*Monterey Renewable Energy and Utility Reliability Program: Enhanced Gas Conditioning*

**Technical Appendix**

**Overview**
The GHG reductions for this EPA CPRG application were calculated using tools developed by the California Air Resources Board (CARB) for the California Climate Investments Programs administered by the California Department of Resources Recycling and Recovery (CalRecycle). Under guidance of this program, CalRecycle has developed multiple project types that meet the objectives of the Organics Grant Funding Programs and for which there are methods to quantify GHG emission reductions. These programs are part of California Climate Investments, a statewide program that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment– particularly in disadvantaged and low-income communities.

The CalRecycle Organics Programs reduces GHG emissions by diversion of organic materials from landfills to anaerobic digestion. These calculations are based on estimates of tonnage of diverted material and emission reduction factors from published sources. For the purposes of this CPRG application, the GHG emission reductions were calculated using the tool for co-digestion of organics at wastewater treatment plants producing biofuels or bioenergy.

The Organics Benefits Calculator Tool and supporting Organics Quantification Methodology are equations used in the Organics Benefits Calculator Tool for estimating GHG emission and air pollutant emission reductions. CalRecycle developed project types that meet the objectives of the Organics Programs and for which there are methods to quantify GHG emission reductions.

In addition to the CalRecycle publicly available tools to quantify GHG reduction estimates associated with waste organics, the EPA's Greenhouse Gas Equivalencies Calculator tool was used to convert the amount of energy produced by M1W's co-heat and power (CHP) units to assess potential additional GHG reductions associated with the avoided use of operating this equipment for electricity generation.

**Measure-Specific Documentation:**
There are three specific measures all designed to achieve cumulative GHG reductions associated with the Project. The three specific measures are: 1) co-digestion of diverted of organic wastes from landfills, 2) reduction of GHG emissions associated with gas conditioning to produce RNG to displace fossil fuels in the utility pipeline and, 3) reduced and avoided use of co-heat and power generating units reliant on burning biogas to generate electricity. The GHG reduction estimates associated with each measure are described individually for the purposes of conveying the methodology used in the calculations.

**GHG Reduction Estimate Method:**
For the GHG reductions associated with the organics diversion, the methodology uses calculations to estimate reductions in GHG emissions associated with the diversion or prevention of food waste from landfills. The GHG emission reductions are estimated using the following equation:

> GHG Emission Reductions = Avoided Landfill Methane Emissions + Avoided Emissions from Use of Biomethane in Vehicle Fuel, Electricity Production, or Pipeline Injection – Fugitive Emissions from AD Process

The Food Waste Prevention and Rescue Program Benefits Calculator Tool automates the calculation using a publicly available tool "The Food Waste Prevention and Rescue Program Benefits Calculator Tool" which is available for download at: http://www.arb.ca.gov/cci-resources

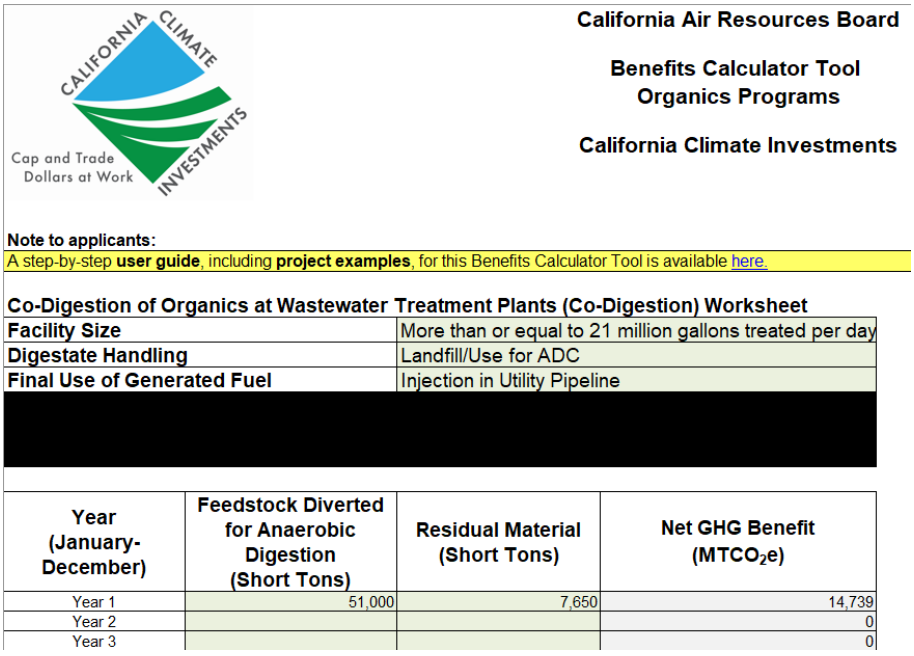
As part of the tool, the calculation requires the following inputs to be used to derive the GHG reduction estimates.

Quantification Inputs: (Co-Digestion of Organics at Wastewater Treatment Plants worksheet)

- Facility Size;
- Digestate Handling;
- Final Use of Generated Fuel;
- Feedstock Diverted for Anaerobic Digestion (short tons); and
- Residual Material (Short tons).

The Project as currently designed will serve the M1W facility having a daily treatment capacity of 29.6 million gallons. The current digestate handling is to provide biosolids for landfill use as alternative daily cover (ADC). Under this Project, the current assumption is that the additional biogas produced will be conditioned for RNG and injected into the utility's pipeline (PG&E) as the final use of the generated fuel.

M1W is actively pursuing a contract for feedstock management services to support co-digestion. The agreement is the provision of 31,000 tons/yr. of organics diverted from landfill disposal which equates to approximately 50 trucks per week (up to 51,000 Tons per Year) of pre-processed liquid organic waste (at <15% Total Solids). The feedstock is intended to be co-digested with wastewater biosolids in anaerobic digesters as a permitted activity under the Agency's NPDES permit, per 14 CCR §17896.6. This measure immediately realizes a net GHG benefit to reduce short term GHG pollutants such as methane production of 14,739 $MTCO_2e$ reductions as of the end of this year and going forward starting in 2025. The inputs and outputs of the model and its associated net GHG benefit are shown in Figure A. below.



**California Air Resources Board**

**Benefits Calculator Tool**
**Organics Programs**

**California Climate Investments**

**Note to applicants:**

A step-by-step **user guide**, including **project examples**, for this Benefits Calculator Tool is available here.

**Co-Digestion of Organics at Wastewater Treatment Plants (Co-Digestion) Worksheet**

| | |
|---|---|
| **Facility Size** | More than or equal to 21 million gallons treated per day |
| **Digestate Handling** | Landfill/Use for ADC |
| **Final Use of Generated Fuel** | Injection in Utility Pipeline |

| Year (January-December) | Feedstock Diverted for Anaerobic Digestion (Short Tons) | Residual Material (Short Tons) | Net GHG Benefit ($MTCO_2e$) |
|---|---|---|---|
| Year 1 | 51,000 | 7,650 | 14,739 |
| Year 2 | | | 0 |
| Year 3 | | | 0 |

Figure A: The Food Waste Prevention and Rescue Program Benefits Calculator Tool for Co-Digestion of Organics at Wastewater Treatment Plants

The second measure of the Project is the conversion of biogas to RNG with gas conditioning equipment. This aspect of the project will utilize the full amount of biogas produced in M1W digesters to be purified and upgraded to meet natural gas pipeline quality requirements by achieving methane content and characteristics similar to those of fossil-fuel natural gas, after which it can be used as an equivalent replacement and injected into the utilities' gas grid. M1W currently generates 371 scfm (normalized to 50% methane), which is predicted to increase to 703 scfm in 2028 as part of M1W's ongoing co-digestion project. The current co-digestion project under construction assumes up to 38,400 gallons per day (gpd) of clean organic slurry will be co-digested at M1W, increasing digester gas production to about 600 scfm at 59% methane (~700 scfm at 50% methane).

Biogas upgrading is where the majority of the emissions associated with digester gas to RNG occur. The objective is to remove $CO_2$, water, and to scrub unwanted components such as hydrogen sulfide to bring the biogas to pipeline-quality standards. At this stage the gas is referred to as biomethane. For the purposes of this analysis, a 90% capture rate of methane is expected with the gas conditioning facility to produce RNG. Furthermore a 95% facility uptime is assumed for the operation of the facility.

With passing of the California Global Warming Solutions Act of 2006 (AB 32) and initiation of California Cap and Trade, the California Air Resource Board (CARB) began its low carbon fuel standard (LCFS) program in April 2009 to meet goals of reduction of greenhouse gas emissions to 1990 levels by the year 2020. The LCFS program involves four key variables: 1) the pathway by which the fuel is generated; 2) the Carbon Intensity (a.k.a. "CI Score") of a fuel; 3) the fuel being replaced; and 4) the overall price per ton of carbon. Using a CI score for a fuel type the grams of $CO_2$ equivalent emitted per megajoule of energy, or $gCO_2e/MJ$ can be calculated. All renewable fuels and their carbon intensity are compared to a reference fuel being replaced which in this scenario is conventional natural gas.

The CARB Current Fuel Pathways spreadsheet contains a list of certified pathways by feedstock, fuel, classification, and facility name (https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities). From this database, the Current Certified CI for RNG using wastewater sludge as the pathway is 35 $gCO_2e/MJ$ which is less than 85 $gCO_2e/MJ$ for the CI of the natural gas it is displacing per the LCFS Dashboard (https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard). The LCFS assumptions are conditioned biogas to produce RNG has an assigned CI of 35 $gCO_2e/MJ$ which represents a negative (-)50 $gCO_2e/MJ$ delta below the CI of 85 $gCO_2e/MJ$ for the natural gas fuel it would displace. The calculations shown to support the $tCO_2e$ for this measure of the overall Project are shown in Table 1 on the next page.

Table 1: Estimated emissions reductions from digester gas to RNG (CNG end use)

| Row # | Column A | B | C |
|---|---|---|---|
| 2 | **Parameter** | | **Unit** |
| 3 | M1W Digester Gas normalized at 50% methane | 703 | scfm |
| 4 | Methane content | 50% | |
| 5 | RNG upgrader methane capture rate | 90% | |
| 6 | RNG upgrader up time | 95% | |
| 7 | M1W RNG potential in scfm (=B3*B4*B5*B6) | 301 | scfm |
| 8 | Unit conversion (volume) | 35.3147 | $cf/m^3$ |
| 9 | M1W RNG potential in $m^3$/yr. (=B7*60*24*365/B8) | 4,472,922 | $m^3/yr$ |
| 10 | Methane density | 0.717 | $kg/m^3$ |
| 11 | Methane HHV | 55.5 | MJ/kg |
| 12 | M1W RNG potential (=B9*B10*B11) | 177,993,203 | MJ/year |
| 13 | | | |
| 14 | Carbon intensity standard NG[1] | 85 | $gCO_2e/MJ$ |
| 15 | Carbon intensity avg wastewater sludge and food waste to RNG[2] | 35 | $gCO_2e/MJ$ |
| | **Estimated $CO_2e$ reductions (=B12*(B14-B15)/10^6)** | **8,900** | **$tCO_2e/yr$** |

[1] LCFS Data Dashboard | California Air Resources Board
[2] LCFS Pathway Certified Carbon Intensities | California Air Resources Board

The major assumption associated with this GHG reduction estimate is the RNG produced would be injected into PG&E's pipeline to be available for off takers to be used in the transportation sector to qualify for the LCFS program GHG reductions. Given the high motivation to procure biogas for this purpose suggests the reasonableness of making this assumption.

The third qualifying measure proposed for this Project involves the potential decommissioning of the co-heat and power units at the RTP for M1W. The GHG reduction potential of this measure is calculated using the EPA's Greenhouse Gas Equivalencies Calculator (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). This tool converts the energy data into annual $CO_2$ emissions. The continued use of the CHP units will be negated once primary power is secured from ReGen and backup power provided from PG&E. The M1W RTP facility currently has three cogeneration engines (825 HP each, 580 kW generator). The total annual power production from these CHP units in 2022 was 8.78 MWh/yr. From the EPA's GHG Equivalencies Calculator, the annual 8,780,075 kWh used in 2022 represents a 3,660 $tCO_2e$ emissions per year. It is anticipated that this performative GHG reduction be achieved once electrical interconnection is made between ReGen and M1W and once the gas conditioning facilities to convert biogas to RNG are built and fully operational. A figure from the online EPA GHG Equivalencies Calculator based on M1W CHP 2022 electrical production is shown in Figure B below.

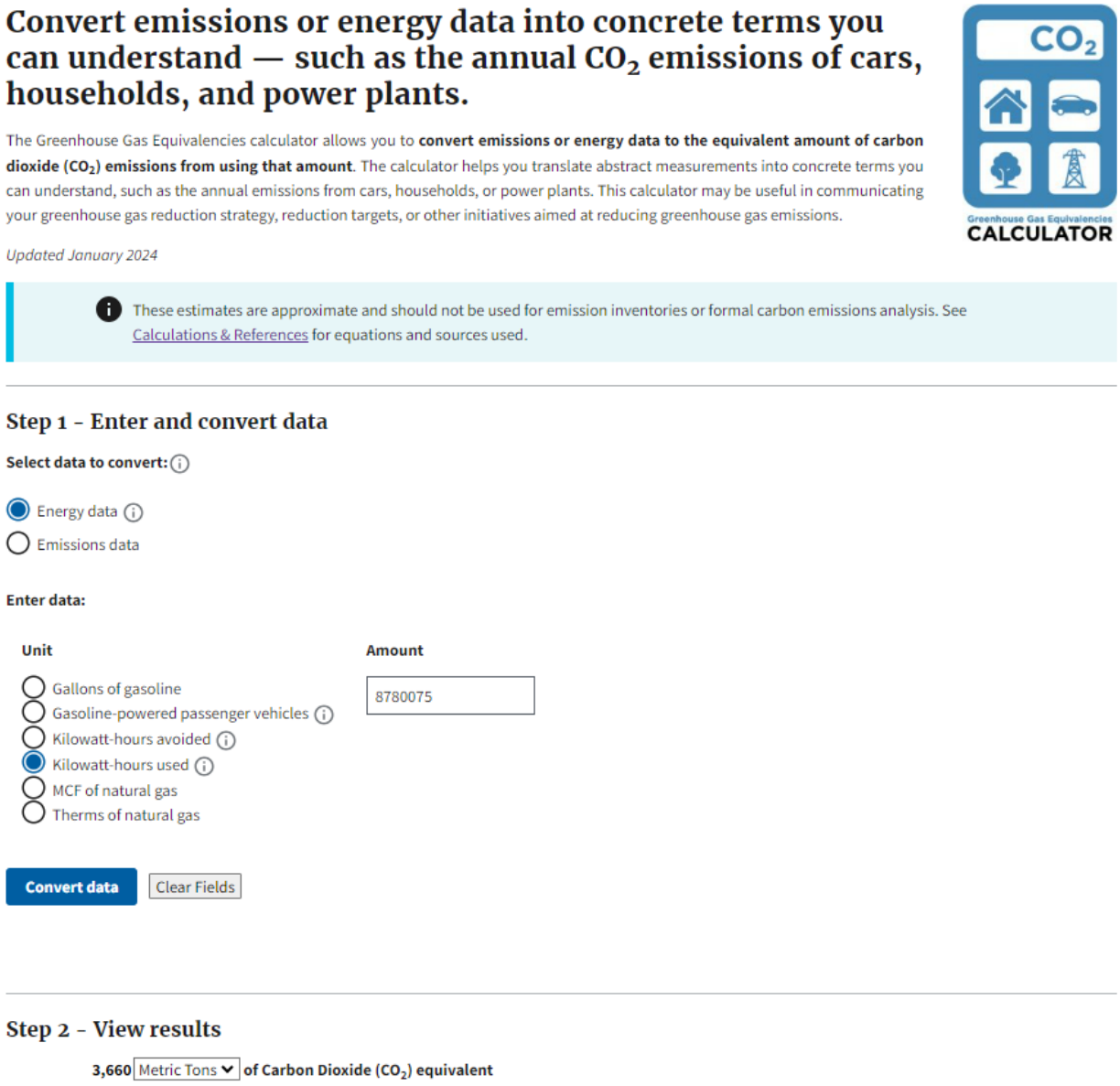


Figure B: EPA GHG Equivalencies Calculator based on M1W CHP 2022 electrical production of 8.78MWh

**Models/Tools Used**

The GHG emission reductions estimates from co-digestion anaerobic digestion is estimated as the difference between the baseline of sending the organic materials to a landfill versus digesting those materials using a co-digestion process. The GHG emission reductions associated with co-digestion include the avoided emissions that would otherwise occur if the food waste had been disposed of in a landfill and the benefits accrued by using the resulting biogas produced of the co-digestion process. For this GHG estimation, CalRecycle's Organics Benefits Calculator Tool for estimating the GHG emission reductions and air pollutant emission was used. First the Food Waste Prevention and Rescue Program Benefits Calculator Tool was used to calculate the GHG reductions associated with organics waste diversion from landfill disposal with a pathway for co-digestion to produce RNG.

The second measure calculates GHG reductions associated with biogas conditioning to produce RNG. For this calculation methodology, the California Air Resources Board (CARB) low carbon fuel standard (LCFS)

program guidelines were implemented. The LCFS is a key part of a comprehensive set of programs in California to cut GHG emissions. This guidance provides a standardized way of calculating the GHG emissions associated with the production, transportation, and use of a given fuel. For the biogas conditioning facility to produce RNG the fuel types evaluated were RNG versus traditional fossil fuel derived natural gas. Production estimates of biogas from co-digestion were calculated based on available capacities of M1W's digesters with all the biogas produced being used beneficially to produce RNG.

The third measure of GHG emission reduction estimates associated with retiring of the CHP units at M1W's RTP was calculated using the EPA's Greenhouse Gases Equivalencies Calculator. This tool provides a mechanism to calculate GHG emission reductions from the avoided use of electrical energy production using biogas based on the total CHP electrical output for the year 2022.

**Measure Implementation Assumptions:**
There are two primary categories of assumptions made with regards to the proposed Project, ones which are programmatic in nature and those where are performance or attribute related assumptions. Addressing the programmatic assumptions first, there are two main assumptions. The first programmatic assumption is that the construction of the electrical connection between ReGen and M1W will be finished and operational to allow for the existing CHP units at M1W to be retired. Unless reliable electrical energy is secured through ReGen and PG&E, then the decommissioning of M1W's CHP units could be deferred. The second primary programmatic assumption is that the gas conditioning facilities will be funded. Without funds, the potential GHG reductions associated with utilizing the biogas from co-digestion for RNG won't come to fruition. Currently, M1W will be co-digesting of organic wastes and will have GHG reductions associated with this measure however, the pathway for the biogas utilization is obscure without funding in place for gas conditioning facilities.

The performance or attribute assumptions associated with Project measures are relatively easy to quantify by comparison. For instance, standard engineering judgement applies when evaluating the feedstock quality specifications as described earlier (51,000 tpy at <15% solids). For convenience, other engineering assumptions that have been made to support the GHG reduction estimates are listed below.

<u>Assumptions for Co-Digestion of Organics at Wastewater Treatment Plants</u>

- 31,000 tons/yr. of organics diverted from landfill disposal which equates to approximately 50 trucks per week (up to 51,000 Tons per Year) of pre-processed liquid organic waste (at <15% Total Solids).
- Final use of generated fuel for injection into utility pipeline

<u>Assumptions for Conversion of Biogas to RNG</u>

- Biogas production through co-digestion is predicted to increase to 703 scfm in 2028
- A 90% capture rate of methane is expected with the gas conditioning facility.
- A 95% facility uptime is assumed for the operation of the facility.
- Low Carbon Fuel Standard assumptions for Carbon Intensity of biogas of 35 $gCO_2e/MJ$
- Low Carbon Fuel Standard assumptions for Carbon Intensity of Natural Gas of 85 $gCO_2e/MJ$
- RNG produced is procured be used in the transportation sector.

<u>Assumptions for Decommissioning of Co-Heat and Power Generating Equipment</u>

- The annual 8,780,075 kWh used in 2022 is representative of the typical electrical production that is capable of being provided by the CHP units in 2030 (i.e., no derating of CHP units over remaining 8 years of operation).

**GHG Reduction Estimate Assumptions:**

To estimate the net GHG emission reduction benefit of biogas use for RNG, emission factors from the quantification methodology for the waste diversion program (CARB) were used. It is assumed that the digestate would be used as alternative daily cover as is currently the disposal method for the biosolids produced. The average emission factors developed for medium-large wastewater treatment plants. The resulting average emission factor associated for converting biogas to RNG (as a low carbon transportation fuel) is 0.26 $MTCO_2e$ per short wet ton of diverted food waste.

The co-digestion emissions reduction benefits and factors are summarized in Table 2. The net emissions reduction factor is approximately 0.70 $MTCO_2e$ per short wet ton of diverted food waste with the assumption that the additional biogas is used to generate RNG for direct pipeline injection.

Table 2: Breakdown of Co-digestion Emission Reduction Factors per Wet Ton of Diverted Food Waste

| **Emissions Reduction Type** | **Emission Reduction Factor ($MTCO_2e$/wet ton food waste as diverted from landfill)** |
|---|---|
| Avoided Landfill Emissions | 0.388 |
| Biosolids Use (Alt. Daily Cover) | 0.055 |
| Biogas Use (RNG pipeline injection) | 0.26 |
| **Net Emissions Reduction Factor** | **0.70** |

**Reference Case Scenario (GHG Emissions or Activity Level):**
Within Section C of the User's Guide for CalRecycle's Organics Program (https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/calrecycle_organics_finaluserguide_6-15-20.pdf) there is an example project which can be referenced to demonstrate a similar scenario of co-digestion using anaerobic digestion at a wastewater facility that provides metrics and a summary of the overall project GHG emission reductions. For the Project measures associated with biogas to RNG upgrading and CHP decommissioning, no example reference project was sourced although the GHG reduction estimates associated with these Project elements is straightforward.

**Measure-Specific Activity Data**
The Project includes provisions for a pipeline injection station. The injection station includes the equipment necessary to monitor flow. The RNG injection station flow meter will ultimately become the primary mechanism to determine the output of the RNG produced which in turn can be used to quantify the GHG emission reductions. The additional GHG emission reductions associated with the decommissioning of M1Ws CHP units will be easily confirmed as the average emissions monitored over the operating period prior to the date the units are retired from service. This parameter can be directly monitored using actual equipment to obtain data from the exhaust of the CHP units and corelate this information to the electricity produced over the same monitoring period.

**GHG Emissions Reduced**
The following table provides a calculation of the GHG reduction estimates for the specific measures considered in this Project. The timeline for implementation is based on the scheduling of various Project elements as they are constructed, commissioned and fully operational as noted in the table. Additional GHG reduction estimates are possible considering the future potential of converting LFG to RNG with the gas conditioning facilities proposed. The volume of LFG available dwarfs the biogas production from co-digestion and thus this project has the potential GHG reduction estimates beyond 2030 that could be several orders of magnitude higher than the conservative estimates shown in Table 3 below.

Table 3: Estimated emissions reductions for Program measures (Years 2025 - 2050)

| Year | Estimated emission reductions (tCO2e) | Program Measure |
|---|---|---|
| 2025 | 14,739 | Co-digestion of diverted organic wastes from landfills |
| 2026 | 14,739 | |
| 2027 | 14,739 | |
| 2028 | 23,639 | Co-digestion and gas conditioning for RNG production |
| 2029 | 23,639 | |
| 2030 | 23,639 | |
| 2031 | 27,437 | Co-digestion, RNG production, and CHP decommissioning<br>*Future potential for LFG gas conditioning to RNG<br>(in parenthesis) |
| 2032 | 27,437 (to 33,953) | |
| 2033 | 27,437 (to 34,211) | |
| 2034 | 27,437 (to 34,469) | |
| 2035 | 27,437 (to 34,727) | |
| 2036 | 27,437 (to 34,985) | |
| 2037 | 27,437 (to 35,243) | |
| 2038 | 27,437 (to 35,501) | |
| 2039 | 27,437 (to 35,759) | |
| 2040 | 27,437 (to 36,017) | |
| 2041 | 27,437 (to 36,275) | |
| 2042 | 27,437 (to 36,533) | |
| 2043 | 27,437 (to 36,791) | |
| 2044 | 27,437 (to 37,049) | |
| 2045 | 27,437 (to 37,307) | |
| 2046 | 27,437 (to 37,565) | |
| 2047 | 27,437 (to 37,823) | |
| 2048 | 27,437 (to 38,081) | |
| 2049 | 27,437 (to 38,339) | |
| 2050 | 27,437 (to 38,587) | |