

Case Study

Company name	Tiger Brands Candies and chocolates Mobeni				
Size of company	Small	Medium	X	Large	
Sector	Manufacturing				
Location	Durban, Mobeni				
Company Contact	Name: Jayendran Govender			Position: Engineer	
	Email: Jayendran.Govender@tigerbrands.com			Telephone: 031 460 7603	
Year joined Project	2015				
Date of Implementation	April 2016	Duration	(16 months)		
Utility Intervention	Steam				
Case Study Author	Edmore Manzunzu, Moses Motaung				
Project Manager	Lindani Ncwane (073 3842589/ 031 242 2373) LNcwane@csir.co.za				

1. BACKGROUND

1.1 Company profile

Tiger brands manufacturers food products in the form of tinned and bottled for a longer shelf life. The company is ISO 9001 certified and all its operations are standardized and documented following written procedures.

Tiger Brands' foundation was built on the strength of family businesses and the spirit of entrepreneurship. In 1896, it was the humble little toothpick that sparked Tiger Brands Oats Limited to life, the forerunner of today's Tiger Brands. As for the flagship All Gold tomato sauce, it was a Scottish chemist who discovered the secret recipe – one that would end up on the plates of King George VI and Queen Elizabeth during their 1947 jaunt on the Royal Train.

The Tiger brands Mobeni plant manufactures candies and chocolates. The table below shows the contact details.

Table 1: Contact details

Company name	Tiger brands Candies and chocolates (beacon eggs; beacon choloate)
Physical Address	1400 South Coast Road, Mobeni DURBAN, 4092
Phone	+27 (031) 460-7690
Fax	+27 (031) 460 7410
Website	www.tigerbrands.co.za
Industrial Processes	Manufacturing

1.2 Plant profile

The Tiger Brands Mobeni plant manufacture candies and chocolates. The company has 3 coal-fired boilers which are operated and maintained by AES. Tiger brands buy steam from AES, which operate two boilers at a time and the third one is used as a backup boiler. The company used **5 450** tons of coal to produce **40 874** tons of steam.

Table 2: Consumption patterns prior to Assessment

Utility	Units	Rate	Annual Quantities	Annual Cost
Coal	Ton	R1000	5 450	R5 450 000
Water	Kl	R22.19	42 918	R952 344
Steam	Ton	R255.57	40 874	R9 816 474

The company spent **R9.8** million to generate **4 0874** tons of steam, and produced **21.989** tons of candies from July 2016 to July 2017 excluding September 2016.

1.3 Nature of the challenges

The steam scoping exercise that was carried out in the initial assessment, showed a total score of 55.9%, and some elements that received a low score were the following:

1. **Boiler heat recovery** – Installation of economisers on all three boilers and automatic control for C1 boiler.
2. **Insulation** – mainly on the distribution lines and condensate return lines
3. **Steam leak severity** – distribution lines and valves at the point of use.
4. **Condensate recovery** – reduction of direct injection systems that lose condensate.

The steam distribution system was old, and the steam leaks were too much leading to increased artificial demand for steam. The insulation of the main steam pipe was poor leading to temperature losses within the distribution system.

The objective of the IEE case study is to check, evaluate and quantify IEE interventions that a company has implemented. The analysis evaluates the expected savings versus the actual savings. The difference between expected and actual will be evaluated and possible solutions recommended.

2. KEY ACHIEVEMENTS

Table 3 :Key findings table

Implementation Period	February 2016 to May 2016
Total Number of project	3
Monetary savings in ZAR 2016	0
Monetary savings in ZAR 2017	2 380 000(2380 x R1000)
Energy savings in GJ 2016	0
Energy savings in GJ 2017	53 567
Total investment made ZAR	R1 670 000
Overall % of total consumption saved	38.8%
Total Savings from no cost interventions	0
Payback time period in years	1.4
GHG Emission Reduction (tonCO2)¹ 2016	0
GHG Emission Reduction (tonCO2) 2017	5067.44 (53567 *0.0946tCO2/GJ)

The plant installed a new boiler to replace boiler C3 that was having a glow on its shell, installed automatic control on boiler C1, replaced the old steam line with numerous steam leaks with a new line and increased condensate recovery by installing 2 condensate tanks.

Boiler C1 efficiency has increased from **45%** to **83%** and boiler C3 efficiency has increased from **79%** to **84%**. The resulted coal savings is **2 380** tons.

The old distribution pipe system which was leaking was replaced with a new piping system, and this has resulted in the decrease of the steam cost required per kg of product produced from **R0.51/kg** to **R0.46/kg**.

Increasing condensate tanks to recover condensate should result in the decreased fresh water supply to boiler feedwater, but the fresh water supply to boiler feedwater did not change.

***Note: calorific value of coal is 22.507143 GJ per ton**

Therefore 2380 x 22.507143 = 53 567 GJ energy saved.

3. IMPLEMENTATION OF ENERGY EFFICIENCY INITIATIVE

3.1 Installation of new boiler to replace boiler C3

Tiger brands Candies and chocolates installed a new boiler to replace boiler C3. The new boiler cost R800 000, this resulted in improved boiler efficiency, reduced carbon monoxide production.

The initial boiler efficiency was 79.1% with oxygen levels ranging from 14.6% to 15%, flue gas temperatures ranging from 190°C to 198°C as shown in table below

Table 4: measured boiler efficiency on 25 February 2016.

C3 Boiler flue gas and efficiency measurements						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Oxygen	14,6	14,6	14,6	14,6	15	14,68
Carbon monoxide	2233	2233	2233	2233	2233	2233
Carbon dioxide	5,3	5,5	5,5	5	4,5	5,16
Efficiency	79,1	79,1	79,1	79,1	79,1	79,1
Flue gas temperature gain	156	158	160	158	155	157,4
Flue gas temperature	198	190	195	190	194	193,4

The measured boiler efficiency after the installation of the new boiler is as shown in figure 1 below.



Figure 1: Current boiler efficiency as of 23 November 2017

The boiler efficiency has increased from **79.1%** to **84.6%**, flue gas temperature has decreased from **193.4°C** to **184°C** and the excess oxygen has decreased from **14.68%** to **11.8%**.

3.2 Installation of automatic control on Boiler C1

The company installed an automatic control on boiler C1. The automatic control cost **R200 000**, this resulted in improved boiler efficiency, reduced carbon monoxide production.

The initial boiler efficiency was **45.4%** with oxygen levels ranging from **18.4%** to **19.3%**, flue gas temperatures ranging from **205°C** to **207°C** as shown in table below

Table 5: Measured boiler efficiency on 25 February 2016

C1 Boiler flue gas and efficiency measurements						
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Oxygen	18,9	19,3	18,9	18,5	18,4	18,8
Carbon monoxide	23	29	27	25	26	26
Carbon dioxide	2,3	1,3	1,8	2,1	2,2	1,94
Efficiency	50,5	35	40,3	51,5	49,5	45,36
Flue gas temperature gain	175	171	165	163	162	167,2
Flue gas temperature	207	206	205	205	205	205,6

The measured boiler efficiency after the installation of the new boiler is as shown in figure 1 below.

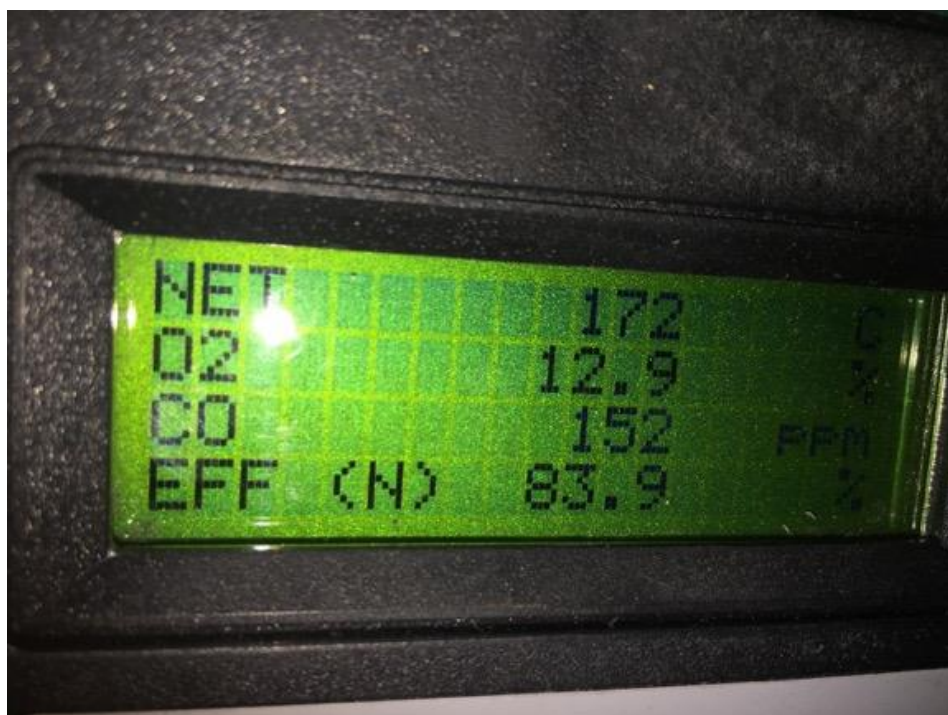


Figure 2: Current boiler efficiency as of 23 November 2017

The boiler efficiency has increased from **45.4%** to **83.9%**, flue gas temperature has decreased from **205.6°C** to **172°C** and the excess oxygen has decreased from **18.8%** to **12.9%**.

The overall improvement in steam generation process can be modelled using the regression model. The efficiency improvement results in reduced coal required to generate a ton of steam, a regression model of coal consumption (tons) and the steam produced (tons) are used to quantify the cost savings from the improved efficiency of the boilers.

Tiger Brands MobeNi weighs received coal from suppliers, and does not measure coal consumption by a single boiler. The plant installed a single steam meter, the installed meter measures the combined steam supply from the three boilers.

3.3 Regression Analysis

The Regression model is used to check the energy performance before and after the energy savings interventions were done.

Figure 3 below shows a time series of coal consumption tons versus steam production in tons. From this trend, there seem to be a relationship between coal consumption and steam production.

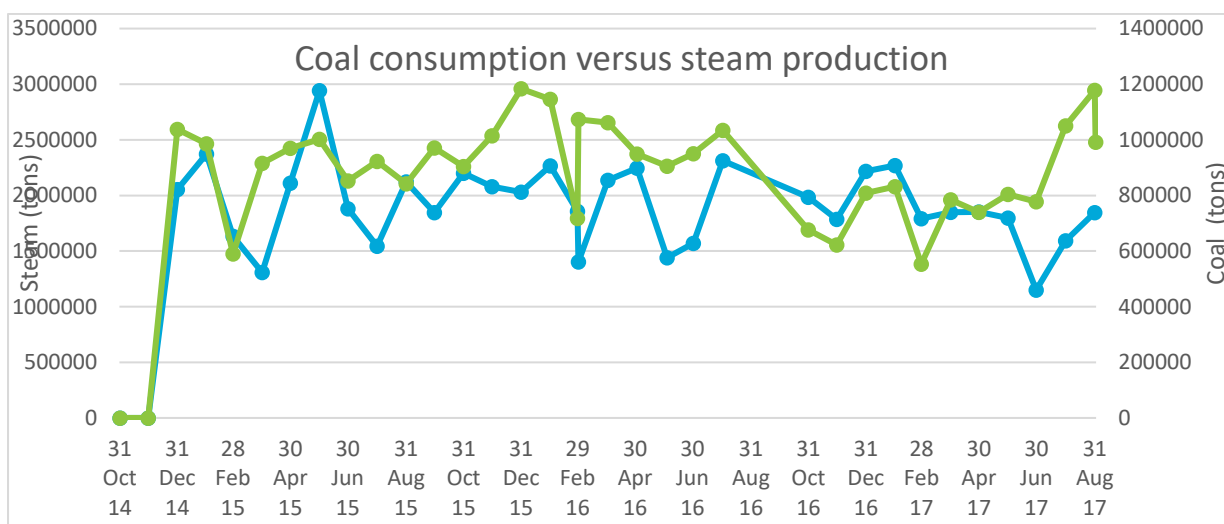


Figure 3: Coal consumption trend vs steam production

Figure 3 shows a regression model of coal consumption versus Steam production (tons). This graph shows a very strong correlation with a coefficient of determination being very high at **99%**. The model equation can, therefore, be used to measure current performance against previous performance before energy savings interventions were implemented.

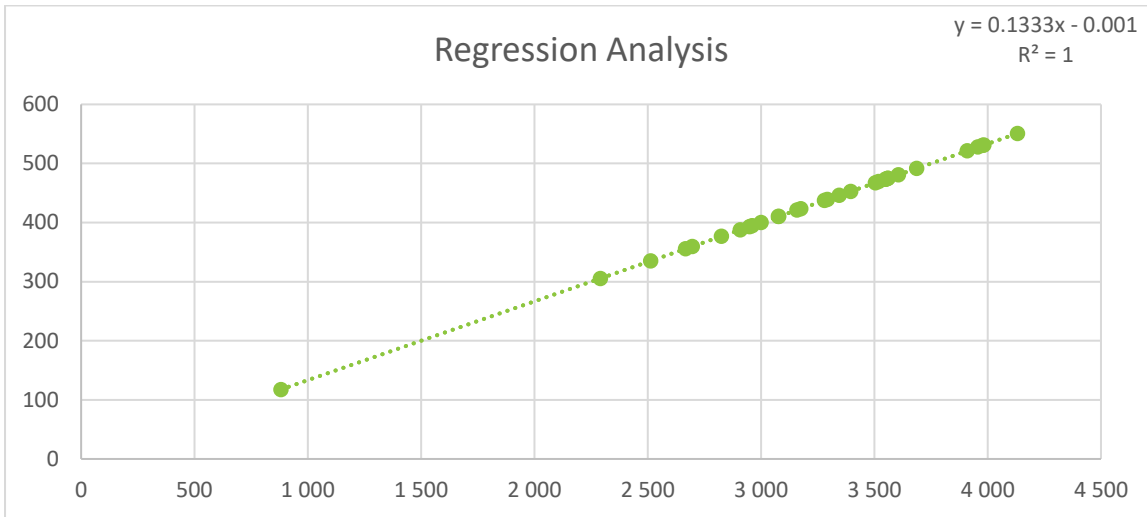


Figure 4: Regression model coal consumption vs steam production

Table 4 below is the performance-monitoring chart from the regression model derived above. The table shows the tabulated results of the model and the performance against the model (Baseline). The following observations can be made from this chart:

1. The **coal consumption** from May 2016 has been generally **lower than the expected coal consumption** as defined by the model (i.e. the baseline).
2. The cumulative coal consumption below the expected coal consumption is currently sitting at **2380 tons**. In cost terms, it means that the company has saved **R2 380 000**.

Table 4: Performance monitoring table

Month	Actual Coal (tons)	Expected Coal (tons)	Energy Intensity	CUSUM
May-16	3000	3 354	0,89	-354
Jun-16	3396	3 397	1,00	-355
Jul-16	3550	3 210	1,11	-15
Aug-16	3077	3 182	0,97	-121
Sep-16	3978	3 280	1,21	578
Oct-16	3957	3 292	1,20	1 243
Nov-16	2697	3 146	0,86	794
Dec-16	3686	3 267	1,13	1 213
Jan-17	3504	3 243	1,08	1 473
Feb-17	3159	3 277	0,96	1 355
Mar-17	2513	3 263	0,77	605
Apr-17	3550	3 406	1,04	749
May-17	3910	3 473	1,13	1 186
Jun-17	3293	3 376	0,98	1 103
Jul-17	881	3 002	0,29	- 018
Aug-17	1783	3 145	0,57	- 2 380

The table above shows that the savings were only attained in 2017.

3.4 Replacement of the old steam distribution system with new piping system

The old steam piping was corroded and leaking steam. The replacement of old steam pipe resulted in the elimination of steam leaks and improved steam distribution from the point of generation to the point of use. The initial steam leak audit results are shown in the table below.

Table 6: Leak Audit Report

No.	Location	System Pressure	Steam Trap Model	Pipe Size	Orifice Size	Inlet Temp	Outlet Temp	t/Hour	dB	Cost
1	Candy distribution line	9		12	1	180	180	0.001	30	R 1,948.80
2	steam valve next to cookers in candy line	8		20	1	180	180	0.02	46	R 38,976.00
3	steam valve next to mellow cookers	8		20	1	180	180	0.02	40	R 38,976.00
4	steam trap leaking in candydistribution line	8		20	1	180	140	0.025	60	R 48,720.00
5	joint in candy line	8		20	1	180	180	0.03	80	R 58,464.00
6	Mainline steam pipe leaking in NID 4	9		20	1	177	177	0.01	30	R 19,488.00
7	Steam pipe leaking in candy section	9		20	1	170	170	0.001	20	R 1,948.80
8	Valve leak on distribution manifold	8		20	1	170	170	0.001	20	R 1,948.80
Total										R 245,548.80

The cost of steam leaks was **R245 549**/year and a total of **961** tons/year of steam was lost through steam leaks.

There was no correlation found between steam production and production output, therefore, comparing the average cost of steam per kg of product produced before and after the interventions were used to measure the energy savings. The average cost of steam per kg of the finished product has decreased from an average of **R0.51/kg** to **R0.46/kg**. The table below shows the cost savings.

Table 7: Steam cost and production output

Month	Steam Purchased in Tons	Monthly Steam cost in Rands	Monthly tonnage produced in Kg's	Rands per Kg	Coal Usage in Ton/Month
31-Jan-15	2 961	915 216	1 307 525	0,70	395
28-Feb-15	3 175	969 654	2 111 405	0,46	423
31-Mar-15	3 280	1 002 538	2 941 794	0,34	437
30-Apr-15	2 667	852 039	1 880 782	0,45	356
31-May-15	2 949	922 630	1 545 000	0,60	393
30-Jun-15	2 825	841 625	2 122 000	0,40	377
31-Jul-15	3 345	971 063	1 845 000	0,53	446
31-Aug-15	3 078	904 714	2 199 000	0,41	410
30-Sep-15	3 519	1 014 401	2 080 000	0,49	469
31-Oct-15	4 131	1 183 445	2 030 000	0,58	551

30-Nov-15	3 984	1 146 439	2 267 000	0,51	531
31-Dec-15	2 291	717 558	1 857 000	0,39	305
31-Jan-16	3 607	1 073 877	1 404 000	0,76	481
29-Feb-16	3 560	1 061 730	2 138 000	0,50	475
01-Mar-16	3 560	949 023	2 245 000	0,42	475
01-Apr-16	2 908	904 937	1 439 000	0,63	388
Average	3240	964430,56	1 963 282	0,51	432,00
Measurements period after the interventions					
02-May-16	3 000	950 000	1 571 000	0,60	400
03-Jun-16	3 396	1 033 717	2 312 000	0,45	453
01-Jul-16	3 550	676 000	1 984 000	0,34	473
01-Aug-16	3 077	622 615	1 786 000	0,35	410
31-Oct-16	3 978	808 491	2 218 000	0,36	530
30-Nov-16	3 957	831 648	2 270 000	0,37	528
31-Dec-16	2 697	553 164	1 792 000	0,31	360
Averages	3 379	782 234	1 990 428	0.40	450.57
31-Jan-17	3 686	784 268	1 850 000	0,42	491
28-Feb-17	3 504	739 212	1 852 000	0,40	467
31-Mar-17	3 159	803 859	1 796 000	0,45	421
30-Apr-17	2 513	777 116	1 150 000	0,68	335
31-May-17	3 550	1 050 022	1 593 000	0,66	473
30-Jun-17	3 910	1 177 943	1 846 000	0,64	521
31-Jul-17	3 293	992 136	1 852 000	0,54	439
31-Aug-17	881	277 946	915 000	0,30	117
01-Sep-17	1 783	550 397	975 000	0,56	238
Average	3121	789283	1735125	0,46	408

The average amount of coal used per month from May 2016 to December 2016 has increased from 432t to 450t. The average amount of coal used per in 2017 from January 2017 to August 2017 has decreased from **432t** to **408t** a month in 2017. The overall average steam cost per kg of production has also decreased from **R0.51/kg** to **R0.46/kg**. Using the production output from May 2016 to September 2017 the company has saved **R1 388 100**.

Table 8: Steam distribution line replacement cost savings

	Production output kg	Initial production cost	Current production cost	Cost savings
Baseline	31 412 507	R16 020 378		
Measurement kgs	27 762 000	R14 158 620	R12 770 520	R1 388 100
Average cost saving per month				R86 756

4. IMPLEMENTATION CHALLENGES

The boiler needs to be shut down for the installation of the new steam distribution line. The number of days required for the installation and testing of the distribution line was 4days, therefore only possible during the annual plant shut down.

5. HIGHLIGHTS OF OPERATIONAL/ESO INTERVENTIONS

5.1 Summary of all interventions

Energy uses/users	Energy Sources	Intervention	Utility saving Period (months)	Investment (ZAR)	Savings (ZAR)	Payback (Yrs)	Utility saving (Units) GJ	GHG Emission Reduction (tonnes CO ₂ /year)
Steam generation	Coal	Boiler automatic control	May – Dec 2016	R200 000	2 380 000	0.7	53 567	5 067.4
			Jan – Aug 2017	-				
Steam generation	Coal	New boiler	Jan - Aug 2017	-				
			May – Dec 2016	R800 000				
Steam distribution	coal	Steam distribution pipe	May – Dec 2016	R670 000				
			Jan-Aug 2017	-				
TOTAL				R1 670 000	2 380 000	0.7	53567	5 067.4

6. BENEFITS AND LESSONS LEARNED

6.1 Benefits

The company has managed to save **53 567Gj** of energy to a cost saving of **R2 38 000** in **16** months. The reduction in greenhouse gas emissions is **5 067.4t** of CO_{2e}

6.2 Lessons

- Investing in energy efficiency have a significant effect in lowering energy cost.
- Contractors need to be monitored, for them to manage their processes efficiently

7. FUTURE PLANS

The plant intends to increase its condensate recovery from **50%** to **80%**. This can be achieved by using hot water for cleaning instead of using steam and channeling all condensate pipes back to the boiler.