



ENERGY FUTURES DASHBOARD

Constructing Hourly Electricity Demand Profiles for Energy Infrastructure of the Future regions

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Introduction

This documentation describes the process by which we built the hourly electricity demand profiles for each of our 13 Energy Infrastructure of the Future (EIoF) regions. The data used for creating these profiles came from the Energy Information Agency (EIA), the Midcontinent Independent Systems Operator (MISO), and the City of Chicago. Each dataset was cleaned and processed to ensure that all data was compatible including standardizing time zones and removing certain data. The data collected from the EIA and MISO were adjusted from the regions shown in Figures 2 and 4 to create the EIoF regions shown in Figure 1. This was done through a process of scaling down the demand data, based on population, to represent the hourly demand that needed to be adjusted. One example of this is the area of the Texas panhandle. For this, the demand of the EIA Central region was scaled down based on the population in the Texas panhandle. That much demand was then added to our EIoF Texas region hourly demand profile. This process is explained in further detail below. There were a few special cases in which



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supplementary data was used to build the profiles. This was done to help improve the accuracy of the profiles, and those special cases are also explained below.

Data Gathering

The main dataset used in creating the hourly demand profiles for the EIoF regions came from the EIA U.S. Electric System Operating Data tool, and it was downloaded using the EIA's API tool. A single .csv file was created for each of the electrical balancing authorities and EIA electric power regions (link to datasets on EIA website: <https://www.eia.gov/opendata/qb.php?category=2122628>). Each dataset contained the demand for the balancing authority or region, in megawatt hours, and the corresponding year, month, day and hour that demand occurred at. For our purposes, only data from January 1, 2016 to December 31, 2017 were collected. When downloaded, the data series values from EIA's Electric System Operating Data API tool are listed with a Greenwich Mean Time (GMT)/*Coordinated Universal Time (UTC)* date-time stamp value.

Two supplementary datasets were used to help improve the accuracy of the profiles. The first was provided directly by MISO. It contained two .csv files that each contained hourly load data. One of the files contained data for each of MISO's ten local resource zone, while the other contained the same data broken down into local balancing authorities. Both of these files were similar to the ones collected from EIA, containing the demand in megawatt hours for each area and the corresponding year, month, day and hour it occurred at.

The second supplementary dataset used was provided by the City of Chicago through the Chicago Data Portal (link to data: <https://data.cityofchicago.org/Environment-Sustainable-Development/Energy-Usage-2010/8yq3-m6wp>). It contained energy usage data for 2010. The relevant data in this data set was the total kilowatt hours consumed in the city of Chicago for that year. These data were used to scale the hourly demand for PJM Interconnection, LLC, to find the hourly demand for Chicago.



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GIS data were used for adjusting the EIA regions to our EIoF regions. The EIA provided a shape file representing the regions specified by their U.S. Electric System Operating Data. A geodatabase was collected from the U.S. Census Bureau TIGER Database that contained data for area and demographic data for U.S. counties (link to data:

https://www2.census.gov/geo/tiger/TIGER_DP/2016ACS/ACS_2016_5YR_COUNTY.gdb.zip).

These were overlaid with a shapefile of our EIoF regions to calculate how much population existed in areas where an EIA region overlapped with an EIoF region.

Data Processing

The data provided by MISO had to be processed in order to be compatible with our hourly EIA data. The formatting for the dates and hour were adjusted to match the formatting used by the EIA. The hours also had to be converted from Central Standard time to Coordinated Universal Time in order to match the time zone used by EIA. As a consequence of converting the time zones, six hours of data was lost at the very beginning of 2016. The demand data for these hours were left as estimated based on patterns of the following few days. The data was then broken out into individual data sets for each of the local resource zones and one local balancing authority (Montana Dakota Utilities). All of these datasets were saved into a single .rdata file.

After building the final profiles for each of our EIoF regions, some final data cleaning was done to fix errors of erroneous data and remove data for February 29th, 2016. The hours removed for each region to represent this 24-hour period were based on the local time zone for that region (e.g. for the Texas region, the hours for January 29th, 2016 CST were removed).

Constructing the Profiles

The main goal was to build hourly demand profiles for our EIoF regions (Fig. 1) using the hourly demand data provided by the EIA. To do this, we needed to adjust the regions created by the EIA (Fig. 2) into our EIoF regions. Some of the regions were the same for both the EIA



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and EIoF (i.e. New England and New York) and required no adjustments. However, some were more complicated and required the use of supplementary datasets in order to adjust the data more accurately. These supplementary data sets were either used to scale the data for the EIA regions down to a smaller area or provide exact values for hourly demand at a more granular level in some parts of the U.S.

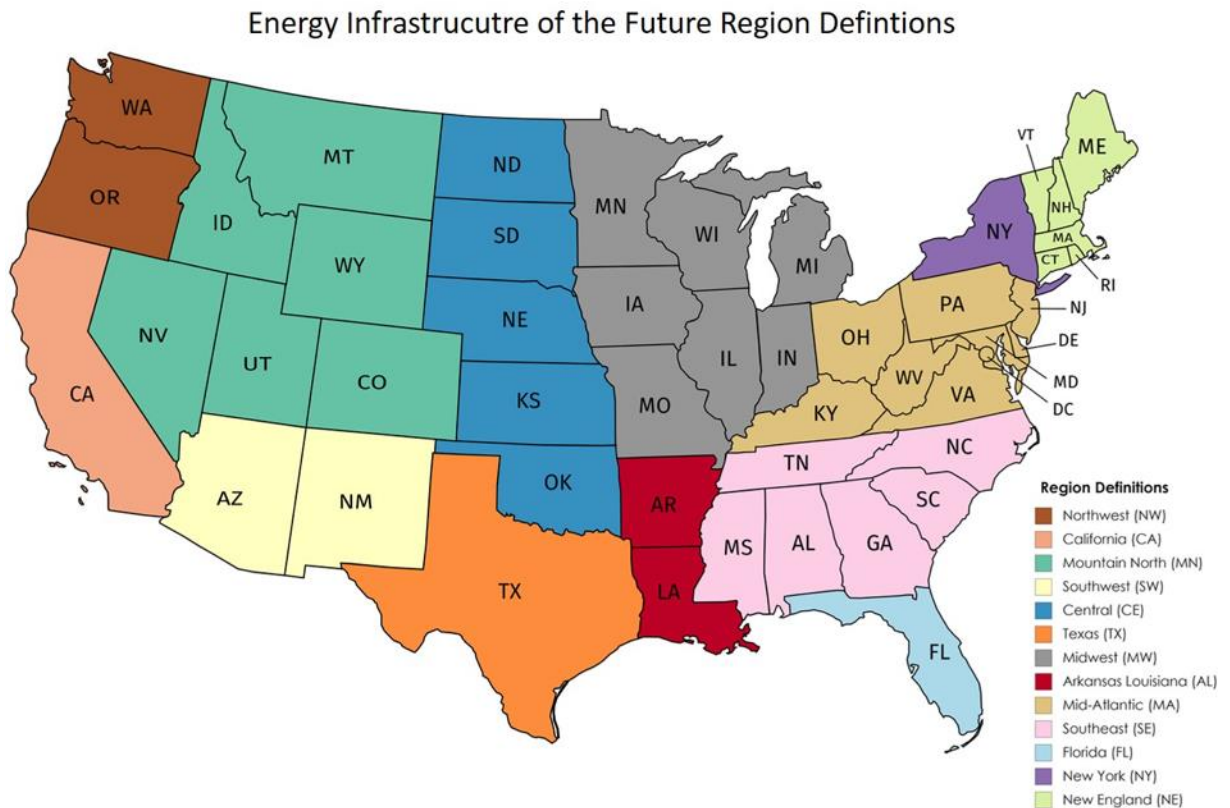


Figure 1. Map of EIoF regions



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U.S. electric power regions



Figure 2. Map of EIA electric power regions

Scaling

In order to determine how much hourly load needed to be adjusted from one of the EIA electric power regions to one of the EIoF regions, the data were scaled by the percentage of the population in an EIA region that overlapped with an EIoF region. To figure out the overlapping population, a map of our EIoF regions was overlaid with the EIA region map and then again with the U.S. counties map. The population of the counties with their centroid in the overlapping area was summed to find the amount of population in any EIA region that is within a given EIoF region. This value was then converted to a percentage of the total population in the EIA region to be used as a weight for adjusting the hourly loads. The demand at each hour for that region was multiplied by the weight to determine the necessary amount of load that needed to be adjusted to the new region.

Example: The EIA specifies the geographic area of ERCOT as one of their regions. However, for our purposes, we were interested in looking at the hourly load for the entire state of



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Texas (one of our EIoF regions). Here is how we determined how much load needed to be adjusted from surrounding regions to get the entire hourly load for Texas

- Of the population in the EIA ERCOT region, 100% of it existed in Texas
 $ERCOT\ Load = EIA\ ERCOT\ Hourly\ Load * 1$
- Of the population in the EIA Southwest region, 7% of it existed in west Texas
 $TX1 = EIA\ Southwest\ Hourly\ Load * 0.07$
- Of the population in the EIA Midwest region, 3% of it existed in east Texas
 $TX2 = EIA\ Southwest\ Hourly\ Load * 0.03$
- Of the population in the EIA Central region, 10% of it existed in north Texas
 $TX3 = EIA\ Central\ Hourly\ Load * 0.1$

$$EIoF\ Texas\ Hourly\ Load = ERCOT\ Load + TX1 + TX2 + TX3$$

This algorithm produced the following demand profile for Texas shown in Figure 3.



Texas Hourly Demand

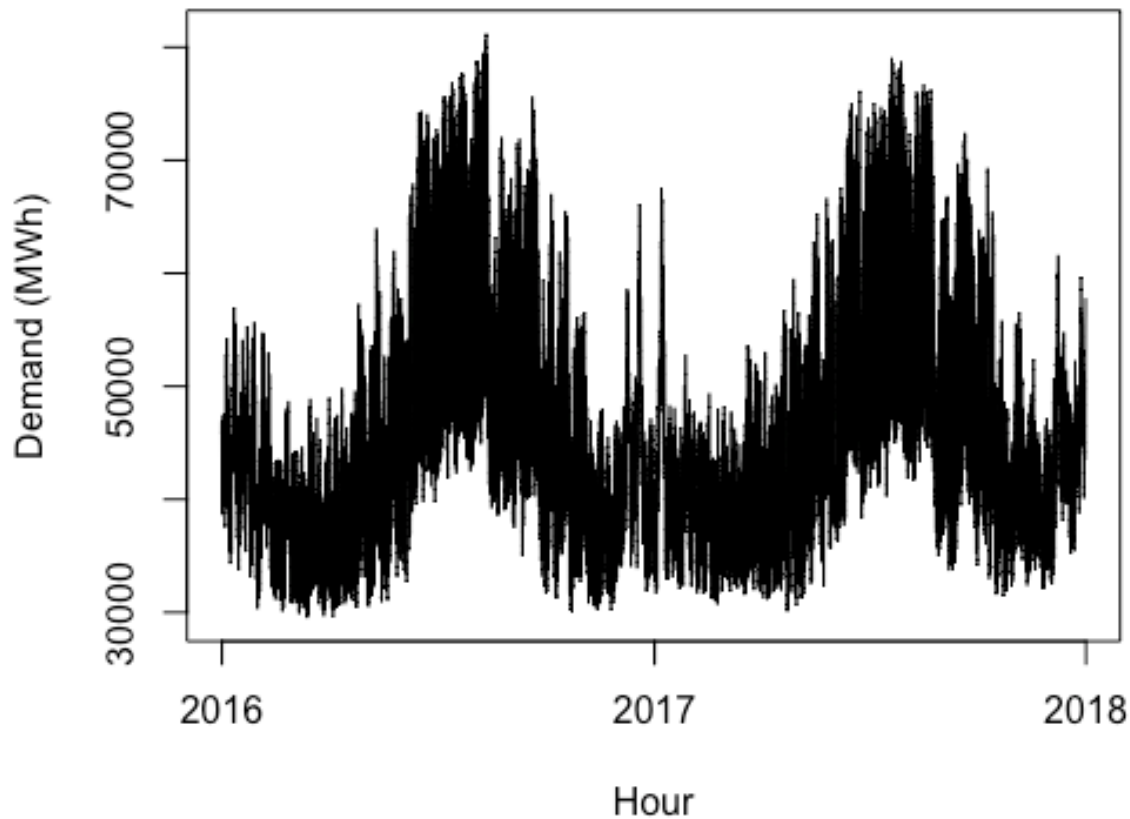


Figure 3. Demand profile for Texas

Special Cases

The EIA Mid-Atlantic region (which contains PJM) also contains the part of the EIoF Midwest region that mainly includes Chicago. In order to find the hourly demand for this area, the profile of the EIA Mid-Atlantic region was scaled by the total consumption (in megawatt hours) of the city of Chicago, for one year, as a percent of the total consumption for the EIA Mid-Atlantic region. This produced a demand profile for Chicago that we could add to our EIoF Midwest region.



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The second special case occurred when adjusting data from the EIA Midwest (MISO) region to our EIoF regions. We were able to gather hourly demand data for each of MISO’s local resource zones and local balancing authorities from MISO. This presented the same hourly data collected from the EIA for MISO in a more granulated format. Figure 4 shows a map of MISO’s local resource zones.

MISO
FERC Electric Tariff
ATTACHMENTS

ATTACHMENT VV
MAP of Local Resource Zone Boundaries
38.0.0

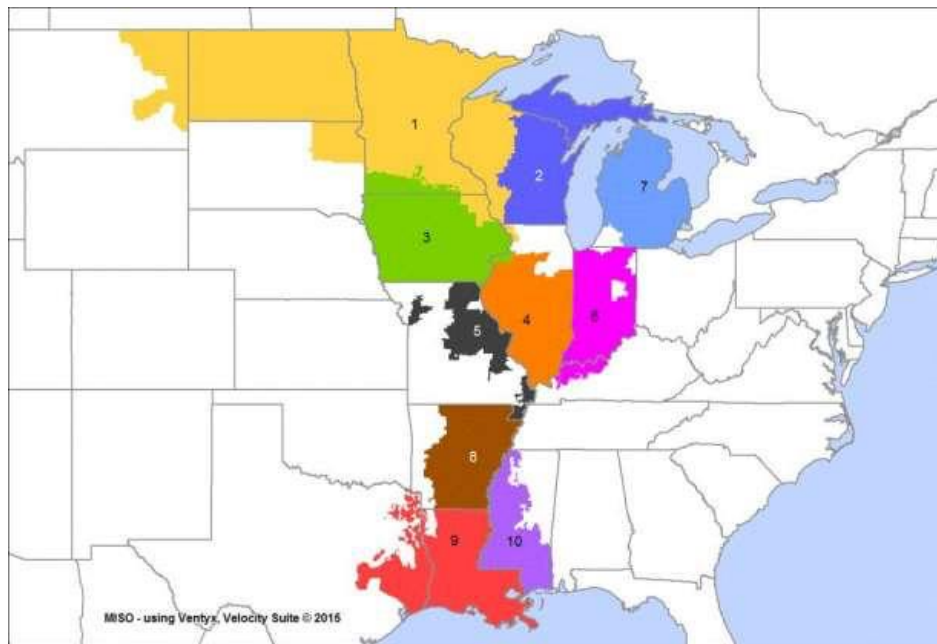


Figure 4. MISO Local Resource Zones

Having this more granulated data allowed us to more accurately build profiles for several of our EIoF regions. Rather than having to approximate the hourly demand in each area by scaling down a larger region, we were able to use exact amounts for these areas. The hourly demand for local resource zone 1 was broken down further using the data provided for the local



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balancing authorities. The hourly demand for Montana Dakota Utilities (MDU) was subtracted from the hourly demand from local resource zone 1 in order to account for the MISO demand in our EIoF Central region.

Table 1 shows a breakdown of the hourly profiles for each of our 13 regions. Each profile is made from a combination of hourly data for independent system operators, balancing authorities, and MISO local resource zones. All calculations done to build these profiles are in the code file *Build_EIoF_Hourly_Profiles_DDG.R*. This program performs the calculations described in the above Texas example and sums the data to build the profile. Each profile is created individually to handle unique challenges and data errors. All of the code files used to build these profiles are listed below with a short description about each one. The data and code files used to build these profiles can be found in the UT Box folder Energy Infrastructure Future/EIoF Hourly Demand Profiles.



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EIoF Region	Components
New England (NE)	New England ISO
New York (NY)	New York ISO
Mid-Atlantic (MA)	PJM + LGEE – City of Chicago
Southeast (SE)	EIA Southeast + TVA + EIA Carolinas + MISO LRZ 10 – 6% of EIA Southeast
Florida (FL)	EIA Florida + 6% EIA Southeast
Arkansas/Louisiana (AL)	MISO LRZ 8 + (MISO LRZ 9 – 3% of EIA Midwest) +10% of EIA Central
Midwest (MW)	AECI + MISO LRZ 2 + MISO LRZ 3 + MISO LRZ 4 + MISO LRZ 5 + MISO LRZ 6 + (MISO LRZ 1 – Montana Dakota Utility) + 14% of EIA Central + City of Chicago
Texas	ERCOT + 7% of EIA Southwest + 3% of EIA Midwest + 10% of EIA Central
Central (CE)	(EIA Central – 36%) + Montana Dakota Utility
Southwest (SW)	(EIA Southwest – 25%) + 2% of EIA Central
California (CA)	EIA California
Northwest (NW)	SCL + TPWR + PGE + PSEI + CHPD + DOPD + GCPD + AVA + BPAT
Mountain North (MN)	EIA Northwest – EIoF Northwest + 18% of EIA Southwest

Table 1. Composition of each EIoF Profile



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Order and description of code files used

1. *EIA_API_Download_Hourly_Demand_DDGR.R*: This R file was used to access the data from EIA using the API. It then organizes the data into individual .csv files for each balancing authority.
2. *Create_BA_rdata_file_DDGR.R*: This R file simply saves all of the .csv files, for the hourly demand of each balancing authority and region, into one .rdata file.
3. *Organize_MISO_Data_DDGR.R*: This R file takes in the secondary, MISO datasets, and processes them into a format compatible with the data collected from EIA.
4. *Build_EIoF_Hourly_Profiles_DDGR.R*: This R file takes in all of the final datasets and uses them to build the EIoF hourly profiles.

GIS Files

1. *ACS_2016_5yr_County.gdb*: The geodatabase was collected from the United States Census Bureau. From this geodatabase, the ACS_2016_5YR_COUNTY feature class was used to map the counties of the United States. The population of each county was pulled from the X00_COUNTS table.
2. *EIA930_Regions_20160506_WGS84.shp*: This is a shape file provided by the EIA that maps the U.S. electric power regions shown in Figure 2.