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Demand Response Potential Estimation Package v1.1
"DR Futures"
User Manual

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Table of Contents

Table of Figures

List of Tables

1. Introduction and Summary

1.1. Purpose

The **DR Futures** model is designed to assist researchers, utility analysts, policymakers and program designers to better understand the potential futures for Demand Response (DR) markets and technology. It was developed specifically to support the California Public Utilities Commission (CPUC) rulemaking R1309011.

The current scope of the data inputs available with the model covers the three major investor owned utilities in California: PG&E, SCE, and SDG&E. A team at LBNL worked with the California Institute for Energy and the Environment and the CPUC to request and process meter data from these utilities to support the model.

The model includes two core modules: LBNL-LOAD and DR-PATH. LBNL-LOAD develops a set of end-use specific, hourly estimates of the electric loads for a set of "clusters", with thousands of representative and aggregated sets of customers that are the basic unit of analysis. DR-PATH uses these forecasts of end-use loads in combination with inputs that describe the available DR technology, markets, and supporting information to estimate the total available DR potential in California in a variety of future year scenarios.

This model release includes inputs that have been anonymized for the purpose of maintaining the '15/15' rule of customer privacy and anonymity. This rule states that data releases cannot include customer information that either (1) has less than 15 customers in a given geographic region (i.e. zip code or cluster) or (2) comprises 15% or more of the total load for a given geographic region, (i.e. large industrial customers in a given zip code or cluster). Within the context of this model release, we have removed customer data from the clusters that does not comply with the anonymization best practices. Inasmuch, the <u>results produced by this model release are lower</u> than what was reported in the Phase 1 results and Interim Report.

This document is a basic user manual meant to be augmented by both reading the Interim Report, which describes the model theory. Additional information is also available in the code notebooks and batch operations files, which describe and demonstrate the algorithms' implementation.

1.2. State of Model Development

LBNL released DR Futures model v1.1 on 8/18/2016, which improved the way the model handles scenarios.

This model is a beta version and is NOT a "production" release. The code was developed to support a specific analysis (the rulemaking mentioned above), and does not include comprehensive error checking that would prevent users from accidentally changing inputs outside the bounds of what is possible.

The intended user of this model is a professional and practicing data scientist -- someone who is familiar with scripted programming languages and can read and understand code. The code in this version of the model is annotated to help users understand the logic and operations, and includes a set of "Jupyter" code notebooks that assist users in running the model. This manual describes the design of the model and software, and the implementation of the algorithms is documented in comments and code notebooks.

Running the model requires executing a sequential set of batch analysis operations using the Jupyter code notebooks. The code in these notebooks could also be distilled and run through typical Python or R environments, however those steps are left to the user.

2. How to Run the Model

2.1. Computing Environment

The software requirements for running the model:

Requires up-to-date versions of:

Jupyter (for interactive, notebook-based computing)

- Also need to install IRKernel to run R inside Jupyter Notebooks

Python 2.7.6

- NumPy version 1.11.0
- Pandas version 0.18.1
- PPrint version 2.5
- Scipy version 0.13.3
- Datetime version 2.7
- Matplotlib version 1.3.1
- Multiprocessing version 0.70a1

R 3.x

- R Packages including data.table, ggplot2, etc. are described in the "model environment setup" directory of DR-PATH. Pre-installing the package "pacman" enables automatic installation of dependencies.

NOTE: Check out the "Anaconda" distribution to streamline installation of Jupyter and Python

The hardware requirements for running the model:

This model requires a high-performance workstation or server to run quickly (but does not require a "cluster"). **We do not recommend** running this on any consumer-grade computer.

The computer we use to run the model at LBNL runs Linux (but this should work on other OS ok too with appropriate software as described above) and has the following key specifications, described here for informational purposes:

1. 2x Intel Xeon processors, each with 8x cores running at 2.1 GHz (32 total cores available with hyperthreading)
2. 128 GB RAM
3. 600 GB System hard drive
4. 10 TB RAID for storing input and output data

The model requires at least 500 GB of hard drive space for all of the inputs and outputs (if a full set of intermediate and final outputs is written). Some operations require extensive RAM to load data into memory, and at least 64 GB of RAM is required to ensure these operate (with tuning described below).

If a machine with fewer processing cores or less RAM is used, the parameters of the parallel computing constructs should be changed by the user to accommodate the limits of that system. The version of the code we are releasing is “tuned” to run on the system we describe above.

On the system we described, the end-to-end compute times are approximately:
- 2 hours for DR-Load and
- 10 hours for DR-PATH

NOTE: Some Jupyter Notebooks provided as part of the DR Futures Model include an “estimated runtime” in the top comments section. These are meant as informative guides for the first time user, and are based on the above hardware and computing resources.

3. Model Inputs and Outputs

3.1. LBNL-Load

3.1.1. Custom Modules

In addition to the publicly available software described in Computing Environment, LBNL-Load includes four (4) custom Python modules:
- config.py
- infrastructure.py
- utils.py
- forecasting.py

These custom modules are imported in the “local imports” section of the Jupyter Notebooks and contain model features such as pre-defined reference lists, I/O functions, scenario tracking, and forecasting tools. These modules are located in the “~/lbnl_load/modules/” directory.

3.1.2. LBNL-Load Naming Conventions

Scenarios

An LBNL-Load Scenario is an, which also has a corresponding Scenario Object defined by the infrastructure.py module. They are named according to *clusteringMethod_weatherYear_demandForecast_energyEfficiencyForecast_calendarYear* (e.g., *anonymized_1in2_midDemand_midAAEE_2025).*

Clusters

The clustering option for a specific Scenario corresponds to a set of customer clusters. These clusters are generated through an algorithm that groups them based on demographic criteria and electric use data (e.g., peak demand and/or annual consumption). The public version of DR Futures utilizes the "anonymized" clustering option for **all** analysis. These anonymized clusters meet the 15/15 rules, which stipulate:

- No data can be provided for residential groups for which there are fewer than 100 customers.
- No data can be provided for commercial or industrial groups for which:
  - There are fewer than 15 customers, or
  - One customer is responsible for more than 15% of the group's annual energy use.

It is important to note that, because of these rules, **some large industrial and commercial customers are not represented by DR-eligible clusters, and therefore will not contribute to the DR-PATH forecasts of DR Potential.**

Clusters are named according to *utility-sector-SLAP-building_type-peakKW-Care-kWh_Percentile;* for example, *sdge-res-SDG1-res_misc-noKW-nonCare-0.9_1.0* is a cluster in SDG&E, in the residential sector, in the SDG1 Sub-LAP, that is identified as a residential miscellaneous building, for which no peak load was reported, is not a CARE participant, and is in the top 10% of similar customers in terms of annual kWh energy use.

3.1.3. Cluster Load Profiles & Cluster Summaries

The primary unit of analysis for the LBNL-Load tool is a "cluster", defined as a grouping of customer accounts that share demographic and energy usage characteristics. This public version of the DR Futures Model includes only aggregate data about these clusters in order to protect the anonymity of specific real-world customers, in line with California's 15/15 Rule. The primary cluster-level input datasets provided with this public model are located in the "~/lbnl_load/outputs/intermediate_cluster_profiles/" directory. Notice that while these are the necessary **inputs** for the public model, they are located in the **outputs directory**. This is because they are outputs of additional processing scripts which cannot be made public due to anonymity rules. Within the "intermediate_cluster_profiles" directory are two (2) subdirectories, one for each 2014 scenario:

- Anonymized_1in10_actual_actual_2014
- Anonymized_1in2_actual_actual_2014

Each of these subdirectories contains:

- 2767 cluster profile CSV files
- 1 cluster summary CSV file

3.1.4. End Use Disaggregation Inputs

A number of input files are needed to disaggregate the temperature-dependent and non-temperature-dependent load profiles provided in "intermediate_cluster_profiles" into their constituent end uses.

Table 1: End-use Disaggregation Input/ Directory Files

File/Directory Name	Description
end_use_penetrations/ ind_disaggregation_inputs.csv	Defines the fractions of annual load attributable to process and non-process loads for different industrial subsectors. Includes data from MECS 2010.
commercial_disaggregation/ ...	This directory includes one CSV file per weather station and CEUS building type combination. Each CSV includes an 8760 profile with hourly end use fractions of the applicable end uses (e.g. ventilation, lighting, refrigeration).
end_use_penetrations/ poolpumps.csv	Defines the penetration of pool pumps in residential clusters, as a decimal. Based on RASS surveys.
load_shapes/ poolpumps.csv	Defines the load shape of residential pool pump loads, generated based on the SCE pool pump study.

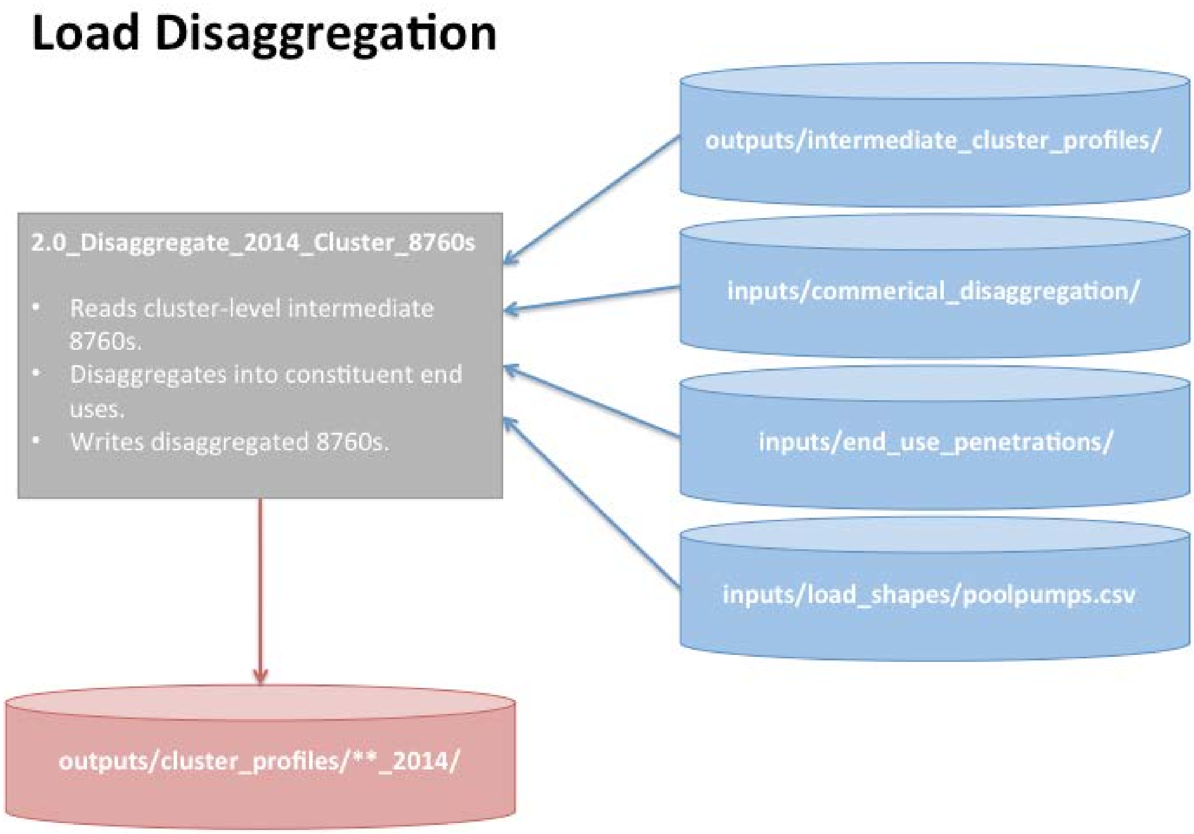

Figure 1: Load disaggregation diagram illustrating input files, disaggregation, and outputs

3.1.5. IEPR 2015 Forecast & AAEE Impacts

The files described below contain the inputs needed to calibrate the LBNL-Load forecasts to the 2015 IEPR forecasts and AAEE Impacts.

Table 2: Forecasting and Load Calibration Input/ Directory Files

File Name	Description
cec_iepr_2015/ midAAEE_mwh_impacts.csv	This file contains the annual MWh load reductions attributable to AAEE for the Mid AAEE scenario as defined by the CEC. Columns are end uses, rows are pairings of utility and forecast year.
cec_iepr_2015/ **_area_adj.csv	For each IOU, one of these files exists that estimates the fraction of the CEC CED load for their respective Forecast Areas.
cec_iepr_2015/ **_dem_inputs.csv	For each IOU, one of these files exists that contains the demographic data associated with the CEC CED Medium Demand forecast.
end_use_penetrations/ cec_ev_forecast.csv	Statewide EV forecast, with a row for each year and columns: bev_cec_high, phev_cec_high, bev_cec_low, phev_cec_low, bev_cec_med, phev_cec_med. This data was processed from the CEC 2014-2024 forecast, and estimates the number of vehicles in California for a set of years.
ev_intermediate/ slap_sector_disaggregation.csv	Defines the proportions of EVs that belong in each SLAP. Has a row for each SLAP and four value columns: res_phev, com_phev, res_bev, and com_bev. Therefore, sum of res_phev and com_phev columns should equal 1, as should the sum of res_bev and com_bev columns.
ev_intermediate/ single_ev_profiles.csv	Contains 8760 demand profiles for an individual electric vehicle of six types: residential bev and phev, commercially-owned bev and phev, and residentially-owned bev and phev charging at a workplace. This data is processed estimates from LBNL's V2G-Sim model.

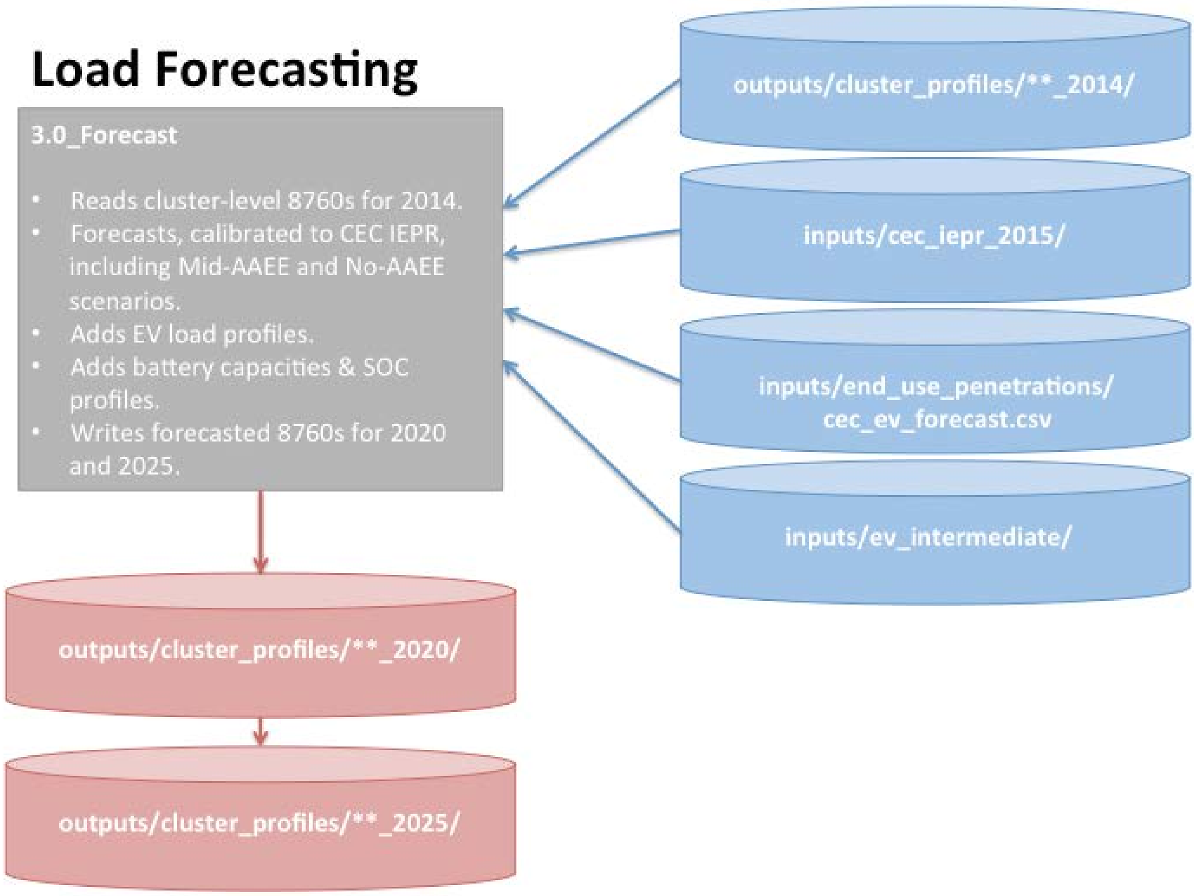

Figure 2: Load forecasting diagram illustrating input files, forecasting process, and cluster level outputs

3.2. DR-PATH

The cluster-level, end-use load forecasts that are developed in LBNL-LOAD are the main input for DR-PATH. DR-PATH takes these baseline load shapes, applies a set of TOU and CPP price assumptions to develop "reshaped" load, and estimates the potential to provide DR service to markets using sets of available technology.

In order to run the model, first ensure that the "working_files" directory (described below) is populated with the appropriate input files. The version of the model released publicly has all of the files in place, in the correct format. Use these examples as the guide for any alterations.

In order to run the model, the user should run each of four DR-PATH code notebooks in sequence. These are numbered and described below.

To change how the model runs (i.e., to change the inputs), there are a few key options:

1) If you want to change assumptions regarding the cost or performance of DR technologies, you will need to change the values in the DRPATH technology input file (/dr_futures/drpath_cache/drpath_tech/drpath_inputs0.csv) for all instances of the technology
2) To change assumptions about the DR market and technology scenarios, change the "scenarios.csv" file in /dr_futures/drpath_cache/working_files/ ("working_files")
3) To change assumptions about how customers enroll in TOU / CPP programs, change the "rate_cases.csv" working file.
4) To change the "tags" used in naming output files, change the variable definitions in the "Control Variables" section that starts each of the code notebooks.

3.2.1. DR-PATH Directory Structure

DR-PATH has two key directories:

1) `dr_path_code` -- a directory to hold model code and control notebooks.
2) `dr_pach_cache` -- a directory to hold input, intermediate, and output datasets and results

The CODE directory structure is self-descriptive, and we direct the reader to inspect the directory and control notebooks.

The CACHE directory has several sub-directories described below:

Table 3: DR-PATH CACHE directory files and descriptions

Directory Name	Purpose
csvs	A flat csv store with 8760 data identified by UUID
csvs_meta	Store metadata objects describing csv files in the csv store
cluster_data	Store original versions of cluster metadata files (combined and updated metadata stored in working_files)
drpath_tech	Store technology input files that describe the available technology for each cluster / end-use. The variables used in this file are described in the "Interim Report", Appendix C.
drpath_out	Store output files describing DR technology, DR market options, and DR pathways that summarize by the best available options under different DR market and technology scenarios. This is the directory where "raw" model output is written.
elec_shape	Store intermediate data describing the electricity shapes, both baseline and adjusted according to TOU / CPP inputs.
working_files	Store the input files required to run the model.
results_output	Store tables and plots that describe the results.

3.2.2. Running DR-PATH

Initialization of DR-PATH

In this initial release of DR-PATH, the **working_files directory has been populated in advance** with appropriate data formats and structures. A detailed list of the contents is available below, with notes on which files are candidates for user modification to change assumptions.

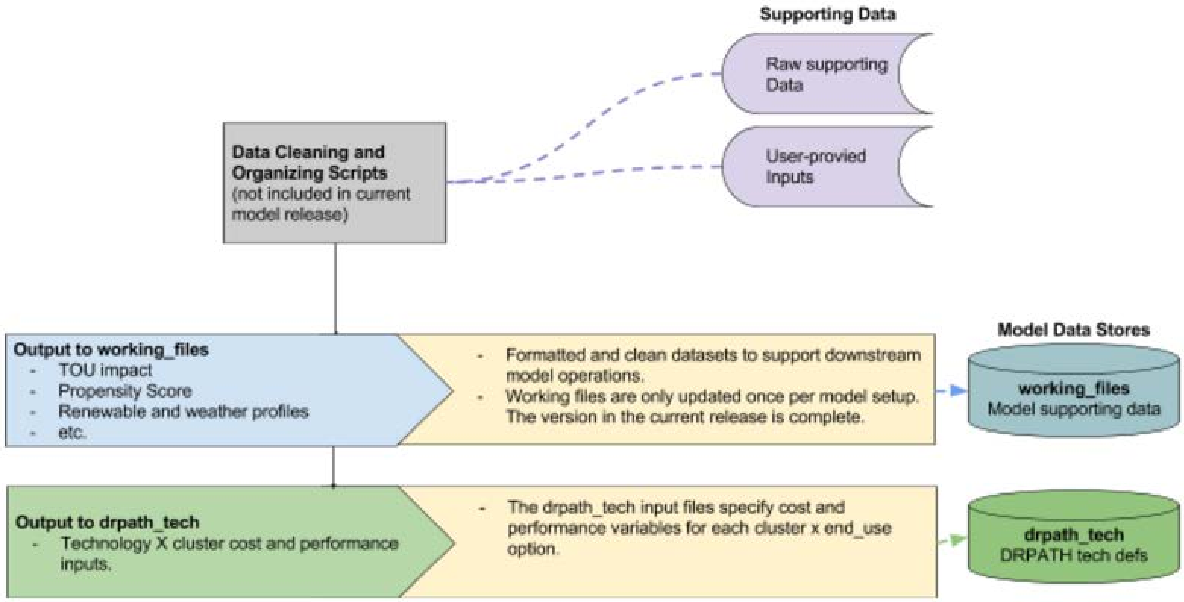

Figure 3: High level overview of initialization for DR PATH module

Control Notebook 0: DEVELOP AND CHECK IN Baseline loads

Run this notebook to set up the working environment and check in files to the csv store.

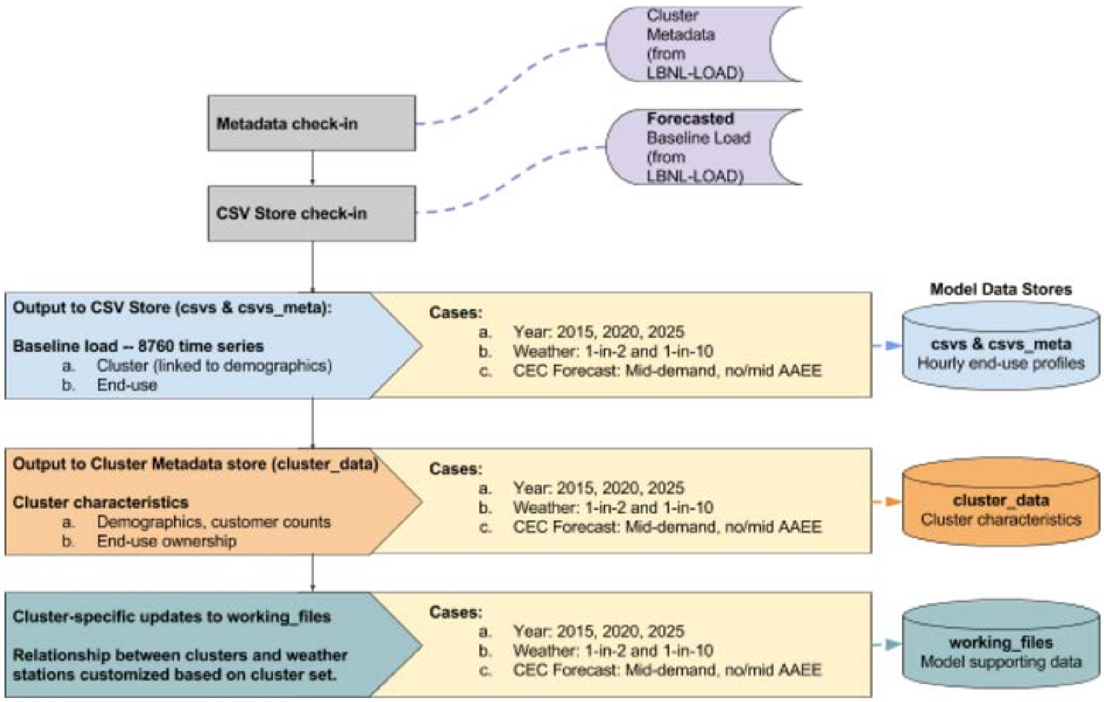

Figure 4: Diagram of DR PATH control notebook 0

Control Notebook 1: SHAPE: Identify the TOU/CPP load impacts

This notebook uses the mixes of TOU/CPP rates defined in the "rate_cases.csv" working file, along with supporting load impact lookup files, to estimate how the baseline loads are reshaped based on price response. These reshaped loads are stored with new labels in the CSV store. In this notebook there are also scripts to look up and store information about the maximum value of the annual load and the effective load-carrying capacity required for the reshaped loads. The information about these shapes is stored in the "elec_shape" directory with the following convention:

[case tag]-[year]-[demand_scenario]-[ee_scenario]-[weather]-"csvs_reshaped"

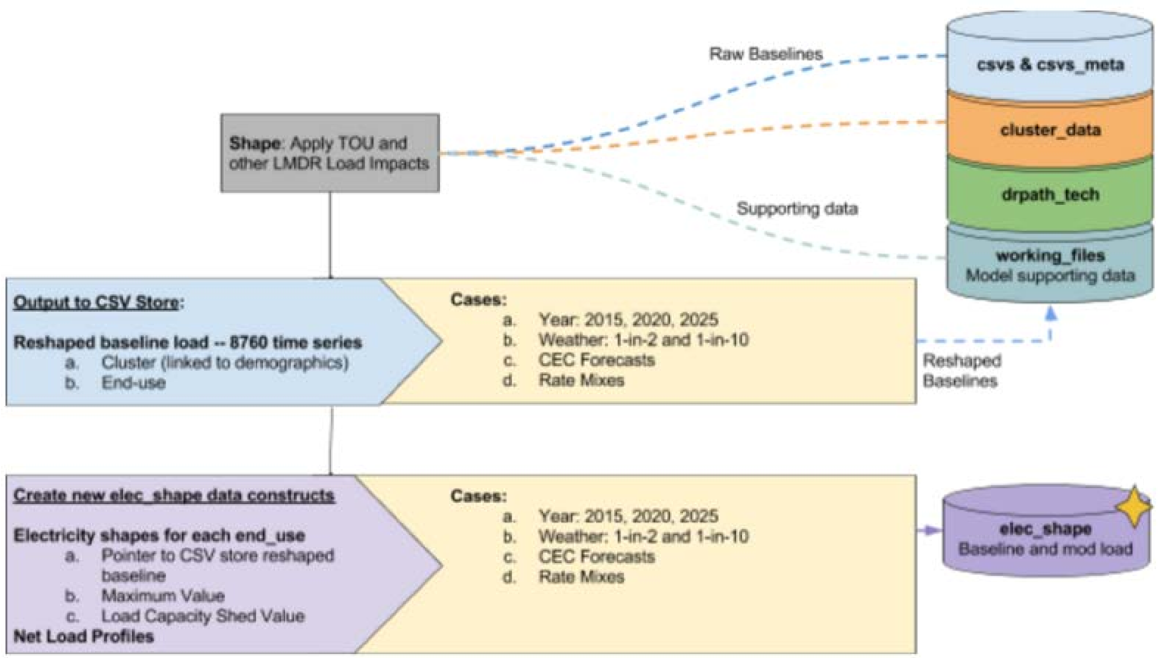

Figure 5: Diagram of DR PATH control notebook 1- developing the TOU/CPP load impacts

Control Notebook 2: Find DR options and DR pathways

This notebook compares DR technology (defined in the technology input file) and product requirements ("product_req.csv" working file), and for eligible DR technology creates estimates for the cost and quantity of DR available. After defining all of the "options" (dropts), the best combinations of technology are chosen for various price ceilings to identify dr pathways (drpath). Based on settings inside the notebook, different files are written to the drpath_out directory. The convention for these files is:

[output tag]--[original-elec-shape-file]--[dr-tech-input-filename]--[file type].

The available file types are as follows (note that options in the notebook may suppress saving these files):

- drtech: the information about DR technology cost and performance
- dropts: information about all of the available DR options for each end-use
- [scenario]--drpath: DR path outcomes for a particular DR market scenario (these are the main "output" files used to analyze results)
- tou-cpp: auxillary files listing the tou/cpp outcomes.

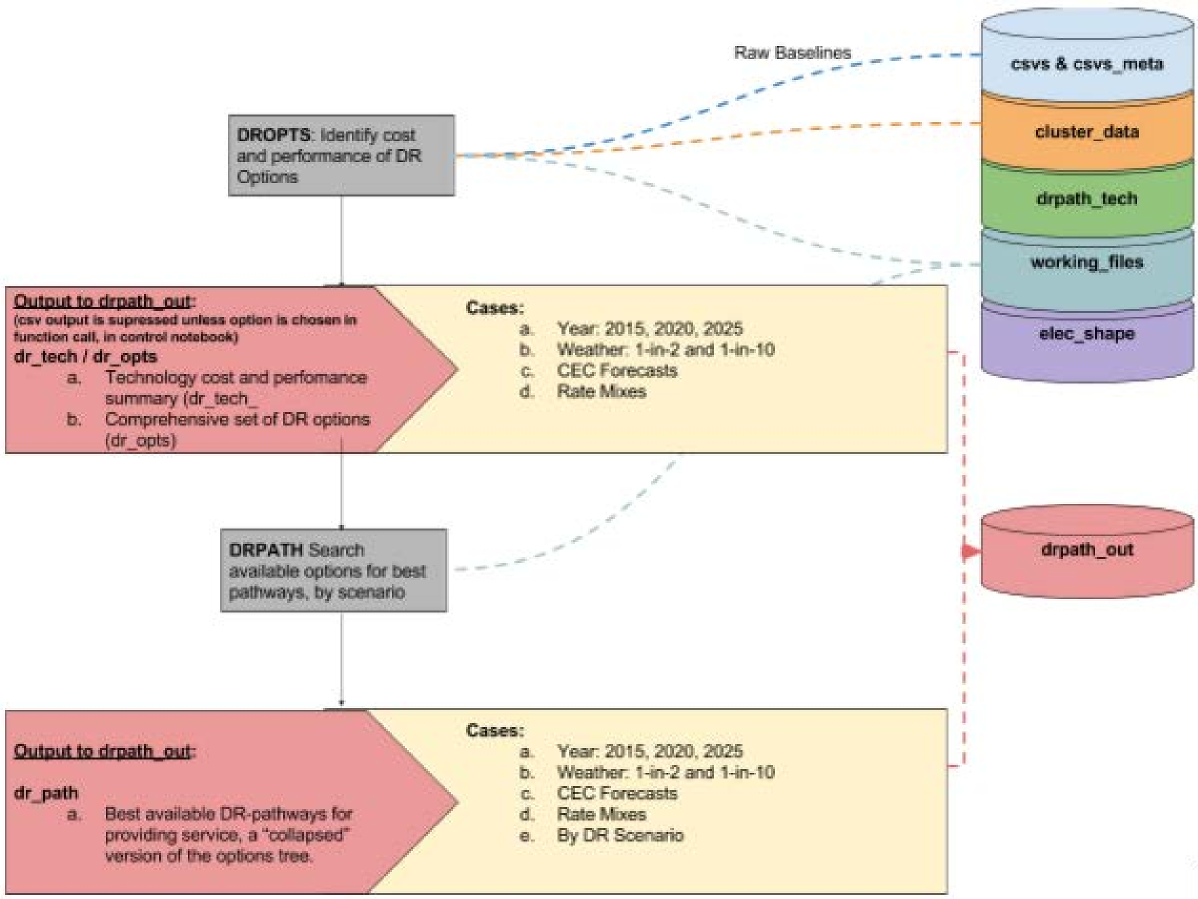

Figure 6: Diagram of DR PATH control notebook 2- developing DR options and pathways

Control Notebook 3: Analyze and Interpret the DR Pathways

This notebook is used to summarized and synthesize results of the model, mainly with analysis of DRPATH output files that have tags matching the tag defined in the Notebook control variables.

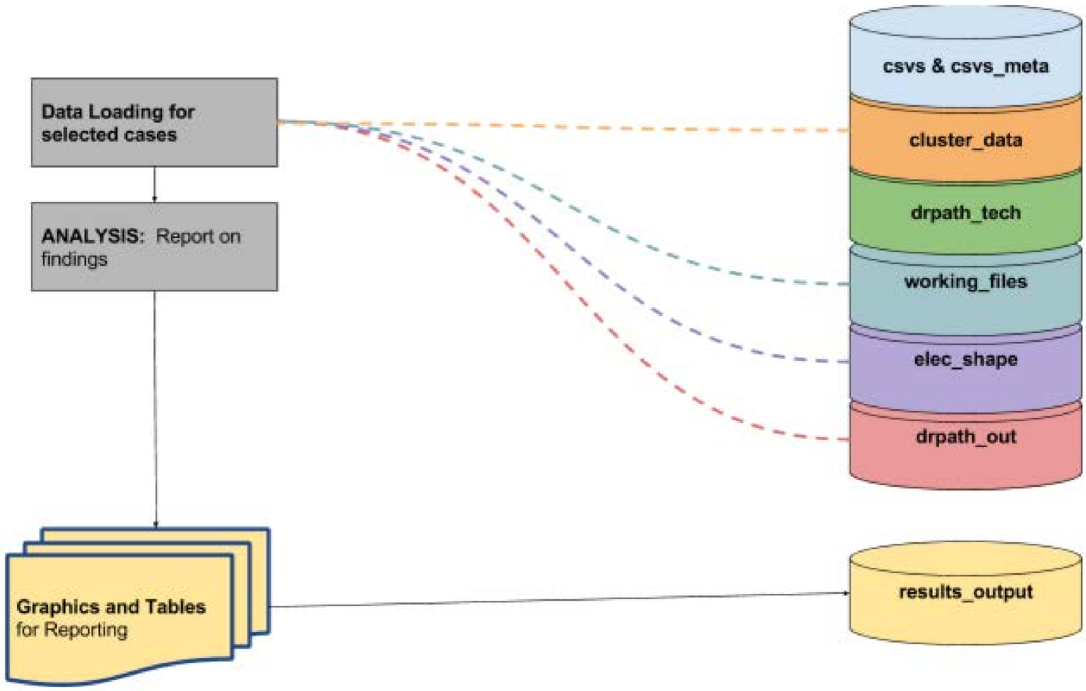

Figure 7: Diagram of DR PATH control notebook 3- Analysis of DR Pathways

DR PATH directory of working files (inputs):

Note that some of these files are designed as purely lookup tables and static inputs, while others can be altered to affect the behavior of the model. **Those that can be altered by the user within the available bounds of the model operation are bold.**

Table 4: DR-PATH directory of input files and descriptions

File name	Description
clus_baseline_metadata.csv	A combined set of cluster metadata, combining files from cluster_data directory into one csv file.
cluster_dr_2014_participation.csv	A file summarizing the actual participation rate of customers in DR programs, by cluster.
cluster_weather_station_lookup.csv	A file that facilitates weather station identification applying to each cluster.
CAISO-LCA-subLAP-revised-final.csv	A file mapping the SubLAPs to Local Capacity Areas in CAISO
com_ind_tou_input_assumptions.csv	A file with input assumptions about commercial and industrial TOU and CPP response. This file is used to build a load impacts lookup file (tou_load_impact_com_ind.csv) described below.
csvs_baseline.csv	A description of the "unadjusted" baseline csv that are loaded in the csv store -- these are the LBNL-LOAD outputs that have been loaded into the csv store data structure.
misc_assumptions.csv	Miscellaneous control assumptions that govern elements of the model. These are self-descriptive. NOTE: one assumption here allows the use of different versions of the "topHours" function that values RA credit according to either rank (the version used in the report) or according to performance during summertime afternoons. See additional detail in the code for implementation.
product_req.csv	An input file describing the specific requirements for market participation, by DR product.
pscore_lookup_lrg_base	A lookup table for estimating the likelihood of DR adoption, for large

.csv	customers.
pscore_lookup_res_base.csv	A lookup table for estimating the likelihood of DR adoption, for residential customers.
pscore_lookup_smb_base.csv	A lookup table for estimating the likelihood of DR adoption, for SMB customers.
rate_cases.csv	An input file describing the mix of TOU/CPP rates to model.
renew_profile_hour.csv	An hourly renewable generation profile, by weather year.
renew_profile_minute.csv	A "minutely" renewable generation profile, by weather year.
renewable_profile_by_year.csv	Lookup table for the total renewable peak MW generation for both wind and solar for years 2015,2020,2025.
scenarios.csv	Lookup table with the various scenarios modeled within DR PATH and the numerical multiplier for each scenario. These values are also discussed in C-11 of the Appendix C on page 91.
tou_impact folder	Folder containing residential TOU load impact lookup tables. *PGE2T_Load_Impacts.csv*: Load impacts for the PG&E rate#2 *SCE2T_Load_Impacts.csv*: This file was not utilized in the model, but we have included it as an illustrative option, which can be used in independent model runs. *SCE3T_Load_Impacts.csv*: Load impacts for the SCE rate #3. *Note: Recall that these files are look-up tables, so each row is an option that can be called upon in the model code, but is not used in all cases.* For each csv lookup file, the following fields are included. ● Rate_id: indicates the rate mix option ● utility name ● Default: indicating if the rate is a default enrollment scenario ● Cpp_adder: field includes the dollar value of the cpp rate adder, which influences the load impact when combined with the TOU scenario. If the adder is zero for a scenario in the lookup table, then the adder is not included.

	• Hvac_pentration: field indicates the percentage of customers with HVAC and the associated load impact for that percentage. For example, if 10% of customers have HVAC within a given cluster, the associated TOU load impacts for a given hour, season, and temperature and scenario are 0.7%. • allelectric: flag for customers with all electric premises, (in other words, no gas service to the premise) (0= no, 1= yes) • Low_income: flag for low income customers (0= no, 1= yes) • Weekday: flag for weekday (0= no, 1= yes) • Season field indicates whether it is spring, winter, summer season • Avgdailytemp : field indicates the daily temp that corresponds to the lookup values for the load impact • Dhour: the hour of the day associated with the load impact case • Pct_impact: the load impact associated with the corresponding values in the lookup table • Care: field that indicates whether the customer is a "Care" (low income) customer
tou_load_impact_com_ind.csv	TOU load impact lookup table for commercial and industrial customers, organized by customer kW size, season, TOU period (on or off peak) and hour of the day. The impacts are reported as percentage change of total load for each hour. A cpp_adder column includes the dollar value of the cpp rate adder, which influences the load impact when combined with the TOU scenario. If the adder is zero for a scenario in the lookup table, then the adder is not included.
weather_station_temp_F.csv	Hourly weather data for each weather station used in the analysis. Weather data includes 1:2, 1:10, 2013 actual, 2014 actual, and typical meteorological year (**TMY**) scenarios for each weather station. Average daily temperature and temp are included for each scenario in 8760 format.
weather_station.csv	Same as above, but including information to estimate weather for clusters with missing weather stations.

4. Model details in the Appendices

The Phase 1 report appendices were released on April 1st with the Phase 1 findings. The methodologies, algorithms, and variable details are described within each of the appendices. We provide a brief description of each of the appendices below, and their corresponding page numbers.

4.1. LBNL-Load Appendix B - Pages 25-69

Appendix B describes LBNL's approach for forecasting end use load in the LBNL-Load model. In Section B-1, we list primary data sources used in the model. Section B-2 describes the aggregation of IOU customers into like-groups, or "clusters." Section B-3 describes end-use disaggregation. Finally, Section B-4 describes forecasting load for future years and Section B-4.3.2 provides a summary of load forecasting results.

4.2. Enabling Technology Methodology- Framework, Inputs and Assumptions, Appendix C- Pages 70-182

The DR-PATH model estimates the potential to provide grid service with demand response (DR) across a range of technology and market pathways (hence, "DR-PATH"). Appendix C describes the framework of the DR-PATH Model, and explains the inputs to the model.

The Appendix C document details the key input file field names, as description of that field, and notes pertaining to the interpretation of the field. *Of importance to note is that some of the values cost and performance parameters detailed within Appendix C do not match those in the DR PATH technology database, as the parameters have been updated since the release of the report.*

It is important to read the code to fully understand and interpret all of the model inputs. There are a number of the economic valuation parameter values hard coded within the CODE file.

In section C-2, we describe the assumptions and characteristics of DR enabling technology, on pages 72-78. This section also describes the fields used in the DR PATH technology database.

Section C-3 details the qualification steps for a technology-end use to qualify to provide service as a DR product. The assumptions and calculations for this approach can be found on pages 78-84 of the appendix. Section C-4 describes the steps in the model to calculate the cost of DR providing the DR product service. The calculations, approach and assumptions can be found on pages 84-88.

In section C-6 we briefly describe the inputs and assumptions on marketing and administrative costs for DR participants. These variables are within the code, rather than an input file.

In section C-10 and C-11, on pages 90-92 we describe the scenarios and "DR Pathways" approach and assumptions.

Sections C-12, C-13, and C-14 describe the assumptions and inputs for the enabling technology cost and performance data for commercial, residential, and industrial sectors. In section C-14, the discussion on inputs and assumptions for the battery technologies can be found. The documentation and sources for this information can be found on pages 92-181. *Some of the values found in the appendices may not match the values in the DR PATH technologies database, as a few technologies have been updated with new costs and performance data.*

4.3. Demand Response Product Framework - Appendix D pages 184-191

In this study we use a DR Products Framework to match these needs with the capabilities of DR. Each discrete DR product has characteristics that can qualify to meet particular (or a set of) system needs, and through this framework we determine what the level of flexibility for each DR product. Our analysis builds a bottom up approach where technologies and end uses are matched with product requirement and characteristics to determine the capability of providing grid service, and then to assess the costs and benefits.

In appendix D, section D-1, we describe the classification of DR Capabilities and System Needs and assumptions, sources, and input used within the model. In section D-2, we discuss the overall framing of the product framework, and in section D-3 and D-4, we define the DR market products modeled in Phase 1 and the approach to capturing the market requirements. This information is found on pages 183- 191.

4.4. Economic Valuation - Appendix E pages 192-205

The value of demand response for offsetting capacity depends on how the DR resource lines up with times of system need on the grid. The approach for defining these periods of need in DR-PATH is based on the estimated system wide net load peaks, including any expected load and uncontrolled renewable generation. In Appendix E, we discuss the methodology for calculating the RA capacity credit, which is based on the net load profiles for years 2014, 2020, and 2025, on pages 195-199. The methodology for forecasting various weather scenarios and corresponding renewable generation profiles is discussed in Appendix H.

The economic valuation methodology is discussed in section E-2, with E-2.1 providing details on the adjustments to the DR Product performance. On Page 200, section E-3, we provide a brief discussion on the methodology for assigning economic value to DR performance. Adjustments and inputs, such as those identified in the C/E protocols and utilized in the DR PATH model are discuss on page 201- 205. Section E-4 on page 202 describes the price referent inputs, which pull from the values used in the C/E protocols.

4.5. Enrollment Rates and Propensity Scores - Appendix F pages 206-222

The approach employed to estimate participation rates involved five general steps, the details of which are explained in Appendix F. Model Assumptions and inputs can be found on page 209, section F-1. Section F-2 focuses on benchmarking to existing DR program participation. Section F-3 describes the achievable participation rates. Appendix I on page 236-237 presents an overview of probit modeling methodology used in the estimation of the enrollment rates.

Note: Nexant was the contractor that developed and provided the enrollment rate and propensity score estimates. This appendix is one of several contributions that the Nexant team made to this effort.

4.6. Price Responsiveness/Load Impacts to Residential Time Varying Rates- Appendix G pages 223- 228

The methodology, assumptions, and approach to estimating load impacts and price responsiveness to time-varying rates is described in Appendix G. In section G-1, the model assumptions and inputs are provided on page 224-225. In section G-2, the elasticity estimation approach is discussed, and in section G-3, the load impact estimation is detailed (pages 226 - 228).

Note: Nexant was the contractor that developed and provided the price responsiveness and load impact estimates. This appendix is one of several contributions that the Nexant team made to this effort.

4.7. Ex Ante Weather and Renewable Generation Forecasts- Appendix H. pages 229-235

The weather and renewable generation forecast methodology and inputs are discussed in Appendix H, beginning with the weather forecasts in H-1.

In the updated run of the Phase results released in August 2016, several years of actual renewable data have replaced the single year as described in section H-2 (pg. 232-235) of this appendix. For the updated run, Nexant used years 2013, 2014, and 2015 as opposed to only 2014. The methodology is largely unchanged, with the exception of using additional data to enhance the precision of the renewable forecast.

Note: Nexant was the contractor that developed and provided the Ex Ante Weather and Renewable Generation Forecasts estimates. This appendix is one of several contributions that the Nexant team made to this effort.