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2011 TECHNICAL REPORT

Vehicle-to-Grid (V2G) Data Dictionary

A Resource for Acquiring Data on V2G and Related Fields

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PRODUCT DESCRIPTION

This data dictionary describes where to find specific data related to the vehicle-to-grid (V2G) infrastructure and its relationship to renewable energy sources, energy storage, and vehicle and electricity usage. Four sections of data listings are presented: renewable energy, vehicle usage, energy storage, and electricity usage; each section describes several available data sets in each field. This report provides a resource for continuing research in these fields and lists data sources related to integrating limited energy storage (LES) devices that provide ancillary services into the grid with renewable energy sources.

Results and Findings

The data sets listed in this report will serve as a source for research in electric transportation, renewable energy, controllable loads and storage, and related sectors.

Challenges and Objectives

This report is designed for technical researchers interested in using data on plug-in electric vehicles (PEVs) and/or renewable energy to develop new ideas and methods for integrating these new technologies into the electricity grid. The data should be useful for all companies or groups in the power industry.

Applications, Value, and Use

As time progresses, the electricity grid and the role of renewable energy and PEVs within the grid will continually be changing. The relevance of the data in this report is therefore time-dependent.

EPRI Perspective

Such a data dictionary does not currently exist, and this report will serve as a resource not only for Electric Power Research Institute (EPRI) staff, but also researchers in similar fields.

Approach

The goal of this report is to create a resource for researchers looking for data in one of the covered topics. The data were collected through online databases and conversations with personnel in the field.

Keywords

Electric vehicle
End use electricity usage
Energy storage
Plug-in electric vehicle
Renewable energy

ABSTRACT

This report serves as a resource for research in the electricity industry and related fields. It includes detailed descriptions of relevant data sets in several areas: renewable energy, vehicle usage, energy storage, and electricity end use. This data dictionary compiles a list of useful data sets into one resource, so that those looking for data can reference this report to find what is available for their research. Each data set is useful for a different level of research; for instance, some are extensive and formatted best for complex data analyses, while other data sets are smaller and best analyzed through observation. The usefulness and format of the data are explained to make it easy for readers to find desired information.

TABLE OF ACRONYMS

Acronym	Description
AVTA	advance vehicle testing activity
CAISO	California Independent System Operator
COOP	Cooperative Observer Program
CRR	congestion revenue rights
CSV	comma separated values
DOE	Department of Energy
EPRI	Electric Power Research Institute
ESVT	energy storage valuation tool
EWITS	Eastern Wind Integration and Transmission Study
GHCN	Global Historical Climate Network
GIS	geographic information system
GW	gigawatts
HEV	hybrid electric vehicle
HVAC	heating, ventilating, and air conditioning
INL	Idaho National Laboratory
ISD	integrated surface data
ITS	Institute for Transportation Studies
LES	limited energy storage
LECG	Law and Economic Consulting Group
MB	millibars
MW	megawatts
NCDC	National Climate Data Center
NERC	North American Electric Reliability Corporation
NHTS	National Household Travel Survey
NNDC	National Oceanic and Atmospheric Administration (NOAA) National Data Center
NREL	National Renewable Energy Laboratory
NWP	numerical weather prediction
OASIS	open access same time information system
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle
PG&E	Pacific Gas & Electric
SCE	Southern California Edison

Acronym	Description
SDG&E	San Diego Gas & Electric
SRRS	service records retention system
WBAN	Weather Bureau, Air Force, Navy

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1
INTRODUCTION

This data dictionary serves as a resource for research in the electricity industry and related fields. What follows is a detailed description of relevant datasets in a number of different areas, including Renewable Energy, Vehicle Usage, Energy Storage, and Electricity End Use. The purpose of this data dictionary is to collect a list of useful datasets in one place, so that those looking for data can reference this document to find what is needed for their research. Each dataset is useful for a different level of research; for instance, some datasets are extensive and formatted best for complex data analyses, while others are smaller and best analyzed through observation. We attempt to explain the usefulness and format of each data so that it is easy for readers to find what they are looking for.

Each dataset description will first describe the usefulness of the data, i.e., for whom it is useful and what it contains. This is the first and probably most important part of the description. We then explain how the data can be obtained. The format of the data is also described in detail, including the type of file, and how the data is laid out. Lastly, the fields of the data are listed in table format, which contains the title of each field, the format of its elements, and what each field means.

2
RENEWABLE ENERGY DATA

The following datasets provide information on climate and renewable energy sources. This data is useful for analyzing the contribution and integration of renewable energy to the electricity grid.

Climate Data: National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) has a large collection of climate data from locations all over the world; specifically, the NOAA National Data Center (NNDC) has a dataset that contains global surface wind and precipitation measurements.

Usability

This data is useful for information on mean temperatures and wind speeds over time, and is based on the hourly observations contained in United States Air Force (USAF) surface wind data and Federal Climate Complex Integrated Surface Data (ISD). There is data from most stations from 1973 to the present, and the data from many stations starts from 1929. For each site, there is a variety of datasets, each of which provides the same wind speed measurements averaged over different time steps: hourly, daily, or monthly.

The data that summarizes the measurements over each day and month is free, however there is a charge for hourly data (approximately $6, but depends on the dataset).

Obtaining the Dataset

The data can be obtained from the website:
http://www7.ncdc.noaa.gov/CDO/cdo

Here, specific data can be found for a given location and time period. From this website, one can navigate to the global summary of the daily surface data, and choose a region/station and a given date range.

Format

The format of the data file can be chosen (space or comma delimited, or XML), and is output to a text file. There are 16 fields of measurements, with one row for each time step (hour, day or month) in the date range.

Fields

The data consists of the following 16 fields, with one measurement for each hour, day or month.

Table 2-1
NOAA Climate Data Fields

Field	Description	Data Type/Units
Station Number	Assigned by the National Climate Data Center	6-digit alphanumeric number; first two digits represent the state code (value range is 01-91), and last four represent the Cooperative Network Index number (value range is 0001-9999).
Weather Bureau, Air Force, Navy (WBAN)	Assigned by the National Climatic Data Center; it originally referred to the Weather Bureau, Air Force, Navy station, and thus may have more detailed data available than stations without this identification	5-digit alphanumeric identification number
Date	Year, month, and day	8-digit number; for instance, 20100801 represents August 1, 2010.
Mean Temperature	Mean temperature for the given day	0.1 precision, Fahrenheit
Mean Dew Point	Mean dew point for the day	0.1 precision, Fahrenheit
Mean Sea Level Pressure	Mean sea level pressure for the day	0.1 precision, millibars (mb)
Mean Station Pressure	Mean station pressure for the day	0.1 precision, mb
Mean Visibility	Mean distance for the day at which an object can be clearly seen	0.1 precision, miles
Mean Wind Speed	Mean wind speed for the day	0.1 precision, knots
Maximum Sustained Wind Speed	Maximum wind speed averaged over a 10 minute for the day	0.1 precision, knots
Maximum Wind Gust	Maximum short burst of high speed wind for the day	0.1 precision, knots
Maximum Temperature	Maximum temperature	0.1 precision, Fahrenheit
Minimum Temperature	Minimum temperature	0.1 precision, Fahrenheit
Precipitation Amount	Total precipitation reported during the day	0.01 precision, inches
Snow Depth	Snow depth	0.1 precision, inches
Indicator of Storm Occurrence	Indicates whether there is: Fog, Rain or Drizzle, Snow or Ice Pellets, Hail, Thunder, of Tornado/Funnel Cloud	1=yes or 0=no

Power Technologies Energy Data: National Renewable Energy Laboratory

The National Renewable Energy Laboratory (NREL) provides a *Power Technologies Energy Data Book*, which contains many datasets and statistics on power technologies. There are several different energy technologies covered in this data, and for each technology there is a profile describing basic information and introductory material, as well as data on the production amounts of each every 10 years or so.

Usability

This data provides basic information on electricity supply, capability, generation, and demand, as well as some related fields. For each of these statistics, there are measurements on the following technologies: Biopower, Geothermal Energy, Concentrating Solar Power, Photovoltaics, Wind Energy, Hydrogen, Advanced Hydropower, Solar Buildings, Reciprocating Engines, Microturbines, Fuel Cells, Batteries, Advanced Energy Storage, Superconducting Power Technology, and Thermally Activated Technologies.

It is important to note that the data is very general, and provides one measurement (or prediction) for every 10 years or so; there are measurements for the years: 1980, 1990, 2000-2004, and predictions for the years: 2010, 2015, 2020, 2025 and 2030. Thus, it can really only be used to give a general understanding of the production and consumption in these fields in a year's time, and how they have progressed over the years. This data is not ideal for complex data analysis or for getting a detailed description of production quantities.

Obtaining the Dataset

The data book can be found at:
http://www.nrel.gov/analysis/power_databook/

Here, it can be downloaded as a PDF document, or read directly from the website. There are four different editions, from the years 2003, 2004, 2005 and 2006, and the older editions can also be accessed via the website.

Format

There are 12 main sections, each of which contains data and information for the years listed above, ranging from 1980 to 2030. The future data is predicted using techniques described in the data book. The 12 chapters are contained in the data book are listed below in Table 2-2.

All data can be downloaded as either an Excel (.xls) or PDF (.pdf) file. There is not much data, only 12 measurements for each field. Therefore, its main use is for a getting a general idea of the statistics, as opposed to data analysis and calculations, and it may not be necessary to download an Excel file when the PDF gives the same information.

Table 2-2
NREL Power Technologies Data Book Chapters

Chapter	Description
Technology Profiles	Gives a 2-3 page description and introduction to each energy technology (i.e., biopower, geothermal energy, etc.)
Electricity Restructuring	Discusses the funding and policy in each state for renewable projects
Forecasts/Comparisons	Projections of net renewable capacity, generation, and CO_2 emissions savings given the projected construction of new renewable energy sources
Electricity Supply	Gives overviews of supplied energy (in units such as Quadrillion Btu or Billion Kilowatt hours) for various power producers and utilities
Electricity Capacity	Electricity capacity for summer and full year (in Gigawatts or Megawatts)
Electricity Generation	Net generation for different plants and losses (in billion Kilowatt hours)
Electricity Demand	Electricity Sales, Revenue, and Consumption by census division and state
Prices	Overview of prices of electricity, fuel, production, operation and maintenance
Economic Indicators	Consumer prices and generator revenue that indicate market behavior
Environmental Indicators	Emission levels from various generators
Conversion Factors	Rates and factors, such as energy impact calculations, coal-displacement calculations, emissions factors, and heat rates
Geographic Information System (GIS) Maps	A GIS allows the user to manage, manipulate, and analyze data in graphic or report form. These maps illustrate things such as renewable resources and installed generating capacity

Fields

The fields vary for the different topics. However, there are measurements/predictions for each year and technology on the following topics.

1. Technology Profile
2. Electricity Restructuring
3. Forecasts/Comparisons
4. Electricity Supply
5. Electricity Capacity
6. Electricity Generation
7. Electricity Demand
8. Prices
9. Economic Indicators
10. Environmental Indicators
11. Conversion Factors
12. Geographic Information System (GIS) Maps

Climate Data: National Climate Data Center

The National Climate Data Center (NCDC) has a large amount of data on weather model output and input datasets, and climate model datasets. The data provided by the NCDC includes historical data from online and offline repositories, as well as model forecast data. The data comes in a variety of formats, including plots, maps, and standard tabular text.

Usability

The most useful data from the NCDC seems to be their "free data," which can be accessed by clicking on the *Free Data* link. This data is not only free of charge, but provides standard format datasets on, for example: daily temperature and precipitation, long-term climatic averages, severe weather reports, wind data, and surface data. These data are very useful for analyses of weather impacts for different time periods in various locations (mostly around the United States), including data on wind, storms, temperature, precipitation, freeze/frost levels, and heating/cooling updates.

Obtaining the Dataset

The following site links to a large number of NCDC free datasets on climate in various areas: http://www.ncdc.noaa.gov/oa/mpp/freedata.html

From this site, one has access to the datasets listed in Table 2-3.

Format

The website has several different datasets. Each one provides different information and is in a unique format. Table 2-3 lists and describes each dataset.

Table 2-3
Datasets

Dataset Title	Description
Regional Climate Center & National Weather Service Online Products	Various maps of the United States that show present measurements across the states, such as temperature, air quality, and water forecasts.
COOP (Cooperative Observer Program) Data / Record of Climatological Observations, U.S.	Historic Meteorological Records – some date back to around 1900, and some have current data, but the date range differs for each location. All files are scanned in, and can be downloaded in PDF format.
1971-2000 U.S. Climate Normals Products	Data on climate statistics (i.e., mean, maximum, and minimum) for different regions across the U.S. for the years 1971 to 2000; the statistics are reported for each month of the given year. Data can be selected by region, and downloaded in PDF format.
Climate Maps of the United States	Provides colorful maps for the United States that illustrate temperature, precipitation, snow, wind, pressure, etc. Most of the maps contain data from the date range 1961-1990, and can be downloaded in PDF format, or as ESRI Shape Files.

Table 2-3 (continued)
Datasets

Dataset Title	Description
Storm Data Publication/Database	Provides a list of storms in a given state and region in the United States, during a given date range. The lists include all weather events from 1993-present, and all thunderstorms and hail from 1955-1992, tornadoes from 1950-1992.
Climatic Wind Data for the U.S. through 1996	This data is from the NCDC's Local Climatological Data publication, Navy & Air Force climatic briefs, and other sources. The data for most locations is from the time period 1930-1996. For each location and each month, the table provides prevailing wind directions (DIR) in compass points, mean wind speeds (SPD) and peak wind gust (PGU) in miles per hour (mph). All the data is provided in a single downloadable PDF document, in which the data is sorted by state and region within each state.
Cooperative Climatic Data Publication	This publication provides statistics for given regions in the United States, for a specific number of years; the number of years for which measurements have been taken is part of the data, and differs for each region. The years range from as early as 1873 to 2011. The data is downloadable as a table, i.e., a space delimited document. For each of the following observed fields, a measurement is reported for each month: highest and lowest record of temperature, mean number of days with a maximum temperature of at least 90°F, mean number of days with a minimum temperature of at most 32°F, mean number of days with a precipitation of at least 0.01 inches, mean snowfall in inches, mean and maximum wind speed (mph), mean percent of possible sunshine, mean number of cloudy days, and mean relative humidity. For each of the following fields, the normal value is reported for each month: daily maximum, minimum and mean temperatures (in °F), heating and cooling degree days, and precipitation (in inches).
SRRS (Service Records Retention System) Weather Maps/Charts	Provides charts in a GIF file of the analysis and forecasts of US weather over land and water, i.e., provides heights, temperature and wind patterns.
Historical Significant Events Imagery	Colorful images of significant storms, such as Hurricane Katrina or the Great Indonesia Tsunami.
Heating/Cooling Degree Day & Temperature / Precipitation Updates	This publication can be downloaded as a PDF document, and provides monthly data on current heating fuel and cooling demand for each state in the US; population is based on the 2000 census weights the data. Each measurement gives the number of degree days per month.
Surface Data- Global summary of the Data	The climate data provided by the National Oceanic and Atmospheric Association, as described above.
Climates of the World	This is a PDF document that describes in detail the climates of different places around the world. It was written in 1969, and slightly revised in 1991. It includes maps that illustrate temperatures and precipitation, and statistics on monthly and annual temperatures and precipitation for approximately 800 stations around the world.
U.S. Historical Climatology Network	The U.S. Historical Climatology Network (USHCN) provides this data. It includes the mean monthly measurement of the maximum, minimum, and mean temperature and the total monthly precipitation. The data is collected from around 1200 stations around the United States, from the COOP. The period for which the measurements are taken varies for each station, but in general includes the years1900-1995.

Table 2-3 (continued)
Datasets

Dataset Title	Description
Surface Data- Global Historical Climate Network (GHCN)	The GHCN provides this database containing historical temperature, precipitation, and pressure data for thousands of land stations worldwide. The time period of measurement varies for each station, with most of them dating back to 1950. The data can be downloaded via FTP (file transfer protocol) from the website in an ASCII file, and includes temperature and precipitation for various locations. Each downloadable file contains different data in a different format, but each includes a Readme file that describes the layout.
Freeze / Frost Data	This data is downloadable in PDF format, as a table listing the occasions when the probability of freezing or frost reaches a certain level in each region, in each state, in the US.

Fields

The fields for each dataset vary based on the measurements.

Eastern Wind Integration and Transmission Study: National Renewable Energy Laboratory

The National Renewable Energy Laboratory (NREL) conducted the Eastern Wind Integration and Transmission Study (EWITS) 0. NREL started collecting data in 2008 in order to answer system operator questions about integrating 20-30% of wind energy into the grid. The data include three years of modeled time-series wind speed datasets; there are reports analyzing the integration and transmission of the energy given the modeled wind energy.

Usability

The data is ideal for analysis, and the reports and analysis share a good understanding about what it means to integrate 20-30% wind into the system.

Obtaining the Dataset

The dataset can be downloaded from the website:
http://www.nrel.gov/wind/systemsintegration/ewits.html

Format

The data consists of 10-minute wind speed values for 1,326 simulated wind plants from 2004-2006, on top of next-day, six-hour, and four-hour forecasts. There are data files for each state, as well as a data file for describing each site; both are downloadable as Excel (.xls) files.

Fields

The data for each state includes the megawatts (MW) produced during each 10-minute period; the data on each site (the file called EWITS_selected_sites.txt), has the following fields listed in Table 2-4.

Table 2-4
EWITS Data Fields

Field	Description	Data Type / Units
Site Number	Site identification number	Integer, range: 1-7856
State	Name of state where site is located	String
Longitude and Latitude	Location in latitude and longitude	Float pair
Elevation	Elevation above the ground	Integer, in feet
Area	Area of wind plant	0.1 precision, in square kilometer (km^2)
Density	Density	0.1 precision, in megawatts per square kilometer (MW/km^2)
Total MW for site	Total megawatts produced at the site	0.1 precision, in MW

Western Wind and Solar Integration Study: National Renewable Energy Laboratory

The National Renewable Energy Laboratory (NREL) assisted 3TIER (a renewable energy company) in using Numerical Weather Prediction (NWP) to model weather for the western United States for the three year period 2004-2006. Samples are taken from the weather model to determine the wind speed every 10 minutes, and spatial samples are taken about every 2 kilometers. The samples are taken at 32,043 sites, providing a total of more than 960 gigawatts (GW).

Usability

The data is most easily accessed when there is a specific site for which data is needed. One can either find the site on the map (that is found on the website listed in the next subsection below), or enter the identification number of the site. This leads to a closer view of the site on the map, with some basic statistics on the site (the same as those listed in Table 2-4), and a link to download the 10-minute wind speed data.

Obtaining the Dataset

The dataset can be downloaded from the website:
http://wind.nrel.gov/Web_nrel/

Format

The data consists of 10-minute wind speed values for each of the 32,043 sites from 2004-2006, on top of next-day, six-hour, and four-hour forecasts. There are data files for each site, for each measured year, which are downloadable as Excel (.xls) files.

Fields

The data for each site includes the following fields at each 10-minute period for the entire year.

Table 2-5
WWSIS Data Fields

Field	Description	Data Type/Units
Site ID Number	Site identification number	Integer, range: 1-32043
Longitude and Latitude	Location in latitude and longitude	Float pair
Power Density	Power Density	0.001 precision, in watts per square meter (W/m^2)
Statistical Correction to Output from a Record Extension (SCORE) capacity factor	Correction technique to ensure wind speed variation at short timescales	0.001 precision, percentage (%)
Wind Speed	Wind Speed at 100 m	0.001 precision, in meters per second (m/s)
Elevation	Elevation above the ground	Integer, in meters (m)
State	Name of state where site is located	String
Rated Power Output	Rated Power Output at 100 m	0.001 precision, in megawatts (MW)
SCORE-lite power output	SCORE-lite power output at 100 m	0.001 precision, in megawatts (MW)

Wind Production Data: TradeWind Study, Intelligent Energy Europe

The TradeWind Study is a European project conducted by *Intelligent Energy Europe*, which is a part of the European Energy Commission. The study was used to prioritize projects for an environmentally smarter Europe. The main findings are that wind power is not constrained by technology limitations, but instead by regulatory, institutional, and market barriers. There is weak interconnection between the control zones, and a fragmented European energy market, that makes the integration of wind energy more difficult. Further, the current transmission system is insufficient to avoid bottlenecks.

Usability

The main results of the study are compiled into a final report, which can be obtained from the link in the following subsection. The actual data used for the analysis was the *Reanalysis Data*, which is provided by the National Oceanic and Atmospheric Administration (NOAA); the data samples wind data every three hours, for at least five years. This data is provided as Numerical Control (.nc) files, which are map-like image files; these data are thus difficult to use for analysis, and ideal for viewing and observing. They give a general idea of the wind, pressure, and/or surface data for a given location.

Obtaining the Dataset

The publications can be obtained from the website:
http://www.trade-wind.eu/

Format

The datasets are provided as Numerical Control files (described above). However, there is a final report that contains an analysis of the results. The project used data produced by Garrad Hassan & Partners (a renewable energy consultancy company), which converted the *Reanalysis Data* from Numerical Control files into a Matlab database. However, this database is not available online.

3
VEHICLE USAGE DATA

The following datasets are useful for analyzing the impact and integration of Plug-in Electric Vehicles (PEVs) into the grid, including the driver behavior and PEV design characteristics.

National Household Travel Survey Data: Department of Transportation

The National Household Travel Survey (NHTS) produces a dataset every 5 to 7 years that represents an inventory of the nation's travel behaviors. Data is collected from people's answers to questions about all trips during a 24-hour period, in all areas of the country, from a large range of people. This data is mainly used to study and quantify travel behavior over time.

Usability

The data for each trip includes its properties, information on the characteristics of drivers and households, a vehicle description, information about the geographic area, the typical number of trips per day, and information about telecommuting and Internet use. There is no information on cost of travel, types of roads used, or reasons for choosing a certain method of transit.

This dataset is created for use in analysis and getting a detailed perspective on driving habits; it is not ideal for devising a general model of driving habits. This is mainly because the data is extremely large, and thus difficult to analyze by observation.

Obtaining the Dataset

The data can be downloaded from:
http://nhts.ornl.gov/

It is available in any of the following formats: SAS Windows Binary, SAS Transport, Dbase.dbf, ASCII.csv. There are four files to be downloaded: data sorted by vehicle, by household, by day and by person.

Format

The data is very large and rather unclean (for example, a number of fields are missing for quite a few of the subjects), which makes it somewhat difficult for analysis or use in obtaining statistics; however it contains a large amount of information. The vehicle data has 309,163 and 41 columns, the day data has 568,469 rows and 87 columns, the household data has 150,147 rows and 33 columns, and the person data has 324,184 rows and 88 columns.

Fields

The data in each file describes the same set of interviewees, but may contains different information about their trips. Each file contains the ID number of the vehicle, person, and/or household for each trip, so that the information among the files can be compared. Each data file contains the following information for each trip:

1. Purpose
2. Means of transportation used (i.e. car, bus, subway, walk)
3. Travel time
4. Time of day
5. Day of week
6. If a private vehicle trip:
    a. Number of people in vehicle
    b. Driver characteristics (i.e. age, sex, worker status, education level)
    c. Vehicle attributes (i.e. make, model, year, amount of miles driven in a year).

Driver Behavior Papers: UC Davis Institute for Transportation Studies

There are a number of papers written by the Institute for Transportation Studies (ITS) at the University of California Davis that analyze the charging behavior of owners of Plug-in Electric Vehicles (PEVs).

Usability

The actual data upon which these papers are based is not actually provided, and the papers are not very technical. These papers tell a story and document the feelings of the drivers, more than reporting their exact charging behavior. They are ideal for giving a general sense of how consumers prefer to charge their vehicles, but not usable for detailed analysis of charging behavior.

Obtaining the Dataset

The main two papers on this topic are:

K. Kurani, R. Heffner, and T. Turrentine. Driving Plug-In Hybrid Electric Vehicles: Reports from U.S. Drivers of HEVs converted to PHEVs, circa 2006-07. UC Davis, July 2008.

and

J. Axsen and K. Kurani. Interpersonal Influence within Car Buyers' Social Networks: Five Perspectives on Plug-in Hybrid Electric Vehicle Demonstration Participants. UC Davis, August 2009.

Both can be found at the website:
http://www.its.ucdavis.edu.

Format

These documents are white papers written by and for non-technical researchers. They include short inserts that tell a story about some of the drivers, and their opinions on charging.

Vehicle Testing Data: Idaho National Laboratory

The Idaho National Laboratory (INL) has done research on Advanced Vehicle Testing Activity (AVTA) that provides insight about real-world vehicle performance.

Usability

The majority of the data on the site is provided in short PDF documents that provide the usage patterns, specifications, and fuel economy for vehicles. This is useful for getting a general idea of the characteristics and fuel efficiency of different vehicles, but is not useful for detailed analysis.

Obtaining the Dataset

Data can be found on their website in the form of PDF documents that describe the usage patterns and capabilities of Plug-in Electric Vehicles (PEVs), Hybrid Electric Vehicles (HEVs), neighborhood electric and hydrogen fueled vehicles: http://avt.inel.gov/.

Format

The data are obtainable in PDF documents, in order to view the data but not analyze it. Most of the documents have a format that includes listing the vehicle specifications, test results and fuel economy; there are also plots that show the fuel economy after a cumulative distance. There are data for vehicles of each of the following types:

Table 3-1
Vehicles

Size	Type
Light-Duty Fleet	Plug-in Hybrid Electric
	Hybrid Electric
	EVProject
	Hydrogen Internal Combustion Engine
	Full Size Electric
	Neighborhood Electric
	Urban Electric
Medium & Heavy Duty Fleet	Diesel Engine Idling
	Oil Bypass Filtration Evaluation
	Electric Ground Support Equipment

Fields

On top of vehicle specifications and test results, the data includes information such as the fuel economy, distance traveled in charge depleting and/or sustaining mode, and percentage of charging done during different time periods.

Plug-in Hybrid and US Light Vehicle Data: Department of Energy

The United States Department of Energy (DOE) worked with the LECG Corporation (Law and Economics Consulting Group) to put together the data book, *US Plug-in Hybrid and US Light Vehicle Data Book,* which consists of a collection of information (publications, reports and newsletters) on Plug-in Hybrid Electric Vehicles (PHEVs).

Usability

The data book provides 46 documents, published from 1999 to 2010, and is most useful for either getting a general sense of the research that has been done with PHEVs, or for finding a report on a given topic related to PHEVs.

Obtaining the Dataset

The list of publications can be found at the website:
http://www.afdc.energy.gov/afdc/vehicles/plugin_hybrids_publications.html.

On the site, there is a list of the titles of the papers, which link to each PDF document.

Format

This data book includes reports on all existing PHEVs, their current battery technologies, daily vehicle travel, light-duty vehicle sales response to increased fuel costs, and light-duty vehicle sales trends. Each is report is a conference paper, brochure, report, fact sheet, plan, milestone, presentation, or abstract, and can be downloaded in PDF format.

4
ENERGY STORAGE

The following datasets provide information on energy storage devices, their characteristics, and their potential impact on the electricity grid.

Energy Storage Valuation Tool: Electric Power Research Institute

The Energy Storage Valuation Tool (Version 2.0) evaluates the costs and benefits of a wide range of energy storage devices based on a set of user-entered parameters, resulting in an estimate of the maximum price and value at which a storage system could produce positive net benefits. The tool contains a preloaded set of default utility system parameters and energy storage device performance characteristics, and also allows users to save a case they have entered for evaluation.

Usability

The Energy Storage Valuation Tool is a Microsoft Excel-based tool that allows the user to evaluate the cost and benefit of an energy storage system at the customer site, or on the utility system at the distribution, transmission, or generation levels. It models the charging and dispatch of the storage device using an algorithm optimizing the net benefit of the system, based on an energy-related value stream, and it models how such benefits would be shared between the utility and a retail customer, if the system is located at the customer site, based on the retail rate design.

Obtaining the Dataset

The software can be obtained off the EPRI website:
www.epri.com

The software tool product number is 1013749.

Format

The energy storage valuation tool is contained in a Microsoft Excel workbook, and requires a working copy of the Microsoft Excel 1997, 2000, or 2003 application running on a Windows operating system such as Windows 2000 or Windows XP, or on Macintosh OSX. The model contains macros and is approximately 11 MB in size, so it is best operated on a computer with 512MB or more of RAM.

Battery Basics: BatteryUniversity.com

BatteryUniversity.com is an online tool for learning about battery technology. The information on the site is based off the book *Batteries in a Portable World- A Handbook on Rechargeable Batteries for Non-Engineers*.

Usability

This site is useful for obtaining a general understanding of battery technology; various types of batteries are introduced and explained. The format of the site also allows for finding a specific battery topic and reading a chapter on that topic.

Obtaining the Dataset

The information is available on the website:
http://www.BatteryUniversity.com

Format

On the website, there are three main sections of information; the following lists the chapters and their general subsections.

1. Part One: Basics You Should Know
    a. Battery History
    b. Battery Types
    c. Norms and Packaging
    d. Charge Methods
    e. Discharge Methods
    f. "Smart" Battery
2. Part Two: The Battery and You
    a. From Birth to Retirement
    b. How to Prolong Battery Life
    c. Battery Testing and Monitoring
3. Part Three: Battery as a Power Source
    a. Battery Applications
    b. Cost Comparisons
    c. The Hunger for Energy
    d. Information

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ELECTRICITY USAGE DATA

The following datasets are relevant to the amount of electricity used by consumers. This is useful for analyzing the system, and how Limited Energy Storage (LES) devices can affect the system.

Power Systems Test Case Archive: University of Washington

The University of Washington has put together a collection of data on Power System Test Cases.

Usability

This data mostly provides historical data on buses and dynamic test cases. It is downloadable in common data format, bus diagram, or 600 DPI TIFF diagram, and is meant to give a general idea of the results from the test cases.

Obtaining the Dataset

The data can be downloaded from the website:
http://www.ee.washington.edu/research/pstca/

This web page contains links to a number of different test cases, depending on the desired information.

Format

The several different test cases with data are documented are listed in Table 5-1. The IEEE Common Data Format (CDF) is described in the paper “Common Data Format for the Exchange of Solved Load Flow Data,” in the November/December 1973 IEEE journal Transactions on Power Apparatus and Systems, Volume PAS-92, No. 6.

Table 5-1
Power System Test Cases: University of Washington

Name of Test Case	Data Included
14 Bus	IEEE common data format (.txt), scanned 300 bus diagram (.jpg), 600 DPI TIFF diagram
30 Bus	IEEE common data format (.txt), scanned 30 bus diagram (.jpg), 600 DPI TIFF diagram
57 Bus	IEEE common data format (.txt), scanned 57 bus diagram (.jpg), 600 DPI TIFF diagram
118 Bus	Data in PECO PSAP format (.txt), IEEE common data format (.txt), scanned 118 bus diagram (.jpg), 600 DPI TIFF diagram
300 Bus	IEEE common data format (.txt), data in PTI format (.txt), scanned 300 bus diagram (.jpg), 600 DPI TIFF diagram
17 Generator (with 162 bus power flow case)	162 bus solved power flow in IEEE common data format (.txt), classical dynamic data for 17 generator system (.txt)
30 Bus "New England" Dynamic Test Case	30 bus dynamic data (.txt)
50 Generator (with 145 bus power flow case)	145 bus solved power flow in IEEE common data format (.txt), classical dynamic data for the 50 generator system (.txt), exciter data for the 50 generator system (.txt)

Commercial, Residential and Industrial End Energy Use Data: Electric Power Research Institute

The Electric Power Research Institute (EPRI) conducted a study of the energy use of commercial, industrial, and residential end uses of electricity.

Usability

The EPRI report that analyzes this data is entitled *Commercial Building Energy Efficiency and Efficient Technologies Guidebook*, with the Product ID Number 1016112. This document explains the intentions of the work—mainly determining how each sector uses electricity and how this information can be used to help them use electricity more efficiently. It details the end use of appliances in certain environments, and can be used to get a basic understanding of the energy use intensity of appliances in different environments (i.e. commercial, residential and industrial), and how to make them more efficient.

Obtaining the Dataset

The report can be downloaded off the EPRI website:
www.epri.com

The report has the document number 1016112, which is useful for searching the site. These reports contain basic graphs and end use statistics of the data. However, it may be possible for EPRI employees to obtain the original data on which the report is based.

Format

The report studies nine typical commercial building types and six climate zones, and analyzes improvements to heating, ventilation, and air-conditioning (HVAC) systems, as well as lighting systems, refrigeration, water heating, and food service equipment. For each building and climate zone, two efficiency scenarios were evaluated: an "efficient" case and an "ultraefficient" case. The energy savings for the efficient scenario range from 12-30% relative to the baseline. The energy savings for the ultra-efficient scenario range from 19-42% relative to the baseline. The report also presents the savings for the summer peak day at 3:00PM. The peak demand savings for the efficient scenario range from 10-29%, and the savings for the ultraefficient scenario range from 22-41%.

The original data is split into three sections: commercial, residential, and industrial. For each sector, there are various Excel spreadsheets (.xls files) that list the amount of energy used per appliance for each hour. Each sector includes hourly data from the 15 sections of the North American Electricity Reliability Corporation (NERC). The following Table 5-2 lists the different data files in each sector.

Table 5-2
Commercial, Residential and Industrial End Energy Use Data Files: EPRI

Sector	Data Files
Commercial	*Cooling*: (1) Hi efficiency Chiller, (2) Efficient CAC (EER 8.5 - EER 11.0), (3) with EMS, 1&3, 2&3
	Heating: Heat Pump (COP 2.8 - 3.6), EMS, Heat Pump + EMS
	Water Heating: Efficient Resistance (96% - 100%), HPWH (COP 3.0)
	Lighting Interior: Incandescent to CFL, LF T12 - T8, Occupancy Sensors, CFLs with Occupancy Sensors, T-8s with Occupancy Sensors; Lighting *Exterior*
	Office Equipment: PCs, Servers, Displays, Copiers, Base to Energy Star
	Refrigeration: (21) High efficiency Compressor, (22) Anti-Sweat Heater Controls, (23) Floating Head Pressure Controls, (24) Glass Doors, (25) High-efficiency compressor + average of 22, 23, 24
	Ventilation: Variable Air Volume, Fans with Variable Speed Controls, Fans with Efficient Motors, Variable Air Volume + Efficient Motors, Fans with Variable Speed Controls + Efficient Motors
Residential	*Central AC*: (1) SEER 13 - SEER 14, (2) Ductless Heat Pumps (mini-splits), (3) Programmable Thermostat, 1&3, 2&3
	Room AC: EER 10.2, EER 11.2; *Central AC*: Ductless Heat Pumps (mini-splits)
	Heating: Heat Pump (HSPF = 12.0; SEER = 18); *Water Heating*: HPWH (COP 2.0), HPWH (COP 3.0)
	Lighting Interior: Incandescent to CFL, Occupancy Sensors, CFLs with Occupancy Sensors
	Refrigeration: Energy Star, Inverter-Driven
	Dishwasher: Energy Star; *Clothes washer*: Horizontal-axis, Horizontal-axis + Inverter-driven, with Moisture Sensor, Heat Pump
	Electronics: Energy Star Television, PC
Industrial	*Process Heating*: Electric Resistance, Radio-Frequency
	Motor Drive: 1-5 HP, 5-20 HP, 20-50 HP, 50-100 HP, 100-200 HP, 200-500 HP, 500-1000 HP, 1000-2500 HP, >2500 HP
	Facility: HVAC; *Facility Lighting*: Incandescent to CFL, Linear Fluorescent, HID; *Other*

Fields

For each of the three sectors, each data file contains certain information. The following Table 5-3 lists the data fields for each sector.

Table 5-3
Sector Data Files

Sector	Data Fields	Data Type/Unit
Commercial	Energy used during hours ending 1-24	Float
	Number of records	Integer
	Peak season	1=yes or 0=no
	Day of week	Integer, 1-7
	Weekday	1=yes or 0=no
	Peak day	1=yes or 0=no
	Percent savings	0.001 precision
Residential	Peak savings	Float
	Total energy used	Float, kWh
Industrial	Energy used during hours ending 1-24	Float
	Number of records	Integer
	Peak season	1=yes or 0=no
	Day of week	Integer, 1-7
	Weekday	1=yes or 0=no
	Peak day	1=yes or 0=no
	Percent savings	0.001 precision

Electricity Market Data: California ISO

The California Independent System Operator (CAISO) has data on its Open Access Same-time Information System (OASIS) website which contains the hourly, real-time updates on the energy market, i.e., on prices, transmission, system demand, energy, and ancillary services.

Usability

This system is very useful for obtaining data on the electricity market and its behavior over time. Since the time period for which the data is obtained is flexible, the data can be used for either mathematical analyses or getting a general understanding of the market, depending on the length of the time period.

Obtaining the Dataset

The data can be obtained from the CAISO OASIS website:
http://oasis.caiso.com/

A version of the hourly average energy price data can also be obtained from within the software package, *ESVT (Energy Storage Valuation Tool) - Modeling Stakeholder Costs and Benefits, Version 2.0*, with the Product ID Number 1013749.

Format

This data lists the features of electricity at the end of every hour of every day for the given year, and can be viewed on the website, or downloaded as an XML or comma-separated values (CSV) file. Each file is in a table format with a measurement for the time frame of the market clearing of the given product, for the total CAISO region, and, if applicable, for its sub-regions.

Fields

For each of the following areas, there are measurements taken in the following fields.

Table 5-4
Data Categories

Data Category	Available Field Labels and Relationships
Atlas (listings and mappings of system elements)	Market resource listing, Publications and revisions, OASIS publication schedule, Peak-off-peak definition, Pricing node listing, All pricing node listing, Load participation factors, Load aggregation point listing, Trading hub listing, Trading hub- pricing node listing, Ancillary service region, Reliability unit communication zone- pricing node mapping, Transmission access charge area- pricing node mapping intertie constraint mapping, Transmission interface listing, System operation messages
Prices	Location marginal prices, Interval location marginal prices, Nomogram/branch shadow prices, Ancillary services clearing prices, Interval ancillary services clearing prices, Intertie constraint shadow prices, Fuel prices, Current locational marginal price, Interval intertie constraint shadow prices, Interval nomogram/branch shadow prices
Transmission	Current transmission usage, Transmission outages, Transmission interface usage, Market available transmission
System Demand	CAISO peak demand forecast, CAISO demand forecast
Energy	System load and resource schedule, Expected energy, Exceptional dispatch, Market power mitigation status, Reliability Must-Run (RMR), Marginal losses, Resource adequacy and minimum load
Ancillary	Ancillary services requirements, Ancillary services results, Actual operating reserves
Congestion revenue rights (CRR)	CRR clearing prices, CRR inventory
Public Bids	Clean bid payloads used in the markets

Of these data fields, some of them are more useful for research in PEVs. The table below lists the fields in each category, which are considered to be more useful by the authors of this report.

Table 5-5
Important Data Category Fields

Data Category	Important Fields	Data Type/Units
Atlas (listings and mappings of system elements)	Market resource listing	String
Prices	Location marginal prices	$/MWh, for each hour ending 1-24
	Ancillary services clearing prices	$/MW-h, for each hour ending 1-24
	Fuel prices	$/mmBtu, for each hour ending 1-24
Transmission	Current transmission usage	MW, for each hour ending 1-24
	Market available transmission capacity	MW, for each hour ending 1-24
System Demand	CAISO peak demand forecast	MW and hour of day in which peak occurred
	CAISO demand forecast	MW, for each hour ending 1-24
Energy	System load and resource schedule	MWh, for each hour ending 1-24
	Expected energy	MWh, for each hour ending 1-24
	Marginal losses	Loss cost in dollars, System loss in MWh
	Resource adequacy and minimum load	Cost in dollars, Load in MW
Ancillary	Ancillary services requirements	MW, for each hour ending 1-24; maximum and minimum values
	Ancillary services results	MW, for each hour ending 1-24
	Actual operating reserves	Max % per 5 minute interval, for each hour ending 1-24
Congestion revenue rights (CRR)	CRR clearing prices	$/CRR, for each hour ending 1-24
	CRR inventory	CRRs, for each hour ending 1-24
Public Bids	Clean bid payloads used in the markets	Various units, for each hour ending 1-24

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