Improving Energy Use and Productivity

in West Coast and Alaskan Seafood Processing Plants

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Abstract

In the summer of 1999, a team of engineering faculty and students from Oregon State University performed assessments at 10 seafood processors in Alaska, Oregon, and Washington. Goals were to increase energy efficiency, reduce waste, and improve productivity. This report is a summary of recommendations and common issues found in these plants.

The assessment team identified annual savings of approximately $4.4 million in the energy, waste, and productivity areas. Total implementation cost was estimated to be $5.0 million for an average 1.1-year simple payback of investment. Energy cost savings were approximately $1.4 million with a $2.2 million implementation cost and 1.6-year simple payback. Productivity cost savings were approximately $2.9 million with a $2.7 million implementation cost and 0.9-year simple payback. Waste cost savings were approximately $85,000 with a $54,000 implementation cost and 0.6-year simple payback. Costs and savings were significantly higher in the Alaskan plants because of higher electricity costs and four electrical generation recommendations that were not economically feasible in the Northwest.

Recommendations included electrical generation, refrigeration system efficiency, process automation, equipment efficiency, and water use reductions. Details of these recommendations and common issues are included in the report.

Introduction

The seafood processing industry is facing rising energy costs, competitive markets, and increasing environmental regulations and waste disposal and treatment costs. Because resources and markets are increasingly global, seafood processors must compete with other processors throughout the world for both catch and sales. Each seafood processor uses and must dispose of tens of millions of gallons of water per year. Because up to 75% of seafood catch can be unused waste or by-product, and because pumping waste to sea is problematic, the industry must find markets or new means of dealing with this waste. To remain profitable, processors in the seafood industry must be efficient in their use of energy, labor, water, and catch.

In the summer of 1999, faculty and engineering students from Oregon State University assessed 10 seafood processing plants in Oregon, Washington, and Alaska. The teams also included one student from the University of Alaska. The Oregon and Washington (Northwest) assessments were conducted as part of the U.S. Department of Energy's (USDOE) Industrial Assessment Center (IAC)[1] program at Oregon State University. The Alaskan assessments were funded by the Alaska Energy Authority (AEA)[2] and USDOE's Rebuild America Program, with support from Oregon and Alaska Sea Grant. Representatives from AEA, local utilities, and the Alaska Marine Advisory program participated in the Alaskan plant visits. This report summarizes recommendations and common issues found in these plants.[3]

The assessment team visited each plant for one day to tour the facilities, observe operations, and collect data on plant operation and equipment. In the weeks following the assessments, engineering students researched ideas for increasing energy efficiency, reducing waste, and improving productivity for each plant and prepared reports on equipment and methods to improve efficiency.

Plant Information

Five of the plants were located in Alaska, two in Washington, and three in Oregon. Alaskan and Northwest plants averaged approximately the same production. Sales and number of employees were double in Alaskan plants because fish processed in Alaska (salmon, halibut, and cod) involve more hand labor and typically have higher market value than the Pacific whiting, bottomfish, and surimi seafood processed in the Northwest plants studied. Number of employees, production, and sales are summarized in table 1.

Table 1. Number of Employees, Annual Production, and Sales in Seafood Plants

	Employees			**Production (million lbs/yr)**			**Sales ($million/yr)**		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Alaska	75	306	211	9.7	18	13.6	17	44	27.7
Northwest	50	200	100	4.8	18.2	13.2	4	30	13
Total	50	306	156	4.8	18.2	13.4	4	44	20.3

Plant daily operating hours varied widely, depending on species processed, fishing seasons, and catch. All plants are seasonal. They often work around the clock during peak fishing seasons and can be shut down for days or weeks at a time when there is nothing to process.

The seafood processors we assessed performed one or more of the following operations:

- In a whole-fish operation, fish are shipped to market, fresh or frozen, whole or with the head, guts, and/or gills removed. Four of the Alaskan plants shipped whole or headed and gutted ("dressed") fish.
- In a filleting operation, fish are cut into skinless, and often boneless, portions called fillets. For smaller fish, this is often done mechanically and for larger fish, usually by hand. The fillets are then inspected for defects, sometimes frozen, and

packaged for market. All five Alaskan and two Northwest plants produced fillets.

- In a canning operation, fish (exclusively salmon) are cut into pieces either mechanically or by hand. For some products, the skin and bones are removed while for other products they are not. The pieces are placed in cans with weights ranging from about 6 ounces to 4 pounds. Most cans are filled and weighed mechanically, but larger cans are sometimes filled by hand. The cans are sealed, cooked in steam chambers called retorts, cooled, labeled, and shipped to market. Three of the Alaskan plants canned salmon.
- In a roe operation, eggs are removed from fish (usually salmon but other species as well), washed, soaked in brine, and packaged fresh or frozen. There are many roe products with specific processes and ingredients. All five of the Alaskan plants processed roe.
- Shrimp are cooked, shelled, washed, and inspected. They can then be packaged and shipped either fresh or frozen. Four of the Northwest plants processed shrimp.
- Crab is shipped either whole fresh, or cooked, butchered, and frozen. Four of the 10 plants processed crab.
- In the surimi process, Alaskan pollock or Pacific whiting are sorted, gutted, and mechanically filleted and sometimes skinned. The fillets are then minced, washed, and screened to remove bones and impurities. Then sugars are added to protect proteins during storage. The resulting mixture, called surimi, is formed into 10-kilogram blocks, frozen in plate freezers, and shipped. The blocks of surimi are an intermediate product used in other processing plants to produce other seafood products. Five of the 10 plants had surimi operations.
- Surimi seafoods are one family of food products made from surimi. One common surimi seafood is known as “imitation crabmeat” in the U.S. and as “crab-flavored seafood” throughout the world. In this process, frozen blocks of surimi are thawed and mixed with salt, color, crab extract, and other ingredients. The solubilized protein paste is then sent through an extruder, cooked, cut and formed in various ways, vacuum packaged, pasteurized, water cooled, frozen, boxed, and shipped. Two of the Northwest plants made surimi seafoods.

The Alaskan plants typically processed halibut, cod, Alaskan pollock, various species of salmon and rockfish, and other species. The Northwest plants typically processed Pacific whiting, bottomfish, crab, and shrimp.

All of the processes are different and use energy, labor, and water in different ways. For a plant using more than one process, it is difficult and often impossible with existing information to quantify and differentiate energy, labor, water, and waste streams between processes. This is because the processes usually have common electric and water meters, lights, labor, and equipment such as forklifts and conveyors, refrigeration compressors and condensers, freezers, cold storage spaces, and boilers.

Energy Use and Costs

In the 10 plants, total costs of energy (electricity, fuel oil, and propane) varied significantly between 1.2% and 3.9% of annual sales with an average of 2.2 percent. Average energy costs were 2.6% of sales in Alaska and 1.7% in the Northwest. Energy costs per pound of finished product varied between 0.6 and 6.8 cents per pound, averaging 3.3 cents per pound for the 10 plants, 4.8 cents per pound in Alaska, and 1.7 cents per pound in the Northwest. There is considerable variance in these statistics, partly because different processes use different amounts of energy (for instance, frozen fish processing uses more energy than fresh fish processing). We were unable to gather enough information to separate energy cost by product category. In addition, the industry is competitive, and several processors were reluctant to provide accurate production and sales figures. Therefore, we believe that the wide ranges of energy cost per pound, from 0.6 cents to 6.8 cents, and energy use per pound, from 700 to 4,200 Btu (electricity and other fuels combined), are partially due to process differences, but also to uncertainty of the production information.

The average cost of electricity for plants in Alaska is more than three times that for plants in the Northwest. Propane, used primarily for forklifts, costs twice as much in Alaska as in the Northwest. Furthermore, natural gas was not available to any of the plants visited in Alaska, so oil, which costs slightly more per Btu than natural gas, is used for boilers there. Because energy costs are generally higher in Alaska, savings predicted from conservation measures are greater. However, in general, many measures were recommended for Alaskan plants, but not for Northwest plants, because they had shorter—and thus more acceptable—payback periods. Average annual energy uses and costs are summarized in table 2.

Energy Recommendations

Projected total energy cost savings from recommendations were $1.4 million per year, averaging $261,500 per year per plant in Alaska and $19,000 per year per plant in the Northwest. The difference between projected savings in Alaska and the Northwest was due primarily to self-generation recommendations that currently are not feasible in the Northwest, and secondarily to higher

Table 2. Average Annual Energy Use and Costs for 1999 Assessments

Area:	Alaska	Northwest
Electricity (incl. Demand and Fees)		
Average Use	3.41 Million kWh (11,640 Million Btu)	3.34 Million kWh (11,410 Million Btu)
Average Cost	$0.14/ kWh ($41.40/Million Btu)	$0.05/kWh ($13.40/ Million Btu)
Fuel Oil (#2 or #6)		
Average Use	157,000 Gallons (22,446 Million Btu)	
Average Cost	$0.77/Gallon ($5.39/Million Btu)	
Natural Gas		
Average Use		102,190 Therms (10,219 Million Btu)
Average Cost		$0.48/Therm ($4.76/Million Btu)
Propane*		
Average Use	10,018 Gallons (918 Million Btu)	3,907 Gallons (358 Million Btu)
Average Cost	$2.49/Gallon ($27.18/Million Btu)	$1.15/Gallon $12.61/Million Btu)
Total		
Average Use	33,502 Million Btu	21,778 Million Btu
Average Cost	$18.71/Million Btu	$9.56/Million Btu

**Based on all data from four Alaskan and two Oregon plants.*

energy costs that increase the number and type of recommendations that are feasible.

Below, we present recommendations by type, number of times recommended, and total savings and implementation costs. We also include the number of times each recommendation was implemented and total implemented savings. We collected implementation results at meetings or phone calls with plant personnel within 6 to 12 months after the report was received. We were unable to reach one Alaskan plant for implementation results.

Implementation depends not only on technical and economic merit, but also on the state of the industry and magnitude of the investment. The seafood processing industry considered in this study depends on the availability of and world market for publicly owned natural resources (seafood). These depend on climate, weather, resource and environmental regulations, market, and other conditions. The current state of the industry is uncertain and one investment criterion is generally to return cost in one year or less. As always, capital investments require longer to plan and budget.

Improve Power Factor

Total power is made up of two parts: real and reactive. Real power does the useful work. Reactive power, which is the power needed to excite the magnetic field of an induction motor or other inductive load, does no useful work and does not register on a real-power meter. But it does constitute an energy loss by contributing to the heating of generators and transformers. Power factor is the percentage of total power that is real. Utility companies often charge for low power factor. We recommended adding capacitance to correct for low power factor in five plants. Although there are no significant energy savings for the plants, there are cost savings.

Annual projected savings in reactive power charges range from $1,000 to $6,000 per year per plant and pay back implementation costs in two to three years. Only one plant implemented this recommendation, others being reluctant because of long payback periods.

Self-Generation

Much of the cost savings projected for Alaskan plants was from self-generation. We recommended installing diesel generators to produce electricity rather than purchasing it from the local utility company. While self-generation saves money, there are no on-site energy savings unless waste heat from diesel generators is recovered to use in other processes, such as preheating boiler feedwater. The Alaskan plants we assessed pay an average of $0.142/kWh (including demand and fees) for electricity purchased from their utility companies. We determined that most plants could purchase diesel generators to generate their own electricity for about $0.068/kWh at the 1999 average cost of $0.81 per gallon for diesel oil. This assumes a generator efficiency of 35% and includes maintenance and engineering costs but not permits, utility negotiation costs, higher costs for backup electricity, or payments and interest on the initial capital investment of over $500,000. We recommended further study before implementation to include these significant additional costs and to further refine savings estimates based on more detailed energy load profiles.

The assessment teams recommended self-generation to four Alaskan plants to save an average of $260,000 per year with a simple payback of about two years. Recovering waste heat from the generators, which depends on matching heat requirements and generator load, can further increase total cost savings. Note that we recommended self-generation instead of "cogeneration," a process that makes maximum use of waste heat while generating electricity. Most plants did not have a good match between electricity and heat loads. Steam is used primarily for canning. When not canning, most steam produced from cogeneration would be wasted. In general we found that heat recovery is economical when there are concurrent applications for waste heat.

Net energy use at each plant increases significantly with electrical generation because generators use about three times as much fuel energy as the electrical energy they produce (~35% efficiency). We calculated annual cost savings as electricity cost savings minus generator fuel and maintenance costs. However, we neglected the approximately 77,000 10^6 Btu of increased fuel use at the four plants because it would have greatly overshadowed the energy savings from all other recommendations. We can justify neglecting site energy increase in part because total electrical system energy use, including utility generation and distribution system efficiencies, should be comparable to site generation, without heat recovery. These were not implemented to date, because of complexity of regulations, likely changes in purchased energy costs that would need to be negotiated, and a 1.8-year payback.

Premium Efficiency Motors

In all five Alaskan plants, we recommended replacing selected standard motors with premium efficiency motors rather than rewinding when a motor needs servicing. More efficient motors will do the same amount of work for less energy. This recommendation would save an average of $13,000 per year per plant. Selected premium efficiency motors pay for the incremental cost over rewinding in an average of 1.6 years. Had premium efficiency motors been recommended in Northwest plants, average payback period would have been closer to four years due to lower electricity costs. Premium efficiency motors are generally installed as policy when existing motors fail.

Refrigeration

Refrigeration equipment operated primarily freezers, cold storage, chillers, and icemakers and used 65 to 85% of the electricity in the processing plants. We recommended reducing the minimum discharge pressure setpoint on the high-stage compressors in 9 of the 10 plants visited. Compressors require less power to compress refrigerants to lower head pressures. Reducing discharge pressure would save an average of $15,900 per year per plant in energy costs. Discharge pressure is regulated by condenser fan controls. Resetting fan switches to reduce minimum discharge pressure costs nothing, but there are sometimes additional costs to add condensing capacity or to modify the defrost system. We also recommended adding adjustable speed drives to blast freezer or condenser fans, replacing natural convection (flooded) ceiling coils in cold storage rooms with fan-driven evaporators, increasing low-stage suction pressure to increase efficiency, and switching from a single-stage to a two-stage refrigeration system. Recommendations to modify controls or setpoints were implemented at a higher frequency than capital improvements, such as converting to a two-stage refrigeration system.

Boilers

Boilers provide steam for cooking crab and shrimp, cooking and pasteurizing surimi seafoods, sterilizing canned foods in retorts, heating the workplace, and cleanup. We recommended tuning boilers in five plants to optimize the combustion air/fuel ratio. Fuel cost savings average $2,500 per year, depending on boiler use. With a tuning cost of about $700 per plant, this usually pays back in less than one year. We also recommended consolidating loads to one boiler, reducing boiler pressure, installing stack gas heat exchangers to preheat feedwater, and returning condensate to the boiler. Boilers were tuned to improve efficiency at relatively low cost, although more expensive recommendations to recover heat or to return condensate were implemented less frequently .

Lights

Lighting uses between 4 and 8% of the electricity in plants we visited. We recommended replacing incandescent and standard fluorescent lights with high efficiency fluorescent lights in two plants. Lighting was replaced at one plant.

Other Energy Recommendations

We recommended changing a natural gas rate schedule in one plant and consolidating electric meters in another to save on utility charges. We also recommended replacing a heated shrink-wrap machine with an automated stretch-wrap machine to save energy.

Other energy uses are vacuum pumps for transporting fish and air compressors. A vacuum pump and tubing is often used to transport whole fish from the hold of a fishing boat to holding tanks or production lines. This operation uses 1 to 5% of a seafood plant's electricity. Compressed air is typically used to control sorting, processing, and packaging equipment. Energy used to compress air in a seafood processing plant is typically less than 1% of total electricity use. Therefore we found little potential for energy savings in vacuum pumping and air compression.

Table 3. Energy Saving Recommendation Summary for 1999 Assessments

	Recommended					Implemented	
Recommended	**No. of Recs**	**Savings (10^6 Btu)**	**Total Savings**	**Implement Cost**	**Payback (years)**	**No. of Recs**	**Total Savings**
Tune Boiler	5	2,342	$12,519	$3,300	0.3	5	$12,519
Boiler Efficiency Improvements	5	7,391	$23,600	$6,050	0.3	2	$17,350
Reduce Discharge Pressure	9	4,793	$142,874	$32,750	0.2	6	$115,302
Refrigeration System Efficiency	3	2,891	$50,690	$105,000	2.1	1	$18,500
Improve Power Factor	5	0	$11,610	$26,200	2.3	1	$1,621
Self Generation*	4	0	$1,048,384	$1,872,030	1.8	0	$0
Premium Efficiency Motors	5	1,745	$65,343	$106,912	1.6	4	$53,685
ASD Drives	3	401	$11,790	$46,700	4	0	$0
Automated Stretch-Wrap Machine	1	117	$4,055	$15,400	3.8	1	$4,055
Replace Incandescent Lamps	2	112	$4,419	$6,889	1.6	1	$661
Utility Service Schedules	2	0	$27,607	$10,000	0.4	0	$0
Total	44	19,792	$1,402,891	$2,231,231	1.6	21	$223,693

**Self-generation without heat recovery is projected to save an average of 3.2 million kWh but use an average of 215,200 gallons of #2 diesel per plant, at a projected generator efficiency of 35 percent. Annual savings are electricity cost savings minus generator fuel and maintenance costs.*

Productivity Recommendations

Projected annual savings associated with productivity recommendations totaled $2.7 million, averaging $419,000 per year per plant in Alaska and $161,000 per year per plant in the Northwest. Productivity recommendations vary from plant to plant and save money by automating or updating equipment to improve or increase product flow, improve product yield, reduce labor costs, or reduce downtime. Most productivity recommendations require capital investment to replace existing equipment or to automate processes. Savings were significant and paybacks relatively short, but only 25% of the productivity recommendations have been implemented to date.

Machine Vision Sorting

Fish fillets must be inspected for size and shape, attached skin, bones, bruises, off-color flesh, and parasites. Defects must then be corrected by trimming. This is a labor-intensive—and thus expensive—process. We proposed inspection equipment that uses machine vision technology to automatically inspect and sort fillets, diverting fillets that need trimming. We recommended installing this equipment in three Alaskan plants to reduce labor costs for inspection. Implementation cost is between $200,000 and $280,000 per plant, averaging $245,000. Projected labor savings varies from $65,000 to over $500,000 per year for each plant. Simple payback ranged from one-half to three years, with an average of 1.0 year. None have been implemented to date because of high cost and the uncertainty of an emerging technology.

Automated Packaging

We proposed equipment to automate weighing and packaging of cans, fillets, and shrimp. This equipment included automated can fillers for production lines currently filling cans by hand, an automated portioning machine to cut fillets before freezing, automated shrimp and fillet baggers, case erectors to automatically build and bottom seal boxes for packaging, and scan graders to automatically weigh product and to fill and label boxes. This equipment is on the market and can be customized, if necessary, to meet customer requirements. In six recommendations, average savings were projected to be $185,000 per year with an average implementation cost of $171,000. Most of these recommendations would pay for themselves in one year. Only one recommendation has been implemented to date, general reluctance being due to high initial cost.

Other Productivity Recommendations

We recommended automating process equipment to save labor and increase product yield. These recommendations include installing a new can filler to eliminate production bottlenecks, replacing an old salmon header with a newer, more precise model to decrease the amount of usable meat removed with the head, and automating salmon gutting because manual cleaning is labor intensive and expensive. We also recommended modifications in the processing areas to reduce labor. These modifications included using labor more efficiently on the canning line and adding conveyor systems and other equipment to improve product flow.

Other productivity recommendations included improving the wastewater drain system to reduce downtime and replacing a cryogenic spiral freezer with a freezer refrigerated by the ammonia vapor-compression system.

Table 4. Productivity Recommendation Summary for 1999 Assessments

	Recommended					Implemented	
Recommended	**No. of Recs**	**Savings (10^6 Btu)**	**Total Savings**	**Implement Cost**	**Payback (years)**	**No. of Recs**	**Total Savings**
Automate Process Equipment	4	149	$342,388	$301,000	0.9	1	$9,905
Machine Vision Sorting	3	0	$725,400	$730,000	1	0	$0
Replace Cryogenic Freezer	1	(1,720)	$198,470	$500,000	2.5	1	$198,470
Modify Process to Reduce Labor	5	94	$210,805	$40,800	0.2	1	$80,220
Automate Packaging	6	0	$1,112,800	$1,028,000	0.9	1	$166,000
Improve Wastewater Drain System	1	0	$310,000	$69,000	0.2	1	$310,000
Total	20	(1,477)	$2,899,863	$2,668,800	0.9	5	$764,595

Water and Waste Recommendations

Water Use

Water use varies by process. Average water use was 9.4 gallons per pound of product in Alaska and 2.0 gallons per pound in the Northwest. Water costs (not including disposal) average $0.88 per 1,000 gallons of water used in Alaskan plants, $1.14 in Oregon plants, and $2.42 in Washington plants. We recommended eight measures to save an average of 13 million gallons of water per plant per year for the Alaskan plants. With an average net savings of $9,300 per plant per year (water savings minus operating costs) and an average implementation cost of $3,800 per plant, most of these recommendations will pay back in less than one year. Three of the recommendations involved recirculating water used for cleaning fish at an inspection table, spraying rotary screens in a process used to remove water from waste, or defrosting blast freezers. Three of the recommendations involved reducing water use in a compressor head cooler, a water-cooled condenser, and a table used to cut and clean fish. The last two recommendations involved replacing water-cooled condensers with evaporative condensers. Four were implemented.

Fish Waste

Processing wastes can compose up to 75% of the landings (raw product entering plant), depending on species and products. Most plants either dumped fish waste into the ocean or had existing contracts with fishmeal plants to accept the waste at a cost to fish processors of $15 to $30 per ton, depending on the processor and species of fish. We recommended that one plant process waste through a screw press to remove water, reducing waste weight shipped to the fishmeal plant by 1,600 tons per year. This is essentially cost savings, not waste reduction, but it was implemented.

It might be beneficial, based on environmental concerns and future regulations, to find alternative methods of disposal. We reviewed fishmeal, protein recovery, and oil recovery but reached no conclusions identifying higher-valued markets for process waste.

Solid Waste

Disposal costs for solid wastes such as plastic, wood, paper, and metals were relatively small, averaging $13,700 per plant per year. Most feasible waste streams were already being recycled. Therefore, we recommended no solid waste improvements.

Table 5. Water Saving Recommendation Summary for 1999 Assessments

	Recommended					Implemented	
Recommended	**No. of Recs**	**Savings (gallons)**	**Total Savings**	**Implement Cost**	**Payback (years)**	**No. of Recs**	**Total Savings**
Remove Water from Waste	1	0	$38,550	$34,600	0.9	1	$38,550
Reuse Process Water	3	15,067,800	$9,048	$11,945	1.3	0	$0
Reduce Water Use	3	25,018,000	$19,650	$6,800	0.3	1	$1,960
Replace Water-Using Equipment	2	24,672,662	$17,719	$490	0	2	$17,719
Total	9	64,758,462	$84,967	$53,835	0.6	4	$58,229

Other Measures

We were unable to recommend some measures because they would take more than five years to pay back the initial investment, calculated savings were small, or we lacked data needed to perform necessary analyses. Some of these measures were problems that we noticed at one or more plants but could not solve within the scope of the reports. These measures are summarized in table 6 and should be considered for additional savings, retrofits, and future research.

Other Assessments

Between 1987 and 1996, 28 seafood processors were assessed by eight centers in the IAC program, with emphasis primarily on energy.[4] Table 7 shows a brief summary of these results, excerpted

Table 6. Measures Considered but Not Recommended in 1999 Assessments

Category	Description of Measure	Reason Not Recommended: Long Payback	High Cost	Small Savings	Savings Uncertain	Affects Quality	Need More Data	Need More Research
Refrigeration Equipment	Add adjustable-speed drives to blast freezer fan motors.	X						
	Replace flooded coils with fan coils to increase suction pressure.[1]	X						
	Add condensing capacity to reduce discharge pressure.[2]	X		X				
	Install electronic refrigeration controls.		X		X			
	Switch to 2-stage refrigeration to increase efficiency.						X	
	Replace rotary-vane boosters with screw compressors.[3]			X				
Freezers & Cold Storage	Replace cryogenic (CO_2) tunnel freezer with ammonia system.[4]		X					
	Redesign blast freezer layout to save energy.[5]		X		X		X	
	Replace less efficient vans with permanent cold storage.	X	X					
Boilers	Tune boilers.[6]						X	
	Add heat exchange to boiler.				X		X	
	Recover fish oil to use for boiler fuel.[7]				X			X
	Alternate retort steam venting to reduce boiler load.							X
Automation	Automate herring sex sorting to save labor and energy.[8]	X	X					
	Automate parasite detection and removal to save labor.[9]							X
	Develop technology to detect soft salmon before processing.[10]			X				X
	Install semi-automated can line feeder to save labor.[11]	X	X					
Product Movement	Add conveyors to transport product.[12]	X	X		X		X	
	Discontinue vacuum transport system to improve quality.[13]				X			
	Improve transport of boxes within plant.				X		X	
Labor & Ergonomics	Install ergonomic plate freezer loading tables.				X			
	Rack fish while grading to save time and labor.[14]					X		
	Switch to continuous retorts to save labor and energy.	X	X		X	X		
Water	Recycle freezer defrost water.	X		X				
	Treat and reuse retort cooling water.	X			X		X	X
	Reuse surimi cooling water and glazing water.	X		X				
Recycling	Find a market for nutrient-rich wastewater.[15]						X	X
	Find a market for fish meal.							X
	Recycle cardboard and steel.[16]			X				
Economics	Produce cans in-house to save shipping and storage.[17]		X	X				
	Operate shipping company to save money.[18]				X		X	

[1]Payback greater than 11 years
[2]Payback 7.8 years
[3]Efficiency gain relatively small
[4]Not enough floor space
[5]Extensive remodeling required
[6]Boiler not operating at time of visit
[7]Additional research necessary
[8]Payback 12.5 years
[9]Technology not developed
[10]Labor savings
[11]Payback 16 years
[12]Currently done by forklift or by hand
[13]Quality losses difficult to quantify
[14]Product freshness at risk
[15]Example: growing yeast
[16]Shipping costs to nearest major city
[17]Volume of cans used insufficient
[18]Unable to determine specific costs

Table 7. Major Energy Saving Recommendations for 1987–1996 Seafood Assessments

	Recommended					Implemented	
Recommended	**No. of Recs**	**Savings (10^6 Btu)**	**Total Savings**	**Implement Cost**	**Payback (years)**	**No. of Recs**	**Total Savings**
Premium Efficiency Motors	20	4,800	$75,000	$235,600	3.1	14	$65,331
V-Belts of High Torque Drives	9	1,251	$19,260	$29,520	1.5	5	$10,320
Improve Power Factor	5	0	$25,300	$30,650	1.2	1	$1,129
More Efficient Lighting	24	2,688	$44,880	$83,280	1.9	17	$32,722
Reduce Lighting Hours	12	1,308	$20,760	$11,520	0.6	8	$15,133
Reduce Discharge Pressure	8	2,632	$35,040	$12,000	0.3	5	$23,604
Tune Boilers	9	1,926	$9,360	$4,140	0.4	6	$7,323
Replace Elec Process Heat with Other	4	236	$6,140	$12,760	2.1	0	$0
Programmable Thermostats	10	1,890	$22,800	$18,100	0.8	5	$7,411
Total	101	16,731	$258,540	$437,570	1.7	61	$162,973

from the National IAC Database.[5] Sixty percent of the recommendations were implemented.

Both 1999 results and 1987–96 results show that significant savings can be achieved in many areas of the plant. Awareness of the amounts and costs of energy, waste, and labor will help seafood processors find ways to improve the efficiency of their plants to make them more profitable and competitive for the future.

Conclusions

There are significant opportunities to improve efficiency in the seafood processing industry. We made 73 recommendations in 10 plants that would save $4.4 million with an average 1.1-year simple payback. Project results are summarized in table 8.

We made 44 recommendations that would save $1.4 in energy costs with a 1.6-year payback, with 21 implemented to date. There are many ways to increase energy efficiency of seafood processors. Adjusting refrigeration-control settings (suction and discharge pressure) and tuning boilers are measures that can save significant energy with little or no investment. Premium efficiency motors and efficient lighting require capital investment but provide acceptable returns on investment. We also recommend that plant managers consider cogeneration to improve combined heat and power system efficiency.

We made 20 recommendations that would save $2.9 million in labor and productivity costs with a 0.9-year payback, with 5 implemented to date. With the advent of new technology, the possibilities for saving labor and improving quality by automating processing, sorting, and packaging seafoods are increasing. If a plant can afford to invest in automation, tens of thousands of dollars in labor costs can be saved.

We made nine recommendations that would save $85,000 in water costs with a 0.6-year payback, with four implemented to date. With increasing regulation and seafood waste and wastewater disposal costs, we found it worthwhile to invest in water and waste-saving opportunities. Many water-saving opportunities require little or no capital investment. In addition, by-products such as compost, fishmeal, or other protein-rich products can be made from seafood waste. Where disposal costs are high or where significant environmental problems exist, developing new by-products from waste streams should be considered.

Table 8. Savings Summary

	Recommended					Implemented	
Recommended	**No. of Recs**	**Savings (10^6 Btu)**	**Total Savings**	**Implement Cost**	**Payback (years)**	**No. of Recs**	**Total Savings**
Energy	44	19,792	$1,402,891	$2,231,231	1.6	21	$223,693
Productivity	20	(1,477)	$2,899,863	$2,668,800	0.9	5	$764,595
Waste	9	(306)	$84,967	$53,835	0.6	4	$58,229
Total	73	18,009	$4,387,721	$4,953,866	1.1	30	$1,046,517

Endnotes

[1]For more information about the IAC program, visit their Web page at http://www.oit.doe.gov/iac/

[2]The AEA maintains an energy saving Web page at http://www.aidea.org/energyconservation.htm

[3]Plant identities and details are confidential. The information contained in this report is designed to report aggregate findings and projected savings due to increased efficiency if recommendations are implemented.

[4]The IAC program was originally established to address energy efficiency. In recent years, the IAC program has expanded to address waste and productivity issues having a direct impact on profitability.

[5]The National IAC Database can be accessed by visiting http://www.oipea.rutgers.edu

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