Methods to Assess Co-benefits of California Climate Investments

Energy and Fuel Costs

Center for Resource Efficient Communities, UC-Berkeley
Agreement #15TTD002, Project Order #1, Task 2 Literature Review
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I. Background

Under California's cap-and-trade program, the State's portion of the proceeds from Cap-and-Trade auctions is deposited in the Greenhouse Gas Reduction Fund (GGRF). The Legislature and Governor enact budget appropriations from the GGRF for State agencies to invest in projects that help achieve the State's climate goals. These investments are collectively called California Climate Investments (CCI).

Senate Bill 862 requires the California Air Resources Board (CARB) to develop guidance on reporting and quantification methods for all state agencies that receive appropriations from the GGRF. Guidance includes developing quantification methodologies for greenhouse gas (GHG) emission reductions and other non-GHG outcomes. Non-GHG outcomes are the positive or negative social, economic, and environmental impacts of projects, which are collectively referred to as "co-benefits." Some agencies use a competitive process to select CCI projects and they require applicants to estimate co-benefits when they submit a request for funding.

This document is one of a series that reviews the available methodologies for assessing selected co-benefits for CCI at two phases: estimating potential project-level co-benefits prior to project implementation (i.e. forecasting co-benefits), and measuring actual co-benefits after projects have been implemented (i.e. tracking of co-benefits). The assessment methodology at each of these phases may be either quantitative or qualitative. As with CARB's existing GHG reduction methodologies, these co-benefit methodologies will be developed to meet the following standards:

- Apply at the project level
- Align with the project types proposed for funding for each program
- Provide uniform methods to be applied statewide, and be accessible by all applicants
- Use existing and proven tools or methods where available
- Reflect empirical literature

CARB, in consultation with the state agencies and departments that administer CCI, has selected ten co-benefits to undergo methodology assessment and development. This document reviews available empirical literature on the ***energy and fuel cost co-benefit*** and identifies:

- the direction and magnitude of the co-benefit;

- the limitations of existing empirical literature;
- the existing assessment methods and tools;
- knowledge gaps and other issues to consider in developing co-benefit assessment methods;
- a proposed assessment method for further development; and
- an estimation of the level of effort and delivery schedule for a fully developed method.

II. Co-benefit description

The "energy and fuel cost" co-benefit applies to any situation where a California Climate Investment (CCI) project will result in a change in the use and cost of energy or fuel to project applicants and/or end-users. Relevant CCI projects can be categorized into three project types (note that one single CCI project may include multiple project types):

1. **Project Type 1. Energy / Fuel Use Shifts**: projects that increase or decrease the total energy or fuel cost and/or use by the applicant. This primarily includes transportation projects that introduce new or expanded rail, bus, or ferry lines, but may also include agricultural or housing projects that install new energy-using appliances, etc. Note that energy and fuel costs incurred *during* project construction are outside of the purview of this analysis.

2. **Project Type 2. Energy Efficiency**: projects that decrease energy cost and/or use by the applicant through technological efficiency improvements. This includes energy efficiency projects on residential, commercial, and agricultural sites, as well as in the transit sector.

3. **Project Type 3. Renewables Conversion and/or Generation:** projects that increase or decrease fuel cost and/or use by the applicant and/or end-user *after* the project has been implemented through conversion to a renewable fuel source (e.g. wind, solar, geothermal, biomass, hydroelectric, etc.). In some cases, these projects generate renewable energy/fuel on-site, and in others the energy/fuel is purchased elsewhere.

We do not include costs associated with environmental impacts of energy use, as these are largely covered by other co-benefit assessment methodologies.

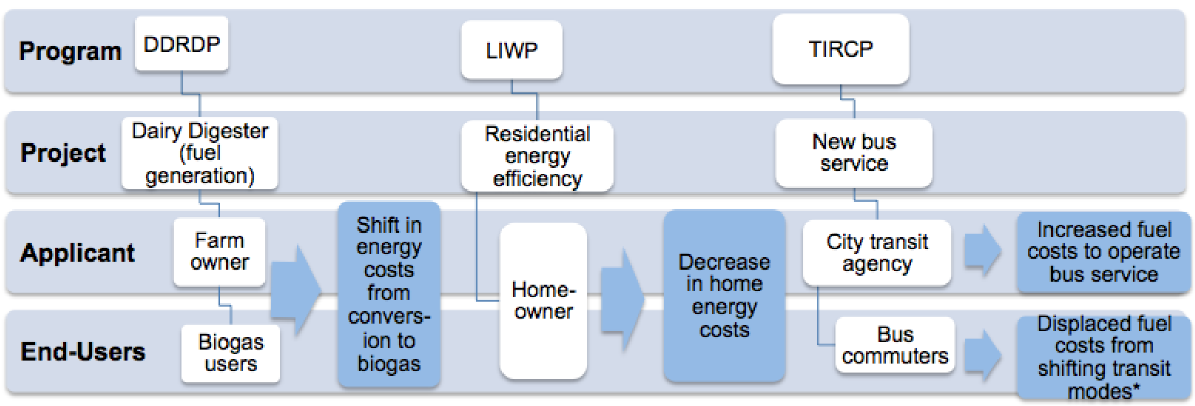
Depending on the Program and Project Type, a CCI project may impact the energy and fuel costs of a project applicant and/or end-user. This distinction between project applicants and end-users for different project types is illustrated in Figure 1 below.

The first two project types (energy/fuel use shifts and efficiency) only impact the amount and cost of energy or fuel used by project applicants themselves, within the project area (i.e., the project applicant is the same as the end-user). For example, in the case of a residential energy efficiency project through the Low-Income Weatherization Program (LIWP), a homeowner may apply for the CCI project funding, and will also benefit from the resulting decrease in home energy costs as an end-user.

Project Type 3 (renewables conversion/generation) may impact the amount and cost of energy or fuel used by the project applicant themselves, and/or downstream by end-users *outside of* the project area. For example, in the case of the Dairy Digesters and Research Development Program (DDRDP), a farm owner may apply for CCI project funding to install a dairy digester, and will either benefit directly from the consumption of biogas on-site, or sell the biogas to the grid for consumption by other end-users.

In addition, certain CCI public transportation projects (such as the High-Speed Rail, TIRCP, and LCTOP programs) also impact the energy and fuel cost of both the project applicant and end-users. However, these end-user co-benefits are captured in the "Transportation User Costs Co-Benefit", and as such are not included here, so as to avoid double-counting of co-benefits. For example, in the case of the Transit and Intercity Rail Capital Program (TIRCP), a city transit agency may apply for CCI project funding to implement a new bus service. The agency itself may incur increased fuel costs to operate the new bus service (which are captured by this co-benefit). Additionally, end-users (commuters) may displace their fuel costs from one transit mode (cars) to another (the new bus service) (captured by the Transportation User Costs Co-benefit).

Figure 1: *Examples of Project Applicants vs. End-Users for the Energy and Fuel Cost Co-Benefit*



*Displaced fuel costs from shifting transit modes are captured in the "Transportation User Cost" Co-benefit.

Table 1 on the following page illustrates the Fiscal Year 2016-17 GGRF programs for which energy or fuel co-benefits (both positive and negative) are most likely to accrue.

***Table 1**: CCI Programs Affected by Energy Cost Co-Benefit (with estimated directionality of co-benefit)*

CCI Program	**Project Type(s) and Directionality[1]**		
	Energy / Fuel Use Shifts[2]	**Energy Efficiency[3]**	**Renewables Conversion / Generation[4]**
High Speed Rail	-		
Transit and Intercity Rail Capital Program (TIRCP)	-	+	+/-
Low Carbon Transit Operations Program (LCTOP)	-	+	+/-
Low Carbon Transportation (LCT)		+	
Low-Income Weatherization Program (LIWP)		+	+/-
Dairy Digesters and Research Development Program (DDRDP)			+/-
Alternative Manure Management Practices (AMMP)	+/-		
State Water Efficiency and Enhancement Program (SWEEP)		+	+/-
Water-Energy Grant Program		+	
Woodsmoke Reduction Program	+	+	
Urban Greening Program		+	
Wetlands and Watershed Restoration	-		
Forest Health Program			+/-
Urban and Community Forestry (UCF)		+	+/-
Waste Diversion Program	+/-		+/-

[1] Positive (+) directionality indicates a positive co-benefit, i.e. a reduction in the amount and cost of energy or fuel used. Negative (-) directionality indicates a negative co-benefit, i.e. an increase in the amount and cost of energy or fuel used.
[2] Energy / Fuel Use shifts impact the project applicant only (the applicant is the same as the end-user).
[3] Energy Efficiency projects impact the project applicant only (the applicant is the same as the end-user).
[4] Renewables Conversion / Generation projects may impact either the project applicant and/or the end-user.

III. Directionality of the co-benefit

See Table 1 above for estimated directionality of each CCI program by project type.

The net energy and fuel cost co-benefit directionality could be positive or negative, depending on energy and fuel prices, and whether the project impacts energy use by the project applicant and/or end-users.

CCI projects that increase the total energy or fuel use by the applicant through changing project activities will have some negative impact on the energy cost co-benefit. This primarily includes transportation projects that introduce new rail, bus, or ferry lines. However, these negative impacts for the applicant may be offset by the displacement of energy and fuel costs for end-users (commuters) who substitute from more energy-intensive transit modes (cars/airplanes) to public transit, walking, or biking.[5] However, as noted above, these energy displacement co-benefits are considered separately in the "Transportation User Costs Co-Benefit."

CCI projects focused on increasing energy efficiency will have a positive net benefit. Changing the energy or fuel mix of a CCI project (conversion) by purchasing and/or generating alternative fuels on-site will also have net benefits that depend on individual energy prices and fuel efficiency.

IV. Magnitude of the co-benefit

The energy and fuel cost co-benefit is likely to be of significant magnitude within certain programs' geographic scopes, but these effects are small when viewed in the context of California's overall energy usage. The co-benefit will be positive and significant for a substantial part of the CCI portfolio, because several programs invest in projects specifically devoted to energy efficiency in residential or commercial buildings, on farms, and in vehicles and transit. Co-benefits or costs associated with renewables generation and/or conversion are not likely to have significant impacts beyond the project scale. Costs associated with the establishment of new bus, rail, or ferry lines will likely be offset when taking into consideration other co-benefits such as the "Transportation User Cost" co-benefit.

The overall magnitude of the energy and fuel cost co-benefit will be dependent on fuel and energy prices. The most recent available national averages for prices of conventional and alternative fuels are presented in Table 3. The most recent available California averages for prices of electricity to customers by end-use sector are presented in Table 4.

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[5] The High-Speed Rail (HSR) project, for example, will create substantial new energy costs within the project area, but it will operate on 100 percent renewable energy, and displace substantial vehicle miles traveled (VMT) from air and car travel.

Table 3. National average retail fuel prices, as of April 2017. (USDOE 2017)[6]

National Average Retail Fuel Prices Conventional and Alternative Fuels, April 2017 *				
Fuel Type	January 2017	April 2017	Change in Price January-April	Units of Measurement
Gasoline	$2.32	$2.38	$0.06	per gallon
Diesel	$2.58	$2.55	-$0.03	per gallon
CNG	$2.11	$2.15	$0.04	per GGE
LNG	$2.53	$2.52	-$0.01	per DGE
Ethanol (E85)	$2.04	$2.11	$0.07	per gallon
Propane**	$2.80	$2.83	$0.03	per gallon
Biodiesel (B20)	$2.57	$2.49	-$0.08	per gallon
Biodiesel (B99/ B100)	$3.06	$3.09	$0.03	per gallon

Table 4. California average price of electricity to ultimate customers by end-use Sector, as of June 2017 (Cents per Kilowatt hour). (EIA 2017)

EIA California Average Price of Electricity to Ultimate Customers by End-Use Sector (Cents per Kilowatt hour)	
Residential	19.39
Commercial	17.32
Industrial	15.05
Transportation	8.47

[6] CNG = Compressed Natural Gas; GGE = gasoline gallon equivalent
LNG = Liquefied Natural Gas; DGE = diesel gallon equivalent

i. Project Type 1. Energy / Fuel Use Shifts

Several programs impact energy use within the project directly, as a result of an increase in overall operations (growth). These programs could result in net costs by increasing the total use and cost of energy within the project and potentially at the program scale. Note that fuel and energy costs incurred during construction (i.e. construction of new rail lines, buildings, etc.) are outside the purview of the quantification methodology. As such, energy use in this context refers to shifts in energy and fuel consumption following the implementation of project activities. The magnitude of energy and fuel use increases will vary with the absolute magnitude of the CCI and the specific composition of project activities. Some activities are more energy intensive than others, and different activities will generate different kinds of energy needs and technology choices.

Projects that **expand or establish new transit services** (rail, bus, or ferry lines) will likely result in a moderate negative energy and fuel use increases, as any fuel costs are new to the applicant (since there is no existing fuel cost that is being replaced and potentially reduced by the new project). This includes the High-Speed Rail (HSR), TIRCP and LCTOP programs. Furthermore, these increases will likely be offset across the CCI portfolio when taking into consideration the “Transportation User Costs” co-benefit, as well as related environmental co-benefits, some of which are quantification using other co-benefit assessment methods.

Projects in **housing and agriculture that increase total energy use** are unlikely to have significant impacts beyond the project level. The CDFA Alternative Manure Management Practices (AMMP) program may increase impact total project energy use (electricity and fuel) associated with new waste management practices. The CalRecycle Waste Diversion Program could also directly increase within-project energy costs through the installation of new energy-using appliances, such as refrigerators for the food waste project type.

ii. Project Type 2. Energy Efficiency

Several programs identify energy efficiency as a central purpose of funded projects, and will produce significant co-benefits at both the project and program scale. This includes projects funded by the LIWP, DWR Water-Energy Grant Program, and CARB Woodsmoke Reduction Program, which implement energy efficiency measures, equipment, appliances, and fixtures in **homes and commercial buildings**, such as upgrades, replacements, and retrofits. The CNRA Urban Greening Program and CAL FIRE Urban and Community Forestry (UCF) programs also indirectly reduce building energy use efficiency by strategically planting trees to shade buildings.[7]

[7] Transit projects within the TIRCP, LCTOP, and LCT programs also fund system or efficiency improvement projects that increase ridership or implement better route planning to minimize travel distance or idle times for passengers. However, the resulting energy use impacts on commuters (end-users) are captured by the Transportation User Cost Co-benefit.

The State Water Efficiency and Enhancement Program (SWEEP) funds **agricultural energy efficiency** projects, including retrofitting or replacing water pumps, conversion to low-pressure irrigation systems, and the use of Variable Frequency Drives to reduce energy use and match pump flow to load requirements.

A significant body of literature focuses on the magnitude of energy cost benefits from energy efficiency practices and measures in residential or commercial buildings. Brown and Koomey (2003) describe strategies for improving commercial energy efficiency. These authors estimate a conservation supply curve for industry that shows cost per Gigajoule of energy savings. Like the Marginal Abatement Curve in emissions control policy, costs of energy efficiency adoption eventually increase dramatically as energy savings increases. Recent work by Schlomann and Schleich (2015), for example, discusses the potential of energy efficiency policies in public/private services, trade, commerce, and small industry. These policies target activities like smarter management (especially switching off when idle or unprofitable) of a wide range of appliances (including lighting), and mainstreaming energy efficiency into investment decisions, including capital expenditure and O&M costs/benefits. One of the most important lessons from these diverse studies is that sectoral heterogeneity has little effect on the efficacy of adopting low-cost energy efficiency measures.

iii. Project Type 3. Renewables Conversion / Generation

Projects that generate and/or convert to renewable fuel and/or energy are unlikely to have significant impacts beyond the project level. There are three use cases for this project type:

1. CCI applicants *generate* their own renewable fuel/energy and *convert* on-site use within the project area. (e.g. CDFA SWEEP installation projects that generate solar energy to power agricultural irrigation systems)
2. CCI applicants *generate* renewable fuel/energy to sell to the grid for downstream use by other end-users.
3. CCI applicants purchase renewable fuel/energy from off-site sources to *convert* on-site use within the project area (e.g. TIRCP, LCTOP, and LCT projects that replace conventional vehicles with electrics or hybrids).

In any of these cases, the magnitude of the co-benefit for the project applicant will depend upon the quantity of units converted to renewable sources (i.e. vehicles, buildings, farms), and the difference in fuel costs between the old conventional fuels/energy and the new.

This project type includes the conversion of **residential and commercial building energy sources** to solar in lieu of electricity or heating fuel. The LIWP program funds projects that install Solar Water Heaters, which use a solar thermal collector to deliver hot water, thereby reducing the need to use electricity or heating fuel. The program also funds Solar Photovoltaics, which use solar panels to provide electricity, thereby reducing grid-based electricity use.

This project type also includes the conversion of **agricultural energy sources** to a less carbon intensive fuel. For example, the SWEEP program funds projects that use solar to power agricultural irrigation systems (in conjunction with water savings measures). In some cases, these projects are paired with on-site renewable generation. The DDRDP program provides financial assistance for the installation of a biogas control system (BCS), commonly referred to as a dairy digester, which captures and utilizes biogas produced by the anaerobic decomposition of livestock manure and/or other organic material. BCS utilizes thermal energy, thereby reducing demand for fossil-fuel based energy either on-site or by down-stream end-users. The CalRecycle Waste Diversion Program funds standalone anaerobic digestion (AD) of organics, and co-digestion of organics at wastewater treatment plants, both of which produce biofuels or bioenergy for use either in transportation on-site or to feed into the grid for use off-site.

The TIRCP, LCTOP, and LCT programs invest in projects that **replace conventional vehicles or equipment owned by the project applicant with cleaner electrics or hybrids**.[8] The TIRCP and LCTOP programs fund the replacement of conventional fleets of internal combustion engine buses, passenger vans, or trucks with electric or hybrid vehicles.[9] The LCT program funds Advanced Technology Demonstration Projects (off-road and on-road) that provide incentives for zero-emission freight equipment used in freight transport. If these vehicles replace existing conventional vehicles, they may be considered under this project type. If the vehicles are not replacements, the project should be considered under Project Type 1, since any fuel or energy costs are new to the applicant.

For these projects, the magnitude of the co-benefit for the project applicant will depend upon the number of project applicant vehicles exchanged and the difference in fuel costs between the old conventional vehicles and the new electric or hybrid vehicles.

V. Limitations of current studies

As noted above, CCI may impact the amount and cost of energy or fuel used by project applicants and/or end-users. In some CCI programs, the applicant is the same as the end-user, and in others, they are separate and unique. This creates some complexity in ensuring that a methodology to quantify the energy and fuel cost co-benefit is exhaustive and avoids double-counting or overlooking benefits. In the case of renewables generation, projects that generate renewable energy for on-site use must

[8] Note that other projects fund cleaner vehicles for end-users (e.g. consumer rebates and incentive programs). The energy and fuel cost co-benefits from these projects should be considered in the “Transportation User Cost” co-benefit.
[9] Note that if the vehicle purchase is new, rather than a replacement, the energy cost should be considered under Project Type 1. Energy / Fuel Use Shifts.

be sure not to double-count the cost of the fuel generated and consumed. In the case of CCI transportation projects that displace energy use across transit modes (HSR, TIRCP, and LCTOP projects), we distinguish here between energy and fuel costs to applicants (e.g. state or city agencies), which are captured by this methodology, versus end-users (commuters), which are captured in the “Transportation User Costs Co-Benefit.”

Despite continued commitments to energy efficiency in California, recent research has emerged that highlights challenges to achieving ever-higher energy efficiency (EE). The practical challenge is essentially a diminishing returns problem. All energy efficiency measures (cleaner vehicles, appliances, etc.) have diminishing efficiency returns. Any quantification methodology must therefore take into account the average effective useful life of each measure. All CARB GHG quantification methodologies for energy efficiency projects include variables to account for diminishing efficiency returns.

Energy efficiency measures also face diminishing returns at the level of market demand, which the California Energy Commission recently described in its 2013 Integrated Energy Policy Report. Addressing California’s more recent progress on energy efficiency, it describes EE as the highest priority resource to offset increased demand due to a new loading order that prioritizes efficient energy to meet new demand before renewables, distributed generation, and then clean fossil-generated energy. 2013 was the third year that publicly owned utilities (POUs) reported declines in EE savings, suggesting that new programs or additional financial incentives will need to be developed for POUs to capture higher levels of energy savings and peak demand reduction. EE may face decreasing marginal returns unless public EE incentives are actively expanded.

Some analysts, such as Levinson (2014), have suggested that California’s constant residential per capita energy use relative to other states is not due to success of energy efficiency regulation, but rather to three unrelated factors:

- migration of populations to the South and Southwest US, where there is relatively higher electricity consumption;
- the concentration of California’s population in mild coastal climates, which means less growth of heating and cooling demand (with income) relative to other states;
- different rates of change in household size, which affects household energy consumption since energy use per capita declines with rising household size.

To the extent that these factors are operative, they may moderate the findings of the larger body of research documenting what has become known as the Rosenfeld Curve (Rosenfeld and Poskanzer, 2009), a consistent trend of household efficiency improvements.

VI. Existing quantification methods/tools

Energy and fuel cost co-benefits for CCI can be directly calculated using simple equations that rely upon readily available inputs. Energy cost is directly related to energy use. The methods for determining energy use are already defined in the CARB quantification methodologies of each program. As such, applicants may simply apply cost co-efficients to these energy use data, using third-party energy pricing information, to calculate the energy and fuel cost co-benefit.

i. Project Type 1. Energy / Fuel Use Shifts

CCI projects in the HSR, TIRCP, LCTOP, AMMP, Wetlands and Watershed Restoration, and Waste Diversion programs may accrue energy cost increases or cost savings due to changing project activities. For these projects, the total energy cost co-benefit may be generally calculated as follows:

*Total applicant energy cost co-benefit = Annual energy use associated with old practice - projected energy use after CCI project * average cost of energy*

Where:

Energy use = annual electricity consumed (MWH/yr) or fuel consumed (gallons or MMBtu/yr))

ii. Project Type 2. Energy Efficiency

Projects funded by the CSD LIWP, DWR Water-Energy Grant Program, and CARB Woodsmoke Reduction Program, implement energy efficiency measures, appliances, and fixtures in homes, farms and commercial buildings, such as upgrades, replacements, and retrofits. For commercial and residential energy efficiency projects, the total energy cost co-benefit may be calculated as follows:

*Total applicant energy cost co-benefit = Projected number of dwellings/buildings anticipated to receive energy efficiency measures * statewide average annual energy use reductions achieved per dwelling estimate based on historical data collected on implemented energy efficiency projects (MWH/yr, gallons or MMBtu/yr)[10] * average effective useful life of all measures installed[11] * average cost of energy*

[10] For LIWP energy efficiency projects, the energy savings values of eligible measures utilize various references to match the LIWP measure with an energy savings value of an equivalent measure. See Appendix B at https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/csd_liwp_finalqm_15-16.pdf

[11] 15 years is the average useful life of measure packages installed as part of LIWP. See https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/csd_liwp_finalqm_15-16.pdf

The SWEEP program funds projects that install pumps and motors for agricultural water-energy efficiency. For these projects, the total energy cost co-benefit may be calculated as follows:

*Total applicant energy cost co-benefit = Projected number of energy efficient pumps/motors anticipated to be installed * (Pump fuel/electricity cost pre-project – anticipated pump fuel/electricity cost post-project) * average effective useful life of all pumps/motors installed*[12]

Where:

*Pump fuel/electricity cost pre-project = Pump fuel/electricity use (gallons, scf, kWh) pre-project * average cost of fuel/energy*

*Anticipated pump fuel/electricity cost post-project = Pump fuel/electricity use (gallons, scf, kWh) post-project * average cost of fuel/energy*

iii. Project Type 3. Renewables Conversion / Generation

The CalSTA TIRCP, Caltrans LCTOP, and CARB LCT programs all fund projects that replace conventional **vehicles** *used by the project applicant* with low-emitting ones. This includes buses and freight vehicles. Note that energy/fuel co-benefits incurred by transportation end-users (commuters) are considered in the “Transportation User Cost” co-benefit, and should not be calculated here so as to avoid double-counting of benefits.

For these projects, the total project applicant energy cost co-benefit may be calculated as:

Annual applicant annual energy/fuel cost co-benefit = annual fuel cost of driving conventional vehicles –annual fuel cost of driving low-emitting vehicles

Where:

*Annual fuel cost of driving conventional vehicles = annual fuel used by conventional vehicle (gallons) * average fuel cost ($/gallon)*[13]

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[12] 10 years is the average useful life of equipment as per the CARB quantification methodology used for SWEEP. See https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cdfa_sweep_finalcalc_16-17.xlsx

[13] Note that the CARB GHG quantification methodology calculators for the TIRCP, LCTOP, and LCT programs already require applicants to estimate the annual fuel consumed before and after project implementation.

*Annual fuel cost of driving low-emitting vehicles = annual fuel/electricity used by low-emitting vehicle (gallons of diesel, kWh of electricity) * average fuel/electricity cost ($/gallon, kWh)*

Other CCI projects convert to a renewable fuel or electricity source for *use by project applicants* in **residential, commercial, and on-farm buildings, machines, and appliances**. In some cases these project applicants also generate the renewable fuel/energy on-site. Note that fuel/electricity generation and consumption should not be double-counted. The CDFA SWEEP program funds projects that convert to less energy-intensive fuels for irrigation pump and motor energy use. The CSD LIWP program funds Solar Water Heaters and Solar Photovoltaics for residential lighting and heating. For these projects, the total energy cost co-benefit may be based on the projected energy/fuel capacity that can be installed. The estimated installed capacity results from historical programmatic data collected on the installation of such systems.

*Total applicant energy cost co-benefit = [fuel/electricity cost of using conventional application – fuel/electricity cost of using alternative or renewable application] * energy generation capacity of each system*

Where:

Energy generation capacity of each system = this will vary depending on the measure installed. Details may be found within each programs GHG quantification methodology.[14]

Other CCI projects generate renewable fuel/energy to be sold to the grid *for project end-users* (not for the project applicant themselves). This includes the CalRecycle Waste Diversion Program (which funds the diversion of feedstock for production of biofuels and bioenergy), and DDRDP projects that sell the biogas they produce. For these programs, the total energy cost co-benefit could be calculated as:

Total end-user energy cost co-benefit = total cost of equivalent quantity of conventional fuel – total cost of quantity of renewable fuel to be produced

Where:

*Total cost of equivalent quantity of conventional fuel = quantity of equivalent fuel * national average retail fuel prices (as shown in Table 3)*

[14] For example, LIWP Solar Photovoltaics (PV) projects energy generation capacity estimates are based on the projected solar capacity that can be installed. This depends on the estimated useful life of PV systems, the estimated solar PV capacity for installation (MW), the rate of system degradation, and the capacity factor, which is the actual output/maximum output of the solar PV system.

*Total cost of quantity of renewable fuel to be produced = quantity of renewable fuel to be produced * national average retail fuel prices (as shown in Table 3)*

VII. Knowledge gaps and other issues to consider in developing co-benefit quantification methods

The accuracy of estimating the user cost co-benefits for transit projects will depend on the accuracy of the estimates of VMT reduction calculated by CCI applicants as part of the existing GHG quantification. Many of these estimates may not be based on robust demand modeling, which require input data generated from travel surveys that may be beyond the financial and technical resources of many transit districts. In addition, as noted in Section V above, existing estimates of the per-mile cost of driving rely on statewide or nationwide averages and incorporate simplifying assumptions.

Even though applicants already provide relatively detailed estimates of expected energy needs, there remain several knowledge gaps that might limit their accuracy and lead to deviations in downstream reporting. These sources of uncertainty are:

i. Permanence (The Rebound Effect)

Permanence refers to the level of certainty that energy cost co-benefits will persist over time and not be reversed. Energy efficiency technology and/or behavior can lead to savings in total energy used and possibly even drive down prices. If this happens, these purchasing power benefits may cause energy demand to “rebound”, leading to smaller-than-expected energy use reductions. Borenstein (2013) finds it unlikely that rebound would “backfire” or more than offset input-use efficiency benefits, but suggest that energy efficiency program benefits could be significantly reduced under plausible behavioral assumptions.

ii. Practice Duration

Related to the rebound effect is the issue of transience and persistence. When do energy users change their behavior permanently and when to they simply try a new use regime and revert to a habitual one over time? Alberini and Fillippini (2014) address this question with estimates from household nationwide data. Their results suggest that US residential sector could save 10% of total energy consumption if it eliminated persistent inefficiencies, and 17% if it could eliminate transient inefficiencies.

VIII. Proposed method/tool for use or further development, schedule, and applicant data needs

Given these findings, we offer the following recommendations for methods to assess energy user cost co-benefits, schedule for development of guidance documents, and applicant data needs.

Overall, the methodology for estimating the energy cost co-benefit should be quantitative for both direct and indirect impacts, amounting to applying simple cost co-efficients to energy use (and generation) within each project. We therefore recommend that CCI project applicants apply cost co-efficients to the energy use information already being provided in GHG quantification documentation.

Methods for estimation prior to award of CCI funds:

- Calculation of project applicant energy/fuel cost co-benefits from all relevant programs funding Project Type 1 (energy/fuel use shifts) or Project Type 2 (energy efficiency) using the equations in Section VI.i. – VI.ii.

- Calculation of end-user energy/fuel cost co-benefits for the DDRDP program funding Project Type 3 (generation/conversion to renewables), i.e. projects that generate renewable energy/fuel for consumption by other end-users, using the equation in Section VI.iii.

- We *do not* recommend that projects in Project Type 3 funded by CalFIRE Forest Health, UCF, or CalRecycle Waste Diversion programs report on energy/fuel cost co-benefits to end-users at this time. These projects divert materials (biomass or feedstock) for downstream generation of renewable energy/fuels (rather than producing the fuel/energy directly). Under the current CARB GHG quantification methodology, these CCI project applicants are not required to calculate the quantity of renewable fuel to be potentially produced. Rather, they are required to report on the quantity of biomass or feedstock to be removed and diverted for delivery to a facility generating fuel or electricity via combustion/gasification. As such, we do not recommend that these CCI applicants report on this type of indirect energy cost impacts at this time.

Methods for measurement after award of CCI funds:

- Application of the same equations as above using data on actual energy/fuel used after project completion, when known by the awardee

Schedule:

Because these methods are straightforward and based directly on existing GHG quantification guidance, we anticipate that we could develop draft co-benefit assessment methodology within three weeks of CARB's instruction to proceed.

Data needs

The only additional data required for this quantification methodology are energy/fuel price data acquired from third parties, such as those in Tables 3 and 4. Data on energy/fuel usage before, and estimates after, project implementation are already required to be reported in CARB GHG quantification methodologies by each qualifying Program. As such, project applicants may simply re-apply these energy/fuel usage data and apply cost co-efficients to calculate the energy and fuel cost co-benefit.

Projects with **direct energy use impacts** (HSR, TIRCP, LCTOP, AMMP, Wetlands and Watershed Restoration, and Waste Diversion Program) are already required to use GHG quantification calculators to estimate annual electricity consumed (MWH/yr) or fuel consumed (gallons or MMBtu/yr) before and after the CCI project.

Residential **energy efficiency** projects within the LWP, SWEEP, Water-Energy Grant, and Woodsmoke Reduction Program are already required to use GHG quantification calculators to estimate the projected number of dwellings/buildings anticipated to receive energy efficiency measures and the average annual energy use reductions achieved per dwelling (MWH/yr, gallons or MMBtu/yr). Transportation energy efficiency projects within the TIRCP, LCTOP, and LCT programs are already required to provide estimates of the annual VMT for each low-emission vehicle type funded by its projects as part of its GHG quantification guidance.

Renewable fuel/energy generation or conversion projects within the TIRCP, LCTOP transportation programs are already required to provide estimates of displaced fuel Inputs (fuel type, annual units of fuel, annual VMT, etc.). Fuel conversion projects within the LIWP, DDRDP, and SWEEP programs are already required to report on the number of systems projected for installation, the energy generation capacity of each system, and the projected energy use before and after the project.

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