Air Resources Board

Mary D. Nichols, Chairman
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Sacramento, California 95812 • www.arb.ca.gov

Matthew Rodriquez
Secretary for
Environmental Protection

Edmund G. Brown Jr.
Governor

December 23, 2014

Dear Researchers:

The California Air Resources Board (ARB or Board) is soliciting draft research proposals from California public universities and colleges to implement the development of the Fiscal Year 2015-16 Annual Research Plan. The enclosed solicitation provides details on projects for which we are soliciting proposals.

If you are interested in submitting a draft proposal to address any of the research topics described in this solicitation, please send an email to Annalisa Schilla (aschilla@arb.ca.gov) indicating your intent to submit by **January 30, 2015**. Draft proposals will then be due no later than **February 27, 2015**. Eligible applicants should submit their draft proposal through our proposal solicitation website at: http://researchplanning.arb.wagn.org/. Guidelines for developing your draft proposal are also included in this solicitation package and available at the solicitation website. Please note that ARB's research budget is approximately $7 million per year and typically supports 10 to 20 projects with two to three year durations. The amount of money allocated for each project is an estimated cost, and the actual cost for submitted proposals may vary. Projects that provide co-funding or other leveraging will be evaluated more favorably.

We expect to select proposals by the end of March for further refinement and review by the Board's Research Screening Committee in May. Final proposals would be needed by early June for a final decision by the Board and our target of executed contracts by September 2015.

Prospective investigators are encouraged to contact Dr. Annalisa Schilla at (916) 322-8514 or aschilla@arb.ca.gov for any clarification on these topics. If you have any questions you may also contact me at (916) 323-4519 or bcroes@arb.ca.gov.

Sincerely,

Bart E. Croes

Bart E. Croes, P.E.
Chief, Research Division

Enclosure

cc: Annalisa Schilla, Research Division

CALIFORNIA AIR RESOURCES BOARD

FISCAL YEAR 2015-16 ANNUAL RESEARCH PLAN

SOLICITATION OF DRAFT RESEARCH PROPOSALS FROM CALIFORNIA PUBLIC UNIVERSITIES AND COLLEGES

Table of Contents

IMPROVED UNDERSTANDING OF THE MAGNITUDE OF TRANS-PACIFIC LONG RANGE TRANSPORTED OZONE ALOFT AT CALIFORNIA'S COAST

I. OBJECTIVE

The objective of this project is to collect upper air ozone data at two sites on the California coast to aid in State Implementation Plan air quality modeling for the State. The project will collect a vertical snapshot of ozone concentrations on a near daily basis, for four months in the late spring and summer. ARB and the scientific community will benefit from a more complete characterization of ozone which acts as the baseline for California's ozone air quality. This knowledge is necessary for the design of effective State Implementation Plans (SIP) to attain the current and future national ambient air quality standards (NAAQS) for ozone.

II. BACKGROUND

Because health effects research has consistently led to more stringent ambient air quality standards for ozone, California must continue to achieve significant new reductions in ozone precursor emissions. The SIP planning process must demonstrate how ground-level ambient ozone will be reduced over time to levels below the health-based standards. At the same time, baseline ozone concentrations have been increasing. Intermittent field studies have documented instances of elevated ozone concentrations aloft (associated with global, regional, and local sources) that could potentially be relevant to ground level exceedances. There have been limited, episodic campaigns of instrumented aircraft flights sponsored by federal, state, and regional groups (e.g., the National Oceanic and Atmospheric Administration [NOAA], the National Aeronautics and Space Administration [NASA], the San Joaquin Valley Air Pollution Control District, the ARB) as well as weekly ozonesonde launches on the north coast of the State (sponsored by NOAA) to investigate ozone events and processes. But these isolated efforts do not provide sufficient information to fully understand the spatial and temporal variations in baseline ozone concentrations entering California. Modeling exercises focused on the contributions of long-range transport and the stratosphere to ozone in the western United States (including California) have been conducted. However, these photochemical models rely on atmospheric boundary conditions specified by coarse resolution global models that have not performed well historically in California due to its complex terrain and meteorology. To better understand the contributions of the external pollution sources and atmospheric processes to high surface ozone concentrations in the State, a routine monitoring program is needed to document incoming layers of ozone aloft from the Pacific Ocean. The data and information collected in this project will help to validate and improve the atmospheric boundary conditions used in the ozone SIP modeling. This research project is a necessary first step toward understanding the difficult policy relevant question of what is the contribution of Pacific long-range transported ozone to surface sites in the state. Additional surface and upper air ozone measurements in specific locations of interest will be needed to estimate the contribution of long-range transported ozone aloft to surface ozone at a surface site.

III. SCOPE OF WORK

To better quantify the magnitude, and the spatial and temporal variations in baseline ozone concentrations entering California, particularly on high ozone days in the San Joaquin Valley, ozonesondes would be launched six times a week during the late spring and summer from two coastal sites. Potential tasks include:

- Review and synthesize the available data and modeling results to identify any critical gaps that can be filled with an ozonesonde deployment.
- Launch ozonesondes from two coastal sites once a day to collect the vertical profiles of ozone concentrations. The data will be processed and fully screened and validated for quality assurance (QA) and quality control. Draft data will be submitted to ARB on a monthly basis. The full QAed data base will be submitted to ARB at the end of the deployment.
- Prepare and submit a final report to ARB for approval.

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE

It is anticipated this project will be completed in 36 months from the start date. This schedule allows 30 months for the completion of all work through delivery of a draft final report; the last 6 months are for ARB review of the draft final report and the delivery of a revised final report and data files to ARB. The estimated budget for this project is $400,000.

MAXIMIZING THE AIR QUALITY, CLIMATE, AND SOCIAL EQUITY BENEFITS OF LIGHT-DUTY VEHICLE INCENTIVE PROGRAMS

I. OBJECTIVE

In order to meet air quality and climate change goals in California, a transformation of the light-duty vehicle fleet will be necessary. Incentives play an important role by accelerating the retirement and replacement of older, high-polluting vehicles and to increase adoption of advanced clean vehicles. The Air Resources Board (ARB) has been providing incentives to California consumers to encourage the retirement of high-polluting vehicles and to support the purchase of new near-zero and zero-emission vehicles, through the Enhanced Fleet Modernization Program (EFMP) and the Clean Vehicle Rebate Project (CVRP), respectively. As the market for light-duty vehicles evolves, incentives need to adapt to changing market conditions. In addition, incentives are also critical in influencing the use of cleaner vehicles in underserved and impacted areas where air quality benefits are needed the most. This research will involve study of two areas: *Vehicle Retirement and Replacement Incentives for Low-Income households* and *Advanced Clean Vehicle Incentives.* The objective of the *Vehicle Retirement and Replacement Incentives* component is to understand the demographics and vehicle retirement and replacement motivations and patterns of eligible participants of EFMP and to help ARB meet the requirements of Senate Bill (SB) 459 and SB 1275. The objective of the *Advanced Clean Vehicle Incentives* component is to investigate factors that impact clean vehicle adoption, assess effectiveness of different financial incentive program structures, evaluate efficient incentive funding levels, determine how incentive funding levels should change as production volumes increase and vehicle technologies improve, and describe the conditions under which the market is self-sustaining and incentive funding is no longer necessary. The results of the research will be used to evaluate the light-duty vehicle market and inform ARB decision makers about the potential options for modifying ARB's incentive programs to ensure they make the best use of limited State resources, as well as provide benefits to underserved populations and disadvantaged communities.

IV. BACKGROUND

Enhanced Fleet Modernization Program

EFMP is a vehicle retirement and replacement program established by Assembly Bill (AB) 118 (Nunez, Chapter 750, Statutes of 2007). EFMP is funded by a $1 surcharge on motor vehicle registration, translating into about $30 million each fiscal year. The purpose of the program is to retire functional, high-polluting passenger vehicles and light-duty and medium-duty trucks by voluntary means. Statute directs that the program should be focused on the areas with the greatest air quality impact and considers cost-effectiveness and impacts on disadvantaged and

lower-income populations[1]. ARB has adopted guidelines to administer two separate elements of the program:

- *Retirement-only element:* Low-income motorists are offered $1,500 to permanently retire their vehicle.
- *Retire and Replace element:* Provides a higher incentive amount for low- and moderate-income motorists to retire and replace their older, high-emitting vehicle with a cleaner replacement.

Although the retirement-only element of the EFMP is very popular, ARB encountered evidence during an EFMP[2] program study conducted in 2013 that suggests consumers participating in vehicle retirement-only element intended to scrap their vehicles even without the EFMP incentive. In contrast to the retirement-only element of the program, the retirement and replacement element saw very limited participation. Additional incentives for replacing older, inherently higher-emitting vehicles with near-zero and zero-emission replacement vehicles can provide additional air quality benefits, reduce fuel costs, and help to transition consumers into advanced technology vehicles. Initial program revisions adopted in June 2014 addressed the concerns highlighted in the 2013 program study, as well as the mandates required by SB 459, however, additional research is needed to inform potential future modifications to the structure and amount of incentives to ensure that they make the best use of limited State funds while remaining effective in supporting air quality improvement through the retirement of functional, high-emitting vehicles. Additional information on EFMP, including program requirements, can be found here: http://www.arb.ca.gov/msprog/aqip/efmp/efmp.htm.

Clean Vehicle Rebate Program

Zero-emission vehicles (ZEVs), including plug-in electric (PEV) and fuel cell vehicles are expected to play a major role in achieving California's long-term air quality and climate goals. Nearly all new light-duty vehicle sales by the 2040 model year need to be ZEVs or plug-in hybrid electric vehicles (PHEVs) in order to achieve California's long term 2050 GHG reduction goals in the light-duty vehicle sector. Additionally, Governor Brown issued Executive Order B-16-2012 in March 2012 that directs for the deployment of 1.5 million ZEVs on California's roadways by 2025. Amendments to the ZEV Regulation in 2012 strengthened requirements and requires manufacturers to produce increasing numbers of ZEVs and PHEVs. Incentive funding, in combination with other monetary and non-monetary incentives, supports early consumer acceptance and adoption of clean vehicle technology to help California meet its clean vehicle goals.

CVRP, also established under Assembly Bill (AB) 118 as part of the Air Quality Improvement Program, offers vehicle rebates on a first-come, first-served basis for new light-duty ZEVs, PHEVs, zero-emission motorcycles, and neighborhood electric vehicles. As the market for advanced clean vehicles grow and technologies improve, the structure and incentive amounts

[1] Low-income is defined as 225 percent of the federal poverty level, consistent with Bureau of Automotive Repair (BAR) Consumer Assistance Program (CAP) income eligibility requirement.
[2] http://www.arb.ca.gov/msprog/aqip/EFMP_Update_Staff_Report_November_2013.pdf

will need to be re-evaluated in order to ensure that they make the best use of limited State funds while remaining effective in supporting clean vehicle purchases.

ARB is funding several research projects to analyze the market for ZEVs, and the role that financial incentives, charging infrastructure, and other benefits (e.g., high-occupancy vehicle lane access, free parking or charging for ZEVs) play in driving the market. Additional research is needed to understand how financial incentives motivate purchase decisions based on various market factors and how financial incentives types and/or amounts may need to be potentially adjusted as the market for clean vehicles grows and technologies are improved. Additional information on CVRP can be found at: https://energycenter.org/clean-vehicle-rebate-project and http://www.arb.ca.gov/msprog/aqip/cvrp.htm.

V. SCOPE OF WORK

This research will investigate variables that affect the adoption of advanced clean vehicles and the retirement and replacement of high-emitting vehicles with an emphasis on lower-income communities. The results will inform potential incentive structure adjustments and refinements to increase the efficacy and cost-effectiveness of light-duty incentive programs in delivering air quality and climate benefits in light of changing vehicle markets and limited resources. ARB anticipates that multiple proposals will be considered for this scope of work. The scope of the desired research consists of two areas, *Vehicle Retirement and Replacement Incentives for Low-Income Households* and *Advanced Clean Vehicle Incentives*, and it is recommended that proposals focus on a single area. However, proposals that address subcomponents of both research areas are also desired. As part of the scope of work listed below, desired research in each area is included and proposals with alternative methodologies will be considered, provided that the research objectives are met.

Vehicle Retirement and Replacement Incentives for Low-Income Households

To assist ARB with meeting the requirements of SB 459 and SB 1275, research focused on *Vehicle Retirement and Replacement Incentives for Low-Income Households* will provide insight into the appropriate incentive amounts to promote retirement of functional, high-emitting vehicles, the most cost-effective methods to increase program participation, and methods to increase adoption of advanced clean vehicles, particularly in lower-income households and disadvantaged communities. Upon selection, the work plan will be finalized in consultation with ARB staff. Work plans are encouraged to include the elements below but applicants may propose alternative methodologies.

- Develop and conduct survey of potential EFMP participants and potential, eligible participants that will provide information on the following:
    - Demographics of potential EFMP participants
    - Awareness of the program
    - Vehicle retirement and replacement motivations of the targeted population
    - Effective outreach and marketing strategies in disadvantaged communities

    - Acceptance of alternative forms of incentives, such as access to car share and transit programs, in lieu of vehicle replacement to increase mobility options for participants
    - Evaluate participation barriers associated with vehicle replacement plus retirement
        - For conventional and advanced clean vehicle replacements
        - Infrastructure required for plug-in zero emission vehicles
- Conduct interviews with lower-income consumers, both program participants and potential, eligible participants, to gain a detailed understanding of the motivations and barriers which affect vehicle retirement and replacement patterns
    - Qualitative insight into purchase motivations and barriers
    - Evaluating effective streams of information most relevant to lower-income consumers that will help increase participation
- Based on the findings from the above, perform analysis and provide insight for ARB decision makers on the following:
    - The appropriate incentive amount relative to the value of the vehicle to promote functional, high-emitting vehicles for early retirement and replacement
    - Investigate effective pathways for near-ZEV and ZEV adoption by lower-income consumers
    - Determine the most effective form of incentives to motivate high-emitting vehicle retirement and replacement by lower-income motorists
    - Quantify social benefits of the program such as return on investments on each retired and/or replaced high-emitting vehicle, increased quality of life (increased mobility capabilities, and health benefits), and supplementary community economic benefits

Advanced Clean Vehicle Incentives

As clean vehicle technology advances and the market for them matures and grows, modifications to financial incentive amounts and structure need to be evaluated to ensure incentives remain effective with limited resources. This research area will provide insight into factors that affect clean vehicle adoption, effectiveness of various incentive structures to increase market penetration, and provide insight to the market conditions that point to when a self-sustaining market may be achieved and incentives are no longer necessary. Research proposals must provide a detailed work plan with elements included to address the following:

- Evaluation of new advanced clean vehicle purchase patterns and the role that various forms of financial incentives and market conditions play in determining those patterns
    - Evaluation of the efficacy of various financial incentive structures and funding amounts while taking into account advancements in clean vehicle technologies and market conditions
        - Financial incentive types considered for this project will be determined in consultation with ARB staff, but will likely include rebates, tax credits, feebates, registration fee reductions, point of sale incentives, sales tax exemptions, and/or a combination of incentives

- Evaluate how incentives interact and can be adjusted with potential ZEV technology advancements and economic indicators to drive vehicle purchase decisions and increase vehicle uptake
    - ZEV advancements should include but not necessarily be limited to lower technology costs, improved vehicle performance, and new vehicle model offerings
    - Economic indicators may include but not necessarily be limited to gas prices, average household income, new car sales, and unemployment rate
- Provide insight into barriers to adoption of ZEVs for various consumer demographics, including consumers in disadvantaged communities
    - Evaluations must include the role that incentives of various forms and amounts could play in mitigating barriers
- Provide insight into indicators of a self-sustaining clean vehicle market without incentives
    - Evaluations must be based on different scenarios including elements such as, but not limited to, cumulative advanced clean vehicle sales, economic factors, and vehicle advancements
    - Assessments must also include ZEV adoption scenarios that meet the goals of the ZEV regulation, Executive Order B-16-2012, and California Governor's ZEV Action Plan, and SB 1275

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE AND BUDGET

It is anticipated that this project will be completed in 30 months from the start date. This allows 24 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $500,000.

TRACKING LAND USE CHANGES THAT SUPPORT SUSTAINABLE COMMUNITIES

I. OBJECTIVE

The objective of this research project is to support the evaluation of progress toward the goals of Senate Bill (SB) 375. The project will develop a methodology, collect data, and construct baseline measures for use in the future to assess land use change in California through time. The results of this project will be useful to ARB as it develops a program to track and monitor progress on SB 375.

II. BACKGROUND

The Sustainable Communities and Climate Protection Act of 2008 (SB 375) requires Metropolitan Planning Organizations (MPOs) to do more integrated land use, transportation, and housing planning. The program, now in its sixth year of implementation, has resulted in the development of Sustainable Communities Strategies (SCS), which show that, if implemented, the major regions of California can reduce transportation-related GHG emissions compared to 2005 levels. By February 2015, all MPOs will have adopted their first SCS and several are already undergoing their second round of SCS planning as part of their Regional Transportation Planning effort.

In the Update to the Scoping Plan, one of the recommended actions to achieve the State's post-2020 climate goals is to "ensure GHG emission reductions from approved SCSs are achieved or exceeded through coordinated planning." In addition to vehicle miles traveled (VMT) and fuel usage data, tracking the effectiveness of land use policies is an important element to verify the progress toward the goals outlined in SB 375. In particular, there is a need to understand the extent to which shifts in regional and local planning are resulting in actual changes in land use across the State through time.

Although several years have passed since the inception of SB 375, land use changes take time and detectable changes in land use from business as usual may not be apparent for several more years. This is particularly true when factoring in likely impacts of the recent recession. However, this project will develop a framework and baseline to enable future tracking and evaluation of how land use changes over time. Given that many factors influence land use change, this proposal does not intend to provide causational attribution to a single State policy or program. As such, additional methodologies may be employed to help assess if SB 375 has contributed to any shifting of land use development patterns in California, to the extent possible.

III. SCOPE OF WORK

- Assess and select land use change indicators. As part of this project, the research team will select key indicators to serve as proxies for land use change. The indicators must rely on recognized and consistent data that is readily available and anticipated to be so in the future. The research team must survey land use monitoring efforts being

conducted by Metropolitan Planning Organizations and to the extent possible, align or leverage this existing work into developing a statewide indicator/set of indicators. Potential indictors include, but are not limited to: average residential and employment densities; new housing start mix (e.g. percent new dwellings that are multi-family vs. small lot attached vs. large lot detached); land use mix; changes in housing affordability relative to local wages; percent of infill vs. greenfield development; etc.

- Potential data sources include, but are not limited to: parcel level data, U.S. Census data, building permit data, satellite and aerial imagery.
- Define and develop an appropriate baseline to allow for future comparison. Map baseline indicator data using Geographical Information Systems (GIS). The appropriate geographical unit of analysis will be determined in coordination with ARB.
- In addition to quantitatively assessing land use change, to the extent possible, this project will develop qualitative methods to explore the extent to which regional and local planning efforts are resulting in changes in actual land development. This may require, among other things, examination of General Plan Updates, zoning ordinance updates, specific plans, land use or habitat conservation plans.

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE AND BUDGET

It is anticipated this project will be completed in 18 months from the start date. This allows 12 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $150,000.

EVALUATION OF IMPACT OF TRANSIT-ORIENTED AFFORDABLE HOUSING ON TRAVEL DEMAND

I. OBJECTIVE

Affordable housing in transit-oriented developments has been recognized as a potential travel demand reduction strategy. However, to date very limited empirical, peer-reviewed research has evaluated the impact of preserving or building affordable housing on travel behavior and associated greenhouse gas (GHG) emissions. The objectives of the research project are to evaluate the impact that preserving and building affordable housing in transit-oriented areas has on travel demand and vehicle miles traveled (VMT), and to assess the economic, health, and well-being impacts on the associated residents.

II. BACKGROUND

The preservation and development of affordable housing opportunities near public transit is a land use planning strategy that is thought to increase viability of the public transit system, and provide mobility options to populations with the greatest need. Affordable housing is also thought to reduce vehicle travel demand. The California State Budget allocated $130 million of the 2014/2015 proceeds from Cap and Trade to support an Affordable Housing and Sustainable Communities Program, part of which will fund affordable housing projects near transit stations in order to reduce GHG emissions.

While there is a general understanding that income and socioeconomic characteristics influence vehicle ownership and VMT, there has been limited research to confirm whether increasing affordable housing in transit-oriented areas actually reduces VMT. A few attempts to understand the impacts of affordable housing on VMT have relied on cross-sectional analysis of household travel survey data and smog check odometer readings from the Department of Motor Vehicles. Additionally, a Caltrans-funded project that aims to develop a trip generation methodology for multifamily housing proposes to survey travel behavior of subsidized housing dwellers; however, this project is not designed to assess the effectiveness of affordable housing as a VMT reduction strategy (i.e. does not use a control/counterfactual) nor will it assess the potential for co-benefits of affordable housing. A novel research effort is needed that 1) provides an empirical, quantitative analysis of the impact of preserving and building affordable housing on VMT in California; 2) utilizes a methodology that contains an appropriate business-as-usual counterfactual or control with which to compare the impacts of affordable housing; 3) employs qualitative research methods to assess the health, economic, and well-being impacts of affordable housing.

The results of this research will provide data and information to metropolitan planning organizations, county and local city planning departments, housing agencies, and local climate action planning efforts on the efficacy of transit-oriented affordable housing as a VMT and GHG reduction strategy. In addition, the results can aid in the evaluation of affordable housing projects funded by the Cap and Trade auction proceeds, and inform future Cap and Trade proceeds investment plans.

III. Scope of Work

This research project will build upon the existing body of work done in this area to develop and employ data collection and analysis methodologies to quantify the VMT impact of preserving and building affordable housing in transit-oriented areas. It will also qualitatively assess the potential additional impacts of affordable housing on the health, economic situation, and general well-being of affordable housing residents. This project will:

- Complete a review of the relevant literature and current research efforts;
- Develop and implement a methodology to quantify the VMT and travel impacts of affordable housing, including:
    - Develop an appropriate operational definition of affordable housing in collaboration with ARB, the Department of Housing and Community Development, Caltrans, and other appropriate state agency stakeholders;
    - Identification of appropriate actual housing dwellings for the study in consultation with ARB and other State and regional stakeholders;
    - Collection of travel behavior data from residents of transit-oriented affordable housing units and other dwelling types as required, or use of pre-existing survey data if appropriate;
    - Methodological consideration of an appropriate counterfactual in consultation with ARB. This could be addressed using before/after experimental/control research design, case-control design, or some other method;
    - Evaluation of travel behavior effects among different income-level categories (e.g. very-low income; low income; moderate income).
- Develop and implement a qualitative methodology to assess the impacts of affordable housing on residents' health, economic situation, and overall well-being.
- If appropriate and feasible, partner with regional, local government stakeholders, housing developers, and/or community organizations to assist with project design, data collection, and utilization of results.

IV. Deliverables

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. Timeline and Budget

It is anticipated this project will be completed in 30 months from the start date. This allows 24 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and

delivery of a revised final report and data files to the ARB. The estimated budget for this project is $300,000.

ZERO CARBON BUILDING TECHNICAL FEASIBILITY STUDY

I. OBJECTIVE

The objective of this project is to provide technical support for the pursuit of low-carbon building in California as part of the state's long-term climate program. Zero carbon buildings were identified in the First Update to the Scoping Plan as the next generation of buildings that can significantly contribute to achieving California's post-2020 climate goals. This research will explore the technical feasibility of net zero or near-zero carbon residential and commercial new buildings which will support the development of state goals and a policy and programmatic path towards transitioning to zero carbon building.

II. BACKGROUND

In 2006, California passed Assembly Bill 32—landmark legislation requiring the state to reduce our greenhouse gas emissions to 1990 levels by 2020. While we are on track to achieving this target, much more must be done long-term to ratchet down emissions to a level needed for climate stabilization. The First Update to the Scoping Plan identifies future actions and policies that can help California achieve our post-2020 climate goals, including advancing zero net energy (ZNE) buildings to be zero net carbon buildings (ZCB). The Scoping Plan Update specifically calls for ARB and stakeholder agencies to "establish target dates and pathways toward transitioning to zero net carbon buildings that expand upon and complement ZNE goals" by 2017. Currently, the state's ZNE goals established by both the California Public Utility Commission and the California Energy Commission are to have all new low-rise residential buildings be ZNE by 2020 and all new commercial buildings to be ZNE by 2030. In addition, the Governor has made a commitment that all new state buildings beginning design in 2025 shall be ZNE.

To build upon these targets, ARB and state agency stakeholders must chart a path for expanding these goals to focus on greenhouse gas emissions, and as a result, consider water, waste, and transportation impacts of a building. A zero or near-zero carbon building would generate nearly no net greenhouse gas emissions over the course of a year from the energy, water, waste and transportation impacts of the building. Essentially, a near-zero carbon building will be a zero net energy building, but will also employ additional strategies to substantially reduce greenhouse gas emissions associated with water, waste, and transportation impacts as well. Zero carbon buildings can utilize high performance design solutions, generate renewable energy on-site, and employ other techniques to eliminate or offset the GHG emissions associated with these impacts. One option for a path forward would be to adopt a carbon budget approach, whereby greenhouse gas emission performance targets are set taking into account building climate zone and other factors and are ratcheted down over time until they reach zero. Ensuring the carbon budget is met for each sector will likely require both demand-side and supply-side strategies. The initial scope of a zero carbon building program can focus on emissions from building operations, and to a limited extent, building construction. As we become more advanced in our understanding of embodied

energy, the definition of zero carbon can be progressed towards one that takes a lifecycle perspective.

III. Scope of Work

This study will provide the technical foundation needed to chart a path for a zero carbon building program and to set aggressive, yet achievable statewide zero carbon building goals. The research will focus on strategies to reduce the carbon associated with building-level water, waste, and transportation impacts, but will consider energy to the extent renewables could be used to offset GHG emissions associated with water, waste, or transportation impacts. Research is needed to evaluate the technical feasibility of achieving zero or near-zero carbon buildings for new residential and commercial buildings *before* the state adopts a ZCB definition and associated metrics. This research will include:

- Assessment of high-performance design solutions, technologies, and building operation strategies most likely to enable zero/near-zero GHG emissions across the water, waste, and transportation impact sectors of a building. This will include 1) the identification of leading-edge GHG reduction strategies and 2) building performance simulations for a set of standard building types utilizing the strategies to determine feasibility of achieving zero/near-zero emissions with known technologies and solutions for both residential and commercial buildings in different regions of the state.
- Evaluation of the extent to which zero-carbon buildings would perform better than those built to meet the latest California Green Building Standards, including both the mandatory and voluntary standards. This comparison can provide a benchmark for progress needed above and beyond current building standards to achieve zero carbon building.
- Discussion of opportunities and challenges in achieving near-zero carbon status on *existing* residential and commercial buildings. As part of this, the identification and prioritization of building types for which retrofitting to zero carbon status is most feasible can inform program strategy.
- Evaluation of feasibility of achieving a range of long-term zero carbon targets for new building. Currently the state has ZNE targets measured in percent of new residential and commercial buildings by a future year that are ZNE buildings.[1] An evaluation to identify feasible ranges of similar targets for zero carbon building can inform future target setting.
- Estimation of construction cost premium and payback period associated with near-zero carbon building, to the extent possible.
- Estimation of potential GHG benefits of zero carbon versus zero net energy buildings, and cost-effectiveness in $/MT CO_2 reduced.
- Assessment of appropriate policy framework needed to support zero carbon building and possible program design and structure, including mandatory versus voluntary pathways. Given the cross-sector nature of zero carbon building, existing and new mechanisms may be needed to successfully transition California's building stock.

[1] California Public Utilities Commission. 2011. California Long Term Energy Efficiency Strategic Plan. http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

The results of this study will be used to assess the practicality and appropriate timeframe for a zero or near-zero carbon building state policy or program. It will also be used to inform any program development and quantification protocols.

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE AND BUDGET

It is anticipated this project will be completed in 18 months from the start date. This allows 12 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $400,000.

CHARACTERIZE ADDITIONAL AND UNCERTAIN N_2O EMISSION SOURCES

I. OBJECTIVE

Nitrous oxide (N_2O) is the third most important greenhouse gas in California in terms of its contribution to the total global warming impact. It is important to accurately quantify N_2O emissions due to the large global warming potential and long lifetime of this pollutant. The bulk of N_2O emissions in California are produced through biogenic processes with large uncertainties due to variability of environmental conditions and the dispersed nature of emission sources. The objectives of this project are to 1) verify the current California Greenhouse Gas (GHG) inventory including identifying sources not yet accounted for; 2) improve the inventory accuracy through field measurements to provide updated activity and emission factors; and 3) identify potential mitigation measures to reduce N_2O emissions. The proposed study will provide a better understanding of N_2O emission sources in California, improve California's N_2O inventory, and assist California to reach its AB 32 goal to curb GHG emissions.

II. BACKGROUND

Nitrous oxide is a potent GHG with a global warming potential of 298, compared to CO_2. N_2O can be emitted from many sources containing nitrogen (N). Both top-down and bottom-up methodologies have been used to estimate N_2O emissions. Individually, each approach has significant strengths and weaknesses, but used in concert can help verify the accuracy of emissions estimates. The current California N_2O inventory was developed using "bottom-up" approach based on statewide activities data and default emission factors (EFs) that were derived from state, national or international emission data. However, there are potentially unaccounted and uncertain N_2O sources from the California inventory due to lack of accurate EFs or activities data. Since 2009, ARB has funded several studies assessing N_2O emissions from nitrogen fertilizer use in agricultural land, a leading source of N_2O in the state, to reduce the uncertainty of the N_2O inventory. Investigation on other important sources such as mobile is also underway. This project will target additional potential sources of N_2O that have high uncertainty or have no methods of estimation. These sources may include landfills, wastewater treatment and discharge, ocean upwelling, plant nurseries, golf courses, water bodies subject to fertilizer runoff, etc.

In California, about 32 percent of the estimated 35 million tons of waste disposed in the landfills annually is compostable organic materials containing significant amount of N. Although N_2O emissions are expected from these landfills, N_2O monitoring data in California landfills are scarce. The current California inventory calculates N_2O emissions only from burned landfill gas as a ratio to methane (CH_4) emissions. Fugitive emissions of N_2O are not included. Several field studies indicate that N_2O emissions vary greatly among different landfills (Rinne et al., 2005; Zhang et al., 2009; Bogner et al., 2011; Zhang et al., 2013; Harborth et al., 2013). Many characteristics of landfills, such as properties of landfill cover, waste type, composition, and age, and in-situ environmental conditions can all affect the formation of fugitive N_2O as well as the emission ratio of N_2O to CH_4. Preliminary studies taken by ARB staff have

detected spikes of N_2O from landfills that contain disposed green wastes. Strong N_2O hot spots of up to 24 ppmv (75 times that of background N_2O) from freshly landfilled wastes were also reported by Harborth et al. (2013).

Another uncertain N_2O source in California is the wastewater treatment system. The wastewater streams generated from homes and industrial and commercial facilities are rich in N, and therefore can produce significant N_2O during their transport, treatment and final disposal stages, in forms of both the treated effluent and sewage sludge (Czepiel et al., 1995; Kampschreur et al., 2009; Foley et al., 2010; Ahn et al., 2010; Law et al., 2012). The emission estimates of N_2O from California's wastewater treatment systems are based on U.S. Environmental Protection Agency (U.S. EPA)'s default EFs, accounting for emissions in both wastewater treatment plants and effluent discharge into surface water. The emissions from sewage sludge, or biosolids, produced from the wastewater treatment process are reported in composting and landfills sectors of the inventory. Besides the great uncertainties in the EFs which would vary with wastewater sources, composition, and treatment and control technology, N_2O emissions from sewage sludge is a potential source given its expected high residual N content. Another study suggests that N_2O emissions from the land applied sewage sludge account for more than 80 percent of GHG emissions associated with the wastewater treatment processes (Johansson et al., 2008).

Urban landscapes such as golf courses across the state, where high fertilizer use and irrigation depth are especially conducive to N_2O production, may be an additional source of N_2O emissions. Studies by Townsend-Small et al. (2011) in southern California indicate that urban landscapes such as lawns in parks and residential turfs can contribute a significant portion of the total N_2O emissions at regional scales. Development of emission factors from field measurements of N_2O emissions from urban landscape and better data on urban fertilizer use can help to improve the California N_2O inventory.

In order to characterize the full spectrum of N_2O emissions from the above sources, it is necessary to conduct field measurements to capture the spatial and temporal variability of the emission fluxes. N_2O emissions from the listed sources are known to occur from nitrification and denitrification processes, which are carried out by microbial activities and are highly sensitive to environmental factors, leading to extremely variable N_2O fluxes in response to site-specific conditions. Limited field studies and ARB's in-house research efforts have proven these additional N_2O sources, but data are not sufficient to allow for the development of emission estimates or emission factors. The proposed study is intended to provide that data so that such estimates can be obtained or improved.

III. SCOPE OF WORK

Due to limited resources, it is suggested that the project focus on landfills, wastewater treatment systems, and urban landscapes, especially golf courses, as the priorities in this research. The contractor may propose and investigate other potential sources if deemed significant. The project should include, at a minimum, the following tasks, which may be accomplished through collaboration with other State agencies such as Department of

Resources Recycling and Recovery (CalRecycle), State Water Resources Control Board (SWRCB), and California Department of Food and Agriculture (CDFA):

- Identify monitoring sites of landfills, wastewater treatment systems, and urban landscapes in California. The selection of the monitoring sites should consider both representativeness and expected emission fluxes. For landfills, the selection should focus on non-hazardous sites that receive compostable organic wastes, especially those that use green waste or biosolids as alternative daily cover. For wastewater treatment systems, factors to be considered should include the type of wastes received (residential, commercial and/or industrial), wastewater treatment technologies (primary and secondary treatment processes), sewage sludge drying methods, and the final disposal or use of the resulting sewage sludge. For golf courses, selection must consider management practices as well as locations to encompass both southern and northern California.
- Develop and implement monitoring plans that would capture the spatial and temporal emission patterns of N_2O from the selected sources and allow for the derivation of emission estimates. Dynamic flux chambers, wind tunnels, or open-path Fourier transform infrared (OP-FTIR) with back trajectory modeling are the preferred monitoring methods. Measurements of other gases that are of environmental significance, such as NH_3, NO_x, CH_4, VOCs, etc., should also be included if possible. Collection of associated ancillary data, such as total Kjeldahl-N and N speciation, total organic and dissolved organic carbon (DOC), total solids, pH, biochemical oxygen demand (BOD), dissolved oxygen (DO), etc. and environmental variables should be conducted, where applicable, to facilitate data interpretation. For urban landscape emissions, urban fertilizer sale and use data in California should also be collected to apportion its contribution to the total emissions.
- Conduct surveys of landfill and wastewater treatment practices and urban landscape (especially golf course) management in California to develop statewide management database or statistics so that results of this project can be scaled up to estimate statewide emissions and incorporated into future California N_2O inventory.
- Develop technical recommendations on potential mitigation measures in landfill and wastewater treatment practices and urban landscaping management that will reduce N_2O emissions from these sources.

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE AND BUDGET

It is anticipated this project will be completed in 36 months from the start date. This allows 30 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $400,000 **.**

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CHARACTERIZE PHYSICAL AND CHEMICAL PROPERTIES OF MANURE AND RELATED EMISSIONS IN CALIFORNIA DAIRY SYSTEMS TO IMPROVE GHG EMISSION ESTIMATES

I. OBJECTIVE

This study seeks to better understand the characteristics, handling, and emissions of manure generated by California dairy systems using a combination of modeling, field sampling, and emissions measurements. Currently there is a lack of data describing California's dairy manure quantity, composition, and management, which all can significantly affect emissions. Improved measurements and modeling will result in more accurate emissions analysis that can better inform policy processes.

II. BACKGROUND

Manure contains significant amounts of carbon and nitrogen, both of which can result in emissions of greenhouse gases (GHGs) and other pollutants. According to the current California GHG emission inventory, which uses national defaults or global emission factors, manure management contributes roughly 1/3 of statewide N_2O emissions (~4-5 $MMTCO_2e$) and about a quarter of statewide CH_4 emissions (~10 $MMTCO_2e$). Despite its importance, there has been little research on N_2O and CH_4 emissions from manure management, particularly with respect to California systems. Fortunately some of the biochemistry pathways for manure emitting greenhouse gases are reasonably well understood. For example, when manure is stored in liquid form (particularly in large lagoons on dairies), the resultant low-oxygen conditions allow anaerobic, methanogenic bacteria to grow and digest the volatile solid portion of manure carbon compounds, thus emitting methane. As for nitrogen, when manure is land applied, bacterial nitrification-denitrification processes occur and release oxides of nitrogen including N_2O. California livestock is modeled to excrete hundreds of kilotons of nitrogen (N) annually in the form of manure, an amount equivalent to more than half of the annual chemical nitrogen fertilizer sales in the state based on the fertilizer tonnage data. Roughly half of the livestock manure nitrogen is produced from dairy farms (dairy cows and heifers). Further study of the ultimate fate of dairy manure nitrogen and volatile carbon and field measurements to characterize manure in representative dairy farms (including manure collection and storage facilities - bedding, gutters, lagoons, etc.), are needed to better understand manure-related emissions and to refine emission factors associated with various manure management practices.

The results of this project will be used to develop California-specific model inputs to refine GHG and other pollutant emission estimates to improve the emissions accounting of manure management practices in California. It will also help quantify the methane impacts from the current industry trend of increasing animal concentrations per farm.

III. SCOPE OF WORK

- Literature review of dairy manure emissions and management systems found in California.

- Sample manure at multiple representative dairies to follow nutrient flow throughout the various stages of manure management for corral and free stall animal systems. Sampling should include at least one thoroughly mixed lagoon. To the extent possible, emissions measurements for pollutants other than greenhouse gases should be included in the sampling protocol, such as oxides of nitrogen, ammonia, etc.
- Use collected data to develop estimates of CH_4 emissions from all lagoons in California and compare the differences in estimated CH_4 and N_2O emissions between modeling results using the current national and international default parameters and using California-specific data.
- Monitor copper inputs due to potential impact on lagoon bacteria.

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE AND BUDGET

It is anticipated this project will be completed in 42 months from the start date. This allows 36 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $400,000.

CHARACTERIZE CALIFORNIA-SPECIFIC CATTLE FEED RATIONS AND IMPROVE MODELING OF ENTERIC FERMENTATION FOR CALIFORNIA'S GHG INVENTORY

I. OBJECTIVE

The purpose of this study is to improve the modeling methodology for estimating cattle enteric fermentation emissions in the California Greenhouse Gas (GHG) Emission Inventory by collecting and modeling California-specific feed data. The modeled results from this study will be compared to the national default model currently used in the California inventory, as well as other models. This study will inform how the diets of California cattle are different from the rest of the nation, and how it affects methane emissions. An improved emissions estimate for the GHG Emission Inventory based on California-specific data will better reflect on-farm realities and better inform policy decisions for focusing sectoral GHG goals, improve understanding of regional emissions, and inform the development of short-lived climate pollutant reduction strategies.

II. BACKGROUND

California cattle operations, primarily dairies, are a significant source of GHGs. Enteric fermentation (bacterial decomposition of feed in ruminant stomachs) emits GHGs, most notably methane in eructation (burping). Enteric fermentation from cattle contributes nearly 30 percent of the statewide methane emission inventory, currently the largest inventoried source of methane statewide. Ninety five percent of California's enteric methane emissions come from cattle, approximately 3/4 of which are from dairy cows. These estimates rely on mathematical models developed to estimate emissions based on various factors. Because enteric methane emissions are highly influenced by diet, the models need to incorporate the effect of various diets or feed ingredients. Total mixed rations fed to California cows have not been widely surveyed. To improve the accuracy of the inventory and determine the level of uncertainty, California-specific feed data must first be collected and used in the emissions model.

USDA's 2012 Agricultural Census indicates there are at least three adult milking cows for every beef cow in California.With approximately 1.8 million milking head, California has the highest number of milking cows in the nation. Due to the large dairy population in the state, feed and enteric methane emissions from dairy cows should be the focus of this research (with beef cattle feed also examined and modeled, though to a lesser degree).

The methodologies to estimate methane emissions from enteric fermentation developed by the U.S. EPA for the Inventory of U.S. Greenhouse Gas Emissions and Sinks form the basis of California's inventory. Dairy feed formulation has changed in the past decade as a consequence of changes in feed price, including the rising price of corn grain due to the large amount of corn used to produce ethanol. California-specific data are especially important when feed compositions are changing with economic conditions.

A significant amount of enteric fermentation research exists, from methanogenic bacterial studies and modeling to diet and breed effects. This proposal focuses on modeling California-

specific data and scenarios, which does not currently exist. This research does not collect emissions samples from enteric fermentation in part because many animals have already been directly measured in other studies, and the limited budget and scope of this work precludes measurements of a sufficient number of ruminant animals. Obtaining California-specific feed data is key to leveraging existing modeling work and tailoring models to California scenarios.

III. Scope of Work

- Literature review of applicable enteric fermentation research on dairy cattle and beef cattle.
- Collect real world data to estimate California's composition of feed rations and how these various diet formulations impact enteric methane emissions; estimate statewide methane emissions from enteric fermentation.
- Develop a suite of equations similar to those published in Global Change Biology (Moraes et al. 2014) but using data that is most specific to California.
- Compare the methane emission estimates based on new models and the methodologies used by US EPA. Make recommendations of how best to update ARB's current methodology.

IV. Deliverables

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. Timeline and Budget

It is anticipated this project will be completed in 24 months from the start date. This allows 18 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $100,000.

References

Moraes, L. E., A.B. Strathe, J.G. Fadel, D.P. Casper and E. Kebreab. 2014. Prediction of enteric methane emissions from cattle. Global Change Biology, in press.

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USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012 (April 2014): http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html#fullreport

EVALUATION OF A VARIETY OF F-GAS EMISSION REDUCTION STRATEGIES

I. OBJECTIVE

This project identifies the optimal policy or combination of policies needed to achieve targeted 2030 and 2050 reductions of fluorinated gas (F-gas) emissions in California. The optimal design of an F-gas fee program, including distribution of fee revenues, will be specified in light of comparable regulatory experience. Emission reduction strategies other than fees will also be evaluated and compared according to their cost-effectiveness, feasibility, economic efficiency and distributional effects, and interaction with other emission control programs. Project results will inform the design of ARB's medium and long-term F-gas emission control programs.

II. BACKGROUND

High global warming potential (high-GWP) gases contribute to global warming at a level hundreds to thousands of times greater than carbon dioxide. A majority of future high-GWP emissions in California will be comprised of F-gases, which are used primarily in refrigeration, air conditioning, insulation and pesticide applications. Emissions of high-GWP F-gases are four percent of today's statewide GHG inventory, but they are the fastest-growing GHG source in California because F-gases are replacing ozone-depleting substances (ODS substances) in response to Montreal Protocol mandates. ARB Scoping Plan control programs already target high-GWP emissions, but even with these regulations in place, annual F-gas emissions in California are projected to increase by about 40 percent (from 18 to 25 $MMTCO_2e$) between 2012 and 2020, and more than double by 2050, to 43 $MMTCO_2e$.

High-GWP emissions from refrigeration, air conditioning and foam insulation are fugitive emissions due to leakage or inappropriate disposal. Other sources, such as inhalers, aerosol propellants, medical sterilants, industrial solvents, semiconductor manufacturing, and pesticides, are emissive by design. Control programs must address both types of emission sources.

The diversity of F-gas emission sources, a dearth of cost-effective, low-GWP alternatives, and the difficulty of enforcement in end-user sectors all pose challenges to future emission reduction programs.

III. SCOPE OF WORK

To ensure that future F-gas control programs achieve reductions in the most reliable, cost-effective and economically efficient manner, relevant regulatory experience will be reviewed and its lessons applied to a systematic comparative analysis of potential F-gas emission reduction strategies. Study goals will be accomplished in four phases: information collection; fee program analysis; optimal policy analysis and the final report. Interim deliverables will mark the completion of each of the first three phases.

A. Information Collection

Investigators will review and summarize peer-reviewed literature and other information relevant to primary study goals, organized around three broad themes: characterization of the F-gas sector; F-gas technology assessment; and control policy design insights from related regulatory experience.

F-gas sector characterization will cover the properties, sources and uses of F-gases. Market size, segmentation and structure of California's F-gas market will be covered, as will pricing, sales and emissions inventory (historical and projected). Drivers of demand for F-gases will be identified and abatement opportunities through 2050 will be quantified in the form of a marginal abatement cost curve.

F-Gas Technology Assessment will review the most recent information on potential low-GWP replacement technologies for both F-gases and F-gas-using products and systems. Emerging technologies for leak detection and management, as well as recovery/destruction of F-gas "banks" will be included.

Regulatory Policy Design will extract policy design insights from relevant GHG and high-GWP regulatory programs including market-based compliance systems, performance standards, fee, refund-deposit, voluntary and incentive programs. Feasibility, enforceability and potential economic impacts of design features will be considered.

Interim Deliverable: Summary of findings, with abatement cost estimates.

B. F-gas Fee Program Analysis

Investigators will systematically evaluate options for both F-gas fee design and application of fee revenues.

F-gas Fee Design -- Compare potential approaches to an F-gas fee program in California by systematically assessing their advantages, disadvantages and likely environmental and economic impacts. Draw on experience with fee-based and other high-GWP control programs to estimate the price elasticity of demand for F-gases and F-gas-intensive products/services. Specify the parameters of the optimal fee program design, including: point of regulation; fee basis, form and level; implementation mechanism; formula; and means for adjustment. Estimate fee collection revenues and costs.

Uses of F-gas Fee Revenues -- Assuming a California F-gas fee program as designed above, investigators will assess the advantages and disadvantages of various approaches to distributing collected funds, while achieving targeted emission reductions. Potential applications of funds should include: "Fee & Dividend"; emission abatement; mitigation;

incentive; research; demonstration; commercialization; and training programs. Investigators will prioritize potential uses of funds.

Both F-gas fee collection and distribution program options should be evaluated by multiple criteria, including:

- Estimated emission reductions and co-benefits;
- Cost, cost-effectiveness;
- Feasibility;
- Economic impacts and their distribution;
- Enforceability and the potential for leakage;
- Interaction with other (state, federal, international) regulatory programs.

Interim Deliverable: F-gas Fee Program Analysis findings and recommendations.

C. F-Gas Emission Reduction Optimal Policy Analysis

Evaluate an inclusive menu of policy options, including sector-specific prohibitions, cap & trade variants, performance standards, deposit-refund schemes, targeted abatement and mitigation programs, as well as the fee program options specified in Part B, above. Applying transparent criteria and assumptions, investigators will systematically compare F-gas emission reduction policy options to identify the policy or combination of policies that offers the optimal approach to achieving targeted 2030 and 2050 F-gas emission reductions. ARB staff will be consulted regarding legal authority or constraints. The optimal regulatory design and two “next-best” alternative control programs will be identified. Policy options will be clearly defined and evaluated using multiple criteria, including, but not limited to:

- Net environmental impacts;
- Reliability and verifiability of reductions;
- Co-benefits, including health impacts;
- Cost and cost-effectiveness;
- Administrative and technological feasibility;
- Economic impacts and their distribution;
- Enforceability and the potential for emissions/economic leakage;
- Interaction with other regulatory programs and jurisdictions.

Interim Deliverable: F-gas Policy Scenario Analysis Findings

D. Final Report & Recommendations

The final report will integrate and summarize the findings and interim deliverables of the first three study activities. It will include a detailed presentation of the short-listed regulatory program designs and estimated impacts. A summary matrix will be included.

IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

V. TIMELINE AND BUDGET

It is anticipated this project will be completed in 24 months from the start date. This allows 18 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $300,000.

Guidelines for Preparing and Submitting Draft Proposals

PROPOSAL PREPARATION GUIDELINES

The technical proposal portion of the draft proposal should be clear and concise, no more than approximately 25 pages in length. To conserve paper, please use single or one-and-a-half spacing. The technical proposal should be paginated as a stand alone document using the "Page xx of xx" format in the top right corner.

The technical proposal must include the following parts:

- Title page. The purpose of this page is to provide in one location information needed by our administrative staff. It must contain all of the following items (see Example A):
  - the title of the draft proposal
  - the name of the principal investigator
  - a statement that the draft proposal was prepared for ARB's Research Division
  - the name and address of the university
  - the date of the draft proposal
  - check box if proposed research uses human or animal subjects
- Table of contents.
- Abstract. A one-page abstract of the proposed research briefly summarizing the main points of the various sections of the draft proposal.
- Introduction. Several paragraphs should be dedicated to explaining the relevance of this project. This section should include a brief description of research that has been conducted or is currently underway by the applicant and others in areas related to the draft proposal.
- Objectives. Describe the objectives of this project and how the results will be beneficial to ARB.
- Technical plan. This shall include at least the following topics:
  - A description of experimental techniques or research methods to be employed, including requirements for test specimens, laboratory animals, or human subjects.
  - A discussion of the major tasks to be conducted and how those tasks will be performed. Provide sufficient detail to allow technical reviewers to compare your proposal to others submitted in response to the same project solicitation. This section should demonstrate that adequate facilities and appropriate equipment are available to complete the project and describe protocols to ensure quality control and quality assurance.
  - A data management plan that identifies the data to be collected, the sample size required to assure statistical validity of the data, equipment or instrumentation that will be used, and approach to addressing quality assurance of the data.
  - If applicable, a description of proposed human or animal subjects, including criteria for inclusion/exclusion, overview of recruitment plans, and need plans for Institutional Review Board (IRB) approval.

- References to publications describing similar work done by applicant(s) or others.

The proposal package must also include:

- Project schedule
  - List each task specified in the technical plan. Addressing each task, display the estimated timespan, with beginning and ending dates, of each individual task over the life of the contract. If tasks are extensive, they may be subdivided. Denote progress review meeting dates and dates of deliverables such as the draft final report (see Example B). Keep in mind that the draft final report must be provided to ARB six months prior to the contract end date in order to allow time for review by ARB staff and RSC.
- Curricula vitae or résumés of the key scientific personnel.
- Preliminary cost proposal.
  - Include the estimated cost breakdown by task (see Example C). Note that ARB's research budget is approximately $5 million dollars per year and typically supports 15-25 projects with 2 to 3 year durations. The amount of money allocated for each project is an estimated cost. Actual cost for submitted proposals may vary. Projects that provide co-funding will be evaluated more favorably.

PROPOSAL SUBMISSION GUIDELINES

- All materials comprising the draft proposal must be consolidated into a single Microsoft Word or Adobe pdf file.
- To submit your draft proposal, please visit our proposal submission website to upload your file: http://researchplanning.arb.wagn.org/.

EXAMPLE A: SAMPLE DRAFT PROPOSAL TITLE PAGE

DRAFT PROPOSAL

Concentrations of Volatile Organic Compounds in Urban Homes

Principal Investigator:
Joanna Phillips

Prepared for:

State of California Air Resources Board
Research Division
PO Box 2815
Sacramento CA 95812

Prepared by:

University of California, Davis
One Shields Avenue
Davis, CA 90210
(888) 555-4433

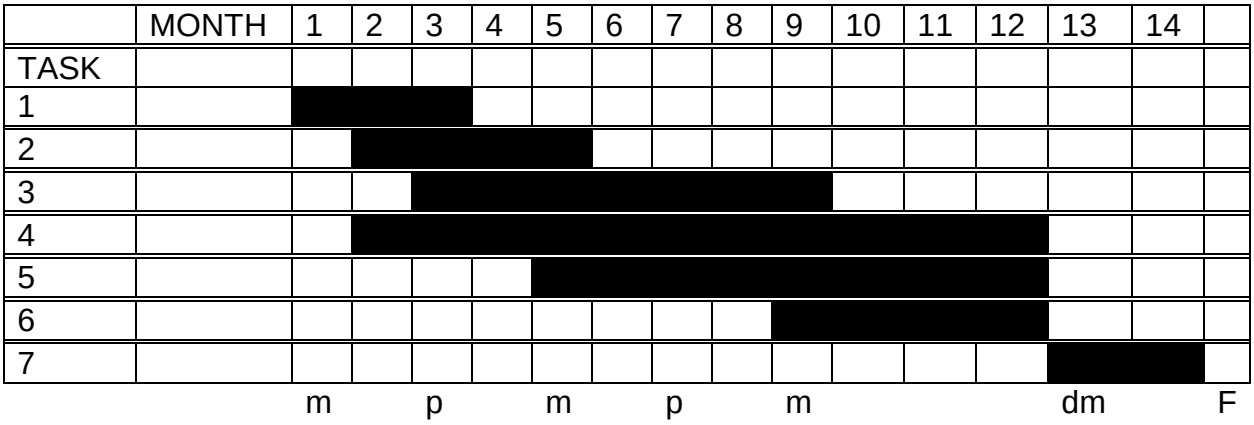
August __, ____

Check if applicable:
Animal subjects _____
Human subjects _____

EXAMPLE B: SAMPLE PROJECT SCHEDULE

PROJECT SCHEDULE

Task 1: Purchase equipment
Task 2: Install equipment
Task 3: xxxxx
Task 4: xxxxx
Task 5: xxxxx
Task 6: Draft final report
Task 7: Amend final report



p = Quarterly progress report
d = Deliver draft final report (to be submitted 6 months prior to contract expiration)
f = Deliver final report
m = Meeting with ARB staff

EXAMPLE C: ESTIMATED COST BY TASK

Task	Labor	Employee Fringe Benefits	Subs, Consultants	Equip	Travel Subsist	EDP	Copy Print	Mail Phone Fax	Materials and Supplies	Analyses	Misc.	Overhead*	Total
1	$4,200	$1,260	$0	$5,200	$4,240	$0	$15	$5	$25	$0	$0	$840	$15,785
2	$5,000	$3,000	$5,430	$0	$0	$0	$45	$60	$34	$0	$0	$2,000	$15,569
3	$10,000	$1,500	$0	$0	$0	$450	$10	$10	$66	$365	$0	$1,000	$13,401
4	$8,000	$102	$0	$72	$340	$0	$5	$10	$52	$1,024	$0	$68	$9,673
5	$4,500	$1,350	$0	$0	$0	$0	$10	$10	$52	$0	$0	$900	$6,822
6	$340	$2,400	$0	$0	$0	$0	$0	$0	$0	$0	$245	$1,600	$4,585
	$32,040	$9,612	$5,430	$5,272	$4,580	$450	$85	$95	$229	$1,389	$245	$6,408	$65,835

*For 2015/16 Proposals – Overhead shall be calculated at 10% of the modified total direct cost (MTDC). MTDC is the total cost less equipment, student fee remission, and the portion of each subcontract exceeding $25,000.