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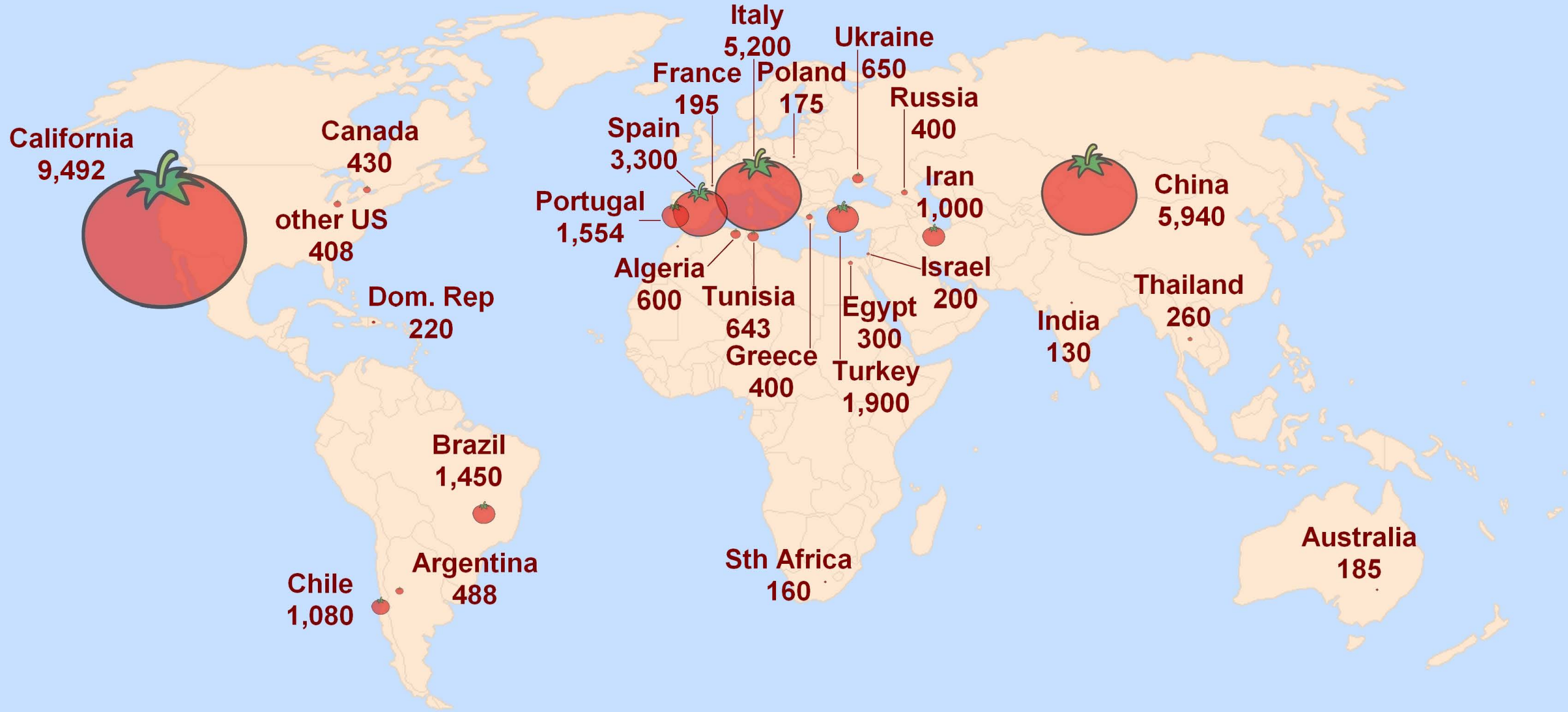
Prospects for Decarbonizing California's Tomato Processing Industry

Tomato Processing in California

- California is the largest producer of processing tomatoes in the world, with an average of nearly 1/3 of the world tonnage.
- The growing conditions, which include warm, dry summers, are ideal in the Mediterranean climate that is prevalent in the Central Valley.
- The harvest season for tomatoes usually begins in early July and extends to mid to late October.
- The development of determinate tomato varieties, which ripen all at once, and mechanical harvesting, helped to spur the growth of the industry in California.

Global Tomato Processing in 1989: 22 million T

Global Tomato Processing in 2017: 37,47 million mT



Top 10 Processing Tomato Countries (in tons)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
California	10,720,000	12,073,000	11,155,000	11,067,000	11,464,000	11,020,000	12,707,000	13,018,000	11,470,000	9,492,000	11,065,000
China	6,405,000	10,700,000	7,500,000	6,792,000	3,230,000	3,850,000	6,300,000	5,600,000	5,150,000	6,200,000	3,800,000
Italy	4,900,000	5,747,000	5,080,000	4,950,000	4,500,000	4,080,000	4,914,000	5,393,000	5,180,000	5,200,000	4,650,000
Spain	1,730,000	2,700,000	2,350,000	1,985,000	1,935,000	1,650,000	2,700,000	3,028,000	2,950,000	3,350,000	2,800,000
Turkey	2,700,000	1,800,000	1,280,000	1,940,000	1,750,000	2,150,000	1,800,000	2,700,000	2,100,000	1,900,000	1,300,000
Iran	2,060,000	2,400,000	1,400,000	1,850,000	1,750,000	1,900,000	2,200,000	1,350,000	1,150,000	980,000	300,000
Brazil	1,200,000	1,150,000	1,796,000	1,590,000	1,294,000	1,670,000	1,400,000	1,300,000	1,450,000	1,450,000	1,400,000
Portugal	998,000	1,242,000	1,280,000	1,065,000	1,190,000	997,000	1,197,000	1,660,000	1,507,000	1,554,000	1,198,000
Chile	510,000	619,000	864,000	794,000	668,000	682,000	810,000	850,000	800,000	1,080,000	1,211,000
Tunisia	800,000	750,000	850,000	868,000	840,000	618,000	720,000	920,000	650,000	643,000	638,000
Greece	670,000	810,000	640,000	324,000	390,000	425,000	470,000	500,000	440,000	400,000	320,000
Ukraine	100,000	340,000	280,000	440,000	385,000	330,000	470,000	550,000	550,000	650,000	735,000
Total Top 10	**32,183,000**	**39,372,000**	**33,555,000**	**32,901,000**	**28,621,000**	**28,617,000**	**34,748,000**	**35,819,000**	**32,407,000**	**31,856,000**	**28,797,000**
Top 10 vs Global	87.8%	88.5%	86.6%	87.4%	85.6%	86.2%	87.1%	86.6%	85.1%	84.3%	83.9%
Other	4,486,000	5,140,000	5,192,000	4,733,000	4,798,000	4,580,000	5,148,000	5,555,000	5,665,000	5,941,000	5,531,000
Global Processing	**36,669,000**	**44,512,000**	**38,747,000**	**37,634,000**	**33,419,000**	**33,197,000**	**39,896,000**	**41,374,000**	**38,072,000**	**37,797,000**	**34,328,000**

Tomato Processing in California

- Processing tomatoes are harvested a the peak of ripeness and then delivered to processing plants.
- This allows processors to lock-in the nutrients and flavors present in the ripe fruit.
- Various products are made with the tomatoes, but the vast majority of the overall tonnage is used to produce bulk tomato paste and diced tomatoes that can easily be shipped and used by food processing facilities around the country and around the world to make the tomato based products that we are all familiar with.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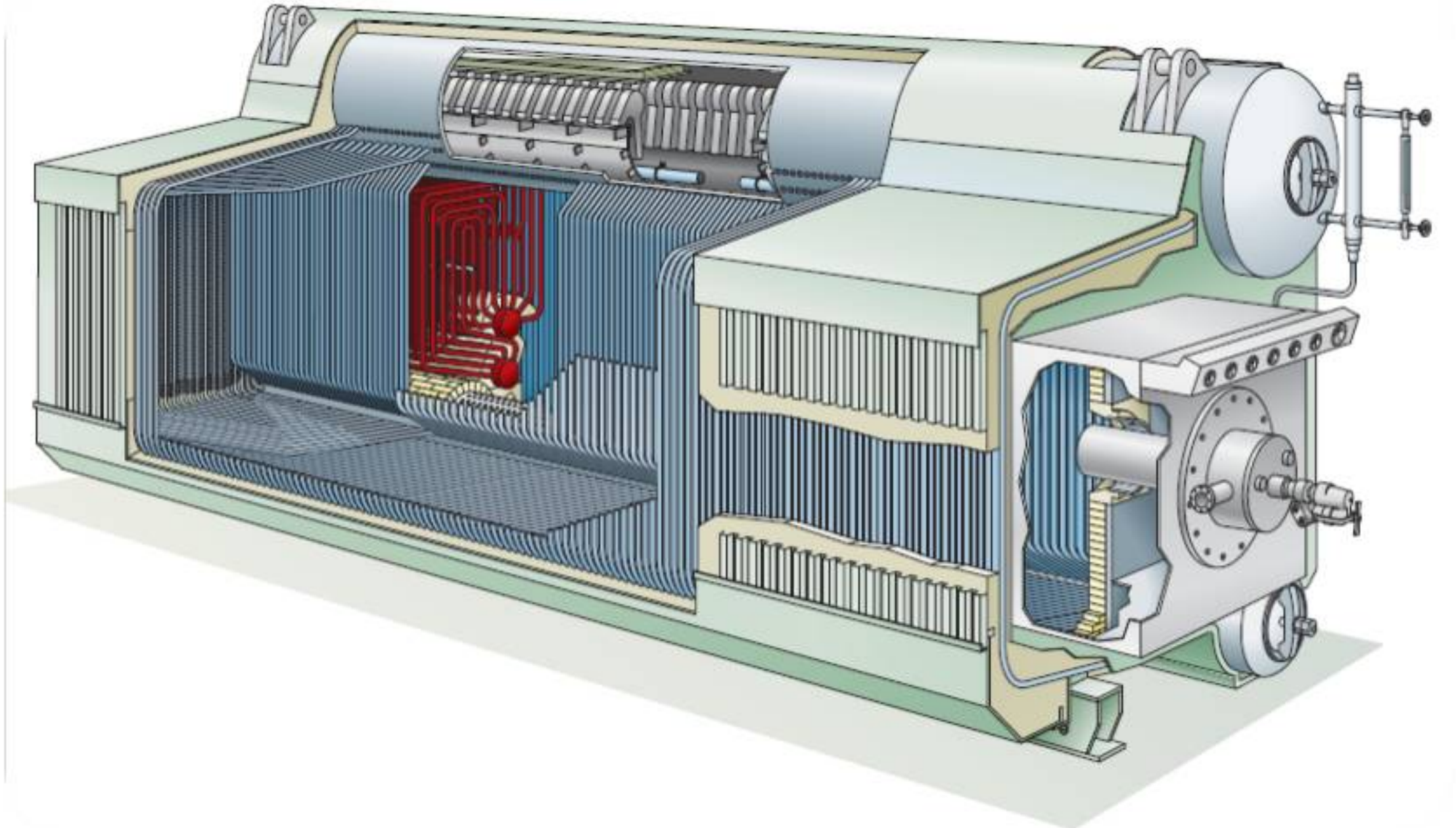
GHG Emissions From Tomato Production

- The processes that produce tomato products, like tomato paste and diced tomatoes, use heat in many steps.
- That heat is supplied by steam, which is created by combusting natural gas in large boilers.
- Making tomato paste requires evaporating water from tomato juice to concentrate the amount of solids from an initial 5% to 30% or more.
- Most tomato processing is aseptic, and steam is used to create a sterile environment. Aseptic products don't require refrigeration during storage and won't spoil.

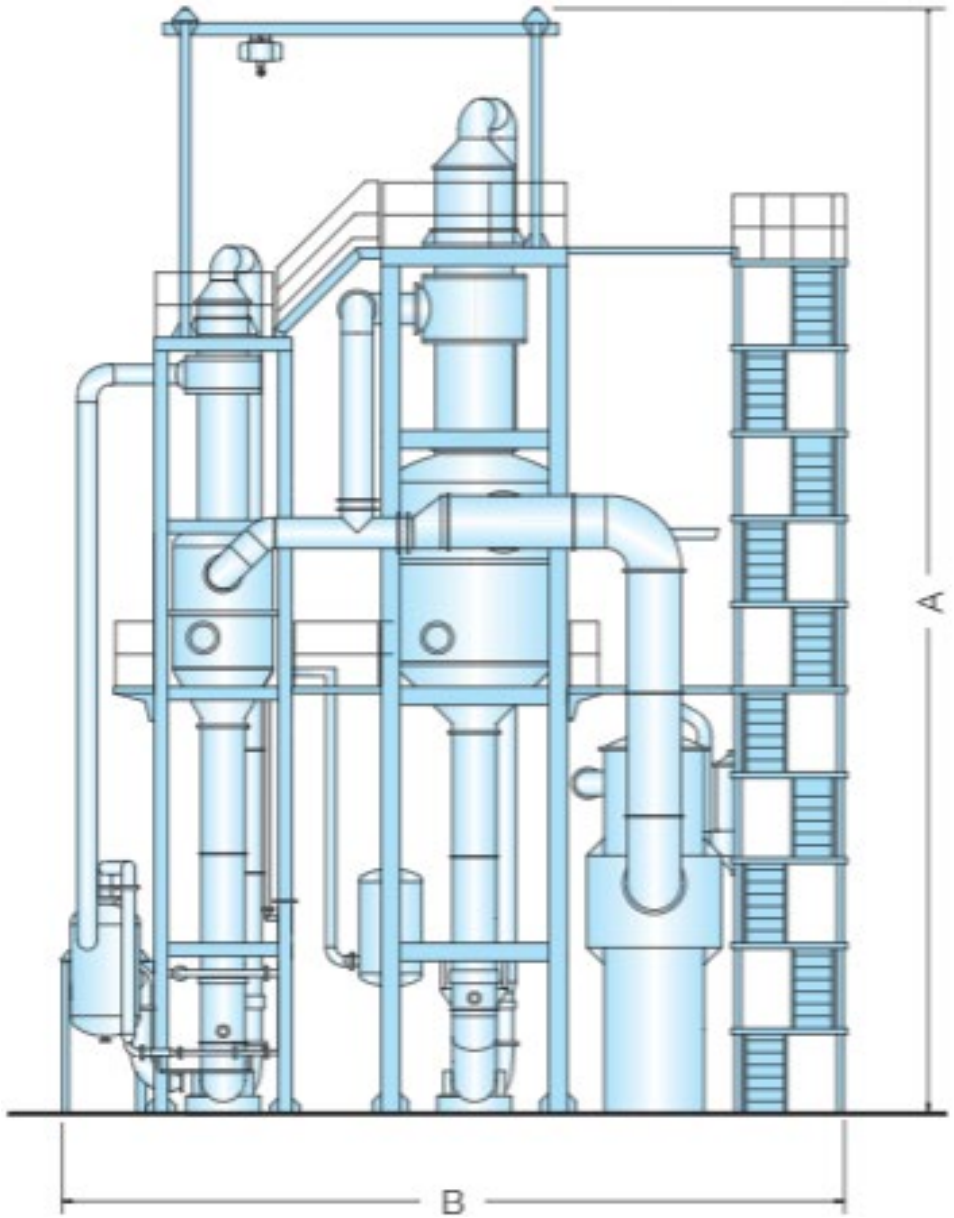
Focus on Energy Efficiency - Boilers

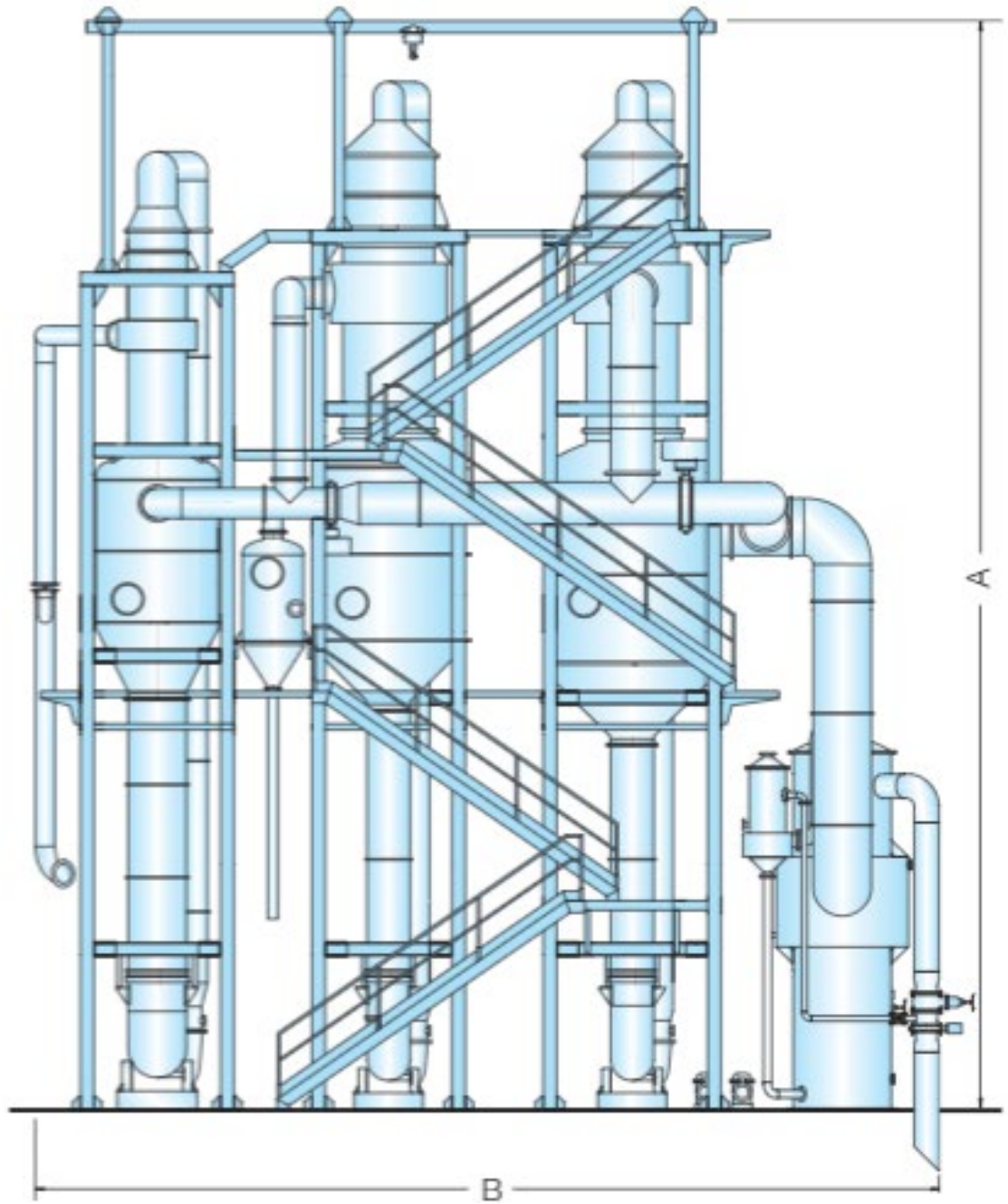
- Boilers are tuned prior to each season to deliver maximum efficiency across a wide range of firing rates.
- Feedwater economizers preheat water entering the boilers with the residual heat from exhaust gases, increasing overall efficiency.
- Returning hot condensate, and even hot tomato evaporate water, to the boilers reduces the need to preheat boiler feedwater.
- Virtually all steam pipes and heat exchangers are insulated to prevent heat loss.



Focus on Energy Efficiency - Evaporators

- Evaporation of water from tomatoes to create tomato paste is a critical process that is also very energy intensive.
- Steam from the boilers is used to drive turbines coupled to large evaporator circulation pumps and vapor compressors. The exhaust steam from these turbines is used to heat the tomato paste in the evaporators, effectively using a large % of the overall energy contained in the natural gas fuel.
- Multiple effect evaporators and Mechanical Vapor Recompression (MVR) evaporators are used to increase the amount of water evaporated for each pound of steam.





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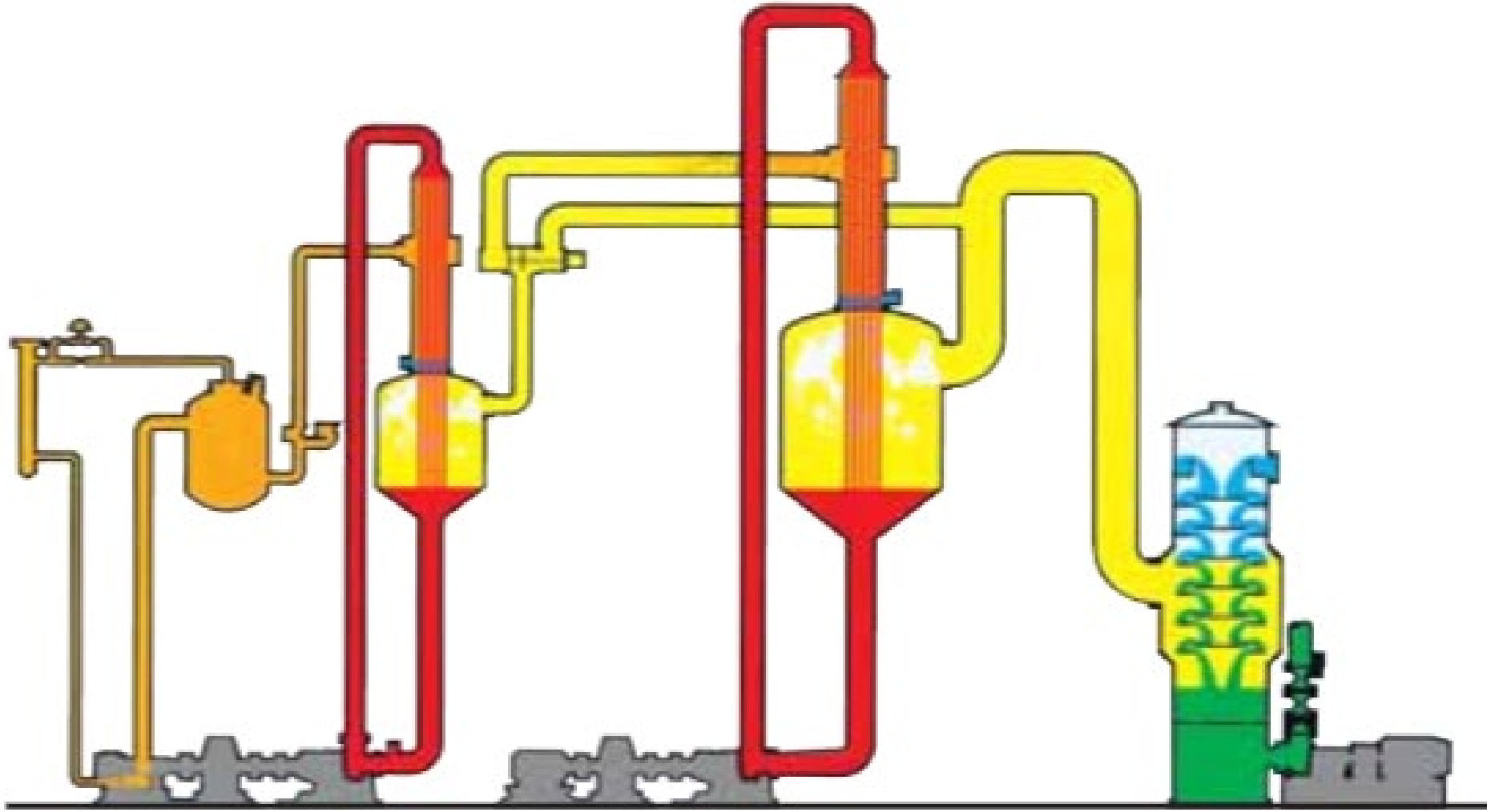
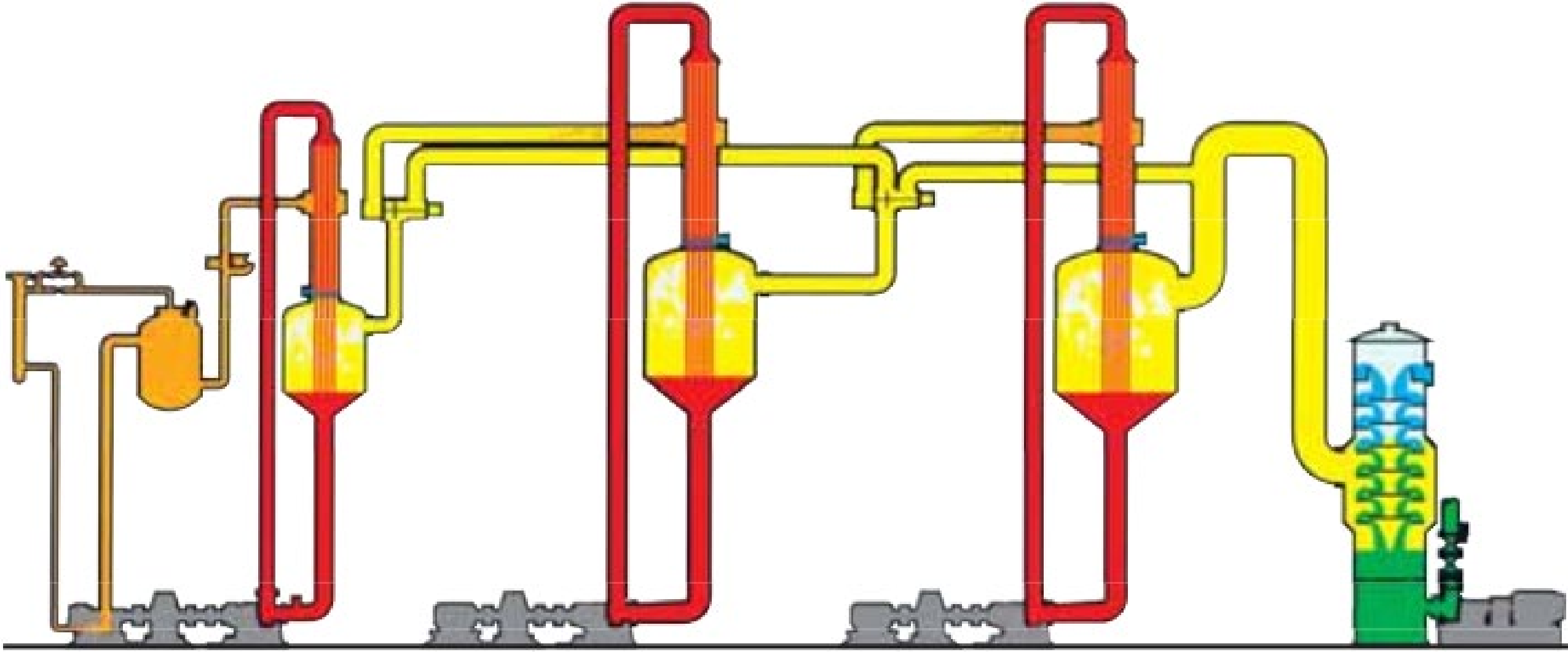
Double Effect Evaporator



Triple Effect Evaporator



Focus on Energy Efficiency – Motors

- Electric motors drive numerous pieces of equipment, including pumps, fans, air compressors, etc.
- Using high efficiency models paired with automated controls and variable speed drives (VSD) helps to minimize electric use, and indirect emissions from electricity generation.
- As the share of renewable electricity grows in California's power mix, the impact of indirect emissions from power is lessened.

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Prospects for Decarbonizing Tomato Processing

- Tomato processing uses processes that have been fine-tuned to maximize efficiency, throughput, and reliability. These are all key factors in controlling the cost of production.
- Because processed tomato products are produced in many areas throughout the world and can be cost-effectively shipped, they are essentially a commodity, and low cost producers are able to gain market share.
- Current alternatives to using natural gas to create the steam for process heat are either much too expensive, or not able to operate at sufficient capacity to be implemented commercially.

Prospects for Decarbonizing Tomato Processing

- Programs investing in innovative technologies are helpful, and may help drive improvements in the economics of processing equipment and techniques that reduce the carbon intensity of the industry.
- The amount of emission reductions required to keep pace with the reductions in the GHG cap will not be able to be met just by incremental efficiency improvements, because most of the "low-hanging fruit" has already been picked.
- Electrification of steam generation would require major investments in electrical infrastructure and electricity costs that are an order of magnitude lower than what they are currently to be competitive.
- If an internationally accepted GHG emission control mechanism is not developed, California producers are likely to be at a competitive disadvantage, leading to emission leakage.

Food Production Investment Program (CEC)

- The Food Production Investment Program uses funds from the Greenhouse Gas Reduction Fund.
- It has two tiers that fund carbon reduction projects in food processing companies.
- Tier I is focused on drop-in energy technologies and Tier II is focused on emerging energy technologies.
- Companies are required to provide a minimum of 35% matching funds for Tier 1 and 15% matching funds for Tier II.
- Awards to Tomato Processors thus far have been for MVR pre-evaporators or electrical micro-grids.

What's the "Next Big Thing"?

- Concentration without evaporation
- Renewable fuels as affordable as fossil fuels and identical in function
- Extremely cheap renewable electricity for electrification
- Solar thermal
- Something else???