FINAL REPORT

A COMPREHENSIVE PLANT-WIDE ASSESSMENT

OF

AMCOR PET FACILITIES

Report A- Project Overview and Presentation of Results

Project Co-Sponsored by:

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Prepared by:

**Yin Yin Wu
Bryan W. Hackett and Ahmad R. Ganji
BASE Energy, Inc.
(**BASE**)
5 Third Street, Suite 530
San Francisco, CA 94103**

And

**Kevin Losh and Hui Choi
AMCOR PET Company**

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1. INTRODUCTION

This report includes the results of the plant-wide assessment of AMCOR PET plants in Fairfield, City of Commerce, and Lathrop California. The project (except the assessment of Lathrop plant) was a cost shared effort between US Department of Energy through Golden Field Office, Golden CO and AMCOR PET Packaging Co. The DOE share of the plant-wide assessment cost was awarded to AMCOR PET in response to the RFP DE-PS36-05GO95009, the 2005 round of funding for “Plant-Wide Energy Efficiency Opportunity Assessments.”

1.1 Project Objectives

It was the specific objective of this project to perform a comprehensive plant-wide assessment of the Fairfield and Commerce plants of AMCOR PET, and dissemination of information for application of the methods in assessment of AMCOR’s other plants in the U.S. The assessment included production processes, utilities and buildings and grounds.

1.2 Scope of the Work

The plant-wide assessment included the processes, electrical and gas equipment. Current production practices have been evaluated against best practice standards, as well as utilization of modern technology to improve energy efficiency, reduce the wastes, and improve productivity.

1.3 Methodology

The methodology utilized in this assessment was a system approach, evaluating the processes from raw material delivery to the finished products. The evaluation considered whether the latest technologies and best practices are being utilized and followed in the production processes. A comprehensive inventory of equipment and their operational conditions was developed. The detailed operational conditions as well as equipment usage were utilized in mass and energy balances of the processes and utilities in order to optimize the operation of the equipment.

Based on the initial evaluation of the processes and equipment, an initial set of energy efficiency opportunities (EEOs) were identified. Detailed measurements of the operation of major equipment (injection molders, blow molders, chillers, pumps etc.) were made to support the final engineering and economic analysis of the identified measures.

Based on the operational conditions and the detailed measurements, annual energy use of each plant was balanced. The energy balance established consists of operating hours, utilization and load factors for all plant equipment.

Based on an assessment of the processes, equipment and utilities at the plants, and considering new and retrofit technologies, engineering and economic analyses of the identified opportunities have been performed. Engineering analyses, based on fundamental engineering principles, include estimation of:

- annual energy and cost savings
- electrical demand savings and demand cost savings
- reduction of carbon dioxide emissions

No detailed engineering design was performed in this project. When the recommended measure is attractive and involves design, it is recommended that an engineering firm with expertise in the field be engaged to perform the detailed design and project cost estimation for implementing the measure.

For economics of the recommended measures, simple payback analysis has been performed. Implementation costs have been estimated based on standard cost estimation manuals (such as RS Mean's Guide) and cost estimation from vendors and contractors.

1.4 Reporting the Results

Three separate reports have been produced as a result of this project:

- a. Final Report - A Comprehensive Plant-Wide Assessment of AMCOR PET Facilities (Report A). Report A also includes information from a comprehensive assessment of AMCOR PET plant at Lathrop CA. The assessment of the Lathrop plant had been sponsored by Pacific Gas and Electric Co.
- b. Plant-Wide Assessment of Fairfield Plant of AMCOR PET (Report B)
- c. Plant-Wide Assessment of Commerce Plant of AMCOR PET (Report C)

In Reports B and C detailed engineering analysis of all energy efficiency measures and plant-specific data are discussed. The plant reports are roadmaps for conservation measures in AMCOR PET plants and directly lead into engineering design for implementation of the conservation projects. The Final Report (Report A) is a summary of results prepared for the use of Company management. An edited version of the final report that excludes the proprietary information has been submitted to the DOE Golden Filed Office.

In addition to the above reports, a spreadsheet tool for evaluation of dehumidification of air for blow-molding production environment and application of desiccant dehumidification have been developed.

2. EXECUTIVE SUMMARY

Recommended Measures

Between the three plants, 26 different energy efficiency measures (**EEOs**) that have application to this type of production processes were recommended. Table ES-1 shows the recommended measures in each plant.

TABLE ES-1 SUMMARY OF RECOMMENDED MEASURES IN EACH OF THE AMCOR PLANTS				
EEO No.	Description	Fairfield	Commerce	Lathrop
1.	Repair Compressed Air Leaks	X	XX	XX
2.	Do Not Operate the Grinders During the Peak Period Hours	X		XX
3.	Interlock Packaging Lines with Blow Molding Machine Operations	X	XX	
4.	Turn Off Idling Grinders	X		
5.	Install Premium Efficiency Motors When Existing Units Ware Out or Require Rewinding	X	XX	X
6.	Insulate the Resin Dryer Hoppers and Dust collectors	X	X	
7.	Control the Air Conveyor Blowers in Buffer	X		X
8.	Reconfigure the Single Loop Chilled Water/Cooling Tower Water Systems to Dual Loop Systems	X	X	
9.	Duct Outside Air to the Air Compressor Intakes When Conditions are Favorable	X	X	X*
10.	Reduce Low Pressure Air Compressors' Discharge Pressure	X	X	
11.	Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air	X	X	
12.	Reduce High Pressure Air Compressors' Discharge Pressure	X	X	X*
13.	Install Adjustable Frequency Drives (ASD) on the Chiller Compressors	X		X*
14.	Insulate the Heating Barrels on the Injection Molding Machines	XX	X	
15.	Duct Oven Heat Out of Air Conditioned Blow Molding Area		X	X
16.	Control the Cooling Tower Fans with ASDs		X	
17.	Replace Cooling Towers with Higher Efficient Units		X	
18.	Replace One of the Low Pressure Air Compressors with a Variable Frequency Driven (VFD) Air Compressor		X	
19.	Install Automatic Controls on the Existing Economizers on the A/C Package Units		X	
20.	Replace the Chillers with Higher Efficiency Units		X	
21.	Replace the Existing A/C Packages with a Central Chilled Water Cooling System		X	XX
22.	Install Daylight Controls on the Main Floor Light Fixtures			X*
23.	Install Digital Timers and Bi-level Controllers to Control Lighting			X*
24.	Install Lighting Occupancy Sensors in Low Occupancy Areas			X*
25.	Install ASDs on Process Water/ Chilled Water Pumps			X*
26.	Replace the Metal Halide (MH) Lighting with High Efficiency T5 Fluorescent Lighting			X

X – EEO, XX – Additional Energy Measure (AEM).

* The measure has been implemented.

Please note that each of the audited plants is involved in planning and various stages of implementing energy conservation projects. The decision on implementation of the measures in Fairfield and Commerce plants awaits detailed review of the relevant reports by management.

Energy Savings

A summary for the savings and costs for the EEOs are listed in Tables ES-2.1A, 2.2A and 2.3A of the three AMCOR plants. Brief descriptions of all EEOs identified in each plant are included in Section 6 of this report. Detailed information on these recommendations and calculations of savings are included in the respective reports for each plant.

AMCOR, Fairfield

The energy efficiency opportunities (EEOs) included in this report could save an estimated 4,480,501 kWh of electrical energy each year, or 6.3% of the facility's total electrical energy consumption. The EEOs could reduce the facility's electrical demand by about 402.4 kW. The EEOs would reduce the natural gas consumption by 52,106 therms each year, or 24.3% of the facility's total natural gas energy usage. These estimated electrical energy, demand and natural gas savings translate into a total cost savings of \$402,372 per year. The savings represent about 6.7% of the facility's total energy costs. Total estimated implementation cost is \$742,887 giving an average simple payback of 1.8 years. A summary for the savings and costs for these EEOs are listed in Table ES-2.1A on page 2-4.

The total potential incentives and rebates from the local utility for these measures are estimated to be \$307,958, shown in Table ES-2.1B on page 2-5. The total cost savings of \$402,372 per year will pay for the adjusted total implementation cost (including incentives) of \$434,929 in approximately 1.1 years.

AMCOR, Commerce

The energy efficiency opportunities (EEOs) included in this report could save an estimated 7,092,505 kWh of electrical energy each year, or 15.4% of the facility's total electrical energy consumption. The EEOs could reduce the facility's electrical demand by about 705.5 kW. The EEOs would save 34,620 therms of natural gas each year, or 25.3% of the facility's total natural gas energy usage. These estimated electrical energy, demand and natural gas savings translate into a total cost savings of \$1,003,721 per year. The savings represent about 15.5% of the facility's total energy costs. Total estimated implementation cost is \$1,927,434 giving an average simple payback of 1.9 years. A summary for the savings and costs for these EEOs are listed in Table ES-2.2A on page 2-6.

The total potential incentives and rebates from the local utility for these measures are estimated to be \$477,610, shown in Table ES-2.2B on page 2-7. The total cost savings of \$1,003,721 per year will pay for the adjusted total implementation cost (including incentives) of \$1,449,824 in approximately 1.4 years.

AMCOR, Lathrop

The energy efficiency opportunities (EEOs) included in this report could save an estimated 3,457,270 kWh of electrical energy each year, or 13.3% of the facility's total electrical energy usage. The EEOs could reduce the facility's average electrical demand by about 381 kW. This estimated electrical energy and demand savings translates into a total cost savings of \$426,938 per year. This savings represents about 12.8% of the facility's total energy costs. Total estimated implementation cost is \$665,690 giving an average simple payback of 1.6 years. A summary for the savings and costs for these EEOs are listed in Table ES-2.3A on page 2-8.

The total potential incentives and rebates from the local utility for these measures are estimated to be \$128,030, shown in Table ES-2.3B on page 2-19. The total cost savings of \$426,938 per year will pay for the adjusted total implementation cost (including incentives) of \$537,660 in approximately 1.3 years.

TABLE ES-2.1A SUMMARY OF ENERGY EFFICIENCY OPPORTUNITIES SAVINGS AND COSTS (FAIRFIELD)							
EEO No.	Description	Potential Energy Conserved	Demand Savings (kW)	Potential Savings (\$/yr)	Implem. Cost (\$)	Simple Payback (years)	
No-Cost Measure							
1.	Repair Compressed Air Leaks	40,780 kWh/yr	4.6	2,246	0	0.0	
Low-Cost Measures							
2.	Do Not Operate the Grinders During the Peak Period Hours	0	93.0**	11,225	785	0.1	
3.	Interlock Packaging Lines with Blow Molding Machine Operations	147,217 kWh/yr	0.0	9,289	9,954	1.1	
Investment Grade Measures							
4.	Turn Off Idling Grinders	228,185 kWh/yr	0.0	14,398	10,138	0.7	
5.	Install Premium Efficiency Motors When Existing Units Wear Out or Require Rewinding [£]	83,740 kWh/yr	6.4	5,986	11,841	2.0	
6.	Insulate the Resin Dryer Hoppers and Dust collectors	6,928 therms/yr	0.0	7,347	15,710	2.1	
7.	Control the Air Conveyor Blowers in Buffer	180,000 kWh/yr	20.5	13,624	22,050	1.6	
8.	Reconfigure the Single Loop Chilled Water System to a Dual Loop System	575,080 kWh/yr	65.6	43,527	55,288	1.3	
9.	Duct Outside Air to the Air Compressor Intakes When Conditions are Favorable	873,503 kWh/yr	129.8	68,815	60,124	0.9	
10.	Reduce Low Pressure Air Compressors' Discharge Pressure	633,792 kWh/yr	72.4	47,971	88,239	1.8	
11.	Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air	45,178 therms/yr	0.0	47,894	106,647	2.2	
12.	Reduce High Pressure Air Compressors' Discharge Pressure	639,445 kWh/yr	73.0	48,399	152,111	3.1	
13.	Install ASD on the Two Trane Chillers	1,078,759 kWh/yr	123.1	81,651	210,000	2.6	
Total Energy Savings	(Electricity)	4,480,501 kWh/yr					
	(Natural Gas)	52,106 therms/yr					
Total Demand Savings			402.4 kW				
Total Cost Savings				\$402,372			
Total Implementation Cost							\$742,887
Simple Payback Period							1.8 years

** Demand shifting, not considered as demand savings.

£ Based on two-year savings. See EEO for details.

TABLE ES-2.1B SUMMARY OF ENERGY EFFICIENCY OPPORTUNITY INCENTIVES (FAIRFIELD)						
EEO No.	Description	Energy Savings	Incentive or Rebate Program and Amount	Potential Incentive (\$)	Installed Project Cost with Incentive (\$)	Simple Payback Period w/ Incentive (yrs)
1.	Repair Compressed Air Leaks	40,780 kWh/yr	NRR-DR \$0.08/kWh	0	0	0.0
2.	Do Not Operate the Grinders During the Peak Period Hours	0	0	0	785	0.1
3.	Interlock Packaging Lines with Blow Molding Machine Operations	147,217 kWh/yr	NRR-DR \$0.08/kWh	4,977**	4,977	0.5
4.	Turn Off Idling Grinders	228,185 kWh/yr	NRR-DR \$0.08/kWh	5,069**	5,069	0.4
5.	Install Premium Efficiency Motors When Existing Units Ware Out or Require Rewinding	83,740 kWh/yr	NRR-DR \$0.08/kWh	5,921**	5,921	1.0
6.	Insulate the Resin Dryer Hoppers and Dust collectors	6,928 therms/yr	NRR-DR \$0.80/therm	5,542	10,168	1.4
7.	Control the Air Conveyor Blowers in Buffer	180,000 kWh/yr	NRR-DR \$0.08/kWh	11,025**	1,1025	0.8
8.	Reconfigure the Single Loop Chilled Water System to a Dual Loop System	575,080 kWh/yr	NRR-DR \$0.08/kWh	27,644**	27,644	0.6
9.	Duct Outside Air to the Air Compressor Intakes When Conditions are Favorable	873,503 kWh/yr	NRR-DR \$0.08/kWh	30,062**	30,062	0.4
10.	Reduce Low Pressure Air Compressors' Discharge Pressure	633,792 kWh/yr	NRR-DR \$0.08/kWh	44,120**	44,120	0.9
11.	Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air	45,178 therms/yr	NRR-DR \$0.80/therm	36,142	70,505	1.5
12.	Reduce High Pressure Air Compressors' Discharge Pressure	639,445 kWh/yr	NRR-DR \$0.08/kWh	51,156	100,955	2.1
13.	Install ASD on the Two Trane Chillers	1,078,759 kWh/yr	NRR-DR \$0.08/kWh	86,301	123,699	1.5
Total Energy Savings		4,480,501 kWh/yr 52,106 therms/yr				
Total Potential Incentives				\$307,958		
Total Installed Project Costs with Incentives					\$434,929	
Overall Simple Payback Period with Incentives						1.1 years

** Measure incentive limited to 50% of implementation cost.

TABLE ES-2.2A SUMMARY OF ENERGY EFFICIENCY OPPORTUNITIES SAVINGS AND COSTS (COMMERCE)							
EEO No.	Description	Potential Energy Conserved	Demand Savings (kW)	Potential Savings (\$/yr)	Implem. Cost (\$)	Simple Payback (years)	
No-Cost Measure							
1.	Reduce Low Pressure Quincy Northwest Air Compressor's Discharge Pressure	69,611 kWh/yr	7.9	9,573	35	0.0	
Low-Cost Measures							
2.	Insulate the Resin Dryer Hoppers and Dust collectors	7,591 therms/yr	0.0	6,274	9,489	1.5	
Investment Grade Measures							
3.	Insulate the Heating Barrels on the Injection Molding Machines	58,984 kWh/yr	6.7	8,111	13,920	1.7	
4.	Duct Oven Heat Out of Air Conditioned Blow Molding Area	93,747 kWh/yr	20.2	12,892	33,514	2.6	
5.	Control the Evapco Cooling Tower Fans with ASDs	160,040 kWh/yr	0.0	22,009	35,206	1.6	
6.	Duct Outside Air to the Air Compressor Intakes When Conditions are Favorable	623,489 kWh/yr	74.1	85,742	59,238	0.7	
7.	Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air	28,413 therms/yr	0.0	22,353	71,098	3.2	
8.	Replace the AEC Plastic Cooling Towers with Higher Efficient Units	167,503 kWh/yr	12.2	23,045	100,843	4.4	
9.	Replace the LP Quincy Northwest Air Compressor with a VFD Air Compressor	362,670 kWh/yr	41.4	49,599	115,297	2.3	
10.	Install Automatic Controls on the Existing Economizers on the A/C Units	800,389 kWh/yr	0.0	110,069	134,550	1.2	
11.	Reconfigure the Single Loop Chilled Water/Cooling Tower Water Systems to Dual Loop Systems	2,374,485 kWh/yr	271.1	326,539	203,469	0.6	
12.	Reduce High Pressure Air Compressors' Discharge Pressure	518,369 kWh/yr	59.2	71,286	219,606	3.1	
13.	Replace the Existing Trane Chillers with Higher Efficiency Units	759,492 kWh/yr	86.7	104,445	396,750	3.8	
14.	Replace the Existing A/C System with a Central Chilled Water Cooling System	1,103,726 kWh/yr	126.0	151,784	534,419	3.5	
Total Energy Savings	(Electricity)	7,092,505 kWh/yr					
	(Natural Gas)	34,620 therms/yr					
Total Demand Savings			705.5 kW				
Total Cost Savings				\$1,003,721			
Total Implementation Cost							\$1,927,434
Simple Payback Period							1.9 years

TABLE ES-2.2B SUMMARY OF ENERGY EFFICIENCY OPPORTUNITY INCENTIVES (COMMERCE)						
EEO No.	Description	Energy Savings	Incentive or Rebate Program and Amount	Potential Incentive (\$)	Installed Project Cost with Incentive (\$)	Simple Payback Period w/ Incentive (yrs)
1.	Reduce Low Pressure Quincy Northwest Air Compressor's Discharge Pressure	69,611 kWh/yr	IEEP \$0.08/kWh	18	18	0.0
2.	Insulate the Resin Dryer Hoppers and Dust collectors	7,591 therms/yr	EERP \$3.0/sq ft	2,916	6,573	1.0
3.	Insulate the Heating Barrels on the Injection Molding Machines	58,984 kWh/yr	IEEP \$0.08/kWh	4,719	9,201	1.1
4.	Duct Oven Heat Out of Air Conditioned Blow Molding Area	93,747 kWh/yr	IEEP \$0.08/kWh	7,500	26,014	2.0
5.	Control the Evapco Cooling Tower Fans with ASDs	160,040 kWh/yr	IEEP \$0.08/kWh	12,803	22,403	1.0
6.	Duct Outside Air to the Air Compressor Intakes When Conditions are Favorable	623,489 kWh/yr	IEEP \$0.08/kWh	29,619*	29,619	0.3
7.	Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air	28,413 therms/yr	CIIP \$0.80/therm	21,329**	49,769	2.2
8.	Replace the AEC Plastic Cooling Towers with Higher Efficient Units	167,503 kWh/yr	IEEP \$0.08/kWh	13,400	87,443	3.8
9.	Replace the LP Quincy Northwest Air Compressor with a VFD Air Compressor	362,670 kWh/yr	IEEP \$0.08/kWh	29,014*	86,283	1.7
10.	Install Automatic Controls on the Existing Economizers on the A/C Units	800,389 kWh/yr	IEEP \$0.08/kWh	64,031	70,519	0.6
11.	Reconfigure the Single Loop Chilled Water/Cooling Tower Water Systems to Dual Loop Systems	2,374,,485 kWh/yr	IEEP \$0.08/kWh	101,735	101,735	0.3
12.	Reduce High Pressure Air Compressors' Discharge Pressure	518,369 kWh/yr	IEEP \$0.08/kWh	41,470	178,136	2.5
13.	Replace the Existing Trane Chillers with Higher Efficiency Units	759,492 kWh/yr	IEEP \$0.08/kWh	60,759	335,991	3.2
14.	Replace the Existing A/C System with a Central Chilled Water Cooling System	1,103,726 kWh/yr	IEEP \$0.08/kWh	88,298	446,121	2.9
Total Energy Savings		7,092,505 kWh/yr 34,620 therms/yr				
Total Potential Incentives/Rebates				\$477,610		
Total Installed Project Costs with Incentives					\$1,449,824	
Overall Simple Payback Period with Incentives						1.4 years

* Measure incentive limited to 50% of implementation cost.

* Measure incentive limited to 30% of implementation cost.

TABLE ES-2.3A SUMMARY OF ENERGY EFFICIENCY OPPORTUNITIES SAVINGS AND COSTS (LATHROP)						
EEO No.	Description	Potential Energy Conserved	Demand Savings (kW)	Potential Savings (\$/yr)	Implem. Cost (\$)	Simple Payback (years)
Low-Cost Measures						
1.	Install Daylight Controls on the Main Floor Light Fixtures [§]	51,022 kWh/yr	21.17	7,781	1,863	0.2
2.	Install Digital Timers and Bi-level Controllers on Equipment Room Lighting	17,098 kWh/yr	1.97	2,136	2,673	1.3
Investment Grade Measures						
3.	Install Premium Efficiency Motors When the Existing Motors Wear Out or Require Rewinding*	47,527 kWh/yr	3.66	5,937	8,652	1.5
4.	Duct Oven Heat From Air Conditioned Blow Molding Area	95,931 kWh/yr	27.79	12,031	19,610	1.6
5.	Control the Air-Veyor Blowers in the Buffer	160,416 kWh/yr	18.52	20,040	19,751	1.0
6.	When Conditions are Favorable, Duct Outside Air To Air Compressor Intakes	403,809 kWh/yr	51.79	48,936	23,546	0.5
7.	Install Lighting Occupancy Sensors in Low Occupancy Areas	108,905 kWh/yr	12.84	13,630	23,601	1.7
8.	Install Adjustable Speed Drives (ASDs) on Chilled Water Pumps	285,288 kWh/yr	0.00	32,608	37,260	1.1
9.	Install ASD on Process Water Pumps	509,287 kWh/yr	38.21	61,728	48,070	0.8
10.	Install ASD on Chiller Compressor	249,610 kWh/yr	28.81	31,182	70,000	2.2
11.	Replace the Metal Halide (MH) Lighting with High Efficiency T5 Fluorescent Lighting	634,246 kWh/yr	73.20	79,232	85,004	1.1
12.	Reduce High Pressure Air Compressors' Discharge Pressure	894,131 kWh/yr	103.20	111,698	325,660	2.9
Total Energy Savings (Electricity)		3,457,270 kWh/yr				
Total Demand Savings			381 kW			
Total Cost Savings				\$426,938		
Total Implementation Cost					\$665,690	
Simple Payback Period						1.6 years

§ Reduced savings based on implementation of EEO No. 11.

* Based on two-year savings. See EEO for details.

TABLE ES-2.3B SUMMARY OF ENERGY EFFICIENCY OPPORTUNITY INCENTIVES (LATHROP)							
EEO No.	Description	Energy Savings	Incentive or Rebate Program and Amount		Potential Incentive (\$)	Installed Project Cost with Incentive (\$)	Simple Payback Period w/ Incentive (yrs)
1.	Install Daylight Controls on the Main Floor Light Fixtures	51,022 kWh/yr	NRR-DR \$0.05/kWh		931*	932	0.1
2.	Install Digital Timers and Bi-level Controllers on Equipment Room Lighting	17,098 kWh/yr	NRR-DR \$0.05/kWh		855	1,818	0.9
3.	Install Premium Efficiency Motors When the Existing Motors Wear Out or Require Rewinding	47,527 kWh/yr	NRR-DR \$0.08/kWh		3,802	4,850	0.8
4.	Remove Oven Exhaust From Air Conditioned Blow Molding Area	95,931 kWh/yr	NRR-DR \$0.08/kWh		7,674	11,936	1.0
5.	Control the Air-Veyor Blowers in the Buffer	160,416 kWh/yr	N/A			19,751	1.0
6.	When Conditions are Favorable, Duct Outside Air To Air Compressor Intakes	403,809 kWh/yr	N/A			23,546	0.5
7.	Install Lighting Occupancy Sensors in Low Occupancy Areas	108,905 kWh/yr	NRR-DR \$0.05/kWh	5,445		18,156	1.3
8.	Install Adjustable Speed Drive (ASD) on Chilled Water Pumps	285,288 kWh/yr	NRR-DR \$0.08/kWh	18,630*		18,630	0.6
9.	Install ASD on Process Water Pumps	509,287 kWh/yr	NRR-DR \$0.08/kWh	24,035*		24,035	0.4
10.	Install ASD on Chiller Compressor	249,610 kWh/yr	NRR-DR \$0.14/kWh	34,945		35,055	1.1
11.	Replace the Metal Halide MH) Lighting with High Efficiency T5 Fluorescent Lighting	634,246 kWh/yr	NRR-DR \$0.05/kWh	31,712		53,292	0.7
12.	Reduce High Pressure Air Compressors’ Discharge Pressure	894,131 kWh/yr	N/A			325,660	2.9
Total Energy Savings		3,457,270 kWh/yr					
Total Potential Incentives and Rebates				\$128,030			
Total Installed Project Costs with Incentives						537,660	
Overall Simple Payback Period with Incentives							1.3 years

* Measure incentive limited to 50% of implementation cost.

Greenhouse Gas Reduction

Reducing energy consumption can also result in decreasing the greenhouse gas emissions, such as carbon dioxide (CO₂). Carbon Footprint Calculators provide by PG&E (it can be assessed from http://pge.com/about_us/environment/calculator/index.html) and The California Air Resources Board (it can be assessed from <http://www.arb.ca.gov/cc/cc/cc.htm>) can assist you to estimate the carbon footprint from the electrical and natural gas usages. We have also used these calculators to estimate the CO₂ reduction based on the energy savings proposed in this report.

AMCOR, Fairfield

The energy efficiency opportunities (EEOs) identified for the Fairfield facility could save an estimated 4,480,501 kWh of electrical energy and will reduce 52,106 therms of natural gas each year as summarized in Table ES-2A. According to the Carbon Footprint Calculator provided by PG&E, the resulted overall carbon reduction is hence estimated to be 3,048,372 lbs CO₂ per year, or equivalent to burning 157,132 gallons of gasoline per year.

AMCOR, Commerce

The energy efficiency opportunities (EEOs) identified for the Commerce facility could save an estimated 7,092,505 kWh of electrical energy and 34,620 therms of natural gas each year as summarized in Table ES-2B. According to the Carbon Footprint Calculator provided by the California Air Resources Board, the resulted carbon reduction is hence estimated to be 5,095,406 lbs CO₂ per year, and it is estimated to be equivalent to burning 215,565 gallons of gasoline per year.

AMCOR, Lathrop

The energy efficiency opportunities (EEOs) identified for the Lathrop facility could save an estimated 3,457,270 kWh of electrical energy each year as summarized in Table ES-2C. According to the Carbon Footprint Calculator provided by PG&E, the resulted overall carbon reduction is hence estimated to be 1,811,609 lbs CO₂ per year, or equivalent to burning 93,381 gallons of gasoline per year.

3. COMPANY BACKGROUND AND INDUSTRY PROFILE

3.1 Company Background

Amcor Ltd. is a packaging company that makes corrugated boxes, cartons, aluminum and steel cans, flexible and film packaging, PET (polyethylene terephthalate plastic) bottles and jars, metal and plastic closures, and multi-wall sacks for customers in the food and beverage, medical, tobacco, and cosmetics industries. AMCOR is based in Australia, and while it has operations in about 40 countries; North America and Europe account for most of its sales. The company is ranked among the top global players in almost every area of its business. AMCOR PET Packaging is a division of AMCOR Ltd. AMCOR PET Packaging is the world largest PET container manufacturer with more than 5,300 people in 66 manufacturing operations in 12 countries. AMCOR PET Packaging operates 13 PET bottle manufacturing facilities in the US.

3.2 A profile of Plastic Bottle Manufacturing in the US

Plastic bottle manufacturing, while being a great contributor to the national economy, is a very energy intensive process. Plastic bottle manufacturing (NAICS 326160) is a subcategory under the plastics & rubber products manufacturing (NAICS 326). Census Bureau and Energy Information Administration (EIA) have compiled information regarding this manufacturing market segment. The table below presents some national statistics and metrics for the nation-wide plastics & rubber products manufacturing (NAICS 326), and the nation-wide plastic bottle manufacturing facilities (NAICS 326160). A summary of national statistics is provided in the following table.

NATIONAL STATISTICS AND METRICS OF "PLASTICS & RUBBER PRODUCTS MANUFACTURING"				
Data	Nation-Wide (NAICS 326)	Nation-Wide (NAICS 326160)	Reference	AMCOR (US) (NAICS 326160)
Total Number of Establishments	16,821	403	Census 2002	13
Total Number of Employees	1,023,060	34,001	Census 2002	N/A
Payroll (\$1,000)	29,804,904	1,132,845	Census 2002	N/A
Cost of Materials (\$1,000)	81,767,677	4,135,473	Census 2002	N/A
Value Added (\$1,000)	91,451,288	3,880,124	Census 2002	N/A
Total Value of Shipments (\$1,000)	159,161,346	7,948,466	Census 2002	N/A
Net Electricity (Trillion Btu)	183	N/A	MECS 1998	0.4898*
Natural Gas (Trillion Btu)	126	N/A	MECS 1998	0.0351*
LPG (Trillion Btu)	4	N/A	MECS 1998	None
Other Fuels (Trillion Btu)	5	N/A	MECS 1998	None

* Total energy consumption of the three AMCOR plants included in this report.

4. PRODUCTION PROCESS

AMCOR PET specializes in manufacturing plastic beverage bottles from pre-forms. Both of the Fairfield and Commerce plants produce pre-forms on site while the Lathrop plant uses pre-forms as the raw material, which are produced in other AMCOR plants. An overview of the plant processes is described as follows. Processes in the Fairfield and Commerce plants include Part 1 and Part 2. Processes in the Lathrop plant include Part 2.

4.1 Overview of the Plant Processes

Part 1

- Resin is unloaded from trucks or railcars and vacuum pumped to storage bins.
- Resin is dried by resin dryers before being fed into the injection molders.
- Bottle preforms are produced by the six injection molders.

Part 2

- The preforms are transferred to the blow molders.
- The preforms are dumped into the hopper.
- The preforms are conveyed to the oven where they are heated via infra-red heaters.
- The preforms are blow molded using both high and low pressure compressed air.
- A laser prints the relevant information on each bottle.
- The bottles are pressure tested.
- The rejected bottles are collected in bins next to each injection molding machine. The bins are then sent to the Grinder Room to be pulverized. The ground plastic is then fed back to the injection molders or transferred to another AMCOR plant that includes injection molding process.
- The formed bottles are transported to the packaging lines.
- A label is applied to each bottle.
- At the palletizer the bottles are bundled into a stack. Depending upon the beverage manufacturer, the pallets may be shrink-wrapped.
- The palletized products are stored in the warehouse.
- The palletized products are shipped via trucks.

A simplified diagram of the manufacturing process is shown in Figure 1 on the following page.

Process Flow Chart

Figure 1 – Process Flow Diagram

4.2 Major Energy Consumers

Major Natural Gas Equipment

Resin Dryers – The natural gas resin dryers consist of a process heater and a regeneration heater. This equipment dries the resin before it is fed into the injection molders for producing performs. Opportunities for energy efficiency exist in this application, including use of recuperator to preheat the circulation air, insulation of resin hoppers and dust collectors, etc.

Major Electrical Equipment

Lighting – A wide variety of lighting systems, including fluorescent units, high intensity discharge lamps (HID), etc. are used for indoor and outdoor lighting in these facilities. Significant energy efficiency opportunities exist in using advanced technology lighting and lighting control in these facilities.

Injection/Blow Molding Machines (IMM/BMM) – Bottle preforms are produced by injection molding machines. Bottles are then made from the preforms by the blow molding machines. Each of the injection or blow molding machines consists of an electric drives and heaters.

Chillers and Cooling Towers – To cool the IMM and BMM drives, chiller compressors and air compressors, a significant amount of electrical energy is used for cooling using chillers and cooling towers. Consequently there exists a significant potential in energy efficiency opportunities (such as reconfiguring the single-loop water systems into dual-loop systems, installation of variable frequency drives on cooling tower fans, etc.) for chillers and cooling towers in these facilities.

HVAC – To control the humidity in the BMM production room, a significant amount of energy is used for cooling using chillers or package A/C units. Consequently there exists a significant potential in energy efficiency opportunities (such as converting the package A/C units into a central chiller system, use of economizers, etc.) for chillers and A/C units in these facilities.

Air Compressors – Compressed air is an essential utility in these facilities, and 40-48% of electrical energy is consumed for air compression. Consequently there exists a significant potential in energy efficiency opportunities (such as application of efficient compressors, reducing the discharge pressures, ducting outside air as inlet air, etc.) for air compression in these facilities.

Pumps – Fluid pumps for chilled water and cooling tower water are a major user of electricity in these facilities. A significant potential for energy efficiency opportunities including proper sizing, use of variable frequency drives (VFD) to adjust to load modulation, etc. exists in these facilities.

Other Motor Drives (conveyers, blowers, grinders, etc.) – Opportunities for energy efficiency exist in application of various motors drives, including use of premium efficiency motors, control the usage of motors, application of VFD, etc.

4.3 Plant Information

4.3.1 Fairfield Facility

AMCOR PET Packaging plant in Fairfield, California produces plastic beverage bottles from pre-forms, which are produced on site as well.

In general, the plant operates 3 shifts per day throughout the year. The office area operates about 9 hours per day for 5 days per week. The production building covers a total of approximately 197,125 square feet, and the warehouse is about 126,774 square feet.

Two pie charts illustrating the percentage of electricity and natural gas consumptions for various functions are shown in Figure 2-A and Figure 3-A.

Figure 2-A - Electricity Consumption by Function

* Includes equipment not covered by the shown categories.

Figure 3-A – Natural Gas Consumption by Function

* Includes equipment not covered by the shown categories.

4.3.2 Commerce Facility

AMCOR PET Packaging plant in Commerce, California produces plastic beverage bottles from pre-forms, which are produced on site as well. In general, the plant operates 3 shifts per day for about 361 days per year. The office area operates about 12 hours per day for 5 days per week.

The production building covers a total of approximately 140,000 square feet, and the warehouse is about 200,000 square feet in area.

Two pie charts illustrating the percentage of electricity and natural gas consumptions for various functions are shown in Figure 2-B and Figure 3-B.

Figure 2-B - Electricity Consumption by Function

* Includes equipment not covered by the shown categories.

Figure 3-B – Natural Gas Consumption by Function

* Includes equipment not covered by the shown categories.

4.3.3 Lathrop Facility

AMCOR PET Packaging in Lathrop California produces plastic beverage bottles from pre-forms that are produced in other plants. In general, the plant operates 3 shifts per day for about 361 days per year. The office and maintenance shop areas operate about 9 hours per day for 5 days per week.

The facility covers a total of approximately 272,000 square feet that includes the warehouse.

A pie chart illustrating the percentage of electricity consumption for various functions is shown in Figure 2-C.

Figure 2-C - Annual Electricity Consumption Pie Chart

* These are the electrical devices not included in other categories.

5. ASSESSMENT PROCESS

A well developed approach to plant assessment that has been experienced and refined by BASE staff in the process of performing over 600 plant assessments was followed in this project. The process was as follows:

1. Obtaining background information from the plant. The information included plant production data, equipment and process operating hours, energy usage and usage pattern, plant layout, at least one full year of utility bills, energy concerns of the facility managers, previous conservation efforts, etc.
2. Plant background information was organized (utility data was graphed) and preliminary ideas about improvements of the plant were formulated and discussed by the audit team.
3. Plant is visited by the audit team. The visit included:
 - Interviewing the personnel in charge of the operation and maintenance of the facility
 - Touring the plant, noting energy usage in each (sub) process
 - Taking inventory of all energy consuming/producing devices in the plant including lighting, electric motors, compressors, generators, etc.
 - Observing and timing of the processes and equipment
 - Making measurement of all major energy consuming devices, including measurement of light intensity, electric power (voltage, current and power factor), temperature, fluid velocity, flue gas analysis (for boilers and engines), etc.
 - Formulation of the energy efficiency, waste reduction and productivity improvement measures at the plant based on the audit findings
 - Performing an exit interview with the personnel in charge of the operation of the plant. All potential cost saves and productivity improvement measures were discussed with plant personnel in the exit interview meeting.
4. Preparation of the plant assessment report.
5. Presentation of the report and discussion of the findings.

The audit team first visited the Fairfield plant a few times, and then performed the assessment of the Commerce plant. Assessment of the Lathrop plant had been done under a separate program before we did the final visit of the Fairfield facility. Due to the similarity of the basic processes between the three facilities, the assessment was performed much faster and more efficiently in the Commerce plant.

6. DESCRIPTION OF ENERGY CONSERVATION MEASURES

This section consists of summaries of the opportunities for energy efficiency at the three facilities. The recommendations suggest methods of implementing energy efficiency measures. Implementation cost estimates are compared with energy cost savings to obtain simple payback periods.

Section 6.1.1 consists of summaries of engineering and cost analysis of major EEOs that were identified in the Fairfield Plant. Section 6.1.2 includes the measures identified at the Fairfield facility that, for the most part, did not lend themselves to detailed analysis for various reasons. Section 6.1.3 summarizes energy efficiency measures that have been implemented by the facility. These measures were identified prior to this plant-wide assessment.

Section 6.2.1 consists of summaries of engineering and cost analysis of major EEOs that were identified in the Commerce plant. Section 6.2.2 includes the measures identified at the Commerce facility that, for the most part, did not lend themselves to detailed analysis for various reasons. Section 6.2.3 summarizes energy efficiency measures that have been implemented or currently being worked on by the facility. These measures were identified prior to this plant-wide assessment.

Section 6.3.1 consists of summaries of engineering and cost analysis of major EEOs that were identified in the Lathrop plant. Section 6.3.2 includes the measures identified at the Lathrop facility that, for the most part, did not lend themselves to detailed analysis for various reasons. Section 6.3.3 summarizes energy efficiency measures that have been implemented by the facility. These measures were identified by BASE in its comprehensive assessment.

6.1 Fairfield Facility

6.1.1 Energy Efficiency Opportunities (EEOs)

EEO No. 1 - Repair Compressed Air Leaks

Reduce low pressure compressed air leaks in the plant by inspecting and tightening loose fittings and valves on a bimonthly basis.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP). The LP system consists of one variable frequency driven (VFD) 400 hp two-stage, rotary screw Kobelco (Model KNW series) compressor and two 150 hp two-stage, rotary screw Ingersoll-rand (Model HH150) compressors. The LP system generates air at 149 psig (10.3 bar). The compressed air is stored in two 2,180 gallon air tanks. The LP compressed air is mainly consumed by the injection molding machines and in the packaging lines. While at the plant, the audit team inspected the production area for air leaks. Leaks were found in many different areas. It is recommended that the facility be checked for air leaks during non-operating hours. A regular, bimonthly survey is suggested. These air leaks represent lost compressor horsepower, which translates directly into increased energy usage for plant operation.

EEO No. 2 - Do Not Operate the Grinders During the Peak Period Hours

Install timers on the grinders (and their associated dust collectors) to control their use to the Off-Peak hours to reduce energy and demand charges.

A high demand charge can result from a high rate of energy usage for short periods during production hours. Scheduling of equipment to run off-peak can result in energy and demand cost savings. A data logger was left on the 100 hp grinder to trend the power draw of the unit. Result of the trend power draw shows that currently the grinder is on for about 60% of the time (out of 8,760 hours) during Peak and Part-Peak periods. It has a load factor of 57% for about 16% of the time (out of 8,760 hours), or 3.84 hours per day. Running the grinders during the Peak period (12 - 6 pm, M-F, May through October) can affect the maximum demand of the facility. Installing timers on the grinders so that they cannot be used during the Peak period and Part-Peak period (8:30 p.m. to 12 p.m. and 6 p.m. to 9:30 p.m.) would shift the electrical load from Peak and Part-Peak periods to the Off-Peak period resulting in electrical and demand cost savings.

Proper rescheduling of equipment can reduce the monthly electric and demand charges. There is no energy savings associated with this EEO, only a cost savings due to a difference in energy cost. The facility has one 60 hp and one 100 hp grinders. The small grinder is equipped with a 10 hp dust collector, and the larger grinder is equipped with a 15 hp dust collector.

This measure is recommended with the assumption that all the grinders and their dust collectors are interlocked controlled (refer to EEO No. 4) to ensure they will only operate when the rejected bottles are being grinded (under loaded condition).

EEO No. 3 - Interlock Packaging Lines with the Operation of Blow Molding Machines

Interlock the packaging lines with the corresponding blow molding machine to reduce energy consumption during periods when the blower molders are not operating.

During the plant visit, the audit team observed that the Packaging line #12 for the blow molder PK #12 and one light weight plastic bottle box conveyor line were left running while no bottles or boxes were processed. There are a total of seven packaging lines. Each packaging line is connected with one blow molding machine to perform quality test and package the finished product. The blow molding machines are some times stopped for maintenance purpose or other issues. Based on discussion with plant personnel, it is estimated that on average, one out of seven packaging lines is left running without bottle processing for half of the time. The packaging lines can be interlocked with the blow molding machines so that they only operate when bottles are being processed.

EEO No. 4 - Turn off the Idling Grinders s

Install current sensors on the two grinders to turn them off when idling for extended periods of time.

The facility uses two grinders, each equipped with a dust collector to re-grind the rejected bottles from the production line. The re-ground rejects are then recycled for molding new preforms by the injection molders. During the plant visit, it was observed that the grinders were left idle (no grinding) for extended periods. A data logger was left on the 100 hp grinder to trend the power draw on this units. The logged data showed that the grinder was on for about 60% of the time (out of 8,760 hours). It was idling for about 44% of the time (out of 8,760 hours) with a load factor of 0.4. Based on this information, electrical energy savings of turning off the idling grinders could be estimated.

EEO No. 5 - Install Premium Efficiency Motors When the Existing Motors Wear Out or Require Rewinding

Install premium efficiency motors to replace the existing standard efficiency motors. It is recommended that the premium efficiency motors be installed only as existing motors wear out (i.e. only on a replacement basis).

It was noticed that some of the existing motors at the plant are “high efficiency” or premium efficiency. Depending on the horsepower rating of a given premium efficiency motor, operating efficiencies may be from 1% to 10% higher that the operating efficiencies of your existing motors. In general, the larger the motor, the smaller the efficiency increase. Normally, a cost premium (or cost differential) must be paid if premium efficiency motors are chosen over standard efficiency motors. Many standard efficiency motors were identified at your facility.

EEO No. 6 - Insulate the Resin Dryer Hoppers and Dust Collectors

Insulate the resin dryer hoppers and dust collectors on the natural gas units. The reduced heat loss from these hot surfaces will result in reduced natural gas energy costs.

During the audit of the facility, it was noted that the natural gas resin dryers' hoppers and dust collectors located on the second floor above the injection molding machines had a surface temperature in the range of 110 °F to 200 °F. Surfaces with temperatures greater than 120 °F should be insulated to reduce heat loss. It is recommended that the resin dryer hoppers and dust collectors be insulated to reduce their heat loss. Reduced heat loss will translate into natural gas cost savings because the resin dryers' heaters will not need to operate as long to maintain the supply air temperature.

EEO No. 7 - Control the Air Conveyor Blowers in the Buffer

Control the blowers which supply air to the air-veyors in the buffer with adjustable speed drives (ASD, the same as variable frequency drive, VFD) to reduce the motor speed when bottles are in buffer.

The preforms are blow molded into bottles in batches. The batch is then transported, all at once, from the blow molding room to the packaging room by air-veyors, which are supplied air by blowers. It was observed in the packaging lines 8, 10, 11 and 12, the bottles transferred to the packaging room are kept in buffer before they are stacked in the palletizers. The stacker groups the bottles into a number of rows for stacking and it requires the continuously air conveyed bottles to be on hold until they are called. Therefore, a buffer is needed to temporarily store the bottles in the production line so that there is a consistent supply for the stackers. Each buffer section contains four (4) 3 hp blowers. It is recommended to install VFDs on the buffer air-veyor blowers and integrate the VFD control with the track control that directs the bottle flow. The VFDs would reduce the load (flow) of the blower to 25% while the bottles are in buffer. This will result in an electrical energy and demand savings.

EEO No. 8 - Reconfigure the Current Single Loop Chilled Water System to a Dual Loop System

Reconfigure the single loop chilled water system to a dual loop system. A dual loop system will allow the secondary pump to be controlled for variable flow, reducing the power consumption of the pumps depending on the temperature or pressure of the returning water.

There is one chilled water system supplying chilled water in the plant. According to plant personnel, currently the process chilled water (CHW) from the two chillers first flows to the air handling units (AHU) for cooling the production room. After that CHW flows to the chilled water tank. CHW in the tank is then circulated through the injection molding machines (IMM) and blow molding machines (BMM). Finally, CHW returns to the chillers from the chilled water tank. There are two 75 hp pumps supplying CHW to the AHUs with bypass valve controls, two

200 hp pumps circulates CHW through the IMM's with variable frequency drive (VFD) control and two 200 hp pumps circulates CHW through the BMM's with VFD control. CHW returns to the chillers from the chilled water tank by three 50 hp pumps with constant flow. Based on observation during the audit, one of the 75 hp AHU pumps, one of the 200 hp IMM pumps, one of the 200 hp BMM pumps and two of the 50 hp circulating pumps were on.

The facility uses one 770 ton water-cooled centrifugal type Trane (Model CVHF770) chiller and one 762 ton water cool centrifugal type Trane (Model CVHF910) chiller to produce and provide chilled water for the plant. The chilled water supply temperature is about 42.5°F and the return temperature is about 46.5°F, giving a temperature drop of 4°F.

It is recommended that the facility reconfigure the current single loop chilled water system to a dual-loop system. This dual loop configuration would consist of a constant-flow primary pumping loop and a variable-flow secondary pumping loop. With this system, the primary pumps circulating into the chillers will be constant flow but the chilled water flow supplied to the process by the secondary pumps will be controlled by adjustable speed drives (ASD, the same as variable frequency drive, VFD). By installing a VFD system, energy savings can be obtained due to the fact that the secondary chilled water supply pump motors will no longer be consuming 100% of its rated power during the majority of its operating hours. The system would be set up so that the VFD controller would respond to the return water temperature by increasing or decreasing the flow to match system demand.

EEO No. 9 - When Conditions are Favorable, Duct Outside Air to the Air Compressor Intakes

When the conditions are favorable, duct outside air to the intake of the air compressors. Cooler outside air requires less energy to compress than hot air from the production floor.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP). The HP system consist of four 550 kW Belliss & Morcom reciprocating compressors, six 450 hp Centac compressors and six 250 hp two-stage reciprocating Ingersoll-Rand (Model PHE-NL) compressors. Each of the Centac compressors produces air at 120 psig, and it is stored in a 1,020 gallon tank. The 120 psig air from the storage tank is then fed into the inlet of a PHE booster air compressor, and the discharge air from the PHE is stored in a 361 gallon tank. The HP air is used for the blow molders. The LP system produces compressed air by two Ingersoll-Rand screw compressors, one Centac three-stage centrifugal compressor and one variable frequency drive (VFD) Kobelco compressor. The LP air is used in the injection molder, labelers, palletizers and miscellaneous applications. The following table summarizes the specifications and operating conditions of each of the compressor systems. All the HP and LP air compressors are located in the compressor room next to the production area.

SUMMARY OF AIR COMPRESSOR SYSTEMS					
Air Compressor	No.	Manufacturer Model No.	Power Rating (hp)	Discharge Pressure (psig)	Comment
Low Pressure (LP) System					
Centac #7 (3-Stage)	1	Centac (C35022M3)	600	150	Inlet valve 100% Open
Sierra # 1 and #2 (2-Stage)	2	Ingersoll-Rand (Sierra HH150W)	150	148	On/Off controlled
VFD LP Air Compressor (2-Stage)	1	Kobelco (KNW 2-D/X)	400	147	Recently installed
High Pressure (HP) System					
HP Air Compressor #1 to #4 (3-Stage)	4	Belliss & Morcom (WH50H3N)	737.3	600 ~ 609	Primary HP system units; two are recently installed
Centac #1 to #6 (2-Stage)	6	Centac (ACV18M2)	450	120	Discharge air feeds to the PHE #1 to #6 inlet
PHE #1 to #6 (2-Stage)	6	Ingersoll-Rand (PHE-NL)	250	596	Inlet air fed from the Centac #1 to #6 discharge

Currently the inlet air for the compressors, except the six PHE booster compressors, comes from the blow molding production area, which is conditioned to a temperature of approximately 75 °F. Since cooler air is denser than warmer air, it will take the compressor's motor less work to compress cool, outside air from ambient pressure (14.7 psia) to discharge pressure (approximately 600 psia for HP and 149 psia for LP). When the outside air temperature is less than 75 °F, the HP compressor inlet air should be taken from outside. According to a climate weather database¹, there are about 6,654 hours per year that the ambient temperature is below 75 °F for Fairfield, California. Of those hours, the average annual outdoor temperature is about 55.2 °F. By ducting outside air to the inlet of the HP air compressors the energy required by the HP compressors to produce compressed air can be reduced.

EEO No. 10 - Reduce Low Pressure Air Compressors' Discharge Pressure

Reduce the operating pressure of the low pressure air compressors from 150 psig to 120 psig and add an additional 6500 gallon air receiver to increase the compressed air capacity for use during times of peak compressed air demand.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP) per details in EEO No. 9. The LP air is stored in two storage tanks with a total capacity of 4,360 gallons.

Compressed air system inspections in the two other AMCOR PET facilities, Lathrop (have blow molding production) and Commerce (have blow molding and injection molding productions),

¹ Western U.S. Climate Historical Summaries. <http://www.wrcc.dri.edu/Climsum.html>

show that all the on/off-controlled LP compressors in these two plants are set to be loaded at 110 psig and unloaded at 120 psig with a targeted pressure at about 115 psig. Since the Fairfield plant has the same production system as the other two plants, it is recommended that the low pressure compressed air system should produce compressed air at 120 psig, which will result in energy and demand savings. It is also recommended that another storage tank be added to the system to compensate for the system storage capacity reduction associated with reducing the pressure. Reducing the pressure of the LP compressed air to 120 psig from 150 psig will reduce the electrical energy and demand of the LP air compressors.

EEO No. 11 - Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air

Install a recuperator, gas-to-gas heat exchanger, on each of the resin dryer process heater exhaust. The recovered heat from the exhaust can be used to preheat the dryer circulating air.

There are thirteen injection molding machines in the plant, and each of the injection molders is equipped with a resin dryer. Ten of the dryers are natural gas units while the other three are electrical dryers. In the resin dryer system, circulating air is heated by an air heater, which then flows through the resin dryer hopper. Humid air is dehumidified by a desiccant dehumidifier before returning back to the heater. Based on temperature measurements, it is recommended that heat exhausted from the ten natural gas process heaters be recuperated to preheat the circulating air.

The recuperator is a gas-to-gas heat exchanger mounted on the exhaust stack. A recuperator can be used to preheat the resin dryer circulating air by extracting waste heat from the exhaust stack. The circulating air to the heater is routed through the heat exchanger to be preheated before entering the air heater intake. The present forced-draft intake line can be used with a slightly larger power draw on the blower to overcome the pressure drop through the heat exchanger. Preheating the intake air will result in less gas usage to maintain the set point temperature of the heater.

EEO No. 12 - Reduce High Pressure Air Compressors' Discharge Pressure

Reduce the operating pressure of the high pressure air compressors from 600 psig to 560 psig and add a second 3000 gallon air receiver to increase the compressed air capacity for use during times of peak compressed air demand.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP) as detailed in EEO No. 9. It is recommended that the high pressure compressed air system should produce compressed air at a pressure closer to the blow molder's required pressure, which will result in energy and demand savings. According to Sidel, the blow molders require 35 bar (507.6 psi) pressure compressed air. It is also recommended that another storage tank be added to the system to compensate for the system storage capacity reduction associated with reducing the pressure. Reducing the pressure that the HP compressed air is produced at to 560 psig from 600 psig will reduce the electrical energy usage and demand of the HP air compressors.

EEO No. 13 - Install Adjustable Speed Drive (ASD) on the Two Trane Chillers

Install adjustable speed drives (ASD, the same as variable frequency drive, VFD) on the two existing electric-driven single compressor centrifugal chillers.

The facility uses one 770 ton Trane (Model CVHF 0770) water-cooled centrifugal chiller (Chiller 1) and one 762 ton Trane (Model CVHF 0910) water-cooled centrifugal chiller (Chiller 2) to produce chilled water. The two chillers are used for cooling the blow molding and injection molding processes as well as space conditioning of the production room. Each chiller has one centrifugal compressor. The chillers use R-123 refrigerant.

Based on the power reading of the compressor control screen, it was determined that the compressors of both chillers were operating at 44% load of full power rating with inlet guide vane at about 31% open. By utilizing an ASD to control the chiller compressors in place of inlet guide vanes, significant electrical energy savings can be realized through accurately matching the chillers' with the actual cooling load requirement.

Note: Based on information from Trane, these two water-cooled centrifugal chillers (Model CVHF) can be equipped with ASD controllers.

6.1.2 Additional Energy Efficiency Measures

In this section some general information about other energy efficiency opportunities (EEOs) at this facility is provided. Some of the items discussed during the assessment of this facility have energy savings potential, but would require relatively lengthy simple payback periods (greater than 5 years). Other items would save very little (less than \$200 per year), and are presented here for this plant's information only. Detailed analysis of some of these measures were not possible due to insufficient data were not available to analyze them. Calculations of savings and costs for all of these items are not included in the main body of the report, but qualitative description and some results are summarized here for this plant's information.

Convert the Existing Electrical Regenerator Heaters to Natural Gas Heaters in The Resin Dryers

There are thirteen injection molding machines an the plant, and each of the injection molder is equipped with a resin dryer. Each of the dryer packages consists of a process heater, a regeneration heater, transport blowers and desiccant reactivators. Based on the nameplate data of the dryers, nine of the units made by Universal Dynamic Inc. (UNA-DYN), are equipped with natural gas process and regeneration heaters. According to plant personnel, the electric process heaters have been converted into natural gas heaters. The regeneration heaters remain as electric units since the conversion would impact in the reactivator and the control system. However, there is a potential of converting the electric regeneration heaters to natural gas units with the control system upgrade. It is recommended the facility consult the manufacturer Piovan regarding the regeneration heater retrofit.

Switching the fuel source from electricity to natural gas does not result in energy savings, but it will reduce the energy cost due to the lower charges for natural gas. An electric heater has a thermal efficiency at or very near 100%. Since the proposed natural gas heater will have a thermal efficiency of about 80%, there will be an increase in energy consumption at the facility. However, due to the efficiency of power plants that supply electricity, there will be less energy consumed on a global basis.

Insulate the Heating Barrels on the Injection Molding Machines

There are thirteen injection molding machines at the plant used for producing performs. Each of the injection molders includes a heater barrel. It is recommended the heating barrels be insulated if currently no insulation is applied. Surfaces with temperatures greater than 120 °F should be insulated to reduce heat loss. Insulating the heating barrels can reduce their heat loss. Reduced heat loss will translate into electric cost savings because the heater will not need to operate as long to maintain the supply air temperature.

Reduction of heat loss from the heating barrels will also result in reducing the air conditioner cooling load in the production room.

6.1.3 Energy Efficiency Measures Implemented

Based on the interview with plant personnel and observations during the audit, it was noticed that the plant had implemented energy efficiency retrofits on some of the systems resulting in energy savings. The measures are summarized as follows:

1. The facility has installed a 400 hp variable frequency drive (VFD) Kobelco (KNW Series) two-stage rotary screw air compressor in the low pressure (LP) system to adjust the LP capacity as required.
2. The facility has installed two new 550 kW Belliss and Morcom three-stage air compressors in the high pressure (HP) system. The total number of four Belliss HP compressors run as the primary units. This implementation can avoid the short term starts on the Centac compressors (refer to the air compressor system summary on page 6-6).
3. The facility has installed air recovery kit (ARK) on the blow molding machines. The ARK can collect up to 60% of the HP air consumption with the recovered pressure of about 120 psig. The recovered air can also be converted into preblow and service air for stretching and nozzle cylinders to reduce the HP consumption as mentioned in the Evaluation of Air Saving with Air Recovery Kit report from Sidel. Therefore, the ARK system will reduce loads on both of the LP and HP systems.
4. The facility has replaced the 1000-watt metal halide lamps and fixtures with 320-watt electronic ballast pulse start metal halide fixtures that are equipped with motion activated bi-level controls in the production and packaging areas.
5. The facility has reconfigured the chilled water system to remove the plate-frame heat exchanger between the chillers, blower molders and injection molders, and use the direct chilled water for cooling.
6. The facility has replaced a desiccant compressed air dryer with a refrigerated compressed air dryer.
7. The facility isolates the chilled water to the injection molding machines (IMM) when the IMMs are not used.
8. The facility has converted the electric process heaters to natural gas heaters on the resin dryers.
9. The facility has installed exhaust fans to duct the hot air out of the ovens on the blow molding machines.
10. All the cooling tower fans are equipped with variable frequency drives.

6.2 Commerce Facility

6.2.1 Energy Efficiency Opportunities (EEOs)

EEO No. 1 - Reduce Low Pressure Quincy Northwest Air Compressor's Discharge Pressure

Reduce the operating pressure of the low pressure Quincy Northwest air compressor in Air Compressor Room # 2 from 130 psig to 117 psig.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP). The LP system produces compressed air with one 200 hp Ingersoll-Rand (Model SSR-EP200) compressor located in the Air Compressor Room 1 and one 250 hp Quincy Northwest (Model QNW-1011-D) rotary screw compressor located in the Air Compressor Room 2. The audit team observed the Ingersoll-Rand compressor discharged air at 117 psig, and it was operating at 95% load at a base unit. The QNW compressor discharged air at 130 psig, and its inlet capacity was controlled at about 60%. Compressed air is then stored in a storage tank at 115 psig. The LP compressed air is mainly consumed by the injection molding machines and in the packaging lines. The storage tank has a capacity of 5,000 gallons. It is recommended that the QNW compressor should produce compressed air at 117 psig, the same as the Ingersoll-Rand unit. Reducing the pressure that the QNW compressor produces at to 117 psig from 130 psig will reduce the electrical energy usage and demand.

EEO No. 2 - Insulate the Resin Dryer Hoppers and Dust Collectors

Insulate the resin dryer hoppers and dust collectors on the natural gas units. The reduced heat loss from these hot surfaces will result in reduced natural gas energy costs.

During the audit of the facility, it was noted that the natural gas resin dryers' hoppers and dust collectors located on the second floor above the injection molding machines had a surface temperature in the range of 110 °F to 200 °F. Surfaces with temperatures greater than 120 °F should be insulated to reduce heat loss. It is recommended that the resin dryer hoppers and dust collectors be insulated to reduce their heat loss. Reduced heat loss will translate into natural gas cost savings because the resin dryers' heaters will not need to operate as long to maintain the supply air temperature.

EEO No. 3 - Insulate the Heating Barrels on the Injection Molding Machines

Insulate the injection molder heating barrels. The reduced heat loss from these hot surfaces will result in reduced electrical energy costs.

During the audit of the facility, it was noted that the injection molder heating barrels located in the packaging room had a high surface temperature, in the range of 220 °F to 250 °F as measured by the plant personnel. Surfaces with temperatures greater than 120 °F should be insulated to reduce heat loss. It is recommended that the heating barrels be insulated with insulating blankets to reduce their heat loss. Reduced heat loss will translate into electric cost savings because the heater will not need to operate as long to maintain the supply air temperature.

Reduction of heat loss from the heating barrels will also result in lowering the temperature of the manufactory floor.

EEO No. 4 - Duct Oven Heat Out of Air Conditioned Blow Molding Area

Duct the blow molder oven heat out of the Blow Molding Area in order to reduce the area's air conditioning load.

The facility has eleven (11) Sidel blow molders and one (1) Krones blower molder. They are used to blow mold plastic beverage bottles. This is done by heating the plastic preforms in an infra-red oven from ambient temperature to a temperature in the range of 217 - 234 °F, depending upon the particular bottle requirements. The infra-red oven is heated in the range of 262 - 338 °F. The blow molders are located in the Blow Molding Room, which is air conditioned to maintain a temperature of 80 °F by eighteen York 20 ton packaged air conditioning units.

Currently, hot air is naturally vented from the blow molder's ovens into the Blow Molding Room. To maintain the blow molding area at a temperature of 80 °F, the packaged A/C units on the roof use mechanical energy to remove heat from the air in the room. Ducts could be installed above each infra-red oven to duct oven heat to the outside air. This will reduce the cooling load on the room's HVAC equipment, which will result in electrical energy savings. This measure has been implemented in Fairfield plant.

EEO No. 5 - Control the Evapco Cooling Tower Fan Motors with Adjustable Speed Drives

Control the Evapco cooling tower fan motors with adjustable speed drives (ASD, the same as a variable frequency drive, VFD) to reduce their energy consumption when the ambient wet-bulb temperature is less than maximum design load.

The plant uses five (5) AEC cooling towers (System #1) and three (3) Evapco cooling towers (System # 2) to produce process cooling water. Each Evapco cooling tower is equipped with one 40 hp fan and each AEC cooling tower is equipped with one 15 hp fan. On average, three out of five (3/5) AEC cooling towers and two out of three (2/3) Evapco cooling towers operate at a time. According to plant personnel, the cooling tower fans operate continuously at full-speed for its annual operating hours due to the lack of temperature or other feedback control. By controlling the cooling tower fans to reduce their rotational speed when the cooling load is satisfied, energy savings can be realized. Energy savings of installing ASDs on the three Evapco

cooling towers is analyzed in this measure. Please refer to EEO No. 8 for savings of replacing the existing AEC cooling towers with higher efficiency cooling towers with ASD control.

EEO No. 6 - When Conditions are Favorable, Duct Outside Air to the Air Compressor Intakes

When the conditions are favorable, duct outside air to the intake of the air compressors and turn off the cooling fans in the rooms. Cooler outside air requires less energy to compress.

The plant has two separate compressed air systems. The high pressure (HP) system produces compressed air with twelve Bellis and Morcom three-stage reciprocating compressors and is used in the blow molding operation. The HP compressed air is produced at approximately 600 psig. The low pressure (LP) system produces compressed air with one Ingersoll-Rand screw compressors and one rotary screw type Quincy Northwest compressor, and is used in the injection molder, labelers and palletizers. The LP compressed air is produced at 120 psig. Half of the HP and LP air compressors are located in the Air Compressor Room 1 and the other half are located in the Air Compressor Room 2.

Currently, the inlet air for the compressors comes from inside the room. Each of the air compressor rooms is cooled by chilled water coils with four (4) 5-hp fans drawing in outside air to the room. On the day of audit, the wall thermometer showed that the room temperature was at 84 °F. According to the plant personnel, the air compressor rooms are cooled between 65 to 85 °F. Hence, the average room temperature is assumed to be 75 °F. Since cooler air is denser than warmer air, it will take the compressor's motor less work to compress cool, outside air from ambient pressure (14.7 psia) to discharge pressure (approximately 600 psia for HP and 120 psia for LP). When the outside air temperature is less than 75 °F, the compressor inlet air should be taken from outside. According to a climate weather database, there are about 8,416 hours per year that the ambient temperature is below 75 °F for Los Angeles, California. Of those hours, the average annual outdoor temperature is about 60.8 °F. By ducting outside air to the inlet of the air compressors the energy required by the compressors to produce compressed air can be reduced.

ECO No. 7 - Recuperate Heat from the Resin Dryer Process Heater Exhaust to Preheat the Circulating Air

Install a recuperator, gas-to-gas heat exchanger, on each of the resin dryer process heater exhaust. The recovered heat from the exhaust can be used to preheat the dryer circulating air.

There are six injection molding machines utilized in the plant, and each of the injection molder is equipped with a resin dryer. In the resin dryer system, circulating air is heated by an air heater, and then it flows through the resin dryer hopper. Humid air is dehumidified by a desiccant dehumidifier before returning back to the heater.

The recuperator is a gas-to-gas heat exchanger mounted on the exhaust stack. A recuperator can be used to preheat the resin dryer circulating air by extracting waste heat from the exhaust stack. Using heat from the hot exhaust gas can save natural gas energy. The circulating air to the heater is routed through the heat exchanger to be preheated before entering the air heater intake. The present forced-draft intake line can be used with a slightly larger power draw on the blower to overcome the pressure drop through the heat exchanger. Preheating the intake air will result in less gas usage to maintain the set point temperature of the heater.

EEO No. 8 - Replace the AEC Plastic Cooling Towers with Higher Efficiency Units

Replace the existing AEC plastic cooling towers with higher performance units, and control the proposed cooling tower fan motors with adjustable speed drives (ASD, the same as a variable frequency drive, VFD) to reduce its energy consumption when the ambient wet-bulb temperature is less than maximum design load.

The plant uses five (5) 200-ton AEC cooling towers (System #1) and three (3) Evapco cooling towers (System # 2) to produce process cooling water. Each Evapco cooling tower is equipped with one 40 hp fan and each AEC cooling tower is equipped with one 15 hp fan. On average, three out of five (3/5) AEC cooling towers and two out of three (2/3) Evapco. Based on the performance data of the AEC cooling towers, higher efficiency cooling towers with VFD control on fans are available to replace the existing units. The cooling tower performance ratio is estimated to be 0.1931 MMBtu/kWh for the existing 200-ton AEC unit with one 15 hp fan. According to manufacturer's literature, each AEC cooling tower is rated under the operating conditions of 95 °F entering water temperature and 85 °F leaving water temperature at 78 °F ambient wet bulb, and the flow of 3 gpm per ton (or 600 gpm for the whole unit). The cooling tower performance ratio is estimated to be 0.2873 MMBtu/kWh for the proposed 200-ton Evapco unit with one 10 hp fan.

It is recommended to replace three of the existing AEC cooling towers with higher efficiency Evapco cooling towers with VFD controls on fans, and use the other two AEC units as backup. A higher performance cooling tower consumes less energy for rejecting the same amount of heat. Also, by controlling the cooling tower fan to reduce its rotational speed when the cooling load is satisfied, additional energy savings would be realized.

EEO No. 9 - Replace the Low Pressure Quincy Northwest Air Compressor with a Variable Frequency Drive Air Compressor

Install a new variable frequency drive (VFD, same as adjustable speed drive ASD) air compressor to replace the current low pressure Quincy Northwest air compressor that is inlet capacity controlled. A VFD air compressor will vary the output of the compressor to match the system's needs.

The plant utilizes one 200 hp Ingersoll-Rand (Model SSR-EP200) air compressor and one 250 hp Quincy Northwest Rotary Screw (Model QNW 1011-D) air compressor to generate compressed

air for the low pressure air system. The audit team observed that the Ingersoll-Rand compressor was modulated at 95% load with air generated at 117 psig, while the Quincy Northwest compressor's inlet capacity was controlled at about 60% open and discharged air at 130 psig. The discharge air from the two compressors is stored in a 5,000 gallon air tank. The air pressure in the tank is 115 psig . A VFD-controlled compressor is more efficient. The energy saving is the result of varying motor speed to meet the load, which needs less motor power consumption. According to the manufacturer's literature when using the modulation control, the QNW compressor uses 87% of full load power for 60% of air capacity while a VFD-controlled compressor uses about 66% of full load power for the same air capacity. It is recommended to replace the 250 hp QNW 1010-D rotary compressor with a VFD-controlled compressor and have the compressed air produced at 117 psig.

EEO No. 10 - Install Automatic Controls on the Existing Economizers on the Air Conditioning Units

Install automatic controls on the existing economizers on the Air Conditioning Units (A/C) on the roof. When the outside air temperature is less than 60 °F, outside air could be used to provide cooling for the blow molding production room. Using economizers to cool the blow molding area will reduce the load on the air conditioning units, which will result in significant energy savings.

The blow molding production area is cooled by eighteen (18) 20 ton York A/C units located on the roof above the manufacturing area. Each A/C unit has four compressor (about 6.64 kW each), two 1 hp or 1.25 hp outdoor fans, and one 7.5 hp evaporator blower. The major heat sources in the production room are the heat rejected from the infra red ovens and the main carousel drives of the blow molders. According to plant personnel, the A/C units are only dry-bulb temperature controlled by a thermostat, without consideration of the room humidity. Each of the A/C units is equipped with an economizer and currently the economizers are manually controlled at 20% open or fully closed.

Economizers are essentially a duct and damper system that allow fresh outside air to be used directly for space cooling whenever outdoor temperature and humidity levels are favorable. By using cool **outside** air whenever possible, the energy consumption by the mechanical cooling units can be reduced significantly. The larger the internal gain (heat from equipment, people, etc.), the more effective the economizers are, and the greater the potential savings as compared with mechanical cooling.

EEO No. 11 - Reconfigure the Current Single Loop Chilled Water/Cooling Tower Water Systems to Dual Loop Systems

Reconfigure the single loop chilled water system and cooling tower water systems to dual loop systems. A dual loop system will allow the secondary pump to be controlled for variable flow, reducing the power consumption of the pumps depending on the temperature or pressure of the returning water.

There are one chilled water system and two cooling tower water systems (the Evapco tower system and the AEC tower system) supplying chilled water/cooling water in the plant. Currently each of the three systems is configured as a single loop system with a process water tank (cold well) and a water return tank (hot well). Each system is equipped with two sets of pumps, the process water supply pumps and the circulation pumps. The facility uses one 150 ton water cool rotary screw type Trane (Model RTHB150, R22) chiller and one 250 ton water cool rotary screw type Trane (Model RTHC1C1F, R134a) chiller to produce and provide chilled water for cooling the injection molding machines and blow molding machines. The chilled water supply temperature is 43°F and the return temperature is 48.2°F, giving a temperature drop of 5.2°F. The Evapco cooling tower system, system #2, have three Model At112814 Evapco cooling towers, which two are normally operate. Tower system #2 provides cold water for cooling the two chillers, air compressors in the compressor room #2 and injection molders. The tower system #1 has five Application Engineering Corp. (AEC) cooling tower that three are running at a time. It provides cold water for cooling the air compressors in the compressor room #1.

It is recommended that the facility reconfigure the current single loop chilled/tower water systems to dual loop systems. This dual loop configuration would consist of a constant-flow primary pumping loop and a variable-flow secondary pumping loop. With this system, the primary pumps circulating into the chillers will be constant flow but the chilled water flow supplied to the process by the secondary pumps will be controlled by adjustable speed drives (ASD, the same as variable frequency drive, VFD). By installing an ASD system, energy savings can be obtained due to the fact that the secondary chilled water supply pump motors will no longer be consuming 100% of its rated power during the majority of its operating hours. The system would be set up so that the ASD controller would respond to the return water temperature by increasing or decreasing the flow to match system demand.

EEO No. 12 - Reduce High Pressure Air Compressors' Discharge Pressure

Reduce the operating pressure of the high pressure air compressors from 609 psig to 560 psig and add a second 5,000 gallon air receiver to increase the compressed air capacity for use during times of peak compressed air demand.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP). The HP system produces compressed air with twelve Bellis & Morcom three stage reciprocating compressors. The audit team observed the HP compressed air system to be producing compressed air at an average of approximately 609 psig. The compressed is then stored in a storage tank at 600 psig. The HP compressed air is consumed by twelve blow molders during the blow molding operation. The storage tank has a capacity of 5,000 gallons.

It is recommended that the high pressure compressed air system should produce compressed air at a pressure closer to the blow molder's required pressure, which will result in energy and demand savings. According to Sidel, the blow molders require 35 bar (507.6 psi) pressure compressed air. It is also recommended that another storage tank be added to the system to compensate for the system storage capacity reduction associated with reducing the pressure.

Reducing the pressure that the HP compressed air is produced at to 560 psig from 609 psig will reduce the electrical energy usage and demand of the HP air compressors.

EEO No. 13 - Replace the Existing Trane Chillers with Higher Efficiency Units

Replace the two existing Trane chillers with higher efficiency units.

The facility uses one 150 ton Trane (Model RTHB150) water-cooled screw chiller (Chiller 1) and one 250 ton Trane (Model RTHDC1CIFOF) water-cooled screw chiller (Chiller 2) to produce chilled water for cooling the machines used in the blow molding and the injection molding processes. The existing 150 ton RTHB unit operates at the performance value of 0.8 kW/ton at full capacity. According to Trane, the 150 ton RTHB model is not capable to be retrofitted with an adjustable speed control (ASD, the same as variable frequency drive, VFD) on the compressor motor, but there are higher efficient models available for replacement. Based on the operating condition of the existing unit, the RTHB unit can be replaced with a higher efficiency 130 ton Trane (Model RTWD130) water cooled screw chiller. The proposed RTWD unit can operate at the performance value of 0.511 kW/ton at full capacity. This provides about 36% higher efficiency than the existing unit. By replacing the existing chiller with a higher efficiency unit, significant electrical energy and demand savings can be realized while providing the same amount of cooling.

EEO No. 14 - Replace the Existing Rooftop Single Package A/C System with a Central Chilled Water Cooling System

Install a dual loop chilled water cooling system to replace the existing rooftop packaged air conditioning units for conditioning the blow molding production room.

Currently the blow molding production room is air conditioned by eighteen (18) rooftop air-cooled, single package air conditioners (A/C). Each A/C unit is rated at 20 ton. The major heat sources in the production room are the heat rejected from the infra red ovens and the main carousel drives of the blow molders. The A/C system is used to dehumidify air in the blow molding room. The existing 20-ton air cooled package A/C units have an energy efficiency ratio (EER) of about 10 (equivalent to 1.2 kW/ton), while a 360-ton high efficiency water cooled centrifugal chiller with VSD control will have a full load chiller performance value of about 0.50 kW/ton. This provides about 58% higher efficiency than the existing A/C system. Replacing the existing A/C system with a high efficiency chill water system will result in significant electrical energy savings as well as maintenance cost savings.

The equipment to be removed includes all eighteen A/C units on the roof. The equipment to be installed include a 360 ton water cooled centrifugal chiller with variable frequency drive (VFD) control and the chilled water (CHW) circulation pump, a cooling tower (CT) with VFD control, cold water circulation pump, and multiple air handling units (AHU) on the roof to supply cool air. It is recommended the CHW and CT water systems should be configured as dual loop systems.

6.2.2 Additional Energy Efficiency Measures

Repair Air Leaks

Production of compressed air is expensive, so we recommend that you have a maintenance person check for air leaks in the throughout the plant on a regular basis. As an example, a 1/32 inch air leak (considered a small sized air leak) will result in approximately \$169 per year in electrical costs. It is recommended that a maintenance person walk through the plant while the air compressors are running, and repair all air leaks.

Install Energy Efficient Motors

Many motors at your facility can be replaced with premium efficiency motors as they burn out. Depending on the horsepower rating of a given high efficiency motor, operating efficiencies may be from 1% to 10% higher than the operating efficiencies of the existing motors. In general, it can be said that the larger the motor, the smaller the increase in efficiency. Normally, a cost premium (or cost differential) must be paid if higher efficiency motors are chosen instead of standard efficiency motors. The estimated efficiencies of the existing motors, potential increase in efficiency and cost premium (rebate included if available) for motors with various horsepower ratings can be obtained from a software package called "Motor Master" distributed by Motor Challenge Clearinghouse. We recommend obtaining this software package, at no cost, by calling (800) 865-2086 or can be downloaded at the DOE Web site (<http://www.oit.doe.gov/bestpractices/>). The software can help you in identifying high efficiency motors that are equivalent to standard efficiency motors.

Interlock Packaging Lines with Blow Molding Machine Operations

There are a total of twelve (12) packaging lines. Each packaging line is connected after one blow molding machine to perform quality test and packaging for the finished bottles. During the plant visit, the audit team observed that package lines #3 and #6 were left running while no bottles or boxes were processed. Interlocking the packaging lines with the corresponding blower molding machine can reduce energy consumption when the blower molder is not operating. According to plant personnel, eight packaging lines have been retrofitted with programmable logic control (PLC) to interlock the line process with blow molder operations, and the plant is working on the rest of the four lines with PLC retrofit.

6.2.3 Energy Efficiency Measures Implemented

Based on the interview with plant personnel and observations during the audit, it was noticed that the plant had implemented or is currently working on energy efficiency retrofits on some of the systems resulting in energy savings. The measures are summarized as follows:

1. The facility has been working on the project of installing a variable frequency drive (VFD) compressor in the low pressure (LP) system to have it run as a trim unit. Installation is expected to be done by December 2007.
2. The facility has started on the project of installing twelve oven hoods to duct the oven heat out of the blow molding machines.
3. The facility has installed air recovery kits (ARK) on two of the blow molding machines for testing of the new systems. The ARK recovers the high pressure (HP) air at about 120 psig and the recovered air is fed to the LP system.
4. The facility has been working on the project of reducing the HP discharge pressure.
5. The facility has installed programmable logic control (PLC) on eight packaging lines to interlock the line process with the associated blow molder operations, and the facility is working on the rest of the four lines with PLC retrofit.
6. The facility has retrofitted the lighting in the production building by replacing the 400-watt metal halide lamps and fixtures with high efficiency T8 or T5 fluorescent lights two years ago. Also, occupancy sensors have been installed in the office area, and photo cells have been installed under the skylights to automatically control the lights.

6.3 Lathrop Facility

6.3.1 Energy Efficiency Opportunities (EEOs)

EEO No. 1 - Install Daylight Controls on the Main Floor Lighting Fixtures

Install daylight controls in the Main Floor metal halide lamps to reduce the lighting energy usage during daytime.

The Main Floor covers approximately 76,668 ft² and has a ceiling height of approximately 35 ft. There are two main operations on the Main Floor: packaging and storage (small warehouse space). Throughout the roof there are a total of 44 skylights (approximately 32ft² each) that provide daylight to the packaging and warehouse area. Additionally there are one hundred and eighty-one 400-Watt metal halide lamps used for general illumination. By controlling the lights with daylight sensors, lighting can be eliminated in the area during daylight hours. Additional savings from a reduced maintenance cost have not been estimated, but are not expected to be significant.

EEO No. 2 - Install Digital Timers and Bi-level Controllers on Equipment Room Lighting

Install digital timers and bi-level controllers on the Air Compressor and Chiller Rooms to reduce lighting energy usage.

Digital timers and bi-level controllers will reduce the electrical consumption of lighting in the Air Compressor and Chiller rooms by dimming the lamps for times that there is no work being done in the area. Because the lamps are dimmed (not completely turned off), workers will be able to activate the digital timer for a preset amount of time (from 5 minutes up to 12 hours, bringing the lamps up to full brightness within 3 seconds. Dimming the lamps when they are unoccupied will result in electrical energy savings.

EEO No. 3 - Install Premium Efficiency Motors When the Existing Motors Wear Out or Require Rewinding

Install premium efficiency motors to replace the existing standard efficiency motors at this facility. It is recommended that the premium efficiency motors be installed only as existing motors wear out (i.e. only on a replacement basis).

It was noticed that some of the existing motors at the plant are “high efficiency” or premium efficiency. Only motors that would have a simple payback period of less than 6 years have been included in this measure. Depending on the horsepower rating of a given premium efficiency motor, operating efficiencies may be from 1% to 10% higher than the operating efficiencies of your existing motors. In general, the larger the motor, the smaller the efficiency increase.

Normally, a cost premium (or cost differential) must be paid if premium efficiency motors are chosen over standard efficiency motors. Many standard efficiency motors were identified at your facility. The estimated efficiencies of the existing motors, potential increase in efficiency and cost premium (rebate included if available) for motors with various horsepower ratings can be obtained from a software package called "Motor Master" distributed by Motor Challenge Clearinghouse. We recommend obtaining this software package, at no cost, by calling (800) 865-2086 or can be downloaded at the DOE Web site (<http://www.oit.doe.gov/bestpractices/>). The software can help you in identifying high efficiency motors that are equivalent to standard efficiency motors

EEO No. 4 - Duct Oven Heat Out of Air Conditioned Blow Molding Area

Duct the blow molder oven heat out of the Blow Molding Area in order to reduce the area's air conditioning load.

The facility has 8 Sidel blow molders. They are used to blow mold plastic beverage bottles. This is done by heating the plastic preforms in an infra-red oven from ambient temperature to a temperature in the range of 190 - 270 °F, depending upon the particular bottle requirements. The blow molders are located in the Blow Molding Room, which is air conditioned to maintain a temperature of 80 °F by nine TRANE 25 ton packaged air conditioning units and one 120 ton air handler unit (AHU)..

Currently, hot air is naturally vented from the blow molder's ovens into the Blow Molding Room. To maintain the blow molding area at a of 80 °F, the AHU inside the area and the packaged HVAC units on the roof use mechanical energy to remove heat from the air in the room. Ducts could be installed above each infra-red oven to duct oven heat to the outside air. This will reduce the cooling load on the room's HVAC equipment, which will result in electrical energy savings. This measure has been implemented in Fairfield plant.

EEO No. 5 - Control the Air Conveyor Blowers in the Buffer

Control the blowers which supply air to the air-veyors in the buffer by shutting of the blowers on the leg of the buffer when bottles are not transported through it.

The preforms are blow molded into bottles in batches. The batch is then transported, all at once, from the blow molding room to the packaging floor by air-veyors, which are supplied air by blowers. As the bottles move to the packaging floor a label is applied to them and then they move to the palletizer. However, the palletizer requires a consistent supply of bottles to operate correctly; it is not able to handle the inconsistent batches of bottles like the labeler is. Therefore, a buffer is needed to temporarily store the bottles in the production line so that there is a consistent supply for the palletizer. It is recommended to interlock the air-veyor blowers, by leg, in the buffer to the track controls which directs the bottle flow. Doing this will shut off the air-veyor blowers on the leg which bottles are not moving through, which will result in an electrical energy savings.

EEO No. 6 - When Conditions are Favorable, Duct Outside Air to the Air Compressor Intakes

When the conditions are favorable, duct outside air to the intake of the air compressors. Cooler outside air requires less energy to compress than hot air from the production floor.

The plant has two separate compressed air systems. The high pressure (HP) system produces compressed air with six Bellis and Morcom three stage reciprocating compressors and is used in the blow molding operation. The HP compressed air is produced at approximately 720 psig, is throttled to 600 psig for the storage tank, and is throttled to 565 psig in the blow molders. The low pressure (LP) system produces compressed air with two Ingersoll-Rand screw compressors and is used in the labelers and palletizers. The LP compressed air is produced at 105 psig and is used at various pressures ranging from 20 psig to 80 psig. The six HP air compressors are located in the equipment room along with one of the LP air compressors. The other LP air compressor is located in the equipment yard.

Currently, the inlet air for the HP compressors comes from the blow molding production floor, which is conditioned to a temperature of approximately 80 °F. Since cooler air is denser than warmer air, it will take the compressor's motor less work to compress cool, outside air from ambient pressure (14.7 psia) to discharge pressure (approximately 614 psia for HP and 120 psia for LP). When the outside air temperature is less than 80 °F, the HP compressor inlet air should be taken from outside. According to a climate weather database, there are 7,796 hours per year that the ambient temperature is below 80 °F for Sacramento, California. Of those hours, the average annual outdoor temperature is about 56.1 °F. By ducting outside air to the inlet of the HP air compressors the energy required by the HP compressors to produce compressed air can be reduced.

EEO No. 7 - Install Lighting Occupancy Sensors in Low Occupancy Areas

Install lighting occupancy sensors in the in low occupancy areas to reduce lighting energy usage. The lights in areas, such as the Plant Manager Office, Preform Warehouse, Production Office, etc., are left on all the time during operating hours. By installing lighting occupancy sensors on the fluorescent fixtures in these areas, lighting can be controlled to operate only when an area is occupied. For metal halide fixtures it will be necessary to install bi-level controllers in each fixture. Bi-level controllers will dim the lamps instead of turning off the lamps for times when the area is not occupied. This will allow the metal halide lamps to come on at full brightness without the re-strike times which are typical of high intensity discharge lamps.

EEO No. 8 - Install Adjustable Speed Drives (ASD) on the Chilled Water Pumps

Install adjustable speed drives (ASD, the same as variable frequency drive, VFD) on the chilled water pump motors. The use of ASD will reduce the power consumption of the supply pumps depending on the temperature of the returning chilled water.

The facility uses a 300 ton McQuay water-cooled centrifugal chiller to produce chilled water for cooling the machines used in the blow molding process as well as for space cooling and humidity control via the Air Handler Units (AHU). The chiller has one centrifugal compressor with R-134a refrigerant. The chiller uses three chilled water pumps to circulate the chilled water; two are 50 hp (both were “on” during the audit) and the third is 60 hp (“off” during the audit). During the audit it was noted that the throttle valves which controlled the chilled water were approximately 30% open. By utilizing an ASD to control the chilled water pumps, energy savings can be achieved due to the fact that the pumps will not be running at 100% load for their entire operating hours. The ASD controllers would be set up to respond to the return chilled water temperature by increasing or decreasing the speed of chilled water pump.

EEO No. 9 - Install Adjustable Speed Drives (ASD) on the Process Water Pumps

Install adjustable speed drives (ASD, the same as variable frequency drive, VFD) on the process water pump motors. The use of ASDs will reduce the power consumption of the pumps depending on the temperature of the returning process water.

The process cooling system serves to provide cooling to the chiller and high pressure air compressors. The process cooling system includes a Marley Cooling Tower, model number NC8309H4BS, a two-speed Marathon fan motor, model number 8H364TTFS7229AT, and three process water pumps, one 60 hp pump and two 75 hp pumps. During the audit it was observed that the fan was operating 40% of the time at high speed. It was also observed that two of the pumps (60 hp and 75 hp) were operating; the other (75 hp) was off and is a backup pump.

The facility uses a 300 ton McQuay water-cooled chiller to produce chilled water for cooling the machines used in the blow molding process as well as for space cooling and humidity control via the Air Handler Units (AHU). As the chiller is water-cooled, heat rejected from the vapor-compression cycle in the condenser is transported by process water to the cooling tower, where the heat is rejected into the ambient air. The chiller was measured to be operating at 62% load during the audit.

The facility uses six Bellis & Morcom three-stage inter-cooled reciprocating high pressure (HP) air compressors to produce compressed air used in the blow molding process. The HP compressed air is produced through three stages, which were observed to be 45 psig, 220 psig and 720 psig. As the HP air compressors are inter-cooled, heat is rejected from the compressed air between the stages and is transported by process water to the cooling tower, where the heat is rejected into the ambient air. It was observed that four or the six HP air compressors were operating at any given time during the audit for a load of 66%.

Based upon two process water pumps operating, the chiller operating at 62% load and the HP air compressors operating at 66% load, it is conservatively estimated that the process water supply pumps will operate at 70% load (capacity). Therefore, the process water pumps can be controlled with an ASD to operate at approximately 70% load. By utilizing an ASD to control the process water pumps, energy savings can be obtained due to the fact that the pumps will not be running at 100% load for their entire operating hours. The ASD controllers would be set up to respond to the return process water temperature by increasing or decreasing the speed of process water pumps.

EEO No. 10 - Install Adjustable Speed Drive (ASD) on McQuay Chiller

Install adjustable speed drive (ASD, the same as variable frequency drive, VFD) on the existing electric-driven single compressor centrifugal chiller.

The facility uses a 300 ton McQuay water-cooled centrifugal chiller to produce chilled water for cooling the machines used in the blow molding process as well as for space cooling and humidity control via the air handler units (AHU). The chiller has one centrifugal compressor to compress the R-134a refrigerant.

Based on a direct measurement on the chiller while at the facility, it was determined that the chiller was operating at 62% load (capacity). An ASD installed on the chiller compressor will result in the chiller compressor not running at 100% load during periods of time when only a part load is required. By utilizing an ASD to control the chiller compressor, significant electrical energy savings can be realized through accurately matching the chiller's motor performance with the actual cooling load requirement.

EEO No. 11 - Replace the Metal Halide (MH) Lighting with High Efficiency T5 Fluorescent Lighting

Replace existing metal halide (MH) lamps with high efficiency T5 fluorescent lighting with electronic ballast. High efficiency fluorescent lighting uses less energy than MH lighting with similar or improved light output.

High efficiency T5 fluorescent lamps are more efficient than MH lamps and feature lower lumen depreciation rates, better dimming options, instant start-up and better color rendition. Because high efficiency fluorescent fixtures feature higher lamp and ballast efficacy and greater fixture efficiency, they consume less electricity than conventional MH systems to produce the same quantity of light. Energy savings can be realized due to less power consumption of high efficiency T5 fluorescent lamps with electronic ballast. Since lighting energy is converted to heat energy, lighting electrical energy savings will also result in HVAC electrical savings.

EEO No. 12 - Reduce High Pressure Air Compressors' Discharge Pressure

Reduce the operating pressure of the high pressure air compressors from 720 psig to 550 psig and add a second air receiver to increase the compressed air capacity for use during times of peak compressed air demand.

The plant has two separate compressed air systems, a high pressure (HP) and a low pressure (LP). The HP system produces compressed air with six Bellis & Morcom three stage reciprocating compressors. The audit team observed the HP compressed air system to be producing compressed air at approximately 720 psig, which is throttled to 600 psig before the storage tank. After the storage tank it is throttled to 565 psig for the header, which leads to the blow molders, where it is throttled again before being consumed. The HP compressed air is consumed by eight Sidel blow molders during the blow molding operation.

It is recommended that the high pressure compressed air system should produce compressed air at a pressure closer to the blow molder's required pressure, which will result in energy and demand savings. According to Sidel, the blow molders require 35 bar (507.6 psi) pressure compressed air. It is also recommended that another storage tank with a capacity of 10,000 gallon be added to the system to compensate for the system storage capacity reduction associated with reducing the pressure. Reducing the pressure that the HP compressed air is produced at to 550 psig from 720 psig will reduce the electrical energy usage and demand of the HP air compressors.

6.3.2 Additional Energy Efficiency Measures

Repairing Air Leaks

The use of compressed air is expensive, so we recommend that you have a maintenance person check for air leaks in the throughout the plant on a regular basis. As an example, a 1/32 inch air leak (considered a small sized air leak) will result in approximately \$169 per year in electrical costs. It is recommended that a maintenance person walk through the plant while the air compressors are running, and repair all air leaks.

Operate the Grinders Out of Peak Period

The facility uses two grinders to re-grind the rejected bottles from the production line. The re-ground rejects are then sent to the Fairfield plant to be made into new preforms. According to plant personnel the grinders are in operation 6-8 hours per day, depending upon how many rejects there are. Operating the grinders during the peak period adds to the maximum electrical load (demand) that is measured by your electric utility (PG&E). The facility is metered on a time-of-use rate schedule, which charges higher electrical rates during the Part-Peak and Peak periods in the summer months. Proper rescheduling of equipment can reduce the monthly demand charges. Operating the grinders after the Peak period (after 6 p.m. and before 8:30 am in the summer) will reduce the metered electrical demand and thus result in lower electrical demand cost. There is no energy savings associated with this recommendation, only a cost savings due to a difference in usage and demand costs.

Replace the Existing Packaged Roof Top HVAC Units with New Air Handlers that Use Chilled Water

The facility currently uses one 120 ton Air Handler which uses chilled water and nine 25 ton TRANE packaged roof top HVAC units to provide cooling to the Blow Molding Area. The 9 packaged units have a total compressor power of 295 hp. The packaged units operate 24 hours per day, 361 days per year for a total of 8,644 hours per year. During the audit it was noted that 6 of the 9 packaged units were “on.” The packaged units have an energy efficiency ratio (EER) of 9.7. EER is a measure of a packaged HVAC unit’s cooling capacity (in Btu/hr) per electrical energy input (power draw in watts). The higher a HVAC unit’s EER, the less electricity the unit uses to provide the same amount of cooling.

The facility also currently uses a 300 ton McQuay water-cooled centrifugal chiller to produce chilled water for cooling the machines used in the blow molding process as well as for space cooling and humidity control via a 120 ton Air Handler Unit (AHU). The load on the chiller from the Blow Molders has been calculated to be approximately 95 tons; from the AHU it has been assumed to be the full 120 tons. Therefore, the chiller has approximately 85 tons of capacity remaining. The Chiller Performance Ratio (CPR) is a measure of the efficiency of the

chiller's electrical energy input (in kilowatts) per cooling capacity (in tons). The lower a chiller's CPR, the less electricity the unit uses to provide the same amount of cooling.

It is proposed that three of the 25 ton packaged units be replaced by an equivalent capacity rated AHU which would use chilled water to cool and condition the Blow Molding Area. Electrical Energy Savings would result from the fact that the chiller is more efficient at providing a unit of cooling per input of electrical energy than the packaged units are. This is shown by converting the EER of the packaged units to the same form as the CPR of the chillers. The equivalent value for the packaged units is 1.237 kW/ton, while the chiller is 0.550 kW/ton. Replacing the 75 tons of packaged unit cooling with an AHU which uses chilled water would result in an electrical energy savings, EES, of approximately 183,841 kWh/yr, which translates into an Electrical Energy Cost Savings, EECS, of \$21,013/yr.

The implementation of this recommendation involves the purchase and installation of a 75 ton AHU, as well as the required water piping and insulation. The implementation cost has been estimated from the RS Means Mechanical Cost Data Guide 2006, and is expected to be no less than \$95,000, resulting in a simple payback of no less than 4.5 years.

6.3.3 Energy Efficiency Measures Implemented

Based on the interview with plant personnel, it was noticed that the plant had implemented or currently being working on energy efficiency retrofits resulting in energy savings. The measures are summarized as follows:

1. The facility has installed daylight controls on the main floor light fixtures (EEO No. 1).
2. The facility has installed digital timers and bi-level controllers on equipment room lighting (EEO No. 2)
3. The facility has installed ducting on the air compressor inlets to duct air from outside when conditions are favorable (EEO No. 6).
4. The facility has installed lighting occupancy sensors in low occupancy areas (EEO No. 7).
5. The facility has installed adjustable speed drives (ASD) on chilled water pumps (EEO No. 8).
6. The facility has installed ASDs on the cooling tower process water pumps (EEO No. 9).
7. The facility has installed ASD on the chiller compressor (EEO No. 10.)
8. The facility has reduced the high pressure air compressors' discharge pressure to about 490 psig, and a 2000 gallon tank was installed (EEO No. 12).

7. OTHER MODERNIZATION OPPORTUNITIES

There are other major modernization opportunities that can be commonly implemented in each of facilities for the same type of application.

7.1 Modernization of Dehumidification Systems

Convert the existing chilled water dehumidification system to a desiccant dehumidification system to dehumidify air in the production area.

The blow molding production room needs to be maintained at the desired dew-point condition to prevent condensation and moisture on the cold mold surfaces, which are cooled by circulating chilled water through the mold when the part is formed. Avoiding condensation and moisture on the mold is essential because it can improve the productivity and ensure the bottle quality. Currently, the supply air is dehumidified by a cooling dehumidification system as identified in the Fairfield plant. The molds are cooled by chilled water at about 43 °F. Heat rejected to the room is mainly from the electric heaters and drives of both of the injection molding machines and blow molding machines. The existing system dehumidifies air by cooling the air below its dew point.

There are other for methods air dehumidification. The most common ones are the liquid and solid desiccant dehumidifiers. Desiccant dehumidification systems utilize both cooling and heating to adjust the air condition, and it can insignificantly reduce the cooling load requirement. This type of system dehumidifies air by absorbing moisture through the desiccant. The desiccant dehumidifier consists of a regenerator that removes moisture from desiccant by heat, and the dried desiccant is then recycled back to the dehumidification process. The desiccant dehumidification processes vary depending on the type of desiccant (liquid or solid) and the dehumidifier system construction (with pre-cooling or post-cooling). A desiccant dehumidification system can economically supply air at 60 °F dry-bulb and 35 °F dew-point to maintain the production room with the set-point condition of 80 °F dry-bulb and 40 °F dew-point.

Figure A illustrates the simplified processes of the cooling dehumidification, liquid absorption dehumidification and solid desiccant dehumidification methods on a psychrometric chart. Descriptions of these three systems are shown in the following page.

T_{db} = dry-bulb temperature and T_{dp} = dew-point temperature.

Figure A Simplified dehumidification processes in a psychrometric chart

Cooling Dehumidification

The existing system dehumidifies air by cooling the air below its dew point. In this system the air dryness depends on the cooling level of the air. Therefore, the humidity content of the air is depending on the supply chilled water (CHW) temperature in the A/C system. According to the Dehumidification Handbook 2nd Ed. from Munters, the cooling dehumidification is summarized as follows:

- (Point 1 → Point 2) The initial air is cooled until saturation (100% RH) with the humidity ratio (ω) remained constant.
- (Point 2 → Point 3) Air is further cooled with the ω and dew-point decreasing and the RH remaining constant at 100%. Moisture condenses at the same time.
- (Point 3 → Point 6) Air is heated by reheat coils to the desired supply dry-bulb temperature.

Note: Currently no reheat coil is used in the Fairfield plant.

Liquid Absorption Dehumidification

A liquid absorption dehumidifier (or liquid desiccant dehumidifier) dehumidifies and cools the warm and wet air by contacting air with the cool and dry liquid desiccant. According to 2004 ASHRAE Handbook, HVAC Systems and Equipment, Chapter 22.1, the liquid absorption dehumidification is a one step process:

- (Point 1 → Point 6) The initial air is cooled and dried by contacting the liquid desiccant to the desired condition.

The liquid absorption dehumidifier consists of a contactor section and a regenerator section. The liquid desiccant, cooled by a coolant in a heat exchanger, is sprayed inside the contactor section with counter flow direction to the inlet mixed air (outdoor air and return air). The humid and warm liquid desiccant is then circulating back to the heat exchanger to be cooled by the coolant. A portion of the liquid desiccant is circulating between the contactor section and the regenerator section to for regeneration. The humid liquid desiccant is heated by a second heat exchanger to be dried by the ambient air in the regenerator section. Figure B illustrates the system schematic of a liquid desiccant dehumidifier from Kathabar.

Figure B System Schematic of the Liquid Desiccant Dehumidifier from Kathabar

Solid Desiccant Dehumidification

A typical solid desiccant dehumidifier dehumidifies wet air and regenerates the desiccant in a rotating wheel. It absorbs moisture from the inlet wet air in one part of the desiccant wheel and utilizes heat to remove moisture from the humid desiccant on the other part of the wheel. The desiccant wheel is then rotated to repeat the two processes. Since the wet air is dehumidified by the hot desiccant, pre-cooling and post-cooling are needed to reduce the supply air temperature as desired. Figure C illustrates the system schematic of a solid desiccant dehumidifier from

Munters. Two types of solid-desiccant dehumidification processes are demonstrated in 2004 ASHRAE Handbook, HVAC Systems and Equipment, Chapter 22.1, and they can be summarized as follows:

Type 1:

- (Point 1 → Point 4) The wet air is dried by solid-desiccant.
- (Point 4 → Point 6) Air is post-cooled to its desired temperature.

Type 2:

- (Point 1 → Point 5) The wet air is pre-cooled and pre-dehumidified by cooling.
- (Point 5 → Point 7) Air is dried by solid-desiccant.
- (Point 7 → Point 6) Air is post-cooled to its desired temperature.

Figure C System Schematic of the Solid Desiccant Dehumidifier from Munters

A desiccant unit combines cooling and heating for dehumidification. It is more efficient and requires less operating cost comparing to a conventional cooling dehumidifier that cools air to a much lower temperature for reducing its dew point. A desiccant dehumidification system will maintain the production room at 80 °F dry-bulb and 40 °F dew-point eliminating any condensation on the molds or products. Converting the current chilled water cooling dehumidification system to a desiccant dehumidification system can reduce the electrical energy consumption and hence result in electrical energy savings. A preliminary energy saving was

analyzed for the Fairfield plant to convert the existing cooling dehumidification system to a liquid absorption dehumidification system. It is estimated to result in an energy cost savings of approximately \$56,340/yr. Based on Kathabar, a manufacturer of dehumidification systems, the proposed liquid desiccant dehumidification includes a conditioner and a regenerator, and the material costs about \$300,000. The installation cost is estimated to be 15% of the material cost. The engineering and project management costs are estimated to be 25% of the material and labor costs, respectively. The total implementation cost is thus estimated to be \$431,250. The total cost savings of \$56,340/yr will pay for the implementation cost of \$431,250 in 7.7 years.

8. PROJECTS PLANNED FOR IMPLEMENTATION

AMCOR PET Packaging management in each plant has been very proactive in identification and implementation of energy efficiency and conservation measures. The energy efficiency measures that have already been implemented were outlined in Sections 6.1.3, 6.2.3 and 6.3.3. The results from the present plant-wide assessment will be reviewed in detailed and the projects will be prioritized for implementation in each plant, and replicated across the company.

9. PROJECT NON_ENERGY BENEFITS

The following will be the major non-energy benefits of this project:

- Green House Gas (GHG) Reduction

As a result of implementation of energy efficiency measures identified in this project, AMCOR plants will incur substantial reduction in their carbon dioxide foot-print based on the amount of energy saved. The following table signifies the extent of reduction of carbon dioxide resulting from implementation of the energy efficiency measures in the audited facilities:

Plant	Potential for GHG Reduction (lb CO2/year)
Fairfield, CA	3,048,372
Commerce, CA	5,095,406
Lathrop, CA	1,811,609

The level of GHG reduction in the audited plants also signifies the potential for reduction of GHG footprint company-wide.

- Reduction of Dew Point in Blow-Molding Area

Application of more effective dehumidification in the blow-molding area results in improvement in product quality. A detailed Excel spreadsheet was developed as a part of this project that can be utilized for evaluation of the dehumidification method for different local climates.

- Employee Comfort in Production Area

Based on personnel statement, because of extensive heat generation in the Injection Molding area of Commerce plant, the work environment becomes extremely warm and uncomfortable for the workers. The proposed measures for insulation of hot surfaces will greatly reduce the heat gain of the ambient, resulting in more comfortable environment for the workers.

10. REPLICATION PLAN

This project has afforded comprehensive energy assessment of two AMCOR PET Packaging plants in the United States. The results of this project will be disseminated as follows:

- The results of the assessments will be shared with the managers in other plants in the Company's regular meetings of energy team. Kevin Losh, a main contributor to this project is a member of AMCOR PET energy team.
- BASE Energy, Inc. will make a power point presentation to the energy team at the team's convenience.
- Based on the results of this project, a paper will be prepared for presentation in the Industrial Energy Efficiency Technology Conference (regularly held in New Orleans, Louisiana) to share the results with the industry at large.

11. PROJECT PARTNERS

The following have been active partners in this project.

AMCOR PET Packaging

2425 S. Watney Way
Fairfield, CA 94533

Contact: Kevin Losh (707-399-6506)

BASE Energy, Inc.

5 Third Street, Suite 530
San Francisco, CA 94103

Contact: Ahmad R. Ganji (415-543-1600)

U.S. DOE Golden Field Office

1617 Cole Blvd.
Golden, CO 80401

Contact: Bill Prymak (303-275-4931)

12. PLANT AND EQUIPMENT PHOTOS

12.1 Fairfield Facility – Plant and Equipment Photos

Figure 12.1 A Sidel Blow Molding Machine (Fairfield)

Figure 12.2 Injection Molding Machines (Fairfield)

Figure 12.3 A Packaging Line (Fairfield)

Figure 12.4 A Desiccant Dehumidifier for the Resin Dryer (Fairfield)

Figure 12.5 A Gas Heater for the Resin Dryer (Fairfield)

Figure 12.6 A Natural Gas Resin Dryer System* (Fairfield)

*Main components included in a resin dryer: a resin silo, a dust collector, a desiccant dehumidifier, a natural gas heater and circulating blowers.

Figure 12.7 A Belliss & Morcom Three-Stage Reciprocating Air Compressor for the High Pressure (HP) System (Fairfield)

12.2 Commerce Facility – Plant and Equipment Photos

Figure 12.8 A Husky Injection Molding Machine (Commerce)

Figure 12.9 A Blow Molding Machine (Commerce)

Figure 12.10 A Resin Dryer (Commerce)

13. REFERENCES

2004 ASHRAE Handbook, HVAC Systems and Equipment, Chapter 22 “Desiccant Dehumidification and Pressure-Drying Equipment”.

MECS (1998), Manufacturing Energy Consumption Survey, Energy Information Administration, 1998.

Munters Dehumidification Handbook 2nd Ed. 2002, Chapter 3.

Plastics Bottle Manufacturing: 2002, 2002 Economic Census Manufacturing, EC02-311-326160 (RV), US Department of Commerce.