Plant-Wide Energy Efficiency Assessment at the Arizona Portland Cement Plant in Rillito, Arizona

FINAL TECHNICAL REPORT
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1.0 EXECUTIVE SUMMARY AND SUMMARY OF RECOMMENDATIONS

A Department of Energy Plant-wide Assessment was undertaken by Arizona Portland Cement (APC), Rillito, AZ beginning in May 2005 with a compressed air evaluation. Following this, process planning and information gathering was undertaken and EPS began their field evaluation in June, 2006. The purpose of this Energy Survey was to identify a series of energy cost savings opportunities at the Plant, and provide preliminary cost and savings estimates for the work.

The Arizona Portland Rillito Plant is one of three owned and operated by California Portland Cement Company. The plant was originally constructed in 1949 and various upgrade projects have taken place since that time. The Plant has four kilns: three smaller, long dry process kilns and one large calciner kiln. All four kilns are operated on a 24/7 basis. In addition, the plant has crushers, several grinding mills, material conveyors and support utilities.

The cement process is very energy intensive and involves the conversion of limestone and other raw materials into the final product of cement powder. The process begins with the mining of limestone rock in a quarry located four miles from the plant. Limestone is crushed and conveyed then blended with other raw materials. This blended mixture is ground to a fine powder then introduced into a rotary cement kiln which is heated to temperatures reaching 3400 degrees Fahrenheit. The material is cooled then ground again with gypsum and other additives to form the final product of cement.

The bulk of electrical energy is consumed in the crushing and grinding operations at the plant whereas most of the fuel energy is consumed in the kiln pyro-process operations.

California Portland Cement Company (CPC) has received Energy Star Ratings from the US EPA for their on-going energy efficiency efforts. The current Energy Survey work by EPS is related to CPC's desire to continue to seek new opportunities.

The Plant has steadily worked to improve energy efficiency and increase production efficiency, and in the process has "bumped" against various limitations of equipment and systems for energy efficient operation. The Plant can currently produce about 1.35 million US tons of clinker per year.

As a result of the Study, a series of recommendations in the form of Energy Conservation Measures (ECMs) was developed by the EPS team. A summary list of these ECMs is shown in Table 1 below and discussed in more detail in Section 6.0.

The measure summary includes data from thermal, electrical, and productivity factors. Many of the ECMs, such as the clinker cooler improvement, in theory only save thermal energy (MMBtus) in the kiln. However in practice, the whole issue is one of better controlling the heat into the kilns. As such, this can reduce the clinker over-burning and hence reduce the associated grinding energy requirement. It can also allow more production throughput for the same amount of external input fossil fuel, thus lowering the MMBTU/ton of clinker. This is because these processes have a chemical impact, and thus are not simple matters. This means that these measures may have an effect on productivity and electrical use as well as the thermal energy requirements.

These ECMs have been prioritized by annual payback, with the fastest paybacks given first, and the longer paybacks last. The ECM numbering was arbitrary, and happened to merely represent the point in the compilation of data. Payback periods went from near instantaneous for some management-related matters, to 2.9 years, counting a combination of electrical, thermal, and productivity enhancement savings. This group of measures appeared to fit the overall general objectives outlined by CPC for the study.

All tons used in this Report are US short tons, i.e. 2,000 pounds/ton.

Table 1: Summary of Recommended Process Energy Conservation Measures (ECMs)

ECM		Energy Savings per Year		Productivity Increase ($)	Cost	Annual Net Benefit ($)	Simple Payback (years)
No.	Title	kWh	MMBtu				
7	Use Additional On-Spec Used Oil	0	0	0	$0	$250,000	0.0
6	Kiln Flame Improvement	0	24,000	0	$20,000	$55,200	0.4
8	Improve Clinker Grinding	2,400,000	0	0	$80,000	$136,800	0.6
3	Increase rotation speed	-280,000	24,000	$57,600	$100,000	$96,840	1.0
5	Upgrade Kiln 4 Clinker Cooler	-360,000	58,320	$95,400	$250,000	$209,016	1.2
1	Coal System Upgrades	312,000	76,500	$159,000	$700,000	$464,940	1.5
9	Optimize Ball Charge, Mills D2, CM7	2,400,000	0	0	$200,000	$136,800	1.5
11	Upgrade Kiln 1-3 Clinker Coolers	108,000	21,600	$54,000	$175,000	$109,836	1.6
2	Add Chain Mass to Kilns 1,2	0	144,000	$72,000	$800,000	$403,200	2.0
10	Monitoring, Control of Well Pumps	75,000	0	$15,000	$45,000	$19,275	2.3
12	Replace Current Homogenizing Silo System	252,000	36,000	$546,000	$1,850,000	$643,164	2.9
TOTAL		**4,907,000**	**384,420**	**$999,000**	**$4,220,000**	**$2,525,071**	**1.7**

Table 2: Summary of Compressed Air Savings Measures

Recommended Action	Estimated Cost ($)	Estimated Non-Energy Savings ($/yr)	Estimated Energy Savings ($/yr)	Estimated Total Savings ($/yr)	Payback (years)	Electricity Savings (kW)
Utilize tower compressor	50,000	15,000	30,000	45,000	1.1	60
Turn off unnecessary equipment	0	0	6,000	6,000	0.0	12
Replace timed valves with traps	9,000	0	5,000	5,000	1.8	10
Replace failed timed valve	500	0	5,000	5,000	0.1	10
Kiln blow-off system management	0	0	3,000	3,000	0.0	6
Utilize blower for motor cooling	20,000	0	12,000	12,000	1.7	24
Dust collector achieved savings	0	5,000	60,000	65,000	0.0	120
D3 dust collector 2	0	0	3,500	3,500	0.0	7
Silo dust collector dp control	4,500	1,000	1,500	2,500	1.8	3
Repair observed leaks	3,000	0	13,000	13,000	0.2	26
Reduce leaks through system	15,000	0	30,000	30,000	0.5	60
TOTAL	**$102,000**	**$21,000**	**$169,000**	**$190,000**	**0.5**	**338**

Based on the following Baseline Data:

- 194,000,000 kWh/yr
- 5,560,000 MMBtu fuel input/year
- 1,350,000 tons clinker production per year

The process ECMs recommended above provide the following savings:

- 4,907,000 kWh/yr
- 384,420 MMBtu/year thermal input
- $2,525,071 savings per year

In percentage terms, these process savings represent the following:

- 2.5% reduction in electricity usage, plus
- 6.9% reduction in fuel usage, plus
- 2.5% annual increase in clinker production

The combined process and compressed air ECMs yield an estimated annual savings of $2,715,071 for an estimated capital investment of $4,322,000.

Prior to conducting the plant-wide assessment, APC expected to find 7,818 MWh, 401,000 MMBtu and $1.216 million in potential energy savings. The plant-wide assessment actually identified 4,907 MWh, 384,420 MMBtu and $1.716 million in potential energy savings.

Based on very conservative assumptions, it is believed the above savings could be as much as approximately double the amounts calculated. However at this time, due to the age of equipment and the limited scope of investigation, basic assumptions were made so that the ECMs recommended, and their associated cost savings, could be reasonably counted on to actually show up on a measurement and verification (M&V) basis.

Other ECMs were evaluated, and are included in Section 6.0 - Energy Conservation Measures. Some of them are not recommended for various reasons at this time, including apparent poor payout period

This Report is organized to provide the reader an overview of the work plan, and the results of this Energy Study:

Section 2.0 - Introduction - provides an overview of the work and goals/objectives of the project undertaken by EPS.

Section 3.0 - Scope of Work - outlines the specific scope of services undertaken for this effort, and the limitations included within the scope undertaken.

Section 4.0 - Evaluation of Existing Supply-Side Costs and Energy Use – This section has been deleted due to the confidential nature of the data.

Section 5.0 - Facility Survey - provides an overview of the Plant and systems focused on during the course of the project. Some of the areas of the Plant were not included in the scope so are not included in this

Section. Notes on site visits and issues and opportunities identified are included.

Section 6.0 - Energy Conservation Measures (ECMs) - provides specific breakdown of the measures, a description of each, and the overall recommended solution. ECMs considered but rejected from close evaluation are also listed at the end of Section 6.0.

Section 7.0 - Conclusions and Recommendations - delineates the overall impact if the ECMs recommended in the study were to move forward to implementation.

Overall, CPC and APC are to be commended for their on-going energy efficiency focus. The Energy Study at APC is one more example of this. The Rillito Plant had already been implementing some measures, and has considered others, and the work described in this Report is an addition the actions and investigations already undertaken as part of a corporate program.

Prior to this Energy Efficiency Survey, CPC and APC had already had another consultant undertake a study of the compressed air systems at the Plant. The results of this study were reviewed by the EPS team but no other action was taken.

2.0 INTRODUCTION

An Energy Survey was undertaken by EPS beginning in June, 2006 at the Arizona Portland Cement (APC) plant in Rillito, AZ. The purpose of this Energy Survey was to identify a series of energy cost savings opportunities at the Plant, and provide preliminary cost and savings estimates for the work.

The Arizona Portland Rillito Plant is one of three owned and operated by California Portland Cement Company. The Plant has four kilns: three smaller, long dry process kilns and one large calciner kiln. All four kilns are operated on a 24/7 basis. In addition, the plant has crushers, several grinding mills, material conveyors and support utilities. There is a total of approximately 160 employees at the Plant.

California Portland Cement Company (CPC) has received Energy Star Ratings and awards from the US EPA for their on-going energy efficiency efforts. The current Energy Survey work by EPS is related to CPC's desire to continue to seek new opportunities. As part of their energy awareness program and objective to lower energy use and costs, CPC holds quarterly management review meetings. At those meetings plant energy managers and engineers compare data and benchmarks, and share ideas from the three plants owned by CPC (Colton, Mojave, and Rillito). Energy Conservation Measures (ECM's) identified in this study will be replicated through reporting and communications that take place at these meetings.

Because of capital investments and new equipment installations in 2000, the Plant now has excess finish grinding capacity. This has allowed the Plant to minimize use of the old, inefficient mills. The Plant can currently produce about 1.35 million US tons of clinker per year.

The Plant is located adjacent to Interstate 10 and on a rail spur from the main Tucson/Phoenix rail line. All finished goods are shipped from the Plant by truck, either in bulk carriers or in palletized bags. There are about 200 trucks per day leaving the Plant with finished product. All coal and most other raw materials purchased from the outside are brought in by rail. Limestone is delivered to the Plant from the nearby APC quarry by conveyor belt.

Figure 1: Aerial Photograph of Arizona Portland Cement Rillito Plant and Quarry

The photograph above shows the Plant in the foreground with I10 below. The light colored area near the top of the photograph is the quarry and the light colored line connecting the Plant and the quarry is the main conveyor.

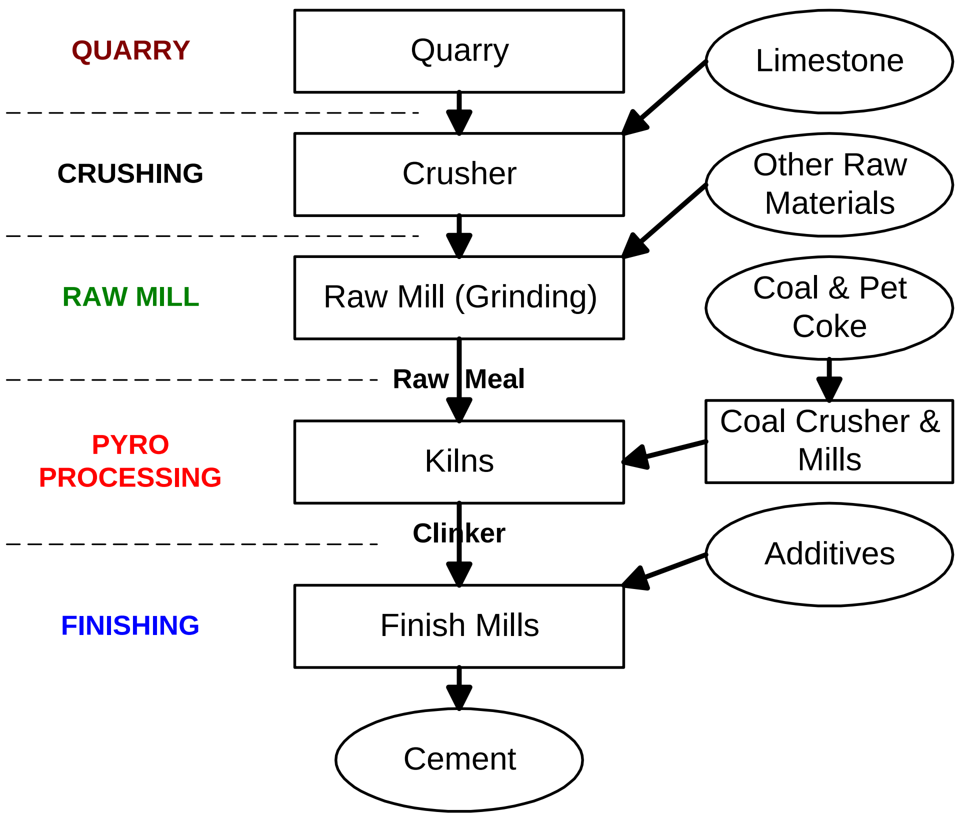
There have been various plans since 1998 to shut down all four existing kilns, and install one new, highly efficient calciner kiln. The Plant is located in a non-attainment area for certain air emissions and, as a result, there have been major air permitting challenges with this proposed plan. As a result, the plans for replacement of all kilns have changed. However, as the remaining years of life of at least the older kilns is low and these may be replaced in the future if a new kiln can be permitted, any energy efficiency or productivity improvement measures applicable to kilns 1 - 3 that require capital investment must meet a relatively short payback period.

The Plant produces approximately 1.34 million tons of clinker and 1.6 million tons per year of finished product. Of this finished product, approximately 95% is Type II-V cement and the remaining 5% is mortar cement. Mortar cement includes lime, fly ash and limestone together with clinker and gypsum. The regular Type II-V cement does not utilize either lime or fly ash.

Limestone for the Plant is mined in a quarry approximately four miles from the main Plant location. Limestone is delivered to the Plant via a conveyor belt.

A general schematic of the functional areas of the Plant is shown in the Figure below.

Figure 2: General Schematic of Plant Functional Areas and Materials Sequence



The survey work conducted by the EPS team generally followed this schematic, from the Quarry to the Finish Grinding.

3.0 SCOPE OF WORK

3.1 GENERAL DESCRIPTION OF SCOPE OF WORK

The overall purpose and scope of the Energy Efficiency Study was the performance of an assessment audit which involved evaluating, identifying, and documenting measures which could reasonably be implemented by the Rillito plant to reduce energy use and lower energy costs. The scope of work agreed to prior to commencing the Study was developed to achieve that objective. It was also agreed that those potential conservation and savings measures that were identified during the Study would be ranked based on their simple payback and only those with a reasonably short simple payback would be investigated and evaluated in detail.

At the outset of the Study, the EPS team reviewed with both Plant and Corporate Management the long range plans of the Plant for upgrades and changes. It was important at the outset to understand these plans as they could impact the direction forward in the detailed study. As part of this initial review, EPS prepared a detailed information request for preliminary data and information about energy use, energy and operating costs, Plant operations, Plant design, and past and planned upgrades and modifications to the Plant.

After initial review of the data and information provided in response to the information questionnaire, the EPS team conducted two on-site investigative visits to gather data on the areas of mutually agreeable focus. During these site visits, the EPS team was able to discuss with Plant and Corporate Management the design and performance of all areas of the Plant, and obtain information in order to evaluate opportunities and analyze the cost savings potential, and productivity and quality enhancements possible.

Because a variety of processes and systems were overviewed as part of the total effort, only those specific measures identified as feasible initially during the first site visit were further evaluated. The second site visit focused more closely on those specific measures and, where information had not been available during the first site visit, focused on obtaining that information.

Upon completion of the two site visits, the EPS team prepared a draft list of Energy Conservation Measures. Using that list, the team focused on their evaluation and refinement, including development of cost estimates, requirements for implementation, and savings potential.

It was found during the initial site visit that the Plant had an extensive data gathering and performance monitoring system (the PI system). This system was found to be most helpful in providing the information needed for the evaluations that were conducted and significantly reduced the need to gather field data.

Based on input from Corporate Management, the EPS team did not evaluate the compressed air systems at the Plant. A study by another consulting organization had been conducted as part of the DOE study.

3.2 DETAILED SCOPE OF WORK

The work undertaken by the EPS Team to complete the Study included the following major scope areas:

1. Benchmarking
2. Electrical
3. Mechanical
4. Thermal
5. Energy Purchases
6. Controls
7. Processes
8. Miscellaneous Small Users of Energy
9. General

The detailed areas of evaluation in each of these areas are discussed below.

3.2.1 Benchmarking

EPS employs benchmarking to evaluate energy usage, and to aid in identification of areas of opportunity. The first step undertaken was to compare the gross plant usage in electrical and thermal energy with industry average and "best in class", and then individual sub processes where possible. This approach was used to assist in identification of appropriate areas of focus. Much of the data needed for this analysis was already available at the Plant and tracked regularly by the Plant.

Areas reviewed as part of the benchmarking process included:

a. Energy consumption profile – Overall, as well as sector wise; monthly as well as annual comparisons
b. Associated production and quality data
c. Fuel quality, costs, distribution

d. Product quality
e. Production of clinker in tons per day
f. Production of cement in tons per day.
g. Power availability – purchased and captive
h. Thermal Energy, Btu/lb Clinker
i. Electrical energy for finish grinding, kWh/ton
j. Frequency distribution of above to the kiln lines, or multiple plants

3.2.2 Electrical

a. High efficiency fans, mechanical vs. pneumatic conveyors
b. Feasibility of variable speed drives, or equivalent, such as fluid couplings (Voith, etc.), Magna Drive (mechanical adjustable speed drive), and similar for large drive systems.
c. Star-Delta starters in crusher
d. Power factor control
e. Electrical harmonic impacts/downtime of PLCs/Computers due to stray currents-losses
f. Sizing of grinding motors to permit off-peak grinding for electrical energy cost reduction/control of demand

3.2.3 Mechanical

a. Roller press and high efficiency separators
b. Fan system optimization- including fan wheels, motors, trim or replace kiln ID fan, and other, to improve efficiency
c. Conversion from belt drives- to either gold cog belts, mechanical/electrical (such as Magna Drive), or similar
d. Minimize pressure drops of air – removal of fan dampers and venturis where not required, elimination of adjustment dampers if VSD or ASD/fluid coupling employed. Evaluation of high efficiency cyclones vs. pressure drop in preheater.

3.2.4 Thermal

a. Lower kiln gas losses (controls, combustion technologies, etc.)
b. Adjust balance of fuel consumption in calciner vs. kiln.
c. Gas conditioning towers, water use
d. High efficiency coolers (IKN KIDS technology, Fuller/F.L. Smidth crossbar cooler for example)
e. Preheater type - 5 stage, 6 stage potential savings vs. cost for adding preheater stages (we understand plant already has 4^{th} stage in and functioning, so this may not be viable)
f. Type of clinker cooler – planetary , grate, or new energy efficient grate coolers

g. Waste heat drying, fuel energy savings vs. power requirements for conveying waste heat sources
h. Waste heat recovery, from preheater exit gases and clinker cooler excess air
i. Kiln heat shell loss – shell fans, refractory selection, etc.
j. Multichannel burner systems in kiln and calciner – optimizing radiative heat transfer in rotary kiln

3.2.5 Controls

a. Cooling tower fan controls
b. High-level expert system kiln and mill controls
c. Compressed air (by others)
d. Process Control Status
e. Idle equipment operation

3.2.6 Processes

a. Factors affecting grinding energy/comminution circuits
b. Size of reject plant screen for raw mill if applicable
c. Calciner height/thermal impacts; heat transfer in calciner
d. Dedusting Systems
e. Clinkerization – combustion, raw mix composition, raw material selection and options
f. Raw mill feed systems – raw material grindability and flow properties; can modify chutes/ replace material feed systems?
g. Low pressure drop cyclones
h. Finish milling

3.2.7 Energy Purchases

a. Evaluation of current supply side contracts and cost impact
b. Potential for waste fuel use beyond current levels with due regard to environmental factors.

3.2.8 Miscellaneous Small Users of Energy

a. Plant lighting
b. Building HVAC

3.2.9 General

a. Determination of purchasing and replacement strategies for high efficiency motors
b. Energy efficiency in purchasing strategies
c. Plant personnel behavioral energy savings

4.0 EVALUATION OF EXISTING SUPPLY-SIDE COSTS AND ENERGY USE

THIS SECTION HAS BEEN DELETED DUE TO THE CONFIDENTIAL NATURE OF THE DATA.

5.0 FACILITY SURVEY

5.1 INTRODUCTION

This Section provides a description of the work carried out during the on-site surveys, the information and data obtained, and some of the initial comments and ideas developed during the site visits. There were two site visits with three EPS senior personnel participating in each visit.

The first site visit was conducted in June 2006. At the end of that visit, the EPS team discussed many of the issues and initial opportunities for energy conservation that had been identified by the team. Additional data was needed in many cases to further confirm the opportunities and better define the potential savings and productivity improvements. These data and additional information were requested after the first site visit and were made available during the second visit which was conducted by the same EPS team in September, 2006.

During the second site visit it was noted that some of the ideas discussed during, and at the end of, the first site visit had been implemented or were in the process of being implemented. The EPS team was pleased to see that Plant and Corporate management were actively pursuing the suggestions and ideas put forward and were making a serious effort to improve energy efficiency.

5.2 INITIAL COLLECTION OF GENERAL INFORMATION

The EPS team prepared and sent a questionnaire to APC prior to the first site visit. This questionnaire requested data and information on energy uses, energy consumption, energy costs, energy purchase contracts, raw materials usage and Plant production, and Plant process design. Some of this information was provided prior to the initial site visit. The rest was provided during the first site visit as it was understood that much of the production trends, operating data and similar information could be obtained real-time from the Plant's PI system.

The EPS team used the data and information provided as a result of the questionnaire to obtain an understanding of the existing Plant operations and design, and the existing energy use and costs. This allowed the team to develop its plan of action and provide a more focused approach to certain areas of the Plant.

The first site visit of two days was undertaken in June, 2006. In addition to three EPS team members, there were representatives from CPC Corporate Engineering and the Plant's Operations and Engineering departments.

Based on the review of the preliminary data received in response to the Questionnaire, and on the previous knowledge of the Plant from one of the EPS team members, an initial focus of work was outlined. This was done to ensure that necessary data was obtained during the site visits to allow the EPS team to study these areas for their energy efficiency potential and payback. The primary focus areas are listed below.

1. Raw Materials Preparation

a. Material transport system
b. Homogenization, meal blending systems
c. Roller mill
d. Classifiers
e. Fuel Preparation - ball mills

2. Clinker Production

a. Process and learning control
b. Kiln combustion system improvements
c. Kiln shell heat loss reduction
d. Utilization of more waste fuels which are permitted
e. Improvement in clinker cooler efficiency
f. Refractory condition
g. Heat recovery for power generation from air exhaust from kilns and coolers
h. Low pressure drop cyclones for suspension pre-heaters and optimize grate coolers
i. Variable speed drives on kilns
j. Oxygen enrichment for combustion

3. Grinding

a. Finish Grinding
b. Improving ball mill grinding
c. Roller press/classifiers

4. Plant Systems

a. Use of high efficiency motors (plant standard now for replacement)
b. Installing VSDs where possible (been underway for about 2 years).
c. Compressed air systems- study performed by another firm recently
d. Retrofit of lighting systems

5. Product Changes

a. Reducing fineness of cement for selected uses/customer demand

5.3 ANALYSIS OF COLLECTED INFORMATION

Following the first site visit, additional analysis occurred as to areas of opportunities, which were then summarized and presented to APC. Some of the key constraints which had to be considered were:

a. air permitting rules;
b. current production rates;
c. the fact that a new, large kiln is being considered, so that new opportunities had to be considered in that light;
d. the electric rates from the power company are at a fixed rate/kWh with no separate demand component; and
e. the Plant has already done much in the way of energy conservation measures, and continues to do so.

The operating metrics of the plant were reviewed, including

- kWh/ton clinker ground
- MMBtu fuel input/ton clinker produced, by kiln
- Total kWh/ton clinker produced
- Age / last overhaul
- Previous measures taken in energy efficiency

It was noted that, although the Plant parameters were within industry bounds, that the kilns had generally higher heat consumption than current kilns. Based on the evaluation of the benchmark parameters, site investigation into grinding, kiln operation, and clinker chemistry and physical characteristics was undertaken. From this, a series of potential energy conservation measures (ECMs) were identified for further investigation. Some of those had second visits based on preliminary assessment, and from those, coupled with review of past energy studies and ideas from APC and the limited benchmarking data our team gathered, developed ECMs.

5.4 TECHNICAL VISITS TO PLANT BY CONSULTANTS.

The three senior consultants from EPS participated in two rounds of site visits for a total of 5 days to gather data, review with Operations Personnel and CPC Engineering Office people the opportunities, and to discuss the Plant's operations. From this work, a series of measures were further refined. APC had some clinker testing performed to evaluate the hardness and grindability data, based on supposition of over-burning of the clinker in the kilns, which then is partially caused by long, lazy flames, and results in high heat rate inputs to the kilns, actually found in agreement with observations.

5.5 GENERAL

5.5.1 Management Commitment to Energy Efficiency And Production

During the second site visit, Management shared that a new, full time position had been created recently for a person to focus exclusively under the Operations Manager to identify and implement energy efficiency opportunities and production enhancement upgrades. The EPS team believes this is a very positive step to identify energy savings opportunities, manage energy use and production improvements and that it demonstrates Management commitment to this important area of Plant operations.

5.5.2 Past Energy Efficiency Work

The APC Plant has been continuing to do energy efficiency work for some time, as have all the CPC plants. For example, a lighting survey was completed, and is being planned at this time; work included offices, warehouse, packing shop, and related areas. They have been adding variable speed drives where possible with new controls. Also timers and dust collectors, are being checked regularly; now they are going to "pulse on demand" timers, to further reduce the kilowatthours. They have employed DOE Motor Master in their evaluation of energy efficiency of existing motor drives. APC has a program with their motor suppliers so that only high E motors are being installed. They did a Kiln 3 Kiln shell replacement to reduce fuel consumption. They earlier performed a compressed air audit. At the Mojave Cement Plant, CPC is testing an incentive bonus plan for efficiency, safety, quality, and production throughput, to further improve these factors on an ongoing basis.

6.0 ENERGY CONSERVATION MEASURES (ECM'S)

6.1 INTRODUCTION

This Section lists all of the Energy Conservation Measures (ECM's) identified by the EPS Team. While the term "conservation measures" implies conservation only, the term ECM has been used in this context to include measures that save energy, reduce costs and/or improve productivity, with the emphasis on energy efficiency improvements.

Included in this Section is a list of ECMs that were considered but rejected without additional work. They are listed here for the sake of completeness and to allow, if circumstances or assumptions change, the reader to re-consider them at a future time.

Calculations associated with savings and benefit generation for the various ECMs used the 2004 and 2005 operating data from APC, as the 2006 current situation was not provided. The kiln operating data evaluation came from a combination of 2004 and 2005 data, as well as recent thermal efficiency data.

6.2 POTENTIAL ENERGY CONSERVATION MEASURES

6.2.1 Process Measures

6.2.1.1 ECM 1 - Coal System Upgrade, Including Coal Mill Upgrade on Kiln 4

Issue/Opportunity

All four coal mills appear to provide poorer coal fineness than desired at times. This results in long, lazy flames in the kilns, which tend to "fry" the clinker, making a hard material which requires more energy to grind.

The kiln primary air velocity for the long kilns is too low to get good mixing. The flames are too long due to poor coal fineness, forcing more combustion further down the length of the kiln barrel.

Recommendation

Renovate the existing crusher to improve the crushing efficiency. The existing unit can have major hardfacing done to help improve the quality and consistency of the crush. This will help the coal mill as it will then be provided with a consistent feed material. The load on the coal mill will be reduced by avoiding the need to try to process variable-sized coal pieces and overall coal throughput will be improved. The hardfacing will extend the life of the rolls and reduce downtime.

To improve the consistency of grinding and grinding size, the Raymond coal mill on Kiln 4 could have a new rotary valve upsized. This would allow for better coal size control.

The benefits of this measure would be reduced interruptions, improved production throughput, and a reduction in MMBtu/ton fuel use.

6.2.1.2 ECM 2 - Increase the Chain Mass in Kilns 1 And 2

Issue/Opportunity

Both Kilns 1 and 2 are running low relative to industry standards, in terms of pounds chain/ton clinker per day. Increasing this mass properly would improve the heat transfer, and reduce the MMBtu/ton clinker modestly. Proper chain design also has the potential to reduce dust carryout from the kilns, which can save thermal energy and reduce fresh material input. Proper optimization of chain with available kiln cross section would avoid the problem of inadequate space for kiln gas volume, with its attendant increase in pressure drop and strain on the ID fan system.

Recommendation

Install additional chain mass. This measure is recommended on the basis that the long dry kilns will have a number of years more of useful service life at APC. A combination of garland and curtain chain would probably be appropriate. Curtain chain is also good for air emissions reductions.

6.2.1.3 ECM 3 - Increase Rotation Speed of the Kilns.

Issue/Opportunity

There is a small opportunity to improve the material flow and heat transfer through speed modification. Faster kiln speed may permit a shallower bed of clinker in the kilns, which may improve radiative heat transfer.

Recommendation

Increase the Kiln 4 rotational speed.

The long dry kilns can probably also be speeded up. Tentatively, we believe that these kilns can operate at about 90 rph, which would be typical for long dry kilns. This should reduce sintering and difficult clinker grindability. It will be necessary to determine that no autoclave problems result.

6.2.1.4 ECM 4 - Oxygen Injection on Kiln 4.

Issue/Opportunity

This measure will reportedly not be implemented at this site due to a plant air permit change requirement, which the Plant will not do, given the considerations of a new kiln to replace the existing units.

6.2.1.5 ECM 5 - Clinker Cooler Upgrade for Heat Recovery on Kiln 4

Issue/Opportunity

This could be performed with modifications to the cooler itself, or addition of heat recovery for steam generation for power generation on site, along with the preheater exhaust gases.

Recommendation

Improve the existing grate coolers, but don't replace them. This would include installation of a new section at the throat of the cooler, clearing the grates, adding upgraded blowers, and clearing the blinds. New flow grates on the front of the cooler #4 will help force the air to go where it needs to, even though it may require a larger delta P; the purpose is to better remove heat from the clinker.

The entrance of the cooler for Kiln 4 can be reconstructed (throat area) to get the secondary air temperature improved. There is more fuel going into the kiln than in the calciner and this shows that a change is needed. A more uniform air flow through the bed is needed, to recover thermal energy more efficiently and to cool the clinker more effectively.

This results not only in reduced MMBtu/ton, but far more importantly, aids in combustion and avoids overburning the clinker, which then can lead to lower grinding energy.

6.2.1.6 ECM 6 - Flame Improvement on Kilns 1 and 2

Issue/Opportunity

A new bluff body burner was installed on Kiln 2 during August 2006 and it seems to be working as it is reducing downtime and saving fuel. So it is recommended to add bluff bodies to Kilns 1 and 3, or other flame stabilizing agents, to improve combustion and keep the flame off the sidewalls of the kilns.

Recommendation

Install bluff body burners on Kilns 1 and 3. A modified bluff body burner designed for indirect firing could be installed on Kiln 4 if other production issues are resolved, but at this time it is deferred.

6.2.1.7 ECM 7 – Use of More On-Spec Used Oil

Issue/Opportunity

It is recommended to use more on-spec used oils as fuel substitutes for Kiln 4, but make modifications to the burner system so as to not upset the process during switchover and blending. This would lower the cost/MMBtu of fuels, although it does not save energy per se. To do this, two things are required:

a. more availability of on-spec used oil waste fuels in the area, and
b. a modified burner system for control of fuel/air blending.

Recommendation

Purchasing should explore the use of additional used on spec oil, on the basis of lower cost/MMBtu.

6.2.1.8 ECM 8 - Improve Grinding of Clinker

Issue/Opportunity

Some of the above measures help reduce the excessive hard grindability of clinker through reducing the excess burning of the clinker in the kilns. Improving the kiln operation automatically creates some savings here, with no hardware modifications.

Recommendation

Implement the changes recommended in the kiln flame ECM. The reduced fineness can be obtained at no extra charge, instead being a management plan for simply controlling the necessary fineness number on the ground clinker to make cement.

6.2.1.9 ECM 9 - Optimize Ball Charge in Mills D2 and CM7

Issue/Opportunity

It appears that the ball charge is not optimized for the higher loading of these units. Part of the work identified was to alter the fineness targets since it had been identified by the EPS team that the cement strengths were higher than the market demanded, and higher fineness costs energy on grinding.

Recommendation

Optimize the ball charges for the finish mills D2 and CM7. Audit and optimize the separator settings, since the classifier air dictates the split of fines and rejects. The fine material is carried pneumatically to the silo, and if the separator is not efficient then too much fine material is re-ground or the system accepts coarse material, so the cement then is ground finer to get the desired strength.

6.2.1.10 ECM 10 - Monitoring and Control of Well Water Pumps

Issue/Opportunity

Water for the Plant is pumped from wells distant from the Plant. Apparently there is no continuous monitoring of the operation of the pumps except for a loss of supply to the Plant. There can be a power failure to the pumps and the plant personnel will not know of this until the water supply runs out at the Plant. At that point, the Plant must shut down for lack of water resulting in lost output and wasted energy.

Recommendation:

Design and install a monitoring and control system with a radio link for the well water pumps. Also use a pressure sensor in pipe from the wells to the Plant to indicate loss of flow, and provide alarms for the operators to take immediate remedial action.

6.2.1.11 ECM 11 - Upgrade the Kiln Clinker Coolers on Kilns 1 - 3

Issue/Opportunity

This measure is offered assuming these kilns will continue to operate for some time. The implementation of this measure should likely assume these kilns will stay in continuous operation for at least 5 years beyond the time the retrofit upgrade is performed.

The clinker coolers for Kilns 1 - 3 require very excessive amounts of outside air for cooling the system now. This requires substantial extra electrical load for the fans, and results in much excess thermal energy being exhausted to the atmosphere, and not being recuperated back into the kiln.

Recommendation

Renovate the existing coolers for Kilns 1 - 3 to improve the front end air flow rate to improve the heat transfer to the clinker, and reduce the back end temperature, by capturing more heat fed back into the kiln. This then reduces the amount of fuel input to the kiln. This work would include installation of a new section at the throat of the cooler, clearing the grates, at least adjusting the blower fans if not upgrading them, and clearing the blinds. This measure is recommended on the basis that the long, dry Kilns 1 - 3 will continue to serve for a number of years into the future.

6.2.1.12 ECM 12 - Replace the Current Homogenizing Silo System.

Issue/Opportunity

The existing homogenizing silos are doing a poor job of mixing materials. They are not fluidizing the materials enough.

As a result of the separate compressed air energy study, the Plant is currently working to reduce the oil in the compressed air. This will aid the current homogenizing system, which has had trouble due to the oil.

Recommendation

Install a new homogenizing system, to both reduce the electrical demand, but most importantly to better mix the material. Install a stacker reclaimer prior to the belt to raw mill, to reclaim perpendicular to the stack and reduce the standard deviation of the raw mill product material.

The benefits will include thermal improvement in the kilns and savings of electricity in the ultimate clinker grinding.

6.2.2 Infrastructure Measures

6.2.2.1 ECM 13 - Control Room Doors

Issue/Opportunity

There is an access door (double) on the wall to allow equipment to be hoisted into the room. There is no seal around the door and the room is air conditioned virtually 24/7. As a result there is minor energy wastage around the door and through the door.

Recommendation:

Insulate doors or replace with thermally insulated doors. Ensure there is a weather seal between the doors and their surroundings. The poor payback limits the value of this measure.

6.2.2.2 ECM 14 - Control Room and Control Building Lighting

Issue/Opportunity

There are T12 fluorescent lamps in the Control Room and within the Control Room Building. As this building is occupied 24/7, these lamps are on virtually all of the time.

Recommendation:

Convert all existing T-12 lamps and fixtures to T-8s and add reflectors to reduce consumption. EPS understands that this work is planned by APC to be implemented, and planning and execution is now underway.

6.2.2.3 ECM 15 - Control Room Windows

Issue/Opportunity

All windows currently installed in the Control Room are single pane and thermally inefficient. Improvement in energy efficiency by use of double pane thermally efficient windows will lower air conditioning requirements and reduce energy use.

Recommendation:

Replace all existing single pane windows with double pane thermally efficient windows. This measure does not have a good payback.

6.2.2.4 ECM 16 - Plant Exterior Lighting

Issue/Opportunity

Plant exterior lighting is controlled by either photocell or timer. There is no procedure in place to ensure that Plant exterior lighting controls are checked regularly for correct operation. As a result, Plant lighting may remain on during daylight hours. This may result from dirty photocells or timers where the time is incorrect.

Recommendation:

Review all Plant exterior lighting for on/off controls to determine whether timers or photocells are being used. For those with timers, ensure they are adjusted correctly. For those with photocells, ensure the photocells are clean. Develop procedures for regular verification and adjustment of timers and cleaning of photocells.

6.2.2.5 ECM 17 – Plant and Office Lighting

Issue/Opportunity

There are various areas in the Plant and offices where more efficient lighting could be used to lower energy use. In areas that are space conditioned (i.e. air conditioned), reduction in lighting energy use will also reduce air conditioning loads and therefore energy use for air conditioning. Even though the energy use of lighting throughout the Plant is small relative to the Plant's total process energy use, any savings in lighting go directly to the bottom line.

Recommendation:

Review lighting in all buildings and throughout Plant. Upgrade to more efficient systems where appropriate. This measure is already underway.

6.2.3 General

6.2.3.1 ECM 18 - Plant Energy Awareness

Issue/Opportunity

California Portland Cement has received Energy Star awards from the US EPA for their program, yet the Arizona Portland Rillito Plant could still improve energy efficiency. Therefore, there is still room to develop an energy awareness and energy utilization incentive program for the Plant, based on the data to date.

Recommendation

Develop program and provide training to all employees on energy use and energy awareness.

6.2.3.2 ECM 19 - Purchasing Procedures

Issue/Opportunity

The goal of purchasing departments in general is to purchase materials and equipment that meet agreed specifications, including delivery and reliability, at the lowest cost. In most cases, the direct or indirect energy costs associated with a purchasing decision are not considered.

Recommendation:

Develop and implement purchasing procedures that take account of energy use and efficiency in all equipment and materials purchases including office equipment.

6.2.3.3 ECM 20 – Electric Power Production

Issue/Opportunity

Although there are four kilns at the plant, the Kilns 1 - 3 are old, long, dry kilns and each is only producing on the order of 125,000 - 150,000 tons/year of clinker. Kiln 4, the pre-calciner unit, has a high throughput, though, and by installing heat recovery exchangers on both the exhaust from the preheat and the clinker cooler systems, additional heat that is otherwise exhausted to atmosphere may be recovered.

Recommendation

Do not implement at this time. This measure, after the other process measures are implemented, would not appear to have a good payout, because the other measures reduce the heat recovery potential of this measure.

6.3 POTENTIAL ENERGY CONSERVATION MEASURES REJECTED

In the course of the evaluation, the EPS team identified a number of potential ECMs that, after initial evaluation were rejected from additional, or more detailed consideration. The reasons for rejection were, in most cases, the likely implementation costs were too high and the potential payback too long.

1. Replace coal mill on Kiln 4

This potential ECM was rejected because of its cost and long payback.

2. Reduction in cooling water requirements

The current recycling of water limits the value of any improvement.

3. Improve collection efficiency of cyclones

Not enough potential payback available for large capital outlay.

4. Use grinding aids in raw mills

5. Install classifying liners on raw mills

Only applicable to Allis-Chalmers mills, and therefore a poor investment.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The Energy Efficiency Study was successfully completed by the EPS team. This study identified 20 Energy Conservation Measures as well as many other suggestions on ways to improve Plant efficiency and productivity and to lower costs. As a result of the on-site discussions, Plant management has already started to implement some of the team's recommendations.

Many of the ECMs are interrelated and have coupling or cross effects. This means that implementing one ECM may affect the potential savings and value of another ECM. It is recommended that Plant management consider the interrelationship between the ECMs before they are implemented.