

Data Development and Validation Manual

WECC Staff

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Executive Summary

The Data Development and Validation Manual (DDVM) is designed to be a “how to” guide for building the 2032 Anchor Data Set (ADS) production cost model (PCM). It describes the sources of data used in the PCM, the process used to validate the data, and the frequency with which the data is updated.

The 2032 ADS PCM represents the Western Interconnection in a year-10 future and contains the most up-to-date data on transmission topology, loads and resources.

The main modeling enhancements/updates included in the 2032 ADS build cycle include:

* Modeling Distributed Generation-Behind the Meter (DG-BTM) on a county level instead of an area level
* Modeling hydro data on a weekly schedule instead of a monthly schedule
* Showing all costs in 2022 dollars
* Updating generation resources for a 2032 future
* Updating loads for a 2032 future
* Updating transmission topology for a 2032 future
* Updating hourly resource shapes
* Implementing year 2018 as a base year for hydro, solar, and wind data
* Updating fuel cost data

Additionally, the structure and format of the DDVM have been revised to follow the ADS workflow included in the approved ADS Process Guide. The current DDVM also includes a summary of the main assumptions used to build the 2032 ADS toward the front of the document.

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#  Glossary of Terms and Abbreviations

| Abbreviation | Term | Definition |
| --- | --- | --- |
| ADS | Anchor Data Set | A dataset describing the loads, resources, and transmission topology for a 10-year planning horizon using stakeholder-vetted data including a production cost model and a power flow model |
| APFWG | Anchor Power Flow Work Group | A work group established by the Production Cost Data Subcommittee (PCDS) that created the 2032 ADS Reference Power Flow |
| BA | Balancing Authority | The entity that maintains load-resource balance within its metered boundaries  |
| BTM | behind-the-meter | Distributed energy resources, such as residential rooftop solar photovoltaic systems that are on the customer’s side of a utility metering device |
| CEC | California Energy Commission | The primary energy policy and planning agency for the State of California |
| CEMS | continuous emission monitoring systems | The total equipment necessary to meet applicable emission limitation or standard |
| EIA | Energy Information Administration | A principal agency of the U.S. Federal Statistical System responsible for collecting, analyzing, and disseminating energy information |
| GADS | Generator Availability Data System | A data system, managed by NERC, which collects information about the performance of electric generating equipment and helps those researching information on power plant outages |
| HTC | hydro-thermal co-optimization | A hydro dispatch approach in which hydroelectric units are dispatched in response to the load on the system and optimized with thermal units also available for dispatch |
| L&R | Loads and Resources | A data request, mandated by NERC, in which Balancing Authorities submit to WECC data on expected L&R for the following 11 years |
| NERC | North American Electric Reliability Corporation | A not-for-profit international regulatory authority whose mission is to ensure the effective and efficient reduction of risks to the reliability and security of the grid |
| NREL | National Renewable Energy Laboratory | A national laboratory funded by the U.S. Department of Energy (DOE) that guides the nation in achieving goals to reduce greenhouse gas emissions and create a decarbonized clean energy future |
| NWPCC | Norwest Power and Conservation Council | A regional organization that develops and maintains a regional power plan and a fish and wildlife program to balance the Northwest's environment and energy needs |
| OASIS | Open Access Same Time Information System | An Internet-based system for obtaining services related to electric power transmission in North America |
| PCDS | Production Cost Data Subcommittee | A WECC stakeholders subcommittee that oversees development of and approves the 2032 ADS |
| PCM | production cost model | A security-constrained economic dispatch of resources to meet forecast loads |
| PLF | proportional load following | Power plant operations in which the power plant automatically adjusts its output in response to the load being served |
| PNNL | Pacific Northwest National Laboratory | A national laboratory, funded by DOE, which applies chemistry, Earth sciences, biology, and data to collaborate with academia in fundamental research and with industry |
| PF | power flow | A model of flows on transmission lines in the Western Interconnection for one hour in the selected planning year |
| RAC | Reliability Assessment Committee | A WECC technical committee that oversees assessments of potential future reliability risks to the Western Interconnection |
| RT | round trip | Conversion of the ADS dataset from PF to PCM and from PCM to PF |

# Introduction

The ADS case represents the expected composition of the Bulk Electric System (BES), including loads, resources, and transmission topology 10 years into the future for a given reference year. This dataset is used by Western Planning Regions (WPR) and International Planning Regions (IPR) in their regional transmission plans.

The ADS includes two parts: a PF case and a PCM case. This Data Development and Validation Manual (DDVM) documents the processes used to develop and validate data used in the PCM case that are not used in the PF case, as well as data that is used in the PF case but used differently in the PCM case.

WECC uses Hitachi Energy GridView (GridView) as its ADS PCM tool. The case’s dataset is stored and maintained in GridView, which is an energy market simulation and analysis software tool distributed by Hitachi Energy. GridView uses a Microsoft Access database file (GV Case Template.mdb) and many text-based shape files (\*.DAT) to store the case information.

This document describes the processes used to create the ADS PCM in GridView. It does not include details of specific data used in PCM cases. Those details are included in other documents such as case-specific case notes. WECC staff and stakeholders should be able to use the processes in this document to create a functioning, fully vetted PCM case, starting with a seed (selected initial input case) PF case.

Data and assumptions addressed in this document include the following types of data used in the ADS PCM:

* Area/Region/BA descriptions.
* Transmission network model and parameters.
* Generation resource parameters.
* Load data.
* Variable operating costs and economics data.
* WECC market model configuration parameters.

The processes described in this manual may be used to create many specific PCM cases, and the processes may need to be revised occasionally. WECC and its stakeholders developed these processes over many years. They have proven to be effective in engaging a variety of knowledgeable stakeholders in the data review and vetting process to produce a reliable and useful PCM dataset. The PCDS will consider modifications to this manual for subsequent approval.

This DDVM will refer to many steps in the ADS Workflow as shown in Figure 1 below:



Figure : ADS Workflow

# Assumptions

| Topic | Data used |
| --- | --- |
| Time zone | Mountain Standard Time |
| Planned resource placement | Planned resources received in L&R submittals are placed by the APFWG |
| [Thermal Resource Data](#_Develop_Thermal_Resource) | Data included in 2020 report by Intertek, EIA, and L&R data submittal and approved by PCDS |
| [Generic Heat Rate Curves—Existing units](#_Develop_Generic_heat) | Data carried over from 2030 ADS |
| [Generic Heat Rate Curves—New Units](#_Develop_Generic_heat) | Data from spreadsheet developed by Kevin Harris combined with the generic heat rate capability in GridView |
| [Hydro—HTC](#_Develop_Hydro_Data) | HTC modeling parameters are based on year 2018Weekly variable schedule is used but, if not available, then monthly variable schedule is usedBanking set to *False*Spillage set to *True* for units greater than or equal to 30 MW |
| [Hydro—Given Schedule](#_Develop_Hydro_Data) | Hydro profiles are based on actual generation in year 2018Pmin = 0Pmax does not exceed the maximum hourly output in the hourly profile for each unitVAR Marginal Ratio = 0 except for Big Fork, which was set to 1 (Big Fork did not have hydro generation, so it is set to 1 to be able to solve the model)Auto calculation of P and K value set to *False*Pvalue (P factor) = 0Banking *False* for all unitsSpillage set to *True* for units above 30 MW |
| [Solar Data](#_Develop_Solar_Shapes) | If a DC/AC ratio was not available, the value of 1.3 was assumedProfiles are unitized (0 to 1) representing the capacity factor for each solar plantValues were taken from EIA 860Reference year for solar data was 2018. |
| [Wind Data](#_Develop_Wind_Shapes) | If a DC/AC ratio was not available, the value of 1.3 was assumedProfiles are unitized (0 to 1) representing the capacity factor for each wind plantValues were taken from EIA 860Reference year for wind data was 2018 |
| [WECC Path Ratings](#_Review_and_update) | The 2022 Path Rating Catalog is the basis for the path definition and the path ratingsInclude Phase II & III projects if the changes are in the 2032 reference PFSome paths are only rated in one direction. When this is the case, the reverse rating is set to 99,999 MW to not constrain the path in the reverse direction |
| [Nomograms](#_Review_and_update_1) | BA EL Paso Electric Company (EPE) generation will meet 85% or greater of its local loadBA Tucson Electric Power Company (TEPC) generation will meet 32% or greater of its local loadThe interaction of Path 8, Montana to Northwest, and Montana hydro generation is modeledPrice penalty on imported Green House Gas (GHG) to California |
| [Wheeling Rates/Hurdle Rates](#_Review/Update_Utility_tariff) | Data from the 2015 OASIS |
| [Forced Outage Rates](#_Forced_Outage_Rates) | Data from the Generator Availability Dataset  |
| [Inflation Rate](#_Thermal_Plant_Fuel) | CEC 2021 Integrated Energy Policy Report (IEPR) gross domestic product (GDP) Implicit Deflator by Moody Analytics |
| [Coal Prices](#_Coal_Price_Development) | Coal prices are based on the CEC’s IEPR for 2022 and are the same as prices used in the 2032 ADS |
| [Natural Gas Prices](#_Natural_Gas_Price) | Natural gas prices used in the 2032 ADS are the monthly burner tip prices provided by the CEC modified by NWPCC’s methods and converted to 2022 prices using Moody’s inflator/deflator series  |
| [Other Fuel Prices](#_Other_Fuels_Prices) | Other fuel prices (uranium, biofuels, black liquor, refuse, solid waste, and geothermal steam) are based on the EIA 923 report |
| [Emission Costs](#_Thermal_-_Develop) | Emissions costs were created for Alberta, British Columbia, and California, and are based on CEC 2021 IEPR as well as PCDS expertiseThe CO2 price provided by Alberta was reduced to $0.017887/lb CO2 upon recommendation by the PCDS to provide a more realistic dispatch |
| [Thermal Unit—VOM, Start-up cost, and Dispatch cost](#_Thermal_-_Costs) | Data included in Intertek Cycling Cost Report |
| [Renewables VOM](#_Solar,_Wind,_Storage,) | Sandia National Labs Handbook and Intertek Cycling Cost Report |
| [Pump and Battery storage](#_Pumped_and_Battery) | CEC, NWPCC, EIA, Utility Integrated Resource Plans (IRP) |
| [Transmission Rights](#_Transmission_Rights) | Transmission rights are not modeled in the 2032 ADS PCM case |
| [Remotely Owned Generation](#_Remotely_Owned/Contracted_Generator) | Data from various PCDS sources |
| [Ancillary Services](#_Ancillary_Services_(AS)) | Reserves for the 2032 ADS are based on data developed by PNNL after release of version 2.0 of the ADS. |
| [Loads](#_Loads) | Monthly Peak and Energy from the L&R Demand Workbook and L&R Year Ten Loads in the 2022 L&R data submittalNREL BTM Data to correctly account for how much BTM data is in the loadsThe 2018 hourly loads to grow the loads to 2032 |
| [EE, AAEE, DG-BTM](#_Develop_shapes_for) | DG-BTM (Rooftop) solar Shapes were created for each county and BA combinationEach county level generator was distributed to each bus in the county based off data from the NREL dGen model for the amount on each bus.Energy Efficiency (EE), Additional Achievable Energy Efficiency (AAEE) were not modeled in the 2032 ADS PCM |
| [Demand Response](#_Demand_response) (DR) | LBNL DR Dispatch Tool is used to determine when to dispatch the DR for each area, which is used to create the hourly DR shape. |
| [Pumping Loads](#_Pumping_Loads) | Pumping load shapes are developed through the California Independent System Operator (CAISO) and L&R submittals |
| [Generator Maintenance](#_Develop/Review_Maintenance_schedule) | A full year run of the ADS PCM is needed to develop the maintenance schedules which are based on the hourly load and generation dispatches for the entire year. |
| [Generator Pmax](#_Create_2032_ADS) | In most cases, the generator Pmax provided in the 2022 L&R submittal was used in the case. However, if the PF value was more than 5% lower than the PCM, then the PCM value was adjusted down to match the PF value by using the VAR margin ratio feature in GV. |

# Create 2032 HS1 Base Case (2b)

### Description:

The 2032 HS1 Base Case is also the 2032 ADS Power Flow base case. The 2032 HS1 Base Case is used as the starting point for the ADS Reference Case that provides the transmission topology for the 2032 ADS PCM.

### Data Sources:

Data for this base case and other base cases come from each member and is submitted to WECC by each area’s Planning Coordinator and/or Area Coordinator. This base case is included in WECC’s annual Base Case Compilation Schedule managed by WECC’s System Stability Planning Department.

This data consists of the Power Flow base case for the specified case, in this instance a heavy summer case for planning year 2032, as well as the applicable dynamic data. More detail about the data submission requirements can be found in the [WECC Data Preparation Manual](https://www.wecc.org/Reliability/2022%20Data%20Preparation%20Manual.pdf).

### Data Development and Validation Process:

**Data Development:**

1. WECC sends Data Request to Data Submitters
2. Data Submitters provide data to WECC
3. WECC compiles case and sends case for review to Data Submitters and Area Coordinators
4. Data Submitters for 2032 HS1 Base Case send comments to WECC Staff
5. WECC staff creates 2032 HS1 Base Case for ADS use (2032 HS1 Base Case (2b))
6. Determine other PCM data needs to be modified

**Validation:**

Validation for base case data requirements is done through the [System Review Subcommittee](https://www.wecc.org/RAC/Pages/SDWG.aspx) (SRS). The SRS develops, implements, and monitors guidelines and policies for the development of interconnection-wide power flow and dynamics stability cases that support RAC’s reliability assessments and WECC members’ ability to meet requirements of NERC Standards

The validation process for each individual case is done by WECC staff and the data submitters. After the base case data has been submitted to WECC by each member area. WECC staff builds the case by using the submitted data. The case is then sent back out to the data submitters for a review period. After the reviewed changed have been implemented, the case is considered validated and final.

However, since this case is acting as the PF component of the Anchor Data Set, the APFWG also validates the case.

### Review/Modification Schedule:

WECC approves the use of the reference base case biennially during each ADS development cycle.

The update schedule for this base case that acts as the ADS Power Flow is every two years. More information can be found in the [2022 Base Case Compilation Schedule](https://www.wecc.org/Reliability/2022BCCS.pdf).

### Milestone:

2032 HS1 Base Case (2b)

# Create 2032 ADS PF "Version 1" using 2021 L&R submittals (3e)

### Description:

The 2021 L&R dataset contains the loads and resources in the Western Interconnection in years 2021-2031. The resources in this dataset included both existing and planned resources till the end of year 2031. If any of this data is different than the data contained in the 2021 HS1 base case, then the data must be reconciled and updated to the 2032 ADS PF. This 2032 ADS PF with these data updates from the 2021 L&R dataset will be known as the 2032 ADS PF “Version 1.”

The 2021 L&R data is used as a first step in creating the 2032 ADS. The loads and resource data used in the 2032 ADS is subsequently updated based on the 2022 L&R data submittal.

### Data Sources:

2021 L&R dataset:

This dataset consists of L&R data submitted to WECC by each Balancing Authority within the Western Interconnection. Each BA is required by NERC standard to submit all L&R data to WECC.

This dataset is used for a variety of analyses, including the State of the Interconnection Report, and is also used by NERC for its reliability assessments. NERC reports parts of the L&R dataset to the DOE’s EIA to satisfy the filing requirements of Form EIA 411.

WECC Members are required to provide LAR information as outlined in the WECC Information Reporting Policy, pursuant to WECC Bylaws § 4.6.11, in addition to MOD-031-2.

### Data Development and Validation Process:

Compare 2030 and 2032 PFs and export updated 2032 HS PF (2c)

1. WECC compares the 2030 and 2032 HS PF cases and the 2020 and 2021 L&R submittals
2. APFWG reconciles differences in 2030 and 2032 HS1 Base cases
3. WECC staff creates an Excel spreadsheet comparing resources of 2032 and 2030 (2d)
4. APFWG compares resources in L&R to resources in 2032 PF 2f (3b)
5. APFWG places L&R planned and retired resources into the 2032 PF 2f (3c)
6. APFWG finalizes resource placement guide
7. APFWG rebuilds comparison into usable spreadsheet
8. APFWG identifies locations for and places new resources
9. WECC staff places L&R planned and retired resources into the 2032 PF 2f (3c)
10. WECC staff solves 2032 PF using data from 2f and all L&R resources (3d)

### Review/Modification Schedule:

Reconciliation between the PF and the L&R data to be reviewed biennially during each ADS development cycle.

### Milestone:

2032 ADS PF Reference “Version 1” (3e)

# Create 2032 ADS PCM "Version 1" (4e) and process to develop final 2032 ADS PCM (7e)

### Description:

The 2032 ADS PCM “Version 1” (4e) acts as the initial 2032 ADS PCM with the updated transmission, and resources from the ADS PF “Version 1” (3e) seed case.

#### Seed PF Case—ADS PF “Version 1” (3e)

The PCM dataset is not created from scratch. Every two years, certain generation data (e.g., electrical location of generators, Pmax and Pmin of generators) and transmission topology data (e.g., lines, transformers, impedances, thermal ratings), are imported into the PCM from a seed PF case. The seed PF case is intended to reflect the transmission plans of the regional planning groups (e.g., CAISO, WestConnect, Northern Grid, Alberta Electric System Operator (AESO), British Columbia Coordinated Planning Group, CENACE). Other data needed for the PCM (e.g., heat rates, fuel prices) will be updated periodically, with biennial changes to the target year.

All data is documented as to source and validation. The default documentation for every item is included in the latest release of the ADS, which documents all differences from the previous release.

* All changes for data elements are integrated or “collapsed” with a release.
* All changes to data and modeling conventions from a prior release of the PCM, other than error correction, are discussed and approved by the PCDS.
* All changes will be documented with cause and details.

The dataset should assume all years start on January 1 and last 365 days, except during a leap year, which adds another day. Time-dependent elements are adjusted to Mountain Standard Time. Holidays are adjusted as appropriate.

### Data Sources:

The data sources required to create the 2032 ADS PCM “Version 1” (4e) are:

* ADS PF “Version 1” (3e) seed case;
* 2032 ADS PCM; and
* 2021 and 2022 L&R Datasets.

### Data Development and Validation Process:

1. Create the 2032HS1 Base Case (2b).
2. Develop the 2032 ADS PF “Version 1” (3e) seed case with updated L&R resources.
3. Apply the previous cycle ADS PCM (2030 ADS PCM) to use as the starting case to build the 2032 ADS PCM.
4. Import the 2032 ADS PF “Version 1” (3e) seed case into the ADS PCM to create a 2032 ADS PCM starting case.
	1. Milestone Product 2032 ADS PCM "Version 1" (4e).
5. Reconcile resources to align all buses, branches, generators etc. from the PF/L&R to the PCM.
6. Identify Incremental Resources needed in 2032 ADS PCM “Version 1” compared to 2030 ADS PCM based on the 2021 and 2022 L&R datasets.
7. Document resources to update other data.
8. Update all resource data and other supporting meta data to the PCM case
9. WECC/stakeholder/RAC review of the case
	1. Milestone Product 2032 ADS PCM (7e)

Other incremental changes to the PCM case from year 2030 to 2032 based on the 2021 and 2022 L&R datasets include:

* Network topology;
	+ Areas and trading hubs,
	+ Regions,
	+ Balancing Authorities,
	+ Trading hubs,
	+ Transmission network model,
	+ Branch Descriptions,
* Add generating resources;
	+ Thermal, hydro, variable, DER, DR, storage,
* Add incremental thermal resources;
* Plant commitment, Pmin, Pmax, ramp rate;
* Heat rates;
* Fuel prices;
* Thermal cycling costs, Start-up cost, and minimum up/down time;
* Forced outage rates;
* Emission rates;
* Model and add incremental pumped storage and battery storage resources;
* Add incremental wind resources with associated shapes;
* Add new solar resources with associated shapes;
* Implement hydro shapes and PCDS approval;
	+ Implement hydro shapes based on 2018 data (energy, min/max generation etc.) in the case.

# Develop Other Data for 2032 ADS PCM "Version 1" (5a)

## Identify Model Types for Thermal, Solar, Wind, Storage, Geothermal

### Description:

Define the correct model/turbine type for all resources in the ADS PCM case.

### Data Sources:

* Integrated Resource Plans
* Generator Testing Reports
* Report and data from Balancing Authorities, Utilities, Owners, etc.

### Data Development and Validation Process:

1. Contract with Kevin Harris (independent consultant) to identify turbine types for thermal units in the case[[1]](#footnote-2).
2. WECC staff inserts other model type information based on 2021 and 2022 L&R datasets.

Spreadsheet/data found here.[[2]](#footnote-3)

### Review/Modification Schedule:

WECC reviews turbine type information biennially during each ADS development cycle.

## Develop Thermal Resource Data

### Description:

Thermal resources use heat energy to produce high-pressure gas or steam, which turns a turbine connected to a generator. There are many different configurations, sizes, and efficiencies, depending on the fuel and design. A combined-cycle configuration produces high-pressure gas for one turbine and extracts heat from the exhaust gas to make steam for a second turbine. Although solar thermal resources use focused solar radiation to produce power, no fuel is consumed.

### Data Sources:

Data for thermal resources comes from various sources including:

* Existing data from previous-cycle ADS PCM;
* Intertek report;
* EIA dataset; and
* L&R datasets.

### Data Development and Validation Process:

#### Plant/Unit Identification

Each thermal unit included in the ADS PCM includes:

* Name(s) of the project and unit numbering (including the U.S. EIA number if available);
* Unit shares assigned to identified Balancing Authorities to allocate operating reserves;
* Geographical location (city or county, latitude and longitude); and
* Network location (interconnection bus name and PF transmission bus number).

####  Operating Characteristics

Each thermal unit included in the ADS PCM will include the operating characteristics in the generator.csv table in GridView. The operating characteristics are listed below.

#### Unit Parameters:

* In-service and retirement dates, initial connected/disconnected status in the case.
* Criteria for activating generators with status initially set to disconnected.
* Criteria for deactivating generators with status initially set to connected.
* Type of unit (e.g., reciprocating engine, combustion turbine, combined cycle, coal, nuclear, geothermal).
* Fuel type (e.g., diesel, oil, natural gas, synthetic natural gas, coal—lignite, coal—low sulfur, nuclear, geothermal steam, biomass, biogas).
* Planned maintenance (model-determined schedule using user-specified planned maintenance requirements (duration of “major” and “minor” planned outages), OR user-determined schedule).
	+ Note that the default method for planned maintenance scheduling is the process built into the simulation program, which attempts to minimize loss-of-load probability.
* The model-generated maintenance schedule can be overwritten in whole or part with externally-generated schedules, whether from an alternative maintenance scheduling tool or other source. Nuclear generating units have an established maintenance schedule linked to their refueling cycle.
* Forced outages (frequency and duration).

#### Variable Costs:

* Start-up cost ($/start).
* Start-up fuel (type and quantity (MMBTU/start)).
* Fuel conversion efficiency (MMBTUs in/net MW out) for net MW output levels at maximum output capability,
* Minimum output capability, and
	+ Note that “net MW out” is the electric injection into the grid less any station power loads withdrawn from the grid through a separate electric meter. Fuel conversion efficiency typically does not include start-up fuel.
* Variable Operations and Maintenance (O&M)
	+ Note that variable O&M can include opportunity costs, if applicable.

#### Operating Constraints

* Maximum output capability.
	+ Note that maximum output capability is typically Pmax from the PF program minus station power load withdrawn from the grid through a separate electric meter when the unit is running full-out.
* Minimum output capability.
	+ Note that minimum output capability is typically Pmin from the PF program minus station power loads withdrawn from the grid through a separate electric meter when the unit is running at its lowest stable level.
* Minimum up and down times, start-up time, up-ramp rate (MW/hr), down-ramp rate (MW/hr)
* “Must Run” status. If the Must Run flag is checked, GridView will always run the unit at its minimum output level, unless, based on its fuel conversion efficiency curve and variable O&M, it is economical to dispatch the unit at a higher level. The exception is hours in which the unit is on planned maintenance or subject to a forced outage; in which case the unit is dispatched at zero. If the unit should be Must Run at a level higher than its physical minimum output level, the minimum output level in GridView needs to be set to the higher level. Note: If a unit is designated as Must Run, GridView ignores start-up costs for dispatch purposes.
* Fuel limits—GridView does not directly model fuel limits. However, GridView does model fuel rates.
* Emission limits—GridView does not directly model emission limits. However, GridView does model emission rates.

#### Fuel Data

* Fuel type (e.g., diesel, oil, natural gas, synthetic natural gas, coal—lignite, coal—low sulfur, nuclear, geothermal steam, biomass, biogas)
* Fuel price ($/BTU delivered at a particular location on the natural gas pipeline system, e.g., power plant burner-tip). Prices can be specified daily, monthly, or annual.
* Emissions—pounds of CO2, NOx, SOx, particulate emitted per MMBTU of fuel consumed.

To validate this data, WECC staff assembles the resource data for all unit types. The PCDS reviews this data and recommends any needed modifications. After PCDS review and approval, WECC staff implements thermal unit data in GridView for the 2032 ADS.

Spreadsheet/data found here.[[3]](#footnote-4)

### Review/Modification Schedule:

WECC reviews thermal resource data biennially during each ADS development cycle.

## Develop Generic Heat Rate Curves

### Description:

Heat rates are measures of the efficiency of a thermal generator expressed as megawatt output as a function of BTU input. The heat rate for a specific unit varies according to the output of that unit, thus creating a curve showing the relationship between the unit’s output and its heat rate. They represent the amount of power produced by a thermal plant for each unit of fuel consumption. For a production cost simulation model, the incremental heat rate of a plant is of particular focus, where the amount of fuel consumed to produce an incremental unit of power is used as an input to the model. The incremental heat rate is typically represented in block sizes.

Barring a few future units, all thermal generators in ADS have specific, unit-level heat rate data developed over multiple cycles of the ADS development process. These few units without specific heat rate curves needed generic heat rate curves assigned to them, which depend on the make of the power plant turbine technology. Hitachi Energy developed a functionality in GridView where standard thermal I/O curves pertaining to the make of each generator and its corresponding turbine type can be assigned on a unit-level.

### Data Sources:

* Hitachi Energy GridView developed an integrated functionality in GridView where generic heat rate data can be assigned to thermal units based on known thermal data.
* The ADS also uses a spreadsheet tool developed by Kevin Harris (independent consultant) based on Continuous Emission Monitoring Systems (CEMS) data

### Data Development and Validation Process:

The heat rate information was integrated into the ADS PCM in a few ways:

1. For existing units, the heat rate information was carried over from the previous year’s ADS PCM; and
2. For new thermal units, the heat rate information was either developed using Kevin Harris’s spreadsheet or by using the generic heat rate development functionality in GridView, where GridView will create the heat rate information based on known thermal model information for each turbine type.

Spreadsheet/data found here.[[4]](#footnote-5)

### Review/Modification Schedule:

WECC reviews thermal resource data biennially during each ADS development cycle.

## Develop Hydro model based on year 2018 hydro generation data

### Description:

The ADS PCM includes data for hydroelectric resources. The PCDS and WECC staff collaborate to develop this dataset. The hydropower dataset is based on normal or non-extreme events (average hydro year) and includes monthly and weekly hydro generation profiles as well as annual hydropower generation for the 10-year planning horizon. This dataset is meant to be adaptable on hydroelectric operations and includes water availability, water management, and power plant operations. Also, this dataset uses the same coincident reference year (2018) as wind, solar, and load to develop hydro models used in the ADS case. Data captures hydro variations and represents typical hydro operations through a median year, weekly targets, daily fluctuations, and evaluations.

### Data Sources:

* PNNL developed the weekly hydro data used in the 2032 ADS with funding provided by the DOE.
* WECC’s L&R data submission process for the year 2018 was used to develop fixed hydro schedules.

### Data Development and Validation Process:

In GridView, hydro resources dispatch was done either through a fixed schedule or through Hydro-Thermal Co-optimization (HTC).

#### Fixed/Given Schedule

The “Given Schedule” is neither price-dependent nor load following but follows a fixed hourly profile to dispatch hydro. In the Given Schedule model, the hourly profiles were created at the plant level or the BA level using year 2018 data. If the hydro generation was not available at the plant level, then the hydro generation at the BA level was used to create the hourly profiles. The PCDS approved using 2018 as the base reference year for hydro modeling.

#### HTC/Load Following

Other approach to modeling hydro dispatch is load following and HTC. The load-following model dispatch of hydro generation is based on load. Under HTC, hydrogeneration dispatch is based on load to be served as well as on the locational marginal price (LMP), which determines locations of high-profit potential in terms of efficiency, which in turn adjusts hydro output. HTC optimizes a portion of hydro as if it were a thermal generator. For 2032 ADS PCM case, most plants were modeled using HTC model excluding few plants which were modeled using “Given Schedule”. The following assumption was further applied to improve the HTC model in GridView: load-wind%-solar%.

The HTC model uses k and p factors to build the model. The k factor represents the relative change in hydro generation proportional to the relative change in load. The k factor is useful for areas that have hydro plants that follow load and lack detailed characteristics. The p factor represents the fraction of plant capacity that can adjust its output based on market price. The p factor optimizes a portion of hydro as if it were a thermal generator. The k factor ties in with the p factor to help build the HTC model. GridView version 10.3.26 and onward (which were used for 2032 ADS case build) automatically calculates p and k factors to use in the load-following dispatch.

#### Data Needed for Hydro Modeling:

The following data descriptions and field names are used in GridView:

* Plant capacity = Capacity;
* Ramp-up rate = RampUpRate;
* Ramp-down rate = RampDownRate;
* Reserve contribution = ReserveContribution;
* Maximum generation = MaxGenCap;
* Minimum generation = MinGen;
* Weekly energy = WeeklyEnergy;
* Daily Operating range = DailyOpRange;
* PLF allocator = PLFAllocator (Between 0-1);
* Whether the plant has the capability of spillage and banking.

Note: Banking and spillage are just field names in GridView, no abbreviated forms or symbols.

#### Data development for the hydro models:

* Given Schedule:The hourly profiles used in this model type were developed by WECC staff and are based on actual hydro generation data collected through WECC’s L&R data submission process for the year 2018. These hourly profiles were then applied to its respective hydro plant in the ADS case.
* HTC model - After receiving weekly hydro data from PNNL, WECC staff converted the weekly schedules into the most recent version of the GridView format, implemented the data into GridView, and worked with PCDS to troubleshoot errors.

#### Data Validation:

* The process of creating hourly profiles was according to PCDS recommendation.
* The weekly data created by PNNL was validated by the PCDS. The PCDS reviewed the data and voted for approval of the data by consensus.

Spreadsheet/data found here.[[5]](#footnote-6)

### Review/Modification Schedule:

WECC creates the ADS every even-numbered year with publication scheduled for June 30. In creating the 2032 ADS, WECC adopted year 2018 as the common reference year for hydro, solar, and wind data, requiring all data to be revised in 2022. WECC expects to review and revise, as needed, all hydro data in 2024 when creating the 2034 ADS. A full update of the hydro data is only needed when PCDS determines that the base year for coincident energy should be changed.

## Develop Solar Shapes Based on 2018 Weather Data

### Description:

The 2032 ADS includes solar energy resources as a major source of energy. The output of solar generators is based on the input of solar energy. Solar input depends on many factors, including the specific location of the generator and weather data. The 2032 ADS requires solar shapes that include the hourly profiles of solar input for each day of the year for each location.

The solar data development of hourly solar shapes is based on year 2018 weather data.

### Data Sources:

There are two sets of data, the actual hourly solar shapes and the source for location, name, etc.

Solar generator name, location, and type come from the following sources:

* L&R data submittal:
	+ Source of generator list, and includes location and generator type, i.e., fixed or tracking.
	+ Also includes a mapping to many of the EIA plant and generator codes for U.S. generators.
* EIA:
	+ Fills in gaps for generators with missing location data for U.S. generators
	+ For existing solar generators, the DC/AC ratio was used to calculate the hourly shapes

Hourly Solar Shapes:

Hourly solar shapes for the 2032 ADS were developed by NREL through funding provided by DOE. NREL used the data collected from the L&R and EIA as well as data available through their own sources.

### Data Development and Validation Process:

The solar profiles were created using the plant and location data provided to NREL by WECC staff. The location information came from the L&R submittals and the EIA-860. For existing generators, the DC/AC ratio from the EIA-860 data was used. If no DC/AC ratio was available, 1.3 ratio was assumed. NREL used weather data from 2018 and solar irradiance information to create 8,760 hourly shapes, one for each hour of the year.

The hourly data was provided in Universal Time and shifted to Mountain Time.

The hourly solar shapes are compared to actual data by entities willing to make a comparison. To avoid releasing proprietary information, the entities mask the solar plant being compared by giving a general area where the plant is located. Several locations throughout California and the PacifiCorp service territory were compared to get a good overall validation of the hourly solar profiles.

If there were differences between actual data and the NREL created shapes, NREL addressed configuration and comparison was redone until the results were satisfactory to NREL.

### Review/Modification Schedule:

A full update of the hourly solar profiles is only needed when the PCDS determines that the base year for coincident energy should be changed.

Any new planned solar generation will be updated each ADS PCM build cycle.

## Develop Wind Shapes Based on 2018 Weather Data

### Description:

The 2032 ADS includes wind energy resources as a major source of energy. The output of wind generators is based on the input of wind energy. Wind input depends on many factors including the specific location of the generator and weather data. The 2032 ADS requires wind shapes that include the hourly profiles of solar input for each day of the year for each location.

The wind data development of hourly wind shapes is based on year 2018 weather data.

### Data Sources:

NREL provided wind shapes to use in the 2032 ADS under funding by DOE.

There are two sets of data, the actual hourly wind shapes and the source for location, name, etc.

Wind generator name, location and type come from the following sources:

* L&R data submittal:
	+ Source of generator list and includes location and generator type, i.e., fixed or tracking.
	+ Also includes a mapping to many of the EIA plant and generator codes for U.S. generators.
* EIA:
	+ Fills in gaps for generators with missing location data for U.S. generators hourly wind shapes
* NREL, under DOE funding, has developed the hourly wind shapes.
	+ NREL uses the data collected from the L&R and EIA.

### Data Development and Validation Process:

The wind profiles were created using the plant and location data provided by WECC staff to NREL. The location information came from the L&R submittals and the EIA-860. For existing generators, the DC/AC ratio from the EIA-860 data was used. If no DC/AC ratio was available, 1.3 ratio was assumed. NREL used weather data from 2018 and wind speed information from the National Oceanic and Atmospheric Administration (NOAA) to create 8,760 hourly shapes for each hour of the year.

The hourly data was provided in Universal Time and shifted to Mountain Time.

The hourly wind shapes are compared to actual data by entities willing to make a comparison. To avoid releasing proprietary information, the entities mask the wind plant being compared by giving a general area of where the plant is located. Several locations throughout California and the PacifiCorp service territory were compared to get a good, overall validation of the hourly wind profiles.

If there were differences between actual data and the NREL-created shapes, NREL-addressed configuration and comparison was redone until the results were satisfactory.

### Review/Modification Schedule:

A full update of the hourly wind profiles is only needed when PCDS determines that the base year for coincident energy should be changed.

Any new planned wind generation will be updated with each ADS PCM build cycle.

## Review and Update WECC Path Ratings and Definitions in PCM

### Description:

A transmission path is a transmission line or set of transmission lines between Balancing Authorities, internal to a Balancing Authority, or a combination of both. Transmission paths are also referred to as transfer paths, paths, or interfaces.

A path rating is the limit within which Transmission Operators must operate flows on a transmission line or a group of parallel transmission lines. In other words, the path ratings are the allowable transfer capability and are made up of a forward and reverse rating for each path. A path rating ensures that flows on each path are within appropriate physical and security constraints. Factors that affect path ratings include facility ratings, seasonal temperature differences, environmental considerations, critical disturbance information, remedial action schemes, and age of equipment. The paths that have seasonal ratings are reflected monthly in the PCM path ratings. Path ratings are proposed by project sponsors and approved by the project review group which is made up of members from the Studies Subcommittee (StS) and the RAC.

Information regarding current path definitions can be found in the [WECC Path Ratings Catalog](https://www.wecc.org/_layouts/15/WopiFrame.aspx?sourcedoc=/Reliability/NDA/WECC%202022%20Path%20Rating%20Catalog.pdf&action=default&DefaultItemOpen=1) (PRC).[[6]](#footnote-7) The PRC is a reference document for planning, a primary source of currently available information on maximum, non-simultaneous path ratings to members, and a resource of discussion of simultaneous interactions between major transmission paths. The PRC includes three phases of transmission projects:

* Existing projects are transmission facilities that are in service.
* Phase 2 projects have studies underway to define path ratings.
* Phase 3 projects have completed study work and the path rating has been accepted and approved.

Phase 2 and Phase 3 projects are currently not existing transmission paths; they are speculative.

For the 2032 ADS case, the APFWG created the 2032 reference power flow (PF) which was used to create the 2032 ADS PCM. As part of that effort, the APFWG verified that interface definitions and ratings for WECC paths used in the Power Flow Reference Case matched those included in the 2022 Path Rating Catalog. Additionally, the APFWG verified that the Reference Case included new paths and Phase 3 projects where appropriate.

In addition, the same changes were to be made in the 2032 ADS PCM. The 2030 ADS PCM path definitions were used as a starting point for the 2032 ADS PCM.

### Data Sources:

The 2022 WECC Path Ratings Catalog is a compilation of all the WECC paths, which includes information such as path definitions, path ratings, locations, etc.

The 2032 Heavy Summer Base Case was the starting point for the 2032 ADS.

The APFWG developed the 2032 ADS Reference Case. The reference case has all the original generation from the Heavy Summer Base Case plus all the new generation from the L&R data. Each resource in the reference case was marked with a tag indicating whether it was present in the original base case but not the L&R, present in both, or only present in the L&R, in which case it was created and added to the reference case.

### Data Development and Validation Process:

1. Compare the 2030 ADS PCM path branch definitions to the 2032 Heavy Summer Base Case (32HS1a1) PF path branch definitions by looking for changes in branch topology and differences in defined branch direction.
2. Verify that new paths and Phase 3 projects are included.
3. Update Paths using the 2022 Path Rating catalog.
4. Implement the validated path ratings and definitions in the ADS PCM.

The PCDS reviewed the data developed by the APFWG and voted by consensus to keep the retired path data.

The APFWG identified errors and possible corrections to the 32HS1a1 PF WECC Path definitions and ratings.

### Review/Modification Schedule:

The path ratings are reviewed biennially for each ADS study cycle.

## Review and update nomograms

### Description:

Nomograms are special constraints created by transmission operators, utilities, generation owners, or other entities that have information regarding a constraint on the system. These nomograms are designed to represent specific operational limitations such as:

* Path or branch coordination schemes;
* Generation and import coordination; and
* Area local generation support (voltage and frequency response).

A user-defined cost penalty is assessed whenever the constraint is exceeded for that nomogram. Complex constraints can be built using multiple nomograms to define the constrained operation. The active nomograms included in this ADS case are described in Table 1.

### Data Sources:

Information used to determine nomograms comes from transmission operators, utilities, generation owners, or whoever has information regarding a constraint on the system, which includes expertise in the PCDS to accurately represent the Western Interconnection.

### Data Development and Validation Process:

Information and expertise are evaluated in the PCDS to determine which nomograms should be implemented in the ADS PCM to model the system more accurately. Below are the nomograms that are included in the 2032 ADS PCM.

Table 1: Nomograms in 2032 ADS

| Active Nomogram | Purpose |
| --- | --- |
| EPE Balance | EPE generation will meet 85% or greater of its local load |
| TEP Local Gen | TEP generation will meet 32% or greater of its local load |
| Path 8\_1, and Path 8\_2 | The interaction of Path 8, Montana to Northwest, and Montana hydro generation is modeled |
| w\_AB32\_NW\_Tier1\_Exports | Price penalty on imported GHG to California |

Spreadsheet/data found here.[[7]](#footnote-8)

### Review/Modification Schedule:

The nomograms are reviewed biennially for each ADS study cycle.

## Review/Update Utility Tariff & Wheeling Rates, Hurdle Rates, Assumptions & Compensate for Modeling Limitations

### Description:

The hurdle rates described are the only monitored wheeling charges in GridView.

Hurdle rates represent the cost to deliver surplus energy among different regions, and they are called “wheeling charges” in GridView. Transmission Owners charge hurdle rates on flows into their associated Balancing Authorities as a way to recover costs associated with use of their transmission facilities. The 2032 ADS PCM case models hurdle rates based on three categories of charges:

* **Tariff rates**: trade policy-based charges applied to power transfers between regions.
* **Wheeling rates**: charges paid to the owner of a transmission line for the right to transport power across the line.
* **Rates per model validation**: interregional charges modeled to encourage reasonable interregional transfers. These are set based on stakeholder review of simulation results and their recommendations.

### Data Sources:

OASIS wheeling rates (in dollars per megawatt) are used in the ADS PCM for each area.

### Data Development and Validation Process:

The tariff rates were derived from the 2015 OASIS rates posted by the applicable transmission owners as compiled by the CAISO. The tariff values are base values and do not include additional charges associated with the California Global Warming Initiative.

These hurdle rates are verified through the PCDS.

Spreadsheet/data found here.[[8]](#footnote-9)

### Review/Modification Schedule:

The hurdle rates are reviewed biennially for each ADS study cycle.

## Forced Outage Rates

### Description:

The forced outage rates represent the percentage of the year that a thermal generator is offline for unplanned outages. The forced outage rates are developed from the Generator Availability Data System (GADS) and are represented as a percentage of time each component will be offline. The point in time at which the component is forced offline during each simulation is random and based on a seed, or number in GridView.

### Data Sources:

Generator Availability Data Set (GADS) using the pc-GAR program from NERC.

### Data Development and Validation Process:

Data from GADS is collected from pc-GAR software. GADS data is considered confidential information at a unit level or even a regional level. Pc-GAR will provide the yearly statistics only if the following rules are followed to mask unit, utility, or regional level data:

* A minimum of two regions, i.e., WECC and SERC;
* A minimum of seven units; and
* A minimum of three utilities.

The Equivalent Forced Outage Rate demand (EFORd) statistic is used in the PCM for the forced outage rate. The simple average was used for gas turbines, combined cycles, and steam-coal turbines. For steam-gas turbines, the median was used.

GridView then randomly forces out each thermal generator according to its seed and Monte-Carlo simulation.

### Review/Modification Schedule:

Forced outage rates are reviewed biennially for each ADS study cycle.

## Thermal Plant Fuel Costs

### Description:

The ADS PCM includes fuel costs for coal, natural gas, and other thermal plants. “Other” thermal plant fuels include uranium, biofuels, black liquor, refuse, solid waste, and geothermal steam. WECC’s PCDS and WECC staff develop thermal plant fuel prices for the ADS PCM.

The ADS also uses a specific inflator/deflator to adjust data to the correct years dollars to match the base year of the ADS.

### Inflation Rate—Inflator/Deflator

Cost data such as fuel prices, variable O&M rates, and start-up costs are often provided in different year’s dollars and require conversion to a selected base year dollar. The base year is determined by the PCDS and is usually the build year for the case. For example, the 2032 ADS PCM case is being built in year 2022, thus the base year is 2022, so the case was built using year 2022 dollars. These conversions are based on the Moody’s GDP Inflator/Deflator series, licensed to the California Energy Commission (CEC). Moody’s series has an average annual inflation from 2020 through 2022 of 105.255 percent.

Spreadsheet/data found here.[[9]](#footnote-10)

### Approval Item:

On March 29, 2022, the PCDS approved the use of CEC 2021 IEPR Implicit GDP Deflator by Moody Analytics for data development in the 2032 ADS PCM database.

Qualification: CEC has a consent from Moody Analytics for the use of its deflator for ADS.

## Coal Price Development

### Data Sources:

* The coal prices used in the ADS are based on the CEC’s Integrated Energy Policy Report (IEPR) for the base year of the ADS.
* The ADS also reports historic coal prices reported by the EIA in its 923 report for the ADS base year.

In some cases, coal plants are under contract for fuel at specified prices for future years. In those cases, future coal prices reflect the contract price rather than the forecast price. Derived prices may be split into a fixed and variable/dispatch portion, depending on the contract terms.

### Data Development and Validation Process:

1. WECC requests the CEC’s IEPR for the ADS base year.
2. If coal prices reported in the IEPR differ from the ADS base year, apply the GDP Deflator Series provided by the CEC to convert the prices from the year reflected to the reference or base year used for the case. Coal prices are reported and modeled as a single price for each year and do not vary monthly.
3. The derived prices may be split into a fixed and variable/dispatch portion.
4. Some coal prices are reflected by a contract price with the coal mine rather than the forecast price.
5. WECC documents the coal prices for the base year and each of the 10 years from the base year through the ADS case year.
6. The PCDS reviews the prices reported by the CEC and EIA to determine which prices to use. Decision criteria include a careful comparison between the EIA and CEC data. The PCDS then approves coal prices to use in the ADS PCM.
7. WECC staff implements the coal prices by adding them to GridView.

Spreadsheet/data found here.[[10]](#footnote-11)

### Review/Modification Schedule:

WECC reviews and modifies thermal plant fuel costs biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also modifies thermal plant fuel costs in even-numbered years.

### Approval Item:

On March 29, 2022, the PCDS approved reuse of the 2030 ADS coal prices in the 2032 ADS PCM, with no escalation except for adjustment to 2022 dollars. This is consistent with the fact that forward information is limited since the industry faces uncertainty due to policy considerations and inflexible price conditions.

## Natural Gas Price Development

### Data Sources:

WECC requests the following data:

* CEC monthly burner tip hub prices, requested from the CEC. This data includes transportation cost (delivery cost from the pipeline to the generation plant) separate from the burner tip prices to the annual North American Gas (NAMGas) prices and converts them to a monthly price.
* CEC burner tip prices are converted to monthly prices using Northwest Power and Conservation Council’s (NWPCC) method.
* NWPCC monthly price forecasts and monthly shapes. The NWPCC derives these forecasts from historic price data and seasonal supply expectations. It also provides hub prices, although the hubs are not the same as those from the CEC. Additionally, WECC requests monthly shapes for natural gas prices.
* WECC adjusts the base year natural gas prices relative to the base year using Moody’s inflator/deflator series described above under coal prices. The ADS PCM uses monthly natural gas prices based on those provided by the CEC and NWPCC.

### Data Development and Validation Process:

1. Receive natural gas price data from the CEC and NWPCC.
	1. Model natural gas prices as a monthly price.
2. Map the CEC price hubs to the CEC burner-tip points.
3. Map the PCM fuel names and the NWPCC hubs to the names used for CEC burner-tip points.
4. Apply the transportation prices to the burner-tip points.
5. Apply a GDP inflator/deflator to adjust the prices to the correct base year’s dollars.
6. Build monthly prices from the annual CEC burner tip prices and the NWPCC monthly shapes.
7. Build a table of natural gas prices for the base year through the ADS year that is importable to GridView.
8. PCDS approves the natural gas prices and methods.
9. WECC staff implements natural gas prices by importing them to GridView.

Spreadsheet/data found here.[[11]](#footnote-12)

### Review and Modification Schedule:

WECC reviews and modifies thermal plant fuel costs biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also modifies thermal plant fuel costs in even-numbered years.

### Approval Item:

On March 29, 2022, PCDS approved the use of CEC natural gas prices in the 2032 ADS:

Natural Gas Prices—developed using the CEC monthly burner-tip prices, validated with EIA and Northwest Power Conservation Council’s prices.

## Other Fuels Prices

### Data Sources:

WECC obtains prices for other fuels including uranium, biofuels, black liquor, refuse, solid waste, and geothermal steam in two ways:

* WECC staff reviews the EIA 923 report to determine whether fuel costs for other generation types are available from this source.
* If data are not available from the EIA, WECC staff requests missing data from the NWPCC.
* Other fuel cost data are modeled as a yearly price that does not vary monthly as natural gas prices do.

### Data Development and Validation Process:

1. Compile other generation sources’ fuel prices as described above.
2. Review and approve fuel prices through PCDS.
3. WECC staff implements approved fuel prices by adding them into GridView.

### Review/Modification Schedule:

WECC reviews and modifies other generation sources’ fuel costs biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also modifies thermal plant fuel costs in even-numbered years.

Spreadsheet/data found here.[[12]](#footnote-13)

### Approval Item:

On March 29, 2022, the PCDS approved the use of “other” fuel prices for the 2032 ADS PCM database as follows:

* Annual Energy Outlook 2022 forecast, if data was missing from the Annual Energy Outlook 2022, it was supplemented with the fuel pricing data from the NWPCC as available.
* For missing price forecasts, values are escalated from the 2030 ADS, using the CEC Deflator.

## Thermal—Develop Emissions Cost

### Description:

The impacts of greenhouse gas for the 2030 ADS PCM are modeled through an emission rate (lb/MMBtu) for each fuel, and a credit cost ($/lb) for CO2 charges for California, British Columbia, and Alberta.

### Data Sources:

* CEC 2021 IEPR;
* PNNL expertise; and
* PCDS expertise.

### Data Development and Validation Process:

The CO2 prices are gathered from data sources listed above and integrated into the case. However, if the data does not exist, the PCDS will determine a value for states not defined for the study year.

Spreadsheet/data found here.[[13]](#footnote-14)

### Review/Modification Schedule:

WECC reviews and modifies the emission costs biennially during each ADS development cycle.

## Thermal—Costs and Economics

### Description:

The ADS PCM includes only variable operating and maintenance (VOM) costs as an operating cost. Other operating costs include fuel labor and maintenance, unlike capital costs, which are “fixed” and do not vary with the level of output. In general, central station generators face a cost tradeoff between capital and operating costs. Plants that have higher capital costs tend to have lower operating costs. Further, generators that run on fossil fuels tend to have operating costs that are extremely sensitive to changes in the underlying fuel price.

Both VOM and fixed costs should be accounted for when considering the most economic project.

### Data Sources:

Intertek Cycling Cost Report.

### Data Development and Validation Process:

###### VOM Cost

The case models VOM costs for thermal generators. The VOM costs for thermal generators were obtained from Intertek’s [Cycling Cost report](https://www.wecc.org/Reliability/1r10726%20WECC%20Update%20of%20Reliability%20and%20Cost%20Impacts%20of%20Flexible%20Generation%20on%20Fossil.pdf).[[14]](#footnote-15)

###### Dispatch Cost

Dispatch costs for generators are developed by PCDS. For the 2032 ADS PCM case, the dispatch costs were carried over from 2030 ADS PCM case.

###### Start-up Cost

Start-up cost of a generator is obtained from the Intertek Cycling Cost report.

Spreadsheet/data found here.[[15]](#footnote-16)

### Review/Modification Schedule:

WECC reviews and modifies the cost and economic information biennially during each ADS development cycle.

## Solar, Wind, Storage, BTM, Geothermal Fixed, and VOM Costs

### Description:

Solar, wind, and BTM units do not have any fixed or VOM costs in the ADS. Battery storage and geothermal have VOM costs.

### Data Sources:

* Battery Storage VOM: Sandia National Labs Handbook.
* Geothermal VOM: Intertek.

### Data Development and Validation Process:

The VOM for each battery type and geothermal plant are collected and integrated into the ADS PCM.

### Review/Modification Schedule:

WECC reviews and modifies the cost and economics information biennially during each ADS development cycle.

## Pumped and Battery Storage—Charging, Discharging Cost/Rates

### Description:

GridView models storage resources as either pumped storage or batteries. To model these resources, GridView needs a cost for charging/pumping (batteries/pumped storage) and for discharging/generating.

### Data Sources:

Data sources for pumped storage and battery storage include

* CEC
* NWPCC
* EIA
* Utility Integrated Resource Plans (IRP)

### Data Development and Validation Process:

The battery and pumped storage charging and discharging costs/rates are represented as pumping and generating prices in GridView. The pumping price is the field in the PumpedStorage\_General.csv table that sets the LMP at the generator bus at which the unit starts to pump in for pumped storage units, or, as in the case of modelled battery energy storage systems (BESS), starts charging. This is set to “0” in the ADS case. Similarly, the “generating price” field in the PumpedStorage\_General.csv table is the LMP at the generator bus at which the pumped storage, the modeled BESS unit, starts generation. This is set to “200” in the ADS case.

The PCDS reviews, validates, and approves all the information pertaining to an energy storage units.

### Review/Modification Schedule:

WECC reviews and modifies pumped and battery storage costs/rates biennially during each ADS development cycle.

## Transmission Rights

### Description:

Transmission rights are not modeled in the 2032 ADS PCM case.

## Remotely Owned/Contracted Generator Model

### Description:

With the topology for area loads and regions, it is necessary to associate remotely owned (or contracted) resources with the participating areas or regions. Remote resources are resources that have an attached transmission service agreement in place to supply a certain amount of power. This provides the information that GridView needs to count the generation shares for reserves and to deliver the associated energy with no hurdle rate charge (assumes that delivery cost is a fixed cost).

### Data Sources:

The list of remotely owned generation is dynamic and depends on utilities and stakeholder input, mainly through the PCDS.

### Development and Validation Process:

Remotely owned generator information can be difficult to find. Members of the PCDS research remotely owned generation to discuss at the PCDS. The PCDS verifies and validates the updated remotely owned generator sources and data to be integrated into the ADS PCM.

The link below shows the list of remote generators that were modeled in the 2032 ADS PCM case.

Spreadsheet/data found here.[[16]](#footnote-17)

### Review/Modification Schedule:

WECC reviews the remote generation list biennially during each ADS development cycle.

## Ancillary Services (AS) Model Description:

Ancillary services (AS) are defined at the Balancing Authority Area (BAA) or region level and the following ancillary services are modeled:

* Regulation up/down;
* Spinning and non-spinning reserve; and
* Load following up/down.

### Data Sources:

For the 2032 ADS, capacity reserves are developed by PNNL. The work is currently underway with reserve calculations expected by the fourth quarter of 2022.

### Data Development and Validation Process:

1. Regulation and load following (Flex) Reserves were developed by PNNL (2032 updates to be developed by PNNL).
2. All the information pertaining to ancillary services is validated by the PCDS.

Spreadsheet/data found here.[[17]](#footnote-18)

### Review/Modification Schedule:

WECC reviews and modifies ancillary services data biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also reviews ancillary services data biennially and modifies it if required.

### Milestones:

Milestone Product: 2032 ADS PCM-2 (5f).

# Incorporate Incremental Resources to Create 2032 ADS PCM-2 (5f)

### Description:

This process incorporates the incremental resources from 2022 L&R dataset into 2032 ADS, develops hourly load profiles using 2022 L&R submittals, and adds remaining data to 2032 ADS PCM "Version 1" to create “2032 ADS PCM-2 (5f)”.

The 2022 L&R submittal dataset resources must be reconciled and put into the PCM case to develop the 2032 ADS PCM (5f). Also, the incremental resources must be put into the 2032 ADS PF Reference "Version 1" to create the 2032 ADS PF reference case.

To incorporate these incremental resources, the following information must be reconciled:

* Create a list of incremental resources—Compare 2022 L&R submittal to 2021 L&R submittal;
* Identify missing information—Create a list of resources with missing information, compare it with the list of missing information for 2021 L&R;
* Send request for missing L&R data to regions or data submitters to get missing locations for incremental units. Get coordinates for units, especially renewable. Request hydro data from CAISO, BC Hydro, NWPCC, pumped and battery storage characteristics;
* Finalize location for resources with no bus information;
* Review requested data;
* Incorporate incremental resources and load profiles;
	+ Incorporate the 2022 L&R into 2032 ADS PF reference "Version 1" to create the 2032 ADS PF reference case; and
	+ Incorporate the 2022 L&R into 2032 ADS PCM (5a) to create the 2032 ADS PCM (5f).

Milestone Product: 2032 ADS PF Reference Case; 2032 ADS PCM (5f)

### Data sources:

* 2021 L&R submittal
* 2022 L&R submittal

### Data Development and Validation Process:

Incremental resources must be validated using the same process as described above for each resource types.

1. WECC staff—document resources included in the 2022 L&R submittal.
2. Compare them to the resources already entered into the case.
3. Create a file of incremental resources that need to be added. These include:
	1. Incremental thermal resources,
	2. Solar and BTM shapes for incremental solar plants,
	3. Wind shapes to incremental wind plants,
	4. Incremental hydro units,
	5. Incremental pumped and battery storage resources, and
4. Implement the incremental resources in GridView.

### Review/Modification Schedule:

Resources for the ADS are updated biennially in each ADS build cycle.

## Loads

### Description:

Expected loads are needed for each load area and are represented as hourly profiles for each hour of the year. These hourly load profiles are created from monthly peak and energy information from the non-validated 2022 L&R submittal. These loads are escalated based on an average year (2018) to create the new Year 10 hourly load profiles.

These developed load profiles are implemented in the PCM as an hourly shape for each area.

### Data Sources:

Data needed to develop the 2032 hourly loads include:

* Monthly Peak and Energy from the L&R Demand Workbook and L&R Year 10 Loads in the 2022 L&R data submittal;
* NREL BTM data to correctly account for how much BTM data is in the loads; and
* The 2018 hourly loads to grow the loads to 2032.

### Data Development and Validation Process:

1. L&R data (Year 10 Loads and Demand Workbook) are requested from each area and submitted to WECC.
2. This data is collected and parsed according to monthly peak and monthly energy according to the type of power or energy i.e., BTM, DSM, firm, etc.
3. This data is then escalated to 2032 using the designated hourly load shape for each area (2018 hourly load shape for the 2032 ADS PCM)
4. Rooftop solar (BTM) not including expected installed capacity is added in with the BTM NREL data for monthly energy
	1. BTM NREL data (capacity for each area) is multiplied by the BTM shape for each area to produce a monthly BTM energy value for each area and added into the monthly energy.
5. This load data is now in a 2032 hourly format for each of the areas, it is then reviewed by analyzing historical data for each of the areas, such as hourly shape, monthly unitized peak, load factor, monthly peak demand, and monthly energy.
	1. If any of the data appears erroneous, WECC reaches out to the data submitters for an explanation of the discrepancy or to receive corrected data.
6. Once the data has been reviewed, it is then verified through the PCDS.
7. Once the data has been verified by the PCDS, hourly shapes/profiles are created and imported to the PCM.

### Review/Modification Schedule:

WECC reviews and modifies loads and profiles biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also modifies the loads in even-numbered years.

Spreadsheet/data found here.[[18]](#footnote-19)

## Develop shapes for EE AAEE, DG BTM (Rooftop) solar shapes

### Description:

Demand side management is also considered. It is meant to affect the power system through the demand side, and it takes on many forms, either through energy efficiencies where technologies or processes can become more efficient to decrease load, or through distributed generation (DG) such as behind the meter rooftop solar.

The PCM allows EE, AAEE, and DG to be modeled.

The 2032 ADS PCM assumes that DG is not included in the L&R load forecasts. DG includes two parts:

* **DG-BTM—**small-scale solar PV installations that customers would install to avoid purchasing electricity from an electric utility.
* **Wholesale DG—**PV systems that are connected directly to the electric distribution network and sell the electricity on the wholesale market, typically 1–20 MW and often procured to meet state DG targets.

Currently, DG is being modeled as a resource in the dataset. The DG in the case is modeled as roof-top PV from the L&R dataset. The 2032 ADS PCM county-level shapes were provided by PNNL and taken from NREL DG 2032.

BTM DG is provided by estimates developed by Energy and Environmental Economics (E3) and Lawrence Berkeley National Lab (LBNL) and vetted through the PCDS. These capacities are used to develop “fixed rooftop” solar PV profiles and modeled as a fixed-shape resource. Wholesale DG is provided to the dataset like any other resource—by L&R data submittals, the EIA, and IRPs—and validated through the generator reconciliation effort.

AAEE and EE were not modeled in the 2032 ADS PCM.

### Data Sources:

DG-BTM by county profiles were developed by PNNL for each county in the Western Interconnection. PNNL used the NREL dGen tool, which provided BTM solar shapes to use in the 2032 ADS through funding by DOE.

### Data Development and Validation Process:

1. Create a generator for each county to act as the DG-BTM generator for that county.
2. Distribute the county DG-BTM generator to load buses for that county.
3. Assign each county generator a county level DG-BTM shape that was developed by PNNL, which used the NREL dGen.
4. BTM solar shapes are reviewed and approved by the PCDS.
5. Put the generators into GridView.

### Review/Modification Schedule:

WECC reviews and modifies DG-BTM biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also reviews and modifies the DG-BTM in even-numbered years.

Spreadsheet/data found here.[[19]](#footnote-20)

## Demand Response

### Description:

Demand response (DR) is a customer reduction in electricity usage such that the customer’s normal consumption pattern is reduced in response to price changes or incentive payments designed to lower electricity use at times of system stress or high market prices.

DR is modeled as an hourly resource that is fed directly into the model. To develop the hourly DR profiles WECC has used the LBNL Dispatch Tool. The tool requires three user-defined inputs:

* Maximum monthly DR capacity for each (non-interruptible) DR program type and BA.
* Hourly energy load for each BA; and
* Hourly LMP for each Balancing Authority from GridView.

The DR forecast is developed by the LBNL.

### Data Sources:

* A full year run (8,760 hours) on the preliminary 2032 ADS PCM case is needed to identify the hourly load profile for each day. This information is needed to create a proper DR shape that would correspond with load and generation.
* LBNL DR Dispatch Tool is used to determine when to dispatch the DR for each area, which is used to create the hourly DR shape.

### Data Development and Validation Process:

DR impacts are an input for WECC’s 2032 ADS and specified as hourly load modifying shapes for each WECC load zone. To derive the hourly shapes, LBNL executed a simulated dispatch of DR resources based on hourly loads and LMPs. LBNL describes the simulated dispatch method below.

LBNL used the 2032 non-firm “expected available” load forecasts submitted by WECC Balancing Authorities as the ADS DR resource capacities. Unlike prior years, LBNL did not adjust the BA non-firm load forecasts to correct for any inconsistencies with other DR program forecasts. LBNL also used the 2032 ADS hourly loads and hourly LMPs (weighted by load and net BTM generation) before adding DR for each WECC load zone to trigger dispatch of the DR resources. Hourly loads and hourly LMPs were provided by WECC staff.

LBNL used the LBNL DR Dispatch Tool to produce an hourly profile of DR load reductions for each WECC load zone, using the 2032 ADS DR resource capacities, hourly loads, and hourly LMPs. When dispatching the DR resources within the tool, LBNL made the following assumptions (see Table 2) about the expected hours of dispatch for each of the DR program types, which are consistent with the assumptions made in the WECC 2024, 2026, 2028, and 2030 Common Case studies.

Table 2: Expected hours of dispatch for each DR program type

|  |  |  |  |
| --- | --- | --- | --- |
| **DR Program type** | **Expected Dispatch Hours per Year** | **Number of Events** | **Duration of Events (Hours)** |
| Interruptible | 10 | 5 | 2 |
| Automated/direct control | 40 | 10 | 4 |
| Pricing | 50 | 10 | 5 |
| Load as a capacity resource | 60 | 10 | 6 |

LBNL also applied an hourly shaping to the available DR resource capacity in each hour to ensure DR programs typically used during system peak months and hours were not used at full availability in non-system-peak months and hours. The same hourly shaping approach was used in the WECC 2024 and 2026 Common Cases and the 2028 and 2030 ADS data sets, in which WECC assumed the size of the available DR resource in each hour was proportional to the ratio of load in each hour to the annual peak load.

LBNL then simulated the operation of the DR resources, using the 2032 ADS hourly prices as the source of the “trigger” for dispatch of the DR resources. This dispatch logic was used in the prior WECC 2024 and 2026 Common Cases and the 2028 and 2030 ADS data sets[[20]](#footnote-21) and represents the dispatch of DR resources for reliability and economic purposes during high system LMPs. The PCDS then verifies the approach. Then the DR shapes are put into the 2032 ADS PCM.

### Review/Modification Schedule:

WECC reviews and modifies DR biennially during each ADS development cycle. As WECC creates the ADS in even-numbered years, it also reviews and modifies the DR in even-numbered years.

## Pumping Loads

Pumping load units and plants are modeled as negative generation and associated reductions are applied to the L&R load forecast. The plants are modeled with hourly shapes either because the information regarding the plant’s operational practices is missing or its operation rarely changes from year to year. For the 2032 ADS PCM, the hourly shapes for pumping plants were modeled with 2018 pump load data collected.

### Data Sources:

* CAISO; and
* L&R submittal.

### Data Development and Validation Process:

1. PCDS decides which year pumping loads hourly shapes should be modeled for and for 2032 ADS case approved year 2018 for coincidental energies.
2. Pump loads for 2018 were requested from the entities.
3. Hourly shapes were created for each plant using the loads for 2018 and implemented for the plant in the case.
4. Pumping loads are backed out of the load forecast.
	1. The hourly pump load shapes are added to the spreadsheet that is used to calculate the hourly loads. After growing the 2018 hourly load shapes using 2032 monthly peak and energy, the hourly pump load is subtracted from hourly load shape.
	2. The resulting shape is what is input into the PCM model.

### Review/Modification Schedule:

WECC reviews pumping loads biennially during each ADS development cycle.

## Develop/Review Maintenance Schedule for Thermal Plants

### Description:

The generator maintenance schedule represents when each generating unit will be offline for planned maintenance.

### Data Sources:

The data needed to determine the maintenance schedules is the hourly load and generation dispatches for the entire year. For this, a full-year run of the ADS PCM is needed to develop the maintenance schedules.

### Data Development and Validation Process:

The actual planned maintenance schedules for each area are proprietary. However, the maintenance schedules for the ADS PCM are based on generation and load levels to determine a best estimate for the most cost-effective time to do planned maintenance.

This is done by the GridView or by the user. GridView can schedule generator maintenance through the program, which will distribute the planned maintenance hour according to the amount of available generation compared to load.

If the user would like to assign the maintenance schedules, a complete full-year run of the ADS PCM is used to analyze the times during the year when there is excess generation. Those times of excess generation can be selected as the times for planned maintenance for each area.

Planned maintenance is done weekly.

### Review/Modification Schedule:

WECC reviews and modifies generator maintenance schedules during each ADS development cycle.

# Review and Publish

The 2032 ADS PCM case has been reviewed by the PCDS. The full 2032 ADS PCM dataset can be found [here](https://www.wecc.org/ReliabilityModeling/Pages/AnchorDataSet.aspx#ADS2032Deliverables).[[21]](#footnote-22)

# ADS Change Process (Under development)

The ADS change tracker is still under development, but when the change tracker is complete, please follow the process below. In the meantime, please notify WECC staff if you would like to recommend a change to the 2032 ADS PCM case.

**ADS Change Tracker Process Steps:**

1. Submit change through change tracker link.
2. WECC staff review and post change to changes spreadsheet, visible to PCDS.
3. PCDS review and discuss change.
	1. Propose resolution.
4. PCDS approve or reject change.
5. Document PCDS decision on the proposed change in change tracking spreadsheet and update status to include or reject change.
6. WECC staff implement or discard change.
7. Document change status to complete.

# Potential Modeling Issues

It is a given that some assumptions provided by the data providers may have an unintended impact on the WECC PCM results. The PCDS has compiled a list of the issues it identified. In some cases, PCDS has a proposed modeling change available. These are called scenarios and are provided as part of the released PCM dataset.

The list of potential modeling issues and the status of each issue can be found [here](https://www.wecc.org/ReliabilityModeling/Pages/AnchorDataSet.aspx#ADS2032Deliverables).[[22]](#footnote-23)

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Version Number | Date | Nature of Revision | Approved by |
| 1 | 06-30-2022 | Restructure of document |  |
| 1.0 | 09-23-2022 | Draft version of 2022 DDVM | WECC |
| 1.1 | 12-09-2022 | Final version of 2022 DDVM | WECC |
|  |  |  |  |

WECC receives data used in its analyses from a wide variety of sources. WECC strives to source its data from reliable entities and undertakes reasonable efforts to validate the accuracy of the data used. WECC believes the data contained herein and used in its analyses is accurate and reliable. However, WECC disclaims any and all representations, guarantees, warranties, and liability for the information contained herein and any use thereof. Persons who use and rely on the information contained herein do so at their own risk.

1. This contract was used to build the 2032 ADS but may not be repeated for future cases. [↑](#footnote-ref-2)
2. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Model%20Type.one#Model%20Type&section-id={3F1CB8D9-2E93-4159-B71D-B1AD85B5DFBF}&page-id={BA301C30-B2A6-4084-B6F5-D6E07FA4ACEE}&object-id={03485423-206A-4797-A687-91EC714B3936}&10 [↑](#footnote-ref-3)
3. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Generation.one#Thermal%20Generation&section-id={9D4610AB-5D42-4E9E-B534-A1047E8C7833}&page-id={6EEB2B21-910A-47B0-8DDB-96379815EAED}&object-id={A68FA80E-1987-019C-3638-41B87D9B9029}&10 [↑](#footnote-ref-4)
4. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Generation%20Resources.one#Thermal%20Resources%20-%20Data%20Development&section-id={4198E5BF-B50E-4D22-8D3D-C6E852B25A29}&page-id={E33FF46F-E8F8-477A-9C17-DDEDBBF68BC8}&object-id={27A40734-A5DA-4388-BEC8-6DEFF405C955}&10 [↑](#footnote-ref-5)
5. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Generation%20Resources.one#Hydroelectric%20Resources&section-id={4198E5BF-B50E-4D22-8D3D-C6E852B25A29}&page-id={3EBB7A9C-666C-48DC-9624-BA742589035D}&object-id={977450B5-F438-44DE-9B7F-BB640D4F3884}&10 [↑](#footnote-ref-6)
6. https://www.wecc.org/\_layouts/15/WopiFrame.aspx?sourcedoc=/Reliability/NDA/WECC%202022%20Path%20Rating%20Catalog.pdf&action=default&DefaultItemOpen=1 [↑](#footnote-ref-7)
7. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Nomograms.one#Nomograms&section-id={DAB67C1D-76CF-4C88-9FE0-FAFBC80E7762}&page-id={F7C0492F-E2B7-49CC-A2CE-D60945450E68}&object-id={A96AE608-82CA-4F24-AD43-AAAE34A3AF7E}&28 [↑](#footnote-ref-8)
8. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Market%20Model.one#Wheeling%20Charge%20Model&section-id={AD118695-276A-4C95-B026-F319C80EF88A}&page-id={F23CBE40-A8CF-4F9A-9D95-EAAA7CCAF327}&object-id={0B5F857E-6559-4323-A93B-0A30027241D2}&10 [↑](#footnote-ref-9)
9. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Costs%20and%20Economics.one#Thermal%20Fuel%20Prices&section-id={3F75144D-F05B-446B-9809-090CF4F0D846}&page-id={5ED6B38F-5E87-4E6E-A3E5-BA5ADA85B25E}&object-id={B43BF569-2B94-0E85-00CB-2B33E2C661C4}&12 [↑](#footnote-ref-10)
10. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Costs%20and%20Economics.one#Thermal%20Fuel%20Prices&section-id={3F75144D-F05B-446B-9809-090CF4F0D846}&page-id={5ED6B38F-5E87-4E6E-A3E5-BA5ADA85B25E}&object-id={1F7303BD-4481-0112-273C-D6D3F84CB411}&41 [↑](#footnote-ref-11)
11. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Costs%20and%20Economics.one#Thermal%20Fuel%20Prices&section-id={3F75144D-F05B-446B-9809-090CF4F0D846}&page-id={5ED6B38F-5E87-4E6E-A3E5-BA5ADA85B25E}&object-id={6C39CCA3-CF3A-0E68-08EC-77FF9B5A0B30}&19 [↑](#footnote-ref-12)
12. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Costs%20and%20Economics.one#Thermal%20Fuel%20Prices&section-id={3F75144D-F05B-446B-9809-090CF4F0D846}&page-id={5ED6B38F-5E87-4E6E-A3E5-BA5ADA85B25E}&object-id={A9397519-5F88-075C-3BCB-BCB3092D1896}&20 [↑](#footnote-ref-13)
13. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Market%20Model.one#Greenhouse%20Gas%20(GHG)%20Model&section-id={AD118695-276A-4C95-B026-F319C80EF88A}&page-id={A96D0734-CA83-46D8-BC98-3164FEF32CB5}&object-id={C16DCFE6-4C62-428E-AA4B-2016A6C66FFA}&10 [↑](#footnote-ref-14)
14. https://www.wecc.org/Reliability/1r10726%20WECC%20Update%20of%20Reliability%20and%20Cost%20Impacts%20of%20Flexible%20Generation%20on%20Fossil.pdf [↑](#footnote-ref-15)
15. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Costs%20and%20Economics.one#Thermal%20Fuel%20Prices&section-id={3F75144D-F05B-446B-9809-090CF4F0D846}&page-id={5ED6B38F-5E87-4E6E-A3E5-BA5ADA85B25E}&object-id={D9C82954-577B-0E2C-2C45-BDEB0DBB90BE}&10 [↑](#footnote-ref-16)
16. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Remote%20Generation.one#Remote%20Generation&section-id={4EC9D6E1-5342-4C91-B8B8-C778F64E5CB8}&page-id={25D001BE-C22F-4183-A91E-6F49F9ABA590}&object-id={04E8CDF5-66AE-4D7F-B3AB-5B0A8279C332}&10 [↑](#footnote-ref-17)
17. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Ancillary%20Services.one#Ancillary%20Services&section-id={6B8868FD-7B69-4930-9743-9F7CC180C46D}&page-id={B2C7D7DD-A11A-4C14-AE9D-DF81389C51FF}&object-id={966C89EB-2829-4799-91BF-2191CB50EA8C}&10 [↑](#footnote-ref-18)
18. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/Loads.one#Loads&section-id={74BB3A13-333C-47A4-9DB9-B23C6757CD29}&page-id={32EDB668-7444-4ECE-92C0-3F7198B61B89}&object-id={BD8FDC64-90E9-4C88-9BD0-35C661125877}&10 [↑](#footnote-ref-19)
19. onenote:https://www.wecc.org/teams/PDWG/Shared%20Documents/2032%20ADS%20PCM%20Documentation/DG-BTM.one#DG-BTM&section-id={A281AA9A-A2FD-487D-88C5-6BD821E7B883}&page-id={B4F00A97-486C-4048-BBFA-B4278E7DAB2C}&object-id={3D028871-D680-4ED9-A7A0-5C92C32E5071}&10 [↑](#footnote-ref-20)
20. Instead of hourly prices, hourly loads were used as the DR resource dispatch trigger in the 2032 ADS data set. [↑](#footnote-ref-21)
21. https://www.wecc.org/SystemStabilityPlanning/Pages/AnchorDataSet.aspx#ADS2032Deliverables [↑](#footnote-ref-22)
22. https://www.wecc.org/SystemStabilityPlanning/Pages/AnchorDataSet.aspx#ADS2032Deliverables [↑](#footnote-ref-23)