Benchmarking of Post-AMMP Dairy Emissions and Prediction of Related Long-term Airshed Effects

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Outline

1. Background and problem statement
2. Project objectives
3. Project tasks and milestones
4. Introduction of the CARB-funded project "Benchmarking of post-AMMP dairy emissions"

Background and problem statement

- The California Air Resources Board (ARB) recently adopted the Short-Lived Climate Pollutant Strategy (SLCP) to reduce emissions of black carbon, methane and other SLCPs
- Recent legislation (SB 1383) requires implementation of the SLCP strategy by January 1, 2018. The strategy includes a 40% methane emission reduction from 2013 levels by 2030

Background and problem statement

- California is the national lead in milk production
- Total sale of milk and its products represented about $65 billion
- The greenhouse gas (GHG) emissions from dairy farms account for 4.3% of all California GHG emissions and 57% of those from California Agriculture
- Anaerobic digesters, as a technology for mitigation of emissions while producing bioenergy, have been installed on only 1.3% of dairy farms in California
- It is imperative to identify alternative manure management technologies that are cost effective in emissions reduction

Ozone Formation Potential of Different VOCs

- Ozone formation potential is the additional ozone formed by a compound in a representative atmosphere (that already has some base level of ozone formation)
- Current Manure Management Practices do not emit Volatile Organic Compounds (VOCs) with high ozone formation potential
- Alternative Manure Management Practices will emit different VOCs.
- The ozone formation potential of VOCs emitted by different AMMPs will be measured, and the regional impact will be modeled.

NOx Emissions

- NOx is a precursor for particulate nitrate formation in the winter months.
- Manure management practices require energy that is primarily obtained through fuel combustion that releases NOx.
- The nitrogen content of the manure spread on fields may impact NOx emissions from soils.
- The NOx emissions under different AMMPs will be predicted, and the regional effects on particulate nitrate formation will be modeled.

Changing Meteorology

- Temperature and humidity affect the efficiency of ozone formation and particulate nitrate formation. Warmer temperatures are more conducive to ozone formation but less conducive to particulate nitrate formation. Increased humidity is more conducive to particulate nitrate formation.
- Future temperature and humidity in 2050 may be higher than current values. The effect of AMMPs on ozone and particulate nitrate formation will be evaluated under expected future conditions.

Changing Emissions from California Cities

- Ozone formation depends strongly on the relative amount of NOx and VOC in the atmosphere. A significant amount of the NOx and VOC in the SJV currently comes from upwind cities. Future emissions from cities will be lower due to continuing efforts to adopt clean vehicles and clean energy sources.
- The ozone and particulate nitrate formation associated with AMMPs will be evaluated in future scenarios that follow (i) Business as Usual or (ii) GHG optimized pathways.

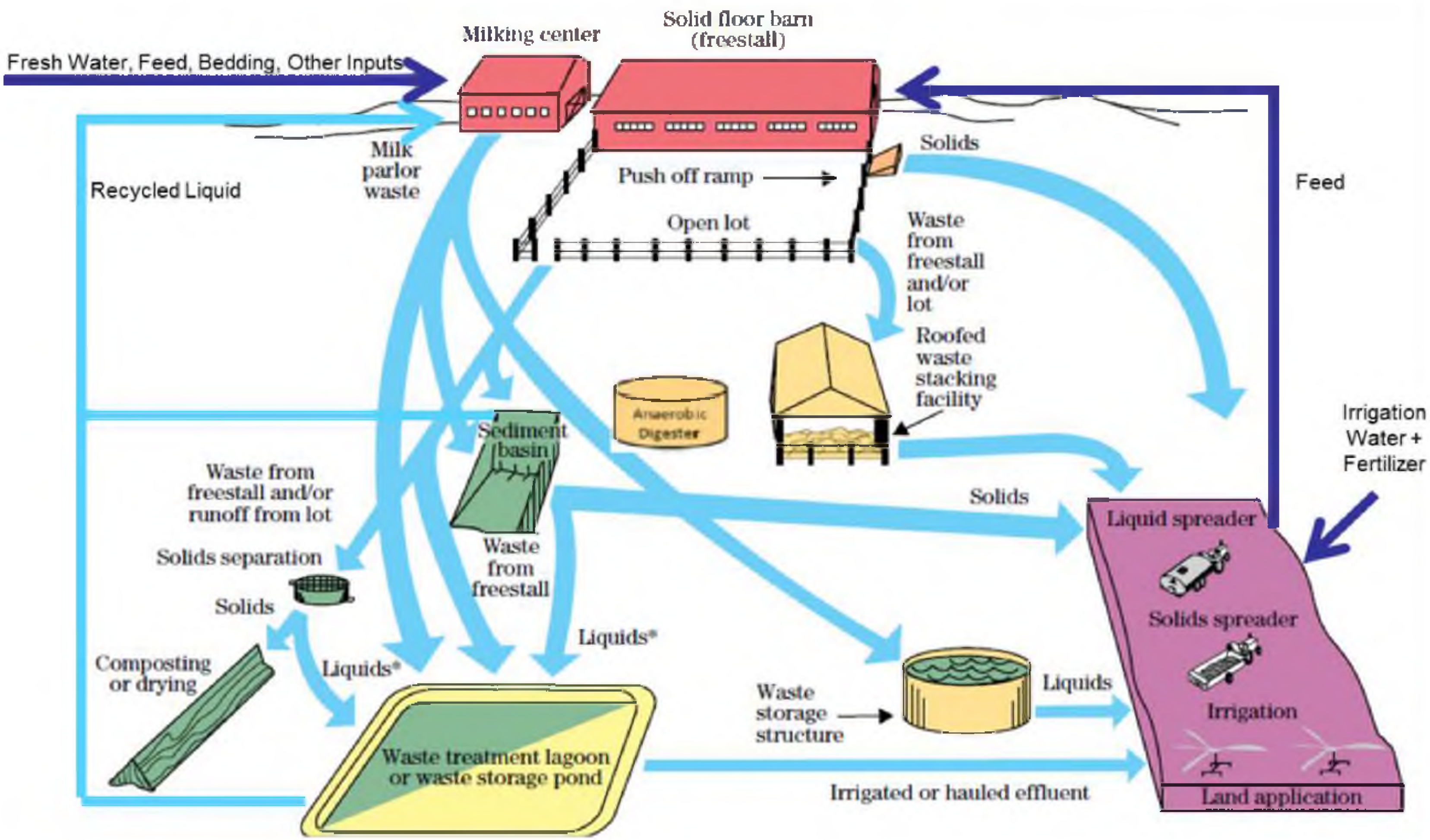
Project objectives

1. Conduct emissions measurements on four selected dairies post application of AMMP practices,

2. Apply regional chemical transport models to determine the effect of AMMP emissions on ozone and $PM_{2.5}$ concentrations in the San Joaquin Valley (SJV) in the coming years, and

3. Analyze, report, and disseminate project results and findings.

Dairy manure management systems



Project tasks and milestones

Task 1a: Selection of study sites and development and recommendation of measurement plans.

Task 1b: Measurement of post-AMMP emissions from selected dairies

Task 2a: Create Present-day AMMP scenarios

Task 2b: Create 2050 AMMP scenarios

Task 2c: Perform AQ modeling to evaluate the effect AMMPs on the emissions from the selected farms

Task 3: Reports (quarter reports, draft final report, and amend final report)

Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Task 1a	■	■	■	■	■	■																														
Task 1b							■	■	■	■	■	■	■	■	■	■	■	■																		
Task 2a													■	■	■	■	■	■	■	■	■															
Task 2b													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Task 2c																						■	■	■	■	■	■	■	■	■						
Task 3: Reports	m		p			p	m		p			p	m		p			p	m		p			p	m		p			d						F

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

Objective 1: Conduct emissions measurements

- Task 1a: Selection of AMMP and study sites and development of measurement plans

➢ Four dairies will be selected

➢ Develop detailed monitoring plans

Dairy locations and herd sizes in the Central Valley of California

Task 1b: Measurement of post-AMMP emissions from selected dairies

- Benchmark measurements for validating model prediction and quantifying impacts following changes in manure management practices
- We will measure the post-AMMP emissions from the selected sites
- The measured gases will include GHGs (CH_4 and N_2O) and select pollutants including NH_3, H_2S, and major VOCs

Measurement of baseline (Post-AMMP) emissions

Flux chambers and wind tunnels

A floating wind tunnel for measuring the emissions from lagoons

Wind tunnels and flux chambers for emissions measurements

Measurement of baseline (Post-AMMP) emissions

Mobile Air Quality laboratory (MAQ Lab)

MAQ Lab

Analyzers and supporting devices inside the mobile air lab (MAQ)

Equipment onboard the MAQ Lab

A Control and data acquisition system	Automated
A Gas sampling system.	Automated
A weather tower	Includes data logger
INNOVA 1412 analyzer	Measures up to six gases simultaneously with an infrared (IR) photo-acoustic method, including methane, nitrous oxide, carbon dioxide, ammonia, methanol, ethanol, acetic acid, and water.
A TEI 55C hydrocarbon analyzer	Measures methane and non-methane hydrocarbons in a wide range from 10 ppb – 1,500 ppm using a Flame Ionization Detector.
An open-path Bruker TENSOR 27 FTIR	Fourier Transform Infrared (FTIR) spectrometers can measure multi-gas simultaneously including methane, nitrous oxides, and other compounds. This unit is equipped with a telescope for measurement over hundreds of feet.
A Bruker TENSOR 27 FTIR with a White Cell	A second FTIR is equipped with a White-Cell which is a measurement chamber of 64 meter path that enables directed chamber gas measurements.
A Teledyne Monitor Laboratories ML9841A NOx analyzer	Uses chemiluminescence to quantitatively determine NO and NOx
A TEI 17i NH_3 analyzer	Measures ammonia using an infrared (IR) photo-acoustic method from 0.2-200ppm.
Six flux chambers and wind tunnels	Can be configured as needed for application
Up to 40 sonic anemometers	Used for accurate wind speed and direction
An Environics 4040 Gas dilution system	Can be used to ensure sample gases are within the optimum range for detectors

Objective 2: Apply regional chemical transport models to determine the effect of AMMP emissions on ozone and $PM_{2.5}$ concentrations

- Predict modified emissions due to AMMP adoption
- Predict O_3 and $PM_{2.5}$ concentrations in present-day scenario
- Predict O_3 and $PM_{2.5}$ concentrations in 2050 scenarios
  - BAU
  - GHG optimized

Objective 3: Data analysis and reporting

- Data from the modeling and measurement objectives will be synthesized to characterize and benchmark the post-project emissions from the selected study sites
- Quarterly project meetings and reports to CARB will be performed
- A final report will be generated to summarize project findings and recommendations for future research, dairy manure management practices, or policy considerations.

Objectives of the companion CDFA-Funded Project (Pre-AMMP)

1. Assess the utility and accuracy of existing air emission models for California dairies
2. Conduct baseline emissions measurements for selected dairies
3. Data analysis and reporting

Studied models

Model name	Category
Integrated Farm Systems Model (IFSM) Dairy Gas Emissions Model (DairyGEM)	Process-based (for liquid) Empirical/emission factors (stacks and stockpile)
Denitrification-Decomposition (DNDC) and Manure-DNDC	Process-based
Livestock Environmental Assessment and Performance Partnership (LEAP)	Life Cycle Assessment
The Intergovernmental Panel on Climate Change (IPCC)	Empirical/emission factors
California Air Resources Board (CARB)	Empirical/emission factors
Manure and Nutrient Reduction Estimator (MANURE) tool	Empirical/emission factors
DairyWise model	Empirical/emission factors
SIMS Dairy	Empirical/emission factors
FarmGHG	Empirical/emission factors
CarbOn Management Evaluation Tool (COMET-FARM)	Process-based (for liquid) Empirical/emission factors (manure piles)

Model selection criteria

- Should be mainly a process-based model
- Should have less number of parameters that should be readily available to obtain
- Should have been validated with data from US dairy farms
- Software and technical help should available
- Selected Models:
  - ➢ DairyGEM
  - ➢ Manure-DNDC
  - ➢ CARB (Livestock Calculation Tool)

Acknowledgments

- California Air Resources Board
- California Department of Food and Agriculture