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A Lean and Green Kaizen Model

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Abstract

The improvement of environmental performance is key for deploying sustainable business. Therefore, following lean concepts, the management of environmental aspects should be focused in improving material and energy flows that can cause significant environmental impacts.

This paper proposes a model based on lean concepts for managing environmental aspects capable of promoting a better integration of the environmental processes to business needs. Integrating Lean and Green concepts by taking a Kaizen approach in a cell level, the model developed has the ultimate goal of reducing environmental impacts generated by the production process.

The paper reports initial findings of recent global application of the developed model in a major engineering international corporation. Some of the conclusions of this testing

consider that the model developed is capable of reducing an average of 30% of production cells material usage and waste generation.

Introduction

With the purpose of promoting a continuous improvement culture within the business, Lean is a business practice that considers the expenditure of resources for any goal, other than the creation of value for the end customer, to be wasteful, and thus a target for elimination. The antidote to such wasteful practices is what is called “lean thinking”, a method that has four interlinked elements which together help achieve the Holy Grail, as defined by customers in search of perfection - the elimination of wastes.

One of the keys to lean thinking is simplification. Applied in the context of the whole process or plant, it has the added benefit of simultaneously saving such resources such as space, materials, energy, transportation and time. Resource productivity and closed loops provide better services, for longer periods, and with less material, cost and aggravation. Lean thinking promotes a customer-defined value flow continuously with the aim of producing less waste. Instead of selling the customer a product perceived as more appropriate, the idea is to achieve what is truly desired, bearing in mind quantity, production rate and methodology.

The logic of lean thinking, with the emphasis on eliminating the seven classic wastes can be redesigned and integrated to the sustainability systemic concept. By minimizing the amount of waste that is produced in manufacturing, reducing energy use, and using the materials and resources in a more efficient way, can lead to financial cost savings and reduction of environmental impacts. Therefore, integrating both concepts offer the foundation for a new business logic, where the pillars of sustainability, social, economic and environmental, can support business goals, requirements and needs.

How then, lean and sustainability concepts can be integrated and put into practice?

Aiming to answer this question, this paper will attempt to investigate the application of lean and sustainability concepts, Lean and Green, by taking a Kaizen approach in a cell level. For accomplish this, it proposes a Lean and Green Kaizen Model, that focus the improvement of the cell supporting flows (water, energy, material, effluent, chemicals, wastes) with the ultimate goal of optimizing the overall cell performance by reducing costs and significant environmental impacts and so putting lean and green in practice.

In order to create the basis for the Lean and Green Kaizen Model, this paper explores the fundamental building blocks of Lean Thinking, Kaizen, Sustainability and lean and Green concepts. It proposes the model structure and dynamics. Also, it reports the application of developed model in automotive parts manufacturing cell of a major engineering international corporation (GKN PLC). The results of this application are presented and analyzed and conclusions are proposed.

Literature Review

Sustainability

Sustainability is a systemic concept relating to the continuity of economic, social and environmental aspects of human society. The term was first used by the Brundtland Commission which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The field of sustainable development can be conceptually broken into three constituent parts: environmental sustainability, economic sustainability and sociopolitical sustainability. **Figure 1** above presents a representative scheme of sustainable development vectors.

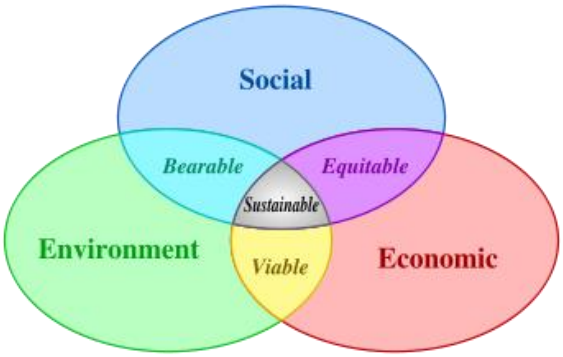

Figure 1: Sustainable Development vectors

Source: *Brundtland report*

Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges facing humanity. Therefore it contains within it two key concepts: (1) the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs." All these definitions of sustainable development proposed understating the world as a system — a system that connects space; and a system that connects time. Therefore, concept of sustainable development is rooted is this sort of systems thinking.

There are many different management strategies proposing the co-existence of industry, the natural environment and their interactions in systems thinking approach. The Lean & Green Report (Zokaei et al., 2010) provides an overview of some of these key management strategies proposed to pursue sustainable development, such as Industrial Ecology, Industrial Symbiosis, Triple Bottom Line, Natural Capitalism. With different structure and priorities, all these strategies describe very similar conditions for sustainable manufacturing systems and propose strategies in order to make sustainable

development concept viable. **Table 1,** adapted from the Lean & Green Report, presents the main essence of these strategies.

Table 1: Sustainable Industry: An Overview of Different Strategies

Source: *Zokaei et al., Lean & Green report, (2010)*

School of Thought	**Key Principles**
Industrial Ecology	(1) Show how environmental concerns can be integrated into economic activities. (2) Offers tools for analysis of the interface between industry and environment, and provides a basis for managing environmental impacts.
Industrial Symbiosis	(1) Demands resolute attention to the flow of materials and energy via local and regional economies. (2) Focus on synergistic possibilities offered by geographic proximity.
Eco-efficiency	(1) It is based on creating more while using fewer resources and creating less waste and pollution.
Triple Bottom Line - (TBL)	(1) aims to integrate into corporate strategy and corporate governance a focus not just on the Economic value that they add, but also on the environmental and social value that they add – or destroy.
Eco-effectiveness	(1) Eco-effectiveness is based on a cradle-to-cradle or closed-loop design strategy reflecting natural systems.
Natural Capitalism	(1) Based on four strategies : (1) Radical Resource Productivity; (2) Bio-mimicry; (3) Service and Flow Economy (4)Investing in Natural Capital; (2) Pictures a new industrial system based on a very different mindset and values than conventional capitalism.
The Natural Step	(1) Definition of sustainability includes four system conditions: avoiding increasing concentrations of substances extracted from the earth's crust, concentrations of substances produced by society and degradation by physical means.
The Biosphere Rule	(1) Biosphere Rules is a complementary set of principles and the latest re-definition of what is '*lean and green*' (2) Reduce, reuse, recycle, is not as lean as it seems: (1) use a limited palette of materials; (2) cycle up – prepare your product to be easily recycled into a new product; (3) exploit the power of platforms or common production systems.

Lean thinking & Kaizen

With the purpose of promoting a continuous improvement culture within the business, Lean is a business practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Where the use of a resource is not viewed as a value by the client, it should be a candidate for elimination. The nearly universe antidote to such wasteful practices is what Womack & Jones, 1998 call "lean thinking". The concept of lean thinking describes the working philosophy and practices of the Japanese vehicle manufacturers and in particular the Toyota Production System (TPS). In general terms, Lean thinking is defined and described by five key principles (Womack & Jones, 1998):

- **Specific value :** define value precisely from the perspective of the end customer in terms of the specific product with specific capabilities offered at a specific time;
- **Identify value streams:** identify the entire value stream for each product or product family and eliminate waste;
- **Make value flow:** make the remaining value creating steps flow;
- **Let the customer pull value:** design and provide what the customer wants only when the customer wants it;
- **Pursue perfection:** strive for perfection by continually removing successive layers of waste as they are uncovered.

One of the keys to lean thinking is simplification. Enlarged to the context of the whole process or plant, it gains the wider ability to save simultaneously resources and space, materials, energy, transportation and time. Considering economic principles, Ohno, 1988 describes seven classic wastes in the context of manufacturing processes. They are

overproduction, waiting, transport, extra-processing, inventory, motion and defects. Resource productivity and closed loops provide better services, for longer periods, with less material, cost and hassle. The logic of lean thinking, with the emphasis on eliminating 7 classic wastes, makes a customer-defined value flow continuously with the aim of producing less waste. Together these practices offer the foundation for powerful new business logic: Instead of simply selling the customer a product, it is perceived more appropriate, to derive what is desired, considering quantity, rate and manner. Based on the analysis of customer value, lean presents a set of tools and techniques for continuous improving processes and eliminating wastes (Rotther & Shook, 2003).

According to Womack & Jones, 1998, the key building block of lean thinking is Kaizen, the Japanese word for continuous improvement – a process oriented philosophy with focus on incremental improvements and standardization of the improved system as the building block for further improvement. Kaizen philosophy has two major objectives (Berger, 1997):

- **Develop a problem solving culture:** with focus in analysis and problem solving by applying scientific and structured thinking. Lean philosophy present a verity of tools and techniques with the ultimate goal of improving processes and eliminating wastes. Developing a problem solving culture is key for deploying the lean thinking; (Rotther & Shook, 2003);

- **People involvement:** Kaizen relies on ongoing effort and engagement of people - it is based on the constant effort for involving and integrates people, from the shop floor workers to the top executives. For the lean thinking the key for success is based on the capacity for training and involving everyone. Based on this idea, producing people ware systems rather than software systems for

sustaining the results. This creates a learning environment, with long term maintenance of results and openness for creativity and improvements (Berger, 1997).

Gordon, 2001 states that for decades, lean Manufacturing has been considered the best way to run a manufacturing company and lean principals have been successful applied in many other industries, including services and government.

According to Langenwalter, 2007, lean ways of working with focus on the Kaizen continuous improvement philosophy for solving problems and involving people can be applied to any kind of problem, process or system, including Environmental Management Systems. For considering scientific methods and involvement of people as basis for its tools, and technique, lean presents a robust methodology for incorporating sustainability principals and environmental issues into its business requirements.

Lean & Green

There has been a concern that improving environmental and social performance would undermine the economic sustainability of an organization and that many business could not afford the cost of meeting their environmental and social responsibilities (Florida, 1996). However, there are many examples where improving environmental performance has improved the company's profit (Porte and van der Linde, 1995, Hart, 1995, Corbertt and Klassen, 2006).

According to the EMAS website, "Minimizing the amount of waste that is produced, reducing energy consumption and making more efficient use of resources can lead to financial cost savings, in addition to helping to protect and enhance the environment". These statements and conclusions suggest that taking a lean approach to waste elimination has considerable potential for environmental and economic sustainability.

According to Womack & Jones, 1998, there are a great potential of integrating the Lean thinking to environmental sustainability. For them, lean is creating a new manufacturing paradigm, which includes an environmental sustainability element. Therefore, they consider that lean thinking is green once it proposes the reduction of materials, wastes and energy that are required by the production. Until recently lean manufacturing and the application of lean thinking has concentrated on the economic and some of the social aspects of sustainability. However, the essence of lean is to produce more with less, this implies that lean thinking organizations use less resource, in the form of raw materials and energy. The lean approach may be applied for deploying an Environmental Management System and a continuous improvement culture.

The use of Lean principals for deploying and improving environmental systems is new. Recently the US Environmental Protection Agency (EPA) has been developing this theme and reported some key findings: (1) Lean produces an operational and cultural environment that is highly conductive to waste minimization and pollution prevention; (2) Lean can be leveraged to produce even more environmental improvement; (3) Some regulatory "friction" can be encountered when applying lean to environmentally-sensitive processes; (4) Environmental agencies have a window of opportunity – while companies are embarking on Lean initiatives and investments - to collaborate with Lean promoters to further improve the environmental benefits associated with lean. As a result of these findings EPA published *The Lean and Environmental Toolkit* in December 2006 to demonstrate that traditional Lean tools can be map and eliminate environmental wastes. This manual establishes guidelines for using lean tools for improving material flow for the main flows that support the production process and that can affect the environment (such energy, chemicals, wastes, etc.)

In fact, there are intrinsic linkages between lean and green – not least due to the relentless focus of lean on waste elimination. Over the past two decades the lean community has focused on operational improvements to build a continuous improvement. The next challenge for the lean community is to consciously account for the environmental issues. Gordon, 2001 discuss some ways for integrating Lean and Green practices with focus in cost reduction practices. Lovins, Lovins & Hawken, 1999 in its Natural Capitalism fundamental text discuss the importance of not only developing a more sustainable society but also how different existing practices can be applied for supporting an environmental oriented businesses.

The fundamental building block of Lean thinking is continuous improvement, *Kaizen*, with focus on problem solving and employee involvement which perfectly fits with the notion of creating a greener industry. Therefore, the pursuit of continuous improvement, i.e. *Kaizen*, created substantial opportunities for pollution prevention and waste and emissions reduction According to Hall (2010), in organization which Lean is already part of its business system and Kaizen is the basis for continuous improvement, the same idea could be adapted for improving production energy and material flows. Deploying this strategy and by improving the way that products and materials are sourced, manufactured, marketed and disposed at the end of its life-cycle means using lean thinking for creating a sustainable manufacturing. This is the main idea that will be explored in this paper.

Research method description: Lean & Green Kaizen Model

The analysis and definitions for designing the research structure for the Lean and Green Kaizen Model were based on the studies presented by Gil, (2010), Bryman & Bell (2007) and Kumar (2005). In general terms, the basic research structure developed for application of Lean and Green Kaizen Model in a production cell of major automotive

global corporation, GKN plc, can be described as applied exploratory case study with qualitative data basis.

The basic and most important idea of the Lean & Green Kaizen Model is considering that Lean & Green approaches will be integrated as part of the continuous improvement process of the cell. In this context, it is understood that a stable production flow is the first step towards achieving a green enterprise. Once the cell stability is reached then it's ready for the next step. That's the reason that the Lean & Green Kaizen Model is only applicable for cells that have achieved a deployment level of Lean. **Figure 2** represents the basic framework for Lean & Green Kaizen Model.

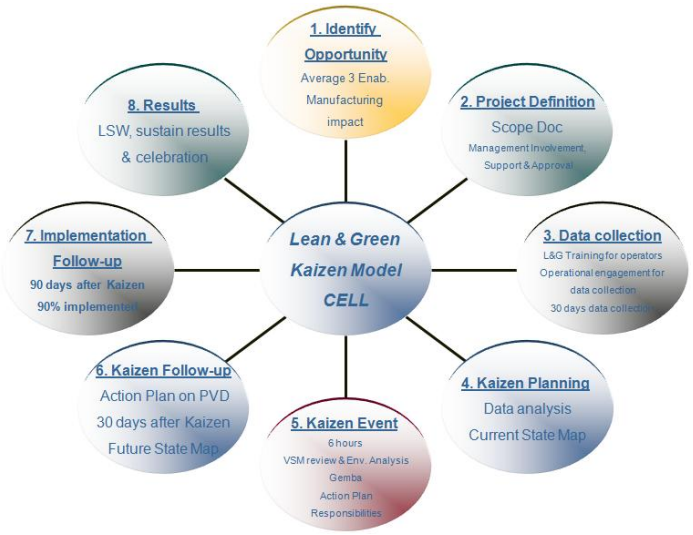

Figure 2: Lean & Green Kaizen Model

Based on lean thinking, the Lean & Green Kaizen Model is developed on the eight steps. The general objective of each step is described as follows:

- **Step 1, Identify the need for improvement:** Identify an operational cell that, by representing a significant use of resources, has a good deployment of lean tools that justifies the application the Lean & Green Kaizen Model.

- **Step 2 & 3, Define the process improvement scope:** Identification of stake holders, expectations, and measures: Align the process "size" and the objectives for the improvement. Identify the environmental process actual data.
- **Step 4, Mapping 'As-Is' process and identification of the cell actual state for its environmental main value:** Measure the environmental waste generation/inputs consumption for the cell (environmental data is something that needs to be collected in advance; this step of the project may involve EHS specialists and Continuous Improvement Leaders).
- **Step 5, Identify waste elimination opportunities in the Kaizen Workshop:** Prioritization of the main production supporting flows to be worked by the team during the Kaizen Event; Team Work (Gemba) for identification of main waste elimination opportunities; analysis of the main wastes in each flow and identification of the main improvements.
- **Step 6, Map the 'To-Be' process in the Kaizen Workshop:** Considering all the analysis developed during step 5; create the future map for the supporting production flows studied during the Kaizen.
- **Step 7 & 8, Develop action and communication plans in the Kaizen Workshop:** action plan and communication plan development; action plan validation with project team leader; Kaizen event action plan consolidation.

Case Study: Model application at GKN Driveline Brazil Monobloc A Cell

The case study presented in this paper was developed in the GKN Driveline operations in Brazil. GKN is 252 years old global British engineering company, with focus on automotive, industrial, aerospace and land systems markets. With operations in more

than 30 countries and more 39.000 employees around the world, over the past decade GKN established solid foundations in both Lean and environmental fields.

In this context, the GKN vision for lean is to create a continuous improvement culture within the business, thus improving the company's flow of value and waste elimination. The GKN vision for Environmental Management is to create sustainable business by reducing emissions and waste through continuously improving operational performance and maximizing the use of resources. So, for GKN, a Lean Enterprise has the ultimate objective of improving process flow. In the GKN concept for a Green Enterprise the objective is maximizing the use of resources and reducing the impact of waste disposal. In this case, an environmental waste is an unnecessary or excessive use of resources or substances released to the air, water, or land that could harm human health or the environment. Environmental waste can occur when the company use resources to provide products or services to customers and/ or when customers use and dispose of products. Therefore, the greatest change for GKN context is using its lean basis for developing a sustainable manufacturing environment, by improving the supporting flows of production (energy, materials, waste, and water) in a cell level.

There are many potential cost savings associated with reducing the environmental impact of a business, for example, reducing the consumption of harmful chemicals and energy will impact directly on overheads, as well as reducing risk to the employees and the surrounding area.

GKN Driveline in Brazil developed a pilot Lean & Green Model application by using environmental concepts in a stable cell to investigate the benefits this could have for the environment and the business, in terms of waste reduction, improved lead time and greater employee commitment. The pilot project was developed in a model cell with

deployment level of lean via a cross-functional Kaizen team event to ensure all the team members were fully involved and had the opportunity to contribute their ideas.

The Kaizen event that was developed involved about 30 people, including all cell operators, leaders and managers, maintenance people, as well as EHS specialists and Continuous Improvement. The Kaizen event agenda is presented below.

Table 1: Monobloc A – Lean & Green Kaizen Model - Kaizen Agenda

Activity #	Topic	Timing	Responsibility	Resources
1	Welcome, concepts and activities	30 min	SSC Member & Project Leader	PPT presentation and group dynamics activity
2	Environmental waste concept review Actual State Analyses	30 min	Environmental Specialist	Environmental Wastes PPT Actual State Map
3	Scope Doc Team Review Env. VSM review and prioritization		CI Leaders	Scope Doc Prioritization matrix and structure
4	Team Work – definition of teams by VSM, participants and leaders	30 min	CI Leader	Data sheets with VSM´s data waste analysis sheets action plan sheets
5	Gemba – In loco waste analysis by team/VSM	1 h 30 min	Team Leaders	Data sheets with VSM´s data waste analysis sheets action plan sheets
6	Team waste analysis consolidation	30 min	Team Leaders	Consolidation sheet brown paper, Post-it notes, pens
7	Team future state map development	30 min	Team Leaders	Black VSM map
8	Team waste action plan development	30 min	Team Leaders	Action plan worksheet
9	Team action plan and future state VSM presentation and validation with SSC	1 hour	Team Leaders	VSM and action plans worksheets
10	Workshop results/data analysis	15 min	CI Leader	Cost analysis worksheet Consolidate VSM map Consolidate action plan worksheet
11	Closing remarks – workshop results analysis (employee involvement perspective)	15 min	SSC Member & Project Leader	Free debate
		6 hours		

After a six hour Kaizen event working in six different teams, with the objective of reducing cost, waste and consumption of natural resources for six different production supporting flows (Energy, Metallic Waste, Chemical Products, Hazards Waste, Effluents and Water), the teams defined a new future state for the cell supporting flows.. The action plan presented in the end of the Kaizen event had the potential to reduce the total cell cost by 27% and natural resource consumption by 50%. **Tables 2 and 3** below present its results.

Table 2: Costs analysis results after the Kaizen

Supporting Flows Monobloc A Cell Cost	R$ Before	R$ After	% Reduction
Energy	61.411	56.498	8%
Metallic Waste	143.389	95.312	33%
Chemical Products	3.554	297	92%
Hazards Waste	180	60	69%
Effluent	87	27	69%
Water	24	16	34%
Total Cost Reduction	R$ 208.645 £62,096	R$ 152.210 £45,300	27%

Table 3: Generation/consumption analysis results

VSM Monobloc A Cell Consumption	Before State Generation or Consumption	Future State Generation or Consumption	% Reduction
Energy (Mwh/Month)	261	240	8%
Metallic Waste (Tones/Month)	55	37	33%
Chemical Products (Liters/Month)	412	35	91%
Hazards Waste (Tones/Month)	0,3	0,1	67%
Effluent (m3/Month)	2,5	0,8	69%
Water (m3/Month)	2,9	1,9	34%
Total	-	-	50%

Findings

Table 4 below shows the Kaizen implementation results for the Lean & Green Kaizen Model implementation at Monobloc A cell, GKN Driveline in Brazil. Observe that not all the savings identified during the Kaizen event were able to be implemented and the table below shows the results only for the improvements that were 100% implemented.

Table 4: GKN Brazil Monobloc A Lean & Green Kaizen implementation results

Monoboloc A - Action Plan implementaion results	Total Environmental Improvement			Total Cost Savings
	Before	After	Reduction = Environmental Benefits	Reduction = Cost Savings
Energy (Mw/month)	261,00	260,88	0,12	R$ 27,46
Steel (Ton/month)	55,33	31,00	24,33	R$ 6.083,00
Water (m3/month)	1,40	0,43	0,97	R$ 8,15
Contaminated Waste (m3/month)	60,03	30,00	30,03	R$ 15.016,52
Chemical Products (liters/month)	602,00	35,00	567,00	R$ 4.114,65
				R$ 25.249,78
				R$ 302.997,36
				£ 131.737,98

Some of the Kaizen before, during and after achievements are shown bellow.

Figure 3: Before - Meters were used to collect energy and resources inputs into the cell

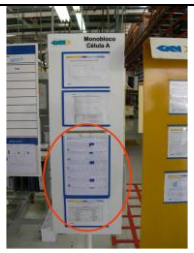

Figure 4: During - Environment measures are part of the PVD on Monobloc A cell, these are reviewed daily

Figure 5: After - Scrap removal belt now does not run continuously

Figure 6: After - Motion sensitive lights and low energy

Figure 7: After - Forgings are produced at Charqueadas and machined at Porto Alegre. As a result of the Kaizen and the focus on metallic waste, POA redesigned the forging so as to reduce the amount of machining

Figure 8: After - Components ('cages') are moved within GKN Driveline in Brazil in plastic containers. Previously the cages were wrapped in plastic, and the plastic was disposed as hazardous waste (because of the amount of oil). An opportunity was recognized

necessary	to eliminate the plastic wrap from the container leading to a substantial savings in disposal costs.

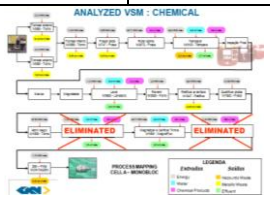

Figure 9: After - Previously, all parts were inspected. Because of the rust proofing coating, they were first washed, and then inspected, and then re-rust proofed. In cooperation with Quality, the decision was made that 10% inspection was appropriate. As a result, there is a 90% reduction in the amount of washing and re-rust proofing necessary.

7. Conclusion

One of the main challenges faced by commercial organizations is to build and maintain business in an ever evolving market and entrepreneurial environment (Kotler, 1998). With the growth of society's concern about the environment, new systems and procedures have to be incorporated within the main business. Because of this, a new function was integrated into the management function - the environmental function (Savely, Carsona & Declosa, 2007).

So, can lean and sustainability concepts can be integrated and put into practice?

The Lean & Green Kaizen Model presents a good example of how Lean ways of working by using the Kaizen spirit (the bottom-up approach) for involving people can be a supporting tool in achieving business sustainability. The analysis of the Lean & Green Kaizen Model application and results at the cell level proposes some conclusions, such as:

- **Cell is a good starting point for a Lean & Green intervention:** Where the things are happening, where people can see the flow of material;

- **Lean deployment level is key for Lean & Green:** It means that the cell manufacturing process is more stable, has good process knowledge, good people maturity, is ready for a new continuous improvement cycle;
- **Lean & Green Kaizen Model is a good pollution prevention strategy:** Results of Model application at GKN Monobloc Cell A represented around 30% improvement in materials, energy consumption and wastes generation;
- **Kaizen approach success for environmental improvement:** represented a bottom-up team effort where the use employee involvement tools raised people environmental understanding to a much higher level.

Therefore, the Lean & Green Kaizen Model application at production cell shows that environmentally sustainable practices can be considered as an extension of Lean philosophy. Sustainability means "meeting the needs of current generations without compromising the ability of future generations to meet their needs in turn". This means that lean leads us toward sustainability initiatives. Because it is much like Lean in both concept and practice, sustainability can be thought of as Lean expanded to achieve a much broader objective.

Sustainability, like lean has a good track record of improving finance, because of the emphasis on eliminating waste. Extensive opportunities exist to save resources and money on the shop floor. GKN experience applying the Lean & Green Kaizen Model shows that in one cell exercise combining both operators' and leaders' ideas and experience, and using the appropriate lean tools and techniques for identifying waste, created an opportunity of operational cost savings of 132.000 GBP per year in one operational cell. .

In a world of uncertainty about the economy and environment, the Lean &Green Kaizen Model demonstrates the case for a new and innovative approach for supporting the development of a sustainable business.

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