Energy Efficiency Audit Report

For

LIEBHERR

Container Cranes Ltd., Killarney, Ireland

IPPC License No. P0146-02

and

In compliance with the

European Union's Energy Efficiency Directive, 2012/27/EU and Irish Statutory Instrument S.I. No. 426 of 2014

Prepared by

Energy-Wise, Coonagh, Limerick

July, 2018

Executive Summary

Liebherr Container Cranes Ltd., Killarney (LCC) could achieve savings of 17%, in its electrical energy usage, 16% in its gas-oil/ yard diesel usage and 11% in its thermal energy usage (LPG & fuel-oil), over the next year; by implementing an Energy Management System (EnMS) and by carrying out the opportunities identified in Table 5 of this report. The scale of the cost-savings will increase with more senior management commitment, which would lead to an upsurge in the intensity of effort given to the EnMS. Imported electricity, gasoil, fuel-oil and LPG are the primary energies utilised at LCC. Table one outlines a summary of the consumption during 2017. If LCC's management team set targets for reducing its electrical energy by 17%, its gasoil/ yard diesel by 16% and its thermal energy usage by 11%, the result would yield savings of €241,375 and would reduce its CO_2 emissions by almost 1,200 tonnes. The overall usage, spend and CO_2 emissions associated with LCC's energy usage during 2017 is outlined in table 1 below.

Table 1: Summary of Energy Usage during 2017

Fuel	2017		
	Quantity [kWh]	Spend	CO2 Emissions [tonnes]
Electricity	11,171,202	€1,084,567	5,393.5
LPG	6,191,718	€304,880	1,419.8
Fuel Oil	1,977,980	€93,941	541.2
Gas Oil	1,219,939	€62,846	321.9
Total	20,560,839	€1,546,234	7,676.3

The management team should continue to measure its electrical and thermal energy performance using key performance indicators; such as kWhs per Cranes & Straddle Carriers per annum, kWhs per day and kWhs per man hour. These are termed Energy Performance Indicators, or EnPIs, and could be used to set targets for enhanced energy performance improvement plans. In a similar fashion, quality and revenue related EnPIs could be utilised such as kWhs (total) per tonne of steel fabricated, kWhs per machined part (e.g. kWh/drum) and kWhs (total) per € revenue per quarter/annum. It is also worthwhile having a managerial level, carbon emissions related, EnPI such as Tonnes of CO_2 per € revenue/quarter. EnPIs are essential for an effective energy management system (EnMS). Liebherr is also encouraged to use operational level EnPIs such as; the Coefficient of Performance (COP)) of its significant energy users (SEUs), such as its compressed air system (CAS). It could do this by measuring, monitoring and reporting m^3 (air) per kWh (e) i.e. air flow per unit of electricity and do this for each compressor.

LCC, Killarney can achieve the targets by implementing some or all of the opportunities identified in Table 5 of this report. There are 17 energy savings opportunities identified which are presented on this table. There are a number of no/low cost opportunities identified that relate directly to the management systems elements such as introducing a formal energy policy; signed by top management, introducing an energy awareness campaign and monitoring and targeting energy use. Another low-cost opportunity relates to the introduction of an energy efficiency clause to its purchasing procedures, so that life cycle costs are always considered prior to making a purchasing decision. That will include the incorporation of an energy efficiency design element to all new capital and renovation upgrade projects.

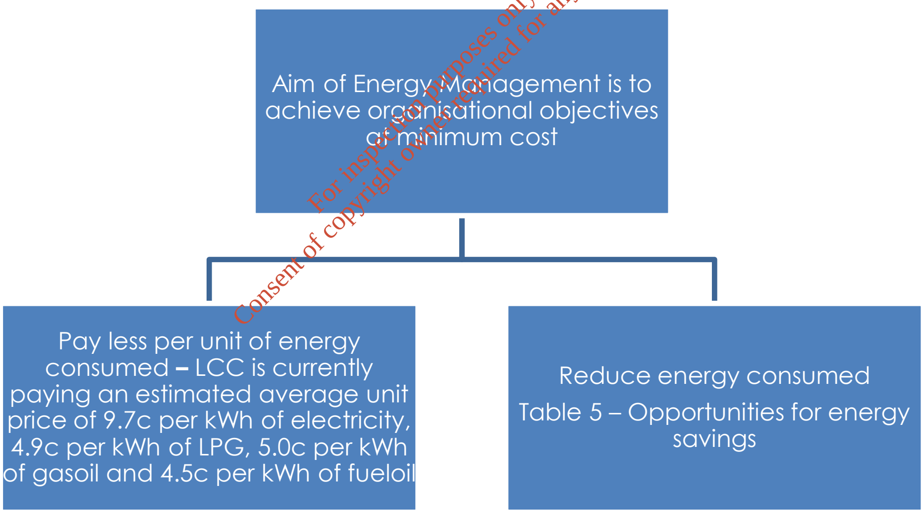
A number of medium cost opportunities are also documented, such as: monitoring the COP of the CAS; and using the COP results to trigger compressed air leak surveys, continuing with the lighting relamping project and adding light sensors (such as PIRs, as appropriate), and introducing Eco Driver training for vehicular operators. Furthermore, motor condition reporting, for all utilities, should be carried out and the results used to develop a motor replacement programme. A life cycle analysis of replacement motors should be considered.

There are also a few high cost opportunities identified as follows: to continue carrying out deep energy retrofits of the production halls and to carry out a detailed feasibility report into installing a comprehensive photovoltaic, roof mounted electrical generation system. The PV System would greatly reduce LCC's carbon footprint and help it to control the average unit price per kWh (e) over the next 25-years.

The table of opportunities is intended to be a dynamic document and the LCC Management Team is encouraged to use a table, such as Table 5, to continuously improve its energy performance. This table aims to build on the opportunities identified on LCC's 2014 Energy Efficiency Programme Plan.

LCC would benefit from implementing a formal EnMS such as ISO50001. Energy Management is a systematic approach to managing energy usage. Its aim is to achieve organisational objectives at a minimum cost, resulting in reduced energy consumption and paying less per unit of energy consumed (see figure 1). This systematic approach enables the organisation to continuously improve its energy performance, which strengthens its ability to grow and succeed into the future.

Figure 1: Aim of an Energy Management System



Andreas Weiss: ____________________ **Date:** _______________

LCC Energy Manager

Energy Auditor John Harrington  **July, 2018**

Energy Auditor # EA10025

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1 Introduction

1.1 Site Visit

Organisation Name:	Liebherr Container Cranes Ltd. (LCC)
Site Name & Address:	Liebherr, Gortroe, Killarney, County Kerry, Ireland.
Dates of Visit:	30th May, 2018
Energy Auditor:	John Harrington 087 2841237 info@energywise.ie www.energywise.ie SEAI Registered Energy Auditor # EA10025
Visit Hosted By:	Andreas Weiss

John Harrington undertook an energy audit, in compliance with the requirements of S.I. 426 of 2014, for LCC, Killarney on 30th May 2018. LCC's main objectives are to comply with the legislation, to reduce electricity, thermal and transport related energy consumption and to improve its overall energy performance. LCC, Killarney has an annual turnover of greater than €50 Million.

This energy audit report has been prepared with all reasonable skill, care and diligence and summarises the findings from the site visit and supporting supplementary data. All values quoted in this report are based on information provided by the client. All values quoted for energy savings are estimates and may require additional detailed investigation to confirm their validity.

The audit was carried out during a normal working day and weather conditions were normal for the May/ June period. The energy data used in this report comprises of all energy used on site for the calendar year 2017. The detailed analysis of electricity consumption was carried out based on ¼'ly hour interval data from 1st January 2017 to 31st December, 2017.

1.2 Description of Site

LCC was founded in 1958 by Dr. Hans Liebherr and was the first Liebherr company to be set up outside of Germany. Cranes manufactured by LCC are exported via Fenit Port. It is a global leader in the design, development and production of Ship to Shore and Rubber Tyred Gantry Cranes.

LCC has 10 distinct operations on site. Its HR/ Admin/ Sales Office and Design & Development Offices are located in the original office buildings. The Works/ Production/ I.T. Office is located in the area adjacent to Hall No. 3. Cutting & preparation and steel construction (portals & lattice structures) is located in Hall No.1. Welding and cleaning operations are located in Hall No's 2, 3, 4. Machining takes place in Hall No's 5 & 9 and Shot-blasting and surface painting operations take place in Hall No's 6 & 7. Sub assembly, machining and quality operations are located in Hall No. 9 and Final Assembly take place in Hall No. 8.

There are approximately 750 persons working at LCC's operations in Killarney. The site comprises 9 large production halls with associated offices, workshops and stores areas.

Operations take place on a 24 hour, 5-day shift pattern with 2 shifts on Saturday and 1 shift on Sunday. Production and energy consumption rates have increased in the period from 2010 to 2017. Electricity consumption increased from approx. 8 million kWh in 2012 to over 11 million kWh in 2017.

The factory was opened in the 1960's. The older buildings are being improved gradually, from an energy efficiency point of view. New buildings have improved fabric that reduces their heat loss and allows a greater control of air circulation and air movement within the production halls. All of the production halls require artificial lighting due to their floor area and height. LCC Killarney is in the process of upgrading all of its lighting systems and traditional high bay metal halide and SON/E lighting is being replaced by LED equivalents.

1.3 Client's Objectives

LCC's main objectives are to comply with the legislation, reduce electricity, thermal and transport related energy consumption and to improve the overall energy performance of the site.

2 Energy Management

Although LCC does not have a formal energy management system (EnMS) in place, it does have an energy monitoring building management system and a lot of experience in implementing energy performance improvement projects and a sensitivity to energy price fluctuations. Liebherr Group Germany (MCCtec) operates a certified energy management system that complies with the requirements of ISO50001: 2011.

An Energy Management Diagnostic Questionnaire was completed and LCC scored 50% overall on this diagnostic. Figure 2 shows the breakdown of the score between the five pillars of energy management. Additionally, an energy management assessment using the Environmental Protection Agencies Tool was carried out and copy of that is outlined on Appendix C. LCC's level of attainment, under each category (Energy Policy, Organising, Motivation, Information Systems, Marketing and Investment), is highlighted in yellow.

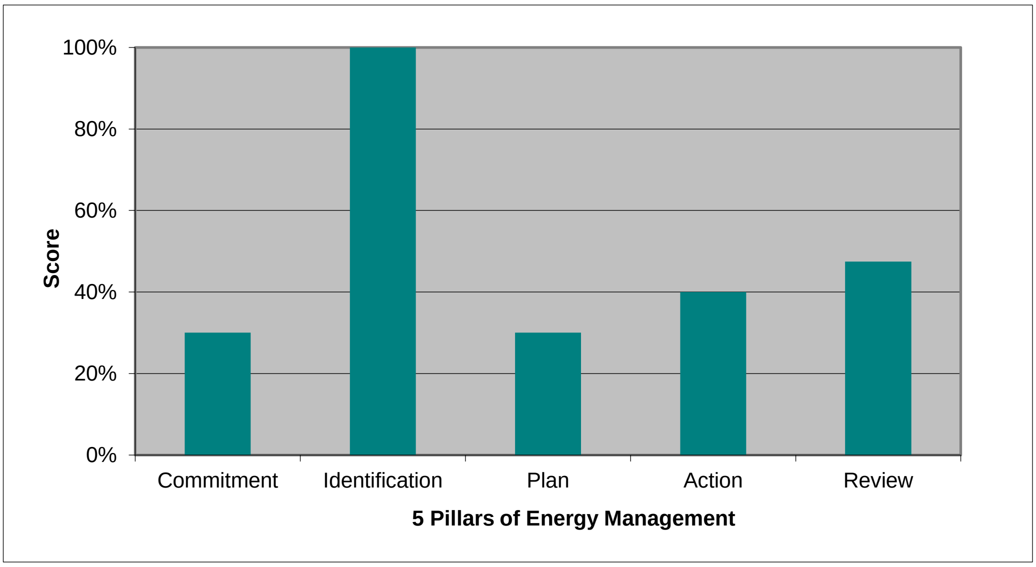


Figure 2: Breakdown of Energy Management Diagnostic Score

The key barriers to developing, implementing and maintaining a full and effective energy management system at LCC are the following factors; committed, site specific energy policy does not exist that would offer the energy manager the support to develop and implement a more effective EnMS. There are no energy performance targets set by the senior management team that would hold people/ personnel accountable (i.e. managers, supervisors and workers). Furthermore, there is no link between energy, production and quality – these three aspects could together become integrated into the production planning and monitoring processes.

The commitment and identification aspects can be improved by having top management sign and approve an energy policy; such as the one outlined in Appendix A. The energy manager would then have the authority to implement the energy policy, developing an energy management structure and routine, as outlined in this report. Planning and taking action aspects can be improved by using the table of opportunities (Table 5) as the basis for LCC's energy action plan. The review aspect would be improved by monitoring and reviewing energy performance indicators (EnPIs) regularly and incorporating the energy management system into existing production and operations management systems. Ideally, EnPIs should be reviewed periodically, during production meetings, and at least once a quarter by top management. Additionally, a formal annual management review meeting would need to take place and that would have the effect of reviewing progress being made and gaining approval for any resources required for the coming period in order to achieve the targets and objectives set. Resources could be human, financial, specialised skills and technology. These actions will help LCC to improve on the all aspects of its EnMS.

3 Energy Consumption

3.1 Annual Consumption

LCC uses electrical, thermal and transport related energy to maintain its operations. The company's energy consumption for the past two years is set out in Table 2 and summarised in figures 3, 4 and 5.

- Energy usage in kWh equivalent is down by **2,264,672 kWh** which is equivalent to **9.9%.**
- However, the overall energy spend during 2017 is slightly higher; **by 1.13%**.

As the price per barrel of crude oil has increased significantly over the past 12 months, it is anticipated that the average unit prices, in all fuel categories, will increase; especially Electricity, Gas and Fuel Oils. See also Appendix D.

Table 2: Annual Energy Consumption & Energy Costs

Fuel	2017			2016			Additional Information – Average Unit Price (AUP)		
	Quantity [kWh]	Spend	CO_2 Emissions [t]	Quantity [kWh]	Spend	CO_2 Emissions [t]	2017	2016	% Increase
Electricity	11,171,202	€1,084,567	5,393.5	11,242,090	€1,074,951	5,427.7	9.71	9.56	+1.55%
LPG	6,191,718	€304,880	1,419.8	7,531,312	€286,997	1,726.9	4.92c	3.81c	+22.56%
Fuel Oil (HFO / MFO)	1,977,980	€93,941	541.2	2,598,794	€101,804	711.0	4.75c	3.92c	+17.47%
Gas Oil	1,219,939	€62,846	321.9	1,453,315	€65,061	383.5	5.15c	4.48c	+13.01%
Total	**20,560,839**	€1,546,234	7,676.3	**22,825,511**	€1,528,813	8,249.2	**Energy usage is down by 9.9%**		

Figure 3: 2017 Breakdown of Energy Consumption (kWh)

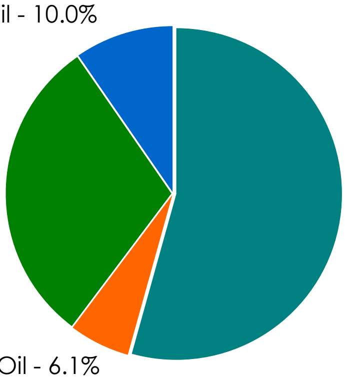
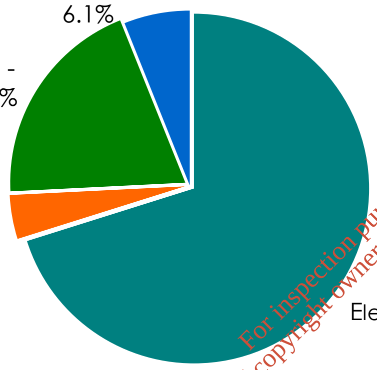
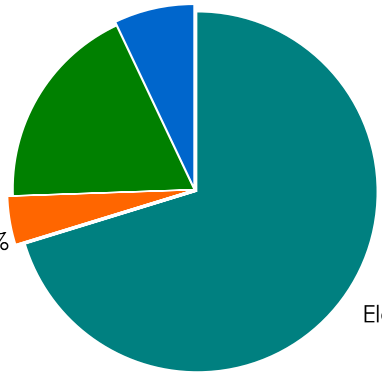


Figure 4: 2017 Breakdown of Energy Spend (€ Euros)



Fuel Type	%	Spend (€)
Electricity	70.1	€1,084,567
LPG	19.7	€304,880
Fuel Oil	6.1	€93,941
Gas Oil	4.1	€62,846

Figure 5: Tonnes of CO_2 emitted to the atmosphere as a result of LCC's energy usage during 2017



3.2 Main Energy Consumers

The main energy consumers are summarised in Tables 3 & 4 below. These tables are termed the significant energy users and are based on the data obtained from the in-house energy monitoring system and an exercise that has been previously carried out by Andreas and his team. Tables such as these can be used to prioritise opportunities as identified in Table 5.

Table 3: Summary of Primary Electrical Energy Consumers

Location	% of Total	Electrical Energy Consumers
Hall # 6	18.0	Shot Blasting (7 AW) (Compressors)
Hall # 1	16.8	Cutting & Preparation (7AC)
Hall # 3	16.3	Steel construction, welding & cleaning 1 (7 AG/ 7AX)
Hall # 7	12.0	Surface paint (7 AP)
Hall # 9	9.3	Sub-assembly (7 AS)
Hall # 2	8.5	Steel construction 2 (7 AF)
Office Blocks # A/B/C/D	8.2	Misc. HVAC, IT equipment, catering
Hall # 9	4.4	Machine shop / Quality (7 AM)
Hall # 8	2.4	Final-assembly (7 AA)
Hall # 5	1.7	Machining (7 AM)
Hall # 4	1.4	Steel construction, welding & cleaning (7 AF)
Hall # 6	1.0	Stores (UBD)

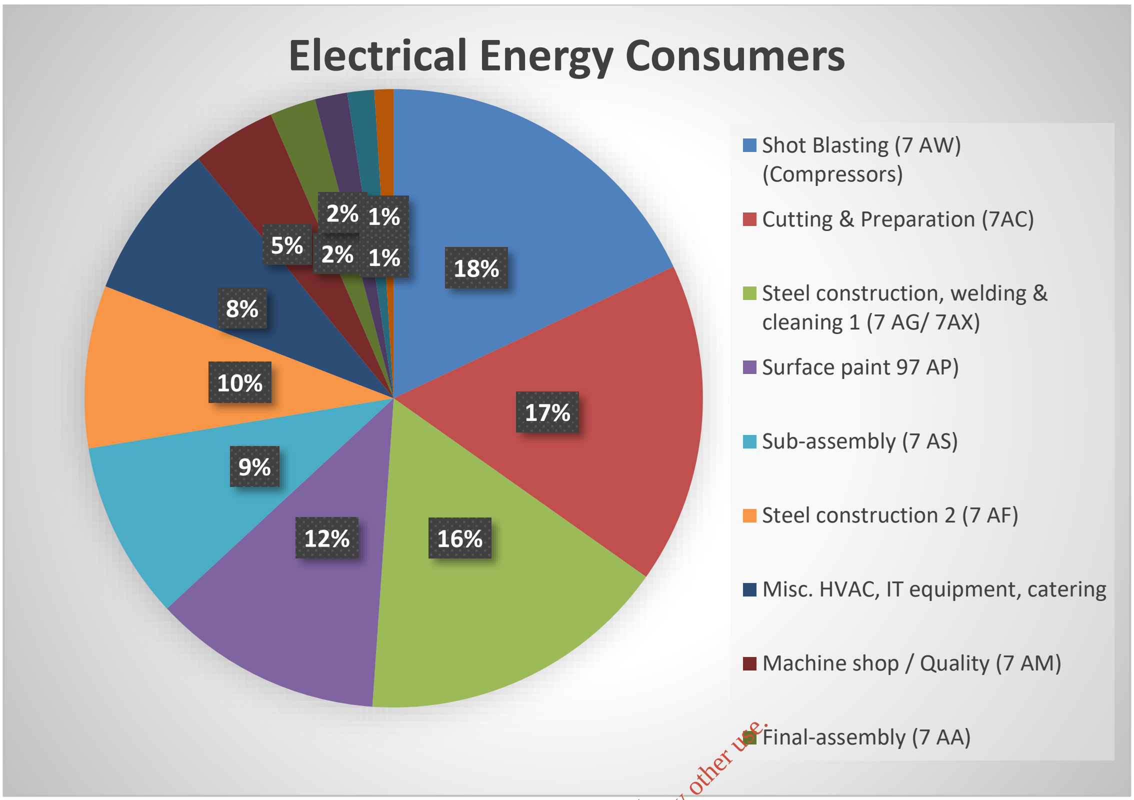


Figure 6: Significant electrical energy users; Electrical, Thermal and Yard Diesel

Table 4: Summary of Primary Thermal Energy Consumers

Thermal Energy User	% of Total	Comments
Space heating related to outside air temperature	80	Estimated using degree day analysis
Space heating not related to ambient- process related	10	Estimated using degree day analysis
Standing losses; boiler and heating distribution system losses	10	Insulation upgrade and maintenance work on the primary pipework

An energy flow diagram or Sankey is outlined in appendix F. It gives an overview of the amount of electrical energy (kWh) used in the various halls/office areas. Additionally, heating and yard diesel energy usage is outlined but not allocated to specific buildings.

3.3 Energy Performance Indicators (EnPIs)

Electrical and thermal energy related energy performance indicators (EnPIs) should be developed at LCC. The management team should use key energy performance metrics in conjunction with existing operational management performance indicators. EnPI data can be used as a springboard for enhanced energy efficiency. EnPIs are essential for an effective EnMS and are also used to set targets for improvement. The management team are encouraged to use EnPIs targets such as kWhs per € Revenue per quarter and kWhs per man hour per month. The latter could be split into electrical and thermal related energy performance and carried out in each distinct production area. Operational level EnPIs could also be used. Examples are kWh (th) per degree day per month, m3 of air per kWh (e) used by the compressor, and compressed air system.

An example of a graphical representation of energy usage per man hour per month is outlined in figure 7, below.

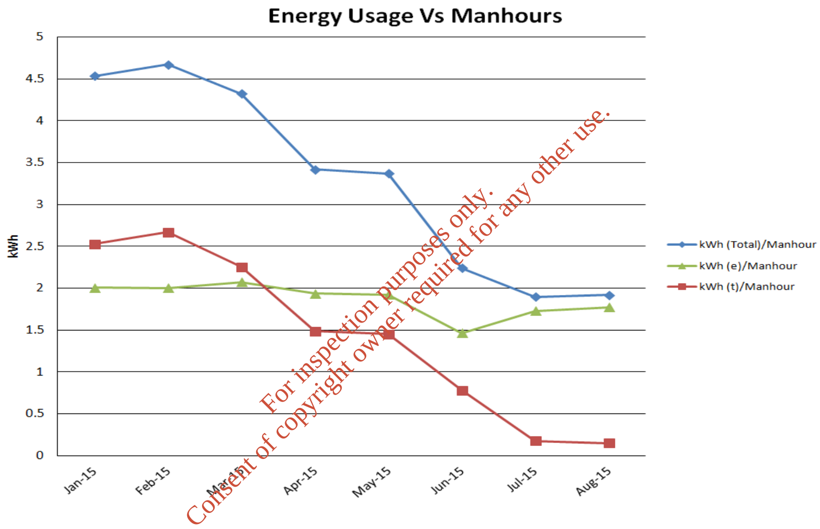


Figure 7: An example of kWh (e & t) per man hour per month

4 Opportunities for Energy Savings

4.1 Recent/Existing Energy Saving Initiatives

The energy manager and his team are doing great work in setting up and managing an energy management system at LCC. They have installed a comprehensive data collection and monitoring system and are using that system to develop projects in a systematic approach. A list of the significant energy users has been developed and employees are receiving training on energy awareness. Furthermore, since 2014 Andreas and his team have carried out other different initiatives for improving energy efficiency; as follows:

1. Lighting upgrade programme. Lighting systems upgrades – migration from fluorescent/son lamps to LED equivalents; installing LED lighting systems across each of the Production Halls. This has resulted in an annual energy saving of €42,000, 432 MWhs & 208,570 kilos of CO_2.
2. Upgraded the heating control systems; installed a limit switch in the gas heater controls in Hall # 8 and introduced an interlock system so that the heating turns

down/ off when the hall door(s) opens in Hall # 5. This has resulted in an annual energy saving of €60,000, 1,200 MWhs & 275,160 kilos of CO_2.

3. Carried out a review of the compressed air system (CAS); including operating pressures, controls and optimum operation of the auxiliary equipment such as the dryers. Downsized one compressor. This has resulted in an annual energy saving of €11,175, 115 MWhs & 55,300 kilos of CO_2.
4. Ongoing maintenance and upgrading of the cladding systems employed in the production halls. This includes windows, doors, curtain walling, wall and roof fabrics. This has resulted in an annual energy saving of at least €7,500, 150 MWhs & 34,395 kilos of CO_2.
5. Extended Hall #5 and installed a more energy efficient machining tool. This has resulted in an annual energy saving of at least €30,480, 622 MWhs & 142,640 kilos of CO_2.
6. Carried out an investigation into upgrading the welding process to reduce the use of welding gases and consumables.
7. Carried out a comprehensive energy audit during 2014.
8. Compressed air leak detection surveys and repairs, ongoing project.

Additionally, by taking an energy management system's approach to reducing energy costs and usage, LCC will continually improve its energy performance (and thus competitive advantage).

4.2 Suggested Opportunities for Energy Savings

The Energy Manager from Liebherr and John Harrington have identified a number of opportunities for further energy savings at the site; these are summarised in Table 5 overleaf. The values quoted for energy savings are reasonable estimates. A feasibility study, or studies, could be carried out to verify their accuracy, prior to carrying out these energy efficiency improvement projects.

Table 5: Opportunities for Energy Savings

Ref	Project Name	Project Description	Expected Annual Energy Saving kWh	Tonnes of CO2 emissions offset	Payback
1	Introduce an Energy Policy that demonstrates management's commitment to an EnMS	LCC Top Management should commit to developing and implementing a formal EnMS. Objectives and targets will be to continuously improve the site's energy performance and pay less per unit of energy and to reduce consumption. See also Appendix A.	557,486 (Combined)[1]	230	No/Low
2	Set up an energy team with representatives from production, quality, purchasing & maintenance depts.	Develop a top-level energy team and sub-teams that are charged with helping to implement the LCC Energy Policy. Always aim to link quality with energy efficiency. Poor product quality is always a poor, and inefficient, use of energy. See also Opp # 4.	411,217 (Combined)	154	No/Low

[1] All – Combined kWh savings (Electricity, LPG, Fuel-Oil, Yard Diesel)

Ref	Project Name	Project Description	Expected Annual Energy Saving kWh	Tonnes of CO2 emissions offset	Payback
3	Carry out regular energy awareness training.	Carry out regular energy awareness training. Introduce energy efficiency training for all operators; starting with those that operate significant energy using equipment such as gas welding and cutting equipment, shot blasting equipment, compressed air, lathes etc. Fit draught excluders to external doors and windows. Get employees to turn off HVAC systems and portable heaters when they are not required. Give training on time of use tariffs and peak electricity charge avoidance. For example, use charge material handling equipment outside of peak tariff times. Turn off water boilers, undersink water heaters and room heaters when they are not needed. See also Opp # 18.	205,608 (Combined)	77	No/Low
4	Use Energy Performance Indicators to support quality improvement plans	Production should be encouraged to report kWh(e) linked to yield (good quality products). Carry out an analysis of the cost of energy invested in each sub-component and each crane type. Use this to support energy awareness campaigns. Add submetering of the significant energy using production equipment. Feed this information back to the sales and cost accounting teams.	308,413 (Combined)	115	No/Low

Ref	Project Name	Project Description	Expected Annual Energy Saving kWh	Tonnes of CO2 emissions offset	Payback
5	Compressed Air System (CAS) monitoring	Consider monitoring the coefficient of performance (COP) of each compressor. COP = m3 Air flow/ kWh (e). This is considered best practice. Regularly check for any deviations in the CAS COP. COP monitoring can be established by measuring the m3 of air flow and measuring the kWh (e) used by the compressor (this may be recorded on the compressor's plc). Consider integrating this into the existing energy monitoring system.	128,163 kWh (e)	62	Medium
6	Compressed Air System (CAS) - Regular air leak detection	It is recommended that air leak surveys be carried out at least once every three months. CAS Leak surveys will also identify, and highlight any dead legs, condensate drains and oil/water accumulators that need to be drained.	384,480 kWh (e)	186	Medium
7	Lighting ~ Relamp Programme; see also section 5 Lux Level Guidelines	Continue on with the production floor area relamp programme. This is a very good project because it produces energy savings and other additional benefits such as improved lux levels, leading to better productivity, reduced maintenance and risk (associated with working at heights).	241,003 kWh (e)	116	Medium

Ref	Project Name	Project Description	Expected Annual Energy Saving kWh	Tonnes of CO2 emissions offset	Payback
8	Lighting ~ Relamp Programme	Add Passive Infrared Sensors (PIRs) to areas that have intermittent human activity.	80,503 kWh (e)	39	Medium
9	Replace existing oil heating systems	Replace oil heating systems with more energy efficient and less expensive LPG, condensing boiler technologies	400,000 kWh (Fuel Oil)	109	Medium
10	Continue with the Production Hall renovation upgrades	Improve the building fabric - walls, roofs, doors, glazing, windows etc. Andreas has started to gather information about upgrading Hall # 9. See also Opp # 14. Additionally, when upgrading large doors, consider incorporating a 'wicket' door to facilitate ease of movement and greater control of ambient conditions.	DTE[2]	DTE	High

[2] Difficult to Estimate

Ref	Project Name	Project Description	Expected Annual Energy Saving kWh	Tonnes of CO2 emissions offset	Payback
11	Process gas usage - LEAN Study	Carry out a LEAN study into reducing the process gas wasted during welding and cutting operations.	DTE	DTE	No/Low
12	Motor condition reporting	It is good practice to inspect and carry out condition reports on all large motors. If needs be, consider introducing a motor replacement Programme. Replace motors with EFF1 motors. Consider installing V-Notch belts with appropriate pulleys on drive systems, as appropriate. Consider having redundancy on process critical motor such as extract systems.	DTE	DTE	Medium
13	Renewables ~ Consider installing a Photo Voltaic Generator on site.	Consider a PV renewable energy opportunity - Add a 'Solar Farm' to the roofs of the factory. Note the South facing angled roof members could be adapted to carry a substantial photovoltaic generation system. Hall #9 roof has approximately 10,600 m.2. of potential space for PV panels. Engage with an expert to carry out an independent feasibility study. See also Appendix B.	874,660 kWh Electricity	239	High

Ref	Project Name	Project Description	Expected Annual Energy Saving kWh	Tonnes of CO2 emissions offset	Payback
14	Purchasing	Always incorporated energy efficiency and lift cycle assessments in the purchase of new plant, equipment and when designing new or renovated buildings. Spaces. Use the Triple E Register - www.seai.ie/energy-ratings/triple-e-register	514,021 (Combined)	192	No/low
15	Continue to link heating energy usage with Degree Days	Continue to monitor and report the correlation between heating energy usage and heating degree days. Share the graphs across all departments. Carry this out on a weekly basis during the heating system. See also Opp # 17.	40,850 kWh (LPG & Fuel Oil)	10	No/Low
16	Monitoring energy usage and targeting improvement opportunities	Accurate and up to date energy efficiency and usage reports will help improve LCC's performance. It will also complement energy efficient projects, actions and energy awareness programmes.	Included in Opp # 4	As over	No/Low
17	Transport Training	Carry out Eco Driver training for yard vehicle operators. This will include movement planning, operating, maintaining and monitoring gasoil usage.	73,196 kWh (Gasoil)	19	Medium

Total savings per annum €241,375 with an investment cost of approximately €320,000

(Excludes costs and savings associated with the Photovoltaic (PV) opportunity #13)

5 Additional Information: Lux level Guidelines

Lux level guidelines

Type of Use	Lux (measured in lumens)
Close Detailed Work	1000-2000
Offices	400
Workshops	300
Stairs & Corridors	200
Rest Rooms	100
Security Lighting	5

Source: Chartered Institute of Building Services Engineers' Guide F, 2012

Appendix A: Energy policy that could be adapted by LCC

Liebherr Container Cranes Ltd. is committed to responsible energy management and we practice energy efficiency throughout our enterprise. Our organisation uses reliable sources of energy and water to sustain our activities, and we will procure and manage these supplies and their use in the most cost effect manner.

Scope

LCC's Energy Management Policy aims to:

- avoid unnecessary energy costs,
- monitor overall electricity, gas-oil, fuel-oil and LPG usage on a regular basis,
- monitor electricity usage of the significant energy using equipment,
- report energy performance indicators (EnPIs) at monthly, quarterly and annual management review meetings,
- improve the energy and cost effectiveness of providing a working environment with favourable ambient conditions,
- comply with current energy & environmental legislation, protect the environment by minimising CO_2 emissions, and prolong the life expectancy of fossil fuel reserves.

Method

Furthermore, LCC will achieve our objectives by:

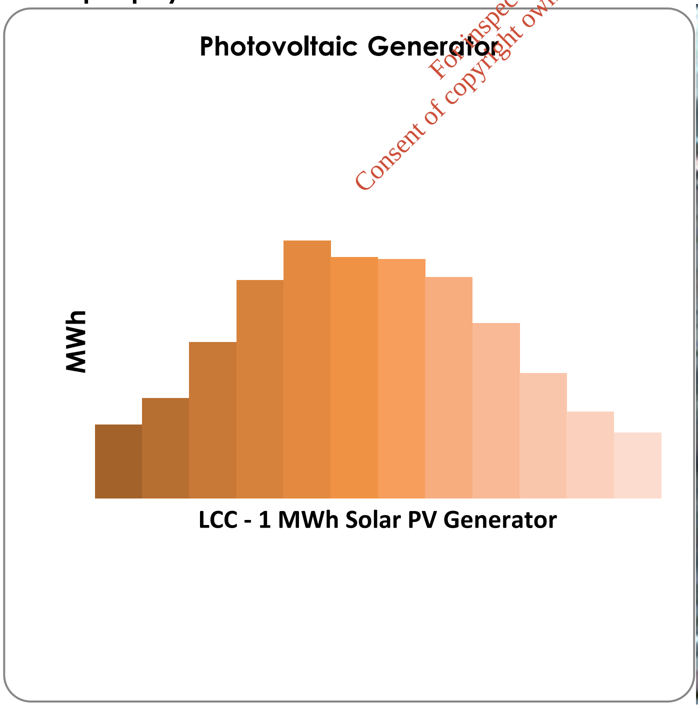
- buying energy economically without compromising security of supply,
- utilising energy in the most cost effective and sustainable manner,
- reducing pollution levels caused by our energy use,
- reducing, wherever cost effective, our dependence on fossil fuels, through the use of best available design and practice,
- controlling process gas usage by manufacturing it right; first time, every time,
- controlling time and temperature of paint shop drying processes,
- controlling heating and cooling in each area, consistent with production and usage patterns,
- advising staff on the objectives of this energy policy,
- increasing awareness of energy issues among suppliers and sub-contractors and encouraging energy responsible attitudes.

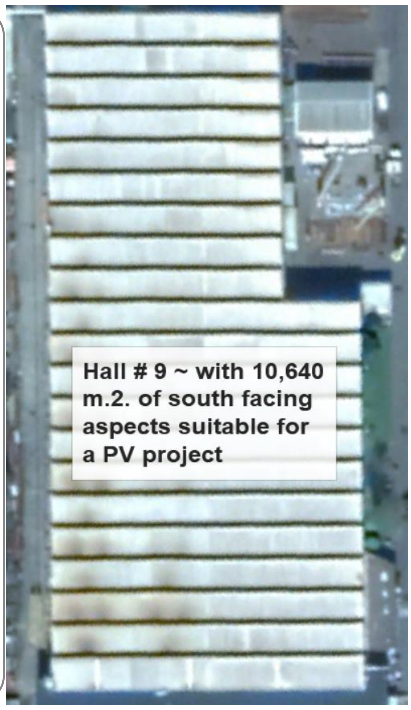
Signed: ____

LCC General Manager

Appendix B: Solar Photovoltaic Pre-feasibility study

Month	Generation Capacity (MWh)	Daily solar radiation - horizontal	Daily solar radiation - tilted
January	32.93	0.76	1.22
February	44.76	1.37	1.84
March	69.76	2.32	2.62
April	97.40	3.76	3.81
May	114.82	4.73	4.39
June	107.66	4.82	4.28
July	106.79	4.59	4.14
August	98.64	3.97	3.84
September	78.22	2.89	3.12
October	55.78	1.67	2.12
November	38.65	0.96	1.50
December	29.25	0.62	1.09
Annual (MWh)	**874.66**		
Average Unit Price /kWh	**9.7c per kWh**		
Total Saving /Annum	**€84.929**		
capital cost	€1,000,000		
Simple payback	**11.77**	**Years**	





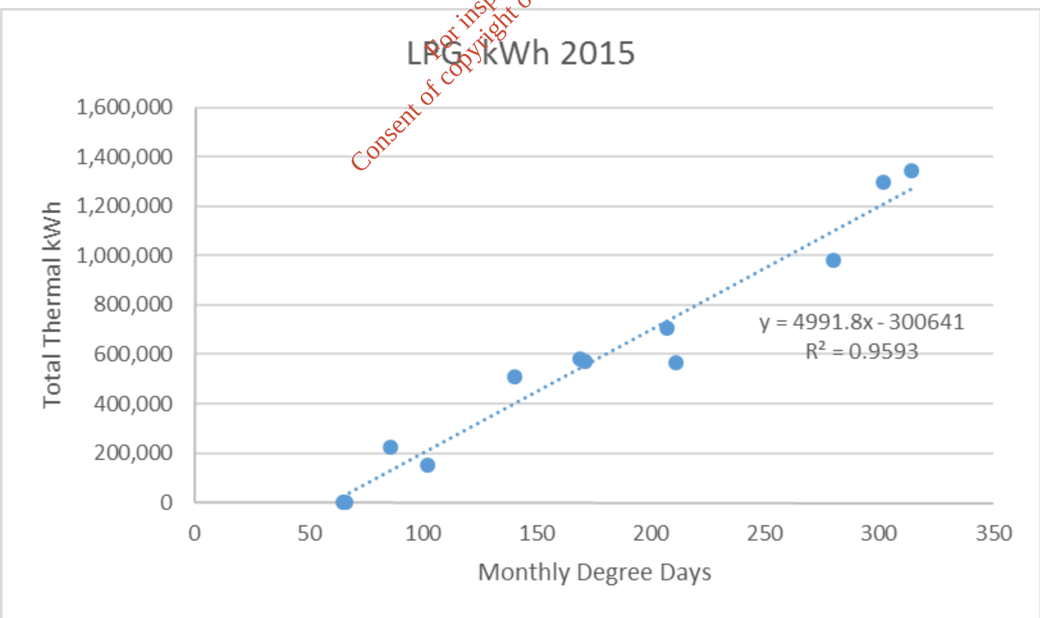
Appendix C: Environmental Protection Agency – Energy Management System Assessment

Level	Energy Policy	Organising	Motivation	Information Systems	Marketing	Investment
Level 4	Energy policy, action plan and regular review have commitment of top management as part of an environmental strategy	Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption.	Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels.	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it.	Positive discrimination in favour of 'green' schemes with detailed investment appraisal of all new-build and refurbishment opportunities.
Level 3	Formal energy policy, but no active commitment from top management.	Energy manager accountable to energy committee representing all users chaired by a member of the managing board.	Energy committee used as main channel together with direct contact with major users.	M&T reports for individual premises based on sub-metering, but savings not reported effectively to users.	Programme of staff awareness and regular publicity campaigns.	Same pay back criteria employed as for all other investment.
Level 2	Un-adopted energy policy set by energy manager or senior departmental manager.	Energy manager in post, reporting to ad-hoc committee, but line management and authority are unclear.	Contact with major users through ad-hoc committee chaired by senior departmental manager.	Monitoring and targeting reports based on supply meter data. Energy unit has ad-hoc involvement in budget setting.	Some ad-hoc staff awareness training.	Investment using short-term payback criteria only.
Level 1	An unwritten set of guidelines	Energy management is the part-time responsibility of someone with limited authority or influence	Informal contacts between engineer and a few users.	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department.	Informal contacts used to promote energy efficiency.	Only low-cost measures taken.
Level 0	No explicit policy	No energy management or any formal delegation of responsibility for energy consumption	No contact with users.	No information system. No accounting for energy consumption.	No promotion of energy efficiency.	No investment in increasing energy efficiency in premises.

Appendix D: Price trend for a barrel of crude (Brent) oil – 52 weeks

Source: Internet on 17th July, 2018 http://markets.businessinsider.com/commodities/oil-price

Appendix E: Andreas is continuously monitoring Heating Degree Day (HDD) and thermal energy usage



There is a strong positive correlation between LPG gas usage and Heating Degree Days; as demonstrated in the graph above.

Appendix F: Sankey diagram representing energy flow within the LCC Killarney Facility