

Assignment B – PVC-U Recycling and Innovation

Introduction

This assignment is looking at the innovation surrounding recycling of PVC-U at Duraflex. Duraflex is part of the UK Windows and Doors Group (UKWDG) who produce and assemble windows and doors. The Duraflex plant in Tewkesbury extrudes the PVC-U, Techni-glass (also part of the group) create the glass panes and the fabrication sites then cut and weld the PVC-U and assemble the glass in the frames.

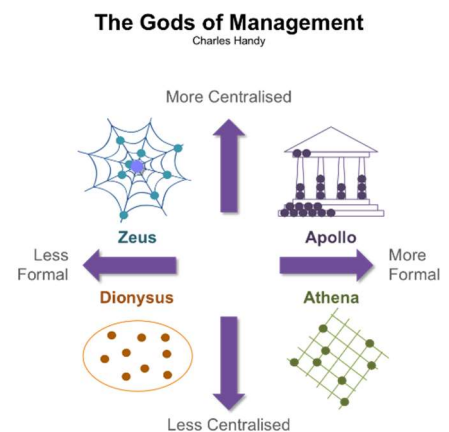
This assignment focus' on the Duraflex plant and the recycling of PVC-U to then be re-used into products extruded at Duraflex.



1. The principal drivers for the innovation.

Duraflex using projects driven by cost savings to innovate and continually improve. Annual cost savings and projects are driven by the UKWDG directors. There are no set innovation teams, only project leaders who hold the most knowledge in the area and drive the project.

Duraflex has a structured organisation to leadership, similar to an Apollo role when comparing with Charles Handys Gods of management. Handy, Charles B. *Gods of management: The changing work of organizations*. Oxford University Press, USA.



Cost saving projects are reported on in weekly and monthly to the directors in Duraflex Operations Review (DOR) meetings.

Duraflex' innovation to recycle PVC-U has multiple steps over the years but started out in 2006. The innovation type can be described as incremental. With the cost of raw materials increasing it was important to save money to ensure the business can stay competitive on prices and retain profit margins for re-investment into the plant.

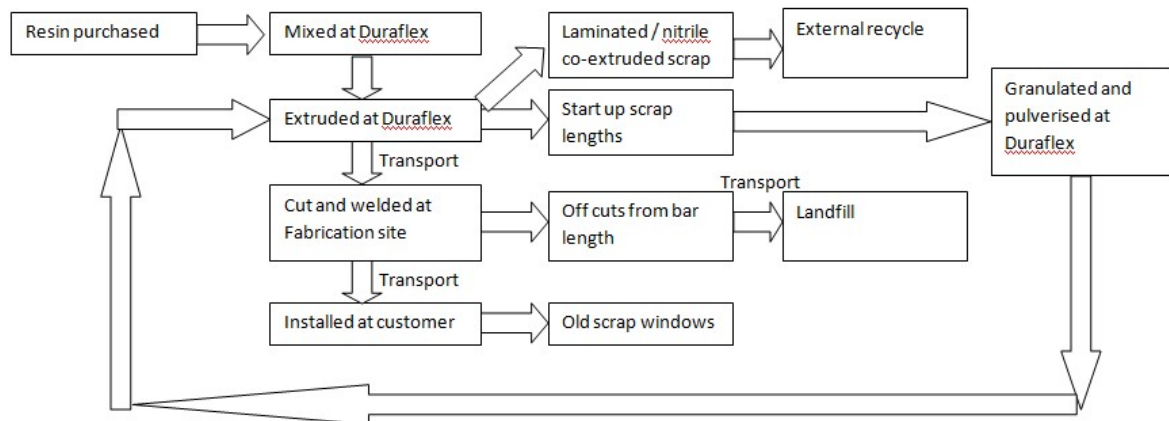
The current cost of Resin is approx £1200 per tonne. Recycled material can be purchased from a recycler for £260 per tonne plus the off cut purchase cost to secure the supply of approx £300 per tonne. Between virgin price and recycled price there is a £640 per tonne saving.

Costs are incurred when material is sent off site to PVC-U recyclers. Within the supply chain business' now are starting to look at component lifecycles, circular economies and green credentials. When we replace our window frames, where do the old frames go?

There is natural scrap within the extrusion process – when a machine starts up or shuts down scrap is produced, when a colour is changed, scrap is produced as this is done as the machine is running, Quality defects can lead to scrap. Although this is costed, the scrap material still needs to be dealt with. What happens to the scrap material?

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In 2005 Duraflex was sending an average of 95 Tonnes of waste PVC-U material off site to PVC-U recycler (reference OP1002 non-recoverable scrap).



As waste is part of the process, can it be re-used? What do other people do? Is there any technology that can help Duraflex?

The answer is Yes! The material can be recycled back into the product, in some cases straight into the product with minor changes to the machine. But what about the 2 main products – can there be a saving to be made by using the recycled material? As these are aesthetic products, visible surfaces will need to be virgin mix. Extrusion tooling specialist Griener came up with a tooling called Combi.CoEx ([Co-Extrusion Profiles](#) | [Co-Extruder \(exelliq.com\)](#)). With this tooling recycled material can be used internally and virgin externally, it is estimated that 50% of the product would be recycled material and can provide a 14% cost saving.



To run the tooling efficiently and ensure there is a consistent supply of the correct grade material further recycling innovations were needed at Duraflex.

Can the material be recycled on site and fed straight back into the plant reducing the need for transport and subcontract costs? Yes, but new granulation machinery is needed.

To run material more consistently removing the risk of material jam ups, tool wear and tool damage the material needed to be pulverised. A pulveriser needed to be installed.

Volume of material is a factor – if there is no material, it cannot be run and savings cannot be made. Therefore a supply chain or recycling loop needed to be established. This was done using fabrication customer off cuts. By using offcuts the customers can remove their waste and earn money back for it. However offcuts contain weather seals that cannot be recycled and potentially metal – a colour sorter with metal detector was needed.

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2. The barriers and risks faced by the company in developing this innovation.

Duraflex like any business during the innovation process face barriers and risks. The innovation project is driven by predicted cost savings by experienced PVC-U technical manager and Engineering manager through a higher management cost saving improvement project, however it still faced barriers when trying to implement the initial innovation.

The inhouse recycling was predicted to reduce external recycling by 833 tonnes from 2005 to 2006 and expected to be met by the management team. *Savings taken from Chris Patterson Sustainability report, 29/11/2006.*

The volume of material needed to run efficiently and the volume available must be considered and sources of material of the correct grade need to be sourced and stabilised to ensure the innovation will meet its targets.

Second extruders will be needed to run co-extruded tooling, the machines will need their own material conveying system.

New tooling will be needed to produce the co-extruded shape and an additional extruder needed for each line that is planned to run a co-extrusion tool. There are minimal additional costings to purchasing a co-extrusion tool to a standard tool as the main downstream tooling is the same, but the die has a slight modification to allow for the co-extrusion. Life expectancy of tooling may be reduced by using chipped material as apposed to powdered material and chipped material is courser. A pulveriser may be required to reduce the material size.

An additional granulator and pulveriser are required to process inhouse material.

If more externally granulated material is purchased additional transport logistics and costs need to be considered, along with the grade of the material. The material may need to be colour sorted and metal detected, if the supplier cannot do this and the volume is needed, additional machinery may need to be purchased.

The waste material from the colour sorter process will need to be considered and process to remove from site put in place.

Grades of material need to be considered as not all grades can be used in visual or structural products. Product testing requirements determine what grades can be used where.

Storage space and machinery space will be needed in the factory, with consideration to the 7 wastes process and reducing movement within the factory between processes.

“You can remember the seven wastes by asking, ‘who is TIM WOOD?’ Answer: Transport, Inventory, Motion, Waiting, Overproduction, Over-processing, and Defects. (this idea came from the Lean Office at Cooper Standard, Plymouth,uk)” (Bicheno John, Holweg Matthias. (2016) *The Lean Toolbox*, fifth edition, PICSIE Books, Buckingham England)

Movement of bags of recycled material will need to be considered Material Handling Equipment (MHE) such as an electric pump truck or a forklift truck will be needed, which operatives will need sufficient training on. MHE must comply with Lifting Operations and Lifting Equipment Regulations (LOLER), “requires that all equipment used for lifting is fit for purpose, appropriate for the task, suitably marked and, in many cases, subject to statutory periodic 'thorough examination'.” *Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)*

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Environmentally there are waste material storage requirements, which may need waste exemption permits. The environmental agency S2 waste exemption allows waste materials to be stored at an intermediate site before being processed – this is needed at Duraflex if off cuts are being collected from fabricators and held at Duraflex before being sent to be processed by a recycler.

www.gov.uk/guidance/s2-waste-exemption-storing-waste-in-a-secure-place

Staff will be required to run the pulveriser, granulator, and colour sorter – all will require training. Risk assessments and work instructions will be required. Maintenance will be required to service the machines at regular intervals, which will require training and spare parts to be held.

Barriers	Risks
Additional extrusion machinery needed to run tooling	Cost of new extruders or reduced capacity in factory if current extruders are used
Co-extrusion tooling needed to run core recycled material	Cost outlay
New granulator, pulveriser and colour sorter may be required to run efficiently	Cost outlay, staff capacity, staff training, maintenance training and spares.
Transportation from offsite of recycled material	Cost of transport, timing of transport.
Transportation of material on site	Capacity of MHE and skill levels of staff that will be required to use them.
Material supply	Not enough of the correct grade material to run efficiently.
Material Storage	Capacity on site, Legal requirements of material storage
Material wastes	Disposal of waste material from colour sorter.

This innovation was a staged innovation which grew over years, initially getting off site material, then bringing in house, changing tooling and implementing additional machinery. Initial pay offs were met but target have increased over the years making the innovation progress.

3. The key determinants in the process of committing to develop the innovation.

The Innovation projects could not progress without the key determinates below:

Tooling – without the co-extrusion tooling, high volume recycled material could not be processed. The tooling identified specifically were the outer frame and sash tools which are the highest volume in the factory as they are key components to manufacturing a window.

Extruder machines – without a second machine the co-extrusion part of the tooling will not work. The recycled material needs to be processed through the co-extruder to feed the core of the tool.

Recycled material - Enough supply / consistency supply is needed to make process work effectively. Although the co-extrusion tooling will run on virgin, this innovation is based on money saving, this is accomplished by using cheaper recycled material.

Pulveriser machine – this machine, although not planned into the initial innovation project has recently been found to be needed for production consistence and reduce tool wear. Without the pulveriser the volume of tool wear will increase the frequency the tool needs to be refurbished or replaced, loosing the cost savings.

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4. The processes and technologies which the company used to carry this development forward.

Greiner, an Austrian extrusion tool specialist developed core tooling, this was in-line with Greiner's "Vision 2020" program and the "plastics for Life" sustainability strategy released in 2014. ([Foreword - Greiner Sustainability Report 2020](#))

The co-extrusion tooling was first purchased by Duraflex in 2014. To run this, additional extrusion machines were needed. To reduce costs Duraflex repurposed 2 of the current extrusion machines and positioned them to enable the co-extrusion tooling to function.



A colour sorter was installed in December 2020 to remove any not white contaminants – these can be nitrile, foil, Qlon weather seal etc. The colour sorter works by scanning conveyed material and using air lines to push out any contaminants. Contaminates are then bagged and can be sold to external recyclers as 'Jazz' material. The Jazz material from the colour sorter cannot be used in Duraflex products.

Pulverising was introduced at Duraflex in 2021, material chips are taken and crushed into a finer powder. This was introduced to prevent tool wear from coarse material and to improve the processing of the material when heated in the extruder.

Metal was found to be an issue in some recycled material. When metal is processed through and extruder, it does not melt but can get stuck in the tool blocking it up. When a tool is blocked this prevents the PVC-U from coming through the tool in that area and can cause loss of features. Removing the metal from the tooling can also cause tool damage. A metal detection system was activated on the colour sorter in 2022.

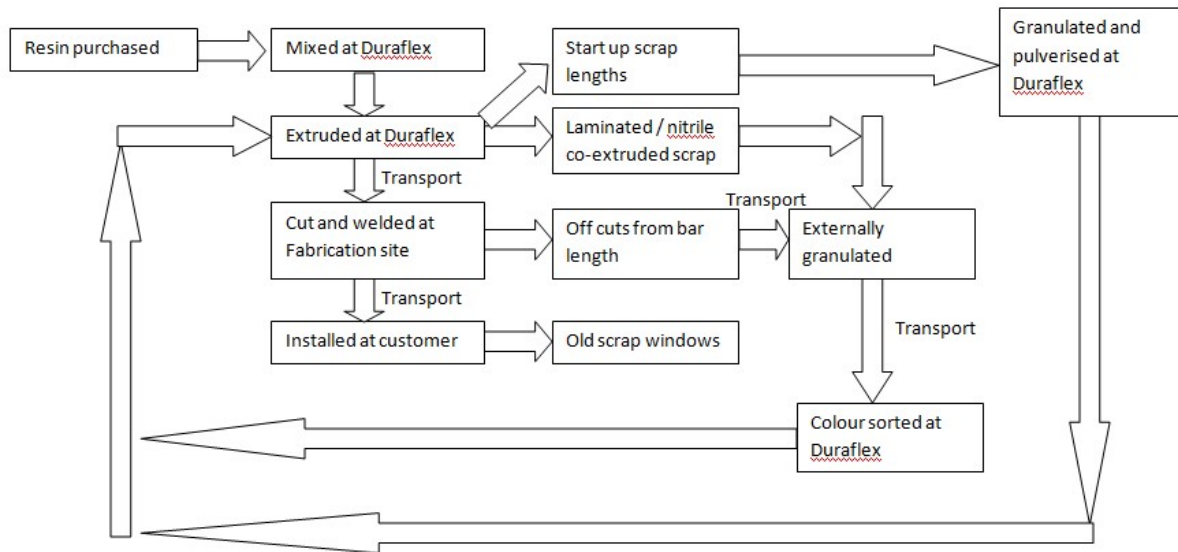
5. The extent to which the development relied on resources external to the company and the ways in which the deployment of these resources was managed.

Recyclers – Recyclers play a big part in this innovation, they allow additional recycling capacity and can remove unwanted wastes. There are 2 main recyclers used at Duraflex with Customer off cuts going to either one or the other to be processed. The relationship between the recyclers and Duraflex is good with material movements almost daily. Transport totes have been established to make collecting and transporting off cuts easier.

Customers – Customers provide the off cuts for Duraflex. The off cuts are collected from customers in set tote bins, the off cuts are weighed and the customer paid for their off cuts. This allows them a safe disposal of their waste and Duraflex a secure source of material.

Transport – Transport of the materials are carried out by Arthur Spriggs Transport. Spriggs is the transport company for all Duraflex product. As good material is shipped to the customer, Spriggs will collect the waste and transport to the recycler and pick up material before returning to Duraflex. Routes have been established to create the least amount of additional transport miles.

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6. How management overview of the development was maintained.

Duraflex managed the initial innovation through their continuous improvement process. This broke the innovation into smaller manageable projects which were led by the Engineering Manager and Technical Manager. Each achievement was logged, and savings documented.

As the company has changed over the years and ownerships have changed, so has the methods of continuous improvement. Projects are now managed from a 'project deck' with fortnightly meetings with the Senior Management Team (SMT). Projects for the project deck are defined by cost savings – a target of cost savings is set at the beginning of the year and projects to hit that target are defined and developed. Each project is assigned to a relevant manager to lead. The projects are formatted as Gantt chart. There are twice weekly general Duraflex Operational Review (DOR) meetings for general operation performance and project improvement performance.

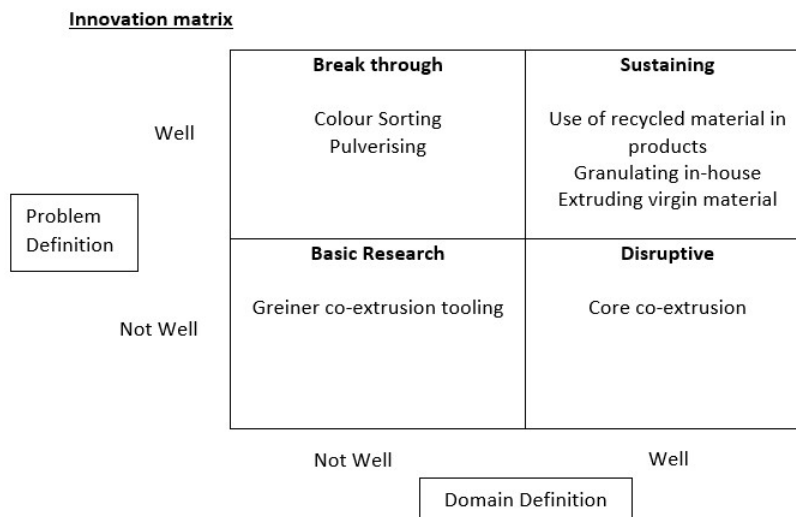
When it comes to recycled material, a target is set for how many tonnes should be used each month and is monitored from daily data inputs on the business COBRA report along with all the production output figures.

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7. The extent to which you feel this innovation process represents best practice.

Greg Satell created a matrix to define the type of innovation is needed to solve problem. Once the innovation type is defined the way to approach the innovation can then be mapped. In the case of Duraflex, the type of innovation is mainly sustaining. Duraflex has the skills and the basis of the methods to progress and improve the recycling process.

Satell, G., 2017. *Mapping innovation: A playbook for navigating a disruptive age* (Vol. 21). New York, NY: McGraw-Hill Education.

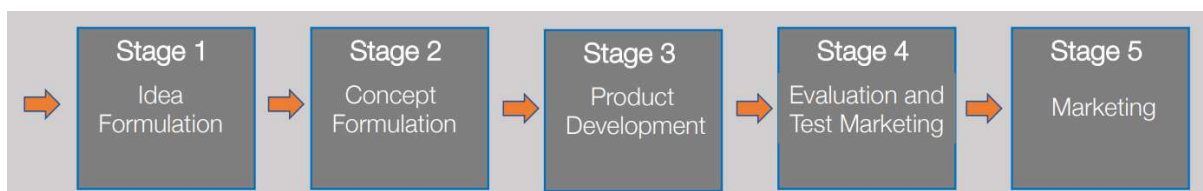


The innovation at Duraflex can be described as incremental – “do what we do, but do it better”. Paul Trott that “Incremental innovation reinforces the capabilities of established organisations.” Trott, P., 2008. *Innovation management and new product development*. Pearson education.

Tidd and Bessant talk about innovation drivers as pushes and pulls. The technology to push this innovation is the tooling and increased sources of material the pull is the cost saving driver. Joe Tidd and John Bessant (2013), *Managing Innovation: Integrating Technological, Market and Organizational Change*, 5th edition Wiley

There is no defined innovation process at Duraflex, most improvement projects are small within the business and run as Kaizen event using lean manufacturing tooling.

R. Cooper’s Stage Gate process as seen in the diagram below is followed informally a part of business improvement projects. The projects are generally run by experienced Managers and area experts.

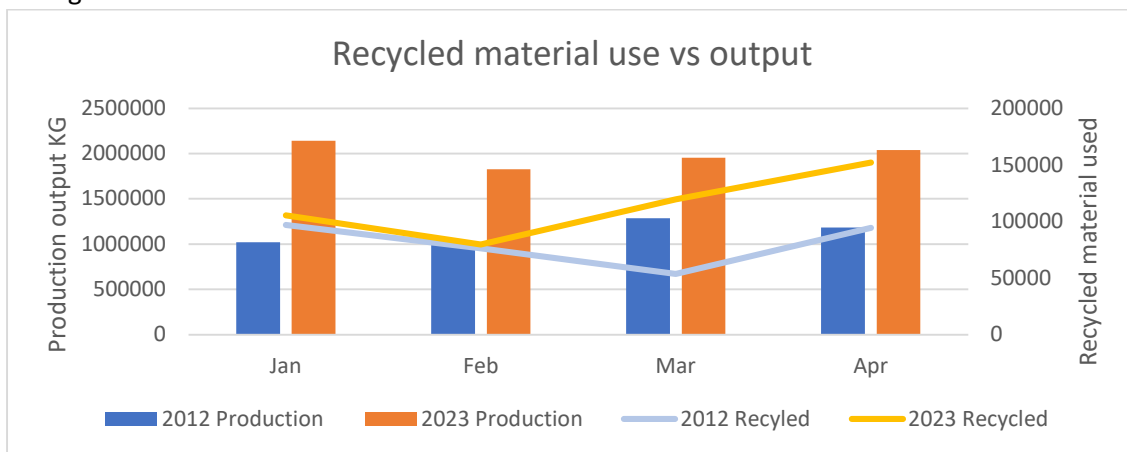


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8. Your report should also provide your own critique of the whole innovation process, and an evaluation (to the extent to which one is possible in the case of very recent innovations) of the success of your chosen innovation.

The current target of recycled material use per month is approx. 150 Tonne which based on the costs of virgin vs recycled material is a cost saving of £97,500 per month.

The Innovation has grown from in-house recycling to creating a demand for more recycled material by purchasing new tooling. This increase in demand has created the need to improve efficiency. The use of recycled material has increase from 80 tonne in 2012 to 114 tonne in 2023 (available data taken from Duraflex production records). With the increase of usage of recycled material, the cost savings also increase.



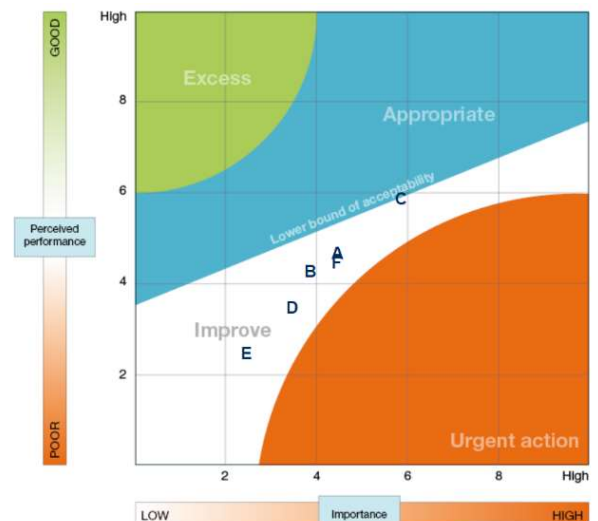
In conclusion the innovation project has met its targets and has been deemed a success. However, the lack of structure and the additional later improvements of a colour sorter and pulveriser demonstrates that the forethought and planning.

The team was led by individuals rather than a full team. This Zeus like structure has driven the innovation but has also closed any forward or outside thinking. To reduce risks a business takes when innovating the costs can be spread overtime.

When the innovation is proven, and savings have been established they can then be re-invested into the next step of innovation.

Ideally stage-gate process should be adopted which allows the involvement of others and asks questions throughout the process to ensure all aspects of the innovation and its introduction has been considered. Using the Cranford University's innovation fast audit on the current innovation strategy at Duraflex fits into the improve category. The audit tool reviews strategy, idea generation, prioritisation, implementation, people and organisation and output.

<http://www.som.cranfield.ac.uk/apps/innovationaudit/>



- A **Innovation strategy**: to what extent is there a clear, effective and communicated innovation strategy?
 B **Idea generation**: to what extent is there a positive, collaborative approach to generating customer focused ideas?
 C **Prioritisation**: to what extent are the most appropriate ideas selected for implementation?
 D **Implementation**: to what extent are ideas quickly and successfully implemented?
 E **People and organisation**: to what extent is there a culture of innovation?
 F **Output**: to what extent are the number of new products and services developed sufficient?

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References and Resources:

Patterson, Chris. (29/11/2016) *Chris Patterson Sustainability report, Duraflex PowerPoint presentation.*

Griener Co-extrusion tooling - <https://www.exelliq.com/en/extrusion-plus/co-extrusion>

Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)

www.gov.uk/guidance/s2-waste-exemption-storing-waste-in-a-secure-place

Bicheno John, Holweg Matthias. (2016) *The Lean Toolbox*, fifth edition, PICSIE Books, Buckingham England

Handy, Charles B. *Gods of management: The changing work of organizations*. Oxford University Press, USA.

[Foreword - Greiner Sustainability Report 2020 \(https://reports.greiner.com/sustainability-report-2020/en/introduction/foreword.html\)](https://reports.greiner.com/sustainability-report-2020/en/introduction/foreword.html)

Paul Trott (2012), *Innovation Management and New Product Development*, 5th edition, London: Prentice Hall.

Joe Tidd and John Bessant (2013), *Managing Innovation: Integrating Technological, Market and Organizational Change*, 5th edition Wiley. Online reference material:
<http://johnbessant.org/theinnovation-portal/>

Peter Drucker (2012) *Innovation and Entrepreneurship*, Taylor and Francis.

Satell, G., 2017. *Mapping innovation: A playbook for navigating a disruptive age* (Vol. 21). New York, NY: McGraw-Hill Education.

<http://www.som.cranfield.ac.uk/apps/innovationaudit/>

Duraflex COBRA reports