



CPUC Fact Sheet on Clean Net Short Emissions Intensities from the RESOLVE Model Used in Integrated Resource Planning

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RESOLVE Background

RESOLVE is an electric resource investment and operational model designed to inform long-term planning for the electric sector and questions regarding least-cost approaches to integrating high levels of renewable energy resources into the electric grid. RESOLVE co-optimizes new electric resource investments and resource dispatch over a multi-year horizon with one-hour dispatch resolution for a target study area, in this case the California Independent System Operator (CAISO) footprint. The model incorporates a geographically simplified representation of neighboring electric balancing authority areas in the West to characterize and constrain flows into and out of the CAISO footprint. The RESOLVE model is used in the CPUC's Integrated Resource Plan (IRP) proceeding to select least-cost portfolios of resources to meet a chosen greenhouse gas (GHG) target.

RESOLVE simulates economic unit commitment and dispatch on each hour of representative days in order to capture system operations under higher penetrations of variable renewable energy. RESOLVE's dispatch modeling includes a linearized formulation of the unit commitment, thereby capturing many but not all aspects of a full production cost model. For each modeled year in the current CPUC IRP analysis horizon (2018-22-26-30), RESOLVE simulates economic unit commitment and dispatch for 37 independent days. The 37 days are the product of a day-selection optimization that chooses days and weighting factors to approximate long-run distributions of:

- Hourly load
- Hourly solar generation
- Hourly wind generation
- Hourly net load
- Daily hydro generation
- Monthly hydro generation
- Monthly renewable capacity factors

Each representative day has a "weight" that indicates the number of days that are represented by the sample day.

Emissions Intensities in the Clean Net Short Calculator

The CPUC has adopted a "Clean Net Short" (CNS) methodology for electricity providers to use when reporting emissions associated with their Integrated Resource Plan resource portfolios.¹ This methodology relies on hourly GHG emissions intensities created from outputs of the RESOLVE

¹ See the ruling at: <http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M214/K861/214861583.PDF>.



simulation of the adopted 2017 IRP Reference System Plan (RSP) portfolio,² which achieves a 42 million metric ton (MMT) GHG planning target for the electric sector by 2030. The CNS methodology assigns emissions associated with the CAISO system's dispatchable thermal generation and unspecified imports to load serving entities (LSE) based on how each LSE plans to rely on CAISO system power to meet its load on an hourly basis.

The CNS Calculator,³ a tool that automates calculations for the CNS method, contains emissions intensities that represent the average of *only* dispatchable thermal and unspecified imports on the CAISO system. The CNS emissions intensities were calculated this way because they were designed for a very specific purpose: to quantify the emissions associated with consuming system power during hours when an LSE does not have enough GHG-free power to serve its own hourly load, while also assuming that CAISO system operations reflect a proportionate achievement of a statewide 42 MMT GHG target for the electric sector by 2030. Consequently, CNS hourly emissions intensities are not directly comparable other analyses that quantify the average emission intensities of *all* generation (and imports and exports), both emitting and GHG-free, and which also do not achieve an electric sector target of 42 MMT by 2030.

Calculating CNS Emissions Intensities from RESOLVE

Month-hour average GHG emissions intensities of *only* dispatchable thermal resources within CAISO and unspecified imports were calculated for each currently modeled year (2018-22-26-30) from RESOLVE RSP results. The steps below describe the method used to calculate the emissions intensities that appear in the CNS Calculator:

1. Calculate the total tons of carbon dioxide (tCO₂) from CAISO dispatchable thermal resources and unspecified imports in each hour using the following steps. This is the numerator in the calculation of hourly tCO₂/MWh values.
 - a. Sum the GHG emissions from all dispatchable natural gas power plants in CAISO in the hour. Include emissions produced when generating energy and also emissions from energy consumed or avoided when providing regulation or load following reserves.
 - i. RESOLVE results data file: fuel_burn_by_resource.csv
 - b. Sum the GHG emissions from all unspecified imports into CAISO in the hour. The unspecified import rate is 0.428/MWh.
 - i. RESOLVE results data file: transmit_power.csv
2. Calculate the total MWh generated from CAISO dispatchable thermal resources and unspecified imports in each hour using the following steps. This is the denominator in the calculation of hourly tCO₂/MWh values.
 - a. Sum the energy output of each dispatchable natural gas power plant in the CAISO balancing area to create the total energy production from dispatchable thermal

² See Decision (D.) 18-02-018 at:

<http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M209/K771/209771632.PDF>.

³ The CNS Calculator is available for download at: www.cpuc.ca.gov/General.aspx?id=6442451195



resources in the hour. Combined heat and power resources are not included in the sum because they are handled elsewhere in the CNS Calculator.

- i. RESOLVE results data file: operations_by_zone_tech.csv
 - b. Sum the energy consumed or avoided when dispatchable thermal generators provide regulation and load following reserves in a similar manner using a 20% dispatch assumption for every MW of reserve committed.
 - i. RESOLVE results data file: operations_by_zone_tech.csv
 - c. Sum the energy imported into CAISO from unspecified imports over importing transmission lines.
 - i. RESOLVE results data file: transmit_power.csv
3. Divide the tCO₂ value for each hour (1) by the MWh value in the same hour (2) to obtain an hourly average emissions rate. A handful of hours have a non-zero but insignificant amount (<100 MWh) of generation and imports. For the purposes of the Clean Net Short calculation, it is unlikely that LSEs would be able to displace significant amounts of GHG-intensive power in these hours because of the very small magnitude of GHG-intensive power relative to the size of the CAISO system. Consequently, a cutoff is applied: if there is less than 100MWh of dispatchable thermal and unspecified imports in an hour, the emissions intensity for that hour is set to zero.
 4. Each RESOLVE representative day corresponds to a specific month. The weighted-average emissions intensity is calculated for each month-hour combination using all the emissions intensities within a month and the weight of each RESOLVE representative day. The process is repeated for each modeled year.

RESOLVE modeling of the 2017 RSP portfolio assumes that 6.5 TWh of GHG-free hydro generation is available to be imported from the Pacific Northwest over the course of each year, but it does not specify the hours in which this GHG-free power is imported. In the CNS calculator, LSEs are credited with a load-weighted share of GHG-free Pacific Northwest hydro generation to reflect that a fraction of the unspecified imports in the hourly calculation above represents specified hydro imports.