Life Cycle Assessment of California Tomato Production and Processing

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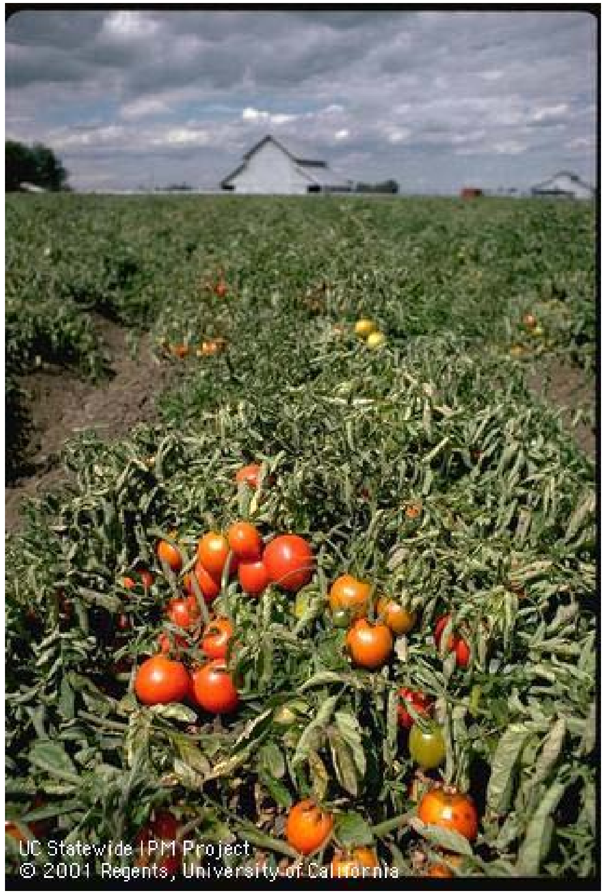
Research Objective

- Comprehensive quantification of a range of environmental impacts from producing California **tomato paste** and **diced tomato products**
- Two time points: **2005 & 2015** to examine trends over time
  - *Also analyzed 2010 data from some processing facilities*

Funded by: Barilla

What did we include?



Greenhouse phase: Transplant production

↓

Cultivation phase

↓

Processing phase: Bulk diced tomato

Processing phase: Bulk tomato paste

What is Life Cycle Assessment?

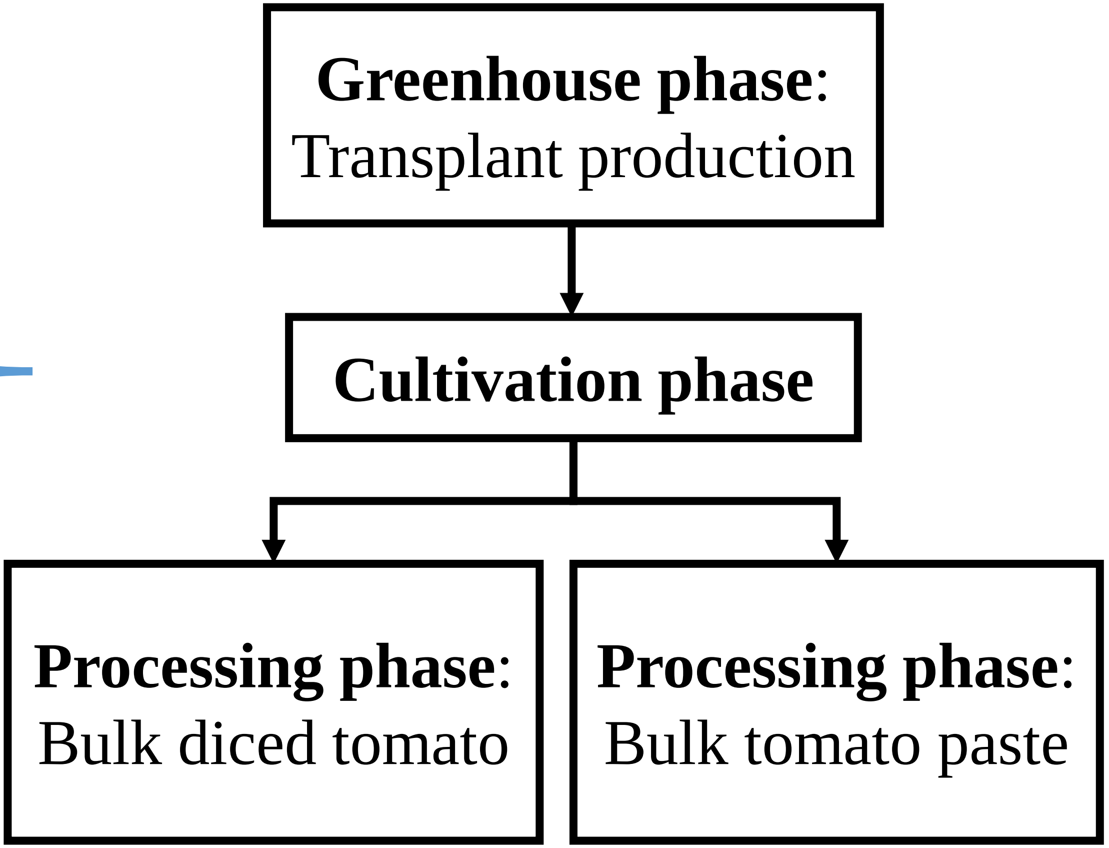
Inputs

Primary data

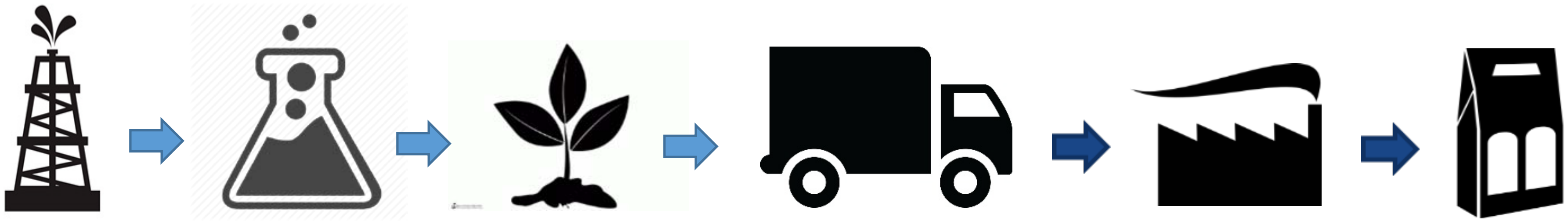
Pesticides, fertilizers, water, energy (diesel, gas, electricity)

Secondary data

Raw material extraction, processing, and energy production



the "compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040)



Environmental Impact Categories

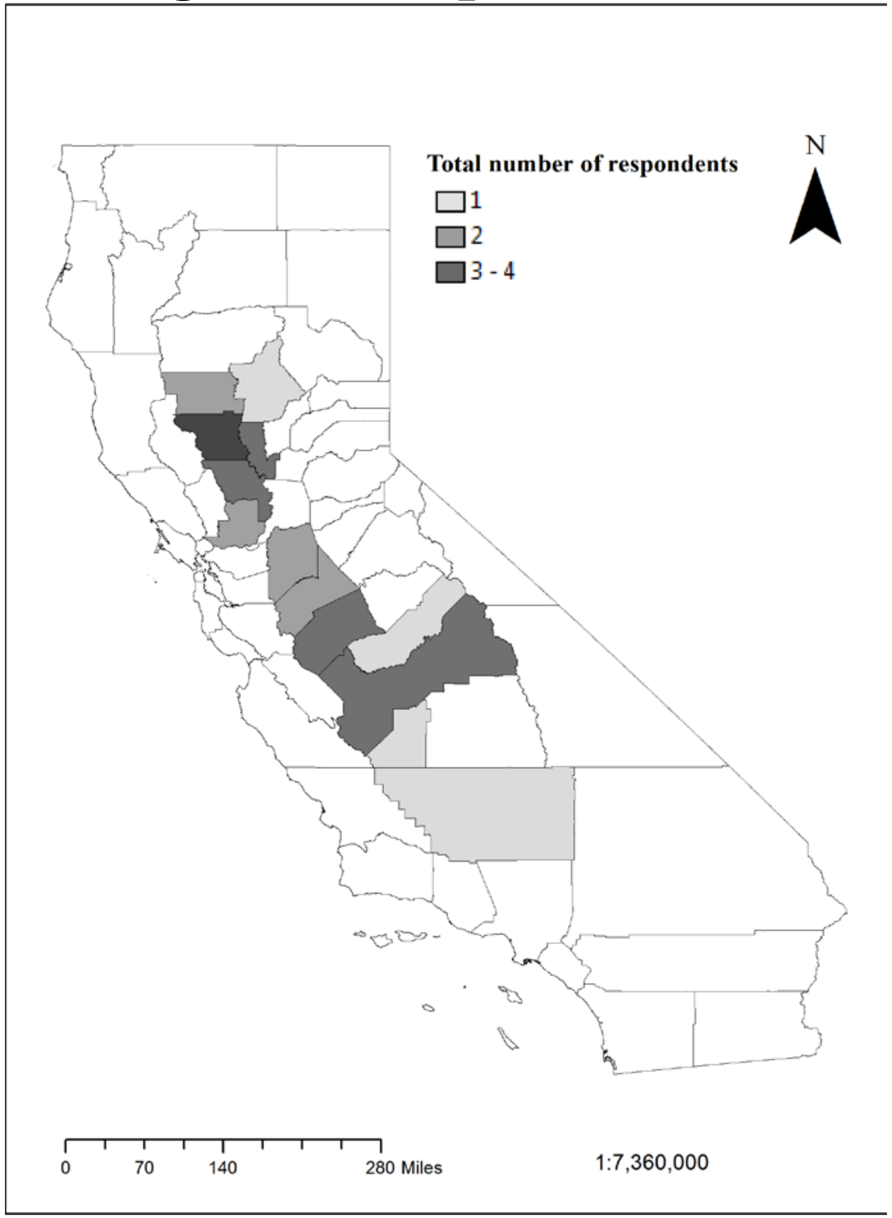
<u>Natural Resource Use</u>

- Primary Energy Use
- Fresh Water Use

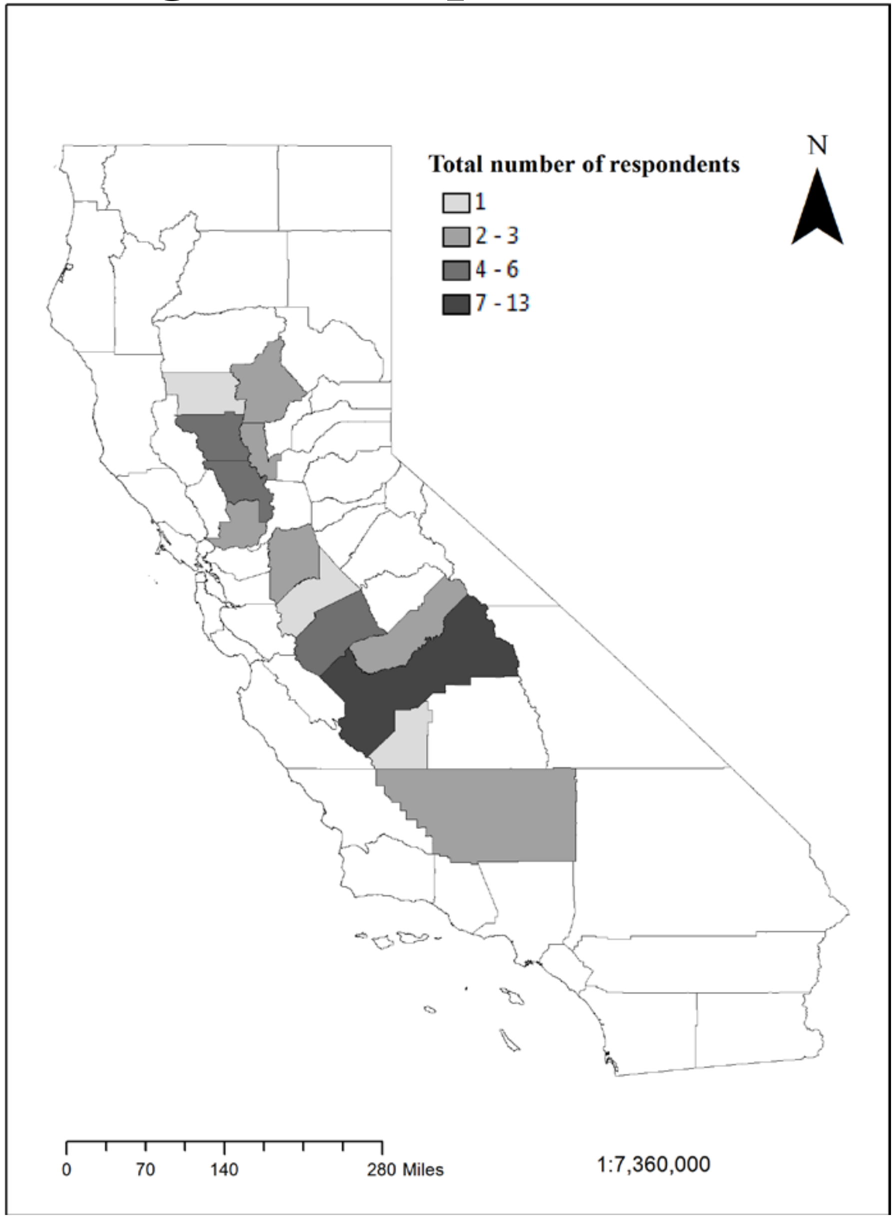
<u>Emissions-Related Impacts</u>

- Global Warming Potential (kg CO_2 equivalents)
- Acidification Potential (kg SO_2 equiv)
- Eutrophication Potential (kg PO_4 equiv)
- Ozone Depletion Potential (kg CFC-11 eq.)
- Photochemical Ozone Creation Potential (kg C_2H_4 eq.)
- Ecotoxicity Potentials: land, fresh water, marine water, human (kg DCB eq.)

2005 grower response



2015 grower response



- **46 completed surveys total** (only 16 could provide 2005 data)

Processing Facility Data

Photo: R. Paul Singh

“Black box” Approach

Survey data of:

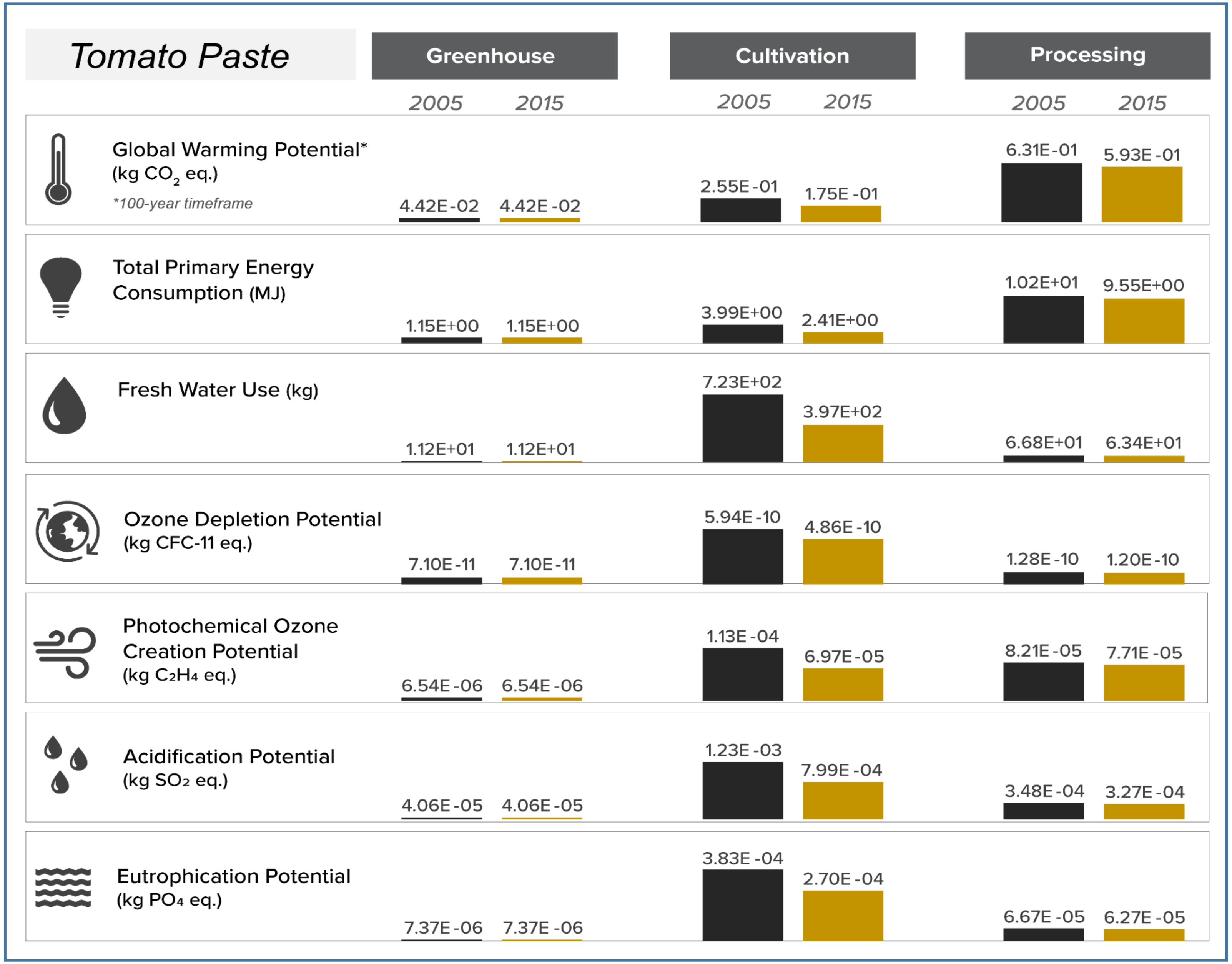
- Overall material and energy inputs for whole facility
- Overall quantity and types of outputs for the whole facility (including co-products, e.g. pomace)

Used **economic allocation** approach (based on relative factory gate prices) to allocate resource use and impacts to paste versus diced product

Survey data:

- Complete datasets for **two** facilities for 2005, 2010, and 2015
- Complete datasets for **five** facilities for 2010 and 2015

Overall Supply Chain Wide Impacts, per Kg Bulk Paste: 2005-2015



Which phases of the supply chain contribute the most to which impacts (on a life cycle basis)?

Impact category	Main contributors across the supply chain	Phase with the highest total contributions
Global warming potential	Natural gas production & consumption	Processing facility
Total primary energy	Natural gas production & combustion	Processing facility
Freshwater use	Direct water use	Cultivation
Acidification potential	Diesel production & combustion	Cultivation
Eutrophication potential	Diesel production & combustion	Cultivation
Photochemical ozone creation potential	Diesel production & combustion	Cultivation

Decreases in life cycle impacts 2005 - 2015

Diced

	% Reduction
Primary energy use	28%
Water use	46%
GWP_{100}	28%
Other environment impacts	From 18% to 36%

Paste

	% Reduction
Primary energy use	14%
Water use	46%
GWP_{100}	12%
Other environment impacts	From 15% to 30%

Key On-Farm Improvements: 2005-2015

Irrigation systems

Direct on-farm water use decreased by 45% per ton of tomatoes.

According to our grower survey, 50% of the growers shifted to drip irrigation, 13% continued to use furrow irrigation, and 13% used drip irrigation in both 2005 and 2015.

Tomato yields

Increased from 41 to 55 tons/acre

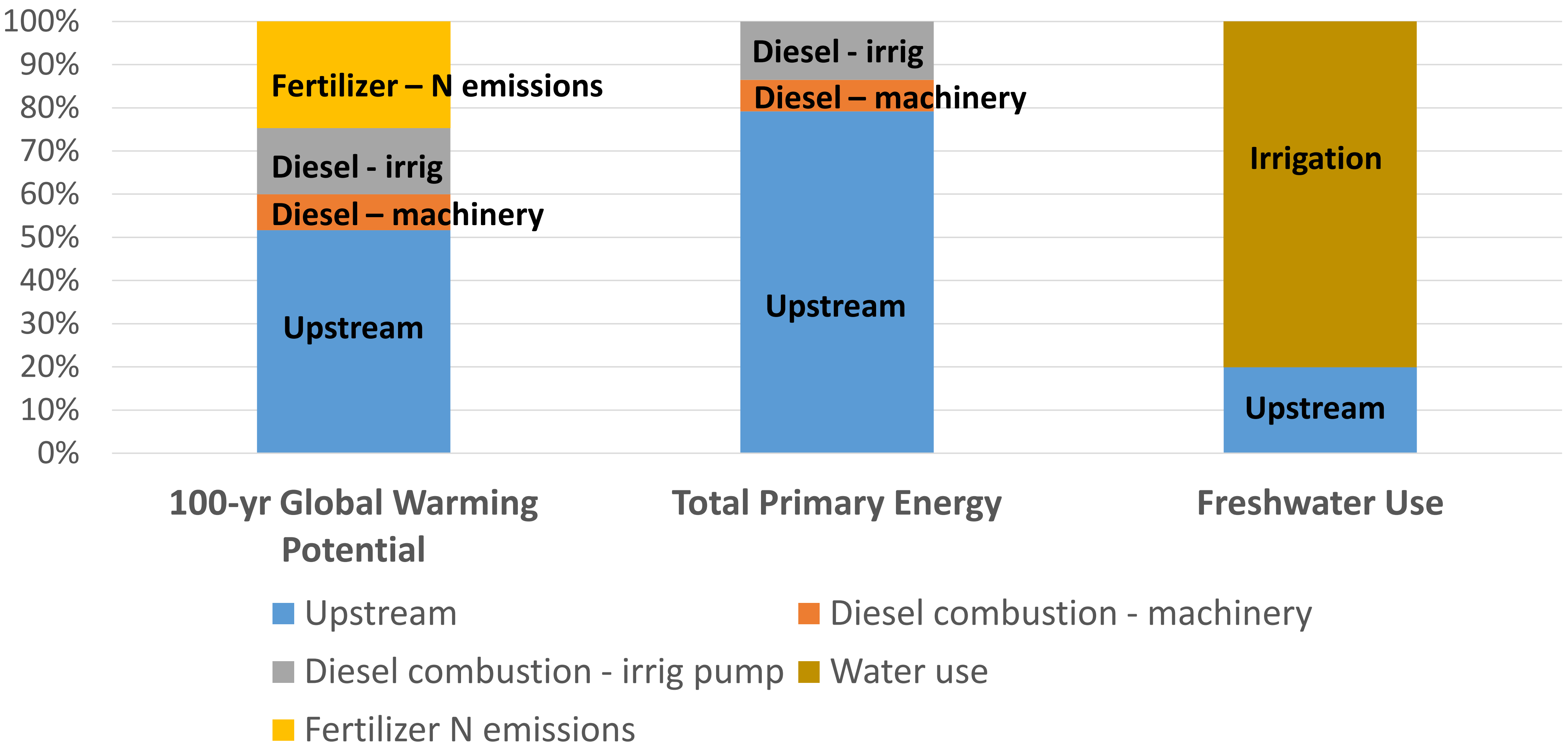
Key Processing Facility Improvements: 2005-2015

Resource use reduction per kg of final product

Resource	Diced	Paste*
Natural gas	27%	5%
Grid electricity	27%	5%
Water	22%	5%

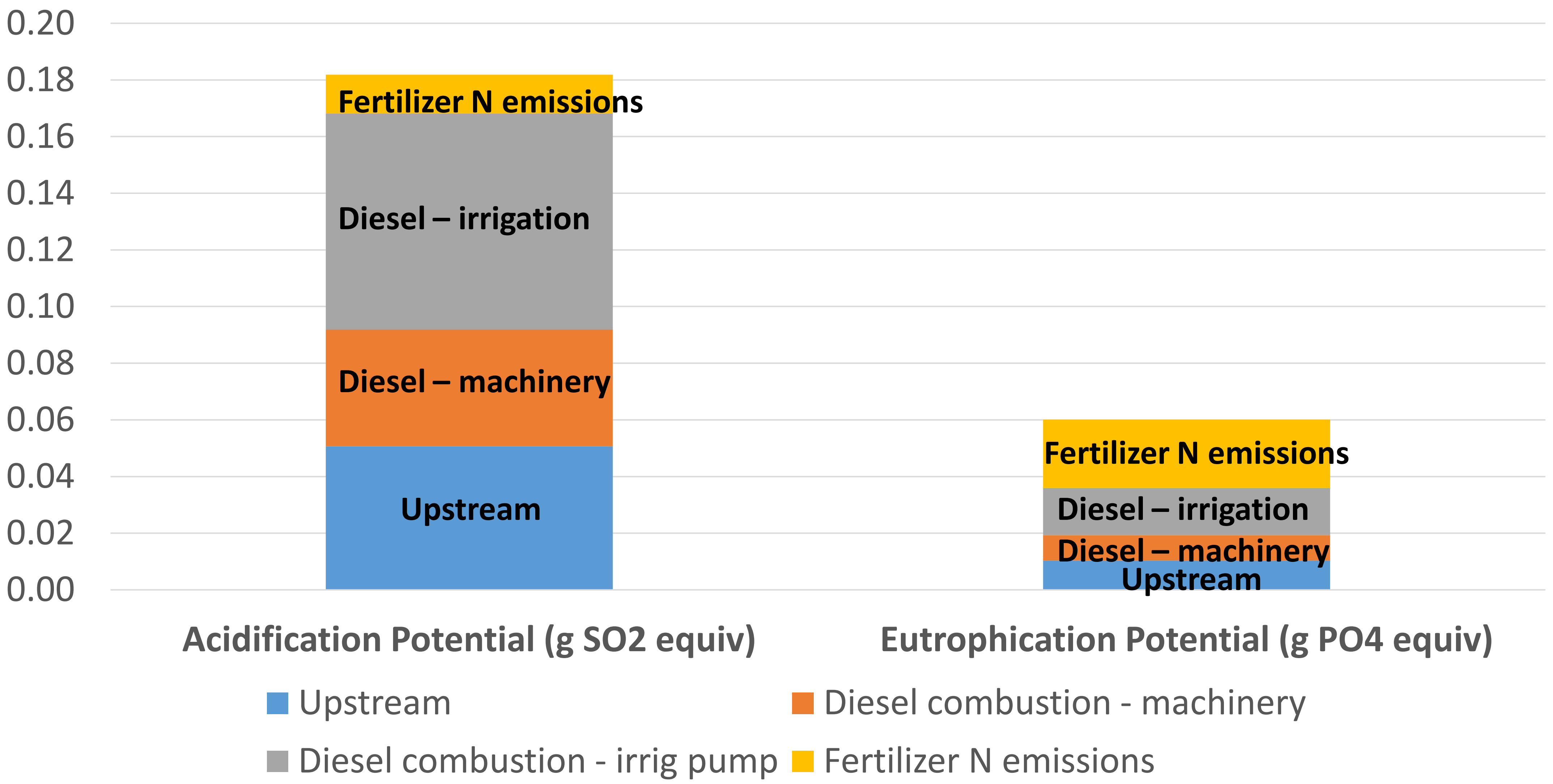
* Life cycle impact reductions in paste due mostly to increased efficiencies in the cultivation phase.

Upstream Vs Onsite Sources of Impacts
per US Ton of Harvested Tomato at Farm Gate

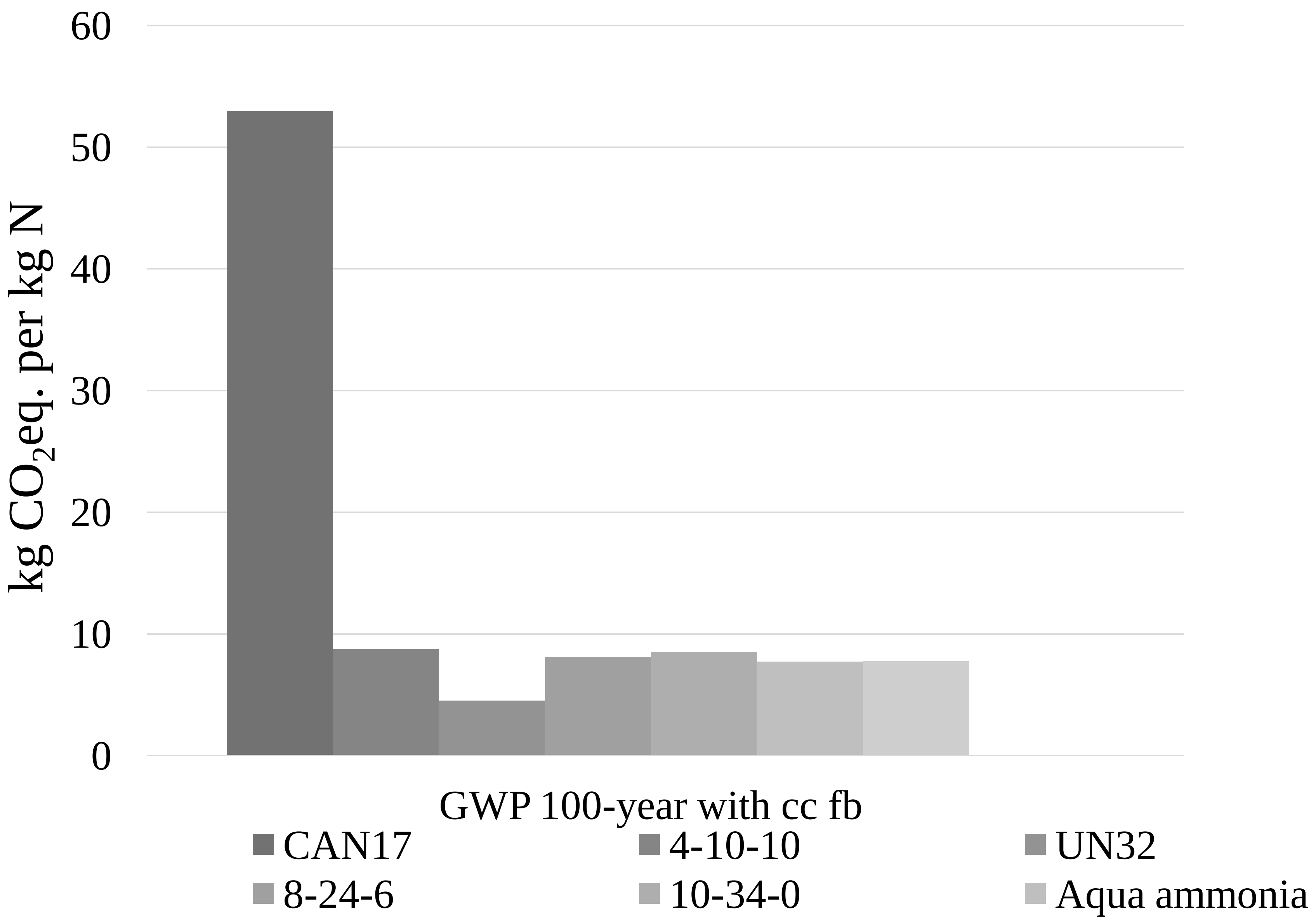


Acidification and Eutrophication Potentials

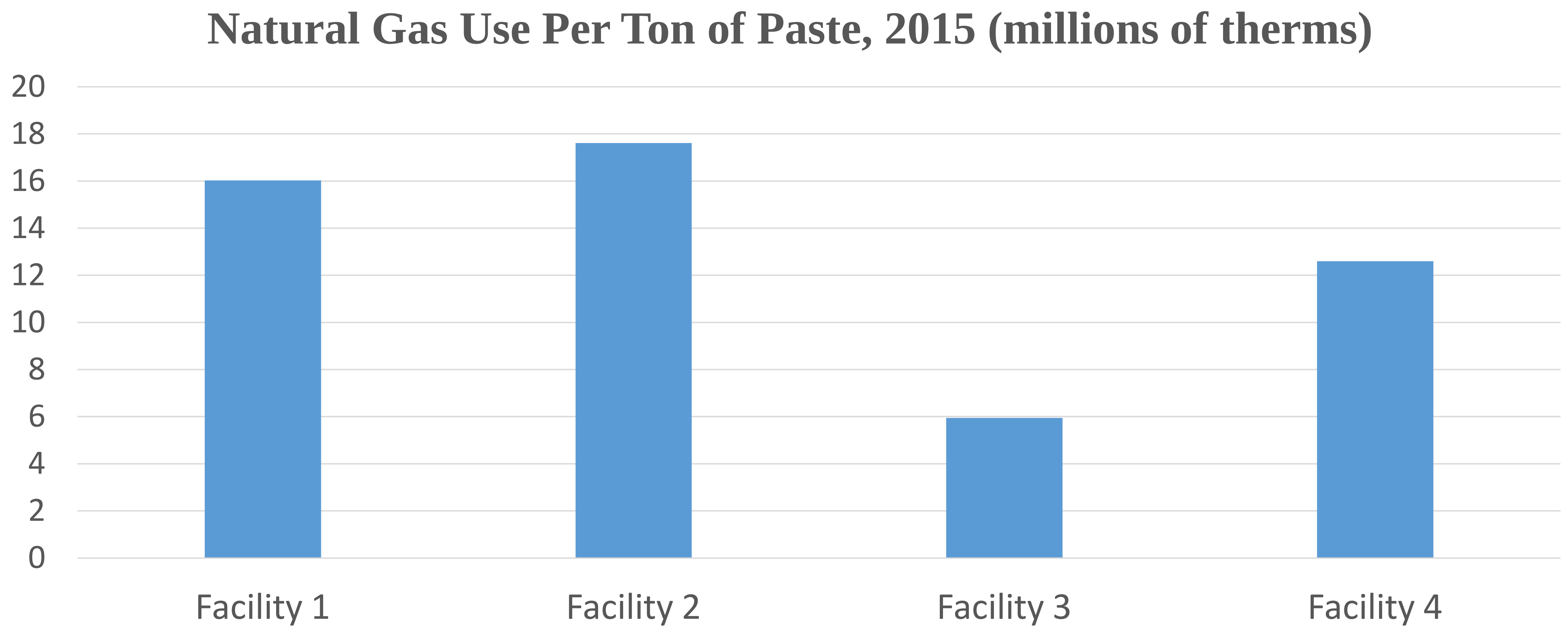
Per US Ton of Harvested Tomato at Farm Gate



Fertilizer production comparison – GWP100 impacts



Processing Facility Variability



Also substantial variability from year to year within the same facilities – perhaps relating to differences in total throughput and the need to keep the facility running continuously throughout the season?

Key Sources of Impacts Across the Supply Chain

Largest Sources of Environmental Impacts (across supply chain)

- Diesel
- Natural gas
- Irrigation water

Secondary Sources of Environmental Impacts

- Electricity use (irrigation and processing)
- Fertilizers (espec.N)

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Opportunities for Additional Improvements

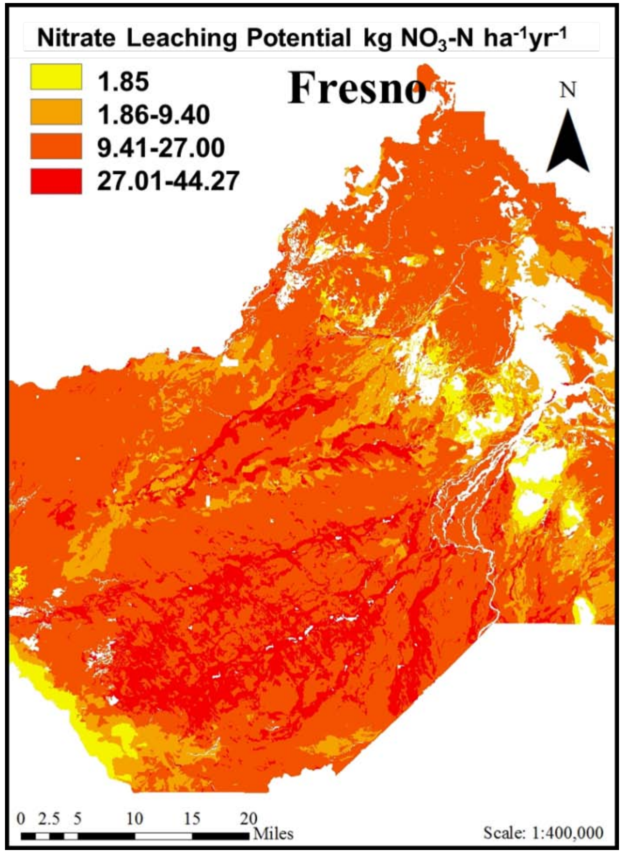
- Renewable energy investments – electric or solar tractors? Solar for processors?
- Energy efficient irrigation pumping (SWEEP)
- Choose lower-GWP nitrogen fertilizers (UN32 vs CAN17)
- Monitoring, decision tools, and precision application of fertilizers and pesticides
- Conduct process-specific energy audits in processing facilities

To keep in mind…..

Efficiency is a necessary but not sufficient condition for overall **sustainability**.

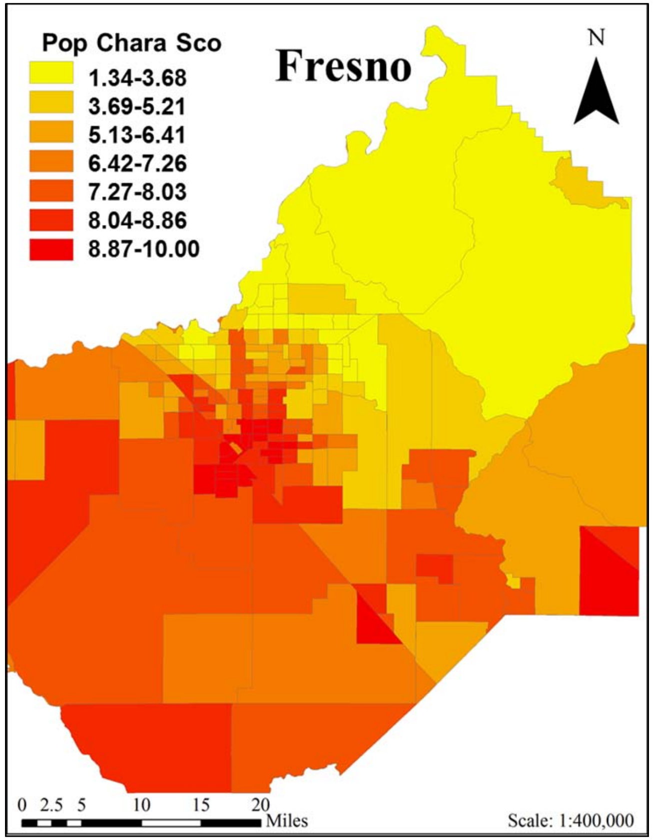
For overall environmental sustainability, we also need to consider **total magnitude of impact** in a given geographic area.

DNDC: nitrate leaching potential



Environmental Justice

CalEnviroscreen: population vulnerability



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