Reducing Energy Use and GHG Emissions in California's Food Processing Sector Through Innovative Program Design

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ABSTRACT

California is working to reduce energy use and decarbonize the food processing sector through an innovative grant program. Administered by the California Energy Commission and funded through California's Cap-and-Trade Program, the Food Production Investment Program (FPIP) funds large, capital-intensive energy projects at food processing facilities in California. Since 2018, FPIP has awarded approximately $116 million to over 40 food processing facilities. The goals of FPIP are to accelerate adoption of advanced energy efficiency and renewable energy technologies, demonstrate their reliability and effectiveness, help industries decarbonize, and benefit California's under-resourced communities.

The program awards grants competitively based on GHG emissions reduced and other technical criteria. Grants are provided for conventional, off-the-shelf energy technologies such as energy efficient boilers, evaporators, air compressors, and low global warming potential refrigeration systems, and riskier, emerging energy technologies such as renewable microgrids, solar thermal, and electrification technologies. To encourage adoption of emerging energy technologies which are challenging to implement, FPIP offers larger awards – one of many innovative ways FPIP encourages adoption of new technologies.

This paper provides an overview of California's climate goals, the Cap-and-Trade program, and FPIP program development, successes, and lessons learned dealing with this industry.

Background

California Food Processing

California is the largest food producing state in the U.S., generating a fifth of the country's dairy products, over a third of the country's vegetables, and two-thirds of the country's fruits and nuts (CDFA 2020). Many of these commodities, such as dairy products, nuts, beer, wine, and fruit and vegetable products, require processing before they can be exported or sold. Consequently, California is also the largest food processing state with 6,041 active establishments in 2019 according to the U.S. Census Bureau – more than the next two highest states, New York (2,611) and Texas (2,485) combined. A map illustrating the number of food and beverage establishments by state is provided in Figure 1 below (USDA 2021). Food processing is also a key economic sector, contributing approximately $82 billion to California's economy (CLFP 2015), 192,000 direct jobs (BLS 2021), and 544,000 indirect jobs[1]. However, food processing is also a significant contributor to greenhouse gas (GHG) emissions with

[1] The California League of Food Producers estimates that each job in food and beverage processing generates an additional 2.84 jobs through indirect and induced activity.

approximately 3.3 million metric tons of carbon dioxide equivalent emissions per year (CARB 2020).

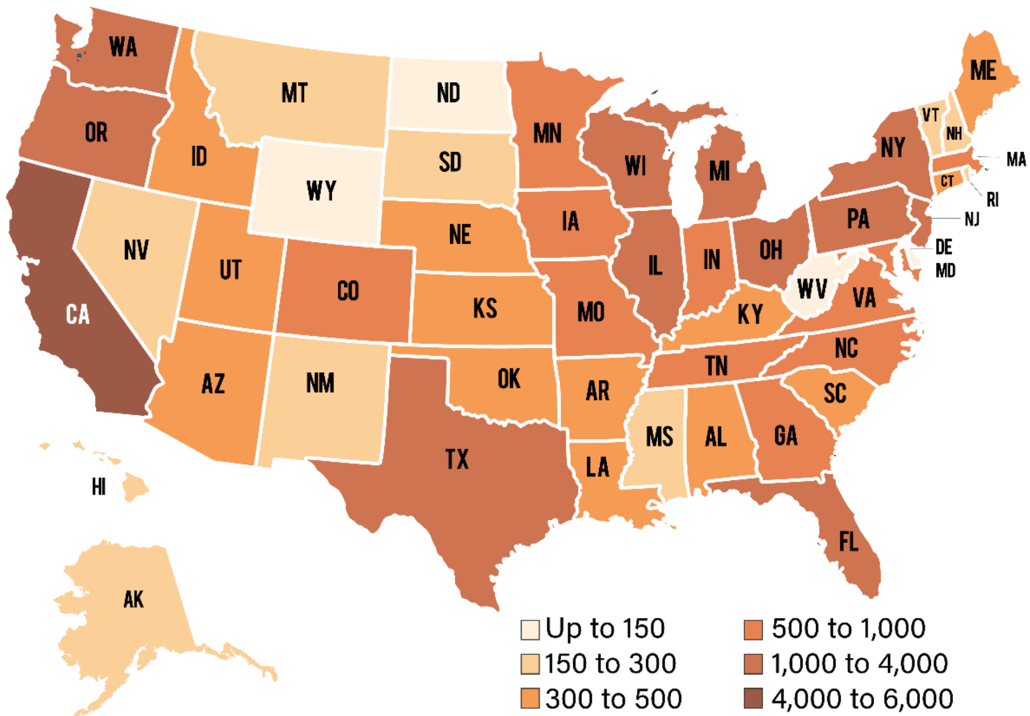

Figure 1: Food and beverage manufacturing establishments, 2019. *Source:* USDA, 2021

Cap-and-Trade and California Climate Investments

In 2006, Governor Schwarzenegger signed Assembly Bill (AB) 32, establishing the first GHG reduction mandate in the nation. AB 32 set a goal of reducing statewide GHG emissions to 1990 levels by 2020 and established California's Cap-and-Trade program. The Cap-and-Trade regulation establishes a declining limit on major sources of GHG emissions throughout California and creates a powerful economic incentive for significant investment in cleaner, more efficient technologies. In the Cap-and-Trade program, "covered entities" are those which emit more than 25,000 metric tons of carbon dioxide equivalent emissions (MT CO2e) annually. This includes industrial facilities, electric generators, and distributors of transportation, natural gas, and other fuels (e.g., utilities). Covered entities are required to purchase emissions allowances from the California Air Resources Board (CARB) at quarterly allowance auctions in order to offset their GHG emissions. Despite only 408 facilities being covered by Cap-and-Trade, these facilities emit approximately 80 percent of the State's GHG emissions (CARB 2021a). Funds collected through Cap-and-Trade auctions are then re-invested into state programs to reduce GHG emissions. This collection and investment cycle is visualized in Figure 2 below.

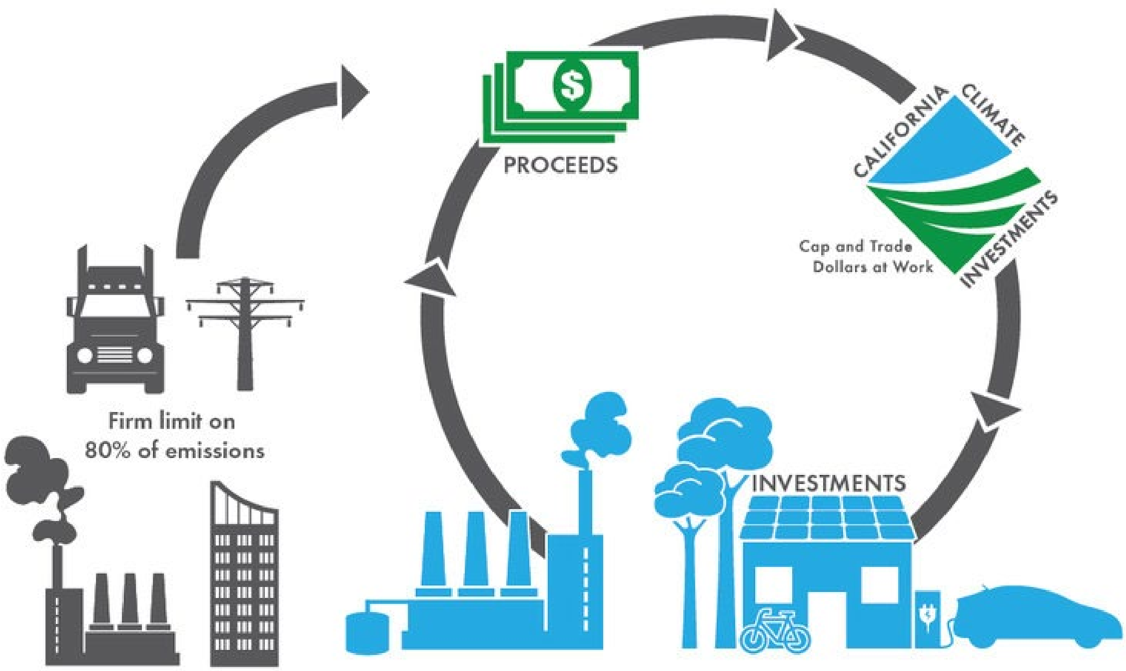

Figure 2: Visual overview of California's carbon pricing and investment cycle. *Source:* CARB, 2021b

California Climate Investments (CCI) is a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment. Over 20 state agencies administer 71 CCI programs – this broad portfolio of programs and projects touches virtually every sector of the economy and spans across California, with an emphasis on disadvantaged and low-income communities. To date, $14 Billion in Cap-and-trade revenues have been allocated to California Climate Investments programs, of which $8.3 Billion has been implemented into GHG reducing projects (CARB 2021b).

Food Production Investment Program Origin and Scoping

Established by the California Budget Act of 2017, with additional funds from the California Budget Act of 2018, a total of $124 million of Cap-and-Trade proceeds were allocated to the California Energy Commission (CEC) to "provide grants, loans, or any financial incentives to food processors to implement projects that reduce greenhouse gas emissions" (Ting 2017; Committee on Budget and Fiscal Review, 2018). This short description eventually developed into the CEC's Food Production Investment Program (FPIP).

In order to flesh out the program beyond this brief description, the CEC engaged in a scoping and stakeholder engagement process from mid-2017 to early-2018. With the help of the California Department of Food and Agriculture, a food processor working group was established which included public agencies, utilities, researchers, trade organizations, and most importantly food producers. A list of the 30 participating organizations is provided in Table 1 below:

Table 1: Food Processor's Working Group

Sector	Organization
Government	California Air Resources Board California Department of Food and Agriculture California Energy Commission California Public Utilities Commission Office of the Governor of California San Joaquin Valley Air Pollution Control District South Coast Air Quality Management District
Utilities	Modesto Irrigation District Pacific Gas and Electric Sempra Utilities Southern California Edison Southern California Gas Company Turlock Irrigation District
Researchers	California Polytechnic State University, San Luis Obispo Lawrence Berkeley National Laboratory University of California, Davis
Trade Organizations	Agricultural Council of California California Cotton Ginners and Growers Association California League of Food Producers West Coast Advisors
Food Producers	California Dairies Campbell Soup Supply Company Foster Farms E&J Gallo Hilmar Cheese Land O Lakes Morning Star Company Pacific Coast Producers Stanislaus Food Products Company The Wonderful Company

Working group meetings allowed CEC staff to engage directly with expert stakeholders and prospective applicants to learn what would make a desirable and effective funding program. This allowed the program to be tailored around the needs of food processors. In addition to working group meetings, public workshops and surveys to food processors were used to gather additional feedback to inform the program's structure. Many of the suggestions proposed during this process, such as bundling multiple technologies and sites into one application and working around the seasonal schedules of food producers, became major facets of the program and are discussed in more detail below.

Program Structure and Innovations

Application and Award Process

In order to receive funding, facilities must first apply to an open grant funding opportunity. Applicants must meet certain eligibility requirements and apply for one or more of the eligible technologies. These requirements and other program features are summarized below.

Applicant Eligibility

Eligible applicants for FPIP are limited to food and beverage production facilities located in California. For the purposed of FPIP, food and beverage production facilities are defined as those with North American Industrial Classification System (NAICS) codes beginning in 311 (food manufacturing) and 3121 (beverage manufacturing). These codes, and their food manufacturing subsector, are summarized below:

Table 2: Eligible NAICS Codes for FPIP Applicants

NAICS 4-Digit Code	Food Manufacturing Subsector
3111	Animal Food Manufacturing
3112	Grain and Oilseed Milling
3113	Sugar and Confectionery Product Manufacturing
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3115	Dairy Product Manufacturing
3116	Animal Slaughtering and Processing
3117	Seafood Product Preparation and Packaging
3118	Bakeries and Tortilla Manufacturing
3119	Other Food Manufacturing
3121	Beverage Manufacturing

Tier System and Eligible Technologies

One of the key innovations of the FPIP program is the tier system. When applying to the FPIP program, applicants may choose to apply for funding in either Tier I: drop-in energy technologies, or Tier II: emerging energy technologies. Tier I funds commercially available energy efficient equipment that are drop-in replacements or additions to current systems and that can result in greater GHG emission reductions and higher efficiency than current best practices or industry standard equipment. Projects must be upgrades or replacements of existing equipment, or additions to existing equipment (e.g., economizers) that will result in GHG emission reductions. Tier II funds cutting edge technologies that are emerging and not widely used in California but have been proven elsewhere to reduce GHG emissions. These projects are not drop-in ready replacements for existing equipment and typically require extensive design engineering (CEC 2019). A list of eligible technologies by funding tier is provided in Table 2 below.

Table 2: List of eligible technologies by funding tier

Tier I	Tier II
Compressors	Solar thermal
Machine drive upgrades	Bioenergy, including biogas production
Mechanical dewatering	Microgrids
Motors and variable frequency drives	Electrification of fossil fueled equipment
Refrigeration system optimization	
Low global warming potential refrigerants	
Drying equipment	
Process equipment insulation	
Boilers, economizers	
Steam traps, condensate return, heat recovery	
Evaporators	
Internal metering and software	
Waste heat to power	
Industrial cooking equipment	

There are key differences between Tier I and Tier II which are summarized in Table 3 below.

Table 3: Comparison of Tier I and Tier II

Funding Parameter	Tier I	Tier I
Grant award size	\$100,000 to \$6 million	\$2 million to \$8 million
Minimum match funding requirement	35% of grant award	15% of grant award
Eligible costs for grant reimbursement	Equipment Measurement and verification	Equipment Measurement and verification Design engineering
Multiple technologies in one application	Allowed	Allowed
Multiple facilities in one application	Allowed	Not allowed

Both tiers provide large grants in which most of the funding (over 90 percent for most grants) is for equipment purchases. Both tiers also allow multiple technologies within the same funding tier to be combined into one application. As noted in table 3 above, match funding is required for all projects and is a percentage of the grant funding requested. The required match funding for Tier I and Tier II is 35% and 15%, respectively. Significantly lower match funding combined with larger award sizes help to mitigate the financial barriers and increased risk of employing emerging technologies. Another significant difference between Tier I and Tier II is the ability to combine multiple sites into one application for Tier I. This allows companies with multiple facilities to streamline their applications.

Focus on Capital Intensive Investments

FPIP focuses on large, capital intensive projects by awarding fewer, but larger grants compared to typical energy incentive programs. In doing so, FPIP accelerates the adoption of technologies which would otherwise take years for facilities to accumulate the funding for. In other cases (especially for Tier II projects), FPIP funding improves economics to the point where payback thresholds are met, thus allowing projects to occur which never would have without grant funding.

Seasonal Schedule

Many California food processors are seasonal, meaning the majority of their operations and energy use occur during a short period of the year. Depending on the crop, seasons typically begin in late spring to early summer and end in late fall to early winter (anywhere between 3 to 6 months). Taking this into account, FPIP applications are due between the last quarter of the yar and the first quarter of the following year. This simple accommodation allows for all food processors to apply to the program, many of whom would be too busy at other times of the year.

Measurement and Verification

Projects awarded funding are required to perform measurement and verification of their energy and GHG reductions. While the preferred measurement and verification method is up to the applicant, it must be robust enough to evaluate and validate GHG emissions and energy reductions at the equipment level and the system or facility level. Most grant recipients employ the International Performance Measurement and Verification Protocol (IPMVP), options A, B, or C (EVO 2021). In order to meet program requirements, the minimum period of measurement is as follows:

- Pre-installation:
    - Year round and seasonal facilities: 3 months pre-installation on the equipment to be retrofit/replaced.
- Post-installation:
    - Year round facilities: minimum 12 months post-installation on the equipment installed.
    - Seasonal facilities: two complete seasons with a minimum 6 months post-installation on the equipment installed.

Measurement and verification must be provided for pre- and post- equipment installation through actual on-site measurements. Energy and GHG reductions are then communicated to the CEC (and later the public) through a series of related reports.

Program Results

Funds Awarded and Projected Emissions Reduction

As of June 2021, FPIP has awarded approximately $116 million in grant funding to 51 projects. A comprehensive summary of awards to date is provided in Table 4 below.

Table 4: Summary of FPIP results to date

	Tier I	Tier II	Total
Funds Awarded	$61,269,291	$54,470,338	$115,739,629
Match Funds	$39,192,421	$21,178,928	$60,371,349
Average Award	$1,571,007	$4,539,195	$6,110,202
Average Match	$1,004,934	$1,764,911	$2,769,845
No. Grant Awards	39	12	51
No. Project Sites	55	12	67
No. Technologies Implemented	101	12	113
Estimated Annual Electric Reduction (kWh/yr)[a]	34,425,741	29,631,419	64,057,160
Estimated Annual Natural Gas Reduction (therms/yr)	21,091,034	2,885,792	23,976,826
Estimated Annual GHG Reduction (MT CO2e/yr)	137,320	26,714	164,034

[a] Projects which increase electric consumption (e.g., mechanical vapor recompression) are not included in this total

Some results worth noting from this table are: 1) average award size for Tier II exceeds Tier I by approximately 3 times; 2) despite approximately equal total funds awarded, estimated GHG reductions for Tier I exceed Tier II by approximately 5 times; 3) match funds committed by recipients greatly exceeds the minimum required – 64% for Tier I (compared to 35% minimum) and 39% for Tier II (compared to 15% minimum); and 4) natural gas reductions have a far greater impact on reducing GHG emissions compared to electric reductions.

Another way to put these numbers into perspective is to compare them to other GHG reduction focused programs. All CCI programs share the same core methodologies and emission factors to predict emission reductions, making them easy to compare. According to analysis by CARB: 1) FPIP is projected to reduce 3.17 million MT CO2e over the life of the projects – the 6th best of all CCI programs; and 2) FPIP has a cost per GHG reduced of $33/MT CO2e – 4th best of all CCI programs (CARB 2021b). This places FPIP in the top 10 out of 71 programs in terms of total GHG reduction and overall cost per GHG.[2]

[2] For all CCI programs, cost per GHG is calculated from state funds awarded. This excludes match funds and other funds required to execute the project.

Project Locations and Facility Types

As of June 2021, FPIP has awarded grant funding to 51 projects. A map of project locations is provided in Figure 3 below.

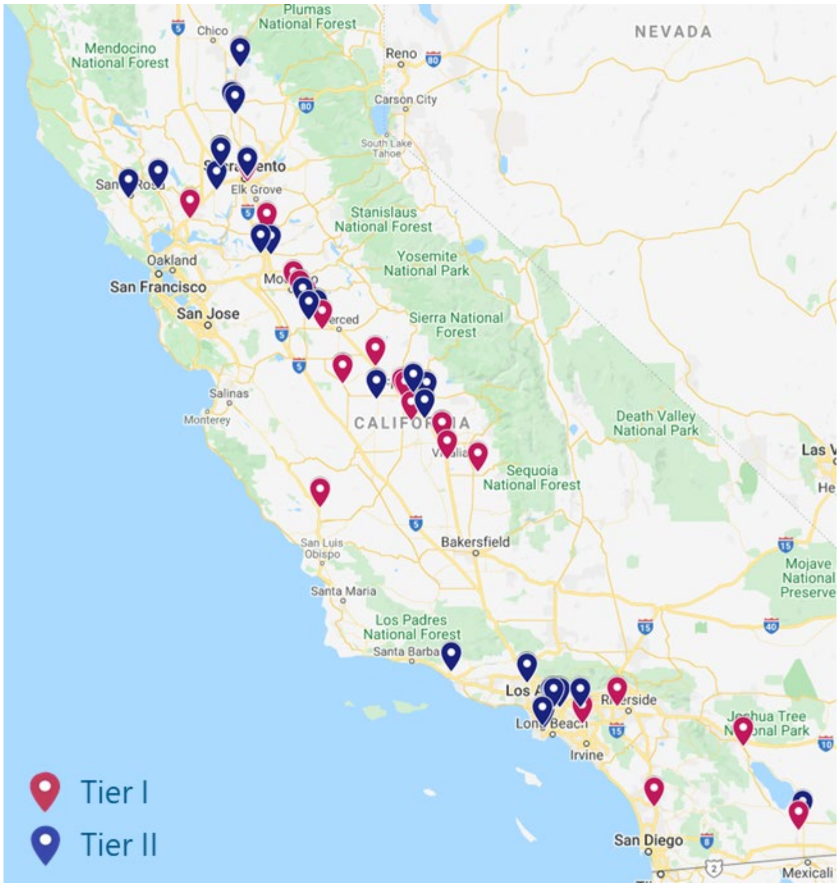

Figure 3: Map of FPIP project locations by tier.

Because facilities may receive multiple grants, there are slightly fewer unique facilities (48) than grant awards (51). FPIP has funded a variety of facility types in locations across the state. A summary of facility types funded is provided in Table 5.

Table 5: Summary of facility types funded

Facility Type	No. Facilities
Prepared Food	11
Meat and Rendering	10
Fruits, vegetables, and nuts	10
Beverage, Brewery, and Winery	7
Dairy Processing	6
Animal feed and ethanol	4
Total unique facilities	48

Geographically, facility locations break down as follows: 10 Northern California, 22 Central California, and 16 Southern California. In addition, 85% of projects are located in disadvantaged and/or low-income communities as defined by CARB (CARB 2018).

Notable Project Types

As outlined in Table 2, FPIP funds 18 eligible technologies – 14 Tier I and 4 Tier II. More than two thirds of Tier I project (28 out of 39) are implementing two or more technologies, for a total of 101 different technologies. For Tier II, each project (12) is implementing a single technology for a total of 12 different technologies. A breakdown of technologies implemented is provided in Figure 4 below.

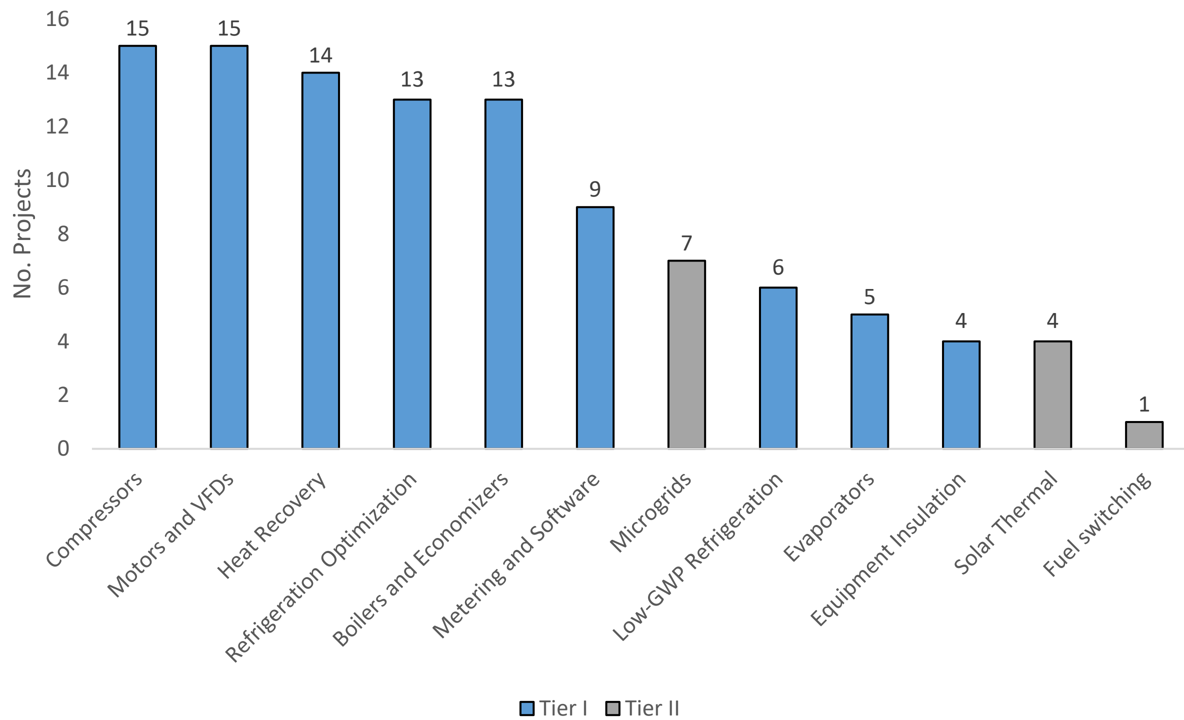

Figure 4: Breakdown of technologies funded.

General energy efficiency. This project type encompasses several Tier I technologies are refers to projects involving retrofit or replacement of existing, inefficient systems with commercially available, energy efficient equipment. The most frequently employed technologies include compressors (15), motors and variable frequency drives (VFD) (15), heat recovery (14), refrigeration optimization (13), boilers and economizers (13), and metering and software (9). Many of these technologies work in conjunction to form one cohesive system. For example, an optimized compressed air system which utilizes VFDs to operate compressors at variable capacity and advanced metering and controls to sequence multiple compressors, allowing them to work in tandem. General energy efficiency projects are often low-risk with high energy saving potential. Despite these strong attributes, many facilities defer these upgrades and continue to maintain and operate aging and inefficient equipment. Often cited reasons for deferring upgrades includes lack of upfront capital necessary to purchase equipment, especially recently due to COVID, or projects not meeting strict payback thresholds required (typically 2-3 years) for internal approval (various food producers, pers. comm.).

General energy efficiency projects are responsible for approximately 40 percent of GHG emission reductions in FPIP. Cost effectiveness ranges widely from as low as $7.48 to $232.87 per metric ton due to the large variety of technologies included in this project type.

Mechanical vapor recompression. This project type refers to a specific and highly efficient evaporator technology called mechanical vapor recompression (MVR). Four of the five evaporator projects in FPIP are employing MVR systems. In MVR, the heat source for the evaporation is the steam generated by the evaporation itself. After compression to a slightly higher pressure by a fan or a centrifugal compressor, the steam has a higher condensation temperature and is used to drive the evaporation. Thus, in an MVR evaporator the high energy content of the steam (its "latent heat") is entirely recovered, resulting in very high energy efficiency. In one case study, an MVR system required only 11% of the steam energy consumed by a triple effect evaporator using the same amount of water, excluding auxiliary power consumption (PG&E 2008).

MVR systems are responsible for approximately 29 percent of GHG emission reductions in FPIP and are one of the most cost effective project types, with cost per GHG ranging from $10.88 to $24.28 per metric ton.

Low-global warming potential refrigeration. This project type involves replacement of existing, high-global warming potential (GWP) refrigeration systems with refrigeration systems that use refrigerants with a GWP of less than 150. This is achieved by using natural refrigerants, which for FPIP is primarily low-charge ammonia (GWP of 0) and transcritical CO_2 refrigeration systems (GWP of 1). These systems significantly reduce emissions associated with leakage of high-GWP refrigerants and are highly energy efficient – especially at very low temperatures.

Low-GWP refrigeration systems are responsible for approximately 14 percent of GHG emission reductions in FPIP. Cost effectiveness ranges from $11.62 to $76.25 per metric ton. This cost is driven mainly by the GWP of the refrigerant being replaced which typically ranges from 1500 to 4000 GWP.

Microgrids. This project type refers to the installation of a renewable energy microgrid which provides electric generation and resiliency to the host facility. For the purposes of FPIP, microgrids were defined as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. Additionally, a microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. Finally, microgrids can also manage customer critical resources and provide the customers, utilities and grid system operators different levels of critical services and support as needed."

Microgrid systems are responsible for approximately 14 percent of GHG emission reductions in FPIP, driven by the renewable energy generated by solar PV systems. Cost effectiveness ranges from $35.61 to $169.92 per metric ton.

Solar thermal. This project type involves installation of solar thermal energy systems which provide thermal energy for process heating or cooling loads. Solar thermal systems collect and concentrate heat from the sun and transfer it to a working fluid. This fluid could be an intermediate heat transfer fluid, such as a mineral oil, or simply water. The heat collected can then be applied to thermal loads (e.g., used to pre-heat boiler feedwater, pre-heat air for a drying system, or converted directly into steam).

Solar thermal systems are responsible for approximately 2 percent of GHG emission reductions in FPIP. Cost effectiveness ranges from $249.71 to $344.36 per metric ton. These numbers may be weak compared to other project types, but it should be noted that the high-temperature solar thermal systems funded are the least mature of the technologies funded in FPIP. In addition, these systems target the decarbonization of process heating loads, atopic in which other decarbonization options (e.g., electrification, hydrogen) are also high cost and low maturity.

Barriers and Lessons Learned

Implementation of FPIP resulted in certain barriers encountered and lessons learned along the way, summarized in the sections below.

Hesitance and low initial program uptake. Implementing an effective public program is no easy task, especially when prospective applicants are hesitant to engage in the process. This was especially true for FPIP where many food producers were unfamiliar with applying to government grant programs, or in some cases avoided them altogether due to poor experiences with previous incentive programs (various food producers, pers. comm.). In order to build a program for a specialized industry such as food producers, trust had to be built first. Involving as many food producers, technology vendors, and other related organizations as possible early in the program through working group meetings and public workshops was critical to building this trust. Taking feedback received from the food producers and implementing their suggestions into the program further built this trust.

In addition, initial uptake of the program was low. It took some initial successful applicants for the program to really take hold. In the program's first funding year, approximately $82 million was requested by applicants. By the second funding year, requested funds more tan doubled to approximately $178 million. To date, approximately $269.5 million has been requested for funding compared to $117.8 million available for grants. A chart of funds requested for each funding opportunity is presented in Figure 5 below.

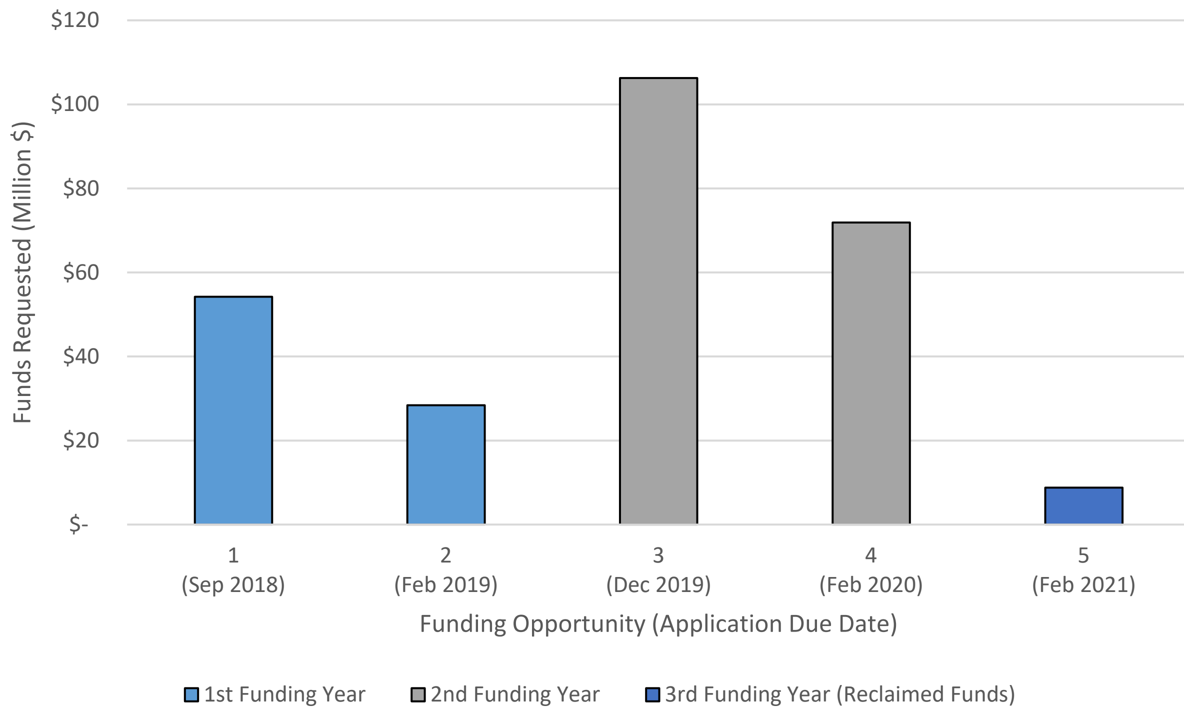

Figure 5: Amount requested for each funding opportunity

COVID-related hurdles. In 2020, food processing facilities were heavily impacted by the COVID-19 pandemic with many impacts still present today. Some of the most notable early impacts which affected implementation of FPIP included: 1) forced closures due to facility outbreaks; 2) limited to no site access for third party contractors such as equipment installers; 3) longer lead times and higher prices for all varieties of equipment; 4) lack of capital for energy projects due to funds spent on worker protection; and 5) significantly decreased revenues due to lower production or lower demand. Some notable long-term impacts still present today include: 1) high global shipping costs which have severely reduced food and ag exports; 2) significantly lower demand for food service products; 3) significant market changes or lower demand for certain products (e.g., milk) which may never recover to pre-pandemic levels.

These impacts affected the entire food processing industry and put most FPIP projects on standby as a result. Flexibility and accommodations for FPIP grant recipients has been critical to ensuring that most projects can still progress. Examples of accommodations made include: 1) extending the term of the grant agreement; 2) substituting or removing equipment from the project, so long as GHG reductions are not heavily impacted; 3) allowing for equipment to be installed in “phases” over two or more years; and 4) providing extra assistance related to project deliverables. Despite these accommodations some facilities still cancelled their projects, mainly due to lack of capital. Fortunately, funds from cancelled projects were able to be reclaimed, re-issued, and awarded to new recipients in early 2021.

Lessons Learned

Funding can accelerate progress toward GHG reduction goals. By providing large grants for capital intensive projects, FPIP significantly accelerates the adoption of decarbonization technologies. Even for projects with good payback, it would take years for most facilities to accumulate the capital funding required to do the projects. By providing grant funding, several years' worth of projects can be done simultaneously, accelerating GHG reductions and investment in decarbonization technologies.

Large grants provide the catalyst needed. Most food processing facilities are constrained by both capital budgets and strict payback thresholds. Therefore even if capital is available, project cannot be approved internally without a good return on investment (ROI). This is especially challenging for emerging technologies which have challenging ROI. In many cases, grant funding improves ROI just enough that facilities can invest in emerging technologies that would otherwise have long paybacks.

There is a need to support both commercially available and emerging technologies. Through its tier structure, FPIP is able to support climate goals by providing both near term GHG reductions and proving out next generation technologies. While Tier I GHG reduction numbers are significantly larger than Tier II, it is important to remember that these projects are focused on energy efficiency. However, no amount of efficiency for fossil fueled equipment will meet California's long-term carbon neutrality goals.

Conclusions

Through careful program design and a large infusion of funds, FPIP has demonstrated that it is possible drive down GHG emissions and accelerate adoption of emerging technologies in the food processing industry. This was achieved, first and foremost, by listening to the needs and concerns of the food processing industry first, then tailoring a program to those specific needs. In doing so, the program structured itself for successful applicants and projects and built trust with its applicant base. FPIP projects are projected to reduce GHG emissions by over 3 million MT CO2e while proving out best-in-class and emerging energy technologies. FPIP's successes and lessons learned are a testament to what can be achieved through effective public-private partnership and could inform GHG reducing programs going forward.

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