat pump. Because the ground is at a much more stable temperature than the air, resistance backup heat can be avoided. It also simplifies the operation of the heat pump because defrost is not an issue.

Measure Applicability

This measure is applicable to new electrically heated residential construction and to existing Duke Energy heat pump customers that have suitable sites.

Incremental Cost

The ground source heat pump is essentially a standard heat pump except that the outdoor unit is replaced by a trenched pipe as a ground heat exchanger a few hundred feet long. The burying of the pipe is highly site specific. In this study the incremental cost will be taken as the cost of the ground heat exchanger only and the remainder of the system will be considered similar in cost to a conventional heat pump.

Average Annual Expected Savings

This measure saves on both heating and cooling relative to the base case which is a standard heat pump. Savings depend on home size, the thermal integrity of the shell, temperature set points, and resident behavior.

Expected Useful Life

The lifetime of this measure is limited by the life of the heat pump. The DEER uses an expected useful life of 15 years; however, for other heat pump measures the DEER uses 18 years.

Wall Insulation (R-21, R-22)

This measure involves increasing wall insulation from R3 and adding insulation to the R11 level. This measure saves both heating and cooling energy. In the case of gas-heated residences, the electric savings are for cooling only and are much less than the heating savings. Therefore the cost effective application of this measure is for electric-heated residences only.

Measure Applicability

This measure is considered applicable to a portion of the residential customers that heat with electricity.

Incremental Cost

This measure contemplates adding wall insulation to a 2x4 stud wall with an existing insulation value of R3. We assume a cost of $1.25 per square foot of wall area. DEER uses a value of $1.32/square foot of wall area. The DEER values are based on going from an R0 to an R13; the equipment costs are given as $0.15 for equipment and $1.17 for labor resulting in the overall cost of $1.32.

Average Annual Expected Savings

Savings from this measure are strongly dependent on the efficiency of the electric heat source. The stock to which this measure is applied consists primarily of older residences with electric furnaces. Therefore the simulations assume the displacement of resistance heat. Expected savings depend on home size, temperature set points, the thermal integrity of the home, and resident behavior.

Expected Useful Life

This measure typically has an expected useful life of 20 to 30 years; the DEER uses 20 years.

Solar Siting / Passive Design (R-23)

This measure applies to new construction that can be designed and sited to capture solar gain through windows in order to displace space heating. In a new building, the cost of proper orientation and of solar design is small to non-existent if the orientation and design decisions are made before construction starts.

It is well known that if a new residence is tightly designed thermally, and oriented so that about 75-100 feet of glazing is near south facing, then its heating requirements can be reduced by about 30 percent. Much larger heating reductions have been demonstrated, but then the designs need to become more extreme with respect to south glass and with respect to protection from unwanted summer sun. This measure is intended to represent a “minimum graceful design”, yielding the maximum savings with the least departure from a normal residential appearance. Physically, this measure consists of reorienting and redistributing glazing that would have been used anyway, and in using proper overhang to provide some summer shade. In passive solar design, the south glazing should usually have a high solar heat gain factor. This is an unusual glazing specification for current residential applications because most residential glazing is intended to reject solar gain for cooling purposes. Passive solar design also includes increasing the thermal mass, such as floor tile, adjacent to south facing glazing. The thermal mass of the existing sheetrock and furniture, etc., in a building also plays a role in thermal storage. Building codes generally try to discourage excessive glazing and solar gain, but they allow for exceptions where thermal design has been explicitly considered and documented.

Measure Applicability

This measure is applicable to new electrically heated construction with suitable solar exposure.

Incremental Cost

This measure is considered a minimum passive design, and it essentially consists of a redistribution or reorientation of materials that would have been used anyway. The cost of this measure is taken as the cost for the information or advice necessary to “tune the design to the sun”. Not very much needs to be done to capture these minimal passive solar heating savings, especially if it is done at the outset. The context for the incremental cost of this measure is assumed to be to a developer for some extra consideration in overall site planning.

In many reported cases of solar design, the cost is many times this and the building is usually much more expensive as well, but these costs are the common costs associated with personalized new construction, not particularly related to solar design.

Average Annual Expected Savings

The annual savings for this measure are considered only for electric-heated residences, though this measure is well suited to gas-heated sites as well. For this analysis, the savings are taken at approximately one-third of the electric energy used in typical heat pump-heated residences in DEK territory. We assume the home is heated and cooled with a heat pump as the base case because it is unlikely that a new electric-heated residence would be built with electric resistance heat. However, relative to the rare case of a new resistance heated building, the savings would be much larger.

Expected Useful Life

This measure will last the life of the building which can easily be 50 years or more.

Energy Star Manufactured Home (R-24)

This measure is essentially a bundle of Energy Star and other measures coordinated to produce a significantly more efficient new residence cost effectively. An Energy Star qualified new manufactured home is required to be more efficient than a similar home that meets the current codes and standards. The mechanism for estimating Energy Star compliance is through the use of a HERS (Home Energy Rating System) score calculated from a brief estimate of annual energy use. The savings for this measure proceed principally from water heating savings, appliance and lighting savings, and from a heat pump upgrade from SEER 13 to SEER 16, and a shell improvement consisting of higher performance glazing. These energy savings measures are essentially the same as the ones used in the Energy Star new site-built construction measure, discussed in more detail with the discussion of measure R-25.

Measure Applicability

This measure is applicable to all electric new manufactured home construction.

Incremental Cost

The incremental cost for this measure consists of the increased cost of building components such as insulation, windows, lighting and appliances. The current more energy efficient code has reduced the incremental cost of this measure to the incremental costs associated with the improved water heater, the SEER 16 heat pump, the improved glazing, and the incremental appliance and lighting costs. Generally the incremental measure cost for manufactured housing is less than noted for Energy Star site-built construction because it is derived from the manufacturing environment where the costs increment is at the original equipment manufacturer level.

Average Annual Expected Savings

The savings for this measure are specifically modeled based on the efficiency improvements included.

Expected Useful Life

This measure has a useful life comparable to that of manufactured new construction.

Energy Star Construction (R-25a) and Major Remodel (R-25b)

This measure is essentially a bundle of single measures coordinated to produce a significantly more efficient new or major remodel residence cost effectively. An Energy Star qualified new home is required to be more efficient than a similar home that meets the current building code. The mechanism for estimating Energy Star compliance is through the use of a Home Energy Rating System (HERS) score calculated from a brief estimate of annual energy use. Recently the building codes have almost caught up with Energy Star. However, the essential principal behind Energy Star, that of setting energy targets and using a compliance inspection, has proved to be a viable method for delivering high efficiency new residences; the efficiency targets can and need to be set a little higher. In the context of this work the Energy Star new construction measure consists of a package of measures designed to be a significant extension beyond current code level building practice. The package of measures consists of at least the following:

1) Low flow water fixtures
2) A high efficiency water heater, either solar or heat pump; this has the highest energy impact of all the measures in the Energy Star package
3) Reduced internal gain through the use of efficient lighting, CFL and LED, and efficient appliances particularly an efficient clothes washer.
4) A slightly more thermally efficient shell resulting from improved glazing
5) A more efficient heat pump, SEER 16 instead of the code required SEER 13. The heat pump installation should include duct testing and sealing. The building design should avoid duct work in an uninsulated attic, and the indoor portion of the heat pump should never be in a poorly insulated attic.
6) Where possible, the residence should be designed and oriented to capture solar gain for heating and to maximize day lighting.

Measure Applicability

This measure is applicable to all electric new residential construction (R-25a), and to major renovation of all electric residences (R-25b).

Incremental Cost

The incremental cost for this measure consists of the increased cost beyond current code of building components such as insulation, windows, lighting and appliances which are all options in the Energy Star new homes. The cost is site specific as the builder has some choice in selecting the package of measures they will use to meet the efficiency criterion of Energy Star Construction. The current more energy efficient code has reduced the incremental cost of this measure to the incremental costs associated with the improved water heater, the SEER 16 heat pump, the improved glazing, and the incremental appliance and lighting costs.

Average Annual Expected Savings

The savings from new construction (R-25a) are variable depending on the particular site treatment chosen, but estimates for this region are in the range of 4,000 to 6,000 kWh/yr. The savings for the major renovation measure (R-25b) are assumed to be 80% of the savings for new construction measure (R-25a).

Expected Useful Life

This measure has a useful life comparable to that of new construction, about 50 years.

Package Detail New Residential Energy Star Plus

Program planning for an assumed package of Energy Star Plus treatments has used a model of a prototypical all electric new residential participant. Using this model the full package of measures is examined to estimate the energy savings for the individual measures in the package.

The Energy Star new residential achieves energy savings principally through improvements to the water heating efficiency, from COP of .93 to COP 2+. There are only small improvements to the building shell because significant improvements to the building shell are part of the new code and the Energy Star inspection process. Reductions in interior appliance energy use and lighting are a significant source of savings, but not nearly so large as the savings due to improvements to the water heating.

As perspective consider an all electric single-story residence of about 1,900 square feet. This residence is heated and cooled by a SEER 13 heat pump which is the current standard.

The Energy Star package consists of three common sense building steps: First, the thermal conductivity of the envelope is reduced by small coordinated improvements to the building shell, better glazing, and by attention to air sealing and framing details. Then, the performance of the heating and cooling systems is improved by the use of a SEER 16 heat pump, and by careful duct design, duct sealing, and post installation testing. Finally, the internal energy use is reduced by using efficient labeled Energy Star appliances, lighting, low flow water fixtures, and by a major improvement in the efficiency of the hot water source. The water heater efficiency improvement is the major source of savings, but the other improvements, taken together, can result in an approximate 10-15 percent reduction in annual energy use. Another 5 percent reduction in energy use is possible if the residence is oriented to use solar gain for daylighting, and to offset winter heating.

In practice each building is unique, and slightly different packages of improvements to shell and appliances are selected based on specific circumstances. In this example the annual energy use for an all electric current code residence has been reduced by 35 percent, with more than one half of this reduction due to attention to water heating efficiency and distribution.

Efficiency Category		**How Achieved**
Shell Improvements		10% reduction in thermal loss, shell and infiltration details
Water Improvements		1.5.0 gpm (@80 psi) showerhead, heat pump water heater or solar water heater
HVAC and Duct Improvements		SEER 16 heat pump, proper duct placement, insulation, and duct sealing and testing
Efficient Appliances		Efficient lights, washer, dishwasher, an average 20% reduction in internal loads
Solar Siting		Enhanced south glazing and daylighting

Window Film (R-26)

Window films are thin layers of polyester, metallic and adhesive coatings that allow some light to pass through but greatly reduce the amount of solar radiation passing through the window and provides a limited IR barrier to heat loss through the window. It is a highly cost-effective measure with wide application.

Measure Applicability

Buildings with 25% or greater of total outside wall area containing windows, single pane windows and south/south-west facing windows will receive greater benefit from this measure.

Incremental Cost

Energy Star lists the incremental cost of Window film ranging from $1.35 to $3.00 per square foot of film.

Average Annual Expected Savings

During the cooling season a significant portion building's heat load can be generated by solar heating though un-shaded windows. During the heating season, some of a buildings heat loss is through window conduction. Window films greatly reduce these energy loads. For typical building installation, annual energy savings are assumed to be 4 kWh per square foot of window film installed.

Expected Useful Life

This measure is assumed to have a relatively short measure life of around 3 to 6 years.

Eliminate Old Refrigerators (R-27)

This measure involves creating electric energy savings by collecting and dismantling underused older refrigerators. Ideally only operating or operable refrigerators would be eligible for removal.

Measure Applicability

This measure is applicable to residential customers with more than one refrigerator.

Incremental Cost

The incremental cost of this measure will be taken as the cost of acquiring and recycling the unit.

Average Annual Expected Savings

Savings from this measure are dependent on the age of the refrigerator and the location where it is used. Savings estimates for this measure also need to include the zero effects of including operable but not operating refrigerators. Reported savings estimates vary widely from an astonishing 1,900 kWh/yr for C&RD to 413 kWh/yr observed in the Connecticut Appliance Turn-In program.

Expected Useful Life

The useful life of this measure is estimated as the length of time the removed refrigerator would have continued to be used absent the program.

Setback HVAC with Ceiling Fan (R-28)

This measure is a voluntary set back of both the heating and cooling set points by 3 deg F. This is the average setback for the whole day not just the night set back. This type of setback could lead to slight behavior changes such as different clothing when lounging around or sedentary. The heating and cooling savings from such a simple change can be large, of the order of 2000 kWh/yr. The savings will be greatest in houses heated by resistance heat, but they will be significant in heat pump houses as well. It also includes installing Energy Star ceiling fans instead of non-Energy Star ceiling fans. Ceiling fans circulate conditioned air throughout the room. This makes the room temperature more uniform and can reduce the tendency to change thermostat settings. The Energy Star ceiling fan has a more efficient motor and compact fluorescent light bulbs making it more efficient than its counterpart.

Measure Applicability

This measure is applicable throughout the residential sector. But the greatest savings will be where the measure is applied to electric-heated homes.

Incremental Cost

This measure has essentially no cost. Energy Star ceiling fan costs vary but are typically in the $75 to $100 range.

Average Annual Expected Savings

The savings for this measure depend strongly on the amount of set back and the heating type. Based on DEK specific weather, low savings would be about 500 kWh/yr for a mild set back to a good heat pump, and high savings would be about 2,000 kWh/yr for a five degree set back to an electric furnace.

Expected Useful Life

This is a temporary measure; the set back strategy may only work for one or two seasons and ceiling fans typically last about 10 years.

Energy Star Clothes Washers (R-29)

This measure involves obtaining an Energy Star clothes washer which is a more efficient clothes washer than a standard clothes washer. This measure has significant water and detergent savings in addition to the electric savings. According to the Environmental Protection Agency, horizontal-axis washing machines can use about 40 percent less water and 50 percent less energy than conventional washers, cause less wear and tear on clothes, and can accommodate large items that won't fit in a top-loader. A typical top-loading washer uses about 40 gallons of water per full load. In contrast, a full-size horizontal axis clothes washer uses between 20 and 25 gallons.

Measure Applicability

This measure applies only to customers who do not currently have a high efficiency clothes washer.

Incremental Cost

The incremental cost for clothes washers vary significantly depending on the features. DEER lists a value of $565.82 while C&RD lists $245.26.

Average Annual Expected Savings

The kWh savings from a clothes washer depend to a significant extent on the source of the water heating and dryer's energy source. If the water heater is a gas water heater the kWh savings are insignificant but if the source is an electric water heater the savings can be substantial. Savings also depend on whether the clothes washer has a built-in heat source which some do have. DEER lists 199 kWh and C&RD lists a range from 54 to 509 kWh depending on the model chosen. This program will be limited to customers with electric water heat and electric dryers. Significant savings also include water and detergent which are not quantified here.

Expected Useful Life

The expected useful life listed in both DEER and C&RD is 14 years.

Energy Star Dishwashers (R-30)

This measure is defined as the purchase of a new Energy Star dishwasher. By definition Energy Star dishwashers are more efficient than a comparable standard new dishwasher. This measure applies strictly to the improved level of performance, Energy Star versus Standard. An Energy Star qualified dishwasher uses at least 41 percent less energy than the federal minimum standard for energy consumption, which was set in 1994. In this measure the dishwasher being replaced has an EF of 0.46 and is being replaced by a 0.58 EF dishwasher, and has an average usage of 215 washes.

Measure Applicability

For this study, we will take the applicability of these units to be 60 percent of the existing residential sector and all of the new residential sector. In fact, Energy Star dishwashers are a required item in Energy Star new construction.

Incremental Cost

The incremental retail cost for dishwashers varies depending on the features present in the model chosen. DEER uses a value of $133 and the C&RD lists $6 as the incremental cost.

Average Annual Expected Savings

The savings from this measure are primarily due to decreased hot water usage. The C&RD lists 119 kWh/yr and DEER lists 72 kWh/yr.

Expected Useful Life

The expected useful life listed in DEER is 13 years and C&RD is 9 years.

Energy Star Refrigerators (R-31)

This measure is defined as the purchase of a new Energy Star refrigerator which is slightly more efficient than a comparable standard new refrigerator. This measure applies strictly to the improved level of performance, Energy Star versus Standard.

It should be noted here that this measure definition will under-count the real savings because the current stock of new refrigerators is much more efficient than the older stock more than 10 years old, and significant savings will result when an old refrigerator is replaced by a new one, even a non-Energy Star one. These savings are a natural part of the background residential usage changes in response to the current standard market and are considered savings that would have happened absent any particular measure. For this particular measure, the measure savings used in program cost effectiveness are only for the Energy Star increment, but the technical potential estimate inherently captures the full replacement savings.

Measure Applicability

This measure is assumed to apply to 90 percent of the residential sector, essentially all of the residential sector for which an Energy Star model is available.

Incremental Cost

The incremental retail cost for refrigerators, vary significantly depending on the features present in the model chosen. DEER uses a value of $135.75 and the C&RD does not list a value due to the variability in the possible costs.

Average Annual Expected Savings

Savings vary by type of refrigerator/freezer configuration and by size. The range is 80-100 kWh/yr. These savings are relative to the energy use of a new but non-Energy Star refrigerator. In fact a significant portion of the new refrigerator purchases are to replace old refrigerators, and even a non-Energy Star refrigerator will save about 300 kWh/yr relative to the old refrigerator it replaces.

Expected Useful Life

The expected useful life listed in both DEER and C&RD is 18 years.

Pool Pumps (R-32)

This measure saves energy by employing a 2-speed pool pump motor. At the lower speed the pump is still doing a good job of filtering, but it uses about 75 percent less energy. This is typical of the savings from slowing down pumps or fans. While these savings are significant it should be noted that the slower pumping rate can adversely affect pool accessories such as a solar pool heater.

Measure Applicability

This measure is applicable to in-ground pools only.

Incremental Cost

The incremental cost for this measure consists of the increased cost of a 2-speed pump about $180 and the increased labor to install it. In a retrofit case the labor is of the order of $300, but in a new installation there is no increased labor.

Average Annual Expected Savings

The savings from this measure depend on the degree of flow reduction and the number of hours of reduced flow. A typical power reduction to be expected is 500 watts, and in a full season the duration of reduced flow is 1,000-1,500 hours.

Expected Useful Life

The expected useful life of this measure is about 10 years.

Efficient Residential Lighting (R-33)

This measure consists of substituting compact fluorescent and LED (light emitting diode) lighting for incandescent lighting. At each socket treated, such a substitution will reduce the energy required for lighting by about 80 percent. A full application of this measure consists of converting all the most used lighting fixtures from incandescent to compact fluorescent. As LED technology matures, it will be possible also to substitute LEDs for linear fluourescent lighting. Currently LEDs are not much brighter than CFLs, but they are much longer lived, (of the order of 20 years), and they are more adaptable to the colder outdoor lighting applications, and to task lighting. The addition of LED lighting to the mix of efficient lighting options is expected to increase the range of efficient lighting options and thereby to increase the penetration of residential efficient lighting. Housing audits taken over the last 10 years show that an average house has about 25-45 lighting sockets with an aggregate connected incandescent lighting load of about 2,700 watts. But of this load, only about 6-12 sockets are used for about an average of 5 hours/day, the rest are infrequently used. It is assumed that the sockets treated with this measure fall within the high use sockets in the home, averaging between 3.5 to 4 hours per day. These sockets are the primary targets for a whole house lighting conversion. A satisfactory conversion of these most important sockets may require recourse to a variety of bulb styles, wattages, and even adapters (such as lamp harps) to facilitate accommodating the CFL or LED to these 12 best locations.

Measure Applicability

This measure is applicable in 100 percent of the residential sector.

Incremental Cost

The cost for the CFL technology continues to decrease, and there are various sales or promotions where the cost may be as low as $1.50/bulb. However, preferences for the higher cost LED lights will tend to drive up the overall efficient lighting costs relative to CFL lighting alone. Depending on program delivery, labor cost to install the bulbs may be included in the incremental cost and is expected to be about $0.50 per bulb in a utility program. Full application of this measure, assuming treatment of the 15 most important fixtures in a residence is taken here.

Average Annual Expected Savings

It is assumed here that the 15 treated sockets reduce the connected load by 750 watts, and that the average on time for these sockets is 3 hours/day, leading to energy savings of 2.25 kWh/day. This equates to 55 kWh/yr/bulb. The savings listed in DEER range from 20 to 59 kWh/yr/light, depending on which type of efficient light is replacing which incandescent bulb.

Expected Useful Life

Compact fluorescent bulbs have a lifetime of 10,000 hours, about 7-10 times as long as the incandescent bulbs they replace. Assuming the average compact fluorescent bulb is used 2,000 hours/yr (5-plus hours/day) gives a conservative estimate of useful life of 5 years. The LED light has a projected useful life of 20 years. The useful life for the energy savings from this measure will cease in the time frame of 2015-2020 as the new federal lighting standards diffuse into the market.

Daylighting Design (R-34)

This measure is intended to reduce the lighting energy in new residential construction. Daylight has the highest lumens/watt of any light source. A little bit of daylight can go a long way toward lighting a space without introducing as much heat as other light sources do. Physically, daylighting takes the form of small skylights or clearstories, and high small windows coordinated with light colored interior wall and ceiling surfaces. In practice, good daylighting design involves the avoidance of glare and over lighting as well.

Measure Applicability

This measure is applicable to 100 percent of the residential new construction.

Incremental Cost

This measure is being applied in new residential construction where lighting is a natural consequence of window placement. In this context daylighting design is considered in the distribution of the windows and skylights to make light distribution more uniform and to avoid glare. These design impacts will have minimal cost if they are brought in at the planning stage.

Average Annual Expected Savings

Properly designed daylighting can save almost all the lighting energy used during daylight hours, but not all residences are used during the day. The EIA Residential End Use Survey finds 1,500 to 1,800 kWh/yr for lighting in the average residence. The savings will wary widely from site to site, but for this study we will take 40 percent lighting savings.

Expected Useful Life

Daylighting features integrated into a house during construction will last the life of the house. For these purposes the lifetime will be taken as 25 years the planning horizon for this study.

Occupancy Controlled Outdoor Lighting (R-35)

This measure is designed to save lighting energy by turning on selected outdoor lighting only when occupancy or movement is detected. This measure has a strong security context, but it also is very convenient at entrances, garages, etc., where light switches can only be accessed from inside and lighting is left on for long periods of time in order to provide light for the short time it is actually needed.

Measure Applicability

This measure is applicable throughout the existing residential stock.

Incremental Cost

This measure physically involves replacing two frequently used outdoor lights by occupancy controlled lights. Costs depend on the number of lights installed and is estimated at about $50 per light, with 2 lights being typical.

Average Annual Expected Savings

The average annual expected savings from this measure depends on the type of light that is being controlled. The preferred type of light to control is a compact fluorescent spot light because of its lower power use and long life. But in colder outdoor applications these lights can take from 30 seconds to a minute to come to full brightness which may be unacceptable in some cases. For this analysis, we will assume that 150 watts is being controlled, and that a savings of 5 hours/day is achieved.

Expected Useful Life

The useful life is typically 10 to 15 years for this measure.

Residential Outdoor Lighting (R-36)

LED lighting applications use much less energy than incandescent or metal halide lighting applications. At the present the color of “white” LED light is somewhat blue tinted and not always suitable for general interior applications. But this color is often suitable for specialty applications such as back lighting of flat panel displays, and outdoor applications. It is probable that LED lighting will find its place ultimately in many applications. The application considered here is an LED outdoor light, often referred to as a “cobra light” which is used to illuminate parking lots and outdoor areas.

Measure Applicability

This measure is still evolving but will likely be applicable to a large percentage of the residential sector.

Incremental Cost

The incremental cost for an outdoor LED light of this type is expected to decrease as the market matures. A significant and favorable cost impact for this measure is its long life, leading to maintenance savings in cases where the light is difficult to access.

Average Annual Expected Savings

Measure savings proceed from the replacement of a 250 watt light by a 19 watt LED assembly.

Expected Useful Life

LED lighting is known for its exceptionally long life, some estimates say 50,000 hours.

Tank Wrap, Pipe Wrap, and Water Temperature Set Point (R-37)

This technology consists of adding insulation around the water heater, checking and resetting the tank thermostat, and replacing leaky shower flow diverters. These measures are principally tank-centric, and can be self-installed or by a site visit if the package is part of a broader program. Resetting the tank thermostat is also a safety issue because it can reduce scaling and burns due to too high a set temperature.

Measure Applicability

This measure is applicable to a portion of the residential sector that heat water with electricity. Applicability for this measure is limited because in some cases the tank cannot be accessed to install a blanket or one has already been installed.

Incremental Cost

The cost of this treatment typically breaks down as $30 for materials and $20 for installation labor and it is assumed the installation will be part of a larger program.

Average Annual Expected Savings

The dwelling savings for these measures is discussed under Low Flow Fixtures (R-36). Based on prior experience and evaluation work on other programs it is estimated that the savings would be about 1 kWh/day.[40]

Expected Useful Life

The lifetime of these measures is potentially quite long. For practical purposes the lifetime will be considered limited by the expected remaining lifetime of the hot water tank. DEER says 15 years for pipe insulation, 9 years for faucet aerators, and 15 years for an efficient water heater. The C&RD lists 10 years for a water heater with a minimum warranty of 10 years.

Low Flow Fixtures (R-38)

This technology consists of a new showerhead rated at 1.5 gallons/minute (gpm) at 80 pounds/square inch (psi) and a swivel aerator for the kitchen faucet and fixed aerators for the lavatory faucets. The current US standard for showerheads is 2.0 gpm at 65 psi. Measurements of the existing shower flows in building stock show a range of 2.75 to 3.75 gpm with frequent individual cases in excess of 5 gpm. Evaluations have shown that programs that replace with 1.5 gpm heads have greater savings than programs that replace with the standard 2.0 gpm shower heads. Program shower heads should be 2.0 gpm @80 psi (1.5 gpm @60 psi) and with a lifetime scaling and clogging warranty. It is important also to be cautious about the use of "pressure compensating" showerheads. These are more prone to clogging and can lead to unintentional increases in flow rate in low pressure situations, typically well water systems or older systems with occluded piping. Customer acceptability is an important

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[40] Khawaja S. PhD, and Reichmuth, H. PE., 1997. Impact Evaluation of PacifiCorp's Ebcons Multifamily Program. Pacificorp.

component in a showerhead program. Customers will remove new low flow showerheads if the quality of the showering experience declines with the new showerhead. Therefore it is important to research and test the showerhead chosen for the program carefully. In addition, the old showerhead must be removed from the premises to decrease the likelihood of having it reinstalled.

Measure Applicability

This measure is applicable to the portion of the residential sector that heat water with electricity.

Incremental Cost

Low flow fixture costs vary widely, and depend on whether the fixtures are purchased retail or in bulk. The costs for a bulk purchase for a showerhead and three aerators also have a wide range, about $8.00-$15.00/set. The most important feature of these fixtures is the long-term acceptability and durability because these factors have a direct impact on the lifetime savings. Because the cost of the showerhead varies significantly and quality is so important for this program, it is essential to test, choose, and pay the price for a high quality showerhead. The DEER Database lists measure costs as $22.946 per unit and $37.946 installed cost.

Average Annual Expected Savings

Field monitoring studies can demonstrate the flow savings, but ultimately the overall savings will be a combination of flow savings and the duration of use. The flow of the showerhead used has a significant impact on savings. This program is designed around a 1.5 gpm showerhead as compared to a 2.0 gpm showerhead. Therefore the savings will be more than the 120–133 kWh per unit listed in DEER. In addition the climate is different and the inlet water temperature is lower so the savings in this DEK program will be greater. Several studies have measured final savings in terms of electric input to the tank, but usually these studies have included savings from comprehensive treatments including other measures including tank and pipe insulation, kitchen and bath lavatory aerators, tank thermostat set back, and leaky diverter replacement. Savings can vary from program to program depending strongly on the choice of showerhead. Savings can also diminish with “take back” in the event that the new showering experience is longer than the original. Actual savings observed in the comprehensive cases include these takeback effects, and are in the range of 650 to 950 kWh/yr.

Expected Useful Life

The lifetime of this equipment is the key to its cost effectiveness. If an adequate, even pleasant, shower can be provided through lifetime warranted equipment, then the practical lifetime of the equipment is the length of time until the equipment is replaced in the course of renovation. The DEER lists a lifetime of 10 years. Normally showerheads will last longer but with renovations and changes in ownership a 10-year expected useful life is a good planning number.

Heat Pump Water Heaters (R-39)

Water heating is one of the largest energy uses in the home. In the case of electrically heated water, the annual water heating energy is about 4800 kWh/yr. The heat pump water heater is essentially a small heat pump drawing heat from the air by cooling and de-humidifying it and injecting this heat into water held in a storage tank. Physically, this measure consists of a small, self-contained heat pump and a water storage tank and associated pumps and controls.

Measure Applicability

This measure is applicable to the residential sector with electric water heat.

Incremental Cost

The incremental cost of this measure consists of the cost of the heat pump water heater, water storage tank and installation plumbing and general construction labor. The siting of such a unit is important; it should never be sited in an attic and freezing situations should also be avoided. Therefore, some special site adaptation and plumbing may be necessary.

Average Annual Expected Savings

For this study it is assumed that the heat pump water heater will perform with a coefficient of performance of 2.

Expected Useful Life

The useful life of this measure is assumed to be that of a similar appliance, a window air conditioner.

Tankless Water Heaters (R-40)

Water heating is one of the largest energy uses in the home. In the case of electrically heated water, the annual water heating energy is about 4800 kWh/yr. This measure saves energy by eliminating the standby energy losses attributable to a hot water storage tank. However these relatively small energy savings are at the cost of a significant instantaneous demand increase. In the case of gas water heating, this type of measure has greater energy savings and no troublesome demand savings. In the context of a switch from an electric tank to an electric tankless heater however, the measure has minimal benefit.

Measure Applicability

This measure is applicable in the residential sector only where space is a premium.

Incremental Cost

Tankless water heaters range in price from $200 for a small under-sink unit up to $1,000 for a gas-fired unit that delivers 5 gallons per minute. Typically, the more hot water the unit produces, the higher the cost. Installation is extra, at about $300 but upgrades to electrical service or additional gas venting would increase that cost. Electric tankless water heaters require a relatively high electric power draw because water must be heated quickly to the desired temperature as a result wiring must be up to the demand. Gas tankless water heaters require a direct vent or conventional flue. If a gas-powered unit has a pilot light, it can waste a lot of energy.[41]

Average Annual Expected Savings

In some cases, tankless water heaters can decrease energy used to heat water by 10 to 20 percent. The savings are due to the elimination of standby losses[42] but it should be recognized that this type of appliance has a negative demand impact.

Expected Useful Life

DEER lists 20 years for this measure.

Solar Water Heaters (R-41)

Water heating is one of the largest energy uses in the home. In the case of electrically heated water, the annual water heating energy is about 4800 kWh/yr. Countless demonstration cases have shown that solar energy can supply all or a portion of this heating. The portion of the water heating load assumed by a solar water heater depends on the size of the solar water heater in relation to the size of the load. Field experience has shown that the best combination of system size to load favors the more moderately sized systems that can fully meet the summer water heat load, but that only meet about 40-50 percent of the non-summer load. In physical terms, this is a system consisting of about 40-65 square feet of solar collector and an additional 80 gallon heated water storage tank and appropriate pumps and controls.

Measure Applicability

This measure is intended to apply to residential customers with electrically heated hot water.

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[41] California Energy Commission Consumer Energy Center
[42] California Energy Commission Consumer Energy Center

Incremental Cost

The installation of a solar water heating system involves a mix of building skills including plumbing, electrical, roofing and general carpentry. In the general market, a turn-key installation for one of these systems is in the range of $5,000 to $7,000.

Average Annual Expected Savings

The savings from solar water heaters depend on site specifics, principally solar radiation, air temperature, incoming water temperature, and hot water usage rate.

Expected Useful Life

Solar water heating systems are essentially plumbing fixtures that are certified products (Solar Rating & Certification Corporation - SRCC) and are often inspected by local building officials. A well designed system will have a lifetime in excess of 25 years, even though the system will take some intermediate maintenance such as inspecting the pump and fluid level.

Efficient Plumbing (R-42)

This measure saves water heating energy by leaving less hot water in the pipes to cool during periods of non-use. Conspicuously, the primary motive for this measure is the amenity benefit of limiting the waiting time for usable hot water at the tap or showerhead; waiting times can be reduced from a significant fraction of a minute to only a few seconds. Physically this measure involves the use of smaller diameter continuous PEX water pipes with no elbows or Tees and the use of carefully sized pipe manifolds. While this measure is tested and viable it involves the use of small diameter piping in a context that is not familiar to the plumbing trade or to building officials. It is therefore considered an emerging technology and will not be included in program recommendations.

Measure Applicability

This measure is applicable to 100 percent of the residential new construction.

Incremental Cost

In large scale use, this measure offers the possibility of actually lowering the cost of hot water plumbing because smaller diameter less expensive pipe is used. But specialized manifolds and system planning are required.

Average Annual Expected Savings

The savings from this measure have not been widely measured but savings of 10 percent of the hot water end-use are reasonable.

Expected Useful Life

This tends to be a very long-lived measure.

Ductless Heat Pump (R-43)

This measure applies to residential electrically heated homes. Ductless heat pumps have two parts, an indoor and an outdoor unit. The outdoor unit can connect to multiple indoor units via a cable and refrigerant lines. The outdoor unit is placed outside at ground level and is connected to the indoor units via a small hole. The indoor units are wall mounted in centrally located rooms within the home and distribute the heated or cooled air throughout the space. Because of its design no ducts are required which eliminates fan energy and heat and cooling losses through the duct work.

Measure Applicability

This measure is applicable to most of the residential stock that uses electric resistance heat.

Incremental Cost

Incremental cost is expected to decline as the market becomes more familiar with this space heating technology.

Average Annual Expected Savings

Savings from installing a ductless heat pump depend on home size, usage, thermal integrity of the home, and temperature set point.

Expected Useful Life

Heat pump technology has been available for some time and its operating characteristics are well understood. The ductless heat pump is a new application of a tried and true technology; as a result the measure life of a heat pump is applied to the ductless heat pump in all applications.

Drain Water Heat Recovery (R-44)

Drain water heat recovery consists of the installation of a single-pass heat exchanger on the down-spout of a residential shower drain. As warm shower grey water flows down the drain and into the heat exchanger, feed water to the resident's water heater is pre-warmed.

Measure Applicability

This measure is applicable for 10% of the residential new construction and retrofit housing stock. Limitations due to space concerns are the primary determinant for the implementation of this measure. High efficiency exchangers require 69 inches of vertical pipe clearance for installation.

Incremental Cost

The installed cost of this measure varies based on the size of the heat exchanger installed and the amount of plumbing required for installation.

Average Annual Expected Savings

For a typical residential household using a single shower for bathing, the annual electrical savings from pre-heating hot water heater feed water is typically 15% to 35% of annual water heating load, with variations based on family size and bathing routines.

Expected Useful Life

This measure is assumed to have a long useful life.

Smart Plug (R-45)

This measure consists of a power strip with load sensing capability. When the primary load is turned off, the secondary loads connected to the power strip are automatically powered down. This measure is typically used in home office spaces where support equipment (printers, projectors, etc.) may be left on after the connected computer is turned off.

Measure Applicability

This measure is applicable to residential home office space and some entertainment center applications.

Incremental Cost

The incremental cost for this measure is determined to be the cost of purchase of the smart plug.

Average Annual Expected Savings

Savings associated with this measure are based on home-energy use surveys, with typical household electronics usages and reasonable assumptions of secondary equipment usage patterns. It should be noted that the household loading due to electronics is increasing steadily and projected savings from this measure will likely increase over time.

Expected Useful Life

This measure will have a medium-term useful life.

Heat Pump Pool Heater (R-46)

This measure consists of the installation of a heat pump unit for the application of below-ground pool heating. This heat pump unit replaces a typical electric resistance pool heater and produces significant savings for applicable locations.

Measure Applicability

This measure is applicable in homes with below-ground pools. Indications are that it is more effective when used to heat indoor pools.

Incremental Cost

The incremental cost for this measure is based on pool size and heating requirements. There is a large variation in costs based on unit size and the necessary installation costs that may be incurred if pre-existing electrical supply gear is not adequate for the new loading requirements.

Average Annual Expected Savings

The U.S. Department of Energy estimates that savings associated with this measure are roughly 80% of the annual pool-heat loading required by resistance heater pool heat. This is based on national survey data and averaged for each region based on seasonal pool usage.

Expected Useful Life

This measure is a self contained unit with high reliability and therefore has a long expected useful life.

Customer Reports (R-47)

Customer Reports is a behavioral measure. It saves energy by focusing customer attention on comparison to one's neighbor as a benchmark. In a generic approach to customer reports, participant households receive periodic reports illustrating their energy use performance in comparison to neighbors in similar homes.

Measure Applicability

All residential customers are technically eligible, however marking and promotion will be to random selected customers in the upper half of the yearly energy usage distribution.

Incremental Cost

The incremental cost is quite low since the form of the measure is simply a report received quarterly or with some other chosen frequency.

Average Annual Expected Savings

Some customer reports programs include resultant energy savings from change in energy use behaviors (reducing waste while preserving amenity), appliance purchases and recruitment into traditional energy efficiency programs as a result of the customer reports. For this measure/program we include only behavioral savings. The initial savings assumption used in program planning (as a one-year percentage of annual kWh usage) has been reported by prior programs. However, for treatments that continue over multiple years the decay of attention should be considered. We have assumed long range annual savings in the order of two-thirds of what might be expected in the first year of treatment.

Expected Useful Life

Until there is at least a decade of experience with scaled up customer reports programs and studies of decay following the last report received, the measure life is taken as one year. However, for a program of duration of more than one year the calculation assumes a decay effect after one year and that amount of savings is assumed to be stable for each year customer reports are received.

Solar Photovoltaic (R-48)

This technology consists of a roof or ground mounted solar electric array with a full sun output of 3 kW. Such an array has an area of 200-300 square feet. Electricity from the array is converted to AC by an inverter and the power is immediately used on-site with excess fed into the grid. This technology needs full solar exposure and shadows can significantly restrict output. This technology is fully mature, but local builders and building officials are still unfamiliar with it.

Measure Applicability

No local studies have estimated the percentage of housing stock with suitable exposure; for this analysis it is assumed that 26 percent of residential buildings are suitable sites.

Incremental Cost

A system installation usually requires an electrical inspection to verify appropriate wire sizing and insulation type, disconnects, and grounding. Costs are quite site specific, with most of the costs associated with solar electric panels, which have come down dramatically in the last few years.

Average Annual Expected Savings

The electrical output for this technology is directly related to the solar intensity. Monitoring studies in this region of the US have shown that 1 kW of installed capacity can yield in excess of 1,000 kWh/yr on a long term basis. For the 3. kW array considered here, the annual savings for the DEK service territories is estimated to be 3,000 kWh/yr.

Expected Useful Life

This equipment demonstrated long trouble free service in severe applications such as remote communications, navigation lighting, and road signage. The long-term output of the cells is assumed to decrease with time, but the rate of decrease for current technology is not known. The crystalline and semi-crystalline forms of the technology have already demonstrated degradation of less than 20 percent in 20 years. But earlier thin film forms of the technology have showed shorter lifetimes. The lifetime of new thin film technologies is expected to be of the order of 25 years but it is not known.

In-Home Displays (R-49)

In-Home Displays is a behavioral measure. It saves energy by focusing customer attention on household energy use by providing a display in the home.

Measure Applicability

All residential customers are technically eligible. However this measure might be seen more generally as “timely feedback on energy use”. As a feedback loop this measure may become part of the other behavioral measures, R-47 customer reports, or R-48 prepay.

Incremental Cost

The incremental cost is high if the standard in-home hardware display approach is used; if, instead, messages are sent by e-mail and text messaging the incremental cost is very low (this is an in-home display without utility furnished equipment).

Average Annual Expected Savings

A small average behavioral savings response is expected at first with rapid decay in a few months to a weak but stable average annual savings.

Expected Useful Life

Until there is at least a decade of experience with scaled up in-home display including studies of decay, the measure life will not be well understood.

APPENDIX D. NON-RESIDENTIAL EEM DOCUMENTATION

The purpose of this appendix is to provide documentation of the assumptions used to screen the Commercial Energy Efficiency Measures identified for consideration in this report. As such, this appendix supports, but does not list, the specific values for savings, measure life and incremental costs for measures used in this study. These specific values for non-residential measures are listed in Table 15 on page 26. Our assumptions are based on references cited throughout this section as well as the direct experience of our team with technologies in the field and actual EE program evaluations. While not all of the field and EE program experience can be cited in published works, published references are used to establish a reasonable range of assumptions. The point estimate used within that range is based on our professional opinion. The mapping of EEM to non-residential EE programs is shown in the table below. The value represents the percentage of participants installing the measure. Cells with no value mean the measure is not included in the program.

Table 51. Mapping of Electric EEM to Non-Residential EE Programs

Program #			**1**	**2**	**3**
End-Uses	**EEM Description**	**EEM Ref #**	**C&I Tune-Ups**	**C&I EE Products**	**C&I Custom**
Customer-Sited Generation	Combined Heat and Power, CHP	C-1			*
C&I Space Conditioning	Small HVAC Optimization and Repair	C-2	0.50		*
	Commissioning - New	C-3			*
	Re/Retro-Commissioning Lite	C-4	0.40		*
	Low-e Windows 1500 ft2 New	C-5			*
	Low-e Windows 1500 ft2 Replace	C-6			*
	Premium New HVAC Equipment	C-7			*
	Large HVAC Optimization and Repair	C-8			*
	Window Film	C-9		0.05	*
Design (new)	Integrated Building Design	C-10			*
	Efficient Package Refrigeration	C-11		0.10	0.10
Motors and Drives	Electronically Commutated Motors	C-12		0.10	*
	Premium Motors	C-13		0.10	*
	Variable Speed Drives, Controls and Motor Applications Tune-Up	C-14a			*
	Single Application VSD	C-14b		0.15	*
Power Distribution	Energy Star Transformers	C-15		0.02	*
	Efficient AC/DC Power	C-16			*
Lighting	LED Outdoor Lighting	C-17		0.05	*
	New Efficient Lighting Equipment	C-18		0.10	*
	Retrofit Efficient Lighting Equipment	C-19		0.90	*
	LED Exit Signs	C-20		0.05	*
	LED Traffic Lights (10)	C-21		0.05	*
	Perimeter Daylighting	C-22			*
Water Heating	Low Flow Fixtures	C-23		0.01	*
	Solar Water Heaters	C-24			*
	Heat Pump Water Heaters	C-25			*
Cooking and Laundry	HE Food Prep and Holding	C-26			*
	Energy Star Commercial Clothes Washer	C-27			*
	Restaurant Commissioning Audit	C-28			*
Other	Grocery Refrigeration Tune-Up and Improvements	C-29	0.05		*
	Refrigeration Casework Improvements	C-30	0.05		*
	VendingMiser®	C-31		0.05	*
	Network Computer Power Management	C-32			*
	Solar Electric	C-33			*

Values in table represent the percentage of participants receiving the measure. Cells with no value mean the measure is not included in the program.

* Custom Program may include any measure found to be cost effective in a particular site specific application. "Included" indicates that the measure is included within the broader concept of Integrated Building Design.

Some programs such as C&I Custom and C&I New Construction are special design situations that may use any of the measures that prove to be cost effective in the particular design context. Likewise, the measures included in the C&I Lighting and C&I EE Products may change over time to include different cost effective subsets of these broadly defined measures.

Combined Heat and Power (C-1)

This measure is a form of site generation with the waste heat applied to large steady thermal loads, usually at an industrial scale. The economics favorable to this measure usually involve a high thermal load factor. Electricity generated by CHP applied to an existing gas thermal load has a unique efficiency opportunity in terms of fuel use and in terms of carbon offset because the fuel use associated with the generated electricity is only the marginal increase in gas use. The CHP resource is strongly favored from the perspective of carbon calculations. System sizes range from about 100 kW to MW scale in electrical output.

Measure Applicability

This measure is applicable in a large scale industrial context.

Incremental Cost

This cost for measure is very site specific, of the order of $500-$1500/kW electric. This measure also has significant annual maintenance costs.

Average Annual Expected Savings

The savings from this measure consist of the net electrical output of the CHP plant. For example, a single moderately-sized plant of 250 kW would have an output of the order of 2 million kWh/yr.

Expected Useful Life

This measure has an expected useful life typical of appliances, of 15 to 20 years.

Small HVAC Optimization and Repair (C-2)

This measure applies to packaged rooftop units. These units are the predominant means of conditioning for small-to-medium scale commercial buildings. The savings proceed from improved compressor performance, better run time control, and fresh air cooling. These rooftop units are a homogenous pool of equipment that has been identified as underperforming. Typically, the refrigerant charge is out of specification, the economizers perform poorly if at all, and the airflow is too low for proper operation. Many utilities (eg, SCE, PG&E, National Grid) are offering programs employing a structured diagnosis and repair protocol. Often these programs use trade named processes such as Proctor Engineering "check me", or PECI "aircare plus" etc. Candidates for this measure are rooftop units found in a wide range of sizes with output capacities of from 4 to 50 tons with the most predominant capacity being 5 tons.

Measure Applicability

This measure is applicable in 70 percent of the commercial sector.

Incremental Cost

The cost for this technology includes site visits and diagnostics with simple repairs performed immediately without need for a second site visit. The costs will naturally vary with the specifics of the repair. Planning estimates for this diverse mix of treatments, made by the Northwest Power and Conservation Council (NWPCC), use $0.20/first year kWh savings.

Average Annual Expected Savings

Savings vary from unit to unit, but in the cases where there have been significant corrections to the refrigerant charge or to economizer operation savings on the order of 2,500 kWh/unit have been observed. At a particular site there will typically be several treated units.

Expected Useful Life

There are inherent limitations to the lifetime of the treatment provided by this measure. The improvements may be superseded by operational changes, and the remaining lifetime of the treated unit may be limited.

Commissioning New and Retro (C-3, C-4)

Commissioning is a systematic step-by-step process of identifying and correcting problems and ensuring system functionality. Commissioning seeks first to verify that the system design intent is properly executed, and it goes further by comparing actual building energy performance to appropriate bench marks to validate building performance as a whole. The best candidates for this measure are buildings larger than about 100,000 square feet. While commissioning in general can become quite complex, often the greatest savings proceed from a simple review of building operations to assure that the building is not being unnecessarily used during non-occupied times. New Commissioning (C-3) should be done as part of the construction contract, and most contractors will claim that this is normal business. But the performance of even new buildings is often erratic for a year or two while unnoticed problems come to light. This new commissioning is a detailed process of initial calibration and control sequence testing or verification. The initial process is usually not done well, but even so, the initial commissioning is inherently limited because usually it takes about a year of building operation to see how the building actually operates as a whole. By contrast, Retro-Commissioning (C-4) seeks to tune a building that is already operating and has a track record of a year or two at least. The Retro-Commissioning process starts with an analysis of the utility bills for all fuels, which to a trained eye will show the larger general operational problems which are then followed up with a limited scope site visit. Retro-Commissioning is usually necessary even for buildings that have been initially commissioned. There will be the occasional building which after years of operation will have its controls so mixed up that it will need a comprehensive new commissioning (C-3). In practice the New Commissioning is the larger more complicated job, while Retro-Commissioning is more superficial and focused on finding and fixing major problems only by applying low-cost/no-cost controls changes.

Measure Applicability

In this analysis New Commissioning is assumed to take place on 100 percent of new commercial stock as a matter of proper business. Retro-Commissioning is applicable in 75 percent of the existing commercial sector, and after a few years, to all of the new commercial buildings.

Incremental Cost

The cost for this technology is quite site specific, based on NWPCC estimates new commissioning costs about $0.37/kWh/yr, which for a typical large commercial building of 100,000 square feet would be about $37,000. For this study we are assuming a brief version of retrofit commissioning. Retro-Commissioning, or “commissioning lite”, that prescreens buildings on the basis of billing data and follows it with a site visit. In this analysis, all program-related commissioning is the Retro Commissioning and the New Commissioning is assumed to be part of the construction process.

Average Annual Expected Savings

Savings from this measure can vary widely. For Retro Commissioning, it is assumed here that the building electric energy use can be reduced by on average 20 percent. A significant portion of the energy savings due to both of these measures is associated with the heating fuel, usually gas. In estimates of program cost effectiveness for electric utilities, gas savings are usually not valued which can underrate the overall cost effectiveness of this measure.

Expected Useful Life

There are inherent limitations to the lifetime of the treatment provided by this measure. The improvements may be superseded by operational changes, and the remaining lifetime of the treated unit may be limited.

Low-E Windows New and Replace (C-5, C-6)

This measure saves energy by reducing the thermal losses and gains through windows. This measure assumes that the efficient window has a heat loss rate of 0.35 BTU/deg F hr, representing the performance of a quality, double glazed argon filled low-e window. The original window is assumed to have a heat loss rate of 0.75 BTU/deg F hr, representing the average losses from a mix of single and double glazed windows.

Measure Applicability

This measure is applicable in 100 percent of new commercial buildings and 30 percent of existing commercial stock.

Incremental Cost

The incremental cost for this technology depends strongly on the context of use. If the efficient windows are used in a replacement context, then the full cost of $20/sqft is applicable. If the efficient windows are used as an upgrade in new construction then an incremental cost of only $3/sqft is used.

Average Annual Expected Savings

It is assumed here that the average site installation will contain 1,500 square feet of high efficiency window replacements.

Expected Useful Life

This is a very long-lived measure that will generally last the life of the building. For the purpose of this study, a periodic change-out due to breakage and the potential for future technological innovations leading to window replacement were assumed.

Premium New HVAC Equipment (C-7)

Premium new HVAC equipment employs more efficient motors/pumps and larger heat exchangers and pipes to lower operating energy requirements. Premium equipment is often designated with an Energy Star rating or by the Consortium of Energy Efficiency (CEE) as Tier I or Tier II, or it may not have an official rating, but it does deliver slightly improved performance and is usually sold as such. Premium HVAC equipment is a very broad category including efficient variable speed fans, and efficient chillers, efficient ice makers, and efficient packaged roof top units. It should be noted that rooftop units serve more than half of the commercial space, and they have therefore been the subject of an ongoing efficiency improvement campaign by CEE and the industry.

Measure Applicability

This measure is applicable in 100 percent of new commercial construction.

Incremental Cost

The incremental cost for this technology will be very diverse and quite site specific. Based on NWPCC estimates, the premium upgrade costs about $0.46/kWh/yr.

Average Annual Expected Savings

Savings attributable to this measure are generally fairly small because they represent only an incremental improvement in performance on equipment that is already required to be reasonably efficient. It is assumed here that the savings in new construction will be 3 percent of total energy use.

Expected Useful Life

The premium upgrades can be expected to last the life of the equipment.

Large HVAC Optimization and Repair (C-8)

This measure refers to restoring large HVAC equipment to its nominal operating performance. This measure needs to be distinguished from commissioning which is used to refine the controls of large HVAC which generally leads to large savings. By contrast this measure applies to the operation of the equipment and includes chiller and condensing tower cleaning, filter maintenance and tune-up etc. It also includes the optimization of economizer operation by verifying that the enthalpy sensors and economizer controls are functioning properly.

Measure Applicability

This measure is applicable in commercial sector buildings with large HVAC systems.

Incremental Cost

The incremental cost for this technology will be very diverse and quite site specific. Based on NWPCC estimates, the premium upgrade costs about $0.34/kWh/yr.

Average Annual Expected Savings

Savings attributable to this measure are generally fairly small because they claim only the savings due to restoring equipment to its original operation. For this study these savings are assumed to be 3 percent of building energy use.

Expected Useful Life

There are inherent limitations to the lifetime of the treatment provided by this measure. The improvements may be superseded by operational changes, and the remaining lifetime of the treated unit may be limited.

Window Film (C-9)

Window films are thin layers of polyester, metallic and adhesive coatings that allow some light to pass through but greatly reduce the amount of solar radiation passing through the window and provides some barrier to heat loss through the window. It is a highly cost-effective measure with wide application.

Measure Applicability

This measure is applicable in 90% of the commercial sector. While all buildings would benefit from the installation of this measure, buildings with 25% or greater of total outside wall area containing windows, single pane windows and south/south-west facing windows will receive greater benefit from this measure.

Incremental Cost

Energy Star lists the incremental cost of window film ranging from $1.35 to $3.00 per square foot of film.

Average Annual Expected Savings

During the cooling season 60% of a building's heat load is generated by solar heating though windows. During the heating season, up to 25% of a buildings heat loss is through window conduction. Window films greatly reduce these energy loads. For typical building installation, annual energy savings are assumed to be 4 kWh/yr per square foot installed.

Expected Useful Life

This measure is assumed to have a relatively short useful life.

Integrated Building Design (C-10)

This measure applies to new construction where careful design and specific engineering can get beyond the rules of thumb, leading to the use of smaller equipment more carefully matched to load. Integrated design refers to an approach commonly used to design energy efficient new commercial buildings. Essentially, the design process lowers building loads, then carefully matches HVAC equipment to the lowered load. In practice the most significant characteristic of efficient new commercial buildings is significantly reduced lighting loads and often reduced plug loads. The other important characteristic is enhanced building shell performance through improved insulation and solar shading, and enhanced daylighting. Taken together these improvements result in significantly altered lighting, heating, and cooling loads. Typically, the cooling loads will be significantly reduced, while the changes to the heating loads are more complex. The reduced internal gain from lighting etc will actually increase the gross heating loads, which the shell improvements may reduce somewhat through insulation or emphasized solar gain.

The altered heating and cooling loads will usually not conform to established equipment sizing rules of thumb, which generally result in oversized equipment. A primary objective in integrated design is to down size or eliminate the HVAC equipment leading to more efficient operation, and often leading to installation cost savings. It is notable that the shell improvements will usually result in more stable and comfortable interior wall and glazing surface temperatures that permit alternative and reduced means of heating and cooling distribution which can lead in turn to reduced fan or pump energy, leading to significantly more efficient heating and cooling distribution strategies. This reduction in distribution can also result in reduced installation costs. The integrated design process usually employs building modeling, but as more efficient new commercial building experience develops, a few basic strategies are emerging which can be used without recourse to costly building modeling. (cf New Buildings Institute, Core Performance Guide).

Measure Applicability

This measure is applicable in 100 percent of new commercial construction, but in national chain or franchise designs, the integrated design may already have been done at the corporate level, or getting to a level of integrated design may require interaction at the corporate design level that may not be possible at the local level.

Incremental Cost

The incremental cost for this technology will be very diverse and quite site specific. The incremental costs of efficient new commercial buildings developed through integrated design are quite building specific, and may range widely from about $3.50/square foot to negative incremental cost. But in general, the incremental cost will be the net of some increased costs for various building elements (such as lighting, external shading elements, insulation, more efficient equipment, more sophisticated controls, etc), and some decreased costs resulting from reduced equipment sizes and simplified distribution strategies. There are examples of highly efficient new commercial buildings that have negative incremental costs, but a good rule of thumb is to assume that the incremental cost will be of the order of $1.75/square foot, or about $0.35/first year kWh saved.

The particular incremental cost for a real building could be quite complex to estimate. Therefore in order to minimize overhead, utility programs that provide incentives for integrated design will base the incentives on modeled and deemed per square foot estimates of energy savings for principal occupancy types (retail, schools, offices, etc) for various HVAC systems and measure packages.

Average Annual Expected Savings

The savings due to integrated design will include the savings due to efficient lighting, efficient HVAC equipment, and controls. Taken as a package these savings can easily be on the order of 20-40 percent of the standard code compliant design. The current US tax code allows preferred treatment for new buildings that are 50 percent better than code or lighting systems that are 30 percent better than code

Expected Useful Life

Integrated design can be expected to last the life of the building.

Efficient Package Refrigeration (C-11)

This measure consists of an efficient packaged and optimized new refrigeration system.

Measure Applicability

This measure is applicable in portions of the grocery sector and in some restaurants.

Incremental Cost

The incremental cost for this technology will be very diverse and quite site specific. Based on NWPCC estimates, the efficient packaged refrigeration costs about $0.15/kWh/yr.

Average Annual Expected Savings

It is assumed here that this measure can reduce a building energy use in applicable sites by 10 percent.

Expected Useful Life

Efficient package refrigeration will be considered operational 8760 hours per year with standard refrigerator operation life.

Electronically Commutated Motors (C-12)

An electronically commutated motor is a more efficient motor with variable speed control capability. In fan and pump applications it can save energy by operating at a more efficient speed. Refrigeration applications involving case cooling distribution fans are especially favored because the power reduction leads to a lower refrigeration load.

Measure Applicability

This measure is broadly applicable throughout the commercial sector.

Incremental Cost

The incremental cost for this technology will be very diverse and quite site specific. Based on NWPCC estimates, the premium upgrade costs about $0.33/kWh/yr.

Average Annual Expected Savings

It is assumed here that this measure can reduce a building energy use by 4 percent.

Expected Useful Life

Highly dependent on operational hours, electronically commutated motors are assumed to have a standard motor useful life.

Premium Motors (C-13)

This measure saves energy by reducing energy losses in motors. Motor energy use is preponderant in manufacturing applications where of the order of 40-60 percent of electric energy is used in motors, and these motor applications are frequently full-time operation or near full-time operation.

Motor efficiency varies with the size of the motor as is illustrated in the figure below.

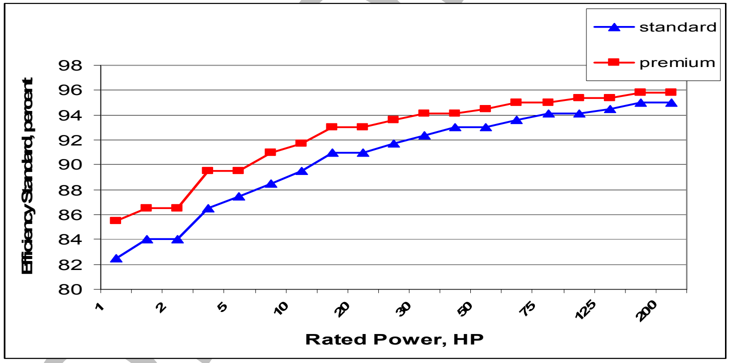

Figure 29. Motor Efficiency Specification NEMA Premium

The figure above shows the efficiency improvement to be gained by using the more efficient motor. While the efficiency gain is only about 2 percent for the smaller motors, it is important because the duty cycle of many motor applications is of the order of 5,000-8,760 hours/year.

In constant speed motor applications, an even greater electric energy savings may be available by properly matching the motor to its load. In particular, the efficiency of smaller motors in the 1-10 horsepower range can vary greatly with the duty load on the motor as illustrated in Figure 30. In this figure it is evident that if a smaller motor is oversized relative to its load, the efficiency can be reduced by of the order of 10 percent.

In motor replacement (and new motor) specifications, it is especially important to consider the fit of the motor to its load in terms of motor horsepower, speed, and starting torque. The greater portion of savings often rests with the proper match of the motor to its load.

A simple one-for-one motor replacement can have unexpected results. An important element in the use of higher efficiency motors is that the equilibrium speed of the higher efficiency motor is often slightly higher than the speed of the lower efficiency motor that was replaced. In fan and pump systems this slight increase in speed will increase the fluid throughput and power. So although a more efficient motor has been used, it may actually lead to an unintended but slight increase in flow and power unless the drive system is adjusted to compensate.

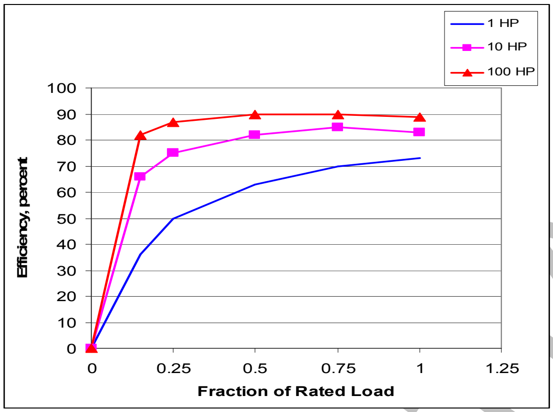

Figure 30. Typical Motor Operating Efficiencies versus Load

Measure Applicability

This measure is applicable in the new commercial and manufacturing sectors, and in suitable retrofit situations.

Incremental Cost

The incremental cost for this technology will be very diverse, and dependent on the size of the motor.

Average Annual Expected Savings

The savings from an efficient motor must assume that the drive has been adjusted as necessary to give equivalent flow or drive effort, and the savings will then depend strongly on the duty cycle hours/yr.

Expected Useful Life

This measure is essentially a built-in measure and is assumed to have a standard motor useful life.

Variable Speed Drives, Controls, and Motor Applications Tune-Up (C-14a, C-14b)

This measure saves energy by providing an efficient way to match a motor to a varying load. Motor controls, commonly referred to as variable speed or variable frequency drives, alter the frequency applied to the motor and thereby permit the motor to run more efficiently at lower outputs. This control capability is particularly important in process applications where a pump or fan is being controlled to maintain a particular and often varying fluid flow. Often the fluid flow is controlled by means of dampers or throttling valves that force the fan or pump motor to operate inefficiently. The savings associated with the proper speed control are most pronounced when the motor is operating at less than its rated capacity. At full capacity there may be little savings.

Situations involving fans, air compressors or pumps, (which is the most common commercial/industrial application of motors), have a very high energy sensitivity to flow rate; typically the energy varies as the cube of the flow rate. Attention to how the flow is controlled with the use of variable speed controls, and elimination of excess flow can often lead to power reductions of the order of 50 percent with only minor reductions in flow. In this manner, variable speed motor control permits finer tuning and control of pumps, fans, compressors, and conveyers.

This is a very broad measure and the cost and savings are based on a complex fully-controlled application, here referred to as C14a. There is also a broad niche for single independent applications of these controls in matching a fan or pump to a fixed load that are much lower cost than a fully controlled application, but can still result in significant savings. This simpler application is here referred to as C-14b.

There is another genre of motors and controls referred to as brushless permanent magnet torque motors. These are very high torque motors that require minimal drive gearing and can be very precisely controlled. These have very good positioning capabilities and are used in machining and manufacturing assembly operations.

Measure Applicability

This measure is applicable in the new commercial and manufacturing sectors, and in suitable retrofit situations.

Incremental Cost

The incremental cost for this technology will be very diverse. Based on NWPPC estimates, an aggregated estimate of the costs of adjustable speed drives is about $0.86/kWh/yr.

Average Annual Expected Savings

It is assumed here that an application of drive control can save about 20 percent of the total building energy.

Expected Useful Life

This measure is essentially a built-in measure and is assumed to have a standard useful life.

Energy Star Transformers (C-15)

This measure saves energy by reducing energy losses associated with stepping down from high service voltages to typical service application voltages. In larger buildings and plants it is often more economic to distribute the power at high voltages to various floors and major areas where it is then stepped down to its ultimate application voltage through a transformer. These transformers are typically efficient (>95%) when they are properly loaded, but an oversized or under loaded transformer can operate at a much lower efficiency; therefore, it is important that the transformers be sized properly. However, even when the transformer is properly sized, it is important to use the most efficient transformer because all power passes through it.

Transformer efficiency varies with the size of the transformer as illustrated in the figure below.

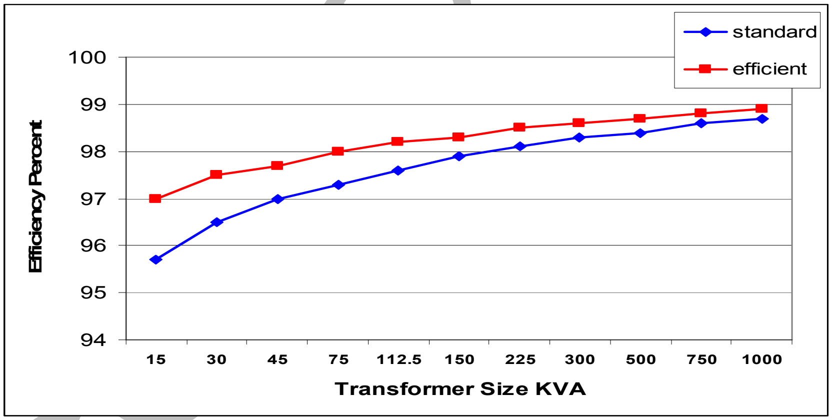

Figure 31. Transformer Efficiency Specification NEMA TP-1

Figure 31 shows the efficiency improvement to be gained by using the more efficient Energy Star labeled transformer. While the efficiency gain is only about 1 percent for the smaller transformers it is important because all power runs through it and the percentage savings will be taken off the top.

Measure Applicability

This measure is applicable in the new commercial and manufacturing sectors, and in suitable retrofit situations.

Incremental Cost

The incremental cost for this technology will vary with the size of the transformer. For this study, we take a 150 KVA transformer as the average.

Average Annual Expected Savings

Transformer savings are based on the size of the transformer, and are based on the power throughput of the transformer as well as standby losses, 8760 hours/year.

Expected Useful Life

This measure is essentially a built-in measure and is assumed to have a standard useful life.

Efficient AC/DC Power (C-16)

A modern office environment has a multitude of electronic appliances, most of which are powered by a small transformer AC/DC converter. Standard transformer based converters are about 30-40 percent efficient. More efficient designs called switching power supplies operate with an efficiency of about 90 percent. The energy savings for this measure proceed from switching to the more efficient power supplies.

Measure Applicability

This measure is applicable in 100 percent of the commercial sector.

Incremental Cost

The incremental cost for this technology will be very diverse. Based on NWPCC estimates, the premium upgrade costs about $0.074/kWh/yr.

Average Annual Expected Savings

Electronics and computers use 12 percent of commercial energy on a US average basis. This equipment is often on 24 hours a day. It is assumed here that doubling the power supply efficiency from 45 to 90 percent would save at least 1.5 percent of the total building energy.

Expected Useful Life

This measure is assumed to have high usage which results in a relatively short useful life.

LED Outdoor Lighting (C-17)

LED lighting applications use much less energy than incandescent or metal halide lighting applications. At the present the color of “white” LED light is somewhat blue tinted and not always suitable for general interior applications. But this color is often suitable for outdoor applications and it is probable that LED lighting will find its place in many outdoor applications. The application considered here is an LED outdoor light, often referred to as a “cobra light” which is used to illuminate parking lots and outdoor areas.

Measure Applicability

This measure is still evolving but will likely be applicable to a large percentage of the commercial sector.

Incremental Cost

A significant and favorable cost impact for this measure is its long life, leading to maintenance savings in cases where the light is difficult to access. Incremental costs vary based on lighting intensity and usage requirements.

Average Annual Expected Savings

Measure savings proceed from the replacement of a 250 watt light by a 19 watt LED assembly.

Expected Useful Life

The expected useful life for this long-lived measure is highly dependent on replacement bulb quality and usage, with varied results between 10-30 years.

New and Retrofit Efficient Lighting Equipment (C-18, C-19)

Lighting efficiency is the major commercial efficiency measure. Lighting accounts for 35 percent of commercial energy, and lighting also accounts for significant cooling energy that is saved when lighting is more efficient. There are literally hundreds of combinations of more efficient lighting elements that can replace less efficient elements. The most prevalent lighting efficiencies are CFL replacement for incandescent, LED replacement for incandescent and for task lighting, and high efficiency fluorescent T5 replacements for high bay lighting and linear fluorescent lighting. This efficient lighting measure goes beyond the light sources only and includes daylighting controls, bi-level switching and occupancy sensors. Recent improvements in daylighting and lighting controls have been dramatic. Taken together it is common to find efficient lighting that can reduce lighting energy by 50 percent from the minimum code required levels.

Measure Applicability

This measure is applicable in 100 percent of the new commercial buildings and in 85 percent of the existing commercial sector.

Incremental Cost

The incremental cost for this technology is essentially the cost of the efficient lighting components. These costs will be very diverse and site specific. Based on NWPCC estimates, and averaging the full range of conditions, efficient lighting costs about $0.26/kWh/yr. For a retrofit application, the cost is increased by 25 percent to allow for installation constraints.

Average Annual Expected Savings

A comprehensive lighting retrofit or new building lighting can save about 25 percent of the 34 percent lighting end-use, in all 8 percent of building energy.

Expected Useful Life

The useful life of the wide variety of lighting equipment varies widely from one light source or ballast to another. However, these elements are the replaceable elements within an overall installed system that determines overall useful lifetime.

LED Exit Signs (C-20)

Typical existing exit signs are incandescent exit signs. This measure is designed to replace these typical exit signs with an Energy Star Light Emitting Diode (LED) Exit Sign which is more efficient than the incandescent versions.

Measure Applicability

In principal, this measure is applicable in the entire commercial sector, and there are no physical constraints to replacing existing exit signs, but to account for already installed LED exit signs the applicability is assumed to be 85 percent of the commercial sector.

Incremental Cost

The incremental cost of an Energy Star LED Exit Sign over an incandescent exit sign is in the order of $50.

Average Annual Expected Savings

The average annual expected saving for this replacement is 245 kWh/year.[43] In the average building considered in this analysis, there are assumed to be 6 exit signs.

Expected Useful Life

LED exit signs are very long-lived light sources.

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[43] C&RD Database

LED Traffic Lights (C-21)

LED traffic lights[44] save energy because LED light sources are a much more efficient and long-lived light source than the incandescent bulbs they replace. They save energy but they also save in terms of bulb replacement costs. LED traffic lights have a variety of configurations. Each color (red, green, or yellow), each size (8 inch or 12 inch) and each type (thru lane, left turn bay, right turn bay, and don't walk large or small) has different incremental cost, savings and effective useful life values.

Measure Applicability

Measure applicability was not estimated due to lack of data on traffic lights in the DEK service territory. But for this analysis, it is assumed that there are 0.3 retrofittable intersections for every commercial building.

Incremental Cost

Depending on the color, size and type, the incremental cost ranges from $110 to $225. For this analysis we consider LED traffic light replacements in groups of 10, approximately the number of lamp replacements necessary to refit an intersection. For this analysis we will assume the average replaced light costs $200. These incremental costs do not assume an installation cost. It is assumed that the installation is done by the agency controlling the lights, and that it is more than paid for by the ongoing maintenance savings.

Average Annual Expected Savings

Depending on the color, size and type, the savings range from 111 to 808 kWh/year. For this analysis we consider LED traffic light replacements in groups of 10, approximately the number of lamp replacements necessary to refit an intersection. For this analysis we will assume the average replaced light saves 500 kWh/yr.

Expected Useful Life

Depending on the color, size and type, the expected useful life ranges from 3 to 16 years.

Perimeter Daylighting (C-22)

This measure saves energy by reducing energy to lighting that is in or adjacent to day lit spaces. Some cooling energy savings are also possible because well controlled day lighting contributes less internal gain to a space. This measure controls lighting based on a well placed day light sensor. This measure also includes design and details to control glare or over lighting.

Measure Applicability

This measure is applicable in the new commercial sector, and in suitable retrofit situations.

Incremental Cost

The incremental cost for this technology will be very diverse. Based on NWPCC estimates, perimeter daylighting costs about $0.85/kWh/yr.

Average Annual Expected Savings

It is assumed here that a full application of perimeter daylighting can save about 3 percent of the total building energy.

Expected Useful Life

This measure is essentially a built-in measure and is assumed to have a standard useful life.

Low Flow Fixtures (C-23)

This technology consists of a new showerhead rated at 2.0 gpm at 80 psi (or 1.5 gpm @60 psi) and a swivel aerator for any kitchen faucets, and fixed aerators for the lavatory faucets. The current US standard for showerheads is 2.5

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[44] All values for LED Traffic Lights are available in the C&RD Database.

gpm. And measurements of the existing shower flows in building stock show a range of 2.75 to 3.75 gpm with frequent individual cases showing in excess of 5 gpm. Evaluations have shown that programs that replace with 2.0 gpm heads have greater savings than programs that replace with the standard 2.5 gpm shower heads. Program shower heads should be 2.0 gpm at 80 psi and with a lifetime scaling and clogging warranty. It is important also to be cautious about the use of "pressure compensating" showerheads. These are more prone to clogging, and can lead to unintentional increases in flow rate in low pressure situations such as well water systems or older systems with occluded piping. Customer acceptability is an important component in a showerhead program. Customers will remove new low flow showerheads if the quality of the showering experience declines with the new showerhead. Therefore it is important to research and test the showerhead chosen for the program carefully. In addition the old showerhead must be removed from the premises to decrease the likelihood of having it reinstalled.

Measure Applicability

This measure is applicable to circumstances where there is showering; such as, schools, hospitality, health clubs, etc. The best application will be a site where the water is heated electrically.

Incremental Cost

The incremental cost for this measure is taken as $1,000, reflecting the installation of 15-40 showerheads by appropriately licensed professionals. Because the cost of the showerhead varies significantly and quality is so important for this program, it is essential to test, choose, and pay for a high quality showerhead. This measure is so cost effective that even with a more expensive showerhead the program will still remain cost effective and a quality showerhead will ensure measure persistence.

Average Annual Expected Savings

The average annual savings for this measure are directly related to the daily number of showers taken. For this study the showering load is assumed similar to a residential one and the overall savings are taken as 6,000 kWh/yr, representing the savings from 15-40 showerheads. The flow of the showerhead used has a significant impact on savings. Programs should be designed around a 2.0 gpm showerhead as compared to a 2.5 gpm showerhead. Therefore the savings will be more than the 120–133 kWh per unit listed in DEER. In addition the climate is different and the inlet water temperature is lower so the savings in this DEK program will be greater. Several studies have measured final savings in terms of electric input to the tank, but usually these studies have included savings from comprehensive treatments including other measures including tank and pipe insulation, kitchen and bath lavatory aerators, tank thermostat set back, and leaky diverter replacement. Savings can vary from program to program depending strongly on the choice of showerhead. A significant but unquantified addition to savings is associated with the water and sewer savings.

Expected Useful Life

The lifetime of this equipment is the key to its cost effectiveness. If an adequate, even pleasant, shower can be provided through lifetime warranted equipment, then the practical lifetime of the equipment is the length of time until the equipment is replaced in the course of renovation. DEER uses a lifetime of 10 years for this measure. Normally showerheads will last longer but with renovations and changes in ownership the average showerhead useful lifetime will be somewhat shortened.

Solar Water Heaters (C-24)

The water heating end-use in commercial buildings is a smaller end-use than in residences. In the DEK service area large commercial water heating will be done by gas and it will not be a very good candidate for this measure. But the smaller commercial water heating applications will be residential scale in usage and often these smaller applications will be electrically heated. These are the candidate applications for this measure. In the case of electrically heated water, the annual water heating energy is about 4,800 kWh/yr. Countless demonstration cases have shown that solar energy can supply all or a portion of this heating. The portion of the water heating load assumed by a solar water heater depends on the size of the solar water heater in relation to the size of the load. Field experience has shown that the best combination of system size to load favors the more moderately sized systems that can fully meet the summer water heat load, but that only meet about 40-50 percent of the non summer load. In physical terms, this is a system consisting of about 40-65 square feet of solar collector and an additional 80 gallon heated water storage tank and appropriate pumps and controls.

Measure Applicability

This measure is applicable to large commercial buildings with reasonably low hot water use, and the system is sized as if it were residential. This measure is taken as applicable to 25 percent of the commercial sector.

Incremental Cost

The installation of a solar water heating system involves a mix of building skills including plumbing, electrical, roofing and general carpentry. In the general market, a turn-key installation for one of these systems is in the range of $5,000-$7,000.

Average Annual Expected Savings

The savings from solar water heaters depend on site specifics, principally solar insulation, air temperature, incoming water temperature, and hot water usage rate. Considering these dependencies for the DEK service area, annual savings are determined for a system sized and designed to be within a cost effective range.

Expected Useful Life

Solar water heating systems are essentially plumbing fixtures that are certified products (Solar Rating & Certification Corporation - SRCC) and are often inspected by local building officials. A well designed system will have lifetime in excess of 25 years, even though the system will take some intermediate maintenance such as inspecting the pump and fluid level.

Heat Pump Water Heaters (C-25)

The water heating end-use in commercial buildings is a smaller end-use than in residences. In the DEK service area large commercial water heating will be done by gas, and it will not be a very good candidate for this measure. But the smaller commercial water heating applications will be residential scale in usage, and often these smaller applications will be electrically heated. These are the candidate applications for this measure. In the case of electrically heated water, the annual water heating energy is about 4,800 kWh/yr. The heat pump water heater is essentially a small heat pump drawing heat from the air by cooling and de-humidifying it and injecting this heat into a storage tank. Physically, this measure consists of a small, self-contained heat pump and a water storage tank and associated pumps and controls.

Measure Applicability

This measure is applicable to large commercial buildings with reasonably low hot water use, and the system is sized as if it were residential. This measure is taken as applicable 25 percent of the commercial sector.

Incremental Cost

The incremental cost of this measure consists of the cost of the heat pump water heater, water storage tank and installation plumbing and general construction labor. The siting of such a unit is important; it should never be sited in an attic, and freezing situations should also be avoided. Therefore, some special site adaptation and plumbing may be necessary.

Average Annual Expected Savings

For this study it is assumed that the heat pump water heater will perform with a coefficient of performance of 2.

Expected Useful Life

The useful life of this measure is assumed to be that of a similar appliance, a window air conditioner.

HE Food Prep and Holding (C-26)

This measure involves cooking and storage equipment that saves energy by keeping prepared food warm more efficiently, providing more efficient cooking methods and water conservation. The measures aggregated within this category are: convection ovens, combination ovens, steam cookers, efficient food holding cabinets and low-flow pre-wash sprayer nozzles.

Measure Applicability

This measure is applicable in portions of the restaurant, hospitality, and education sectors.

Incremental Cost

Incremental cost for this category of measures combines a weighted ratio of costs among the bundled measures. Individual measure costs range from $50 for a single spray nozzle with installation and $17,000 for a new combination oven.

Average Annual Expected Savings

It is assumed here that this bundle of measures will provide an average annual savings based on the individual penetration of each measure within the available population. Weighted averages were developed with the following assumptions:

Measure	Market Penetration
Spray Nozzles	35%
Convection Ovens	15%
Combination Ovens	7%
Steam Cooker	2%
Holding Cabinets	10%

Expected Useful Life

Measure life for this aggregate was based on a weighted average dependent on individual component potential market penetration rates.

Energy Star Clothes Washer (C-27)

Energy Star rated commercial clothes washers provide a marked savings increase over standard washers with higher volume wash loads and greater energy and water savings per cycle. Energy Star rates washers as Tier 1, Tier 2 and Tier 3 (MEF>1.80, 2.00, 2.20 respectively). For the purpose of this evaluation, Tier 1 washers were assumed to be the installed measure at all sites.

Measure Applicability

This measure is applicable in portions of the hospitality sector.

Incremental Cost

DEER lists the incremental cost of Tier 1 clothes washers as $347 per unit with an assumed installation cost of $116.

Average Annual Expected Savings

Savings are based on Tier 1 clothes washers with electric dryers. The average treated site is assumed to have 3 washers.

Expected Useful Life

This measure is assumed to have a standard useful life.

Restaurant Commissioning Audit (C-28)

This measure consists of an audit conducted by a restaurant energy professional to identify the potential for efficiency in a commercial kitchen. Savings proceed from small things such as leaky faucets and unnecessary equipment operation to larger things such as major process changes. Since kitchen equipment is energy intensive the audit includes identification of cost effective equipment changes.

Measure Applicability

This measure is applicable to commercial kitchens in the restaurant, hospitality, and education sectors.

Incremental Cost

The incremental cost for this measure is limited to the cost of the audit only. The cost of any major equipment changes is associated with other measures. The cost for the audit is assumed to be $.0738/kWh/yr.

Average Annual Expected Savings

It is assumed here this measure can reduce the energy use in an applicable facility by 8 percent for the average building considered in this analysis.

Expected Useful Life

This measure will have a relatively short life.

Grocery Refrigeration Tune-Up and Improvements (C-29)

This measure consists of cleaning heat exchangers and assuring proper airflow at the freezer cases and condenser coils. It also involves appropriate belt adjustment and refrigeration charge correction and the addition of a floating head pressure control if appropriate.

Measure Applicability

This measure is applicable in portions of the grocery sector and in some restaurants.

Incremental Cost

Based on NWPCC estimates, the grocery refrigeration tune-up costs about $0.19/kWh/yr.

Average Annual Expected Savings

It is assumed here that this measure will save 6 percent of site electrical usage for the average building considered here.

Expected Useful Life

This measure is assumed to have a short useful life.

Refrigeration Casework Improvements (C-30)

This measure refers to improvements to refrigeration casework that can lower the refrigeration load. These include high quality insulated glass doors on the refrigeration case or other transparent refrigeration case covers that limit mixing of the warmer store air with the refrigerated air.

Casework improvements also include attention to two refrigeration case auxiliaries that emit heat into the refrigerated space. The first is the anti-sweat heater made part of the clear refrigeration door to melt frost that could accumulate on the door and obscure the view of the contents. These heaters are commonly on all the time when they are only needed during high humidity episodes with humidity greater than 55 percent. The control improvement is to control the anti-sweat heaters with a humidistat thus allowing operation only to times when it is needed. While this control improvement will depend on the store humidity and the specific heater size, the savings for a typical refrigeration case are estimated here to be 400 kWh/yr.

The second heat emitting auxiliary is lighting and small fans used to distribute the cooled air inside the refrigerated case. These fans typically use a small inefficient motor coupled to an inefficient fan blade. In a typical medium-sized refrigeration case the existing fans may use about 70 watts, with the efficient fans using only about 20 watts, for a savings during 8,760 hours/yr of 50 watts or about 450 kWh/yr/case.

Measure Applicability

This measure is applicable in portions of the grocery sector and in some restaurants.

Incremental Cost

Based on NWPCC estimates, an average refrigeration case upgrade costs about $0.33/kWh/yr.

Average Annual Expected Savings

It is assumed here that this measure will save 5 percent at a suitable site.

Expected Useful Life

This measure is assumed to have a standard useful life.

VendingMiser® (C-31)

The VendingMiser® is a controller placed on vending machines which powers down the lighted vending machine face during low use times while maintaining product quality. It cycles the machine to maintain temperature and uses occupancy sensors to control the lighting on the vending machine.

Measure Applicability

This measure is assumed to be applicable in 25 percent of the commercial sector.

Incremental Cost

According to DEER, the incremental cost for a VendingMiser® unit is $179 and installation costs are expected to be $35.50 in labor for a total incremental cost of $215.

Average Annual Expected Savings

Measure savings range from 800 to 1,200 kWh/yr, depending on the vending machine. Large machines with an illuminated front save 1,200 kWh/yr; and small machines or machines without an illuminated front save 800 kWh/yr.

Expected Useful Life

The expected useful life for this measure is the useful life of the associated vending machine.

Network Computer Power Management (C-32)

This measure involves powering down unused network functions during unoccupied hours.

Measure Applicability

This measure is technically applicable in 100 percent of the commercial sector, but it is assumed that only 10 percent of the commercial sector will have the networks large enough and staff conversant enough to execute the measure.

Incremental Cost

The incremental cost for this technology will be very diverse. Based on NWPCC estimates, the premium upgrade costs about $0.115/kWh/yr.

Average Annual Expected Savings

Approximately 12 percent of commercial energy is for electronics and computers. It is assumed here that, at an applicable site, 2 percent of energy can be saved by efficient network power management.

Expected Useful Life

This is a transient measure dependent on the current system configuration. It is assumed to have a very limited useful life.

Solar Electric (C-33)

This technology consists of a roof or ground mounted solar electric array with a full sun output of 50 kW. Such an array has an area of 4,000-6,000 square feet. Electricity from the array is converted to AC by an inverter and the power is immediately used on-site with excess fed into the grid. This technology needs full solar exposure and shadows can significantly restrict output. In the commercial context, this technology can be an architectural enhancement.

Measure Applicability

This measure is applicable wherever there is sufficient space and solar exposure. For this study we assume applicability to 15 percent of all commercial buildings.

Incremental Cost

A system installation usually requires an electrical inspection to verify appropriate wire sizing, disconnects, and grounding. Costs are quite site-specific, with most of the costs associated with the solar electric panels. In the current 2011 market, costs are $2.50-$3.50/watt peak for the solar cells alone. Installation and balance of system can be expected to add $4.00/watt.

Average Annual Expected Savings

The electrical output for this technology is directly related to the solar intensity. Monitoring studies in this region of the US have shown that 1 kW of installed capacity can yield in excess of 1,300 kWh/yr.

Expected Useful Life

This equipment demonstrated long trouble free service in severe applications such as remote communications, navigation lighting, and road signage. The long-term output of the cells is assumed to decrease with time, but the rate of decrease for current technology is not known. The crystalline and semi-crystalline forms of the technology have already demonstrated degradation of less than 20 percent in 20 years. But earlier thin film forms of the technology have shown shorter lifetimes. The lifetime of new thin film technologies is expected to be of the order of 25 years but it is not known.

APPENDIX E. SEGMENTATION AND CIS SAMPLING PLAN

In order to accurately understand the nature of loads and DSM opportunities, we start by disaggregating the Duke Energy customer base into smaller groups of customers. These customer segments are chosen so that customers with similar energy attributes can be grouped for modeling purposes.

Duke Energy provided an extract from their customer information system (CIS) that included the information we requested for all customers in the Duke Energy service areas. Using the CIS extract, segments were developed using the following rules-based approach:

1. Aggregate customer loads (kWh) to the premise level.
2. Group customers into Residential based on the rate schedule.
3. Residential customers were then grouped into housing type and vintage.
    a. Housing type based on facility type field.
        i. Single Family
        ii. Multifamily including apartments and condominiums
    b. Vintage based on initial service date. (Note: The importance of delineating between new and existing stock is to describe and contrast current construction practices.)
        i. New construction (2009 and after)
        ii. Existing stock (prior to 2009)
4. Non-Residential customers were then grouped by load and SIC
    a. Customers with exceptionally small loads were assigned the small loads segment (less than 3,000 kWh over a recent 12-month period unadjusted for weather).
    b. Customers not classified in the small load were assigned segments based on their SIC code.

The segmentation strategy is shown in the table below.

Residential (based on rate code)			**Non-Residential (based on rate code)**
Single Family New Construction	Single Family Existing		Manufacturing and Non-Manufacturing Segments Based on SIC
Multifamily New Construction	Multifamily Existing		Small Loads (< 3,000 kWh/year)

Customer counts and usage by segment are shown in the attached PDF file. Non-residential segment assignments based on SIC code are shown in the table below.

SIC Code	Business Type Assignment
01 – 17	Agriculture, Mining and Construction
20 – 39	Manufacturing (further segmented as follows: Primary Metals Chemicals Transportation Equipment Food Products Other Manufacturing
42, 50 and 51	Warehouse
54	Grocery
58	Eating/Drinking
70	Hotels
80 (except 806)	Health Services (excludes hospitals)
806	Hospitals
82	Schools
52 – 59 nec	Retail
40 – 98 nec	Office
All other SIC nec	Other
nec = not elsewhere classified	

There were nearly 3,000 non-residential customers with small loads (< 3,000 kWh). This is fairly typical in that electric utility services include facilities that are not typical commercial establishments. Examples include billboards and railroad signals and switching equipment. The 3,000 kWh cutoff was determined after a review of the distribution of kWh usage and considering what a reasonable lower limit might be for a small commercial establishment.

Sample Selection

A random sample of customers served before July 2010 (to allow sufficient 2011 billing history) was drawn by segment for modeling purposes as follows:

1. Randomly select 1,200 customer sites for each segment.
2. All manufacturing customers are included in the sample to allow for various groupings to be explored without having to request another round of data.
3. Any customer with exceptionally large usage (over one million kWh) that was not included in the random sample was manually selected.

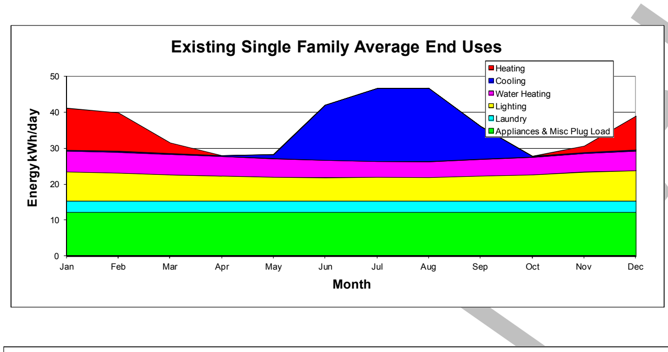
Monthly 2011 billing data for sample premises served as the basis for our energy modeling and analysis by market segment.

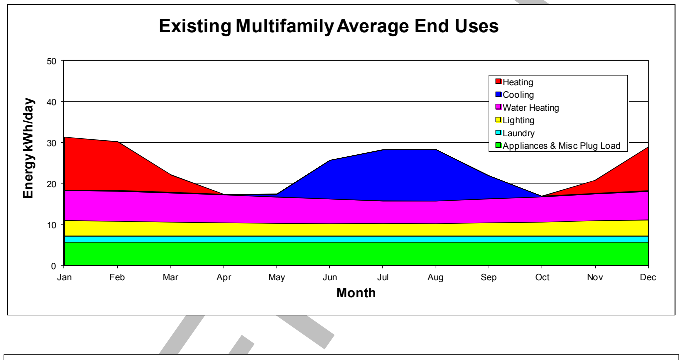
APPENDIX F. SEGMENT LOAD CHARTS

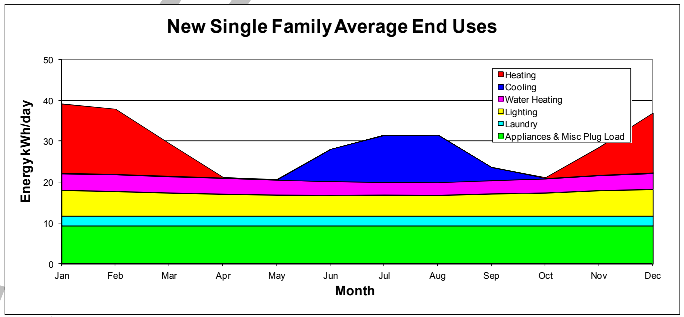
In this appendix, end-use charts are provided for each segment beginning with the residential sector. See Appendix A for additional information on typical end-uses by sector.

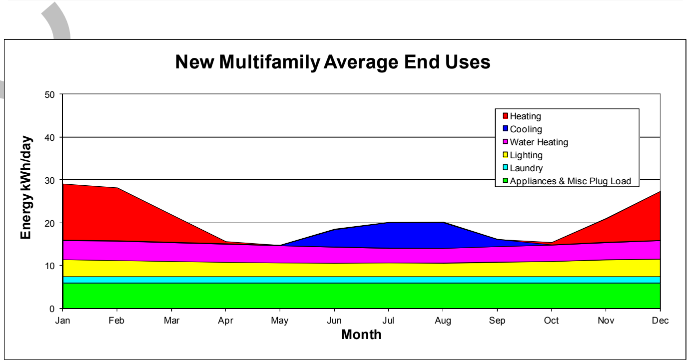
Residential

The following four charts show monthly usage by end-use for each of the residential segments.



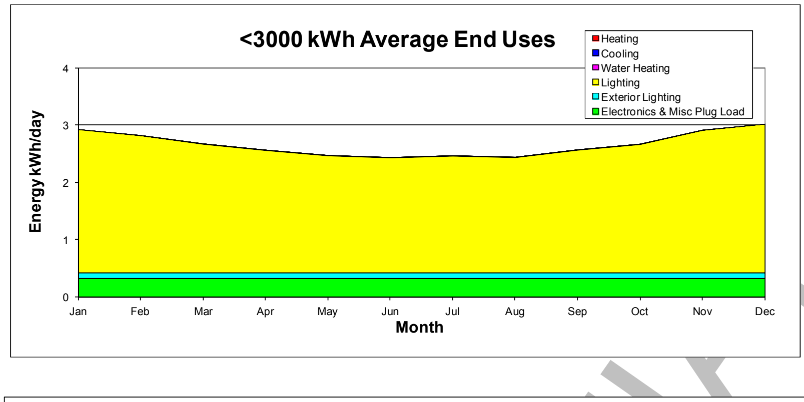


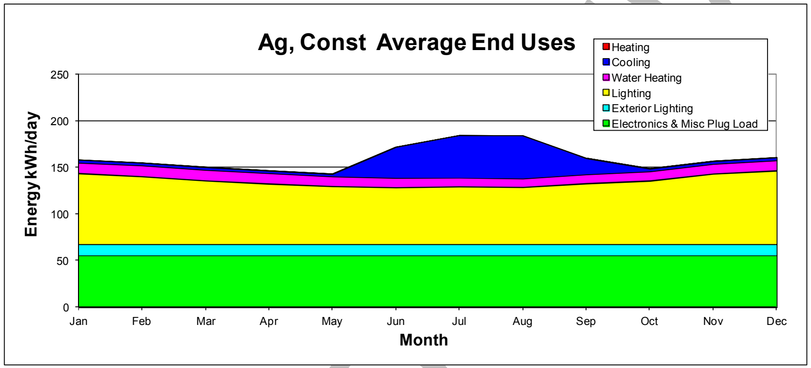


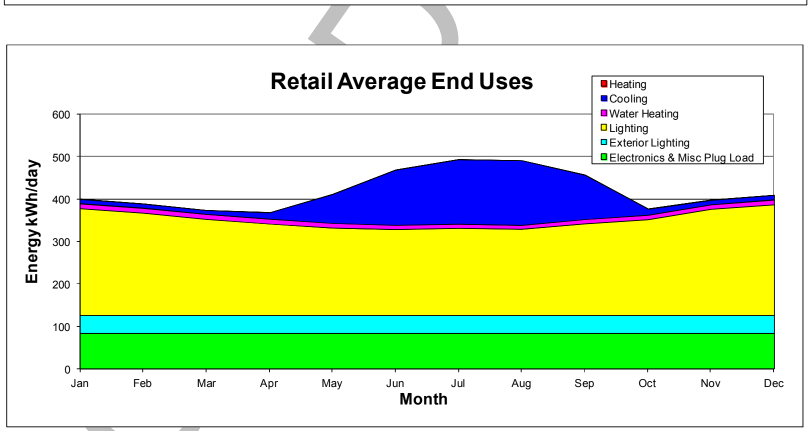


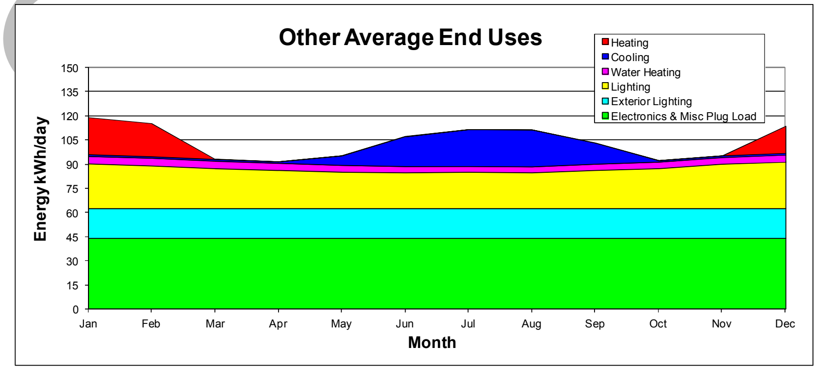
Non-Residential

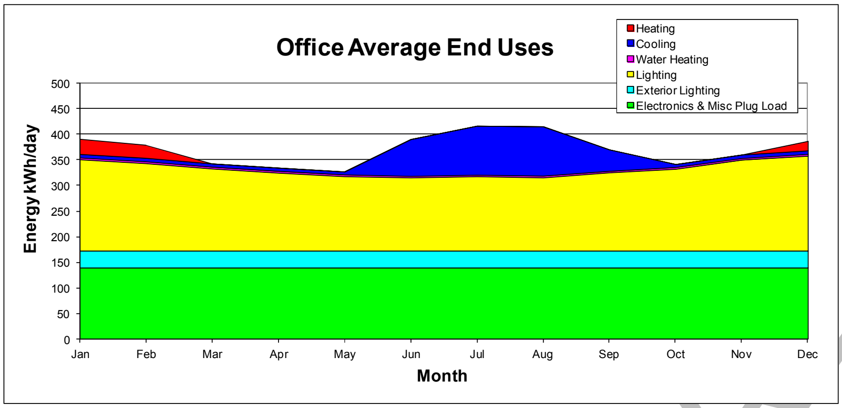
The following seventeen charts show monthly usage by end-use for each of the non-residential segments.

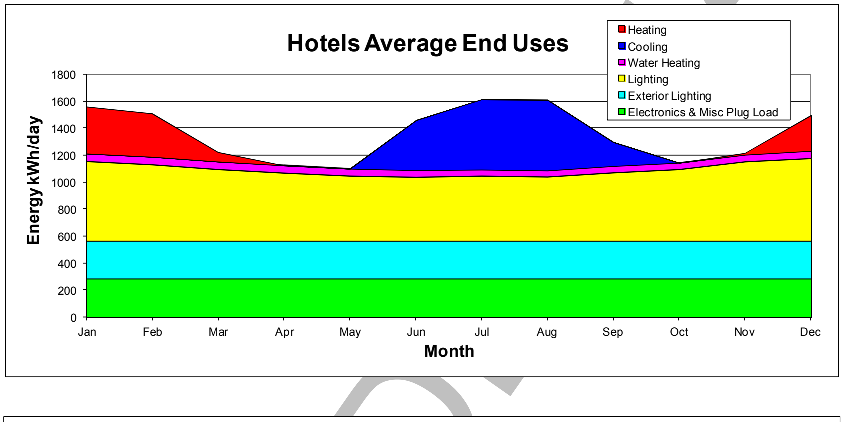


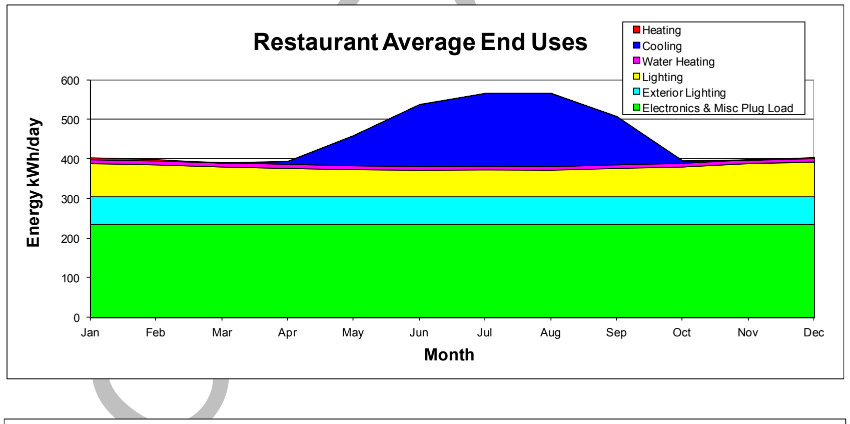







Office Average End Uses
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load
Energy kWh/day
500
450
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Hotels Average End Uses
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load
Energy kWh/day
1800
1600
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Restaurant Average End Uses
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load
Energy kWh/day
600
500
400
300
200
100
0
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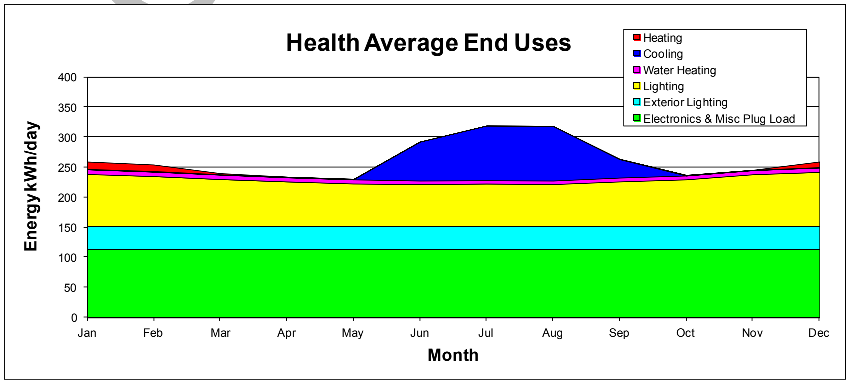
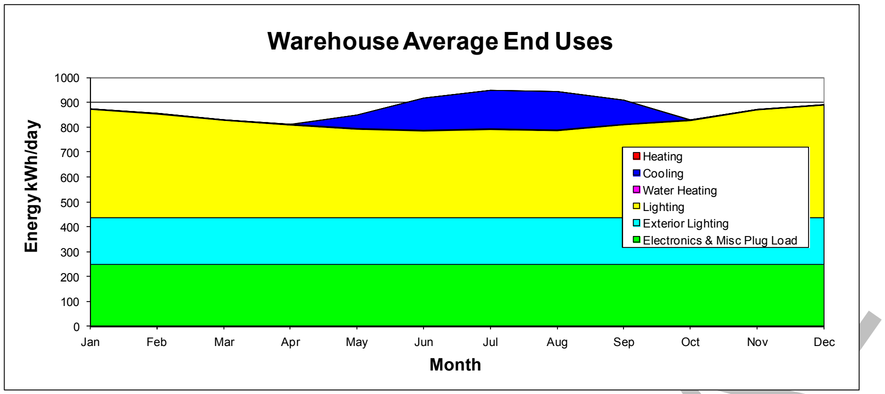
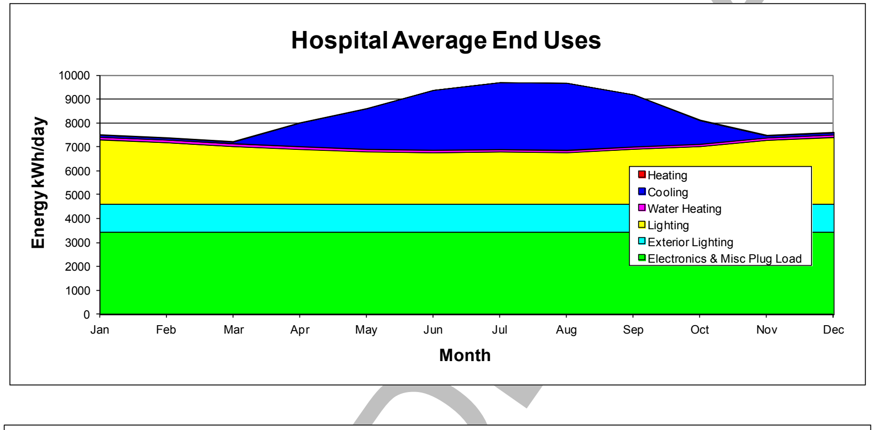
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Health Average End Uses
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load
Energy kWh/day
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Warehouse Average End Uses
Energy kWh/day
1000
900
800
700
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load


Hospital Average End Uses
Energy kWh/day
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
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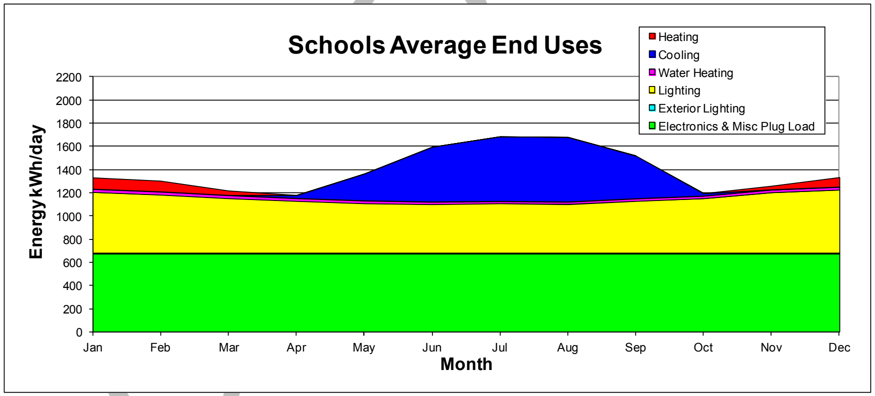
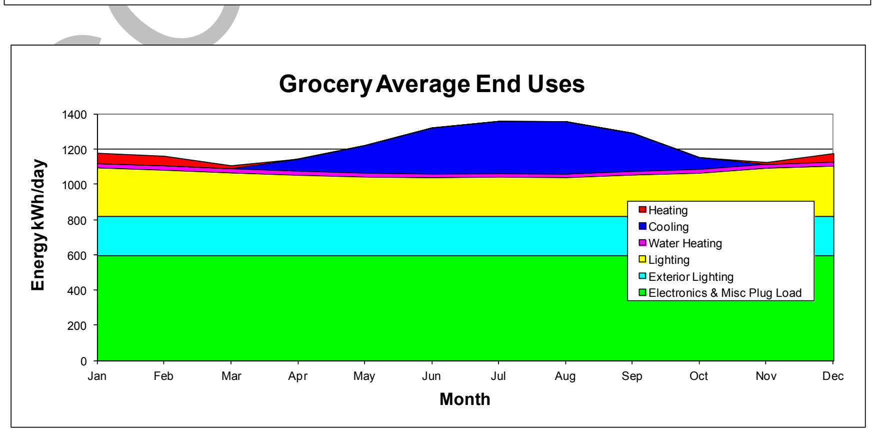
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load


Schools Average End Uses
Energy kWh/day
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load


Grocery Average End Uses
Energy kWh/day
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
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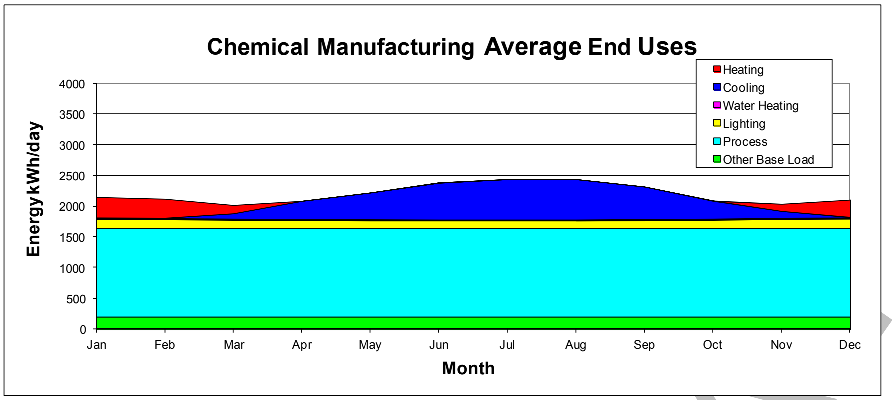
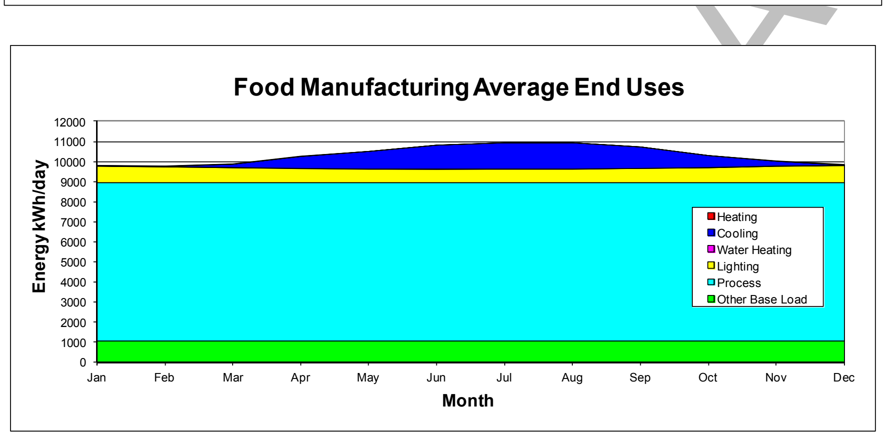
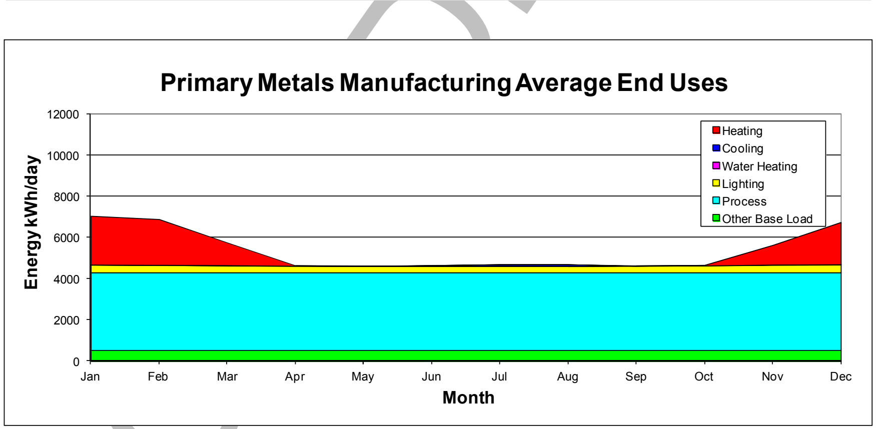
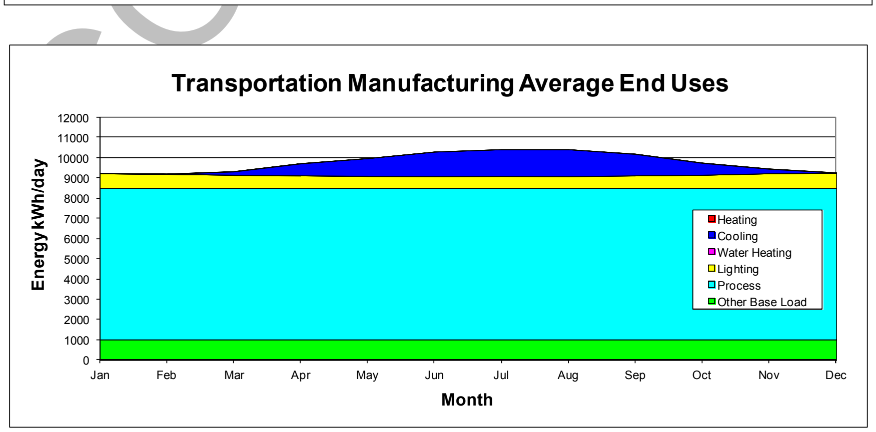
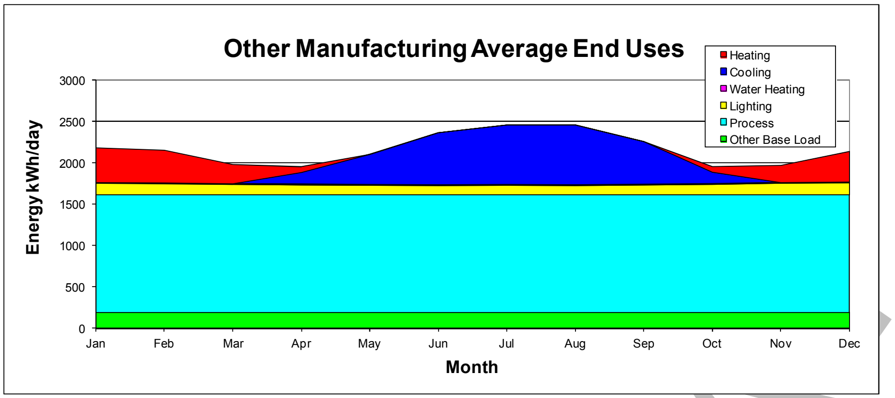
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Exterior Lighting
Electronics & Misc Plug Load


Chemical Manufacturing Average End Uses
Energy kWh/day
0
500
1000
1500
2000
2500
3000
3500
4000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Process
Other Base Load


Food Manufacturing Average End Uses
Energy kWh/day
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Process
Other Base Load


Primary Metals Manufacturing Average End Uses
Energy kWh/day
0
2000
4000
6000
8000
10000
12000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Process
Other Base Load


Transportation Manufacturing Average End Uses
Energy kWh/day
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Heating
Cooling
Water Heating
Lighting
Process
Other Base Load


Other Manufacturing Average End Uses
Heating
Cooling
Water Heating
Lighting
Process
Other Base Load
Energy kWh/day
3000
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

STAFF-PHDR-01-004

REQUEST:

Provide a calculation of the average residential customer credit received as a result of Duke Kentucky's approximately $800,000 credit created by providing energy to PJM during Winter Storm Elliott.

RESPONSE:

Duke Energy Kentucky received Capacity Performance Bonus credits in the months of March through August 2023 totaling $973,347 and received a net charge in the months of February and March 2024 of ($87,221). The total Capacity Performance Bonus credit included in the Profit-Sharing Mechanism (PSM) was $886,126, which resulted in a total bill credit of $2.55 for a typical residential customer using 1,000 kWh per month. These credits were provided to customers through bills effective June 2023 through September 2024. Please see STAFF-PHDR-01-004 Attachment for each quarterly filing's credit or charge during the 2023-2024 period. The net charge in the months of February and March 2024 was due to the implementation of the settlement approved by FERC in Docket No. ER23-2975 on December 19, 2023. The settlement resolved complaints that challenged PJM's assessment of capacity performance penalties during Winter Storm Elliott.

The Company also had increased off-system sales in December 2022 during Winter Storm Elliott, which resulted in $9 million of Off-System Sales Margin to be credited to customers through the PSM. The typical residential customer using 1,000 kWh per month received a total credit of $34.12. The credit was received in PSM tariff filing TFS2023-

00074 dated 1/31/2023 effective March through May 2023. The credit rate in that filing was $0.0111373 / kWh. The $34.12 typical residential customer credit was calculated by taking the rate multiplied by 1,000 and multiplied by 3 for the 3 months the rate was effective ($0.011373 x 1000 x 3 = $34.12)

PERSON RESPONSIBLE: Sarah E. Lawler

DUKE ENERGY KENTUCKY
WINTER STORM ELLIOTT PERFORMANCE CAPACITY BONUS CALCULATION EFFECT ON THE AVERAGE RESIDENTIAL CUSTOMER CALCULATED AND SHARED WITH CUSTOMERS THROUGH THE PROFIT SHARING MECHANISM (PSM)

	Expense Month [c]:		1/2023-3/2023	1/2023-6/2023	1/2023-9/2023	1/2023-12/2023	1/2024-3/2024	
Line No.	Description		5/2/23 Filing TFS2023-00232	8/1/23 Filing TFS2023-00353	11/1/23 Filing TFS2023-00546	1/31/24 Filing TFS2024-00044	5/3/24 Filing TFS2024-00203	Total
1	Net Capacity Revenue (Expense)	(+)	$ 183,039	$ 783,735	$ 973,347	$ 973,347	$ (87,221)	
2	Actual Amount Credited (Charged) to Customers	(+)	0	(183,039)	(783,735)	(973,347)	0	
3	Net Refund due to (from) Customers	=	$ 183,039	$ 600,696	$ 189,612	$ -	$ (87,221)	$ 886,126
4	Percentage Allocated to Customers (90% of net margin) [b]		90.00%	90.00%	90.00%	90.00%	90.00%	
5	Total Amount of Credits due to (from) Customers (Line 3 x Line 4)	(+)	$ 164,736	$ 540,626	$ 170,650	$ -	$ (78,499)	
6	Sales (kWh) from FAC Filing for the current quarter (FAC Schedule 3, Line C)	÷	934,022,239	898,854,277	1,107,725,094	880,234,836	958,063,726	
7	Profit Sharing Mechanism Credit (Charge) Rate ($/kWh) [a]	=	$ 0.000176	$ 0.000601	$ 0.000154	$ -	$ (0.000082)	
8	Typical Residential Monthly Customer Credit (Charge) Using 1,000 kWh		$ 0.176000	$ 0.601000	$ 0.154000	$ -	$ (0.082000)	
9	Total Quarterly Amount of Credits due to (from) Customer (line 8 x 3 months		$ 0.528000	$ 1.803000	$ 0.462000	$ -	$ (0.246000)	$2.547000

Notes:

(a) Rider PSM credits, reductions to bills, are shown as positive numbers without parentheses.
Rider PSM charges, increases to bills, are shown in parentheses.

(b) Per Commission Order dated April 13, 2018 in Case No. 2017-00321.

(c) Rider PSM quarterly filings are based on an accumulated year-to-date calendar year.

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

STAFF-PHDR-01-005

REQUEST:

Regarding the optimized portfolios, under both the with the EPA CAA Section 111 update and without the EPA CAA Section 111 update, under the full natural gas conversion portfolio:

a. If generation units that are converted from coal fired to 100 percent natural gas fired or are retired and replaced with a combined cycle gas turbine (CCGT), only run up to 40 percent load factor to avoid modeling or adding carbon capture and sequestration (CCS) requirements, explain whether PJM lowers the unit's accredited capacity by 60 percent even though the unit's available maximum capacity will not have changed.

b. If the response to 5(a) is that the unit's accredited capacity is unchanged by the conversion, assume that PJM calls the unit to run above a 40 percent load factor, explain whether the utility will be subject to EPA penalties.

RESPONSE:

a. Currently, PJM has not assessed whether there would be impacts to a unit's accredited capacity. However, at this point, the Company would expect to operate the unit such that it is available to operate at full capacity during peak demand or high loss of load expectation (LOLE) hours. As such, if the unit is fully available during those peak hours, then the Company expects that it would receive close to full accreditation from PJM.

b. First, as a point of clarity, the unit can operate above 40% capacity factor over periods of time as long as the annual average capacity factor remains below 40%. The

Company expects to offer the unit into the PJM market, and subsequently operate the unit, so that it remains in compliance with all EPA requirements. If the unit were to operate above the 40% capacity factor limit on an annual basis, it is unknown what those penalties would be and whether the Company could successfully defend itself against those penalties based on the circumstances that caused the unit operated above the limit.

PERSON RESPONSIBLE: Mike Geers
Matthew Kalemba
John Swez

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

STAFF-PHDR-01-006

REQUEST:

Refer to Duke Kentucky's response to Commission Staff's First Request for Information (Staff's First Request), Item 18, Attachment, Tab Figure 6.1 PVRR ($000) – Optimized With EPA CAA Section 111 Update.

a. Compare the cost information in 111 Scenario with DFO Conversion 2030 (DFO Conversion) with cost information in 111 Scenario East Bend 2 Retires 2032 (Retires 2032). As the costs are incurred in each of the scenarios, explain the reasons for the cost differences between the two scenarios over the forecast period. If the response to 5(a) is that the unit's accredited capacity is unchanged by the conversion, assume that PJM calls the unit to run above a 40 percent load factor, explain whether the utility will be subject to EPA penalties.

b. For the DFO conversion scenario, explain whether the EnCompass model maintains a 50/50 natural gas to coal burn over the forecast period and that the forecast coal and natural gas prices are the same for all scenarios, both with and without the EPA CAA Section 111 Update.

c. Other than the differences and timing of the fuel mixes between the two scenarios and the timing of the transition to a combined cycle gas turbine, explain the differences in the cumulative costs throughout the forecast period.

d. Explain why the DFO Conversion is beneficial to customers when they must wait until 2040 for the scenario to be cost effective and the basis for the Preferred portfolio.

e. Confirm that CCS is not included in these scenarios because East Bend Station as a base load unit does not run above a 40 percent load factor. If not confirmed, explain why it is not modeled.

RESPONSE:

a. The Company discovered there was a transcription error in the original file labeled “STAFF-DR-01-018.xls”. Four of the cases had incorrect values in some of the years. The attached file, “STAFF-DR-01-018_Revision.xls” corrects those errors. The corrected values are in blue font. These corrections align the data with the figures in the filed IRP and they do not change our conclusions in the IRP. Additionally, the trends identified based on the original 01-018 attachment for when a particular case becomes more or less economic vs another case are largely unchanged as a result of this correction.

Regarding response to Part (a) of PHDR-01-006, there are a few differences in costs between the “DFO Conversion” case and the “Retires 2032” case in the 111 Scenario.

Both cases show similar costs through 2027, as both cases have the same resource portfolio. In 2028, the “DFO Conversion” case includes expenses for a maintenance cycle due to the later retirement date of East Bend. East Bend must continue in operation longer and requires more maintenance cost then the “Retires 2032” case. In 2030, the “DFO Conversion” case includes the capital cost for the conversion of East Bend to dual fuel.

In 2032, the “Retires 2032” case replaces East Bend with a mix of battery storage, solar, and a combustion turbine. More resources, including battery storage, solar, and wind continue to be added throughout the planning horizon to meet reserve margins. The carrying cost of adding these new resources results in higher costs for the “Retires 2032” case as compared to the “DFO Conversion” case from 2032.

In 2039, the “DFO Conversion” case replaces East Bend with a combine cycle with carbon capture and sequestration (CCS). The model selected this replacement resource to take advantage of the 45Q tax credits under the Inflation Reduction Act. The new combined cycle with CCS can dispatched unconstrained under 111 and immediately realizes the CCS tax credits which makes the “DFO Conversion” case more cost effective through 2040.

At the end of the planning period, the “DFO Conversion” case has less overall cost as compared to the “Retires 2032” case. There is more cost in the beginning related to keeping East Bend operating longer, however, the addition of a combined cycle with CCS in 2039 brings the total overall cost lower versus the “Retires 2032” case.

b. For the DFO conversion scenario, the EnCompass model does maintain a 50/50 natural gas to coal burn over the forecast period, however 50% natural gas burn was the minimum required, and the model allowed up to 100% based on economics. The forecasted coal and natural gas prices are the same for all scenarios, both with and without the EPA CAA Section 111 Update.

c. Refer to Part (a) for detail between the difference in costs between scenarios. The other costs beyond capital for new generation and operating costs are the on-going maintenance for East Bend to keep the unit operating through 2038.

d. Please note the Commission Staff is referencing Table 6.1 which is the “*Optimized* Portfolios with EPA CAA Section 111 Update”. The optimized portfolios were allowed to select any available technology, and did not consider factors such as market exposure risk, technology risk, or the requirements associated with Kentucky Senate Bill 4 or Kentucky Senate Bill 349. Specifically, the optimized case that retires East Bend in

2032 replaces the unit with a combination of CTs, standalone solar, standalone storage, and solar paired with storage. This combination of assets increases customers exposure to the market, and also includes replacement assets that are not dispatchable (i.e., solar) and that rely on federal incentives (i.e., solar and storage) which conflict with Kentucky's policies. Additionally, the DFO conversion case replaces East Bend with a CCS. While CCS technology may be viable by 2039, the Company did not feel it appropriate to include this nascent technology in its preferred portfolio. Given the issues with the "optimized" portfolios, the Company developed portfolios with more viable replacement technologies. These portfolios are presented in response to Commission Staff's First Request for Information (Staff's First Request), Item 18, Attachment, Tab Figure 6.2. In those portfolios, the DFO case with accelerated renewables is a lower cost portfolio than the retire in 2032 case by the mid-2030s.

e. As explained in Part (e), a CC with CCS is the optimized replacement resource for East Bend in 2039. This was not included as an option in the retire by 2032 case because the Company does not believe the CCS technology will be an available technology by 2032. As further explained in Part (e), the Company felt that including CCS technology in the preferred portfolio, even in 2039, was not prudent given the nascent state of the CCS technology.

PERSON RESPONSIBLE: Matthew Kalemba

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

STAFF-PHDR-01-007

REQUEST:

Refer to Duke Kentucky's response Staff's First Request, Item 18, Attachment, Tab Figure 6.3 PVRR ($000) – Optimized Without EPA CAA Section 111 Update. Regarding the different cost information provided:

a. In the absence of the EPA CAA Section 111 Update, explain why the DFO Conversion portfolio (Duke Kentucky's preferred portfolio) is still better for customers.

b. Other than the differences and timing of the fuel mixes between the two scenarios and the timing of the transition to a combined cycle gas turbine, explain the differences in the cumulative costs throughout the forecast period.

c. Confirm that CCS is not included in these scenarios because East Bend as a base load unit does not run above a 40 percent load factor. If not confirmed, explain why it is not modeled.

RESPONSE:

a. As described in response to STAFF-PHDR-01-006 there was a transcription error in the original file labeled "STAFF-DR-01-018.xls". Four of the cases had incorrect values in some of the years. The attached file, "STAFF-DR-01-018_Revision.xls" corrects those errors. The corrected values are in blue font. These corrections align the data with the figures in the filed IRP and they do not change our conclusions in the IRP. Additionally, the trends identified based on the original 01-018 attachment for when a particular case becomes more or less economic vs another case are largely unchanged as a result of this correction.

As detailed on Page 56 of the Duke Energy Kentucky IRP, the Company's preferred portfolio in the absence of the EPA CAA Section 111 Update, is to retire East Bend in 2035 and replace with a Combined Cycle generator. However, should the EPA CAA Section 111 Update be repealed after the Company has made financial commitments towards the DFO Conversion project, the DFO project would still be considered the least regrets pathway for Duke Energy Kentucky customers primarily because of the increased fuel flexibility, fuel diversity and reliability that the DFO project provides.

b. Similar to the Company's response to STAFF-PHDR-01-006, there are a few differences in costs between the "DFO Conversion" case and the "Retires by 2036" case in the no 111 Scenario.

Both cases show similar costs through 2029, as both cases have the same resource portfolio and load. However, there are slight differences between the cases over this period due to variability of random unit outages in the EnCompass model. In 2030 the "DFO Conversion" case becomes more costly than the "Retires by 2036" case and remains so throughout the planning period due to higher capital cost for the cost of conversion of East Bend to dual fuel as well as firm transport of gas to the site. In 2036, the "Retires by 2036" case replaces East Bend with a new Combined Cycle gas turbine (CC) with carbon capture and sequestration (CCS) resource. While a higher capital cost than the DFO conversion, the new CC with CCS unit operates at high capacity factor both due to the improved efficiency of the CC unit vs East Bend and the ability to generate valuable 45Q tax credits. Between 2036 and 2039, on-going operating costs of East Bend are reflected in the "DFO Conversion" case. In 2039, the "DFO Conversion" case replaces East Bend with a CC with CCS resource and both the capital cost of the new unit plus the benefits of the new unit are reflected in the PVRR in the final two years.

c. Similar to the Company's response to STAFF-PHDR-01-006, a CC with CCS is the *optimized* replacement resource for East Bend in 2035 and 2039, and the costs/benefits of which are included in Duke Kentucky's response Staff's First Request, Item 18, Attachment (Revised), Tab Figure 6.3 PVRR ($000). The Company evaluated replacing East Bend with a CC *without* CCS in Figure 6.4 of the same attachment, because of the risks of CCS being a viable technology, even in 2039.

PERSON RESPONSIBLE: Matthew Kalemba

Duke Energy Kentucky
Case No. 2024-00197
STAFF's First Set Post Hearing Data Requests
Date Received: December 16, 2024

PUBLIC STAFF-PHDR-01-008

REQUEST:

Refer to Case No. 2024-00354,[1] Direct Testimony of Ibrar A. Khera, page 7, lines 1 through 4 and the hearing video transcript of 2024-00197,[2] time stamps 07:12:12-07:12:36 and 07:12:49-07:13:27. Provide clarification regarding the commitment of a large energy intensive commercial customer locating in Duke Kentucky's service area.

RESPONSE:

CONFIDENTIAL PROPRIETARY TRADE SECRET

The large commercial customer reference in my Direct Testimony of Case No. 2024-00354 is [redacted] It is important to note that [redacted]. The adjustment reflects [redacted]

PERSON RESPONSIBLE: Ibrar Khera

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[1] Case No. 2024-00354, *Electronic Application of Duke Energy Kentucky, Inc. For: 1) An Adjustment of The Electric Rates; 2) Approval of New Tariffs; 3) Approval of Accounting Practices to Establish Regulatory Assets and Liabilities; And 4) All Other Required Approvals and Relief* (filed Dec 2, 2024), Application.
[2] Hearing Video Transcript of the Dec. 10, 2024 Hearing at 07:12:12-07:12:36 and 07:12:49-07:13:27. Volume 16 at 168.