Appendix D Model Documentation

The model developed by the Study Team relies on user input, historic data, and documented future demand projections to estimate future water supply and energy use. This section will describe the operation of the model and the algorithms used to obtain the final results. Illustrative diagrams are used to convey the relationships in the model as well as model operation. A key to these diagrams is contained in Table 1.

Table 1: Key to Model Diagrams

Symbol	Description
User Input	Inputs are obtained from users. These inputs pertain to future demand scenarios, policies affecting demand, and policies affecting supply. The model does contain default user inputs.
Model Input	The model contains several inputs that cannot be altered by users. For example the model steps though five defined water year types as well as two future years (2020, and 2030). The model also contains current capacities for certain water supplies and their energy intensities. All energy data are stored as model inputs.
Model Calculation	The model performs numerous calculations given the user inputs and model inputs. These are intermediate calculations to help arrive at the outputs.
Model Output	The model outputs total water supplied by each supply type as well as the energy consumption associated with each supply.

The model operates at the hydrologic region level. Future demand is projected in each of the 10 hydrologic regions and then the associated supply to meet that demand is calculated. The general operation of the model is depicted in Figure 1.

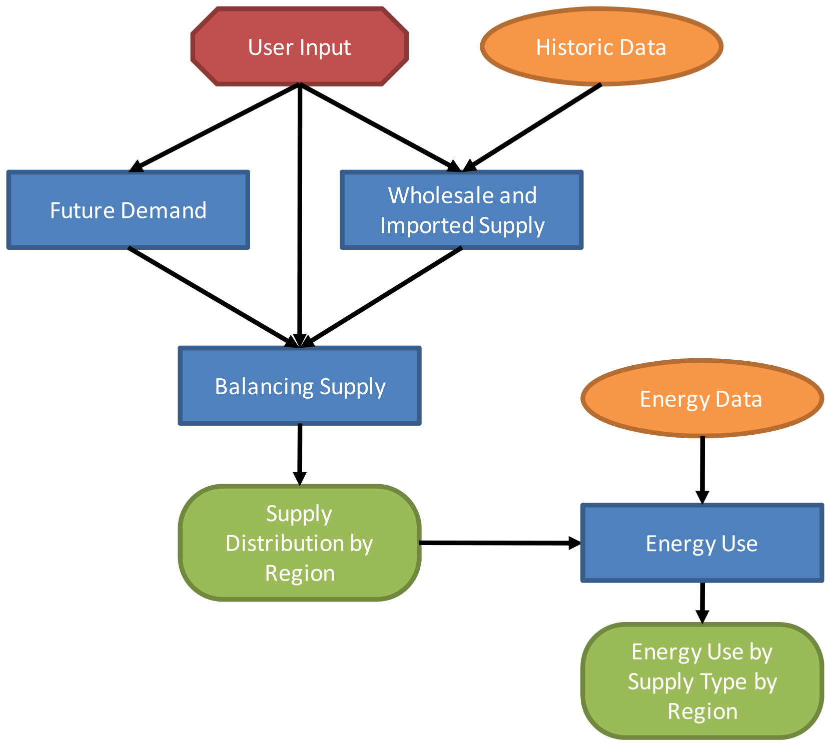


Figure 1: General Model Structure

User inputs are first fed to the model. They determine the future demand, adjust wholesaler supply, and set the limits for balancing supply. Once future demand and wholesaler supply are determined, the balancing supply is calculated as the remaining demand not met by wholesale supply. The balancing supply includes all supply sources that are not wholesale water supplies included in this study: local surface water, groundwater, recycled water, seawater desalination, and brackish water desalination. The model divides the total balancing supply into the different components. The combination of balancing supply and wholesaler supply provide the total supply distribution by region. Energy use by supply type is calculated using the calculated supplies and energy data collected by the Study Team. Total energy calculated is the physical energy consumption within a hydrologic region regardless of the ultimate destination of the water that is moved by the energy consuming facilities. All calculations (demand, supply, and energy use) are initially obtained on an annual basis and then spread to a monthly basis.

Each major processing and calculation routine of the model is described below: Future Demand, Wholesale and Imported Supply, Balancing Supply, and Energy Use.

D.1 Future Demand

The structure of the demand calculations is illustrated in Figure 2.

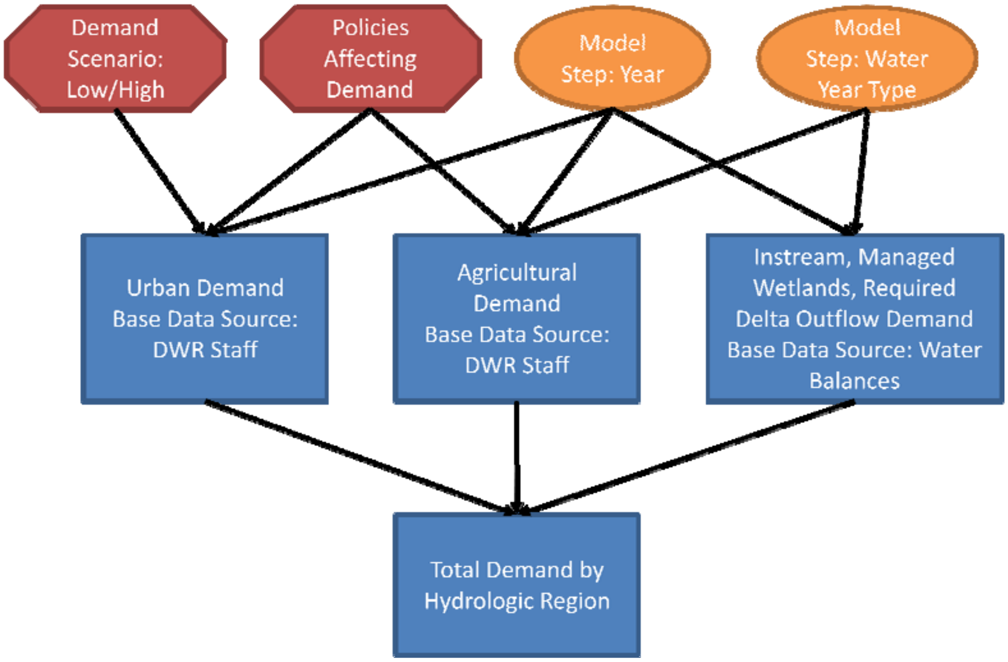


Figure 2: Demand Calculations

The user may choose from a drop-down list one of three future demand scenarios: Baseline, Low Demand, and High Demand. This will change the set of data used for future demand projections, sourced by DWR. See Demand Inputs for documentation. Agricultural demand varies by year type following historic trends of water use during various year types, with the Above Normal year being the baseline. The variation determined by the Study Team is quantified in Table 2(see Appendix F for details):

Table 2: Agricultural Demand Variance in Water Year Types

Agricultural demand variance	
Wet	80%
Above Normal	100%
Below Normal	105%
Dry	105%
Critical	99%

The user will also have the option to further investigate the implications of future water policies by inputting individual percentage changes in demand for each hydrological region for 2020 and 2030. The controllable urban demand sectors are Large Landscape, Commercial, Industrial, Residential – Interior, and Residential – Exterior. The controllable agricultural sector is Applied

Water – Crop Production. These percentage changes update the future demand projections from DWR.

The user may input absolute changes in water supply available from new construction of Recycled Water, Seawater Desalination, Brackish Desalination, and Surface Storage facilities. The new construction will add to the supply mix in the future scenarios, and the user's edits alter historical supply by region, according to the water balances.

D.2 Wholesale and Imported Supply

The structure of the wholesale and imported supply calculations is illustrated in Figure 3.

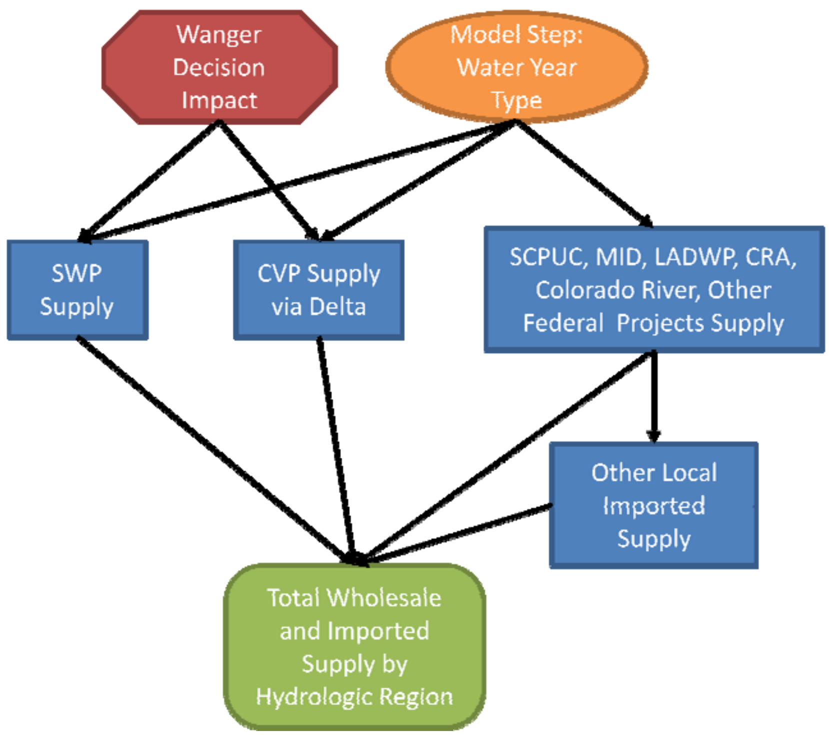


Figure 3: Wholesaler and Imported Supply Calculations

The model assumes current infrastructure and capacity limits will remain the same in the future; thus, the general approach to estimating future water supply use is to reference historic data (there are a few exceptions). Annual deliveries made by each wholesaler vary in each hydrologic year. The model uses historic data from one of five representative year types to forecast future energy use by a given wholesaler in that water year type. For example, future energy use for a dry year is equivalent to the historic energy consumption by the wholesaler in 2002, a representative dry year. This general approach will be referred to as the "Historic Data Approach" for the remainder of this section. The source for the historic data reference by this approach varies for each wholesaler. Additional variations on this approach were required for different wholesalers. Specifics for each wholesaler are described below.

One exception to this approach is the method for accounting current and future restrictions in water withdrawals made from the Bay Delta. Users can input future reductions (or increases) in the amount or water that is allowed to be withdrawn from the Bay Delta. Users input a percent change (positive for reductions and negative for increases) for both 2020 and 2030. These restrictions are applied to the historic data of the wholesalers they affect.

Another exception is the way the model handles the Colorado River Aqueduct. The Quantification Settlement Agreement in 2003 had the effect of reducing deliveries via the aqueduct. Most of the historic data available to the study team was prior to this agreement. The Study Team thus references typical projected deliveries provided to the Study Team by MWD staff (see Appendix C – CRA section for details). User input determines the amount of imports MWD receives via the CRA in future years; users can specify Low, Average, or High deliveries.

D.2.1 State Water Project Supply

As explained in Chapter 4, the Study Team relies on the Regional Water Balances for information on historic deliveries made by the State Water Project. The SWP's operations are affected by the Wanger Decision, restricting water withdrawals from the Bay Delta. As historic data is based on operations prior to the restrictions, it must be adjusted. First the Historic Data Approach is used to reference the appropriate data from the Water Balances. Then, the model takes the user input for restrictions in Bay Delta withdrawals and applies it to all deliveries by the SWP reducing them by the input percentage specified. This can be done because the SWP pro-rates reductions in supply to all its contractors equally. The result is to reduce the total deliveries by the SWP to each hydrologic region in the state.

D.2.2 Central Valley Project Supply

Similar to the State Water Project, Central Valley Project historic delivery data is obtained from the Regional Water Balances. Part of the CVP's operations are affected by the Wanger Decision, restricting water withdrawals from the Bay Delta. Only deliveries made along the Delta-Mendota and San Luis Canal are affected. Deliveries in all other canals operated by the CVP are not affected as they do not utilize the Bay Delta for conveyance; see the CVP Profile in Appendix C Agency Profiles for details. As historic data is based on operations prior to restriction, it must be adjusted. First the Historic Data Approach is used to reference the appropriate data. Then, the model takes the user input for restrictions in Bay Delta withdrawals and applies it to affected deliveries in the CVP reducing them by the input percentage specified. Most of the water delivered to CVP customers in the San Francisco Bay Region and San Joaquin River Region is conveyed via the delta; thus deliveries to these two regions are reduced. However deliveries to all other regions in California are assumed to remain unaffected by the decision.

D.2.3 Colorado River Aqueduct

Historic data does not reflect future deliveries made via the Colorado River Aqueduct due to the passing of the Quantification Settlement Agreement in 2003. Water deliveries via the CRA are determined by users who can specify Low, Average, or High deliveries. The input draws upon data developed by the Study Team based on discussions with MWD Staff (see Appendix C – CRA section for details). For the purposes of this model, deliveries are not dependant on California Water Year types

D.2.4 SFPUC

Data on historic deliveries was collected from SFPUC. Data from the SFPUC was used because the water balances do not itemize deliveries by the SFPUC, it lumps it under "Local Imported Deliveries". The model uses the Historic Data Approach to reference the appropriate data from SFPUC.

D.2.5 LADWP

Data on historic deliveries was collected from LADWP. Data from the LADWP was used because the water balances do not itemize deliveries by the LADWP, it lumps it under "Local Imported Deliveries". The model uses the Historic Data Approach to reference the appropriate data from LADWP.

D.2.6 SCVWD

The model does not account for any supply available from SCVWD in its supply calculations. The model only tracks imports received via CVP for use in energy calculations, though the actual water is attributed to being supplied by CVP. Regional Water Balances were not used because they do not itemize deliveries by SCVWD.

D.2.7 MWD

The model does not account for any supply available from MWD in its supply calculations. The model only tracks imports received via SWP and CRA for use in energy calculations, though the actual water is attributed to being supplied by SWP and CRA. Regional Water Balances were not used because they do not itemize deliveries by MWD.

D.2.8 SDCWA

The model does not account for any supply available from SDCWA in its supply calculations. The model only tracks imports received via MWD (from the SWP and CRA), though the actual water is attributed to being supplied by SWP and CRA. Regional Water Balances were not used because they do not itemize deliveries by SDCWA.

D.2.9 MID

Data on historic deliveries was collected from MID. Data from the MID was used because the water balances do not itemize deliveries by the MID, it lumps it under “Local Deliveries”. The model uses the Historic Data Approach to reference the appropriate data from MID.

D.2.10 Other Federal Deliveries

The model sources water supply from Other Federal Deliveries using the Historic Data Approach to reference data from Regional Water Balances.

D.2.11 Local Imports

The model sources water supply from Local Imports using the Historic Data Approach to reference data from Regional Water Balances. To avoid double counting, the model removes SFPUC from the SF region local imports and LADWP from the SC region local imports. This is done because SFPUC and LADWP are considered local imports lumped in the local import category in the regional water balances, yet they are also separately itemized in the model.

D.3 Balancing Supply

The structure of balancing supply calculations is illustrated in Figure 4. This general approach is followed for all regions with a few noted exceptions.

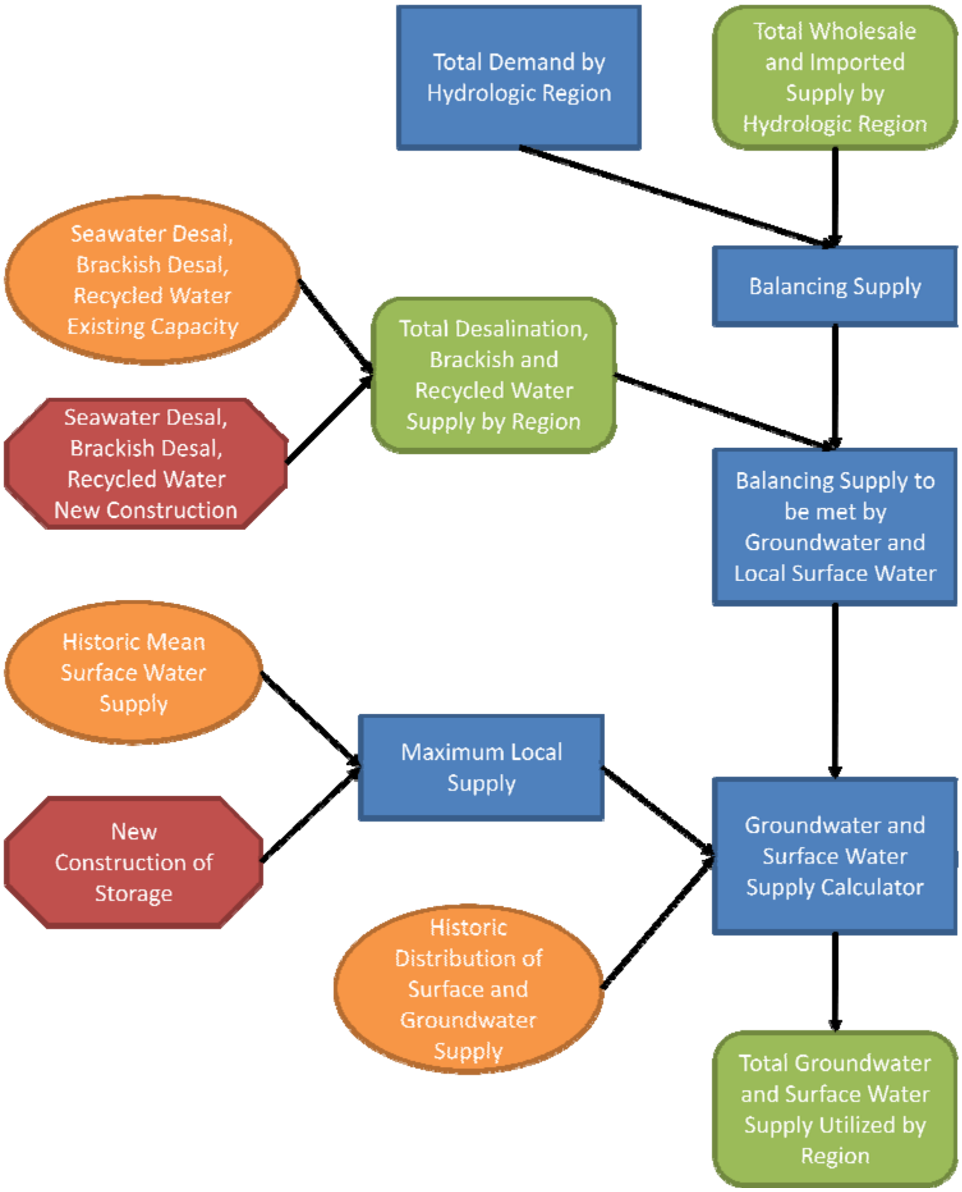


Figure 4: Balancing Supply Calculations

All future water demand must be accounted for by some form of supply. To make up for the difference between fixed historic deliveries and the future projected water demand, the model calculates a balancing supply for each region consisting of Local Deliveries, Groundwater, Recycled Water, Seawater Desalination and Brackish Desalination. Users effect this calculation in two ways. First, the future demand scenarios and demand policy changes both affect the demand that needs to be met in each region. Second, Bay Delta Flow restrictions, CRA flows, and addition of new Recycled, Storage, and Desalination facilities alter the supply mix that is calculated to meet demand. For example, if the user inputs a 100 TAF increase in Seawater Desalination in the South Coast in 2020, that will increase the amount of available supply from Seawater Desalination and decrease the amount of Local Deliveries and Groundwater needed to meet demand in that region.

Future demand in each region is calculated based on the Urban, Agricultural and Environmental projections provided by DWR and depends on the inputted scenario year of Low, High, or Baseline Demand. Environmental demand is modified to remove Wild and Scenic Applied Water because it is not a controllable source. Urban and Agricultural demand is modified by user inputted percentage policy reduction for 2020 and 2030.

$$Future\ Demand = Urban + Agricultural + (Environmental - Wild\ And\ Scenic)$$

The model then totals available surface water deliveries by the major wholesalers and other surface water supplies for each region to determine the amount of fixed supplies available. Subtracting this number from the future demand results in the supply needed to be met by alternate sources (balancing supply).

$$\begin{aligned} Fixed\ Supply = {} & SWP + CVP + CRA + Other\ Federal\ Deliveries \\ & + Local\ Imported\ Deliveries + Colorado\ River + MWD + SDCWA \\ & + SCVWP + SFPUC + LADWP \end{aligned}$$

$$Balancing\ Supply = Future\ Demand - Fixed\ Supply$$

Recycled Water, Seawater Desalination and Brackish Desalination take priority in the calculation when allocating resources to meet demand because those facilities are typically run constantly to make up for high capital costs. The new construction user inputs are added to historic supply for each region and this total is then subtracted from the amount of supply still needed to be met.

The remaining supply is to come from a combination of Groundwater and Local Deliveries. In the DWR Regional Water Balances, Groundwater tends to be the balancing supply. Local Deliveries consist of surface water used for urban, agricultural, instream, managed wetlands and managed delta outflow. The model contains an upper limit for the total local surface supply available in each region (see Appendix H). The user inputs for new construction of surface storage increases can increase this upper limit. This model prioritizes Local Deliveries and uses Groundwater to balance.

$$\begin{aligned} & Local\ Deliveries + Groundwater \\ & \quad = Balancing\ Supply - Recycled\ Water - Seawater\ Desalination \\ & \quad - Brackish\ Desalination \end{aligned}$$

To determine the amount of local deliveries and groundwater used in each region, the model references the historic ratio of these two supplies in each region (see Appendix H for details). The value for the remaining supply that must be met by either Local Deliveries or groundwater is multiplied by the historic ratio of Surface Water to Groundwater, if this value exceeds the Local Delivery Upper Limit, it is truncated at the limit. Once Local Deliveries are determined, the remaining supply comes from Groundwater.

$$\mathit{Local\ Deliveries} = \min\left\{(\mathit{Historic\ Local\ Deliveries} + \mathit{New\ Surface\ Storage}), \left(\frac{\mathit{Historic\ Local\ Deliveries}}{\mathit{Historic\ Local\ Deliveries} + \mathit{Groundwater}}\right) * (\mathit{Historic\ Local\ Deliveries} + \mathit{New\ Surface\ Storage})\right\}$$

In the end, the model outputs the balancing supply in each HR with Recycled Water, Seawater Desalination, Brackish Desalination, Groundwater and Local Deliveries.

D.3.1 Exceptions and Special Case in Balancing Supply

The study team made three exceptions to the general method above; these were made for the South Coast, San Francisco, and the Colorado River Region.

The South Coast sees extensive use of groundwater pumping to meet supply for many retail agencies. It is possible in some future scenarios for other supplies to be able to provide enough volume to theoretically groundwater pumping to near zero. However, due to the nature of the infrastructure and water delivery system in the South Coast, many agencies will still depend on groundwater when other supplies are abundant. For this reason the South Coast has a groundwater pumping minimum value that is set to 1 MAF, see (see Appendix H for details). A similar phenomenon may occur in the San Francisco Region as well. Groundwater is capped at a minimum of 37.6 TAF.

The majority of water used in the Colorado River Region comes from diversions from the Colorado River and is mostly used for irrigation purposes. When future agricultural demand decreases, it is possible that total demand in the region is less than historic diversions made from the Colorado River. When this is the case the model assumes historic levels of local surface water and groundwater and surface water continue to be drawn while diversions from the Colorado River are decreased.

D.4 Energy Use

Energy consumption is calculated two ways in the model. The first is the Physical Energy Use and the Second is the Embedded Energy use. These terms were defined in Chapter 4.

Calculations for both are initially obtained on an annual basis, and then physical energy use is spread to a monthly basis. Annual energy consumption calculations depend on the following: detailed historic data analysis of each wholesale system included in this study, estimates of energy intensity for water supplies not detailed in this study, and user inputs. Once annual energy consumption is calculated, physical energy use is spread to each month of the year using monthly energy use profiles generated by Study Team. The details of annual energy calculations and monthly energy consumption are documented below for each supply.

The model assumes current infrastructure and capacity limits will remain the same in the future; thus, the general approach to estimating future energy use is to reference historic data. Annual physical energy use by a wholesaler varies with the annual deliveries made and annual deliveries vary in each hydrologic year. The model uses historic data from one of five representative year types to forecast future energy use by a given wholesaler in that water year type. For example, future energy use for a dry year is equivalent to the historic energy consumption by the wholesaler in 2002, a representative dry year. The model makes this reference for each facility in the wholesaler's system and then totals the physical energy use in each hydrologic region. This general approach will be referred to as the "Historic Data Approach" for the remainder of this section. Some variations on this approach were required for different wholesalers and these are described below.

Embedded energy for a region represents all the energy associated with conveying water that is ultimately delivered to that region. Embedded energy for each region is calculated by supply type (including each of the 9 wholesalers). Embedded energy is attributed to the wholesaler that consumed the energy to move the water. The methods for calculating and accounting for embedded energy by each wholesaler and supply type are discussed below.

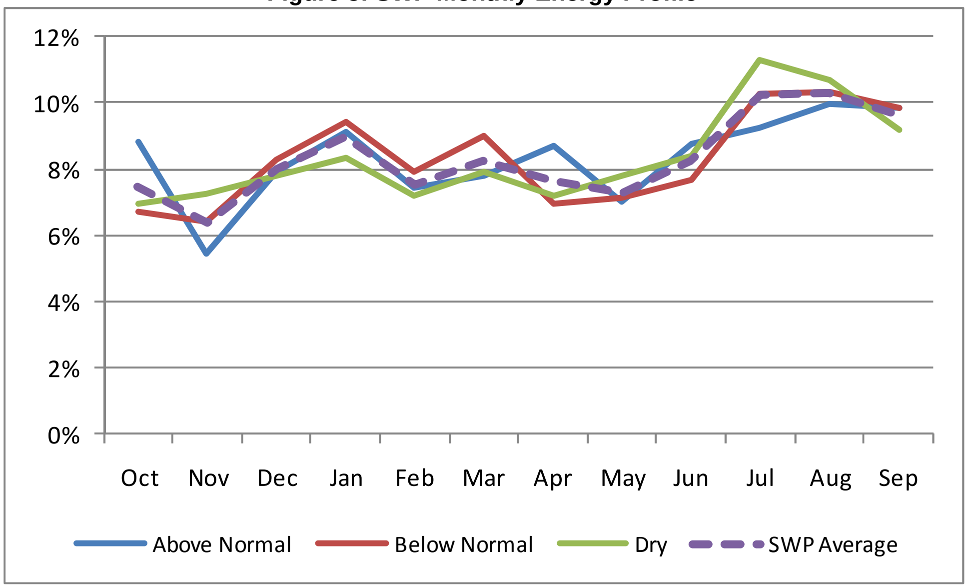
D.4.1 State Water Project

Detailed energy use data was collected for all major State Water Project pumping stations and in-conduit hydro electric facilities. The energy use, water flows, and energy intensity analysis of these facilities can be seen in the State Water Project Profile in Appendix C. The Study Team indexed each facility's location to one of the 10 hydrologic regions in the state.

The Historic Data Approach was used to calculate physical energy use by the SWP in future years, though slight modifications to the approach were needed. The SWP's operations are affected by the Wanger Decision, restricting water withdrawals from the Bay Delta. As historic data is based on operations prior to the restrictions, it must be adjusted. First the Historic Data Approach is used to reference the appropriate data from the Water Balances. Then, the model takes the user input for restrictions in Bay Delta withdrawals and applies it to all deliveries and energy use by the SWP reducing them by the input percentage specified. This can be done because the SWP pro-rates reductions in supply to all its contractors equally. The effect of this is to reduce the flows through and physical energy consumption by each SWP facility by an equal percentage.   Total physical energy use in each hydrologic region is then calculated by summing the energy consumption by each facility in each respective region.

Physical energy use is then spread to a monthly profile using a historic profile of total energy consumption by the SWP in Above Normal, Below Normal, and Dry years. This profile is depicted in Figure 5 and was obtained from data in water years 2000, 2002, and 2004.

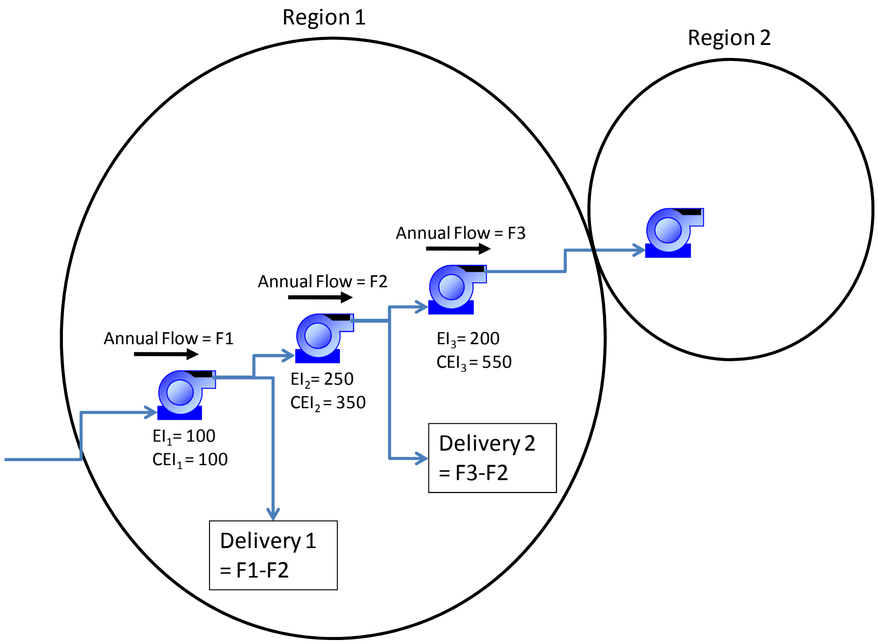
Figure 5: SWP Monthly Energy Profile



Embedded energy in each region is calculated by multiplying the total deliveries made by the SWP in that region by the average cumulative energy intensity of SWP pumps located in that region. The State Water Project's pump stations are located in 7 different hydrologic regions and make deliveries to 8 regions.

The cumulative energy intensity of a facility is calculated by adding the energy intensity of that facility to the energy intensity of all other SWP facilities upstream. It represents the total energy required to move an acre-foot of water from its source all the way though the given facility. Cumulative energy intensity by facility is illustrated in Figure 3-3 in Chapter 3. Multiple SWP pump stations are physically located in each region and multiple points of delivery exist between each pump station within a region. For this reason a weighted average of the cumulative energy intensities of pumps stations within a region was calculated. This calculation was weighted on the estimated amount of deliveries made after each pump station in a hydrologic region.

The method for calculating average cumulative energy intensity is illustrated in Figure 6 and the equation accompanying it. Note that the third pump, while physically located in Region 1, does not make any deliveries to Region 1, thus it does not affect the average energy intensity of deliveries to the region. The Study Team researched the SWP system and deduced which pump stations contributed to the deliveries in each region. Then an analysis similar to the method illustrated in Figure 6 was applied to each region.



$$\text{Region 1 Average Energy Intensity} = \frac{Delivery\ 1 * CEI_1 + Delivery\ 2 * CEI_2}{Delivery\ 1 + Delivery\ 2}$$

EI = Energy intensity of an individual pump station
CEI = Cumulative energy intensity including the energy intensity of all upstream facilities

Figure 6: Illustration of Cumulative Energy Intensity

A few noted exceptions to this method are:

- No SWP pumps are physically located in the Central Coast Region; however deliveries are made via the Coastal Branch of the California Aqueduct. The energy intensity associated with deliveries made to the Central Coast are equal to the cumulative energy intensity up through the last pump station in the Coastal Branch
- No SWP pumps are physically located in the Colorado River Region, and no SWP Canals extend to the Colorado River Region; however SWP deliveries are made to the Coachella Valley Water District located in the region. The deliveries are possible via an exchange agreement between Coachella and MWD. Coachella purchases SWP water and exchanges it to the MWD for an equal amount of water that is physically delivered via the Colorado River Aqueduct. Thus deliveries to the Colorado River region have a cumulative energy intensity associated with the CRA.

Once the average cumulative energy intensity of SWP deliveries to each region is calculated, they are multiplied by the deliveries to that region to estimate the embedded energy associated with the region.

D.4.2 Central Valley Project

Detailed energy use data was collected for all major Central Valley pumping stations. These facilities include only those associated with deliveries made along the Delta Mendota Canal and the San Luis Canal (California Aqueduct). CVP makes deliveries along other major canals and waterways; however the energy use associated with these deliveries is very low.[1] The energy use, water flows, and energy intensity analysis of these facilities can be seen in the Central Valley Project Profile in Appendix C. The Study Team indexed each facility's location to one of the 10 hydrologic regions in the state.

The Historic Data Approach was used to calculate physical energy use by CVP in future years, though slight modifications to the approach were needed. Part of the CVP's operations are affected by the Wanger Decision, restricting water withdrawals from the Bay Delta. All CVP facilities included in the model are affected by the Decision as they pump water that was conveyed through the Bay Delta. As historic data is based on operations prior to the Decision, it must be adjusted. First, the Historic Data Approach is used to reference the appropriate data from the Water Balances. Then, the model takes the user input for restrictions in Bay Delta withdrawals and applies it to all energy use by the modeled CVP facilities reducing their energy consumption by the input percentage specified. Total physical energy use in each hydrologic region is then calculated by summing the energy consumption by each facility in each respective region.

Physical energy use is then spread to a monthly profile using a historic profile of total energy consumption by the CVP in Wet, Above Normal, Below Normal, Dry, and Critical years. This profile is depicted in Figure 7 and was obtained from data in water years 1998, 2000, 2001, 2002, and 2004.

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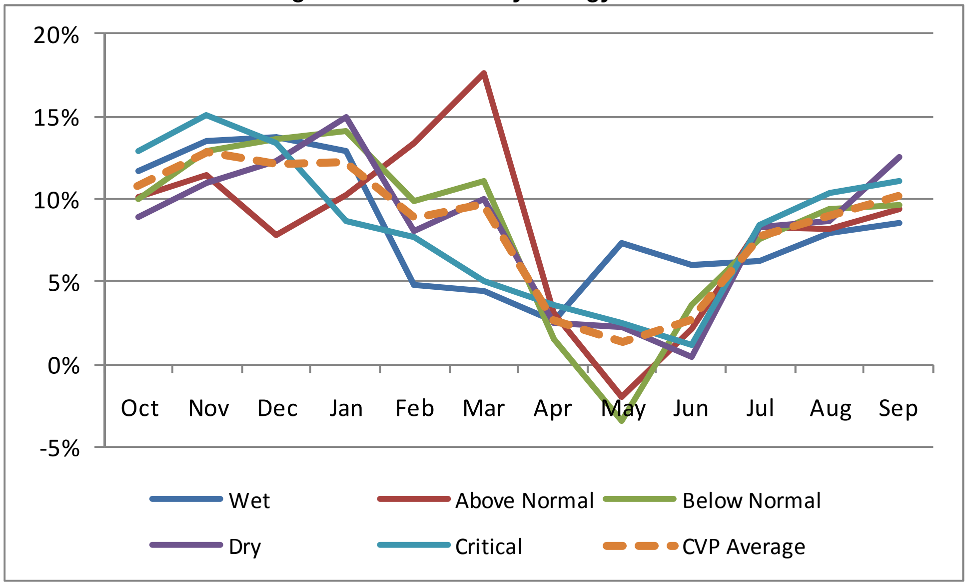
[1] See Central Valley Project Profile in the Appendix for details.

Figure 7: CVP Monthly Energy Profile



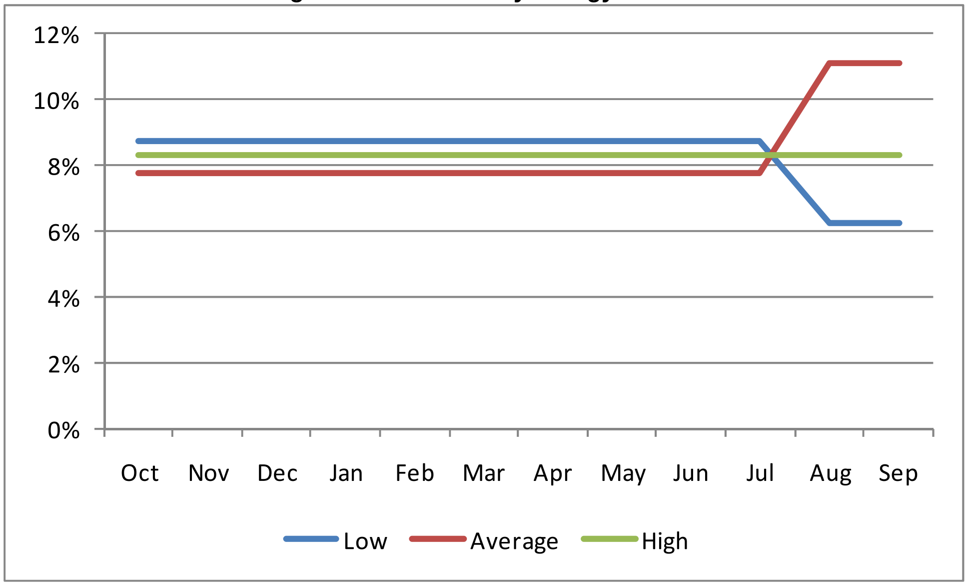
The Central Valley Project's pump stations are located in two different hydrologic regions and make deliveries to three regions. Additional CVP deliveries are made to other regions mainly via gravity flow in other canals (see Appendix C – CVP section). Embedded energy in each region is calculated by multiplying the total deliveries made by the CVP in that region by the average cumulative energy intensity of CVP pumps located in that region. CVP energy is only used to make deliveries to the San Francisco, San Joaquin, and Tulare Lake Regions; deliveries to all other regions have no embedded energy associated with them.

The average cumulative energy intensity of CVP deliveries to the three regions mentioned above are calculated using the same method for the SWP illustrated in Figure 6. Total embedded energy associated with the San Francisco and San Joaquin regions is calculated by multiplying total deliveries by the region's respective energy intensities. However, embedded energy associated with deliveries to the Tulare Lake Region requires special calculations. CVP also makes deliveries to the Tulare Lake region via the Fraint-Kern canal which requires no energy use. Thus embedded energy for the region is calculated by multiplying its cumulative embedded energy by only water flows through Dos Amigos Pumping Plant, the facility that ultimately feeds the region.

D.4.3 Colorado River Aqueduct

The Historic Data Approach was used to calculate physical energy use by CRA in future years. This energy consumption occurs only in the CR region. Physical energy use is then spread to a monthly profile using three possible profiles that depend on user inputs (Low, Average, or High). These profiles are depicted inFigure 8 and were developed by the Study Team based on discussions with MWD Staff (see Appendix C – CRA Section).

Figure 8: CRA Monthly Energy Profile



While the Colorado River Aqueduct pumps are physically located in the Colorado River region, they make all their deliveries to the South Coast Region. Thus when accounting for embedded energy, all CRA energy use is associated with the South Coast region and none with the Colorado River region.

D.4.4 San Francisco Public Utilities Commission

Detailed energy use data was collected for all major San Francisco Public Utilities Commission facilities. The energy use, water flows, and energy intensity analysis of these facilities can be seen in the San Francisco Public Utilities Commission Profile in Appendix C. The Study Team indexed each facility's location to one of the 10 hydrologic regions in the state. The Historic Data Approach was used to calculate physical energy use by SFPUC in future years. We assume that the physical energy is spread evenly to each month of the year.

SFPUC water originates from the San Joaquin River Region and all deliveries are made to the San Francisco Region. All SFPUC energy consuming facilities that are included in the model are physically located in the San Francisco Region. Thus, there is no difference between the locations where embedded and physical energy are associated with for SFPUC.

D.4.5 Santa Clara Valley Water District

Historic energy use data had to be estimated for Santa Clara Valley Water District facilities using water flow rates and estimate energy intensity.[2] The facilities included in the model are those pump stations which import water from CVP. SCVWD imports from SWP and SFPUC have little energy use and are not included in this model.

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[2] See Santa Clara Valley Water District Profile in the Appendix for details.

The Historic Data Approach was used to estimate energy use by SCVWD to deliver CVP imported water in future years; however, slight modifications to the approach were needed. SCVWD's CVP imports arrive via the Bay Delta, thus they are subject to flow restrictions resulting from the Wanger Decision. The model accounts for the effects of the Decision on SCVWD energy use similar to its affects on the SWP and CVP. First, the Historic Data Approach is used to reference the appropriate data from the Water Balances. Then, the model takes the user input for restrictions in Bay Delta withdrawals and applies it to all modeled SCVWD facilities reducing their energy consumption by the input percentage specified. We assume that the energy is spread out evenly to each month of the year.

SCVWD makes all its deliveries to the San Francisco Bay region. However one of its pump stations is located in the San Joaquin River Region. When accounting for embedded energy, all energy associated with all pump stations is attributed to the San Francisco Region and none with the San Joaquin Region.

D.4.6 Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California is a net producer of power generating electricity from 16 in-conduit hydropower facilities. The Study team estimated power generation intensity of 3 sets of power plants: those fed by SWP water only, those fed by CRA water only, and those fed by a combination of SWP and CRA water only.[3] For its calculations, the model first obtains annual imports by SWP and the CRA by using the Historic Data Approach and accounting for the effects of the Bay Delta flow restrictions on SWP. Then, power generation is calculated by the multiplying the flow feeding each set of power plants by its respective power generation intensity. The source of flow feeding each set of plants is summarized in Table 3. Total energy generation for MWD is calculated as the sum of each set of power plants. Based on discussions with MWD staff, the study team assumes power generation is spread out evenly to each month of the year.

Table 3: Source of Flow Data for MWD Power Plants

Feedwaters to MWD Power Plants	Flow Data Source
SWP	Total SWP imports to MWD as reported by MWD
CRA	Total Flow in the CRA as reported by MWD
Combination of SWP and CRA	The sum of the above two flows

[3] See Metropolitan Water District of Southern California Profile in the Appendix for details.

The power generated by MWD from deliveries occurs in the South Coast and all deliveries by MWD are made in the South Coast. Thus there is no difference between the locations where embedded and physical energy are associated with for MWD.

D.4.7 Los Angeles Department of Water and Power

The Study Team is only examining LADWP's water conveyance system, the Los Angeles Aqueduct. The entire aqueduct is gravity fed consuming no energy. Some power is generated using the water conveyed by the aqueduct; however, for the purposes of this study it is not being treated as in-conduit generation and is thus excluded from the model, see the LADWP Agency Profile in Appendix C for more detail. The model does not attribute any physical energy consumption or production or embedded energy to LADWP in any hydrologic region.

D.4.8 San Diego County Water Authority

The Study Team is only examining SDCWA's main wholesale water conveyance system, the San Diego Pipelines. The entire aqueduct is gravity fed consuming no energy. Some power is generated by MWD using the water conveyed by the aqueduct; however, it is being attributed to MWD in the model. See the SDCWA and MWD Agency Profiles in Appendix C for more detail. The model does not attribute any physical energy consumption or production or embedded energy to SDCWA in any hydrologic region.

D.4.9 Modesto Irrigation District

The Study Team is only examining MID's surface water supply and conveyance systems originating at Don Pedro Reservoir. The entire conveyance system is gravity fed consuming no energy. Some power is generated using the water conveyed at Don Pedro Reservoir; however, for the purposes of this study it is not being treated as in-conduit generation and is thus excluded from the model, see the MID Agency Profile in Appendix C for more detail. The model does not attribute any physical energy consumption or production or embedded energy to MID in any hydrologic region.

D.4.10 Other Colorado River Deliveries

Deliveries taken from the Colorado River that do not include those made by the CRA were not studied in detail. These deliveries only occur in the Colorado River Region and are mostly deliveries to the Palo Verde Irrigation District, the Yuma Project, Imperial Irrigation District and the Coachella Valley Water District. The majority of these deliveries are made via gravity. However, not having studies the system in detail the Study Team assumes an energy intensity of 10kWh/AF associated with these deliveries. The model calculates physical energy associated with these deliveries by multiplying annual deliveries by the assumed energy intensity. We assume that the energy is spread out evenly to each month of the year. All energy associated with these deliveries is attributed to the Colorado River Region.

D.4.11 Other Local Imports

The Study Team assumed the majority of Other Local Imports are made via gravity. However, not having studied the system in detail the Study Team assumes an energy intensity of 10kWh/AF associated with these deliveries. This category excludes imports by SFPUC and LADWP as they are separately accounted for in the model. The model calculates physical energy associated with these deliveries by multiplying annual deliveries by the assumed energy intensity. We assume that the energy is spread out evenly to each month of the year. All energy associated with these deliveries is attributed to the respective region in which the deliveries are made. This is a simplifying assumption as the study team did not examine these supplies in detail.

D.4.12 Other Federal Deliveries

The Study Team assumed the majority of Other Federal Deliveries are made via gravity. However, not having studies the system in detail the Study Team assumes an energy intensity of 10kWh/AF associated with these deliveries. The model calculates physical energy associated with these deliveries by multiplying annual deliveries by the assumed energy intensity. We assume that the energy is spread out evenly to each month of the year. All energy associated with these deliveries is attributed to the respective region in which the deliveries are made. This is a simplifying assumption as the study team did not examine these supplies in detail.

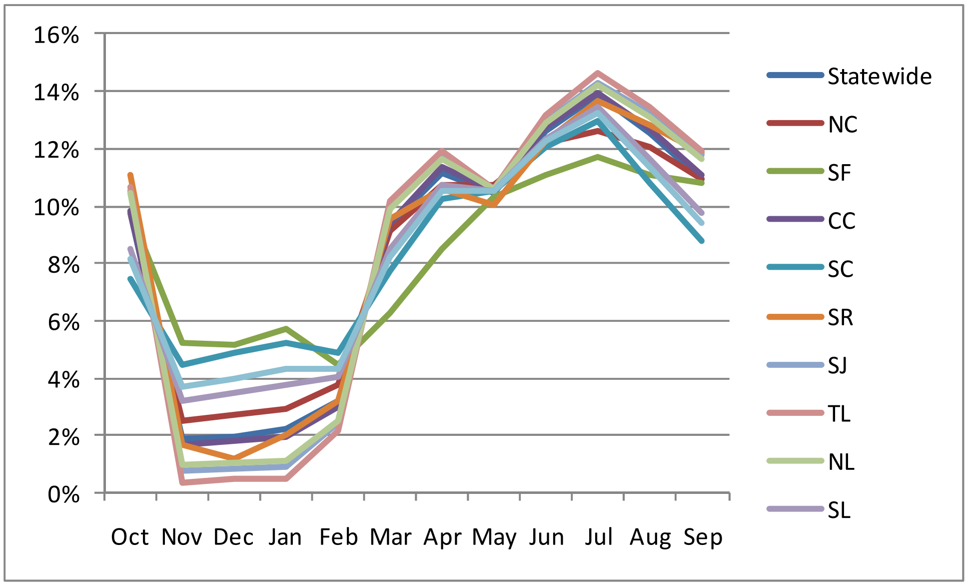
D.4.13 Local Surface Supply

Physical energy use by Local Surface water is calculated by multiplying energy intensity by water deliveries. We did not study in detail but assume energy intensity is low (10 kWh/AF), and we assume that the energy is spread out evenly to each month of the year. All energy associated with these deliveries is attributed to the respective region in which the deliveries are made. This is a simplifying assumption as the study team did not examine these supplies in detail.

D.4.14 Groundwater

Physical energy use by Groundwater is calculated by multiplying energy intensity by groundwater withdrawals. The Study Team developed estimates for groundwater energy intensity in each hydrologic region and year type. Additionally the Study Team developed monthly profiles for each hydrologic region; these are illustrated in Figure 9. See Appendix G for details. All energy associated with these deliveries is attributed to the respective region in which the deliveries are made.

Figure 9: Groundwater Monthly Profiles



D.4.15 Recycled Water

Physical energy consumption by Recycled Water facilities are estimated using energy intensity. Total Recycled Water production is multiplied by the assumed energy intensity of Recycled Water, 1,129 kWh/AF. This assumption is obtained from Study 2 data analysis of the Orange County Water District.[4] Recycled Water plants are typically run at full capacity year round to enable the most cost effective use of the facility. Thus annual energy use by Recycled Water is spread equally to each month of the year. All energy associated with this water supply is attributed to the respective region in which the water is produced.

D.4.16 Seawater Desalination

Energy consumption by seawater desalination facilities are estimated using energy intensity. Total seawater desalination production is multiplied by the assumed energy intensity of seawater desalination, 4000 kWh/AF. This assumption is obtained from the California Sustainability Alliance.[5] Seawater desalination plants are typically run at full capacity year round to enable the most cost effective use of the facility. Thus annual energy use by seawater desalination is spread equally to each month of the year. All energy associated with this water supply is attributed to the respective region in which the water is produced.

D.4.17 Brackish Water Desalination

Energy consumption by brackish water desalination facilities are estimated using energy intensity. Total brackish water desalination production is multiplied by the assumed energy intensity of brackish desalination, 1301 kWh/AF. This assumption is obtained from Study 2's

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[4] Based on data from 2008 on the Advanced Water Purification Facility

[5] From the *Role of Recycled Water* Report

analysis of operations at IEUA's Chino Desalter. Brackish water desalination plants are typically run at full capacity year round to enable the most cost effective use of the facility. Thus annual energy use by brackish water desalination is spread equally to each month of the year. All energy associated with this water supply is attributed to the respective region in which the water is produced.