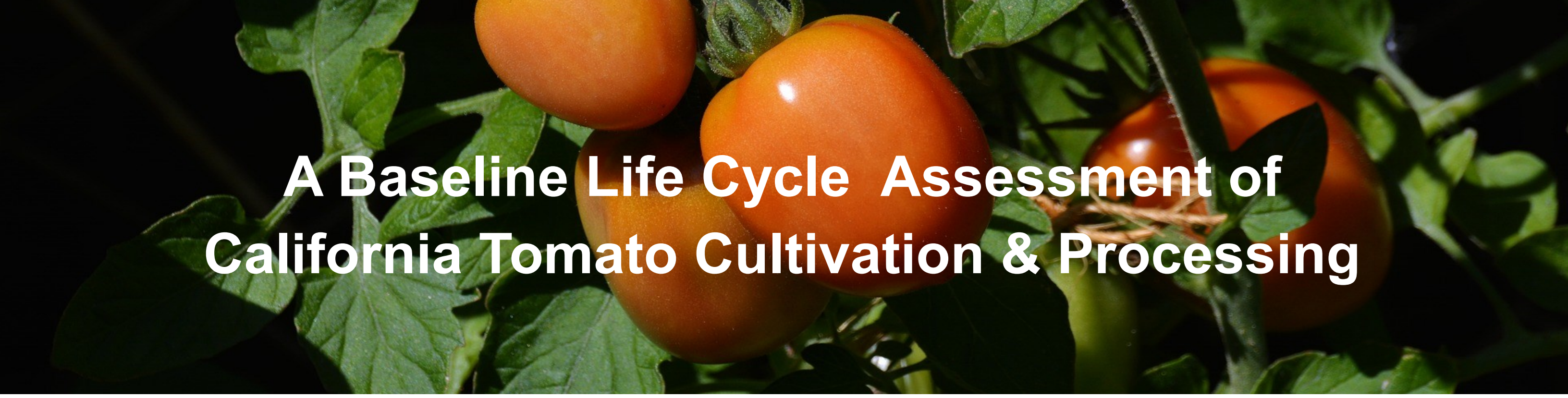


A Baseline Life Cycle Assessment of California Tomato Cultivation & Processing

What is Life Cycle Assessment?

Life Cycle Assessment (LCA) is a comprehensive analysis method for assessing the environmental impacts and resources used throughout the full life cycle of a given product. LCA considers environmental impacts at each phase of the life cycle (e.g. raw material production, manufacturing, use, end of life)

This study quantifies resource use, including energy, water, and other resources, and estimates environmental impacts, including (but not limited to) global warming, ozone depletion, photochemical ozone creation, acidification, and eutrophication, for **bulk tomato paste** and **diced tomatoes**.

It includes the following phases of tomato production and processing:

1. Greenhouse production of transplants
2. Field cultivation of tomatoes
3. Facility processing

This analysis ends at the facility gate. It includes transportation of transplants and tomatoes between phases, but it does not include packaging of final products. Researchers collected data from all three phases for the 2005 and the 2015 seasons to track changes over time.

Environmental Performance Improvements

Efficiency of energy use and water use increased substantially over this time period, calculated per kg of final paste and diced product.

Over the total 3-phase life cycle:

- Energy use efficiency increased by 14% & 28%
- Water use efficiency increased by 41% & 43%

Especially notable are the following sources of gains:

- Improved water use efficiency in the field through widespread conversion from furrow to drip irrigation
- Increases in per acre yields (from 41 tons to 55 tons among surveyed growers) without proportional increases in input use (e.g. fertilizers and water)
- Increases in water use efficiency in processing facilities by over 20% for diced tomatoes

Increased efficiency of resource use is largely accountable for reductions in many environmental impacts, including global warming potential, ozone depletion, photochemical ozone creation, acidification, and eutrophication. These impacts decreased from 6% to 43% (see table on reverse) on a per kg of product basis. In addition, estimates of water, terrestrial, and human toxicity potentials also declined.

However, efficiency gains must be balanced with consideration of the total magnitude of impacts of the industry in California and other locations where inputs are produced.

The total acreage of processing tomatoes increased by 12% between 2005 and 2015, and total harvested output increased by over 40%, requiring more total harvest and processing activity. In addition, per acre applications of certain inputs, including fertilizers and some pesticides, increased from 2005 to 2015.

Largest Sources of Environmental Impacts

Across the three phases of the supply chain, the following factors make the largest contributions to the range of environmental impacts measured:

- **Diesel** production and combustion
- **Natural gas** production and combustion
- **Irrigation water** pumping and use

The largest contributors to impacts by phase:

Greenhouse phase:
- Natural gas production and combustion

Cultivation phase:
- Electricity and diesel use for irrigation pumping
- Gypsum and fertilizer production and in-field emissions

Processing phase:
- Natural gas production and combustion
- Grid electricity production

Notably, grid electricity production, for uses across the supply chain, accounts for a significant amount of water use. For pesticides, the production of active ingredients does not account for large impacts relative to other factors, but a preliminary analysis suggests that post-application toxicity impacts need to be better estimated.

Options to Improve Environmental Performance of Processed Tomatoes

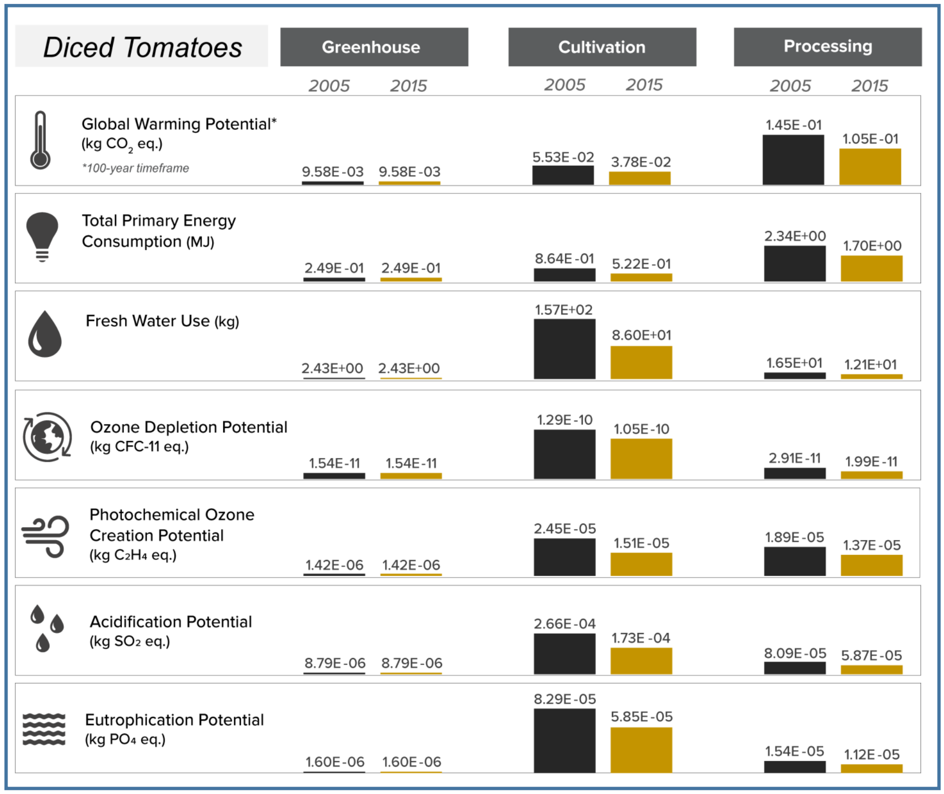
- Invest in renewable energy generation at all 3 phases.
- Invest in more energy efficient irrigation pumps.
- Choose lower-energy nitrogen fertilizers, such as UN32, over calcium ammonium nitrate (CAN17).
- Continue improvements in fertilizer and pesticide inputs through increased grower use of decision support tools, precision application technologies, and Integrated Pest Management.

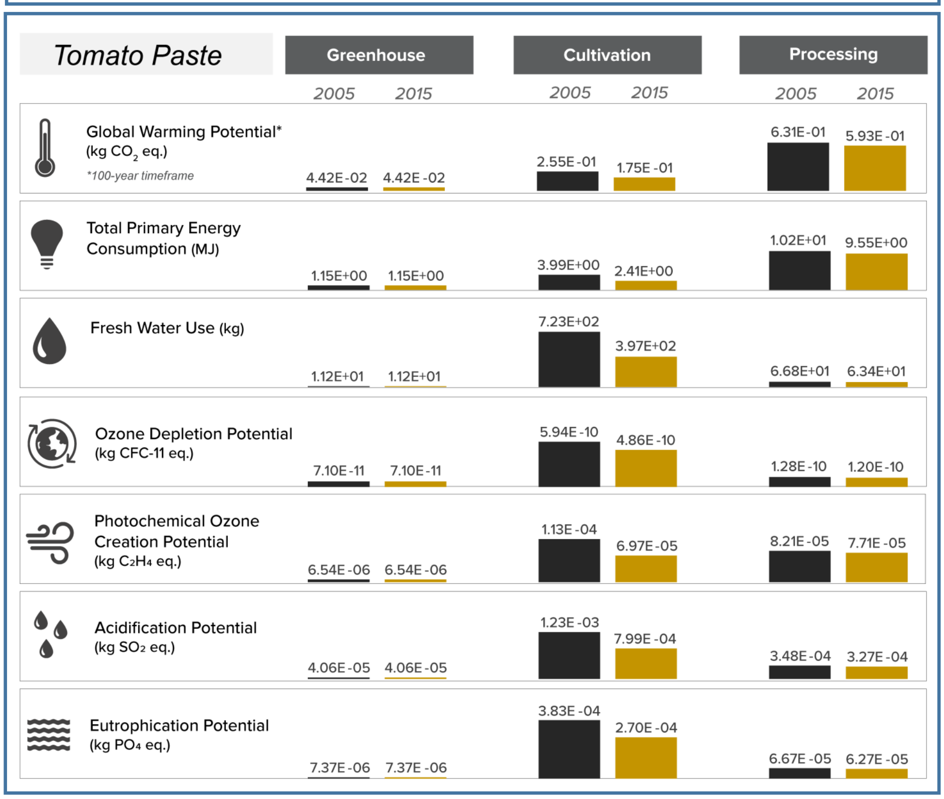
Uncertainty and Research Needs

- More process-specific assessments within facilities are needed to explain large variability between facilities and identify exact sources of impacts. Data from more greenhouse operations are also needed.
- Field research is needed to understand tradeoffs between upstream and downstream impacts of different fertilizer choices.
- Increasing application rates of a few highly toxic pesticides and uncertainty in post-application impacts requires further research coupling LCA with regional fate, transport, and toxicity models.

Environmental Impacts Per Kg of Diced and Paste Bulk Product

Note that *Global Warming Potential* includes climate carbon feedback.





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Funding provided by Barilla
May 2018