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## The Dayton Power and Light Company Load Profiling Methodology

Revised 7/1/2017

### Overview of Methodology

Dayton Power and Light (DP&L) load profiles will be used to estimate hourly loads for customers without interval metering for use in retail energy imbalance calculations. In addition, these same load profiles will be made available to Alternate Generation Suppliers in order to assist in scheduling hourly loads for retail load aggregations of customers they may serve within the DP&L distribution service territory.

In developing load profiles for various customer classes, DP&L has utilized a *dynamic modeling* methodology based on Company load research data. Each of DP&L's retail electric distribution customers without interval metering has been assigned to one of seventeen load profile categories developed by the Company. Load profile categories were developed in order to group customers with homogeneous load patterns and usage characteristics. Rate class and voltage level load research data was examined to determine the appropriate profile segments based on rate classification, usage and demand level characteristics.

Each of the DP&L profile segments was used to develop a dynamic profile model that will be used to produce daily profiles based on day of the week, season and actual weather conditions where applicable. The *dynamic modeling* approach entails developing hourly class load models that relate hourly demand with day of the week, season, and weather conditions. *Dynamic modeling* is one method of reflecting a weather response mechanism in a mathematically modeled form. This method builds on DP&L's available load research data and incorporates calendar and weather information that will be secured from external sources.

Each day, DP&L will post the following load profile information to its supplier web site (<http://cres.dpandl.com>):

- 1) Up to 17 load profiles for the previous day, based on day of week and actual weather (when applicable).

This daily load profile information will be used to inform suppliers of the profiles that will be used in developing hourly load allocations for retail energy imbalance settlements, and to assist suppliers in developing their own retail load forecasts and energy schedules.

### Definition

Load profiling is an estimation and allocation process. Customers with hourly interval metering will have their actual demands used to determine their load responsibility on the system. For customers without interval demand meters, load research data is used to build profiles that

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provide a mechanism to convert their daily or monthly energy use into an hourly load responsibility.

Load profiling is defined as: 1) the application of generic industry load shapes as a proxy for local customer usage patterns; or 2) the use of a load shape generated from load research samples to be used as a proxy for customer usage patterns.

The use of generic industry load shapes is the least complex approach to gathering load research data, but it includes error due to both sampling and the differences between generic and utility specific customer usage patterns. DP&L has utilized load research samples to develop its load profiles.

### **DP&L Load Profile Classes**

DP&L has developed seventeen (17) load profile classifications for its non-interval metered retail electric distribution customers. Customers are classified according to rate classification, usage and demand level characteristics. Customers will be reassigned to profile classes based on these characteristics on an annual basis, during the month of October.

- The residential electric heat rate class represents its own profile class (1 profile).
- The residential non-electric heat rate class customers are grouped into two strata based on annual usage levels. The load research samples demonstrated that customers within this rate class have different load patterns depending on whether they are high or low usage customers. A class average default profile will be assigned to any customers within this rate class with insufficient usage data for profile classification, i.e. new service points (3 profiles).
- The commercial and industrial profiled tariffs employ a more defined segmentation where the segments are based on a combination of rate class, usage, kW demand and load factor. Secondary rate class customers are grouped by usage level. A class average default profile will be assigned to any customers within this rate class with insufficient usage data for profile classification (7 profiles).
- Many commercial and industrial customers at the primary voltage level or above are interval metered; those that aren't interval metered are assigned the primary, primary-substation or high voltage load profiles (3 profiles).
- The street lighting/outdoor lighting segment represents its own profile class. Because this segment is unmetered, the street lighting/outdoor lighting profile was developed as a "deemed" profile that recognizes the changes in sunset and sunrise, and daylight savings time (1 profile).
- The school rate class represents its own profile class for those accounts that do not have interval metering (1 profile).
- The traffic signal rate class represents its own profile class. Because this segment is unmetered, the traffic signal profile was developed as a "deemed" profile based on the assumption that traffic signals exhibit no hourly variation (1 profile).

A table containing each DP&L load profile class, the associated load profile code, and a description of each class, is provided below.

<b><u>Load Profile Class</u></b>	<b><u>Code</u></b>	<b><u>Description</u></b>
Residential No Heat Default	RS00	Residential No Heat Default
Residential No Heat Low kWh	RS01	Residential No Heat <= 7200 annual kWh
Residential No Heat High kWh	RS02	Residential No Heat > 7200 annual kWh
Residential Heat	RH01	Residential Heat
Secondary Default	SS00	Secondary Default
Secondary Low kW Low LF	SS01	Secondary Low kW and <= 33% Summer Load Factor
Secondary Low kW High LF	SS02	Secondary Low kW and > 33% Summer Load Factor
Secondary Med kW Low LF	SS03	Secondary Medium kW and <= 38% Summer Load Factor
Secondary Med kW High LF	SS04	Secondary Medium kW and > 38% Summer Load Factor
Secondary High kW Low LF	SS05	Secondary High kW and <= 61% Summer Load Factor
Secondary High kW High LF	SS06	Secondary High kW and > 61% Summer Load Factor
Primary	PR01	Primary
Primary Substation	PS01	Primary Substation
High Voltage	HV01	High Voltage
Street Lighting	SL01	Street Lighting
Schools	SC01	Schools
Traffic Signals	TS01	Traffic Signals

**Secondary Low/Medium/High kW Breakdown:**

<b>Low</b>	<b>Medium</b>	<b>High</b>
< 5 kW	>= 5 kW < 150 kW	>= 150 kW

**Profile Class Models**

Historical load research data was used to develop the profile segments. The historical data was then expanded to the current population to generate current population profiles. Seventeen profile models were developed from these average customer profiles. The profile models are executed on a daily basis to estimate the settlement day profile (based on actual calendar and weather data). DP&L's daily profiling process is composed of two steps:

1. Prior day and forecasted information is extracted (i.e. weather data) and imported into the profiling system.
2. The profiling models read weather and calendar information and generate a use-per-customer hourly profile for each profile class.

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## Weather Variables

The profile models utilize the following weather variables:

- ***Cooling Degree Hours – 60°F (CDH60)***  
The number of degrees that an hour's temperature is above 60° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 60°F – 24 Hour Moving Average (CDH60\_MA24)***  
The previous 24 hour moving average of the number of degrees that an hour's temperature is above 60° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 60°F – 3 Hour Moving Average (CDH60\_MA3)***  
The previous 3 hour moving average of the number of degrees that an hour's temperature is above 60° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 65°F (CDH65)***  
The number of degrees that an hour's temperature is above 65° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 65°F – 24 Hour Moving Average (CDH65\_MA24)***  
The previous 24 hour moving average of the number of degrees that an hour's temperature is above 65° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 65°F – 3 Hour Moving Average (CDH65\_MA3)***  
The previous 3 hour moving average of the number of degrees that an hour's temperature is above 65° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 70°F (CDH70)***  
The number of degrees that an hour's temperature is above 70° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.
- ***Cooling Degree Hours – 75°F (CDH75)***  
The number of degrees that an hour's temperature is above 75° Fahrenheit. This weather variable gives an indication of how much cooling a building might need on a day that is warmer than normal.

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- ***Heating Degree Hours – 30°F (HDH30)***  
The number of degrees that an hour's temperature is below 30° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 40°F (HDH40)***  
The number of degrees that an hour's temperature is below 40° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 45°F (HDH45)***  
The number of degrees that an hour's temperature is below 45° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 50°F (HDH50)***  
The number of degrees that an hour's temperature is below 50° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 55°F – 24 Hour Moving Average (HDH55\_MA24)***  
The previous 24 hour moving average of the number of degrees that an hour's temperature is below 55° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 60°F (HDH60)***  
The number of degrees that an hour's temperature is below 60° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 60°F – 24 Hour Moving Average (HDH60\_MA24)***  
The previous 24 hour moving average of the number of degrees that an hour's temperature is below 60° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.
  - ***Heating Degree Hours – 65°F (HDH65)***  
The number of degrees that an hour's temperature is below 65° Fahrenheit. This weather variable gives an indication of how much heating a building might need on a day that is colder than normal.

## **Model Format**

The profile classes use the modeling approaches described below:

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- ***Hourly Weather Sensitive Model***

In this modeling approach, a linear regression of historical weather data is run against the generic profiled loads from the load research study. It consists of a series of regression equations expressing the relationship between certain weather variables, seasons, day types and loads. The relationship is a piece-wise linear regression whose parameters are estimated using a search algorithm. The algorithm identifies the optimal breakpoints for the regression lines in order to ensure the best possible statistical fit to the historical load data. For each hourly regression, the model generates load profiles forecasted according to that hour's actual conditions.

- Variables used per profile class:
  - HV01
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75 & HDH60
  - PR01
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, HDH30, HDH40, HDH50, HDH60 & HDH60\_MA24
  - RH01
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday & Saturday
      - Monday – Friday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75, HDH30, HDH40, HDH50, HDH60 & HDH60\_MA24
  - RS00
    - Seasons (Months)

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- January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday & Saturday
      - Monday – Friday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75, HDH30, HDH40, HDH50, HDH60 & HDH60\_MA24
  - RS01
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday & Saturday
      - Monday – Friday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, HDH30, HDH40, HDH50, HDH60 & HDH60\_MA24
  - RS02
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday & Saturday
      - Monday – Friday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75, HDH30, HDH40, HDH50, HDH60 & HDH60\_MA24
  - SC01
    - Seasons (Months)
      - January, February, March, April, May, September, October, November & December
      - June – August (baseline)
    - Days of the Week
      - Sunday/Holiday & Saturday
      - Monday – Friday (baseline)
    - Weather
      - CDH60, CDH65, CDH65\_MA24, CDH65\_MA3, CDH75, HDH40, HDH50, HDH60 & HDH60\_MA24
  - SS00
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December

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- April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75, HDH45, HDH55\_MA24, HDH60 & HDH65
  - SS01
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, HDH40, HDH50, HDH60 & HDH60\_MA24
  - SS02
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75 & HDH60
  - SS03
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, CDH75 & HDH60
  - SS04
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week

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- Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH60, CDH60\_MA24, CDH60\_MA3, HDH45, HDH55\_MA24 & HDH65
  - SS05
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH65, CDH65\_MA24, CDH65\_MA3, HDH40, HDH50, HDH60 & HDH60\_MA24
      - HDH55\_MA24 & HDH65
  - SS06
    - Seasons (Months)
      - January, February, March, May, June, July, August, September, October, November & December
      - April (baseline)
    - Days of the Week
      - Sunday/Holiday, Monday, Friday & Saturday
      - Tuesday – Thursday (baseline)
    - Weather
      - CDH60, CDH60\_MA24, CDH70, HDH40, HDH50, HDH60 & HDH60\_MA24
  - ***12 Season / 3 Day Type Model (No Weather Sensitivity)***

The PS01 profile class uses the 12 Season / 3 Day Type modeling approach. This model does not use any weather variables since the few customers assigned to this class have high consumption and are not very sensitive to changes in weather. The model instead uses 36 regression models for each hour to forecast the kW consumption by month and day type.
  - ***12 Season / 1 Day Type Model (No Weather Sensitivity)***

The SL01 profile class represents street light and outdoor lighting customers. Because these types of customers are not weather sensitive, the profiles use day type models with only seasonal/monthly variables. The model uses 12 regression models for each hour to forecast the kW consumption.
  - ***1 Season / 1 Day Type Model (No Weather Sensitivity)***

The TS01 profile class represents traffic signals. The model for this class uses a constant kW value for each hour that is consistent across all seasons and day types.

### Profile Class Model Formats

Model	Model Format
HV01	Hourly Weather Sensitive Model
PR01	Hourly Weather Sensitive Model
PS01	12 Season / 3 Day Type Model
RH01	Hourly Weather Sensitive Model
RS00	Hourly Weather Sensitive Model
RS01	Hourly Weather Sensitive Model
RS02	Hourly Weather Sensitive Model
SC01	Hourly Weather Sensitive Model
SL01	12 Season / 1 Day Type Model
SS00	Hourly Weather Sensitive Model
SS01	Hourly Weather Sensitive Model
SS02	Hourly Weather Sensitive Model
SS03	Hourly Weather Sensitive Model
SS04	Hourly Weather Sensitive Model
SS05	Hourly Weather Sensitive Model
SS06	Hourly Weather Sensitive Model
TS01	1 Season / 1 Day Type Model

### Generic Interval Class Profiles

Accounts with interval meters are assigned a generic interval class profile according to its voltage level of service. However, a unique profile is established for each interval account to be used for PJM settlements. The unique profile model for load settlements is generated using actual hourly usage history for each account. See below for the list of generic interval class profiles.

<u>Load Profile Class</u>	<u>Code</u>	<u>Description</u>
INT-HIGH VOLTAGE	IHV1	All interval meter high voltage class accounts
INT-PRIM LOW LD FCTR	IPR1	Interval meter primary class accounts with annual average load factors less than or equal 65%
INT-PRIM HI LD FCTR	IPR2	Interval meter primary class accounts with annual average load factors greater than 65%
INT-PRIM SUB	IPS1	All interval meter primary substation class accounts
INT-SEC LOW LD FCTR	ISS1	Interval meter secondary class accounts with annual average load factors less than or equal 65%
INT-SEC HI LD FCTR	ISS2	Interval meter secondary class accounts with annual average load factors greater than 65%