



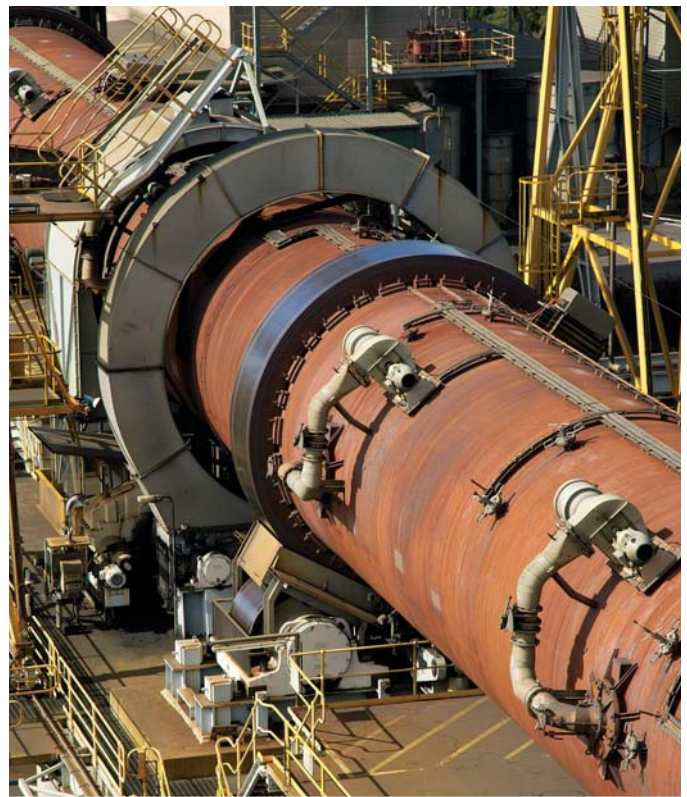
CASE STUDY

ILUKA RESOURCES LIMITED

RESOURCE PROCESSING ENERGY-MASS BALANCE

To successfully identify and pursue energy efficiency improvements in a facility, it is important to gain a detailed understanding of the facility's energy consumption and the key factors that influence overall energy performance. To achieve this, Key Element 3 of the EEO Assessment Framework encourages the use of energy analysis methods, foremost of which is the energy-mass balance (EMB) analysis.

This case study presents Iluka Resources Limited's successful adoption of the EMB as the core method of energy analysis in its Synthetic Rutile facility in Iluka's South West Operations, Western Australia. It discusses key aspects of Iluka's experience, such as the EMB modelling approach, results achieved, lessons learned and the role the EMB will play in Iluka's future energy improvement initiatives.



Large rotary kiln used to produce synthetic rutile.

KEY RESULTS

- A combined total saving of 338 TJ per year or 8.7% of total South West operations energy usage.
- The EMB process model used in four of the eight implemented projects contributed approximately 99% to the total energy reduction achieved to date.
- Energy savings of 179 TJ per year or 4.7% also achieved at the Mid West operations.
- The EMB is available as an onsite tool, where the team can input updates into the software model to simulate further energy efficiency improvements and other changes to the plant.
- EMB methodology is now an important part of Iluka's business improvement process

OVERVIEW

Understanding energy use and the factors that influence it is the main aim of Key Element 3 in the Energy Efficiency Opportunities (EEO) assessment framework. The framework outlines the use of a number of techniques, including the use of an Energy-Mass Balance (EMB) as a thorough way for companies to develop a deeper understanding of energy flows in their business.

This case study provides an example of EMB analysis applied in the resource processing industry, as completed by **Iluka Resources Limited (Iluka)**. Iluka, one of the world's largest mineral sands companies, conducted an EMB analysis as part of their EEO Assessment, focussing on their South West site in Western Australia.

Their EMB centred on the process used to make synthetic rutile (SR). In this process, iron is removed from ilmenite to increase the titanium content, resulting in a high value SR feedstock.

This is used to create titanium dioxide for a variety of products, such as paints, paper, plastics, aircraft engines and dye-sensitised solar cells.

Iluka used a process modelling software package to prepare an EMB, which was then used to improve the understanding of energy flows within the SR process and to assess proposed energy efficiency improvements. The EMB meant that Iluka's decision-makers had access to more comprehensive and detailed energy information than would otherwise have been available. The EEO assessment of Iluka's South West operation resulted in an 8.7% reduction in their energy usage on the site.

This case study outlines how the EMB was prepared and applied to understand energy use in the SR process and identify where energy efficiency improvements could be made.

WHAT IS AN ENERGY-MASS BALANCE?

An energy-mass balance is an analytical technique that can be used to meet the requirements of Key Element 3 – Information Data and Analysis of the Energy Efficiency Opportunities (EEO) Assessment Framework.

An EMB is a description of energy and mass flows in a given process system. It demonstrates where energy enters into the system, where it is transformed and where it exits the system, even in streams where direct measurement may be difficult.

Preparing an EMB model requires knowledge of the processes involved, mass flows through the system, the thermodynamic model which governs the system, the physical state of the inputs and key chemical reactions in the system, such as combustion. Once a model of the system has been constructed, keeping track of energy flows and process interactions becomes much easier. Importantly, it will allow the user to determine impacts of changes in operational parameters, providing a platform for undertaking off-line testing to optimise those parameters.

ILUKA RESOURCES LIMITED

Iluka is a major participant in the global mineral sands sector and is involved in the exploration, project development, operation and marketing of zircon and titanium mineral products, which includes rutile, ilmenite, leucosene and synthetic rutile.

Iluka is the world's largest producer of zircon, with a market share of approximately one third. It is the second largest producer of titanium dioxide minerals, and within this sector, the largest global producer of the higher value titanium dioxide products of rutile and synthetic rutile.

Iluka's operations are based in Australia, with mining and processing operations in Victoria, mining operations in South Australia, as well as processing and ilmenite upgrading operations in Western Australia. The company also has mining and processing operations in Virginia, in the United States. The company has a major exploration tenement holding in South Australia, Victoria and New South Wales.

The company, with approximately 900 people across its operations, is committed to operating in a sustainable and environmentally responsible manner. In keeping with its values of Commitment, Integrity and Responsibility, the company aims to achieve high levels of performance and seeks to pursue "best practice" in the areas of environment, health and safety management.

IMPORTANCE OF ENERGY EFFICIENCY IN ILUKA'S OPERATIONS

Iluka is committed to achieving energy efficiency improvements and reducing its carbon dioxide gas emissions on a unit of production basis. The company's annual energy use and carbon emissions are regularly reported in its annual report.

Iluka's total energy consumption in 2010 was 10,071 TJ. The company recognises that significant benefits can be realised by pursuing improvements in the way energy is used in its operations.

"I am committed to the process of improving energy efficiency within Iluka operations as it is the responsible thing to do and it makes good business sense."

David Robb, Iluka's Managing Director, in highlighting the company's position towards energy efficiency.



Synthetic rutile is a processed ilmenite with a composition of 88 to 95 percent titanium dioxide.

ASSESSMENT OF THE SOUTH WEST OPERATIONS

The energy use at Iluka's South West operations was assessed during 2009. At that time, the South West operations incorporated mining and minerals processing operations, with the major energy consumer being the synthetic rutile production process at North Capel. The need for an improved understanding of energy flows in the synthetic rutile production process was identified as both a requirement of the EEO program and a valuable addition to the canon of process knowledge at the plant.

To understand the energy flows within the synthetic rutile process, it is important to start by looking at the physical process itself, shown in Figure 1. The synthetic rutile process removes the iron from ilmenite to yield synthetic rutile via a process of reduction and chemical and physical separation steps. Ilmenite is reduced to synthetic rutile by the action of carbon monoxide gas produced from coal, in a 90 metre long rotating kiln that operates at temperatures above 900 °C.



Tight monitoring and control of the SR kiln process parameters is required to achieve efficient operations.

THE IMPORTANT PARAMETERS IN CONTROLLING THE KILN PROCESSES ARE:

- Coal to ilmenite ratio
- Combustion air to ilmenite ratio
- Bed temperatures
- Gas temperatures
- Char production rate

The kiln gas is used to provide the heat energy required to drive the reduction reaction as well as reacting with the ilmenite in the reduction reaction. The air to ilmenite ratio and combustion air profile are the most important operating parameters for the control of the reduction kiln. The distribution of combustion air directly impacts on gas temperatures in each zone of the kiln. The challenge faced by the process engineers is to maintain the optimal bed temperatures while maximising kiln gas temperatures and minimising the amount of coal consumed.

The coal to ilmenite ratio is the major long-term performance indicator. If high coal consumption rates are maintained for long periods of time then operating costs are driven up. Maximum production rates go hand in hand with a minimised coal to ilmenite ratio. High coal ratios are an indicator of operating issues, and are quickly targeted and resolved.

The South West synthetic rutile plant incorporates a waste heat recovery plant (WHRP) which uses the waste heat from the kiln to generate electricity for the rest of the operation. Kiln off gases are used to generate steam which drives a steam turbine generator that powers the downstream physical and chemical separation stages of the plant. This plant was in operation prior to the EEO assessment, and the potential for further optimisation of the Waste Heat Recovery Plant was identified as a key benefit of the energy-mass balance modelling process.

Synthetic Rutile Process Flow Chart

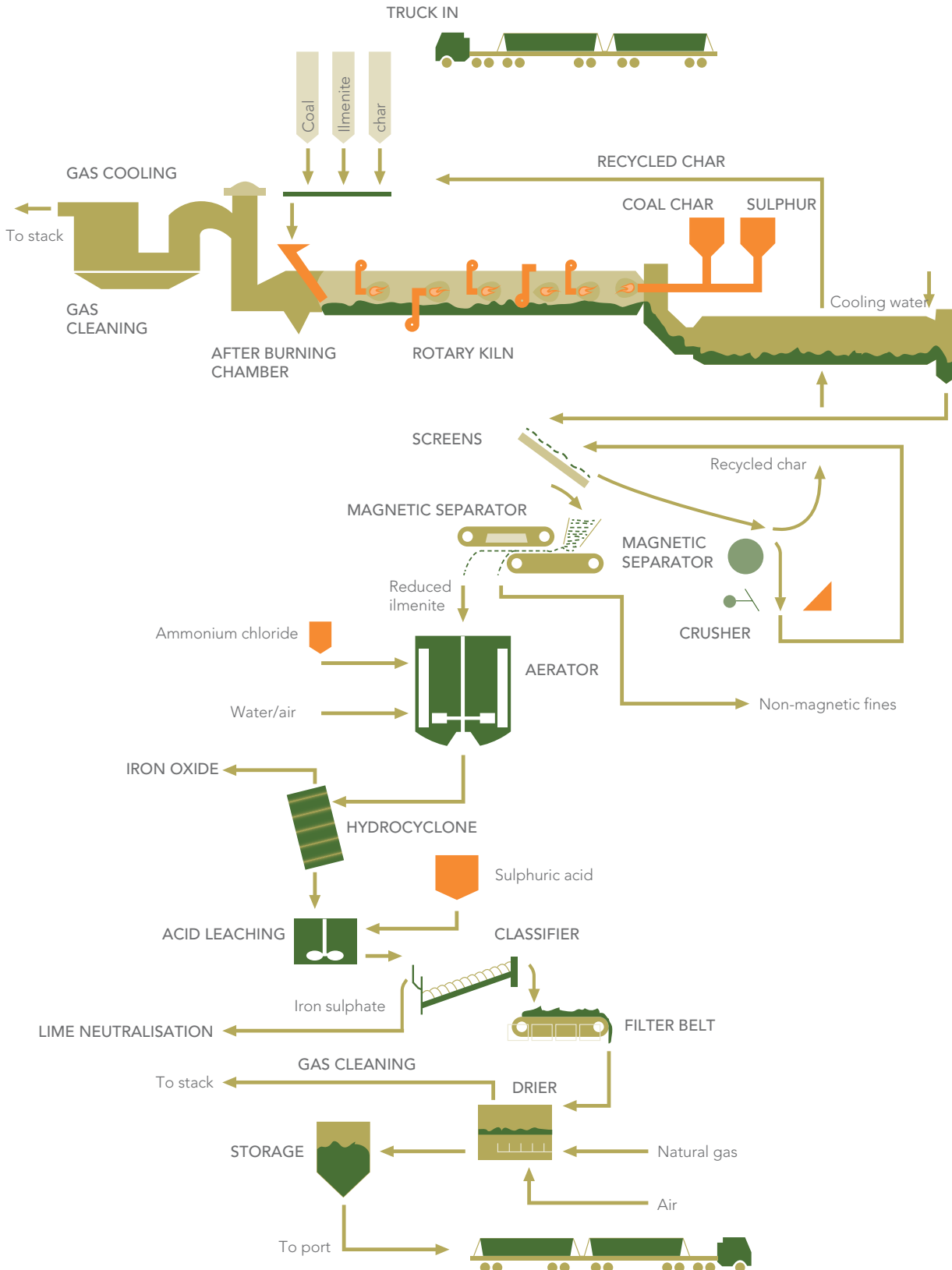


Figure 1 Synthetic rutile production process flow

ILUKA'S APPROACH TO EMB MODELLING

The South West site management decided that the energy-mass balance was a worthwhile exercise and would provide benefits to Iluka, including unique insights into plant operation and performance improvements.

To capture the benefits of the study, Iluka's overall approach was to communicate the business requirement, plan the project, allocate skilled personnel to conduct the work and provide support, and ensure that the appropriate tools and data resources were available to produce the desired result.

STEPS UNDERTAKEN BY ILUKA TO DEVELOP AND APPLY THE EMB

- Communicating the business need
- Project planning and resourcing
- Forming an initial energy baseline and identifying process boundaries
- Collecting the data and filtering for a modelling data set
- Using process modelling software to model heat and energy flows
- Validating the model against actual plant data and operator experience
- Presenting and discussing the results to identify energy efficiency ideas
- Using the model results to evaluate energy efficiency opportunities
- Ongoing use of the energy-mass balance model

COMMUNICATING THE BUSINESS NEED, PROJECT PLANNING AND RESOURCING

Iluka has a culture of continuous business improvement and their existing project management systems were used to resource and track the EEO assessment process. Consistent with other projects at the company, Iluka drew up a project charter which detailed the business need, scope, project outcomes, timing, constraints and key members of the project team. The EEO assessment was incorporated into the team members' performance objectives and goals.

The energy-mass balance aspect of the assessment was managed as part of the overall EEO assessment of the South West operations. Iluka established a multi-disciplinary team to ensure that all relevant perspectives were represented. They did this by including team members from the environmental, operational, engineering, technical and finance departments.

Links to energy knowledge and experience in the broader organisation were maintained via the Greenhouse Gas Strategy Group, the Engineering Manager – Energy and Carbon, and the Continuous Improvement Team on Energy. The relationship between the governance structures at corporate level and the South West EEO project team are shown in Figure 2. The team roles and responsibilities are defined in the Project Charter, as shown in Figure 3.

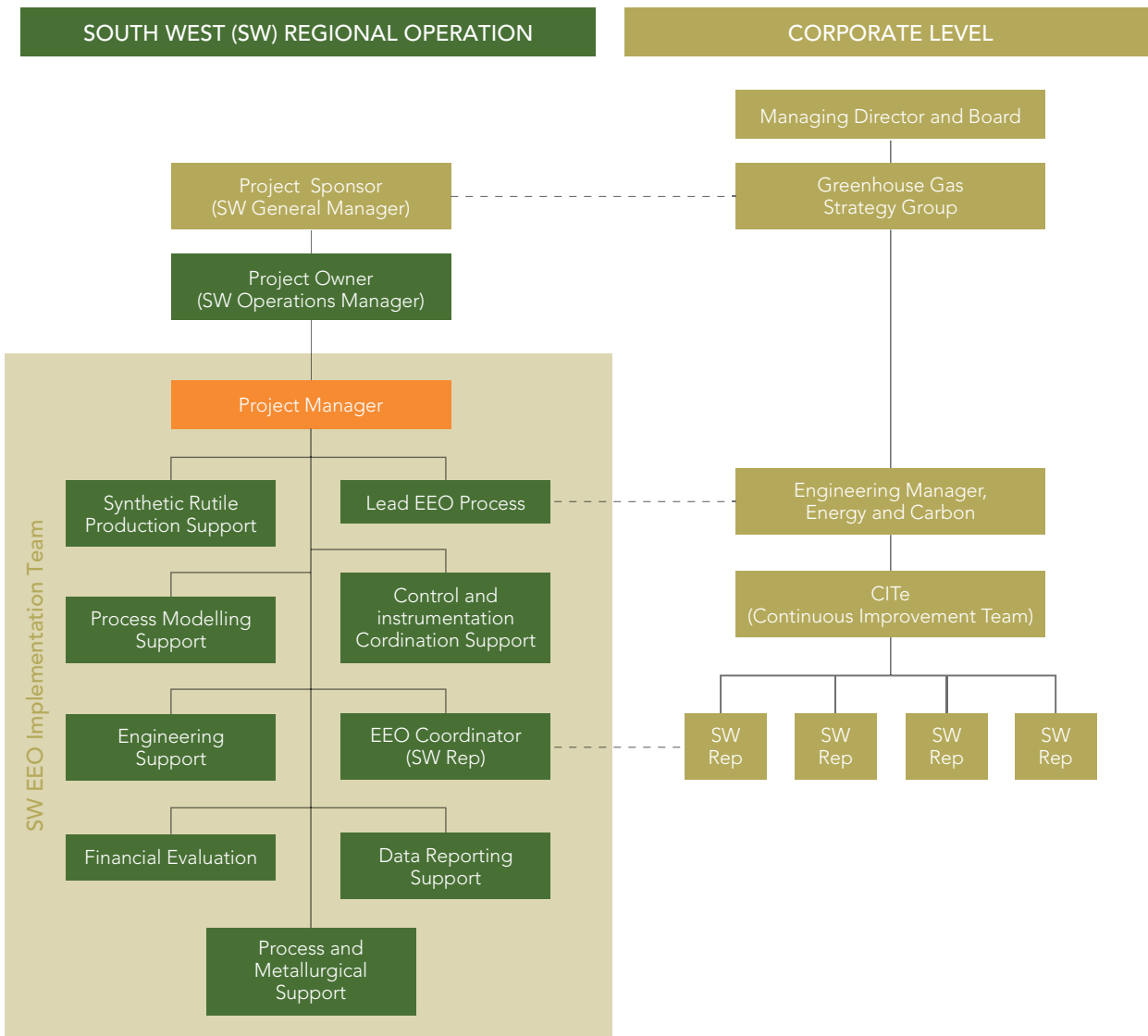


Figure 2 Governance structure for EEO in the South West operations at Iluka

Iluka ensures successful EEO assessments by defining specific responsibilities according to the project charter. To provide high-level visible support, project sponsorship is normally assigned to the GM Operations, who is also a member of the Greenhouse Gas Strategy Group. Project ownership is assigned to the regional Operations Manager to ensure necessary resources are deployed. The Project Manager is assigned to someone with strong leadership, technical and project management competencies and is nominated by the Project Owner.

The Project Team is intended to be a multi-disciplinary team comprised mostly of relevant people from the operations site. Some of the key competencies from the regional organisation are process and metallurgical engineering, SR production, maintenance and engineering, process modelling support, control and instrumentation, data management and reporting, financial evaluation and EEO co-ordination.

An additional 'fresh view' on the operation is provided by the Lead EEO Process role which is filled by the Engineering Manager – Energy and Carbon, who does not belong to the site organisation. Technical personnel at the corporate level also provide assistance and insight as required.

Role	Title	Responsibilities (*note: time allocation spread over 2 months)
Project Sponsor	General Manager - Western Australia	Ensure visibility of management commitment to achieve deliverables on-time. Provide necessary leadership support, resources and guidance.
Project Owner	Operations Manager South West	Allocate site resources to meet objectives. Provide onsite leadership support and guidance.
Project Manager	Regional Operations Manager	Plan activities, delegate members, set priorities and ensure progress of actions to meet the deliverables on time. Provide team leadership. * Time required: 20-40%
EEO Coordinator / Continuous Improvement Team – Energy (CITE)Rep	Electrical / Instrumentation Engineer	Assist Project Manager in following areas: <ul style="list-style-type: none"> • coordinate the activities of the Team • advise on EEO requirements Provide specialist inputs to the team. * Time required: 50-70%
Process & Metallurgical Support	Site Process Engineer	Provide specialist technical inputs to the team.
Synthetic Rutile Production Support	SR Operations Superintendent	Assist Project Manager to achieve project deliverables by contributing to the following activities: <ul style="list-style-type: none"> • Formulate detailed activity plans
Engineering Support	Reliability Superintendent	<ul style="list-style-type: none"> • Facilitate collection of data needed for energy and process analysis and benefit-cost evaluation • Facilitate idea generation of energy efficiency and plant improvements
Process Modelling Support	Principal Process Engineer	<ul style="list-style-type: none"> • Conduct evaluation of opportunities • Document assessment process and outcomes
Control & Instrumentation Coordination support	Site Process Control Specialist	* Time required: 20-50%
Data & Reporting Support	Environmental Officer or Sr. Environmental Specialist	
Financial Evaluation Support	Business Analyst	Advise the team in financial evaluations, ensuring that benefit, costs and financial calculations are aligned with Iluka commercial procedures. * Time required: 10-15%
Lead EEO Process Support	Engineering Manager – Energy and Carbon	Provide overall technical advice Audit site processes
EEO Process Support/ Regulatory Quality Control		Describe and provide guidance on EEO principles * Time required: 50-70%

Figure 3 Roles and Responsibilities for the EEO Team

FORMING AN INITIAL ENERGY BASELINE AND IDENTIFYING PROCESS BOUNDARIES

Key Requirement 3.1 of the EEO Assessment Framework requires corporations to identify and document business contextual information that influences energy use. This includes the identification of key site processes and activities that consume and produce energy. As part of meeting this requirement Iluka identified the following key site processes which would be the focus of the EEO assessment and energy-mass balance study due to their high energy use:

- The Synthetic Rutile (SR) kiln
- The Waste Heat Recovery Plant
- The Aeration Process
- The Acid-leach Process
- The SR dryer

The requirements for the collection of energy data as part of an assessment are contained in Key Requirement 3.2 of the EEO Assessment Framework. The collection of appropriate data enables the development of an energy baseline, which is an important step in managing energy use. Once the baseline is established, process changes and improvements in energy use can be tracked against it.

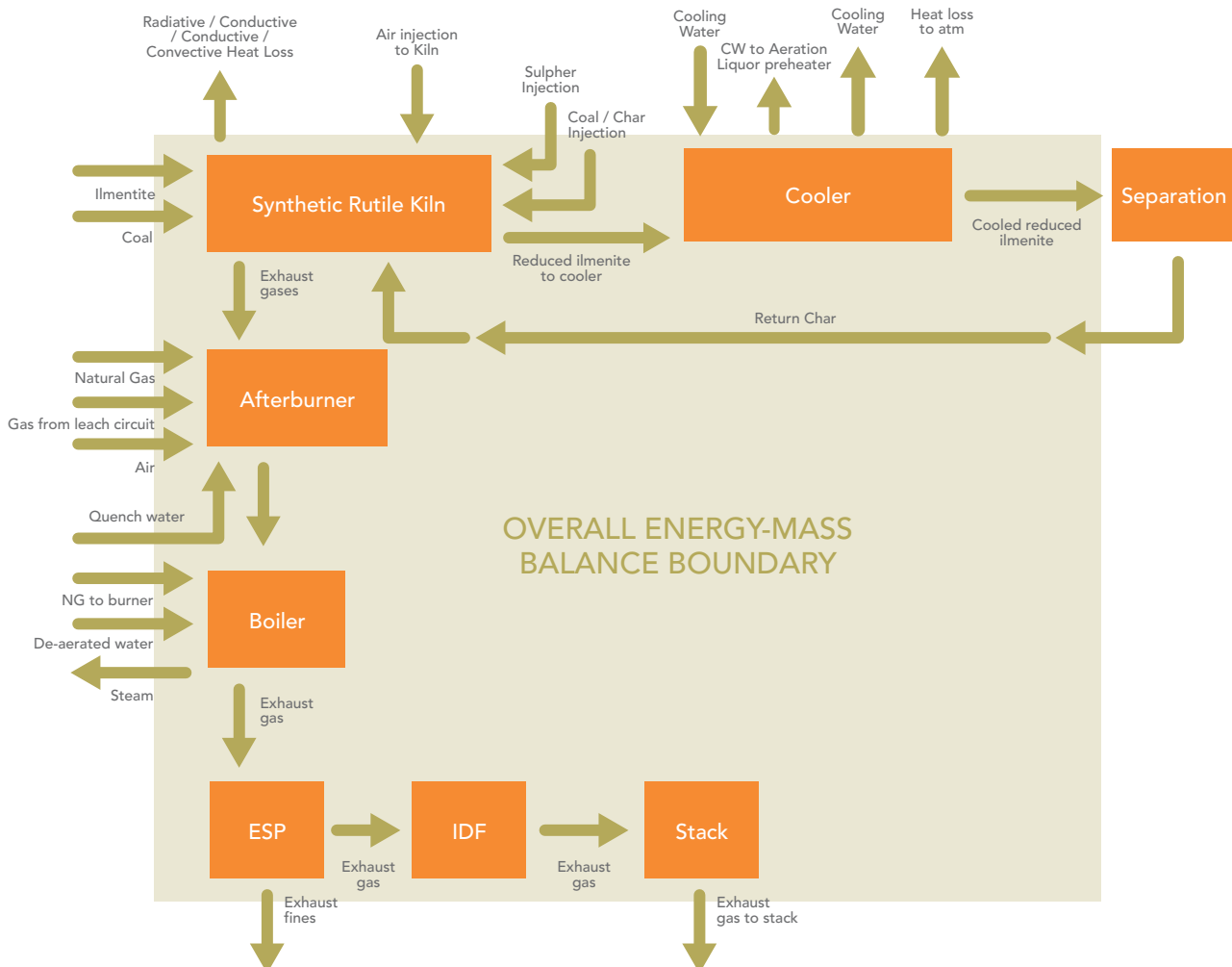


Figure 4 Flowsheet diagram and EMB boundaries for the SR process.

The energy baseline can be constructed from invoices and other records of energy consumption. For most facilities this information is recorded in management, accounting and production systems. The accounting system also takes into account inventory and stock levels for energy commodities such as coal. The energy baseline for Iluka's SR process was calculated by analysing two years of data on the usage of:

- Natural gas
- Purchased electricity
- Coal

After the initial determination of baseline energy consumption, the process was mapped out to determine where the energy and mass inputs occur in relation to the process stages. This required an understanding of the process flow and the definition of the process boundaries. Iluka mapped out the process boundary for the SR kiln as shown in Figure 4 which also defines the flows of materials and energy across the boundary. This assisted the team to determine what process data must be collected and what processes must be modelled to create the EMB.

COLLECTING THE DATA AND FILTERING FOR A MODELLING DATA SET

The SR plant has an advanced SCADA (Supervisory Control and Data Acquisition) system comprising a Scitech DCS (Distributed Control System) and a Matrikon historian. Types of data that were collected from the existing measurement sensors included:

- Mass flow rates from in-plant weigh feeders
- Temperatures of input steams
- Processing temperatures
- Steam pressures

While data from plant instrumentation was extracted from Matrikon, raw material consumption and product chemical assays were brought across from a production and quality database called Prodtrak, which is a manual entry production data archiving system.

The combination of the two data sources was used to provide a more complete picture of the process and allowed the identification of the process streams to be modelled.

A sample of the data acquired from the Matrikon system is shown in Figure 5. This data was captured by the process engineers who regularly use the system. Hourly data was downloaded for the various instrument tag names and stored in spreadsheets in chronological order. The spreadsheet comprised numerous sheets to group different areas of the plant.

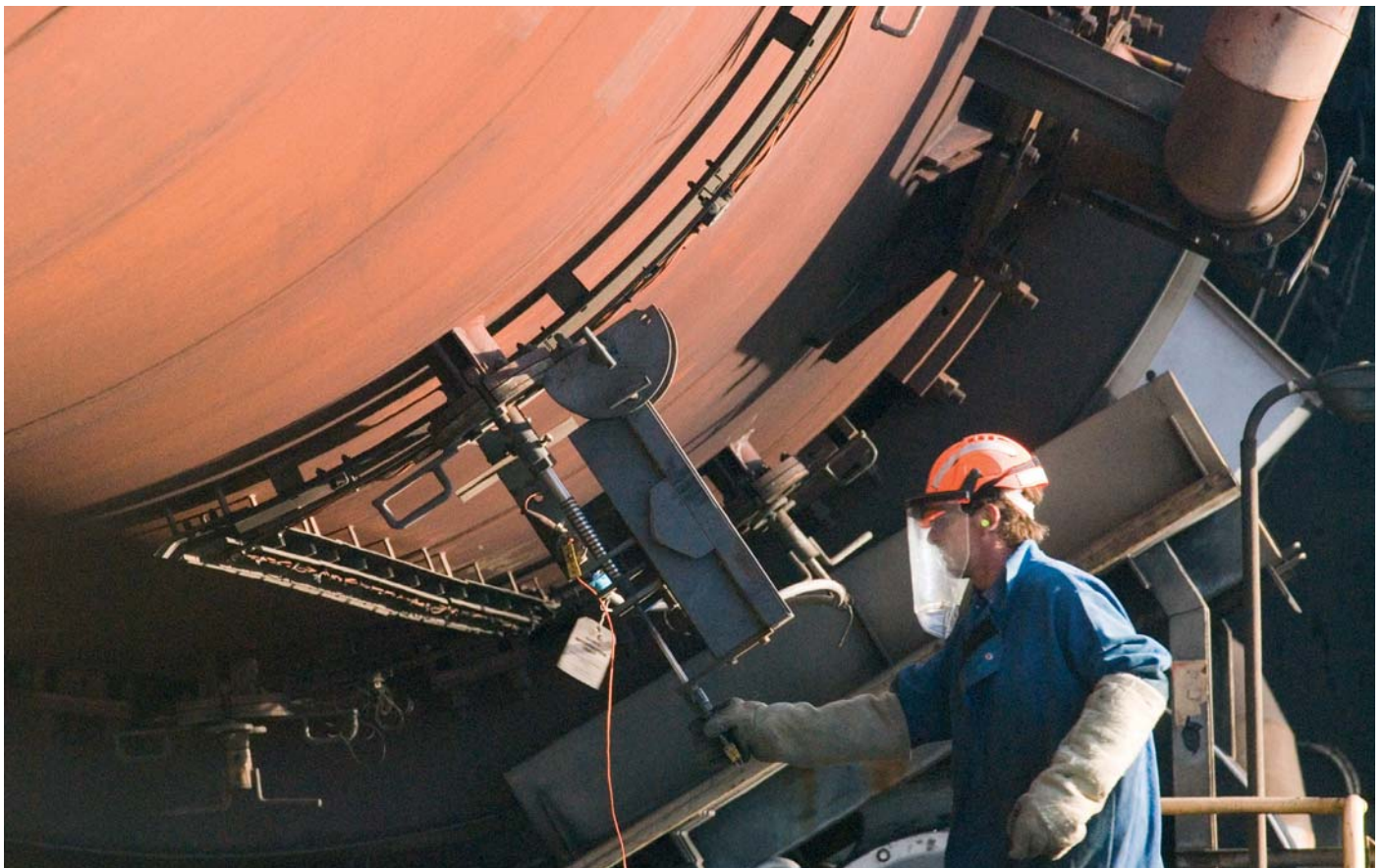
Once the raw data was extracted and combined into a single source, a process of filtering was applied to ensure only periods of steady-state operation were used to build the EMB. The filtering process also required the removal of 'zero data' created during both planned and unplanned shutdowns that would otherwise result in averaging errors.

Planned shutdowns occur once every six weeks where the kiln is shut down for 8 hours. After start-up it is generally found that steady-state operation is not achieved for 24 hours after recommencing feed. The period of operation where the process is not in a steady state represents 2.6% of operating hours and it was therefore decided there was more value in studying and improving the normal steady state operation. If the process was subject to more regular disturbances or intermittent operation it may have been necessary to assess the effect of operation outside of steady-state conditions.

The collected and filtered information was then used as an input for the EMB model, which was created using commercially available process modelling software.

	1	2	3	4	5	6	7	8
Description	Makeup Water Flow	Condensate Tank temperature	Deaerator Left Pressure	Condensate heater Outlet Temp	Deaerator condensate flow	Deaerator pressure	Deaerator feed water temperature	Feed Water Pump Pressure
Units	t/hr	°C	kPa	°C	t/hr	kPa	°C	kPa
Tag Name	P25F034	P24T023	P24P032	P24T024	P24F038	P24P037	P24T042	P24P046
Criteria	>0	>0	>0	>0				
Average	0.80	49.11	1302	135	24.10	294	136.12	5875
Standard Deviation	0.51	8.07	10	93	1.49	23	2.45	156
Minimum	0.13	37.56	1276	40	15.18	15	82.79	5173
Maximum	2.31	104.50	1362	276	31.04	368	141.83	6291
10/01/2006 12:00	0.398	104.4	1298.3	74.28	22.6	324	138.36	6054
10/01/2006 13:00	0.882	104.4	1295.3	72.791	23.1	319	138.46	6102
10/01/2006 14:00	0.334	104.4	1298.7	68.29	24.0	313	138.12	6013

Figure 5 Snapshot of Matrikon process data capture sheet (actual data)



Routine maintenance at the synthetic rutile kiln.

USING PROCESS MODELLING SOFTWARE TO MODEL HEAT AND ENERGY FLOWS

Iluka's processing plant involves multiple sophisticated heat and mass transfer processes, as well as complex chemical reactions. Software is available that can model these complex processes in a way that provides a convenient interface, a database of the required materials' properties, and a process modelling framework. The modelling package HSC, developed by Finnish minerals equipment developer Outotec, was chosen to model the process. The software greatly simplified the modelling exercise, which would otherwise have been a complex and time intensive process. Further to this, the software enables the user to experiment with process changes without the need to rewrite or rebuild major parts of the model code.

WHY HEAT CAPACITY, ENTHALPY, ENTROPY AND GIBB'S ENERGY ARE IMPORTANT

These physical quantities are requisites to apply the Second Law of Thermodynamics. Enthalpy and Entropy are terms in the Gibb's Equation which gives an indication of the maximum theoretical (non-mechanical) work that can be done by a system. The Second Law provides a means for:

- Predicting the direction of processes
- Establishing the conditions for equilibrium
- Determining the best performance of thermodynamic systems and applications

Iluka used the in-built thermodynamic functions to model the steady state process. Because it was a steady state process, reaction kinetics did not need to be included in the model, but the software is capable of modelling reaction kinetics if needed.

Figure 6 shows an example of the software data input interface for the mass and energy flows. The HSC software uses a spreadsheet-style data input format which makes it easy to use. The user is required to input the reactants for a given reaction. Then the program will use its database of physical data to calculate the result of the reaction, showing the amounts of products and heat produced (or consumed). The reactions are divided into three sections:

- the reaction involving the metal ores
- the reactions involving the production of gas from burning the coal
- the phase change reaction which in this case applies to moisture entering the kiln

The software gives the enthalpy change for a given reaction at a given temperature. The HSC software also models the heat loss from vessels based on the physical and thermal properties of the vessels.

The model calculates the total enthalpy change from the individual components to give the energy balance, which accounts for all heat flows passing through the system boundary, such as the overall heat that is removed by the hot gas flowing out of the kiln and the cooling water used to cool the reduced rutile. The enthalpies are shown in Figure 7.

A14	OUTPUT SPECIES (1) Formula	Temper. °C	Amount kmol	Amount kg	Amount Nm³	Latent H kWh	Total H kWh	Lat H	Tot H
1	PROCESS GAS:	25.000	0.36054	10.893	8.081	0.00	-8.85		
2	CO2(g)	25.000	0.06477	2.851	1.452	0.00	-7.08	0.000	-109.307
3	H2O(g)	25.000	0.02586	0.466	0.580	0.00	-1.74	0.000	-67.174
4	SO2(g)	25.000	0.00044	0.028	0.010	0.00	-0.04	0.000	-82.448
5	N2(g)	25.000	0.26948	7.549	6.040	0.00	0.00	0.000	0.000
6	O2(g)	25.000	0.00000	0.000	0.000	0.00	0.00	0.000	0.000
7	ASH:	25.000	0.00086	0.068	0.000	0.00	-0.24		
8	Fe3O4	25.000	0.00006	0.014	0.000	0.00	-0.02	0.000	-309.861
9	SiO2	25.000	0.00045	0.027	0.000	0.00	-0.11	0.000	-253.016
10	Al2O3	25.000	0.00017	0.017	0.000	0.00	-0.08	0.000	-465.470
11	CaO	25.000	0.00012	0.007	0.000	0.00	-0.02	0.000	-176.367
12	MgO	25.000	0.00002	0.001	0.000	0.00	0.00	0.000	-167.111
13	SiO2	25.000	0.00003	0.002	0.000	0.00	-0.01	0.000	-253.016
14									
15									
16									
17									
18									
19									

Exit Stream < > BALANCE (1) kmol: -0.078, kg: 0.000, Nm³: -0.274, kWh: 0.00, kWh: -8.83

Figure 6 Example of HSC Excel Interface for material and heat balances (not actual data)

Bed reactions				
Delta H MWh	delta H / kmol kW/h / mol	Flow kmol/h	Temp, °C	Reaction
8282	130	64	1150	$\text{Fe}_2\text{Ti}_3\text{O}_9 + 3 \text{C} = 3 \text{TiO}_2 + 2 \text{Fe} + 3 \text{CO(g)}$
5799	97	59	1150	$\text{FeTiO}_3 + \text{C} = \text{TiO}_2 + \text{Fe} + \text{CO(g)}$
1344	37	36	1150	$\text{TiO}_2 + 0.5 \text{C} = 0.5 \text{Ti}_2\text{O}_3 + 0.5 \text{CO(g)}$
15425				Overall

Gas reactions				
Delta H MWh	delta H / kmol kW/h / mol	Flow kmol/h	Temp, °C	Reaction
-7290	-32	227	1250	$\text{C} + 0.5 \text{O}_2(\text{g}) = \text{CO(g)}$
-17106	-70	246	1250	$\text{H}_2(\text{g}) + 0.5 \text{O}_2(\text{g}) = \text{H}_2\text{O(g)}$
-34872	-156	224	1250	$\text{O}_2(\text{g}) + 2 \text{CO(g)} = 2 \text{CO}_2(\text{g})$
-59268				Overall

Phase Change				
Delta H MWh	delta H / kmol kW/h / mol	Flow kmol/h	Temp, °C	Reaction
3097	12	253	25	$\text{H}_2\text{O(l)} = \text{H}_2\text{O(g)}$

Figure 7 Balanced chemical equations and reaction energies (enthalpies) in the reduction kiln.

VALIDATING THE MODEL AGAINST ACTUAL PLANT DATA AND OPERATOR EXPERIENCE

While the software is a user-friendly and powerful tool, it was still important that experienced operations staff derive the model and develop an understanding of its limitations. The team members that worked with the software had a detailed understanding of Iluka’s processing plant. This knowledge was required to develop a model that accurately reflected the plant operations and could be verified against the actual operating data.

The preparation of information for the software tool and the development of the model also gave rise to useful questions and resulting knowledge on the process that was valuable to the team.

The overall process flow diagram was detailed in the simulation module of the HSC software. A section of this is shown in Figure 8. An imbalance or error in the flow sheet can be quickly identified through an out-of-balance error in the incoming and outgoing mass balance sheets or energy flows. The modelling team added two-year averages for the process inputs which were obtained by the data collection process discussed earlier. Output parameters could be selected using the software as shown in Figure 9 where temperatures are shown.

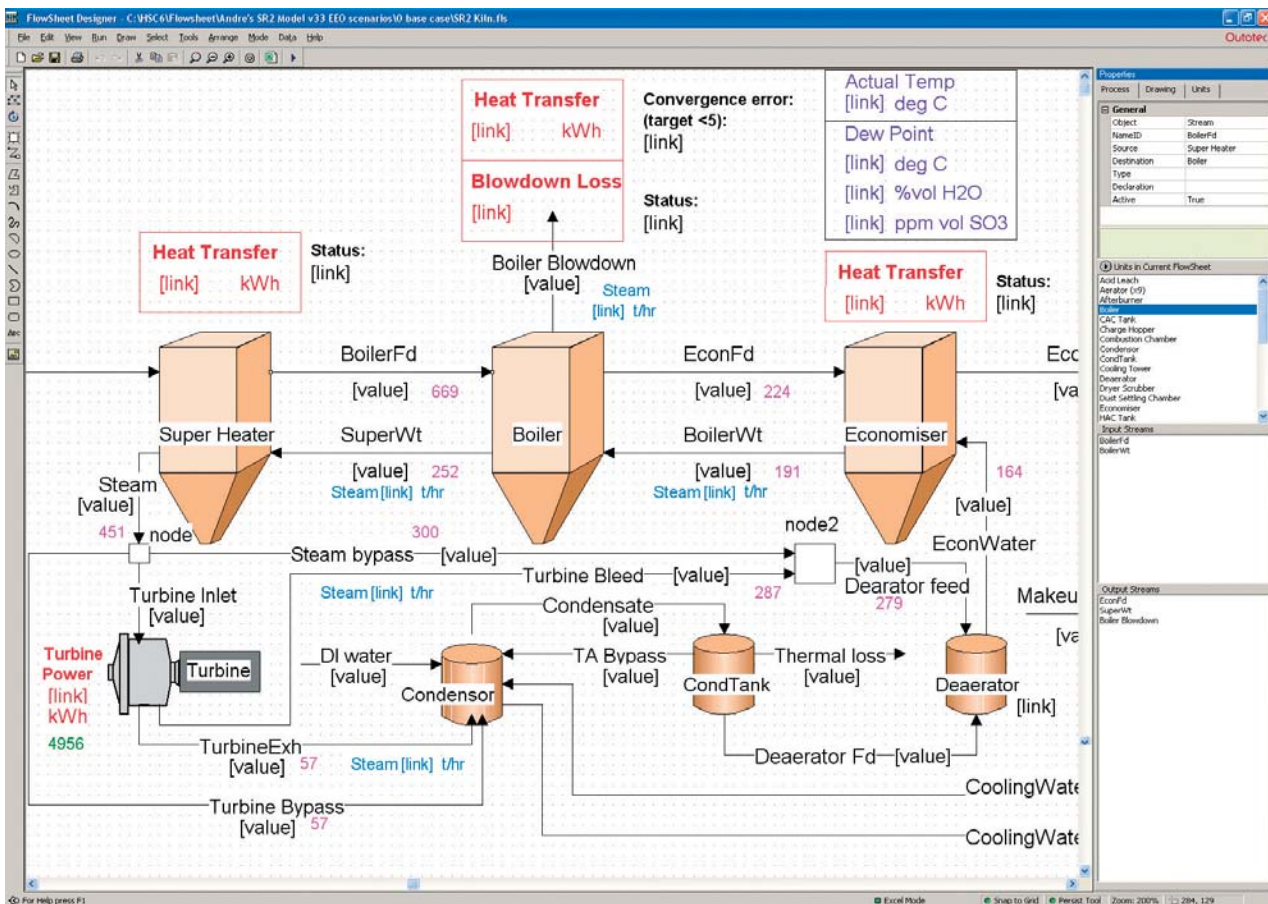


Figure 8 A snapshot from the process flow sheet construction page showing the Waste Heat Recovery Plant and steam properties in the side bar.

DATA MEASUREMENT

In this case study, Iluka did not need to install extra measurement equipment to develop their EMB model. Many plants however, may not have such comprehensive instrumentation. So, as a first step in the EMB model development, organisations may need to install extra measurement equipment. In order to determine where extra measurement may be required, it may be helpful to develop the EMB with estimates of unmeasured parameters to see what effect they have on the overall result. If a reliable and representative result cannot be gained from the model with estimated amounts, additional measurement would then be advised.

THE OUTPUT PARAMETERS THAT WERE RECORDED WERE:

- The mass flows of product
- Temperatures of product
- The heat loss from various vessels
- The amount of steam generated in the process
- The heat transfer across the various unit operations

Once the model had been created, the output was compared against actual performance of the plant at average conditions. It was found that the model predicted actual conditions to within 3-5%. This was a key step as it assured the team that they could:

- Rely on the overall heat and mass flow information, and
- Use the model to determine the impact of any changes to the process.

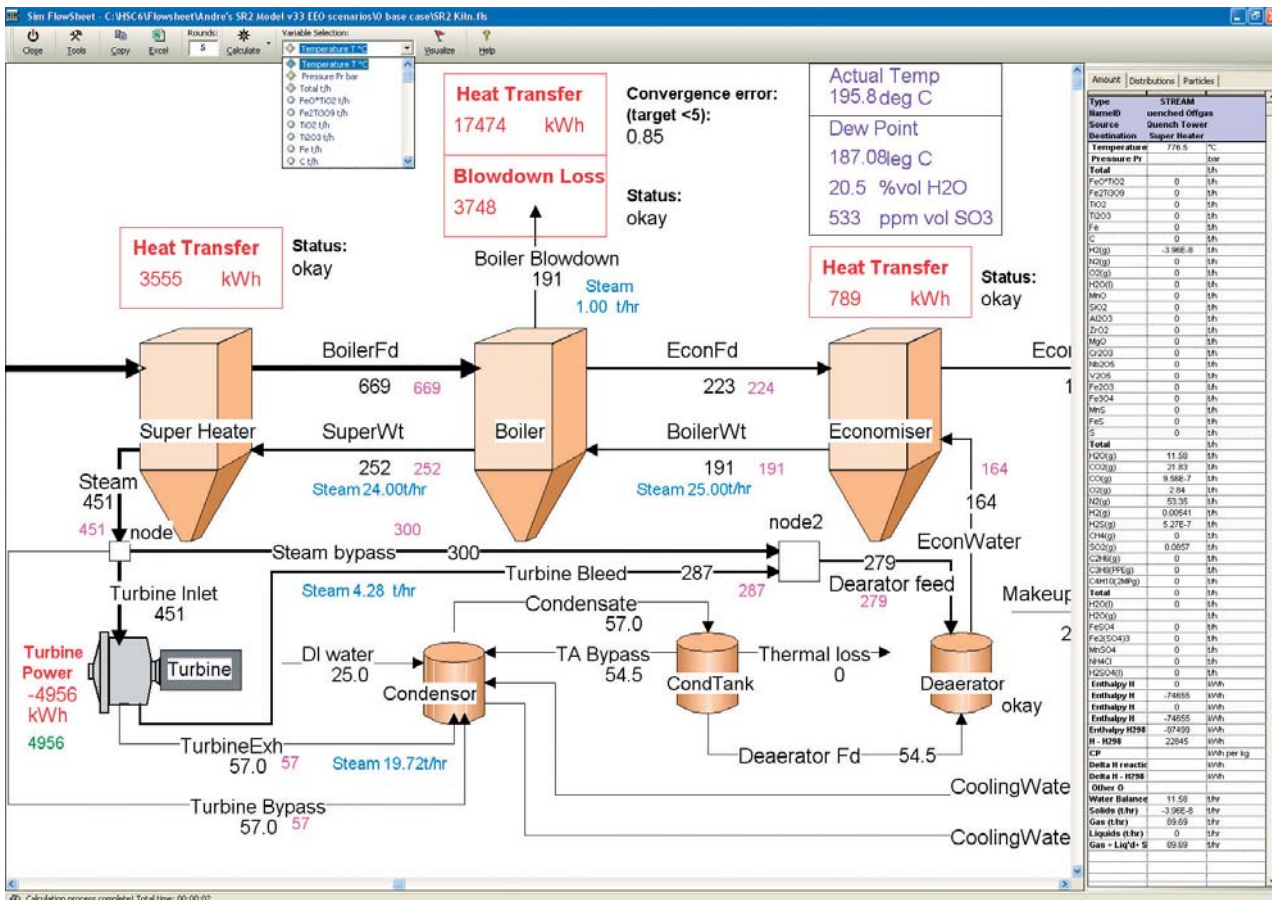


Figure 9 A steady state mass balance around the Waste Heat Recovery Plant showing stream temperatures

PRESENTING AND DISCUSSING THE RESULTS TO IDENTIFY ENERGY EFFICIENCY IDEAS

Iluka used the output from the energy and mass flows model to generate a Sankey diagram to represent the results in a visually effective and concise manner. The Sankey diagram illustrates where energy is supplied to the process, how it is transformed and where it leaves the process. The Sankey diagram is shown in Figure 10.

The width of the arrows is in proportion to the amount of energy associated with each part of the process.

The Sankey diagram is an effective and intuitive way to communicate the energy flows at the plant. The diagram was used extensively during Iluka’s opportunity workshops. The diagram assisted the staff at the workshop to focus their attention on where the largest energy flows exist and identify where the main areas for improvement lie.

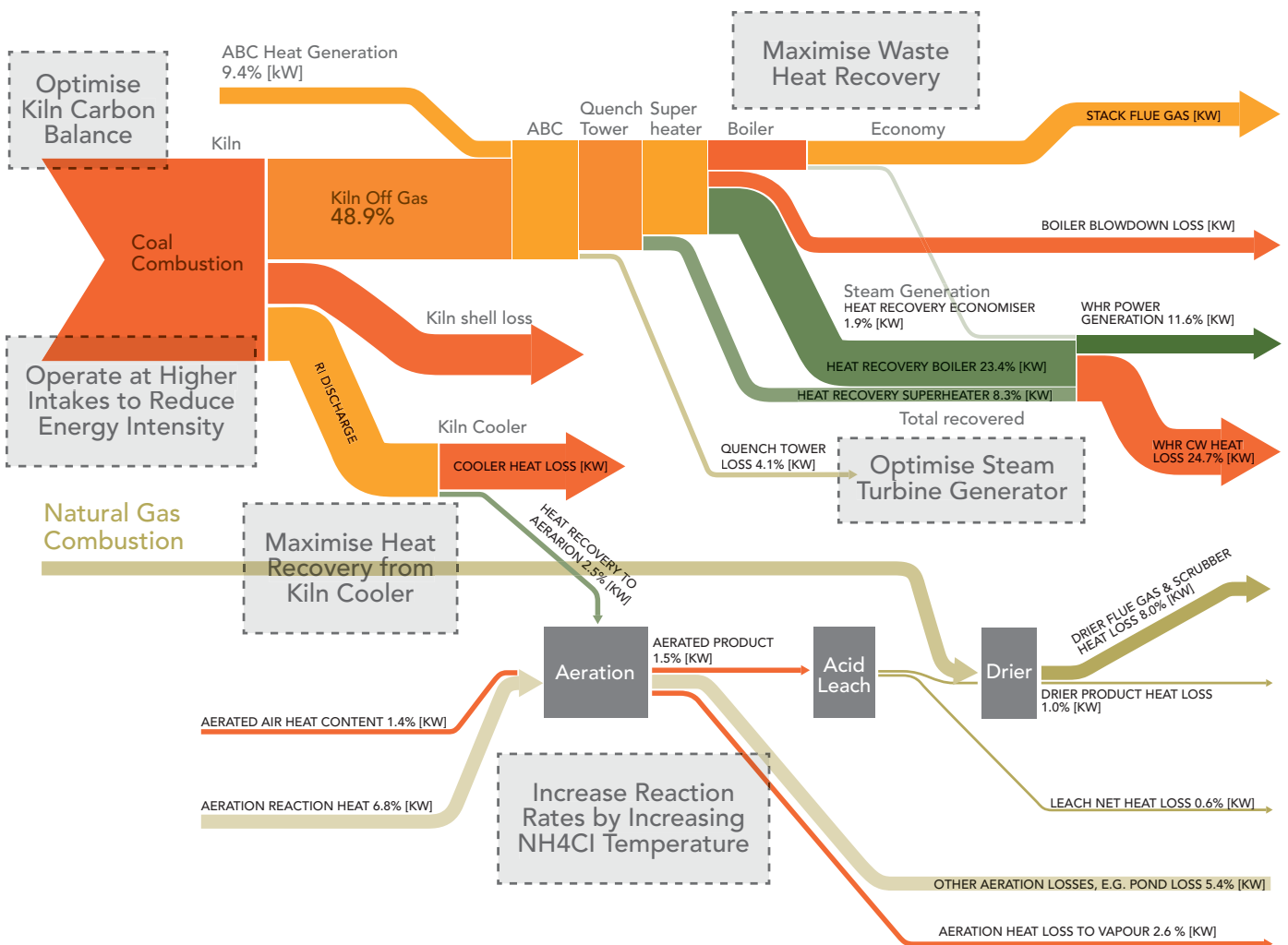


Figure 10 Sankey diagram of energy flows in SR2 (actual results)

Key Element 4 of the EEO Assessment Framework requires corporations to develop and assess energy efficiency opportunities. It requires companies to compile a comprehensive list of opportunity areas based on a review of information, data and analysis, and the knowledge of experienced people. Opportunities with a payback period of less than 4 years must be investigated in greater detail. Detailed investigations need to take into account all relevant business costs and benefits, resulting in a 'whole of business' analysis of the opportunity.

During the course of data analysis, the EEO team used the energy balance and the process flow diagrams to graphically represent areas where energy efficiency improvements could be worth exploring.

To launch the ideas generation process, some initial ideas were identified and presented at the workshops on the relevant part of the SCADA display.

The workshop process generated a range of initial ideas including:

- Use hot water on the filter belt to result in a drier filter cake of SR which requires less natural gas in the drying process
- Increase the temperature of the air used in the aeration process to reduce the residence time in the vessel. This results in less electricity use for agitation per mass of product through the plant. This also means that a higher proportion of waste heat from the kiln is used for a production purpose in the plant, rather than being lost.
- Increase waste heat recovery and power generation from the waste heat recovery plant, by implementing additional maintenance and process control measures.



Synthetic rutile processing plant at Capel.

USING THE MODEL RESULTS TO EVALUATE ENERGY EFFICIENCY OPPORTUNITIES

The workshops generated around 160 energy savings ideas. These opportunities were identified by studying and discussing the EMB. Many of them were around the kiln because the EMB indicated that most of the plant's energy flows were in this area. The EMB highlighted that new ways of trying to use the kiln waste heat would be worthwhile to investigate.

Iluka prioritised the various ideas based on ease of implementation and expected benefits. The top ideas were selected by performing rough calculations on the 160 ideas to get an idea of their magnitude and their practicability. The results from the EMB modelling exercise were used in the evaluation of the potential benefits of the ideas and the prioritisation of ideas. The ideas that were second in priority were also to be considered for future investigation, while no action was recommended for those that were considered unattractive or too difficult to implement.

The EEO team selected the most attractive 16 ideas for further investigation. Some of the 16 opportunities were:

- Optimise oxygen control for both kilns
- Reduce water content in filter belt product
- Heat recovery from SR Kiln No.1 to reduce natural gas for drying
- Investigate a lower conductivity refractory
- Preheat boiler water from waste heat resources on SR Kiln No.1

The 16 opportunities were assigned to different members of the EEO team for evaluation and further investigation. Each team member was presented with a Task Assignment to guide them with the analysis and to explain the task. An example is shown in Figure 11.

Each of the opportunity investigations was documented in a spreadsheet which was developed to standardise the process and assist the EEO team.

Results from the EMB model were used in the detailed investigation of a number of the opportunities. Investigators were also expected to consult with site, and if necessary, external experts to conclude the investigation. The idea evaluation template prompted the investigator to detail:

- Capital costs
- Operational costs (energy and other)
- Operational savings (energy and other)
- Potential throughput impacts
- Capital equipment spend deferrals
- How the investigations were carried out
- How benefits would be measured
- Explanation of which Key Performance Indicators would be affected
- Barriers to successful implementation
- Net Present Value calculations
- Maintenance requirements
- Assessment of energy savings accuracy

The EEO Project Manager presented the evaluation results to the South West Operations Manager for a decision on how to progress each opportunity. For each opportunity, the Project Manager made a recommendation. The Operations Manager made the decision on whether to implement, investigate further, or not to implement.

Energy Efficiency Team Task Assignment

Context	<p>After a series of workshops and a presentation to the management team 16 ideas have been selected for detailed evaluation as part of the Energy Efficiency Program.</p> <p>After detailed evaluation of the ideas is complete these 16 ideas will be further refined to a group of projects that will be implemented as part of the program. The energy and business savings from these implemented projects will be monitored over the next five years.</p> <p>The Management Team will have the final decision on which projects will be implemented and the project outcomes will be presented to Senior Management.</p> <p>Each year Iluka will report it's energy consumption and the Group CEO will sign off on energy reporting.</p>
Deliverables	Assisting in the evaluation of the energy and business impact of selected EE ideas
Quantity	<ul style="list-style-type: none"> • Projects that will required assistance
Quality	<ul style="list-style-type: none"> – Increase Ammonium Chloride Temperature – Preheat Condensate from alternate source – Replace drier lifter bars – Produce and Transport drier HMC • The following evaluation steps should be used <ul style="list-style-type: none"> – Opportunity Definition – Establish the Energy Baseline – Forecast the Energy Savings – Establish the Business Cost and Benefits – Prepare Business Case for Evaluation – Energy Monitoring and Reporting • Ensure that you agree with the person that is responsible for the idea evaluation the deliverables that you are required to produce – including the format of those deliverables.
Resources	<p>EE Guidelines – Carbon and Energy Manager Evaluation Template Evaluation Process Presentation Accuracy Presentation</p> <p>As per the attached responsibilities sheet</p> <p>Production superintendent as required</p>
Time	<p>Task Completion October 28th</p> <p>Task Monitoring – Review Task Progress Mondays and Wednesdays at 1130 in Production Superintendent's Office</p>

Figure 11 Task Assignment for detailed opportunity investigation

RESULTS

The EMB model created for the South West operations has directly resulted in a greater understanding of energy use, the identification of energy efficiency opportunities and the evaluation of those opportunities. It has also been valuable in communicating the outcomes of the program.

KEY RESULTS ACHIEVED INCLUDE:

- Iluka's South West operations have implemented eight energy efficiency projects during the course of Iluka's first five-year EEO Assessment cycle, for a combined total saving of 338 TJ per year, or 8.7% of total site energy use.
- Iluka used the EMB model during opportunities identification and project evaluation. Projects that made use of the model results accounted for 99% of the total energy reduction achieved to date. An example of a project that utilised the model and has commenced is the project to increase the SR2 ammonium chloride liquor temperature.
- At the Mid West site, which applied the lessons learned during the South West EEO program, energy savings have amounted to 179 TJ per annum or 4.7% of total site usage.
- With an EMB already developed as an on-site tool, energy impacts resulting from future operational changes, such as de-bottlenecking projects or plant improvements, could now be assessed with good accuracy and minimal effort despite the complexity of energy process flows and interactions in the SR plant.
- The EMB methodology is now an important part of Iluka's business improvement process, and will continue to be used to identify and assess energy improvement projects.
- These results indicate that the proper assessment of energy use, as indicated by the EEO program, adds significant operational value and that its implementation improves the overall business and engineering process.

LESSONS LEARNED

Iluka highlighted the following as the key lessons they learned from conducting the EMB in the South West operation:

- The EMB process provides real and quantifiable business benefits
- Good preparation for the Assessment is essential
- A multi-disciplinary approach is crucial to a good outcome
- A good working understanding of overall energy flows is required before embarking on the EMB modelling exercise
- Presentations and general inclusion of staff helps to improve team engagement with the process
- Software is available to model processes and analyse energy-mass balances. The use of software allows desktop assessment of proposed changes in process and operating conditions
- The EMB software can be used at other sites where an EMB would be beneficial
- An EMB is an effective tool in raising awareness of energy efficiency within Operations

CONCLUSION

Iluka has developed an energy-mass balance model that gives the energy and mass flows within the SR process in the South West operations. This was conducted as part of Iluka's EEO Assessment of the South West and specifically addresses Key Element 3 of the EEO Assessment Framework.

The energy-mass balance has been useful in communicating the way energy is used and transferred within the process and was a valuable input in the identification and evaluation of ideas to become more energy efficient and to use waste energy for productive purposes. The methodology has been applied at other sites (Mid West SR operations), and the model has been fully documented for future use.

Iluka will be using the EMB model for the next EEO five-year cycle, and will incorporate process changes where they have occurred. The energy impacts of operational changes such as de-bottlenecking projects or plant improvements can now be assessed in an accurate and straightforward manner despite the complexity of interacting energy and mass streams.

The EMB model is an important part of Iluka's business improvement process and will continue to be used to raise awareness and understanding of energy use, and to identify and assess energy improvements. Experience gained and lessons learned from the EMB modelling exercise means that Iluka is well positioned for the next EEO cycle.



Iluka as a company believes that targeting high levels of performance and pursuing best practice in the areas of environment, healthy and safety reflects the company's key values of Commitment, Integrity and Responsibility.

CAVEATS

These findings are based on the data and analyses carried out by the corporation. Findings may not be comprehensively detailed in this document due to intellectual property and business in confidence reasons.

Readers should be aware that this case study outlines key learnings and does not necessarily represent a complete assessment as required by legislation.

CREATIVE COMMONS

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OTHER EEO PUBLICATIONS AND RESOURCES

The EEO program produces a range of guidance materials and case studies relevant to the mining and resource processing sectors, downloadable from www.energyefficiencyopportunities.gov.au.

- EEO Assessment Handbook
- Energy Savings Measurement Guide
- Representative Assessment Guide
- Energy Mass Balance - Mining
- Energy Mass Balance - Resource Processing
- EEO Verification Handbook
- First Opportunities Report - Mining Industry
- Driving Energy Efficiency in the Mining Sector
- Functional skills for an energy efficient assessment
- Mining Sector - Significant Energy Efficiency Opportunities Register
- EEO Trial Case Study – Xstrata Copper
- EEO Trial Case Study – Xstrata Coal
- EEO Case Study – Thiess’ Australian Mining Business Unit
- EEO Case Study - Analysis of diesel use for mine haul and transport operations

ENHANCING AUSTRALIA'S ECONOMIC PROSPERITY

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ILUKA

The aim of the Energy Efficiency Opportunities program is to increase the uptake of cost effective energy efficiency opportunities by Australian industry through improving the identification, evaluation and public reporting of energy efficiency opportunities by large energy using corporations.

