



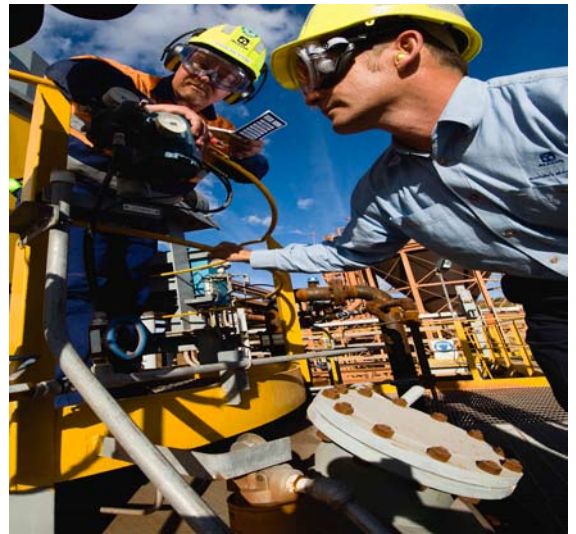
Industry Leader Case Study

ALCOA PINJARRA

This case study showcases how Alcoa has set about managing and minimising energy use and greenhouse gas emissions through:

- establishing public energy and greenhouse gas emissions targets;
- developing systems that regularly analyse, monitor and report energy performance;
- building information and communication networks to engage people; and
- conducting rigorous and ongoing assessments to effectively identify continuous as well as 'step-change' improvements in the way that energy is used.

This case study outlines the systems and approaches that Alcoa has developed over the last 20 years and how ongoing systems can meet the *leadership, people and information, data and analysis* assessment requirements of the Energy Efficiency Opportunities program. It demonstrates how these systems operate at Alcoa's Pinjarra refinery and the outcomes and benefits delivered to date.



Engineers undertaking maintenance checks at the Pinjarra refinery to ensure equipment is operating at maximum efficiency

KEY ACTIONS AND OUTCOMES

Energy intensity has improved by 5% from 2001 to 2007 at the Pinjarra refinery. This is largely due to two major projects:

- an \$800 million upgrade of the refinery (completed in 2006) which significantly improved heat exchange systems and increased alumina yield; and
- the construction of two co-generation plants (one commissioned in 2006 and the other in 2007) which use waste heat from power production to simultaneously generate power and steam for the refinery.

As a result of the upgrade, export revenue increased by \$160 million per annum due to increased alumina yields of 17% to 4.2 million tonnes (an extra 660,000 tonnes). The co-generation plants have reduced energy consumption at Pinjarra by approximately 0.52 GJ/t of production, saving A\$7.5 million per year at current gas prices. They have also cut greenhouse gas emissions by over 300,000 tonnes or approximately 15% per year.

More recently, the Pinjarra refinery conducted a *Strategic Technical Analysis* in 2007 and identified 15 new energy efficiency opportunities which, if implemented, are expected to reduce energy intensity by a further 5% over the next 5 years.



An aerial view of Alcoa's Pinjarra refinery



About the company

Alcoa is a public company involved in bauxite mining, alumina refining, aluminium smelting and aluminium product manufacture for sectors such as packaging, building and construction, and transport. It has operations in 44 countries.

Alcoa of Australia Limited, trading as Alcoa World Alumina Australia is 60% owned by Alcoa Inc. and 40% by Alumina Limited. The company operates three alumina refineries in Western Australia at Pinjarra, Kwinana and Wagerup with a combined annual production of approximately 8.5 million tonnes. In Victoria Alcoa owns two aluminium smelters, at Point Henry in Geelong and Portland. Portland Aluminum is a joint venture with CITIC Resources Australia Pty Ltd and Marubeni Aluminum Australia Pty Ltd. Alcoa Australia Rolled Products operates manufacturing plants in Victoria and Yennora (NSW).

Since its recent efficiency based upgrade the Pinjarra refinery has an annual capacity of 4.2 million tonnes and employs over 1,000 people.

Energy use at Alcoa Pinjarra

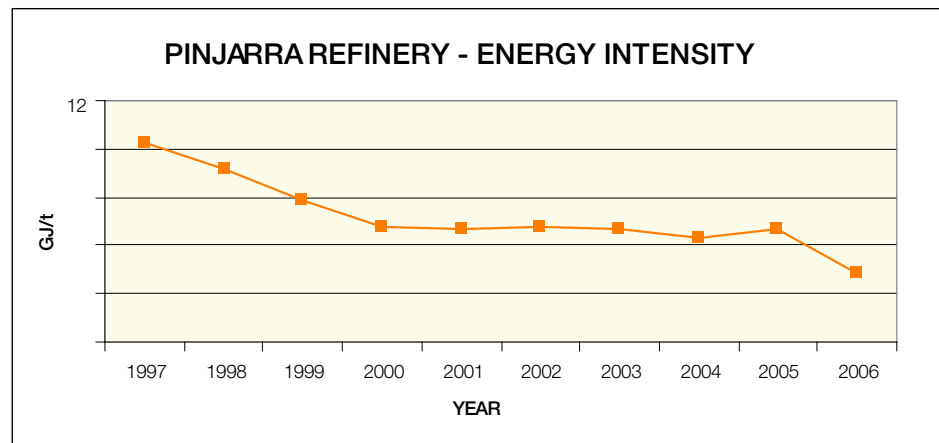
The extraction of alumina (aluminium oxide) from bauxite is an energy-intensive process. Alcoa uses the Bayer refining process which involves four steps - digestion, clarification, precipitation and calcination. Energy contributes around 20% of operating costs for Alcoa's operations in WA. Annually, the refinery consumes around 38 PJ of natural gas, over four million kWh of electricity and smaller amounts of automotive diesel oil and petrol.

Corporate leadership

Energy goals

Energy efficiency is driven by the Chairman and CEO of the Company. Alcoa's *Strategic Sustainability Framework*, developed in 2000, includes a number of challenging targets for all its businesses, including:

- a 25% reduction in greenhouse gas emissions by 2010 compared to 1990 (achieved by 2003); and
- a 10% reduction in energy intensity by 2010 compared to 2000.



Energy intensity at the Pinjarra refinery (GJ/tonne) has already fallen significantly since 1997 (due to the sensitivity of the data, the Department is not able to present the full GJ/tonne scale).

Energy efficiency is particularly important to Alcoa because energy use makes up a high proportion of operational costs and has a direct relationship to greenhouse gas emissions. Alcoa is forecasting a 40% increase in oil and gas prices over the next few years. Together with climate change mitigation objectives, Alcoa has a strong driver for improvement in energy use.

Kim Horne, Director of Human Resources, Environment, Health and Safety, Australia commented that:

“As a company Alcoa understands that ambitious environmental, social and financial goals can all help to deliver competitive advantage. Alcoa Management’s focus on safety in the 1980s demonstrated to the Board that a social indicator can be used to improve the share price. This understanding has now flowed into environmental activities such as energy efficiency and climate change. Energy efficiency is now driven from the top, a key element of EEO leadership requirements”.

People

Integrating energy management into core business systems

Alcoa's energy management is integrated within existing business systems and involves people at every level of the company. A few years ago Alcoa adopted and customised the *Toyota Manufacturing System* which aims to eliminate any process or activity which does not add value to the business. Called the *Alcoa Business System (ABS)*, this system aims to involve all plant management personnel, particularly those associated with safety, environment, productivity, cost (which includes energy) and profitability. This system drives problem solving and decision making down to an operational level to ensure the achievement of business goals.

The ABS has improved energy efficiency through increased staff involvement and accountability for housekeeping activities. Operators on the shop floor identify and correct issues before they escalate into major problems. Energy use is monitored on a shift and daily basis by comparing the latest key performance data to targets. These are prominently displayed in work areas to ensure that they are clearly visible to staff.

“The focus of the ABS is on people. Operators on the shop floor can deliver energy savings but they need to have clear standards to work towards. Performance data needs to be visual and it has to show relationships between specific activities and energy consumption. If a standard is not being met then there will be a visual trigger. Operators are required to record anything on the board which might have happened on the shift to cause a change, and then it can be fixed quickly”.

Trevor Ralph, Regional Manager, Alcoa Business Systems

Key staff members are provided with weekly performance information highlighting gaps between plans and achievements. Energy efficiency performance is also reviewed by the CEO and the Board at least monthly and often more frequently.



Operational staff reviewing the latest performance data and work schedule during their shift

Accountability

Every major Alcoa site has someone designated as the '*single-point accountability*' for energy. These energy champions report to the Global Technical Manager, Energy and Raw Materials, based at the Pinjarra refinery. There is also an *Energy Council* within Alcoa which is responsible for energy management. The council includes operational and technical representatives and meets twice a year.

In addition, every person who has an influence on energy consumption at Alcoa has an individual energy target which is used to evaluate their performance. The company also encourages staff members to suggest opportunities for improvement. If someone's suggestion results in an efficiency improvement they are recognised and rewarded. For example, a suggestion which resulted in a modification to the boiler system resulted in a reward of thousands of dollars to an employee. All suggestions are recorded and tracked through a central database.

Information flows and networks

Information sharing is encouraged. An '*Energy Community of Best Practice*' (CoP) meets by teleconference once a month and face-to-face every 18 months. The group has its own intranet site which includes information on best practice projects, members, actions, and a discussion board. All managers and engineers are expected to use the web site as a standard business practice to help solve problems or improve operational performance.

The Global Technical Manager also circulates a monthly list of *Best Energy Efficiency Practices* (BEEPS) to CoP members and other interested personnel around the world. Sites which adopt a best practice are recognised and rewarded, more so than the donor or initiator of the practice. Nominations for best practice awards are recorded and evaluated and winners in several categories are selected. Nominees are invited to a formal 'black tie' presentation where the winners are announced and given specially designed awards and congratulatory letters from the company's President.

The assessment process

Energy data analysis and reporting

Alcoa's energy management system is underpinned by a comprehensive data collection and analysis program. Overall efficiency is measured and monitored continuously by looking at key trends such as energy intensity (GJ consumed per tonne of alumina) in relation to annual targets. Following the introduction of the ABS, plant managers also focus on indicators which provide early warning of efficiency problems, such as steam usage, boiler efficiency, evaporation efficiency, yield and power generation efficiency, as well as key indicators such as energy consumption. These indicators are monitored constantly and any deviations from targets are highlighted in daily, weekly and monthly management meetings.

Data is collected and analysed for all major processes and the refinery as a whole. This enables Alcoa to calculate the total energy impacts of a project with a high level of accuracy. If an energy efficiency opportunity in one area is evaluated in isolation then the potential impacts on other parts of the plant might not be considered. Detailed computer models give Alcoa a more complete understanding of impacts across the site and help them to optimise overall process performance.

Key energy and emissions data is published weekly and on a monthly basis on what is called 'Wallpaper' – a computer-generated technical summary of performance. The data is often presented in the form of graphs showing gaps between optimum and actual results along with possible causes and effects of any deviation. These reports are published on the Alcoa world-wide intranet and are reviewed by senior corporate management (technical, operational, administrative and financial).

In 2006, the Pinjarra refinery developed a detailed energy-mass balance covering the whole site. Every month an energy-mass balance report is produced covering all energy on the site. This report balances all energy use throughout the site to an accuracy of 1% to 2% and the results are verified through checking meter readings and calculations. The energy balance has allowed the site to accurately:

- account for how much and where energy was used each month;
- forecast how much energy will be used in the month ahead;
- account for variances in energy use; and
- identify preventative maintenance measures to improve the site's energy efficiency.

Two sets of international benchmarks are used to evaluate performance against international competitors - one is provided by the International Aluminium Institute and the other is calculated internally by Alcoa. These allow Alcoa to compare and monitor energy performance over time against industry best practice for comparable sites.

Opportunity identification

As part of Alcoa's energy management system, strategic and operational reviews are conducted on all sites at three yearly intervals. These involve detailed assessments of energy performance compared to 'theoretical', 'potential' and 'practical' limits. Theoretical values are those which are based on the chemistry and thermodynamics of the process, while practical limits are based on best practice or the outcomes of known technologies. 'Enablers', or actions, are identified to help reduce the gaps between current performance and best practice. These enablers feed into annual *Energy Improvement Plans* which require six monthly updates on progress, while gaps between current performance and more ambitious goals that address theoretical and potential limits are tackled by investing in research and development projects.

A *Strategic Technical Analysis* was undertaken at the Pinjarra refinery from 26th March to 4th April 2007. Led by Winston Rennick from Australia, this detailed energy assessment involved a variety of people from the site as well as a team of Alcoa energy experts from the US, Brazil and Spain.

In the lead up to the assessment, participants were sent background information including a detailed model of the site and energy performance data and analysis. This information gave the participants an understanding of the business drivers for the assessment, an insight into the performance of the site, and an opportunity to prepare.

During the assessment, the team physically started at the beginning of the process and walked through the whole site discussing with operational staff the process, questioning assumptions in energy use, taking measurements, conducting analysis, reviewing the energy and mass balances, identifying areas where inefficiencies existed, and discussing possible energy efficiency opportunities. This approach allowed the team to gain a detailed understanding of the process, and to engage directly with operators to draw off their knowledge and experience of the equipment. The process also effectively utilised the first hand knowledge of the overseas experts in specific process and technology options.

Participants in the Strategic Technical Analysis during their walk-through review of the site



Through this process 15 new energy efficiency opportunities were identified and the feasibility of two major projects was confirmed – condensate heat recovery from the co-generation plant and the installation of larger heaters in the digestion process.

In all, 20 individual participants including technical managers and plant managers spent between five to ten full time days (depending on their role) undertaking the opportunity identification process. Significant amounts of time were also spent analysing data, undertaking detailed investigation and evaluation of opportunities, and in writing up the results of the assessment. The approach used in the assessment, combined with Alcoa's ongoing leadership, people and data analysis practices, meets many of the key requirements of the Energy Efficiency Opportunities program's Assessment Framework, in addition to meeting the standard requirements for Alcoa's internal strategic and operational reviews.

Research and development

While Alcoa strives to achieve continuous improvement through a large number of incremental changes, the company is also investigating innovations which could involve more significant changes to manufacturing technology. Alcoa in Australia invests millions of dollars each year in R&D and employs over 80 scientists, engineers and support staff in a research group which is based at the Kwinana refinery. The R&D team works on developing processes and equipment to support cleaner production and maximise resource efficiency at Alcoa refineries worldwide.

As part of its brief, a separate team of R&D researchers (the Transformational Technology Group) is also investigating 'step-change' technologies which, if successful, will dramatically improve energy efficiency in the production of alumina.

Investigation and implementation of projects

It can be difficult to accurately estimate the costs and benefits of a project due to changes in raw material quality and the variable costs of engineering and construction. Projects are often justified with a wide margin of uncertainty which is improved as detailed requirements are finalised.

Identified projects are first evaluated using the 'A3 process' which summarises the business case, current situation, proposed situation, required actions and relevant data on a single sheet of A3 paper. Measures of success and criteria for proceeding with the opportunity are then determined using the 'blitz process'.

With the assistance of engineering staff a 'contract book' is then developed. Following the publishing of the contract book, a Request for Authorisation (RFA) is prepared and sent to a list of key personnel accountable for authorisation of capital, which includes environment, health and safety (EH&S), technical, engineering, commercial and administrative managers. The system is electronic and once authorisation is received the budget is allocated and funds released. If approved, detailed engineering is then undertaken.

Energy savings are determined through the use of detailed modelling of the site, which takes into account the impacts of an energy efficiency project on other parts of the process and overall site efficiency. After implementation and handover to operations, the performance of the project is evaluated to verify if the actual savings were achieved, and a report is prepared for review by senior technical, financial and operational managers.

Project management

All projects are tracked through a detailed project management system which provides a summary of each project along with its estimated and actual cost, milestones, objectives and benefits.

Opportunities identified and investigated

The *Strategic Technical Analysis* identified an additional 15 opportunities. Three of these opportunities will be implemented in the short term and include a significant opportunity to recover heat from the condensate in the co-generation plants. The other opportunities including a large project to optimise heat recovery systems have been deemed to be feasible and are under active consideration.

Status of opportunities

Total number of projects identified	15
Projects to be implemented in the short term	3
Projects to be implemented during future capacity expansion projects	2
Projects still under investigation	8
Projects with greater than 4-year payback (will remain under review)	2

Condensate heat recovery

Condensate from steam generated in the co-generation plants will be used to warm boiler feed water rather than being released to a cooling pond, which is a waste of both water and energy. This project will be implemented in a joint activity with Alinta and is expected to save 0.2 GJ for every tonne of alumina produced per year.

Co-generation plants

Two co-generation plants have been built as a joint venture with Alinta, with the first unit commissioned in 2006 and the second in early 2007. The gas power plants are owned by Alinta and operated by Alcoa who utilise the waste heat to generate power and low-pressure steam for use in the refining process. This alternate supply will eventually enable Alcoa to decommission a number of steam boilers. Co-generation plants are more than 82% energy efficient, which is significantly better than the 25-50% efficiency achieved by conventional power plants in Western Australia. Each gas power plant supplies 140 megawatts of electricity to consumers and businesses via the south-west Western Australia electricity grid.

Co-generation has reduced energy consumption at the refinery and greenhouse gas emissions have been cut by an estimated 270,000 tonnes per year.



The first co-generation plant built at Pinjarra

Pinjarra plant upgrade

The Pinjarra refinery was built in 1975. In 2001, a major upgrade was planned to meet business needs and also provide an opportunity to improve overall efficiencies, including energy. The upgrade, which was completed in 2006 at a cost of around \$800 million, enabled Alcoa to:

- upgrade its existing equipment with best-practice technology including significantly improved heat exchange systems;
- install new emissions control technology; and
- increase alumina production by 17% to 4.2 million tonnes annually (an extra 660,000 tonnes) while decreasing energy use.

Lessons learned

The importance of whole-of-business project evaluation

A whole-of-business evaluation is used for all projects at Alcoa using the 'balanced score card', which includes impacts on environment, health and safety, production, product quality and cost. Energy efficiency projects tend to proceed because they contribute to more than one business objective. For example, water availability is becoming a critical issue for Pinjarra and because steam is widely used in the process, energy conservation projects often save water as well – a dual benefit. Energy efficiency can deliver multiple benefits including cost savings, water savings, increased production and reduced greenhouse gas emissions.

The value of stretch performance targets

Alcoa sets targets based on practical, potential and theoretical limits for key variables. Practical targets are relatively straightforward because they involve the transfer of known technologies and processes. However, stretch targets such as energy intensity based on theoretical limits, challenge staff to find solutions which go well beyond incremental improvement.

Everyone can contribute to energy efficiency objectives

The *Alcoa Business System* ensures that all personnel are aware of corporate objectives and targets and the actions which need to be taken to meet them. Data is continuously collected and reported so that everyone knows how their team is progressing towards targets. A3 project sheets are visually displayed within control rooms and offices which provide a focus for daily, weekly and monthly meetings. From an energy perspective this means that all key personnel associated with processing operations or technical development are working together to achieve corporate efficiency objectives.

Next steps

An energy opportunity assessment was undertaken at the Wagerup refinery in late 2007 and assessments will be carried out at the Point Henry and Portland smelters in May 2008. The opportunities identified from these assessments, as well as those identified at Pinjarra, will be investigated in detail and implemented where suitable.

The company will continuously re-evaluate and look for opportunities to further reduce energy and will set up a system for annual reviews of energy management and new projects to ensure continuous improvement in energy efficiency. In addition, all further expansions will have a high focus on energy minimisation by integrating an energy cost premium into project evaluation.

“Alcoa is proud to support the Energy Efficiency Opportunities program. By promoting energy efficiency, the program delivers real outcomes in managing our scarce energy resources while helping cut greenhouse gas emissions.

Alcoa has long recognised that energy efficiency and sustainability go hand in hand. Energy accounts for a significant part of Alcoa’s costs. Energy efficiency – along with new technology and productivity improvements – is also helping Alcoa reduce greenhouse gas emissions.

We’ve been closely involved in the Energy Efficiency Opportunities program from the start and were one of the first companies to register. The program helps businesses like Alcoa improve accountability and learn from and communicate best practice, while driving real improvements in energy use. It is an outstanding program and we encourage others to consider the benefits of taking part”.

Alan Cransberg, President and Managing Director, Alcoa World Alumina Australia

The Department of Resources, Energy and Tourism thanks Alcoa World Alumina Australia for its active participation and involvement in the Energy Efficiency Opportunities program, and for sharing information on its systems and approaches to improve energy efficiency.

© Commonwealth of Australia
Energy Efficiency Opportunities
Department of Resources, Energy and Tourism, April 2008
Tel: 1300 799 186
E-mail: energyefficiencyopportunities@ret.gov.au
Website: www.energyefficiencyopportunities.gov.au