John Cosgrove

TEMPO

A methodology for verified energy savings in manufacturing facilities through changes in operational behaviour.

John Cosgrove, Frank Doyle, Mike O'Neill, John Littlewood & Paul Wilgeroth.

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LIT
ACTIVE LEADERSHIP IN
EDUCATION, ENTERPRISE
AND ENGAGEMENT

Background

John Cosgrove
Technical Director – ACORN Research Centre.
Limerick Institute of Technology, Ireland.

ACORN Research Centre
Focussed on the development of Intelligent Systems and Smart Sustainable Factories under Industry 4.0.

Co-ordinator – TEMPO - **Total Energy Management for Production Operations**. Collaboration of Multi-National and SME Manufacturing sites with three Research Centres.

Demonstrated a methodology and set of tools for energy management based on;

- Principles of **LEAN** Manufacturing
- Product Centred View / Value Stream Mapping

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Key Points:

- Energy management in small to medium enterprises (SMEs) remains undeveloped due to competing priorities and a lack of specialist knowledge.
- The set-back of machines through the E-Stop mode effectively reduced the idle energy consumption of 25 machines by 60%.
- An Energy KPI was developed to provide continuous monitoring of progress.
- A Behavioural change model was adopted for energy management in an Irish Manufacturing SME
- Resulting in a 12% reduction in annual energy consumption in production through change in practice.

Industry Energy Efficiency

[I2E2, 2013; SurfEnergy, 2014; Deshpande, 2012; UDIAC, 2013; NRCAN, 2015]

These initiatives and others, demonstrate the savings that can be achieved through the optimisation of the technical services in Industry (Air, Heat, Water) but they also highlight the significance of also addressing production equipment, machines and processes.

Harrington et al, (2014) showed that correctly attributing the direct and indirect energy consumption in six large manufacturing facilities gave a split of 57% **Direct Energy** consumption and 43% **Indirect Energy** consumption. 26% or nearly half of the direct energy was identified as not adding value (Waste).

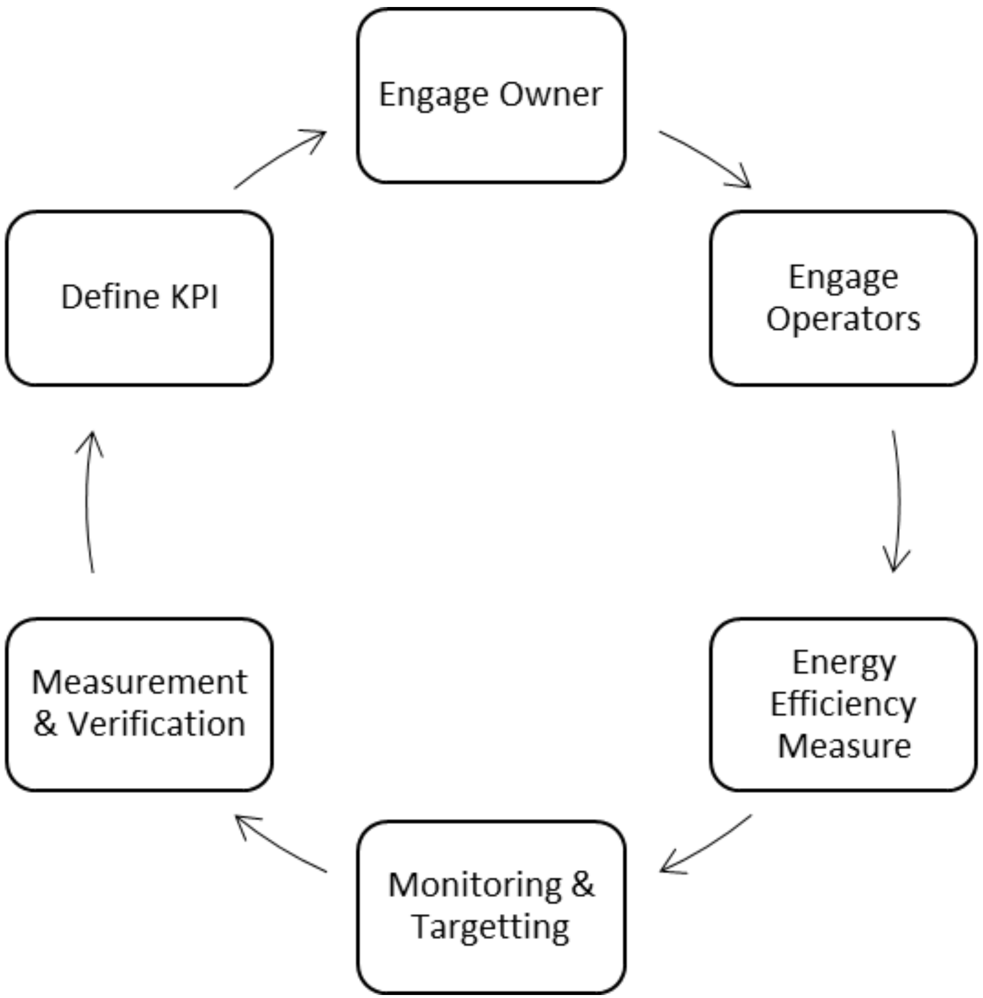
Jollands et al, (2009); Granade, (2009) shows potential to reduce energy consumption in energy intensive industry by an average of 20%. The same research indicates that energy management and behavioral changes can achieve up to half of this remaining energy efficiency potential.

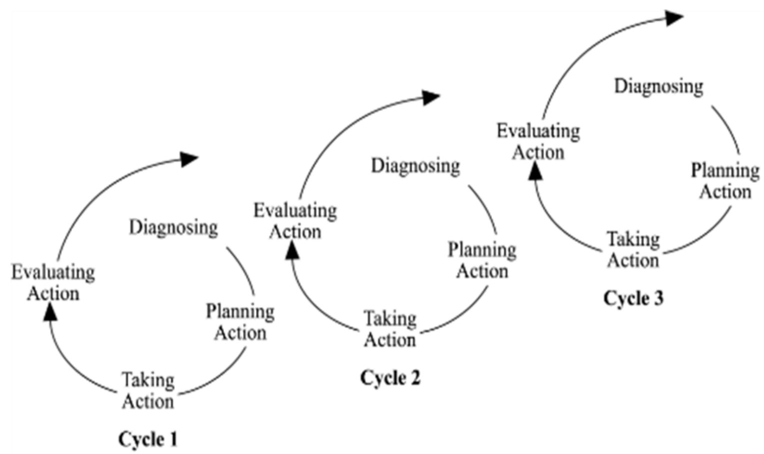
Barriers

Study	Identified Barriers
O'Malley et al, 2003	Access to capital, hidden costs, imperfect information and values & organisational culture
Sorrell et al, 2011	'Hidden costs' are real, significant and form the primary explanation for the ‘efficiency gap’. Senior management unaware of the opportunities available.
Wijnants & Wellens, 2013	EE Measures known but not implemented.
Lunt et al, 2014	lack of accountability, no clear ownership and no sense of urgency
USDoE, 2015	Failure to capture the value of energy savings, lack of knowledge of incentives and risks, lack of disaggregated energy consumption data, and lack of in-house technical expertise.
Fawkes et al, 2016	Risk, Imperfect Information, Hidden costs, Access to Capital, Split-incentives and Bounded Rationality.

Methodology

Virtuous Circles of Engagement and Energy Saving

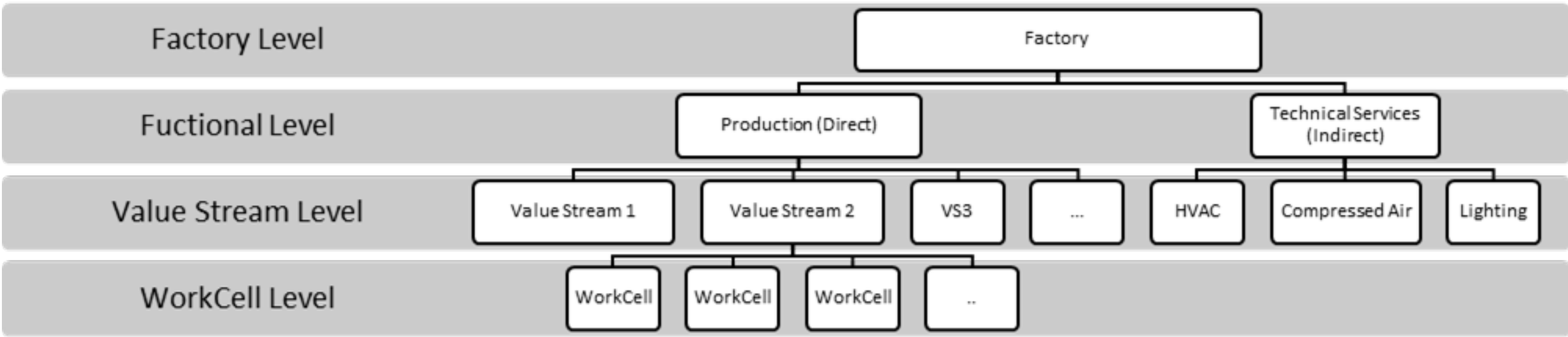




Source: Coghlan and Brannick (2001) p. 19

Methodology

Hierarchy of Energy Analysis



	Level	Key Performance Indicators	Energy Tools
Cycle 0	Factory	Total Energy Consumption	Utility Energy Analysis, Deskstudy, Electricity HeatMap, Waste Energy Cost Study
Cycle 1	Function	Significant Energy Users (SEU)	Facilities Analysis, Walkthrough Audit, Aggre-gated time of use Costs.
Cycle 2	Value Stream	Specific Energy Consumption (SEC) Co-efficient of Performance (CoP)	Process Mapping, Specific data logging, Power Profile Analysis.
Cycle 3	WorkCell	Energy Performance Co -Efficient (EnPC)	Monitoring of activity and energy consumption in realtime.

Case Study – Manufacturing SME

The barriers to energy efficiency include the lack of visibility, low awareness, limited know-how and fragmentation of energy consumption. [IEA, 2012]

Challenges for Manufacturing SMEs

- Limited / No Metering in place.
- Contract manufacturing, large variation in products, material types and job-run length
- Lack of expertise

Need to Develop

- Key Stakeholder responsible for Energy
- Energy Data from Utility Company and Temporary Metering
- Simple analysis methods and tools (Excel)
- KPIs for ongoing management attention

Takumi Precision Engineering Ltd

Established: 1998
Factory: 22,000 sq. ft.
Employees: 50
Machines; 25 Lathes/Mills
Energy: 680,000kWh of electrical energy annually

Takumi means craftsman or artisan in Japanese

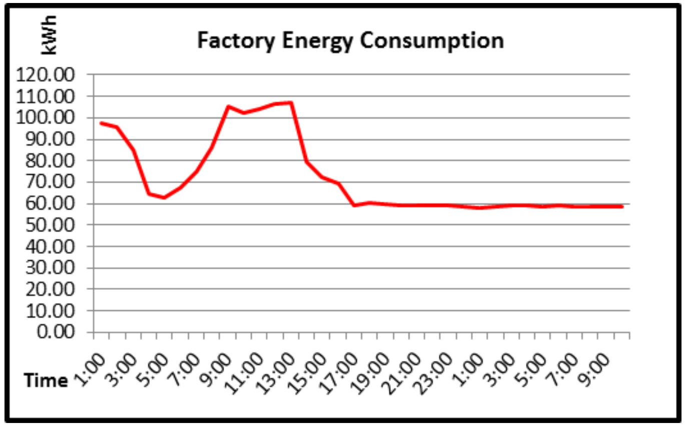
Case Study – Manufacturing SME

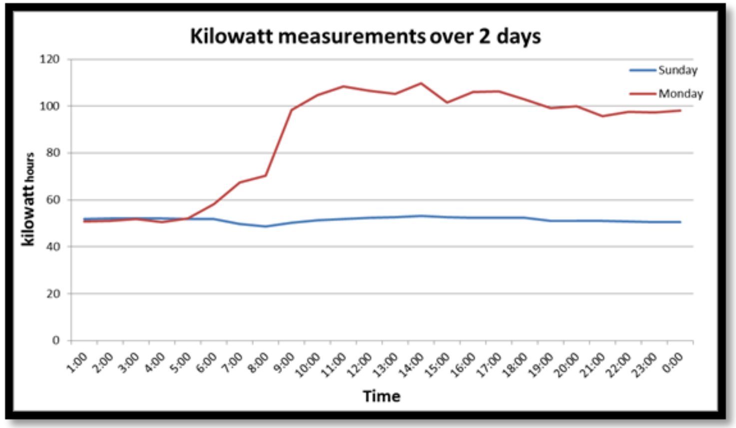
[Wising et al, 2014] Eight Dimensions to promote energy reduction through management and behavioural change.

Dimension	Application
Accountability	Facilities Manager Identified
Commitment	Energy KPI included in Monthly Management Meetings
Visibility	EE Signage, Energy Awareness Board – Historical Data, KPI
Collaboration	Employee briefings, Suggestions Box
Targeting	Specific Idle Energy KPI developed
Motivation	Energy Savings used to fund Staff Social Activities
Learning	Group Training and Knowledge Provision. Energy Doctor.
Progress	Reported & Displayed

Case Study – Manufacturing SME

Temporary electricity consumption data was gathered using a range of data-loggers and electricity monitoring meters and systems to show the baseline auxiliary power consumption of the factory.



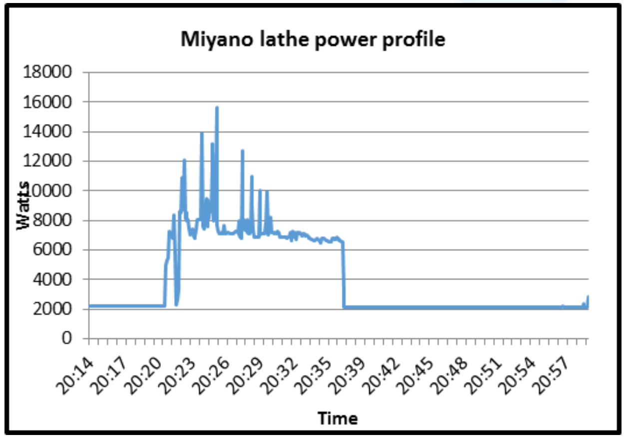


Auxiliary Energy (Waste) was recorded at 60 kW per hour. The cost of this AuxE represents **28%** of the total annual electricity utility bill in euros.

$$Electricity\_AuxE\_Factory = \sum_{m=1}^{12} (\text{AuxE\_DayUnits x Day\_UnitCost}) + (\text{AuxE\_NightUnits x Night\_UnitCost})$$

Case Study – Manufacturing SME

Previously:
Powering off the machines was discouraged - due to the complexity of the machines and high precision tolerances.
Frequent switching on/off of some machines could lead to failures in the sensitive electronic equipment.



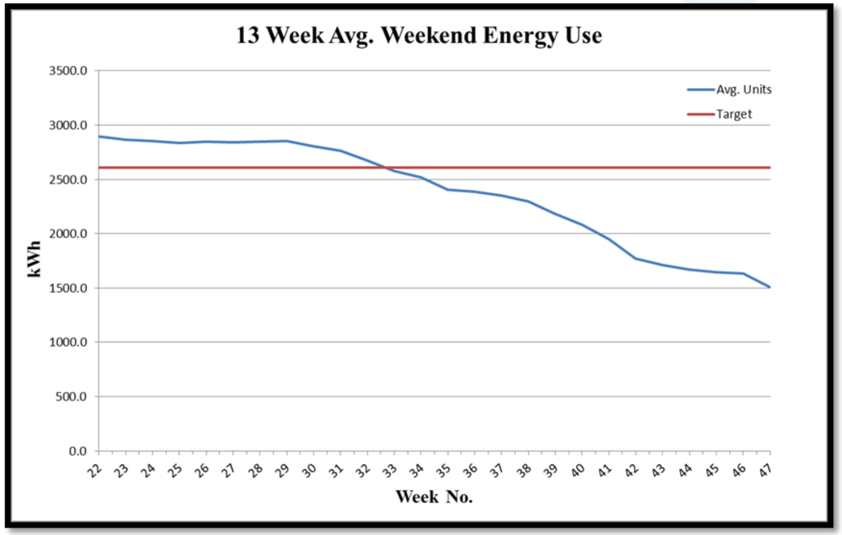
Machine	Idle Power (W)	E stop Power(W)	Difference(W)	No. of machines	Total Difference(W)
Doosan CNC 5AX Mill	4954	759	4195	2	8390
Doosan CNC Lathe	4155	1985	2170	2	4340
Lamb CNC Mill	2186	310	1876	3	5628
Spinner CNC Mill	2043	830	1213	1	1213
Arrow 750 CNC Mill	2508	2475	33	3	99
Arrow 1250 CNC Mill	1442	631	811	1	811
Miyano CNC Lathe	978	488	490	1	490
Agie EDM	2347	768	1579	1	1579
Agie Spark EDM	1644	820	824	1	824
Sodick EDM	5565	1255	4310	1	4310
Mori Seiki CNC Mill	3457	2979	478	1	478
Deco CNC Lathe	3872	1694	2178	3	6534
Hawk CNC Lathe	2966	1010	1956	2	3912
Doosan CNC 5AX small	2519	790	1729	2	3458
Doosan CNC 3AX small	1865	1308	557	1	557
Doosan CNC 3AX	762	670	92	1	92
Totals (Watts)	**74989**	**32274**		**26**	**42715**

E-STOP Set-back
E-Stop mode showed savings of **60%** of idle energy with no risk to production.

Results

A simplified methodology to achieve verified energy savings through changes in operational behaviour was developed for application in Manufacturing SMEs.

Management & Staff Engagement was key to drive change in behaviour.



The Case Study Company are on-target for a **20%+** saving in Electricity Consumption (€22,000 p.a.) despite increasing production capacity.

Additional Non-Energy Benefits (NEBs) Identified.

$$KPI_{Weekend\ \ Energy} = \frac{\sum_{0}^{13} WeekendEnergyUnits\ (KWh)}{13}$$

Further Machine Level Monitoring and OEE Metrics are being developed to improve the Energy and Production Tracking.

John Cosgrove
Limerick Institute of Technology
John.Cosgrove@lit.ie