

# Dairy Research



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CALIFORNIA AIR RESOURCES BOARD

AUGUST 14, 2017

California Environmental Protection Agency  
 **Air Resources Board**

# Background

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## **National Academy of Sciences (2003)**

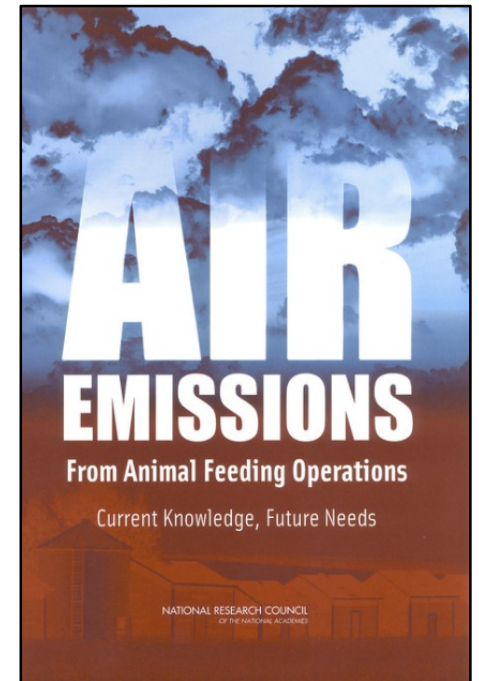
- Recognized the need for a better understanding of emissions from livestock farms
- Developed guidelines for estimating air pollutant emissions from livestock farm operations
- Set priorities for both short- and long-term air emissions research

## **SB 700 (2003)**

- Required ARB to define “Large Confined Animal Facilities” by July 1, 2005
- Large CAFOs as defined by ARB are subject to permitting by local air districts

## **Historical ROG Emission Factor Issues:**

- 1938 – Methane measurements of ruminants
- Late 1970s – Assumptions made about TOG and ROG in relation to historical methane
- 1970s to early 2000s – Assumptions carried through multiple literature reviews and publications



# Dairy Permitting – SB 700

- 1) ARB defined Large Confined Animal (CAF) as dairy facilities that exceed:

Areas	# of milk cows
Nonattainment	1,000
Attainment	2,000

- 2) SJV APCD formed Dairy Permitting Advisory Group (DPAG)
- 3) Permitting requirements outlined in SB 700 (HCS 40724.6(c)):
  - SJV APCD: over 12.5 tons ROG per year
  - SC AQMD: over 5 tons ROG per year
  - Other areas in the State: over 50 tons ROG per year
- 4) Dairy Manure Technology Feasibility Assessment Panel Report



Methane digester on California dairy farm.  
Source: Andy Alfaro – [aalfaro@modbee.com](mailto:aalfaro@modbee.com)

# Other Statutory Obligations

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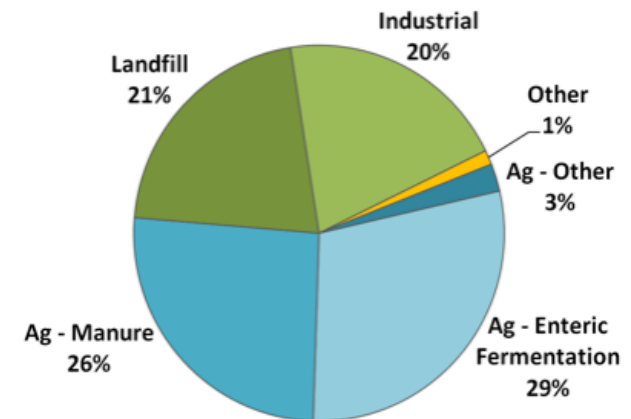
## California's combat against climate change:

- AB 32 and SB 32 – Set 2020 and 2030 GHG reduction targets
- SB 605 – Required California to develop a Short-Lived Climate Pollutant reduction strategy
- SB 1383 – Requires California to reduce methane by 40% below 2013 levels by 2030
- AB 1496 – Monitor and measure methane emissions from major sources in California

## Perspective using Statewide GHG Emission Inventory:

- >50% of annual CH<sub>4</sub> emissions from livestock
- >35% of annual N<sub>2</sub>O emission from livestock
- These percentages are higher in the San Joaquin Valley

2015 Total CH<sub>4</sub> Emissions: 39.6 MMTCO<sub>2</sub>e



# Dairy Emissions Research in 2000's

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## **PM, ammonia, GHG (such as methane), and VOC emissions research for dairy operations:**

- Evaluation and improvement of emission inventory (Battye et al., 2003, Pinder et al., 2004, Scott et al., 2003, etc.)
- Process-level emissions modeling (Pinder et al., 2004, Mitloehner et al., 2009, etc.)
- Ambient air monitoring and source-level measurements (Rabaud et al., 2003, Shaw et al., 2007, Alanis et al., 2008, Chow et al., 2006, Card and Schmidt, 2006, etc.)
- Regional air quality modeling (Kleeman et al., 2005, Ying et al., 2008, Zhao et al., 2009, etc.)



# Previous Research Efforts

No.	Funding Source	Title	Pollutant of Concern	PI	Period
1	ARB	Dairy Operations: An Evaluation and Comparison of Baseline and Potential Mitigation Practices for Emissions Reductions In the San Joaquin Valley	VOCs	Charles Krauter, CSU Fresno, and Donald Blake, UCI	2004-2009
2	ARB	Volatile Fatty Acids, Amine, Phenol, and Alcohol Emissions from Dairy Cows and Fresh Waste	VOCs	Frank Mitloehner, UCD	2005-2006
3	ARB, SJVAPCD, and CSU Agricultural Research Initiative	Dairy Air Quality Monitoring of ROG and Ammonia in the Central Valley of California	VOCs and NH3	Charles Krauter, CSU Fresno	2006-2007
4	USDA	Photochemical Ozone Formation Potential of Agricultural VOC Sources	VOCs	Peter Green, UCD	2006-2007
5	ARB, CDFA, and Ag Air Research Council	National Air Emissions Monitoring Study (NAEMS): Air Emissions from California Dairies	VOCs, NH3, H2S, and PM	Frank Mitloehner, UCD	2007-2010
6	ARB	Process-Based Farm Emission Model for Estimating Volatile Organic Compound Emissions from California Dairies	VOCs, Total Solids, Volatile Solids	Ruihong Zhang, UCD	2006-2010
7	ARB	Determining NOx Emissions from Soil in California Cropping Systems to Improve Ozone Modeling	NOx	Will Horwath and Martin Burger, UCD	2010-2012
8	ARB	Assessment of Baseline Nitrous Oxide Emissions in California's Dairy Farms	N2O	Will Horwath and Martin Burger, UCD	2010-2012
9	ARB	Quantification of the Emission Reduction Benefits of Mitigation Strategies for Dairy Silage	VOCs, NOx, NH3, and N2O	Frank Mitloehner, UCD	2011-2016
10	ARB	Evaluation of Dairy Manure Management Practices for Greenhouse Gas Emissions Mitigation in California	CH4	Stephen Kaffka, UCD	Completed 2016
11	ARB	Improving DNDC Modeling Capability to Quantify Mitigation Potential of Nitrous Oxide from California Agricultural Soils	N2O, CH4, NOx and NH3	Changsheng Li/Jia Deng, University of New Hampshire	2014-2017
12	Dairy Cares	Identify and verify dairy farm components mainly responsible for methane emissions and better understand their relative shares of overall emissions	CH4	EDF	Being finalized

And more... (<https://www.arb.ca.gov/ag/2017apr21agresearch.pdf>)

# Planned/On-Going Research Efforts

No.	Funding Source	Title	Pollutant of concern	PI	Period
1	CDFA	Producing Valuable Co-Products and Improving Nutrient Management for Dairy Manure Digester Systems	CH4	Ruihong Zhang, UCD	2014-2017
2	ARB	California Airborne Methane Survey – Detection of Potential Sources from Agricultural and Waste Sectors	CH4	Riley Duren	2016-2017
3	ARB	Characterize California-specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California’s GHG Inventory	CH4	Ermias Kebreab, UCD	2016-2018
4	CDFA	Converting Manure to Reduce Greenhouse Gas Emissions, Minimize Environmental Impacts, and Enhance the Economic Feasibility of Dairy Operations	CH4	Will Horwath et al., UCD	2016-2018
5	CDFA	Effect of Solid Separation on Mitigation of Methane Emission in Dairy Manure Lagoons	CH4	Ruihong Zhang, UCD	2016-2018
6	ARB	Characterize physical and chemical properties of manure in California Dairy Systems to improve Greenhouse Gas emission estimates	Total Solids, Volatile Solids, and N species	Deanne Meyer, UCD	2016-2018
7	CDFA	Benchmarking of pre-AMMP dairy emissions	CH4, VOCs, NOx, NH3, and N2O	Frank Mitloehner, UCD	2017-2019
8	NGO	Effectiveness of seaweed in reducing methane emissions	CH4	Kebreab et al., UCD and Stanford	2017
9	Zaluvida	Effectiveness of feed additive Mootral in reducing methane emissions	CH4	Ermias Kebreab, UCD	2017
10	ARB	Research and Technical Analysis to Support and Improve the Alternative Manure Management Program Quantification Methodology	Total Solids, Volatile Solids	TBD	In planning
11	ARB	Multiple pollutant mitigation strategies for dairy sources	CH4, N2O, NH3, NOx, and VOCs	TBD	In planning
12	ARB	Strategies to reduce methane emissions from enteric and lagoon sources	CH4	Ermias Kebreab, UCD	In planning

And more... (<https://www.arb.ca.gov/ag/2017apr21agresearch.pdf>)

# Remaining Research Needs

- Nitrogenous Compounds (ammonia, nitrous oxide, nitrates, etc.)
  - Better characterization of emissions
  - Evaluation of mitigation options for each component of the manure system
- Volatile Solids (VS)
  - Additional data collection to develop a better understanding of baseline emissions
  - Understanding the effectiveness of separating VS on lagoon emissions
  - Farm specific information on flow of manure and VS at each management control point
- Co-Benefits
  - Understanding the economical and environmental impacts of updating dairy feeds
  - Understanding the co-benefits of updating dairy manure management strategies
  - Additional life-cycle and air quality benefits analyses for renewable energy from dairies
- Other Needs
  - Long-term dairy air quality monitoring for modeling validations
  - Identifying effective air pollution mitigation strategies





# Contacts

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For more information, please visit:

<https://www.arb.ca.gov/homepage.htm>