The Role of Technology Orientation in Enhancing Environmental Performance -3M case study-

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Summary: This study aimed to identify the role of technology orientation in enhancing environmental performance. 3M Company was chosen as a model for the case study. To test the study hypothesis, the study relied on the descriptive approach to analyze the company's sustainable report for the year 2020, and the annual report for the year 2019.
The study concluded that adopting a technology orientation enhances the company's environmental performance, through innovation and incorporation of cutting-edge technologies, as well as the implementation of best management practices.
Finally, suggestions were made to help companies seeking to enhance their environmental performance through technology orientation.

Keywords: 3M Company; Environmental performance; Innovation; Management practices; Technology orientation.
Jel Classification Codes : L25 ; O31 ; M1 ; O32.

I- Introduction :

After the industrial revolution, the world witnessed dramatic developments in the rates of industrial activity of companies. These developments were accompanied by an alarming depletion of natural resources, toxic emissions, in addition to industrial waste, which have adversely affected the environment and threatened various forms of life. This is what has called actors and various stakeholders such as shareholders, employees, managers, the government, NGOs, the public, industry associations, competitors, suppliers and buyers[1]; to pressure these companies to rationalize the use of natural resources and to convert to renewable natural resources, reduce emissions and industrial waste, produce environmentally friendly and recyclable products, and generally improve the environmental footprint of their activities, which in turn, enhances their environmental performance. In this context, some studies suggest that technology may be a tool, which helps companies to improve their environmental performance.

Among these studies Gholami et al. (2013), which investigated Green information system adoption as a form of technology and its relation to environmental performance, the study found that only long-term Green IS adoption was positively related to environmental performance. Klassen and Whybark (1999) explored the relationship between environmental technologies and performance, and concluded that environmental technologies, specifically prevention technologies affect both manufacturing and environmental performance. Shrivastava (1995) examined environmental technologies as another possibility of technological innovation that can produce ecological efficiencies, and enhances company's environmental performance. The results revealed that environmental technologies offer a new substantive orientation and a management process for minimizing ecological impacts of economic production while enhancing Competitiveness of companies.

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Furthermore, Shrivastava (2008) argued that with the advent of green technologies, companies could find many ways of simultaneously reducing their ecological impacts. Overall, the study of Pucci et al. (2019) took a broader perspective and investigated the impact of green technology orientation that arises from the link between technology orientation and environmental orientation, over company's environmental performance. The study showed that green technology orientation has an overall positive impact over company environmental performance, at both land and ecosystem environmental performance level and energy and emission environmental performance level.

The findings from previous studies, particularly Pucci et al. (2019) prompted this study to look into the direct impact of technology orientation on a company's environmental performance. This study, however, differs from the study of Pucci et al. (2019) in that it considers the entire technology orientation perspective (hardware and methods). Furthermore, unlike Shrivastava (2008), technology orientation in this study encompasses all of the company's technologies and practices, rather than concentrating solely on green ones. Based on the above, this research seeks to address a problem centered in a major question: Does adopting a technology orientation enhance the company's environmental performance?

Drawing from strategic and environmental management literature, the paper suggests that: Adopting a technology orientation enhances the company's environmental performance.

The remainder of the paper is structured as follows: in section 1, theoretical background of technology orientation and environmental performance will be provided. In section 2, a company overview (3M) in addition to its sustainability and technology strategy will be explained. Section 3 will discuss 3M's environmental performance by analyzing global waste disposal by type and global waste diversion by type, as well as 3M's pollution prevention achievements between 1975 and 2019. Finally, the study ends with results and suggestions.

I.1. Technology orientation

A technology-oriented company can be defined as "a company with the ability and will to acquire a substantial technological background and use it in the development of new products"[2]. In the context of environmental management, it is known as green technology orientation and is defined as "the company orientation towards the adoption of green technologies and the commitment to re-think processes, practices and decision making activities according to the goal of improving environmental performance"[3].

Furthermore, in a technology-oriented company, creativity and invention are the organizational norms and value that guide its activities and strategies[4]. In addition, extant research notes that companies that are technology oriented devote their resources to R&D, new technologies acquisition and technology capabilities development, use sophisticated technologies in new product development, are able to rapidly integrate new technologies and are proactive in developing new technologies, and also look for externally developed technologies and cooperate with third parties[5].

In this study, we refer to technology orientation as the creation, innovation, adoption, and search for best practices, methods, and technologies to improve the company's products and processes.

I. 2. Environmental performance

Pollution is one of the main indicators of environmental performance, being a classic side effect of the manufacturing process[6]. That is to say, everything related to a company's activity, whether it is a waste of resources or emissions generated during the manufacturing process...etc., that has a detrimental influence on the environment could be classified as pollution. In other words, pollution, like quality defects, indicates wasteful input consumption as well as errors in product design and manufacturing[7].

Overall, environmental performance is a multifaceted concept[8] that has been defined by several researchers. For instance, Clemens defined it as "the degree to which companies green effectiveness, responsiveness, conscientiousness and investment strategy are better for the environment than those of their competitors" [9]. It has also been defined as "a company's effectiveness in meeting and exceeding society's expectations with respect to concerns for the natural environment" [10]. Moreover, a more comprehensive view refers to it as "following the governmental environmental regulations, reducing emission of pollutions (e.g., CO2 and CFC), increasing usage of recycled materials, and controlling the usage and storage of hazardous materials"[11].

Based on the above we define environmental performance as a company's efforts to reduce the environmental footprint of its operations and products.

I.3 Company overview

3M is a diversified technology company with a global presence in the following businesses: Safety and Industrial; Transportation and Electronics; Health Care; and Consumer. In the U.S., 3M's general offices, company research laboratories, and certain division laboratories are located in St. Paul, Minnesota. The Company operates 71 manufacturing facilities in 29 states. Internationally, the Company operates 100 manufacturing and converting facilities in 35 countries[12]. In all, 3M has 96.000 employees worldwide[13].

3M has a Value Model (see Fig.1) that sets it apart from competitors. It is how the company provides exceptional value to customers while also generating superior returns for shareholders. The model is based on four elements: 3M vision, 3M strengths, 3M priorities, and 3M values. Furthermore, the Value Model outlines the Company's long-term strategy[14].

3M's vision is the first element of the Value Model, which guides everything the company does: 3M Technology Advancing Every Company, 3M Products Enhancing Every Home, 3M Innovation Improving Every Life. The second element is 3M's strengths, which allow the company to continue to evolve in order to provide differentiated value to customers while growing at above-market rates. They also allow it to capitalize on shifts in consumer preferences, technology, and marketing channels. The third element is 3M goals, which place the company for long-term growth and success by demonstrating how it is continually changing to expand on its strong base.

The fourth factor is 3M Values, which unite all 3M employees – through business groups and geographies – as one 3M. They involve company leadership behaviors, or how the company wants its leaders to behave in order to drive success, develop others, and win in the marketplace[15]. The Value Model establishes a connection between 3M's vision, its core strengths, the company's priorities, and its values[16].

I.4 Sustainability at 3M

The 3M Vision of advancing every company, enhancing every home, and improving every life inspires and motivates the company. This vision demonstrates the company's commitment to sustainability. Its mission-driven creativity is anchored in products, manufacturing processes, and emerging technologies[17]. Furthermore, just as sustainability is ingrained in the Value Model, sustainable thinking is incorporated in the heart of 3M and the strategic planning process that the company employs in every field, sector, and industry.

3M has dedicated sustainability leaders in each of its business groups and regions, who create a relevant and well-informed plan tailored to their consumer needs and business goals. Furthermore, as a broad and diverse global science company with customers from a wide range of sectors and global markets, 3M has the potential to make an even greater contribution to sustainability[18].

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From its pioneering Pollution Prevention Pays program, which began in 1975, to its increasingly ambitious collection of 2025 Sustainability Targets, which are designed to reduce 3M's own footprint, assist customers in meeting their own sustainability goals, and push progress on global environmental and social issues, 3M has a long history of dedication to sustainability. 3M documents these efforts in its annual sustainability report[19]. Further to that, 3M sees it as its duty to create goods that are better for the environment during their entire life cycle, which includes raw material selection, product design, formulation, production, marketing, sale, expected and anticipated usage or misuse, recycle, reuse, repurpose, and disposal[20].

3M's sustainability is led by the Innovation Steering Committee and supervised by the Science, Technology, and Sustainability Committee, which was created in November 2019 by the 3M Board of Directors to provide general oversight of the significant scientific and technological aspects of 3M Company's businesses, as well as the Company's sustainability and stewardship activities. The Committee will examine the company's sustainability policies and initiatives, defining and reviewing important sustainability, material vulnerability, and geopolitical concerns that could have an effect on overall business policy, global business continuity, and financial performance[21].

I.5 Technology at 3M

Science at 3M evolves at the same rate as society's challenges. The business is constantly developing and adapting its solutions to help solve current and future problems. 3M's Periodic Table of Technology Platforms (see fig.2) was developed 13 years ago, and it was revised in 2019 to ensure it correctly represented 3M's focus and investment in future technologies. Using the 51 Technology Platforms and collaborative culture, 3M’s employees apply their creativity to combine technologies across industries, creating new solutions for customers and society, all in the context of the general welfare[22]. The table, which was originally generated in 2006 with 44 elements, now has a grand total of 51 elements. The elements reflect the materials, processing, capabilities, digital technologies, and applications that 3M uniquely and creatively combines to generate value for its customers[23].

Every day, 3M combines and employs its 51 Technology Platforms as the company continuously innovates to create a future of clean, affordable, dependable, and ubiquitous energy[24] as illustrated in the following examples. In terms of materials, 3M's Porous Materials & Membranes platform ensures that water, air, and other fluids can be handled in an efficient and cost-effective manner to achieve the necessary fluid quality. In terms of processing, 3M leverages its Thin Film & Plasma Processing platform to produce products with unique durability, reflectivity, barrier, and chemical properties. In terms of capabilities, 3M leverages its Sustainable Design capability of its products, processes, and packaging to avoid materials that adversely impact health/environment, Minimize waste energy, water, and air/water emissions, and facilitate product disassembly and recycling. In terms of digital, 3M leverages its Electronic Systems platform to create smart materials, smart devices, and smart systems, all while providing a smart service[25]. In terms of applications, 3M leverages its Light Management platform to provide innovative solutions that lower the cost and increase the reliability of solar energy systems[26].

3M operations combine 51 unique Technology Platforms to manufacture over 55,000 products that are sold in nearly every country. 3M’s 51 Technology Platforms are shared and combined across businesses and regions to create one-of-a-kind products for a wide range of industries. They are owned by the company and can be used by any of the businesses to support their clients or markets[27].

The Strategic Sustainability Framework of 3M offers a guiding structure and focus for its ongoing environmental and social commitments and actions. The company's Sustainability Goals are aligned with its Strategic Sustainability Framework and arranged to assist in the advancement of its efforts under three pillars: Science for Circular, Science for Climate and Science for

Community[28], while Building on its global capabilities and diverse technologies. These pillars or priority areas can be described as follows[29]:

A-Science for Circular: In this area, 3M develops solutions that accomplish more with less material, contributing to the advancement of a global circular economy, which includes developing solutions that keep goods in use rather than generating waste.

B-Science for Climate: 3M innovates in this area to help decarbonize manufacturing, drive global climate solutions, and reduce its environmental footprint.

C-Science for Community: In this area, 3M uses science to make the world a better place and to motivate people to join the company.

These target areas guide 3M's business decisions and strategy, as well as how it focuses its community impact activities locally and globally[30]. However, for the purpose of this study, we will highlight 3M environmental achievements in Science for Circular and Science for Climate areas only, since they best represent 3M's environmental performance in terms of climate and recycling.

II– Methods and Materials:

To obtain the theoretical background of the study, a desk survey of the original previous studies that are directly related to the topic was carried out. In the practical side, the descriptive approach based on quantitative analysis was adopted to track the most important environmental performance indicators of the company under study (3M), and it was supported by qualitative analysis to diagnose the value model of the company; which links the company's vision with its core strengths, priorities, and values, in addition to examining the periodic table of 3M's technology platforms and determining its role in enhancing its environmental performance. The data used in the practical side have been collected from 3M's official reports, including the 2020 sustainability report and the 2019 annual report.

III- Results and discussion :

To adequately provide the environmental results achieved by 3M through its dependence on its strengths, the most essential of which is technology, it will be divided into three segments: the first segment will provide the environmental results of 3M's main plants. The second segment will present the environmental results achieved by the company in two pillars (science for circular and science for climate). In the third segment, graphic representations that describe pollution at 3M as a whole will be analyzed.

III.1 3M's main plants environmental results

3M has taken a comprehensive approach to minimizing its energy footprint, which involves assessing the effect of its products, manufacturing processes, equipment, and sites, as well as reducing the energy footprint of its current manufacturing and administrative sites. This approach has led 3M to enhance its environmental footprint across its main sites including[31]:

A-3M's plant in Columbia Missouri stopped delivering waste to the local landfill in September 2018 and is now a "zero landfill[32]" approved site, removing 180 tons of landfill waste from the Columbia landfill per year.

B- Advanced coating equipment, fully automatic warehousing, quality control labs, and research & development labs are all available at GTA's Kuan-Yin manufacturing facility. These manufactures make packaging tapes without the use of solvents and masking tapes using innovative coating machinery that can collect and reuse more than 99 percent of solvents, resulting in significant reductions in volatile organic compound (VOC[33]) usage and emissions.

C-3M's plant at Springfield reduced its environmental performance through multiple projects, such as replacing light fixtures with LED lighting, installing light sensors in the

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warehouse to turn off lights when no one is present, and identifying air leaks to minimize the running periods of air compressors, the actions have reduced energy usage at the site. The Quality Department at 3m Springfield changed its systems to employ an energy-saving, on-demand water heater system.

D-3M's IMPD California plant energized a 1-megawatt solar array that provides 20% of the electrical power required by the plant. In addition, all forms of the mined rock are used in 3M products or in the aggregate industry, resulting in no mineral waste generated.

E-For a 7.3 percent reduction in energy intensity between 2015 and 2017, 3M's Nevada, Missouri plant received the 2018 3M Plant Energy Platinum Level Award. Energy use per pound of product was reduced by 6.1 percent as a result of energy conservation efforts. Furthermore, from 2018 to 2019, Plant engineers submitted over 30 3P projects, resulting in the diversion of 1,316 tons of waste from landfills.

From the foregoing, it can be said that each plant enhanced its environmental footprint in a different way, such as by reducing waste, lowering volatile organic compound usage and emissions, and optimizing energy use at the site; as a result, the company's overall environmental footprint was improved.

III.2 3M's pillars environmental results in 2019

As mentioned before, 3M has focused its sustainability efforts on three pillars that represent the company's strategic sustainability framework. In this segment, we will only provide the results of the pillars related to the environment namely science for circular and science for climate.

In science for circular, 3M achieved the following results[34]:
• 100% Sustainability Value Commitment[35] goal for new products in 2019;
• Reduced manufacturing waste by 12.6%, indexed to sales; exceeding goal of 10%;
• Moved to 35.4% (69 manufacturing sites) zero landfill; exceeding goal of 30% of manufacturing sites;
• Increased water efficiency by 5.76%, indexed to sales; working toward goal of 10% reduction;
• Engaged with 100% of sites (18 sites) located in water stress/scarce areas; maintaining goal of engaging with 100% of communities;
• Decreased total water consumption by 43.3% between 2005 and 2019;
• Decreased waste, indexed to net sales, by 32.9% since 2005;
• More than 169 metric tons of solid waste reduction in 2019 in sites across Brazil, India, Poland, and Mexico;
• Reduction of packaging weight by more than 1,300 metric tons;
• Prevention of more than 2.66 million short tons of pollutants and saved over $2.30 billion in the last 45 years;
• Moved 35% of manufacturing sites to zero waste.

In science for climate, 3M achieved the following results[36]:
• Improved energy efficiency by 3.2%, indexed to sales; behind goal of 30% improvement;
• Increased renewable energy footprint to 32.6%, total electricity use;
• Reduction in Scope 1[37] and 2[38] emissions by 68.1% below baseline; ahead of goal of 50% below baseline;
• Over 58.3 million metric tons CO_2 equivalent customer avoided emissions.

According to the above, we conclude that 3M has achieved great results in terms of circularity and climate through the adoption of innovative methods that seek sustainability at all levels. For example, the company increased the usage of renewable and recycled raw materials through product design and operational considerations that helps assure its products support the circular economy. The company also continued optimizing packaging used for inter-company, international shipping, aiming to shift from single-use wood crate and core to a reusable steel rack

and core. Moreover, 3M has increased its waste disposal efficiency by adopting standards such as Disposal of Chemical Waste Standard that calls for appropriate management and disposal of chemical waste to manage risks and protect the environment, by reducing the amount and hazards of waste materials generated, recycling or reusing those materials whenever practical, and by controlling waste disposal through final disposition.

III.3 3M's pollution analysis

In this segment, and in order to provide a better understanding of 3M's environmental performance improvements, we will analyze three different graphic representations including global waste diversion by type (see fig.3), global waste by disposal type (see fig.4), 3P global pollution prevention achievements between 1975 and 2019 (see fig.5). After that, potential reasons for these achievements will be provided.

We can see from fig.3 (see appendices) that 3M has improved its waste diversion volume. The global waste diversion volume has risen from 300.000 metric tons in 2015 to approximately 320.000 metric tons in 2019. Although the diversion of waste to energy largely contributed to this rise, but offsite recycle denotes the largest volume of diverted pollution. 3M attained these results by incorporating waste management practices into its operations, such as the use of reusable, renewable, and recyclable materials.

Based on fig.4 (see appendices), 3M's global waste has decreased from nearly 160.000 metric tons in 2015 to less than 145.000 metric tons in 2019. The decline in waste disposal by landfill accounted for a significant portion of this reduction. 3M achieved these results by adopting the "zero landfill" status which reduced the volume of operations waste sent to landfills resulting in 35.4 percent of 3M sites had achieved zero landfill status by the end of 2019. Moreover, the "zero waste" thinking with 3M's product designs and process technologies also contributed in decreasing the amount of materials sent to incineration and landfill.

According to fig.5 (see appendices), 3M has made significant strides in pollution prevention. The company has increased its global pollution prevention (air, waste, and water) pollution from less than 100,000 short tons in 1975 to more than 2,500,000 short tons in 2019. We also note that waste pollution prevention contributed significantly to this increase, whereas water pollution prevention contributed the least. These results were mainly achieved through the implementation of the pollution prevention pays (3P) program in 1975, which drove the company's efforts toward the invention and adoption of more sustainable solutions.

Employees at 3M will enter pollution prevention ideas for air, waste, and water pollution into the 3M pollution prevention system, as well as any obstacles to implementation. Engineers, developers, and managers can see potential in any of the 3M Periodic table of technology platforms. This visibility allows the company to gain a better understanding of pollution prevention and mitigation opportunities. This system is used by 3M to create, identify, and share best management practices and technologies for pollution prevention and reduction[39]. This approach has resulted in attaining significant results in several areas and at all levels as mentioned earlier.

IV- Conclusion:

Sustainability is at the heart of 3M, and it is shown by the company vision of advancing every company, enhancing every home and improving every life. This vision encompasses the company's own goals and the ones of its stakeholders. From another point of view, 3M is a large and diverse company; therefore, it has the potential to protect and damage the environment.

However, since the company is dedicated to its stakeholders and the world as a whole, it should strive to reduce its environmental footprint and contribute in every way possible to continuously driving the world toward a future of clean, inexpensive, reliable, and ubiquitous energy, and achieving sustainability on all fronts. One way to do so is to innovate and incorporate cutting-edge technologies, as well as to implement best management practices that result in improved

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environmental performance. At 3M, this was made possible through its periodic table of technology platforms that contains 51 technology platforms organized into five categories: materials, processing, capabilities, digital, and applications, and which can be used by all 3M's four businesses. Each technology platform has distinctive features that 3M employees use alone or in combination with other technology platforms to provide more sustainable solutions to various problems, with a focus on environmental issues. The findings of the study supported the hypothesis that adopting a technology orientation enhances a company's environmental performance.

The study yielded a number of results, the most noteworthy of which are:

- 3M's technology orientation, which is based on a clear vision that encompasses environmental and social values, has played a critical role in improving the company's environmental performance, as the company relies on modern technologies to achieve its sustainability goals and beyond;
- To be a leader in environmental sustainability, 3M has focused its efforts on three areas: Science for Circulars, Science for Climate, and Science for Community, based on an integrated system guided by the company's vision and values, and by leveraging its strengths, on top of which is technology embodied in the periodic table of technology platforms.
- Thanks to its technology orientation, 3M has been able to accomplish industry-leading environmental improvements and attain environmental results that are difficult for competitors to match. Consequently, 3M is regarded as a model to be emulated in the environmental sustainability of industrial companies;
- 3M has proven its ability to transform diverse ideas and creativity into advanced technologies, commercial assets and innovative product platforms by designing a periodic table of 51 technology platforms which reflect materials, processing, capabilities, digital technologies, and applications;
- 3M supported its technology with deep intellectual property, combined with multiple other technologies to enable it to do unique things, particularly in terms of its environmental footprint.

3M is well-known for its environmental leadership, which began in 1975 with the pollution prevention pays program, which changed many ideas and behaviors Therefore, it is fair to say that 3M has put in a lot of work and effort to fulfill its sustainability goals, and it is always striving to improve in the future. For that reason, we believe that all companies should follow suit, in order to meet the needs of the current generation while preserving the rights of future ones.

To conclude, companies seeking to enhance their environmental performance through technology orientation should consider the following recommendations as part of their strategy:

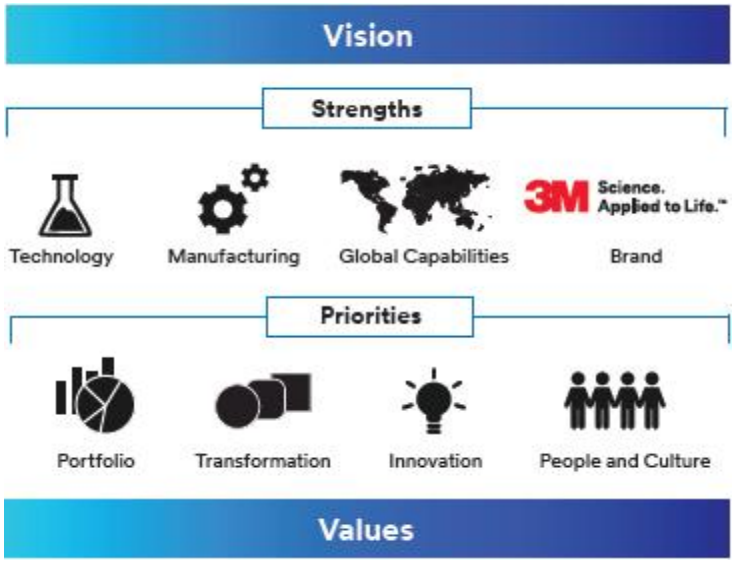
- ✓ Devoting more resources to research and development activities;
- ✓ Develop the appropriate organizational climate for employees to create and innovate;
- ✓ Training and educating employees of different levels and occupations about the value of sustainability and strategies for achieving it;
- ✓ Taking advantage of the expertise of companies who have achieved obvious improvements in terms of increasing their environmental performance;
- ✓ Fostering relationships with various stakeholders by increasing their involvement in company's decisions, particularly those affecting the environment;
- ✓ Attracting individuals with advanced knowledge of technology and its use; to boost the company's environmental performance;
- ✓ Selecting leaders with advanced backgrounds and expertise in sustainability and technology;
- ✓ Establishing collaborations with a variety of companies and research centers in order to profit from the most recent advances in technology, as well as collaborating with them to reduce the environmental effects of these technologies.

This study, like any other, has its limitations. For instance, the research was limited to a single case study. Furthermore, this study relied solely on company reports, namely the sustainability report and the annual report. In order to obtain more accurate results, future studies

should empirically investigate the relationship between technology orientation and environmental performance.

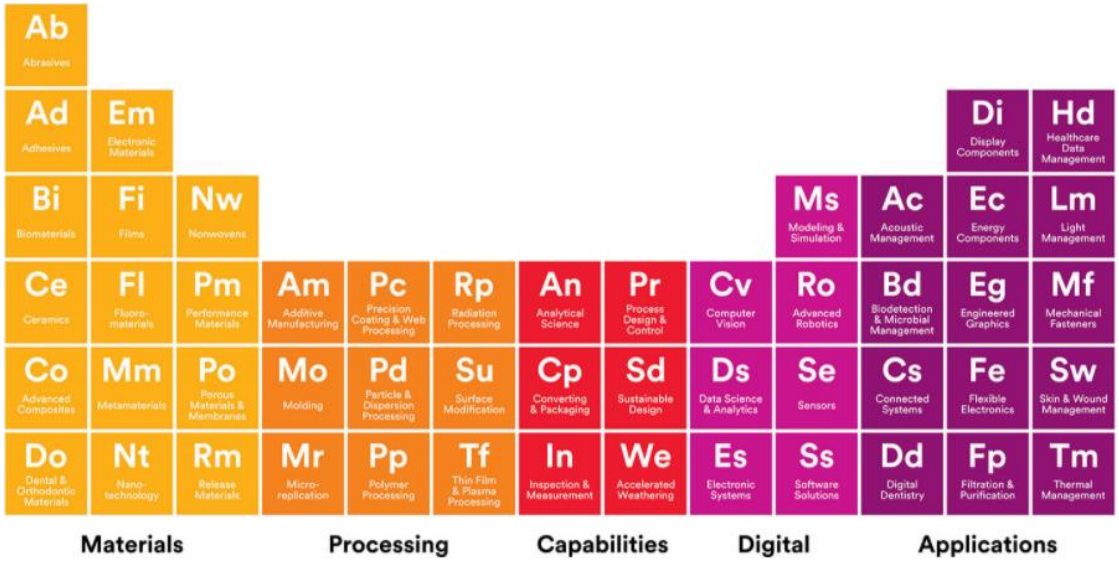
- Appendices:

Figure (1): 3M's Value Model



The source: (3M Corporation, 2021a)

Figure (2): 3M's Periodic Table of Technology Platforms



The source: (3M Corporation, 2021b)

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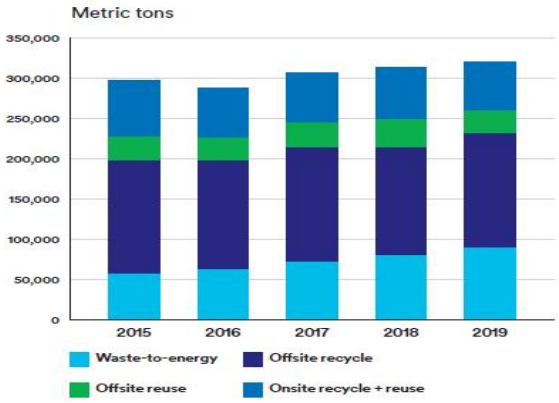
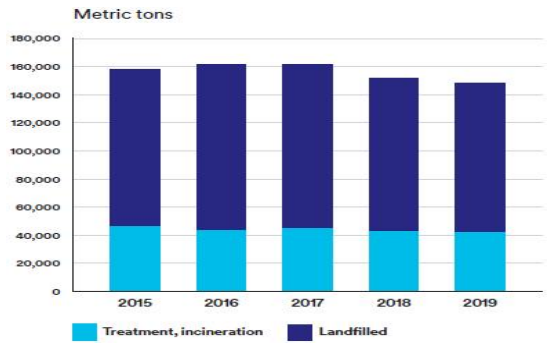
Figure (3): Global Waste diversion by type



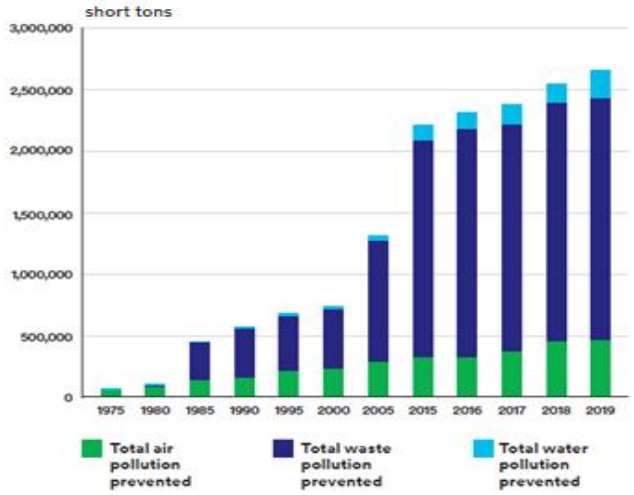
The source: (3M Corporation, 2020a)

Figure (4): Global Waste by disposal type



The source: (3M Corporation, 2020a)

Figure (5): 3P Global Pollution Prevention Achievements (1975-2019)



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30 Idem.

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31 3M Corporation. (2020a), Op.cit.

32 Zero landfill means no byproduct is sent directly to a landfill from a 3M manufacturing site in a calendar year.

33 Emissions that are primarily attributed to coating lines, Reactors and mixing.

34 3M Corporation. (2020a), Op.cit.

35 Requires all new products going through 3M's new product commercialization process to show how they contribute to the greater good.

36 3M Corporation. (2020a), Op.cit.

37 A company's direct emissions from sources it owns or controls. Examples include a company's facilities and owned vehicles.

38 All indirect emissions from the generation of energy purchased by the company.

39 3M Corporation. (2020a), Op.cit, P151.

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