CIRCULAR ECONOMY CALCULATOR – DATA ANALYSIS AND VISUALIZATION

A Thesis

by

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ABSTRACT

Circular Economy (CE) has been a popular topic in many countries where its primary purpose is to push for a green, cyclical use of energy and material resources and diminish the challenges arising from limited resources, excessive waste and greenhouse gas (GHG) emissions. Many business corporations can start addressing these challenges by creating a supply chain that is working towards CE. A supply chain model contains every stage required to make and deliver products or services for the consumer. It is beneficial for a company to measure their CE performance as it tracks the waste and pollution, the lifespan of products and materials, helps aim towards a regenerative and restorative economy.

Metrics and specific indicators have been established to be used as measurements for CE. Because past studies and research have only focused on measuring CE at a national or product level, there is still ambiguity on which exact metrics are needed to measure CE in a business or supply chain level. This research is focused on delivering the metrics and indicators needed to measure CE at a business level and demonstrate visuals and analyzed data for a business. This will allow companies and small businesses to be more informed on their path to CE, contain visuals of the company's energy consumption and track to CE, and have a record over their consumption on energy, waste, water, and GHG emissions to be able to compare and contrast with other companies. It will be able to compare the circularity of a company over a period of 5 years to other companies by adding the graphs and diagrams that track their performance. This will allow the shift and transition towards circular economy as companies will be able to see their progress and the areas that need improvement to reduce carbon emissions. By tracking their progress, companies will be able to eventually redesign their products and materials to increase the durability and reuse of it. With companies tracking their circularity and acting on it, the energy consumption can decrease and the product value can increase.

Keywords: Circular Economy (CE), energy, indicators, business, economy, GHG emissions

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1. INTRODUCTION

In many modern societies, such as the United States of America, businesses have an impact on the country's economy and environment. These modern societies have relied on energy throughout their life and know it is an immediate supply in their country, but the American consumer does not realize the usage of non-renewable energy (such as fossil fuels) is not only running out, but also, negatively impacting the environment.

1.1.1. Challenges and Motivations

In a Sandford article, "When Fossil Fuels Run Out What Then?", the Millennium Alliance for Humanity and Biosphere (MAHB) Admin states, "Taking into consideration the current rate of natural gas production and current natural gas reserves, we have about 52.8 years' worth of natural gas reserves left" (Kuo 2019). Many corporations contribute to the CO_2 emission by burning fossil fuels; this is also contributing to global warming (Kuo 2019). Adapting Circular Economy could help these modern societies eliminate pollution, regenerate natural resources, and eliminate waste.

Circular Economy has been implemented into business core practices in the United Kingdom and China (MacArthur 2018). Both of these countries have signed a joint Memorandum of Understanding on Circular Economy Cooperation; this means that they will both align policies that support to a circular economy to transition towards a low carbon, regenerative economy (MacArthur 2018).

According to a 2015 Ellen MacArthur Foundation report, Europe's GDP could increase by €0.9 trillion by 2030 with the transition to a Circular Economy (MacArthur 2018). Additionally, it will also reduce carbon dioxide emissions by 50% compared with current levels (MacArthur 2018). Circular Economy is constructed not only for manufacturing companies, but service companies as well.

1.1.2. Objective

It is important to know how Circular Economy focuses the full life cycle of business practices and works on improving them. Because every business and organization uses energy and resources, every business and organization can adapt and implement Circular Economy's principles in order to eliminate transition to regenerative economy and clean environment. In this thesis, the different aspects of Circular Economy will be explained and demonstrate how American businesses are rated through those specific aspects. This tool and method will serve as a guidance for the American companies to compare themselves with each other and see how they can contribute towards a low carbon, regenerative economy.

2. LITERATURE REVIEW

2.1. Circular Economy

Because CE is a new and ambiguous concept, there is not one solid definition for it (Saidani, 2019). Saidani mentioned that Kirchherr reviewed 114 circular economy definitions and it had a total of over 17 different dimensions for it. This article refers to the CE definition of "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes". CE uses three levels: micro-level, meso level, and macro level. Micro-level refers to the products, companies, and consumers, meso level refers to the eco-industrial parks, and macro-level refers to the city, region, nation, and beyond. The purpose of CE is to achieve sustainable development, therefore simultaneously creating environmental quality, economic prosperity, and social equity (Saidani, 2019).

2.1.1. Linear Economy

In the past recent years, studies have shown that our current socioeconomic system will soon lead to shortage in energy recourses (Reike et al. 2018). This system is known as Linear Economy (LE). LE is a simple flow that starts with the producer producing their products. Then, the consumers use those products and finally, dispose of them once they are no longer in use. This system ultimately leads to needless resource losses through "production chain and end-of-life waste, excessive energy use and erosion of ecosystems" (Michelini, 2017). This caused some countries to act and change their socioeconomic system to a model that will be resource efficient. The European Union (EU) was one of the first countries to act on this issue and ultimately regenerate to CE by changing their policies. The flow difference between LE and CE can be seen in Figure 1.

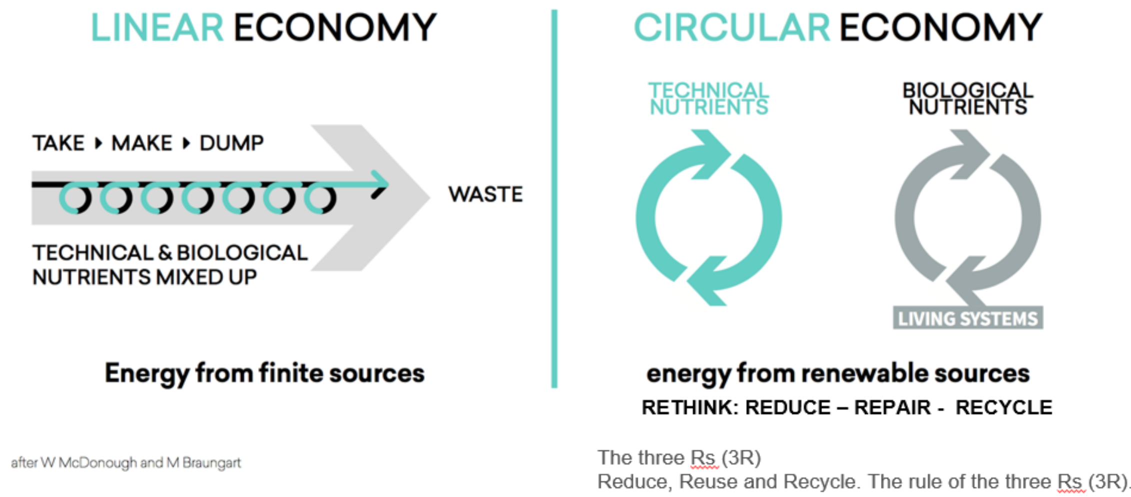


Figure 1 Linear Economy vs. Circular Economy (Image source: Sustainability Guide Website [1]).

2.2. Economic Standpoint

Although Linear Economy and Circular Economy both have strategies to maintain a stable economy, the one that is pushed towards when it comes to benefiting the economy is Circular Economy. This is because CE is able to keep resources longer than usual so they can be reused and therefore increase the recourses' value (Di Maio, 2017).

Linear Economy has a current approach of "take-make-dispose," but experts have calculated that that approach will result in current and future resources being insufficient amount of for this global population in the quality of a modern, developed world. Because of this, it was necessary to develop a model where waste and bio-feedstock will be reused as inputs—now, known as Circular Economy. This will also help businesses increase the value of the natural resources they currently use compared to the linear economy model where resources were disposed instead of being reused (Di Maio, 2017).

When businesses or organizations are in the process of decision making, economic value is a great indicator because it measures resource efficiency and it also addresses the weakness. The economic value of a resource will not only represent quantity but quality as well (Mayer et al. 2019).

Additionally, as mentioned by Di Maio, it is better to use value-based performance indicators because they better aligned with policies and strategies, which makes them more effective in policymaking and management (Di Maio, 2017). Policymakers will also be able to identify stressed resources to increase recourse efficiency.

Transitioning to CE will not only increase products and materials lifespan, but it will also offer a $4.5 trillion economic opportunity by “reducing waste, stimulating innovation and creating employment” (McGinty 2021). It is important for businesses to create new business models (transitioning from linear to CE) to include the reusing or innovative use of secondary products and materials.

This will not only benefit the environment but also benefit the economy by increasing the number of jobs in the recycling and sustainability field. As described by McGinty, transitioning to CE, could increase jobs by 6 million by 2030 (McGinty 2021). However, CE does not only provide a boost in the economy, but also business that transition towards CE can also benefit. According to Wright, there are $3.2 trillion worth of materials used in the consumer good industry, but only 20 percent of the materials are recovered (Wright 2021). Businesses can reduce their operational cost by reusing their materials instead of practicing what they do now: create new materials and discard the old materials. Additionally, companies risk themselves by relying on products and materials that can only be obtained from one place because of unexpected geopolitical or environmental crises that will make the products and materials unavailable to them. Instead of relying on other sources for their materials, companies can focus on gaining control over their resource supply and cycles (Wright 2021). This will lead to companies being more independent and sustainable.

2.3. Measuring Circular Economy

2.3.1. Benefits of Measuring Circular Economy

It is beneficial for a company to measure their CE performance as it tracks the waste and pollution, the lifespan of products and materials, helps aim towards a regenerative and restorative economy. By tracking their progress, companies will be able to eventually redesign their products and materials to increase the durability and reuse of it. Additionally, the companies policymakers will be able to see the areas that need improvement; this is beneficial because they can focus on those areas to progress their circularity.

2.3.2. Different Tools to Measure Circular Economy

Circular Economy has been a common topic that pushes for a green, cyclical use of energy resources to benefit the economy, businesses, society, and the environment. Although CE does not have one direct concept, it is agreed that CE is designed as an action plan supported by particular indicators (Moraga, 2019).

2.3.2.1. Method 1: Tools to Measure CE

Because CE is approached as an umbrella concept instead of a "one" definition, it is difficult to specify measuring indicators; however, Moraga grouped "What to measure?" and "How to measure?" as broad indicators. To find out the *what* in the question, CE has to be defined and grouped under *sensu stricto* or *sensu latu* (Moraga, 2019) where *sensu stricto* is more narrow focus and focuses on long-life goods and increasing the life of a product. *Sensu latu* is seen as the economic model that thrives for sustainability and positive impacts on the economy, environment, and society. Afterwards, the measurement type is then decided and finishes off listing the CE Strategies (Figure 2).

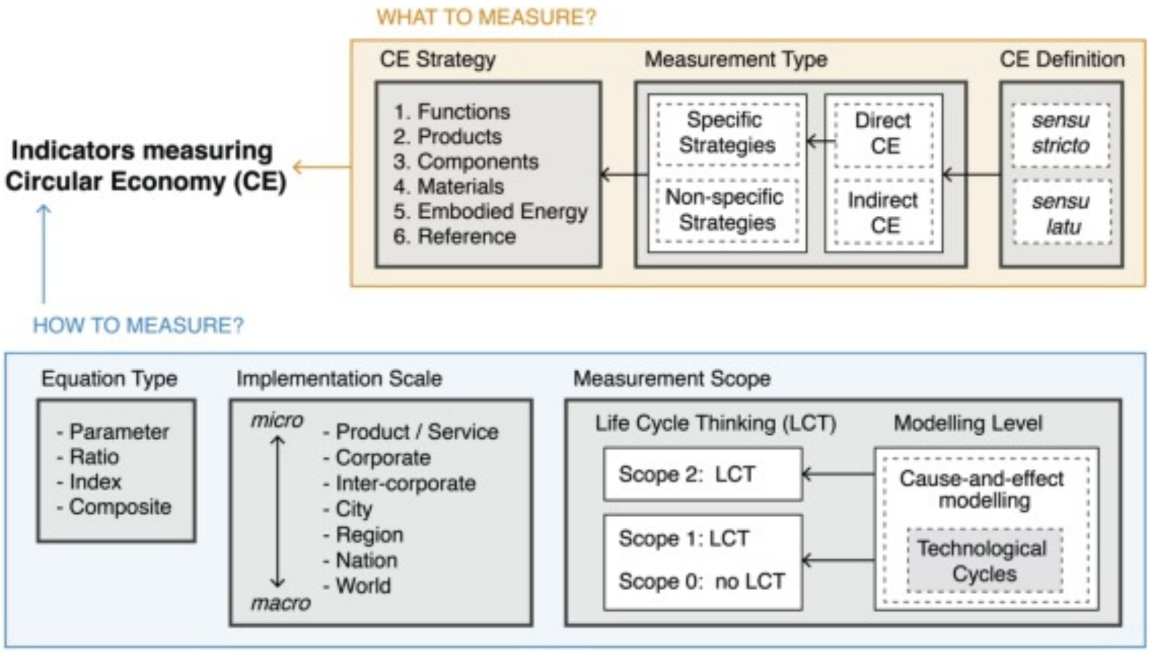


Figure 2 Classification framework for Circular Economy indicators. (Image source: Resources, Conservation and Recycling Water [2]).

2.3.2.2. Method 2: Tools to Measure Circular Economy

In Elia's et al. 2018, the new CE paradigm introduces a different perspective to view the industrial ecosystem. Within the system, the economic growth is "decouple from resource consumption and pollutant emissions as end-of-life materials and products are conceived as resources rather than waste". In other words, the loops of materials must be closed, and the need for raw materials and waste disposal need to be reduced. Because the CE paradigm's issues must be evaluated and analyzed, a four-level framework has been created. The framework's four levels are to the processes to monitor, the actions involved, the requirements to be measured, and the implementation levels of the CE paradigm (Figure 3).

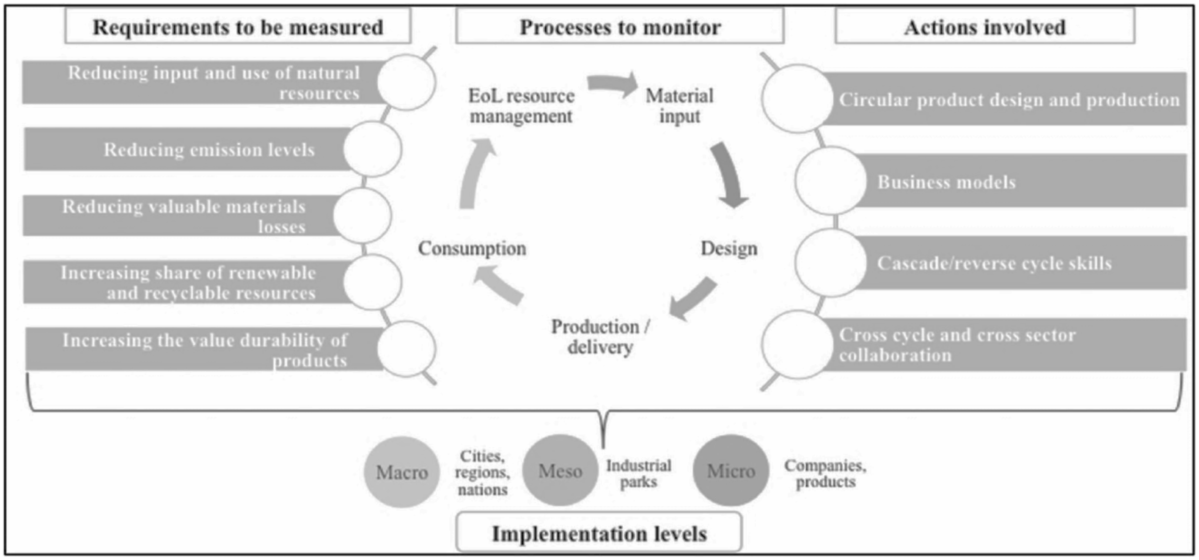


Figure 3 The Circular Economy framework (Image source: Journal of Cleaner Production Website [3]).

As the research for CE expands, there are different indicators selected and used to measure the effectiveness of CE. Elia et al. focused on methods constructed on a life cycle approach and adopted on a standardized approach through a product-level. The taxonomy of index-based methodologies was developed on two factors: the index-based method typology and the parameter(s) to be measured. They include four parameters are then subcategorized by using a “single indicator” or “multiple indicators.” The four parameters include: i) Material flow, ii) Energy Glow, iii) Land use & consumption, and iv) Other life cycle based. Majority of the parameters had several single indicators. Table 1 presents a summary of the techniques along with a description and possible impact to effectively measure the CE by Elia (2018).

Table 1 The proposed taxonomy of index-based methodologies

Parameter / Type	Single Indicator	Multiple Indicators
Material Flow	1.Water Footprint 2.Material Input per Unit of Service 3.Ecological Rucksack	1.Material Flow Analysis 2. Substance Flow Analysis
Energy Glow	1.Cumulative Energy Demand 2.Embodied Energy 3.Energy Analysis 4.Exergy Analysis	
Land use & Consumption	1.Ecological Footprint 2. Sustainable Process Index 3. Dissipation Area Index	
Other Life Cycle Based	1. Carbon Footprint 2. Ecosystem Damage Potential	1. Life Cycle Assessment 2. Environmental Performance Strategy Map 3. Sustainable Environmental Performance Indicator

(Image source: Journal of Cleaner Production Website [4]).

Based on both methods, we can identify the three different scales being mentioned: micro, meso, and macro. Micro-level focuses on a single product, consumer, or company. Meso-level is for industrial parks, and macro-level is for cities, regions, or nations. In terms of CE, micro is the scale that incorporates the circularity in a product or company level. However, because the topic of CE is still a new concept, there are selected indicators to use only in the product-level and not in the company level. It is important to measure CE in a company level as this will help a company analyze their progress towards sustainability along with comparing their circularity with other companies. Additionally, measuring CE will guide towards the industries that need extra resources to improve their transition towards CE. With companies tracking their circularity, they will only see areas that need improvement, which results in a step closer to the CE.

3. METHODOLOGY

The project's objective is focused on building on a new tool to compute the circular economy for small and large businesses and manufactures. The five principal categories below are the different C.E. indicators selected to measure the circularity of businesses and organizations. These include 1) energy, 2) Greenhouse gas (GHG) emissions, 3) Water, Procurement, Material 4) waste and 5) durability.

3.1. Indicators to Measure Circular Economy

Table 2 Selected Indicators to Measure C.E. with Characteristics

C.E. Indicators	C.E. Characteristics
1. Energy	a. Total Energy Consumed b. Total Renewable Energy Consumed c. Total Energy Generated d. Total Renewable Energy Consumed
2. Greenhouse Gas (GHG) Emissions	a. Total Energy Direct GHG emissions b. Total Energy indirect GHG emissions c. CO_2 Offset d. Nitrogen oxides [NOx], sulfur oxides [SOx], and other significant air emissions
3. Water, Procurement, Material	a. Total Water Consumed b. Water Discharge i. Fresh Water ii. Other Water c. Water Recycled or Reused d. Packaging Materials used i. Non-Renewable

	ii. Renewable e. Recycled Packaging Materials Used f. Reusable, compostable, or recyclable packaging materials
4. Waste	a. Waste Generated i. Hazardous waste ii. Non-Hazardous waste b. Waste Reused, Recycled, or Recovered c. Environmental Fines
5. Durability	a. Materials/Products reclaimed/recovered b. Lifespan of Product

(Table created by student but information retrieved from C.E. calculator)

On top of these five indicators, there was an additional indicator labeled "Organization", which is where the company's business activities are recorded and analyzed. An example of the business activities that are measured is the company's revenue; this helps us see the total energy consumed by the company over the company's annual revenue. By measuring and collecting this data, we are able to report the progress and report how efficient a company's circularity has been. This also allows us to provide meaningful contrasts and comparisons with other companies' progress towards the CE goals. Table 3 shows the CE goals for each indicator.

Table 3 Circular Economy Goals

Circular Economy Goals as defined in Avraamidou et al.		**Target**		
Reduction of material losses/residuals: Waste and pollutants minimization through the recovery and recycle of materials and products.	→	**Waste**		
Reduction of input and use of natural resources: The reduction of the stresses posed on natural resources through the efficient use of natural resources (e.g. water, land, and raw materials).	→	**Water**	**Procurement**	**Material**
Increase in the share of renewable resources and energy: Re- placement of non-renewable resources with renewable ones, limiting the use of virgin materials.	→	**Energy**		
Reduction of emission levels: The reduction in direct and in- direct emissions/pollutants.	→	**Emissions**		
Increase the value durability of products: Extension of product lifetime through the redesign of products and high-quality recycling.	→	**Durability**		

(Reprinted from Avraamidou et al. [18])

3.1.1. Tools to Measure Circular Economy

In order to give businesses their "circularity" in terms of energy, data is collected from the annual reports. These reports include the company's financial, sustainability, and Environmental-Social-Governance (ESG) reports. Previous years reports are also collected and further analyzed based on the indicators and metrics. The indicator will specify the information needed in order to measure and analyze it with a CE objective. For example, one indicator is the amount of energy that the company consumed. The metric focuses on the measurement of an indicator compared to the company's level of their activity and productivity. After selecting the indicators and measuring the metrics, the measurements are displayed through a diagram where their consumption will be shown and compared to the different CE categories.

The companies are categorized in four different sectors: energy and utilities, services, manufacturing, and automotive. Each sector has specific, selected indicators to evaluate the company's progress towards each CE goal. These indicators coordinate with the Global Reporting Initiative (GRI) Standards, which ensures consistency in the reports and can be used as an additional reference guide. Each sector has corresponding indicators and GRI codes that were measured and analyzed in each company. All of the GRI codes used across all four sectors along with a description for each can be found in Table 4.

Table 4 Principal Categories with GRI Description

Primary Categories	**GRI Codes**	**Description**
Organization	GRI-102-7	Scale of organization/Number of Full Time employees
	GRI-201-1	The direct economic value generated and distributed; this includes revenues and operating costs, employee wages and benefits, etc.
	GRI-203-1	Infrastructure investments and services supported
Procurement: Production & Packaging	GRI-301-1	Materials used by weight or volume. More specifically, total amount of non-renewable and renewable materials used to produce and package the company's products/service. *Renewable: a substance of economic value that can be replaced or replenished in less time than it takes to draw the supply down. Examples: biomass, wind, solar, hydropower, etc. *Non-renewable: a natural substance that is not replenished with the speed at which it is consumed. Examples: oil, natural gas, coal, and nuclear energy.

	GRI-301-2	Recycled input materials used. This includes the percentage of recycled input materials used to manufacture the company's product/service.
	GRI-301-3	Reclaimed products and their packaging materials. More specifically, this is total percentage of the reusable, compostable or recyclable packaging materials.
Energy	GRI-302-1	Energy consumption within the organization **Fossil Fuels: a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms. **Non Fossil Fuels: a hydrocarbon chemical that was not sourced from a geological deposit. Examples: Solar, wind, biofuels.
Water	GRI-303-1	The amount of water withdrawal by source
	GRI-303-3	Water recycle and reused
	GRI-303-4	Total water discharged • A breakdown of total water discharge to all areas in the two categories: Freshwater and Other Water. *Freshwater is water with concertation of total dissolved solids equal to or below 1,000 mg/L
GHG Emissions	GRI-305-1	Direct (Scope 1) GHG emissions • Direct emissions from sources that are owned or controlled by the organization. ▪ It includes on-site fossil fuel combustion and fleet fuel consumption .
	GRI-305-2	Energy indirect (Scope 2) GHG emissions • Indirect emissions from sources that are owned or controlled by the organization ▪ It includes emissions that result from the generation of electricity, heat or steam purchased by the organization from a utility provider.

	GRI-305-5	Reduction of GHG emissions *Greenhouse gases (GHG) are gases in Earth's atmosphere that trap heat and absorb infrared radiation.
	GRI-305-6	Emissions of ozone-depleting substances (ODS) *Ozone-depleting substances (ODS) are chemicals that destroy the earth's protective ozone layer.
	GRI-305-7	Nitrogen oxides (NOx), sulfur oxides (Sox), and other significant air emissions Other significant air emissions = persistent organic pollutants (POP), Volatile organic compounds (VOC), Hazardous air pollutants (HAP), Particulate matter (PM), Other standard categories of air emissions identified in relevant regulations
Durability	GRI-306-2	Waste by type and disposal method. This refers to collecting, reusing, or recycling products and their packaging materials at the end of their useful lives.
Waste	GRI-306-3	These are significant spills and the impacts it has had. More specifically, it is asking for the amount of waste generated in the two following categories: hazardous waste and non-hazardous waste. *Hazardous waste: waste with properties that make it dangerous or capable of harming effect on human health or the environment.
	GRI-306-4	Transport of hazardous waste. More specifically, it is asking for the waste from disposal that was either reused, recycled or recovered.
	GRI-307-1	Non-compliance with environmental laws and regulations. More specifically, the environmental fines that the organization was charged.

(Table created by student but data retrieved from GRI Database [15]).

Although the GRI codes listed in Table 4 are all the codes used, each industry sector has specific indicators used to measure CE. For instance, the Energy and Utilities industry does not contain any questions regarding the procurement category. Please see the tables in the appendix, which will display the specific indicators asked under each industry: Energy, Manufacturing, Automotive, and Service, respectfully (Figures 4-7)

As mentioned, each industry asks for specific indicators, which coordinate with the Global Reporting Initiative (GRI) Standards. There are many companies that already use these standards as their annual sustainability reports, so they will just have to report specific indicators, depending on the industry sector. After knowing the selected indicators, the information will then be calculated and displayed through multiple visualizations showing the company's circularity evaluation through the CE index template. Additionally, the CE evaluation will be available through a web-based calculator. The calculator will be available to everyone, easy to follow, and short enough to be completed in less than ten minutes with all of the company's data.

3.2. Importing Companies Data into C.E. Template to Calculate Circularity

Within the CE index template, all four sectors start off collecting data with questions over the company's organization. Although the primary categories ask for a specific indicator depending on the industry, each category follows a similar calculation throughout all the industries.

3.2.1. Data Collected over the Companies' Organization

The organization section of the manufacturing template is shown in Figure 4 with the company X's data. To reference what specific indicators are asked for under the Manufacturing industry, please see Table 5. The annual revenue (GRI-201-1) of the company is collected along with their investment towards sustainability (GRI-203-1) and CE and the number of products sold (GRI-301-3).

	GRI-201-1	GRI-203-1	GRI-301-3
			Material
Year	Organization		
	Revenues [million $]	Total Social Investment for environmental sustainability and circular economy [million $]	Products sold within the reporting period [# of products] reporting period
2010	87,235.6	N#A	43,648,985
2011	90,619.7	N#A	45,181,018
2012	91,927.3	N#A	47,737,735
2013	95,599.6	N#A	52,089,038
2014	96,231.1	N#A	53,542,683
2015	88,696.3	N#A	54,593,807
2016	87,287	N#A	55,781,969
2017	87,687	N#A	55,591,895
2018	93,400	N#A	54,251,973
2019	93,127	N#A	52,954,014
Specific Measuring Unit	million $	million $	metric ton of product

Figure 4 Organization section from Manufacturing Template (Information given by Dr. Avraamidou [15]).

3.2.2. Data Collected over Companies' Energy Section

Under the Energy sector, we are able to see total annual energy consumed (GRI-302-1) along with the amount that was renewable energy (GRI-302-1). Figure 5 shows the data collected for the energy section.

GRI-302-1	GRI-302-1
Energy	*Energy*
Energy	
Total Energy Consumed [joules or multiples]	Total Renewable Energy Consumed [joules or multiples]
89,092,110	10,601,961
90,301,976	10,836,237
90,318,070	11,289,759
99,017,653	13,268,365
97,145,137	14,086,045
94,156,848	14,405,998
93,258,358	15,760,662
91,317,787	17,624,333
88,333,377	19,345,010
87,837,527	17,743,180
GJ	GJ

Figure 5 Energy section from Manufacturing Template (Information given by Dr. Avraamidou [15]).

3.2.3. Data Collected over Companies' GHG Emissions

In the next category, the data that is collected is the company's GHG emissions. In Figure 6, five different indicators are displayed; 1) Total direct GHG emissions 2) Total Indirect GHG emissions 3) Emissions neutralized by Carbon Offset Projects 4) Emissions of ozone-depleting substances (ODS) and 5) Any nitrogen oxide, sulfur oxide, and other significant emissions.

GRI-305-1	GRI-305-2	GRI-305-5	GRI-305-6	GRI-305-7
Energy	*Energy*			
GHG Emissions				
Total Direct GHG emissions [Scope 1] [metric tons CO2 equivalent [tCO2e]]	Total Energy indirect GHG emissions (Scope 2) [metric tons CO2 equivalent (tCO2e)]	Emissions Neutralized by Carbon Offset Projects [tCO2e]	Emissions of ozone-depleting substances (ODS) [metric tons of CFC-11 (trichlorofluoromethane) equivalent]	Nitrogen oxides [NOX], sulfur oxides [SOX] and other significant air emissions* [kg or multiples]
3,833,273	3,267,609		3.4	17,303.4
3,860,872	3,418,625		1.4	16,576.3
3,780,785	3,444,642		1.3	15,727.3
4,067,384	3,835,010		1.0	18,514.2
3,912,249	3,723,944		1.0	16,936.3
3,745,646	3,678,144		1.9	15,882.5
3,613,278	3,230,041		0.7	15,860.2
3,534,393	2,681,866		0.7	14,993.8
3,349,632	2,547,851		0.6	13,533.9
3,291,303	2,305,914		0.6	12,542.5
tCO2e	tCO2e	tCO2e	metric tons of CFC-11	tons NOx + Sox

Figure 6 GHG Emissions section from Manufacturing Template (Information given by Dr. Avraamidou [15]).

3.2.4. Data Collected over Companies' Water Information

After the GHG emissions, the template then asks to collect data over the water use of the company. Figure 7 shows what data is collected under the water category. It first starts off with collecting the annual amount of water withdrawn by the company. It also collects the amount of water discharge that was fresh and non-fresh (other water). The last column collects the amount of water that was recycled or reused.

GRI-303-1	GRI-303-4	GRI-303-4	GRI-303-3
Material	*Material*	*Material*	*Material*
Water			
Water withdrawal [volume]	Total FRESH water discharge (<= 1,000mg/L TDS) [volume]	Total OTHER water discharge (>= 1,000mg/L TDS) [volume]	Water Recycled or Reused [volume]
144,689,740	58,598,181	36,245,252	4,900,014.7
143,776,245	57,945,737	35,941,566	4,815,972.3
138,204,374	48,602,970	35,787,226	4,709,055.4
151,885,650	55,496,381	34,996,502	5,120,872.4
147,554,757	52,391,800	36,421,840	5,519,932.3
140,514,104	47,696,748	34,294,819	5,475,745.8
138,357,095	45,073,163	34,600,565	5,120,352.2
131,582,443	43,718,648	34,010,482	6,259,620.1
126,537,212	42,219,468	32,934,960	5,860,728.7
120,847,287	32,158,868	35,329,091	4,797,312.0
m3	m3	m3	m3

Figure 7 Water section from Manufacturing Template (Information given by Dr. Avraamidou [15]).

3.2.5. Data Collected over Companies' Waste

The template then asks to collect data over the company's waste, Figure 8. It first collects the waste generated that was hazardous and then it ask for the non-hazardous waste. The third column gathers the waste that was not disposed, so the waste that was either reused, recycled or recovered. For all of these, the weight of each waste is what is being collected. The last column focuses on the annual environmental fine.

GRI-306-3	GRI-306-3	GRI-306-4	GRI-307-1
Material	*Material*	*Material*	
Waste			**Spillages & Fines**
Waste generated - Hazardous [weight]	Waste generated - Non Hazardous [weight]	Diverted Waste from Disposal (reused, recycled, recovered) [weight]	Environmental Fines [$]
6,606.9	1,342,702.53	963,425.4	N#A
4,780.6	1,428,034.08	1,093,412.0	31,921
4,063.9	1,428,133.39	1,110,989.8	6,906
3,222.1	1,506,112.55	1,248,711.3	114,001
2,538.8	1,551,652.53	1,322,704.7	78,714
2,255.5	1,598,924.88	1,433,750.6	80,086
636.7	1,667,957.63	1,560,529.0	135,707
343.0	1,663,796.93	1,600,944.8	49,672
372.3	1,657,073.50	1,622,693.6	84,796
332.7	1,669,115.2	1,654,859.6	26,157
metric ton	metric ton	metric ton	$

Figure 8 Waste Section from Manufacturing Template (Information given by Dr. Avraamidou [15]).

3.2.6. Data Collected over the Companies' Procurement: Production & Packaging

The two final sections that the Manufacturing template requests are Procurement: Production & Packaging and Durability. Under the category Procurement: Production & Packaging, it collects the annual total of non-renewable and renewable packaging materials that were used. Additionally, the company will also input the annual amount of recycled packaging materials that were used and the percentage of the reusable, compostable or recyclable packaging materials. In terms of durability, it collects the percentage of the packaging materials (or number/percentage of products) that were either reclaimed or recovered. Figure 9 shows the data asked for both sections of Procurement: Production & Packaging and Durability.

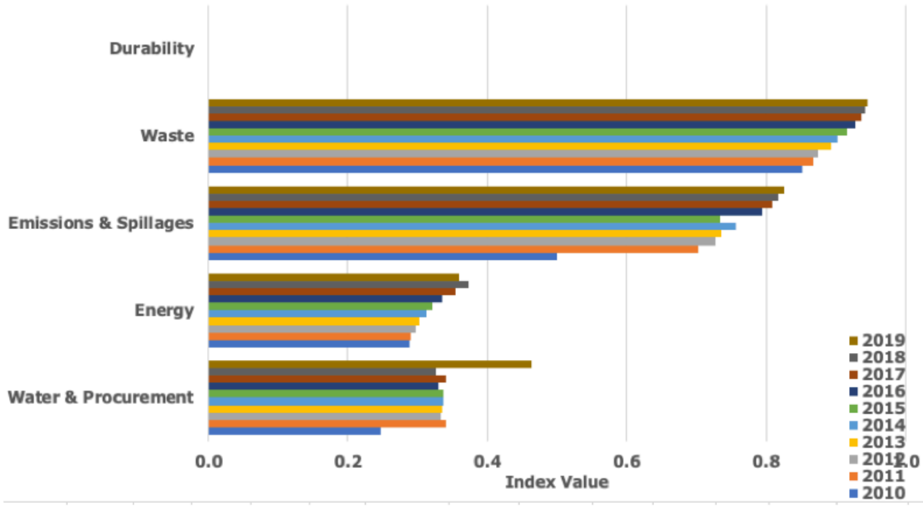
GRI-301-1	GRI-301-1	GRI-301-2	GRI-301-3		GRI-306-2
Material	*Material*	*Material*	*Material*		*Material*
Procurement: Production + Packaging					**Durability**
Non-Renewable Packaging Materials Used [volume or weight] (i.e. minerals, metals, oil, gas, coal etc)	Renewable Packaging Materials Used [volume or weight] (i.e. wood, water)	Total recycled packaging material Used [volume or weight or %]	Reusable, compostable or recyclable packaging materials [%]		Packaging Materials [# of products or %] reclaimed/recovered
4,624,422.4	N#A	N#A	N#A		N#A
4,452,031.1	1,731,840	27.1%	N#A		N#A
5,112,012.2	1,988,573	27.1%	N#A		N#A
5,621,277.3	2,186,677	27.1%	N#A		N#A
5,580,196.5	2,209,758	26.8%	N#A		N#A
5,031,723.1	1,927,150	28.1%	N#A		N#A
4,915,494.6	1,715,508	27.4%	N#A		N#A
4,909,365.8	1,929,381	28.7%	N#A		N#A
4,998,789.6	1,669,596	23.6%	N#A		N#A
4,700,000.0	1,739,000	26.0%	87%		N#A
metric ton	metric ton	%	%		%

Figure 9 Procurement: Production and Durability from Manufacturing Template (Information given by Dr. Avraamidou [15]).

3.3. Companies' Circular Economy in Visualizations and Graphs

After inputting all of Company X's data, visualizations and graphs are presented to show their progress towards CE. Figure 9 displays Company X's progress towards CE where they are outperforming under waste and GHG emissions. Figure 10 also helps demonstrate where Company X needs to improve their transition towards circularity.

The index values also allows the company to see where they fall in comparison to companies in the same industry.



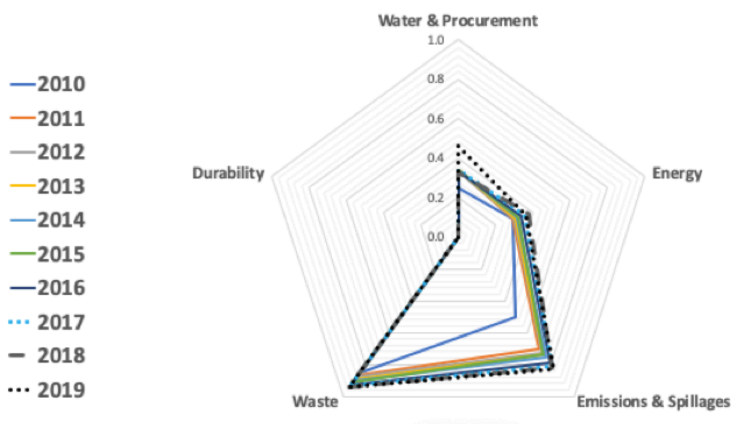


Figure 10 Visualizations for Company X: Progress towards Circularity

3.4. Importing Companies' data into the Web-Based C.E. Calculator

The web based calculator will also ask the same data collected in the template (Figures 4-9). Figure 11 displays the web based calculator. The calculator is accessible to the companies and the public, as it is the one being used for companies to measure and track their transition towards circularity.

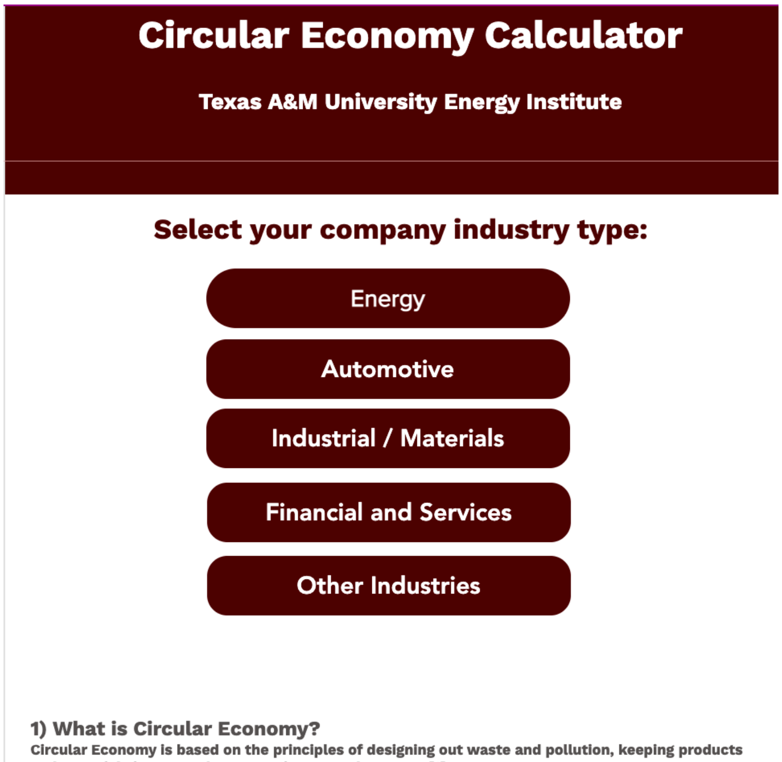
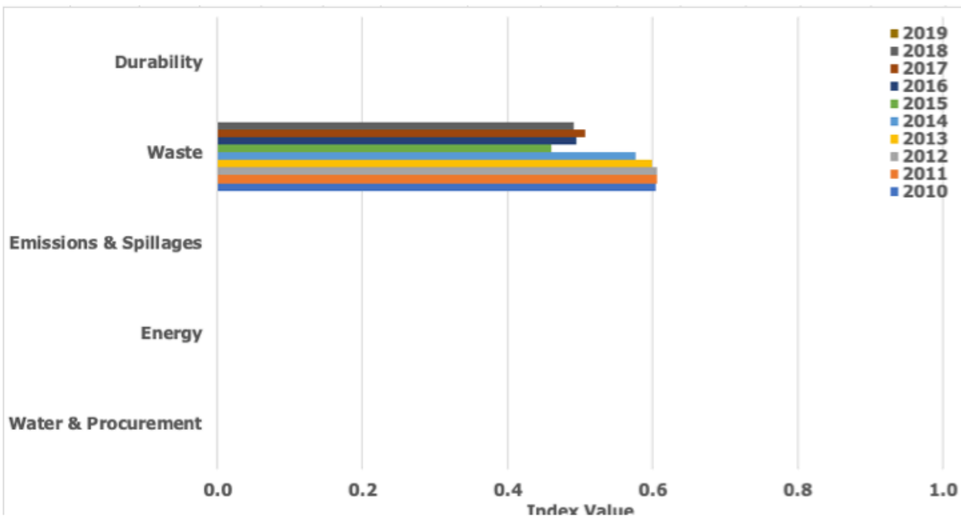


Figure 11 C.E. Calculator: homepage of the Online Calculator

4. RESULTS AND DISCUSSIONS

4.1. Hasbro's Circular Economy Evaluation

Six companies from different industries were tested on the CE Index templates. Hasbro was one of the companies for the Manufacturing industry. Figure 12 is showing their progress towards circularity under each primary category.



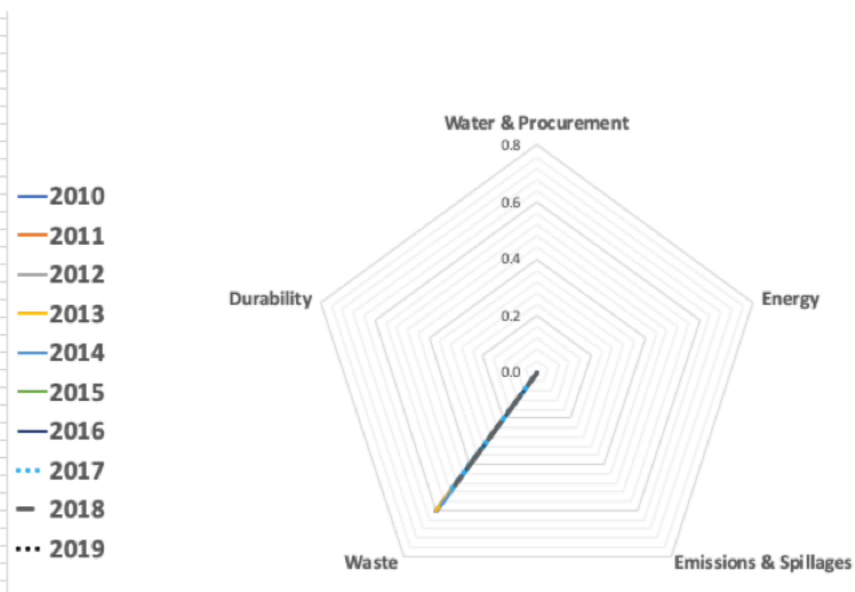


Figure 12 Hasbro's Progress towards C.E. 2010-2019

In comparison to the visuals shown in Figure 10, Hasbro did not report their full data for "Durability", "GHG emissions", "Energy", and "Water". Based on the reported data, it is shown in the bar graph how they have been diverging from the transition towards CE from 2010 up until 2019. Because Figure 12 shows a detailed progress for each year, it is also important to have visualizations that quickly summarize the detailed data. Although a scatter or line charts could have also been used to display their progress, Figure 13 shows a clearer visualization on the areas that need improvement through a column and line chart; the lines are the most recent 5 years of collected data while the line chart has data collected between 2015 through 2019. Because the line charts are the most recent 5 years of their progress towards improving their circularity, it is quickly shown that Hasbro has only regress under "Waste" by comparing the column charts with the line charts.

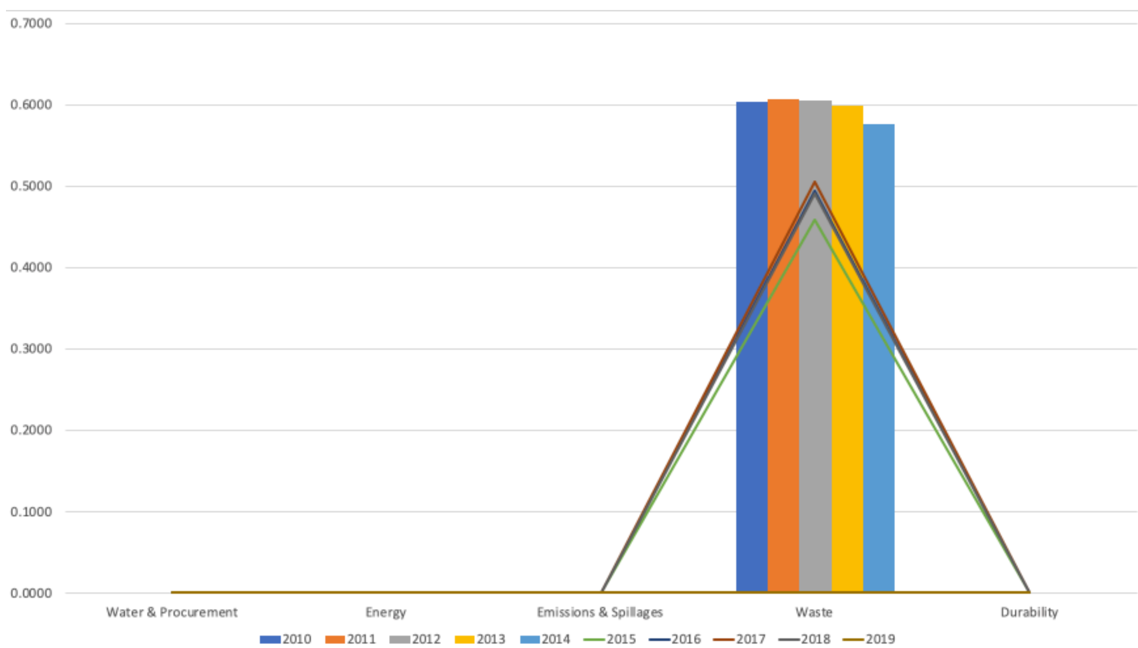


Figure 13 Hasbro's C.E. Progress –Combo Visualization

After collecting data over the company's organization, it is shown that the annual revenue has slowly increased but it remains in the same range between 2010 to 2019. Under "Energy," Hasbro only reported the total energy consumed and we can see the energy being consumed has decreased by over 40 percent from 2019 to 2019. Between the same years (2019-2019), Hasbro worked on decreasing their direct GHG emissions by over 20 percent and decreased their indirect GHG emissions by a little over 67 percent. As reported in Figure 12, Hasbro has decreased the hazardous waste generated, but they have also decreased the waste that is being either reused, recycled, or recovered. Based on the reported data, it is recommended to focus on the waste that is being diverted from disposing. In comparison to other companies in their industry, Hasbro is not transitioning to circularity under the waste category. However, this is just based on the data stated, but not enough data was reported. It is recommended to focus on the remaining of the principal categories to perform a full evaluation towards CE.

4.2. Best Buy's Circular Economy Evaluation

For the Service industry, Best Buy was one of the companies whose data was collected for a CE evaluation. Figure 13 is demonstrating the data that was reported under Best Buy's sustainability reports.

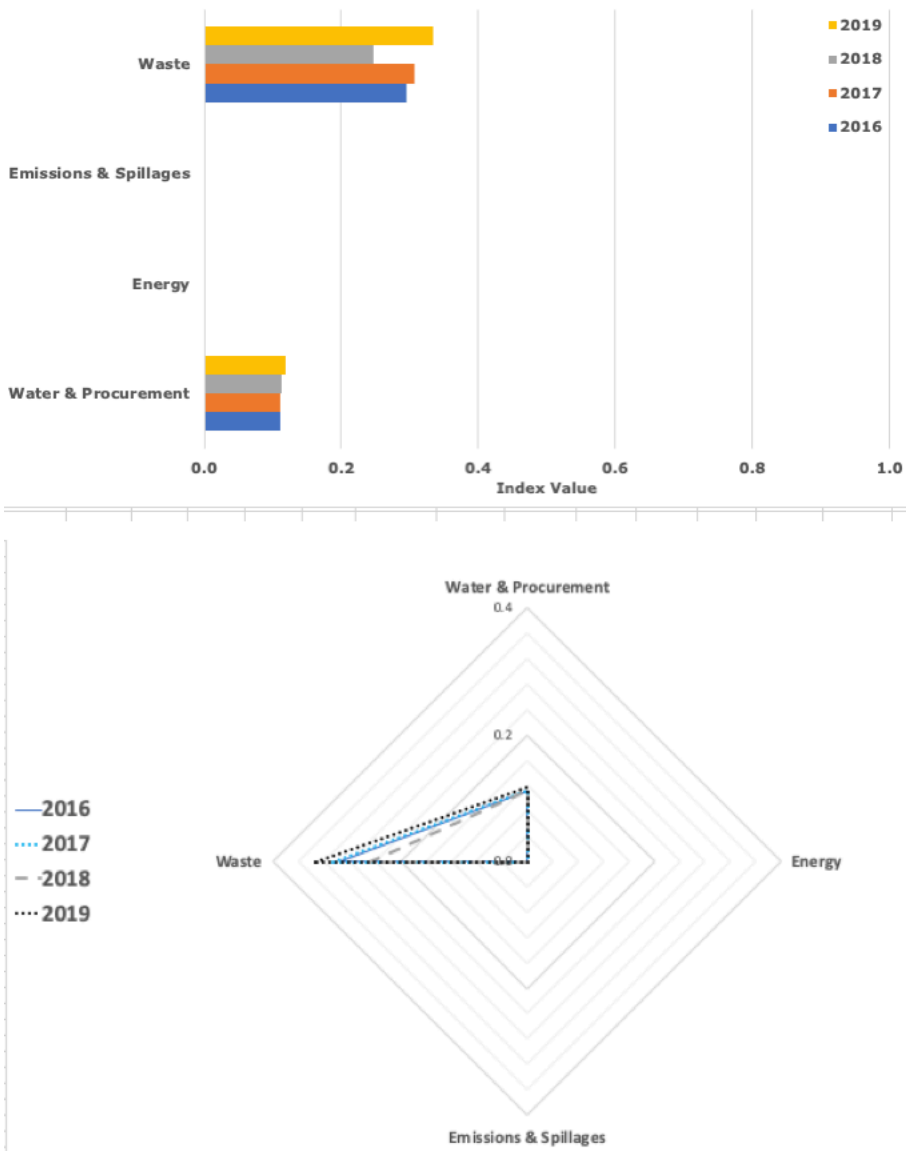


Figure 14 Best Buy: Progress towards C.E. 2012-2019

In similarity to Hasbro, Best Buy did not report enough data for all of the primary categories. However, it is shown the transition towards circularity from 2016 to 2019. In Figure 15, the column charts are displaying 2016 and 2017 data while the line chart is displaying data from 2018 and 2019. It is shown the progress made under “Waste” where the 2019 line chart surpasses 2018 and 2017; this means that Best Buy improve their waste consumption and circularity.

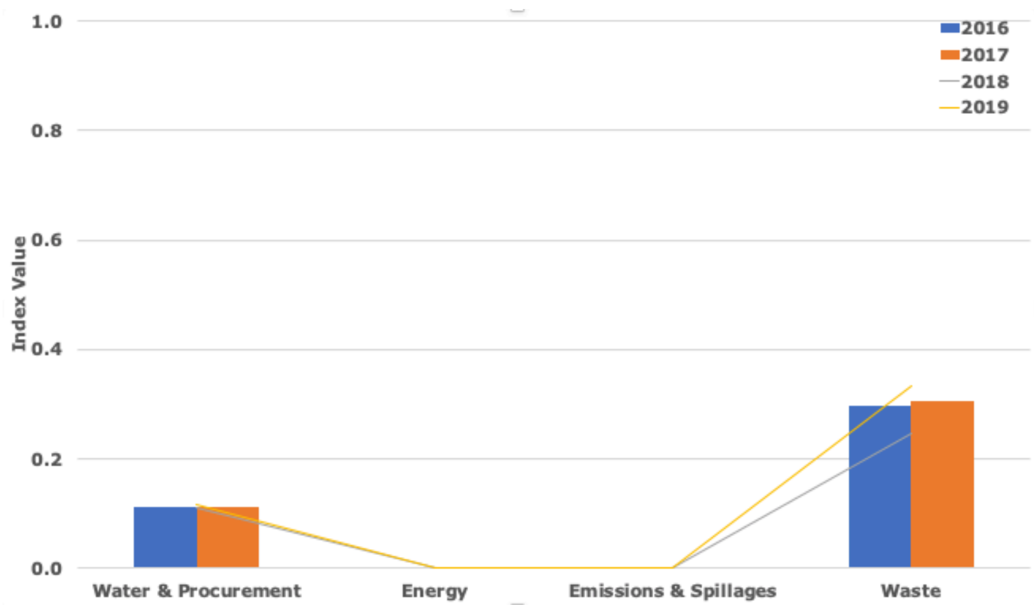


Figure 15 Best Buy's CE Progress – Combo Visualization

Best Buy's data report can be found in the Appendix section. Based on Best Buy's revenue, there is slight 15 percent decrease. Starting with 2016, there is more data reported over Energy and GHG emissions. Between 2015 to 2019, Best Buy showed a slight increase in direct GHG emissions, but they decreased their indirect GHG emissions by an estimate of 40 percent. We are able to see small increase, but it is still not enough collective data to give a full evaluation on the remaining categories: "Energy" and "GHG emissions". It is recommended to pay more attention to the data in their "Energy" and "GHG emissions."

4.3. Chevron Corporation's Circular Economy Evaluation

Under the Energy and Utilities industry, Chevron Corporation's data was input into the CE template. Although the sustainability report did provide sufficient data for some categories, it still did not provide all of the data for a full evaluation. The report did have the total energy generated by the company but it did not have the percentage or number that is non-fossil fuel energy. Also, based on the reported data, Chevron has generated energy in the same range amount from 2014 to 2019. Chevron's GHG emissions are overall decreasing from 2012 to 2019, which means that they working on reducing emissions. Figure 16 shows Chevron’s progress towards circularity. Although Chevron did contain data covering emissions, the full data under water recycled or reused and water discharge was not reported.

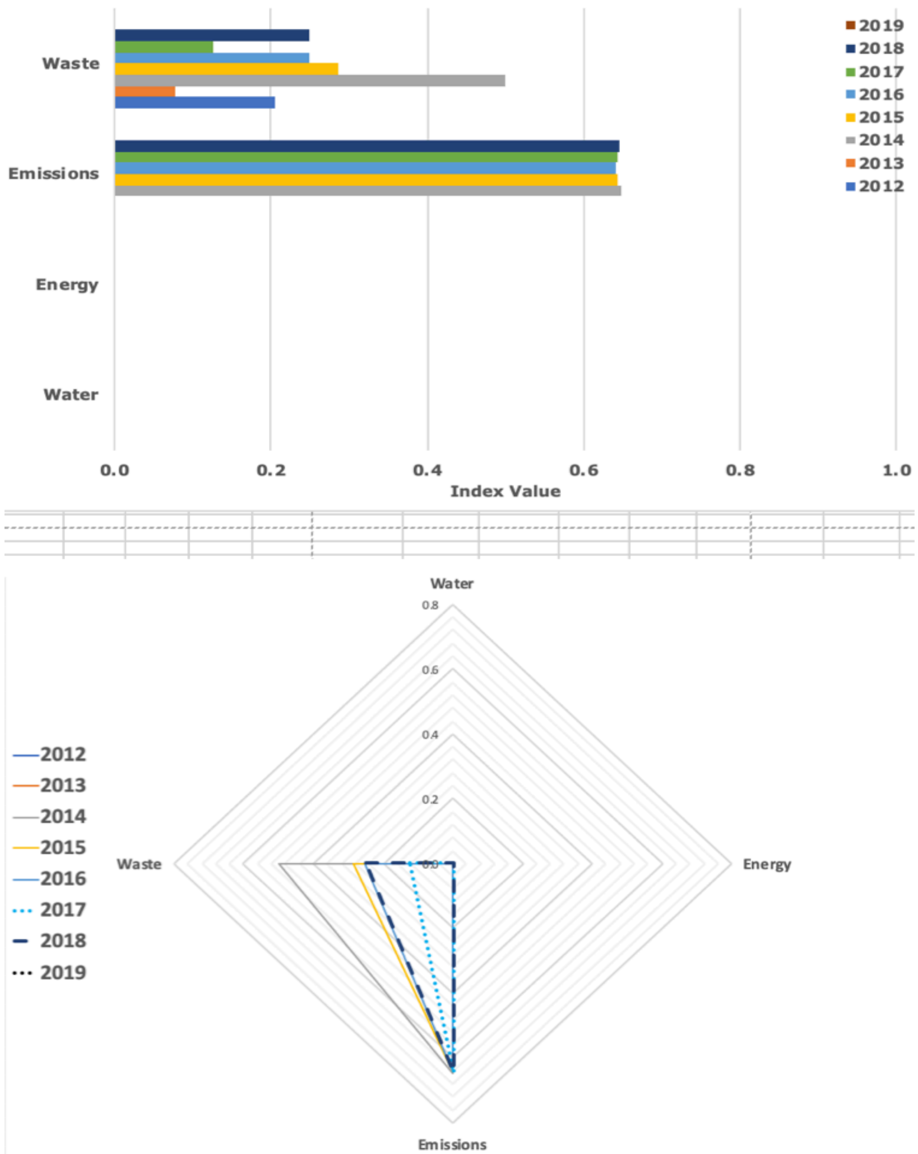


Figure 16 Chevon Corporation: CE Progress 2012-2018

Chevron did not progress or regress significantly from 2014 to 2018. Based on Figure 17, we see the most recent years (line chart) that did not peak the column graphs under “Emissions” and “Waste.” This means that there has not been an improvement or a transition towards circularity.

From the data that was reported, we see an overall decrease in the water Chevron has withdrawn from 2012 to 2018. Although the hazardous waste generated by Chevron decreased by over 50 percent between 2012 to 2019, the amount of waste diverted from disposal has only slightly increased and the environmental fees greatly fluctuated. It is recommended to report all of the data regarding energy and water use, as well as improving their circularity for “Waste”.

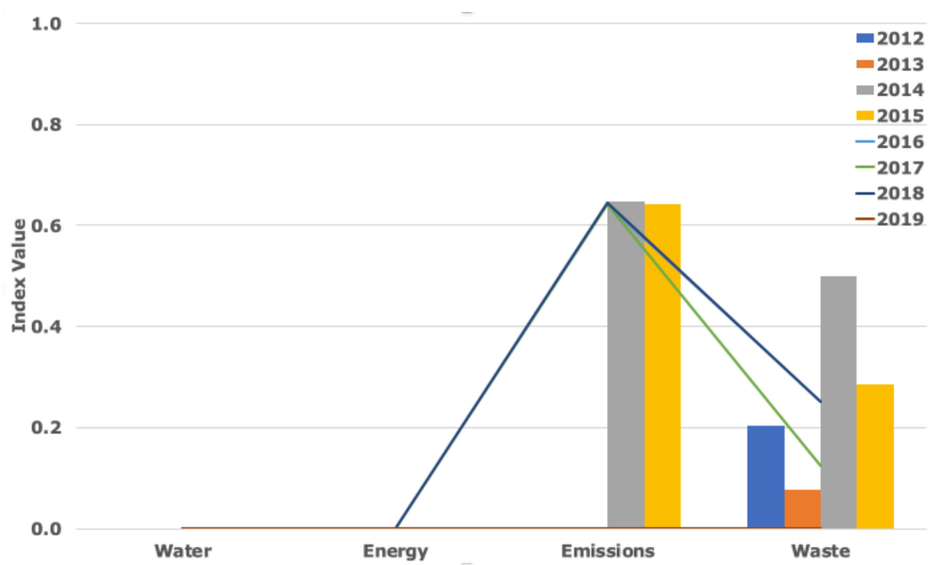
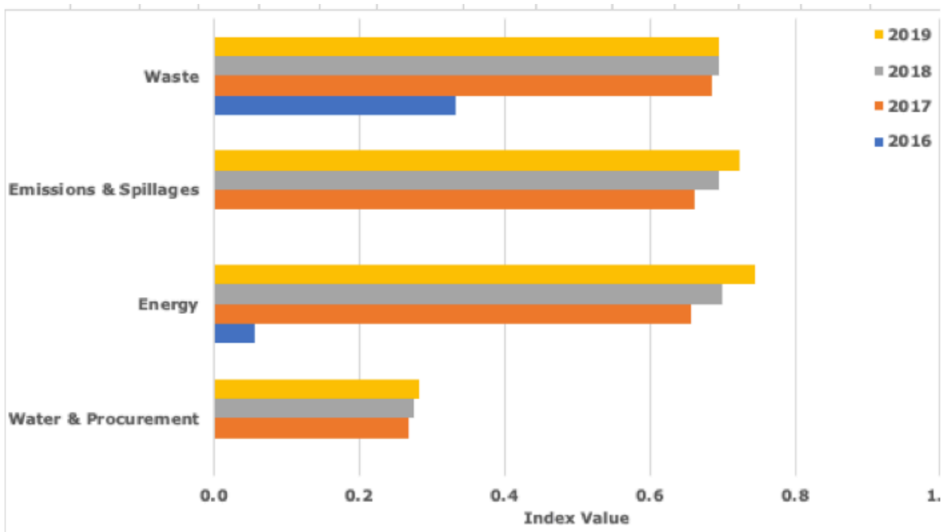


Figure 17 Chevron’s CE Progress – Combo Visualization

4.4. Bank of America Circular Economy Evaluation

Under the same industry, Bank of America (BOA) was also evaluated for their transition towards circularity. Figure 18 shows their results based on the reported data.



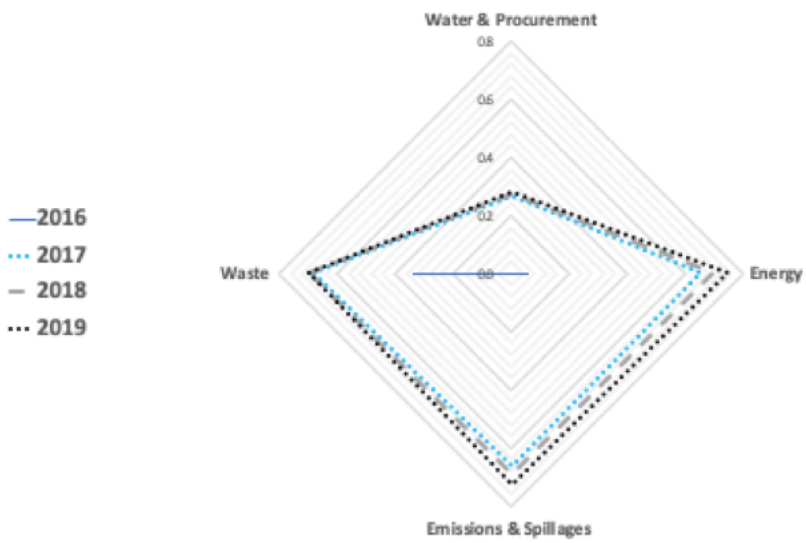


Figure 18 Bank of America: CE Progress 2016-2019

The transition to renewable projects help increase the overall performance. In similarity to Best Buy, BOA also showed an increase of direct GHG and decrease in indirect GHG emissions between 2017 to 2019. In those same years, it is reported that the water withdrawn by BOA has decreased by a little over 5 percent, but there was not any data reported on the amount of water being recycled or reused. Under "Waste," we see a decrease off over 55 percent in the waste generated that was hazardous. That being said, there is an increase of a slight 3 percent for the non-hazardous waste that was generated by BOA. From the reposted data, it also shows that BOA has increased the amount of waste being reused, recycles, or recovered. It is recommended to pay more attention to "Water" and "Procurement" of BOA as there was not enough data for procurement to make a full evaluation.

BOA shows an improvement over the years for "Energy" where it consumed more renewable energy and started its transition towards circularity. From 2017 to 2019, BOA has overall slightly decreased the energy being consumed but there was also a slight increase in the renewable energy being consumed; this leads to an improvement to the overall circularity under "Energy" as shown in Figure 18 and 19. Under "Energy" in Figure 19, the data clearly demonstrates the improvement towards circularity from 2016 to 2019.

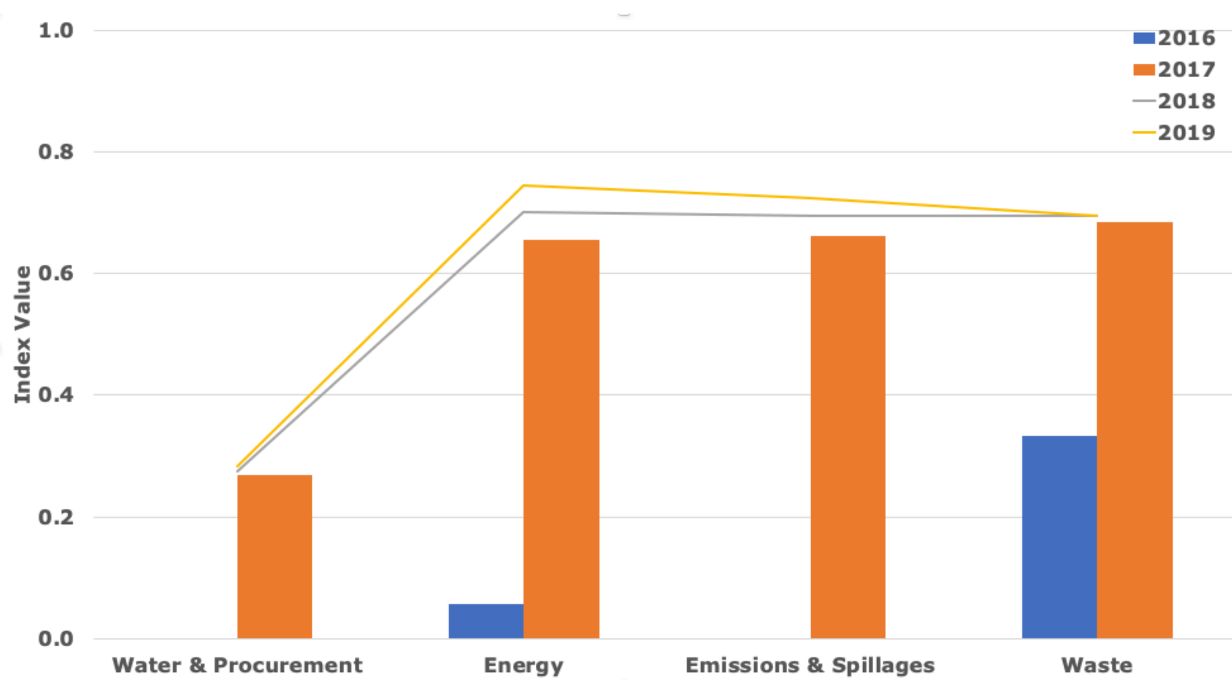


Figure 19 Bank of America's CE Progress – Combo Visualization: Clustered Column –Line

It also demonstrates the most recent years in the line chart and the clustered columns are the earlier years. The purpose of this visualization is for companies to have a quick glance of their circularity. Based on Figure 19, BAO has improved over the years as the lines (2018 and 2019) are higher than the columns (2016 and 2017) for all four sectors: Water and Procurement, Energy, Emissions & Spillages, and Waste.

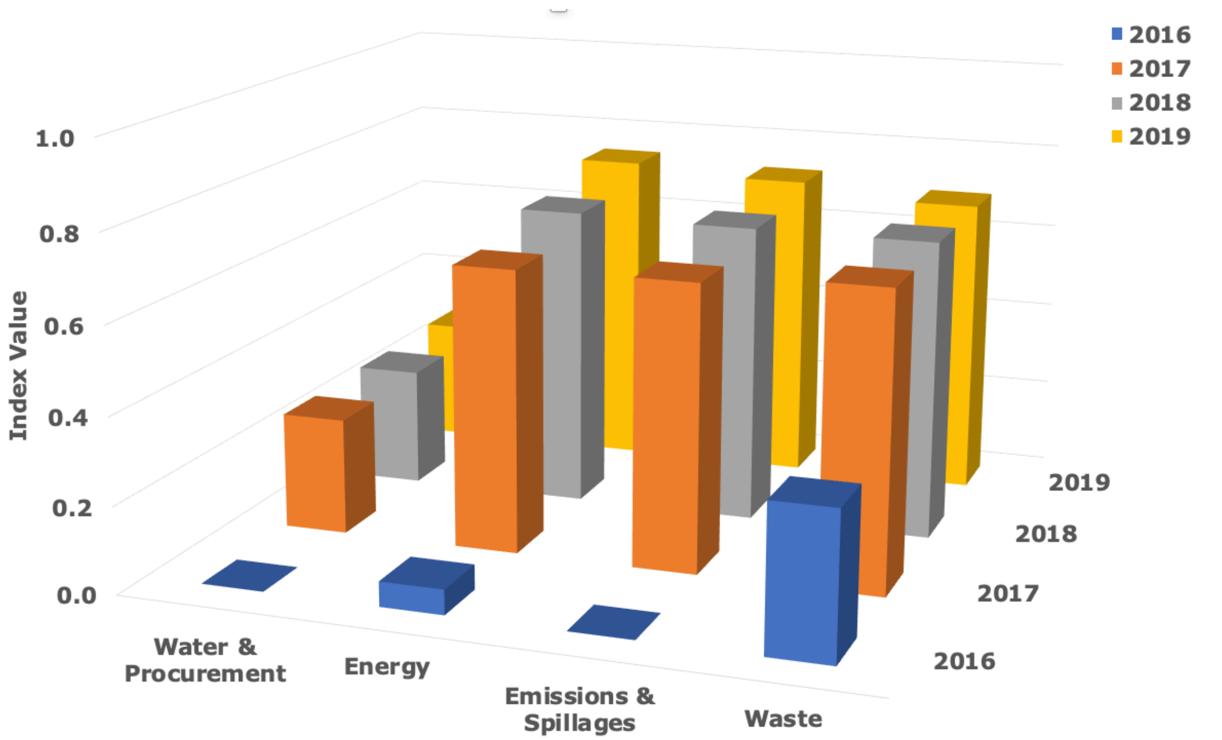


Figure 20 Bank of America's CE Progress –3D Column

The 3D Column visualization shows a more detailed view of the progress throughout the years. There is a noticeable difference between 2016 to 2017 where there is significant improvement across all four sectors. Instead of the columns being next to each other, they are right behind one another, which can help get a detailed view of how much it is improving by the height of the columns.

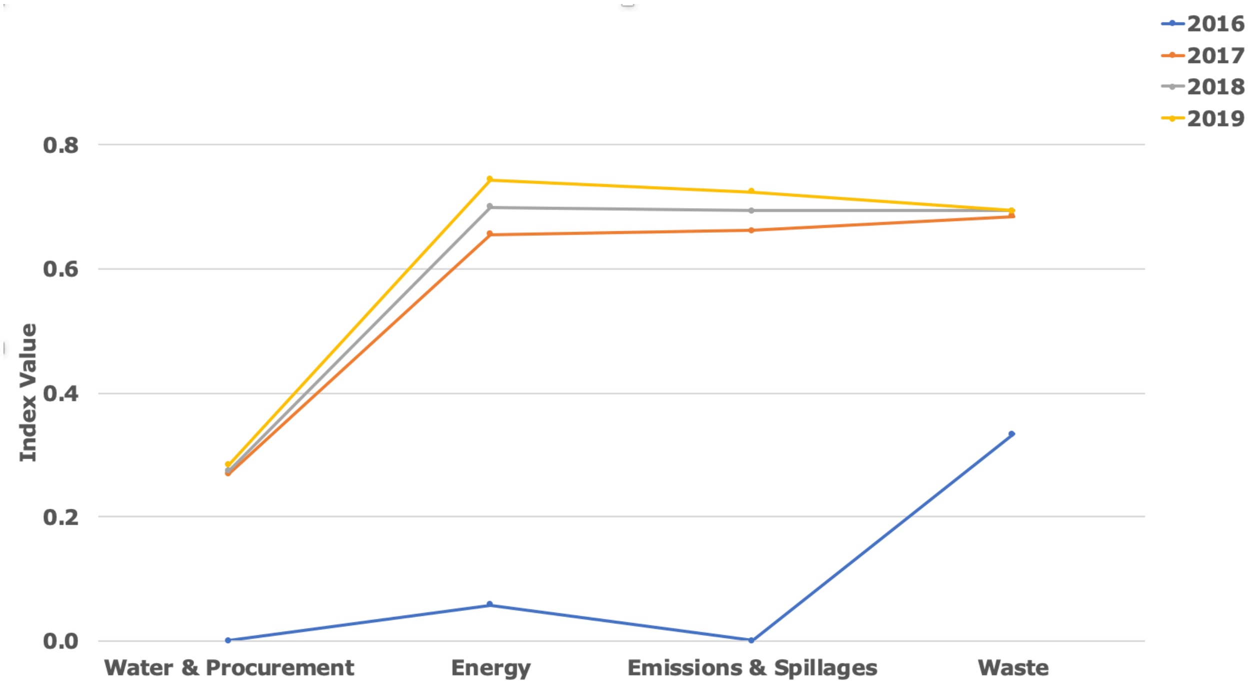


Figure 21 Bank of America's CE Progress –Line with Markers

The Line with Markers chart is not as detailed as the 3D column, but with the markers above each sectors, it is shown exactly where their index values are. Figure 21 connects the all of the reported data by the year. It helps to see the yellow line (2019) is above all the previous lines across all four sectors.

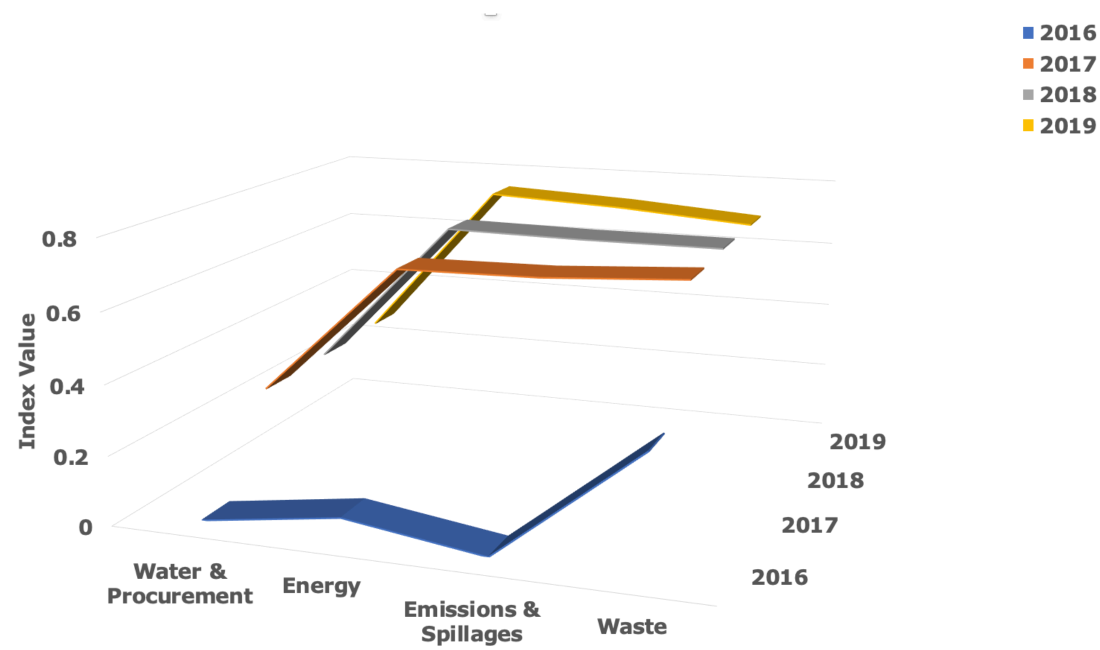


Figure 22 Bank of America's CE Progress –3D Line

Similar to Figure 21, 3D Line connects all the reposted data with a line, but instead of the data being presented on vertically (on top or below one another), it is presented behind one another. However, it can be difficult to see how little improvement there was under "waste" between 2017 to 2019 whereas other types of visualizations greatly distinguish the difference such as Figure 21.

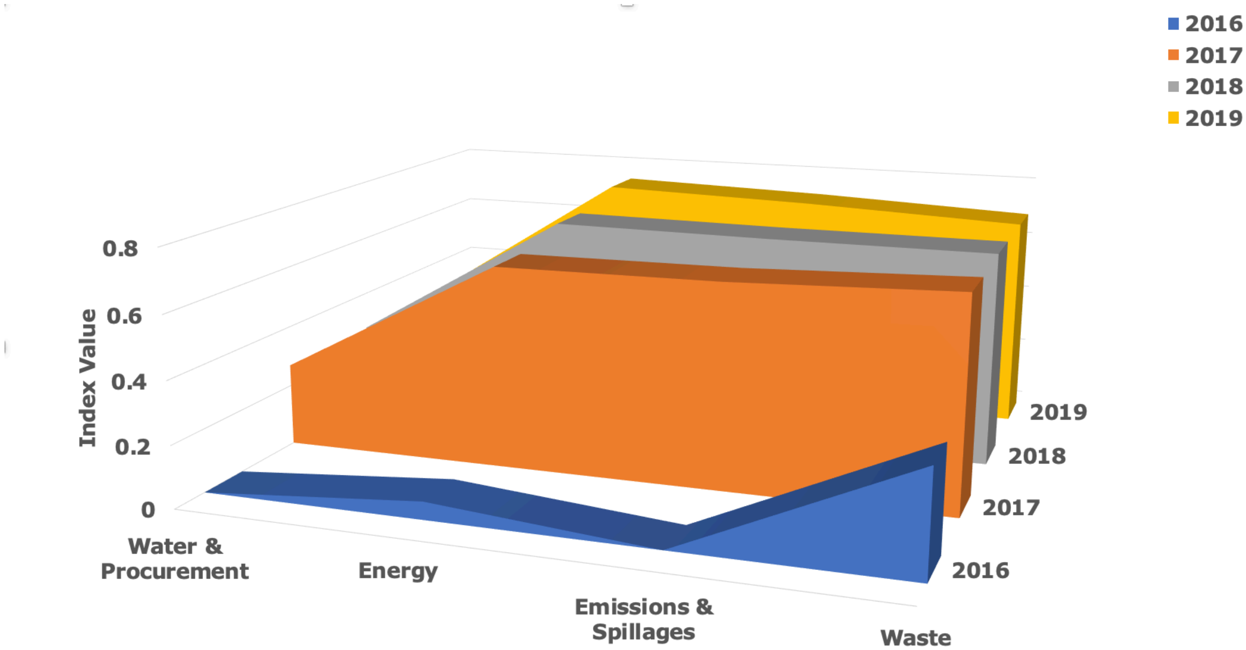


Figure 23 Bank of America's CE Progress –3D Area

Because of the filled area, it is shown which sector needs more attention and improvement. In the first row (2016), "Water & Procurement" has the least filled area underneath, which means that they need to focus on it to improve their circularity. A weakness about the visualization is that the filled in data from the earlier years can cover the data from the most recent years, as it is shown under "Water & Procurement" from 2017 to 2019.

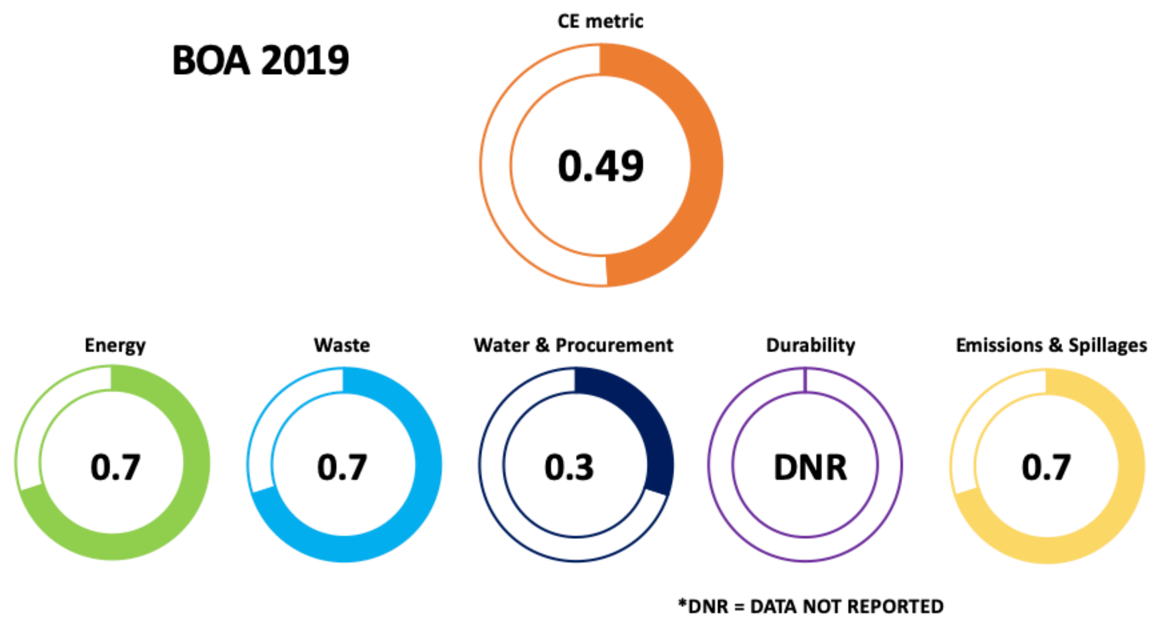


Figure 24 Bank of America's CE Progress –Doughnut

Unlike the previous visuals where all of the years were incorporated in one visual, the doughnut visualization focuses on presenting their performance one year at a time. Figure 24 shows BOA's circularity performance for 2019. This visualization helps companies see their score for each CE indicator along with the overall performance. However, a weakness about the Doughnut visualization is that it does not show a clear comparison to the previous years. Because BOA did not report any data over the lifespan of their infrastructure. The missing data lowered the score for the overall performance in 2019. If the CE metric score did not take into consideration the missing data, then the CE metric score would have been 0.61 instead of 0.49. However, it is important to consider the entire data, whether reported or not, to have a more accurate score.

4.5. Bayerische Motoren Werke's Circular Economy Evaluation

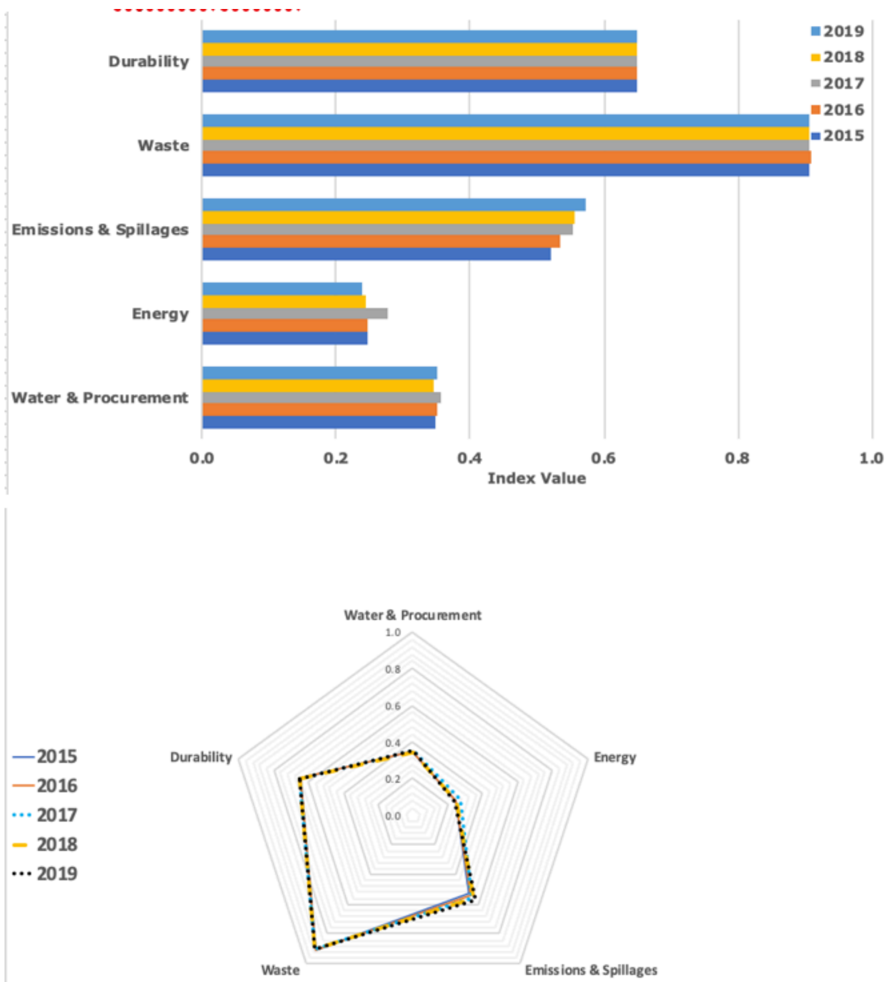


Figure 25 Bayerische Motoren Werke: CE Progress 2015-2019

Under the Automotive industry, Bayerische Motoren Werke's (BMW's) data was input into the CE template between 2015 to 2019. From the visualizations, it is shown that BMW circulates their waste and it outperforms the other sectors in terms of their progress towards CE. However, there has not been significant improvement since 2015. It can also be said for the remaining four sectors as there has not been any significant difference between 2015 to 2019. It is also shown under "Energy" how little progress they have done to transition to CE. It is the one sector that needs more attention and improvement.

Following "Energy", BMW could also focus on their circularity for "Water and Procurement". Based on the reported data, it is also shown that there was a slight increase on the total amount of energy and a decrease in the total amount of renewable energy that was consumed by BMW. To improve their circularity under "Energy", BMW should focus on consuming more renewable energy.

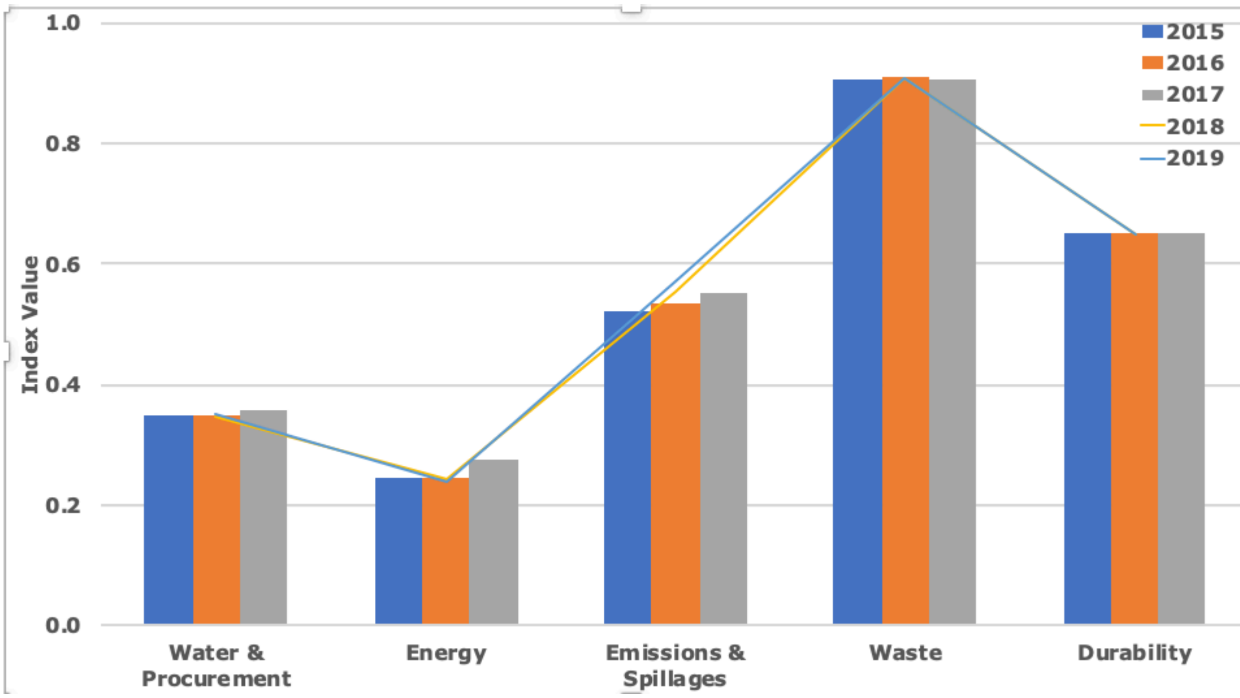


Figure 26 BMW's CE Progress – Combo Visualization: Clustered Column –Line

The combo visualization demonstrates the most recent years in the line chart and the clustered columns being the earlier years. The purpose of this visualization is for companies to have a quick glance of their circularity. Based on Figure 24, BMW has not had a significant improvement over the years as the lines (2018 and 2019) are almost the same as the columns (2015-2017) for all five sectors: Water and Procurement, Energy, Emissions & Spillages, Waste, and Durability.

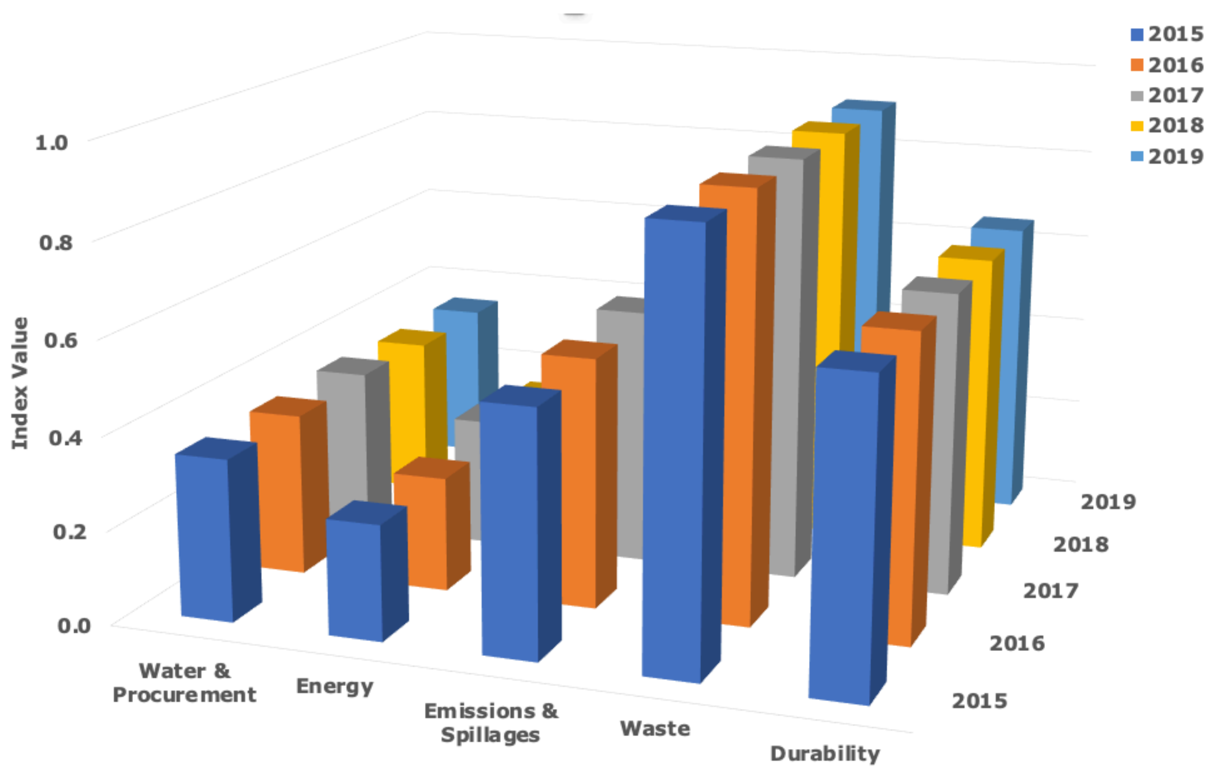


Figure 27 BMW's CE Progress –3D Column

The 3D Column visualization shows a more detailed view of the progress throughout the years. There is not a noticeable difference from 2015 to 2019 where there is not a significant improvement across all five sectors. Instead of the columns being next to each other, they are right behind one another, which can help get a detailed view of how much it is improving by the height of the columns. However, a weakness about this visualization is that the most recent years can be cover by the earlier years as seen under "Energy" for 2018 and 2019.

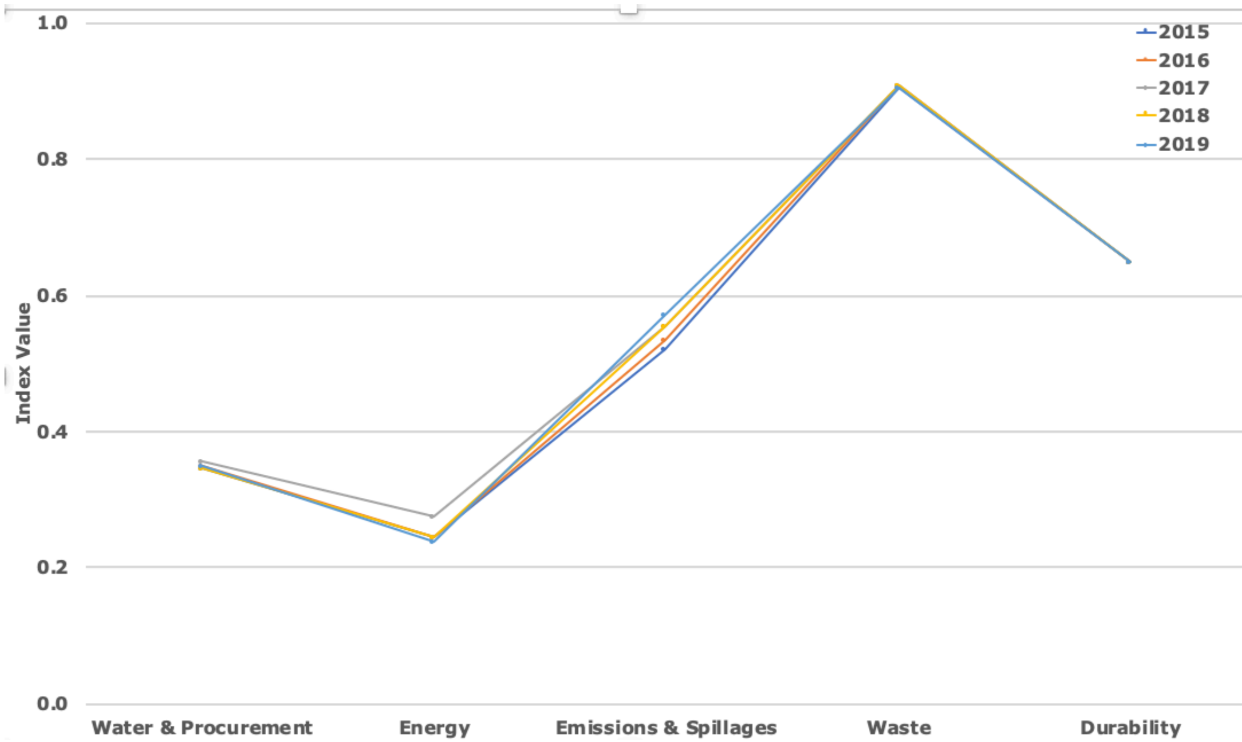


Figure 28 BMW's CE Progress –Line with Markers

The Line with Markers chart is not as detailed as the 3D column, but with the markers above each sectors, it is shown exactly where their index values are. Figure 28 connects the all of the reported data by the year. As mentioned earlier, it is shown based on the lines being so close to one another that BMW has not had any significant improvements across all five sectors.

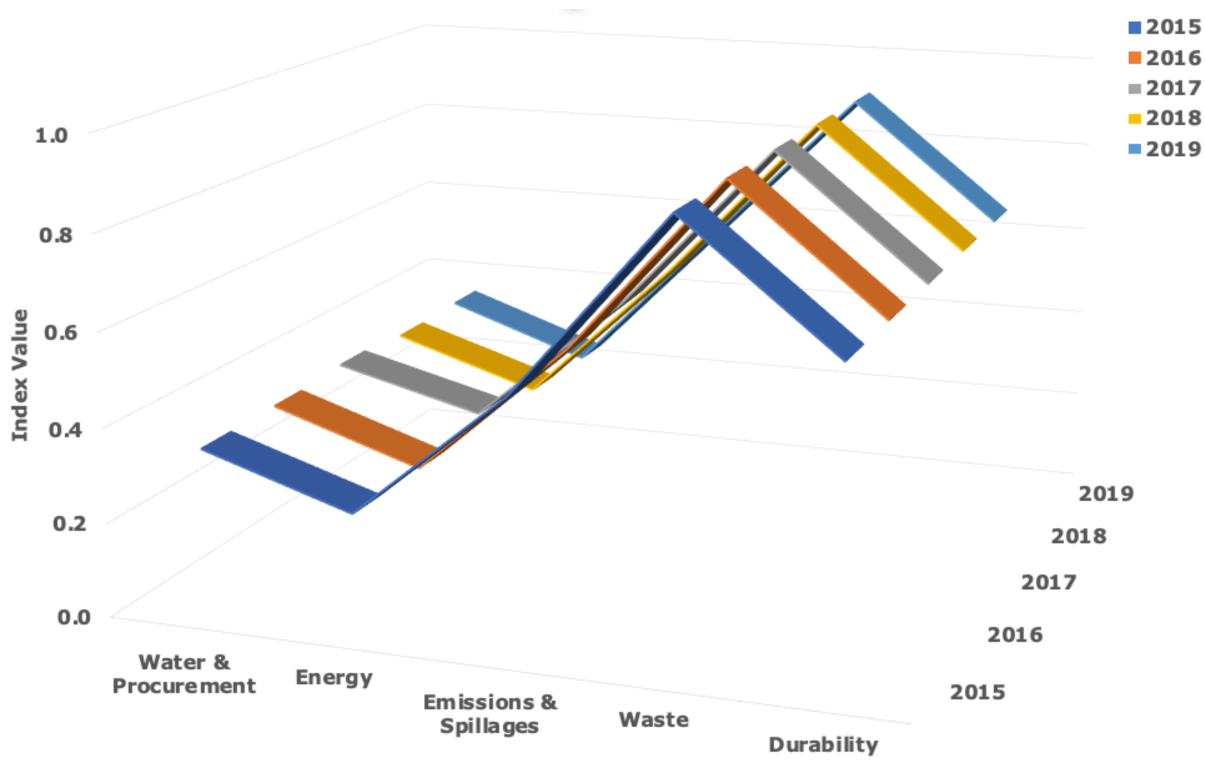


Figure 29 BMW's CE Progress –3D Line

3D Line connects all the reposted data with a line, but instead of the data being presented on vertically (on top or below one another), it is presented behind one another. However, it can be difficult to see the exact progress there was under "Emissions & Spillages" between 2015 to 2019 whereas other types of visualizations greatly distinguish the difference such as Figure 28.

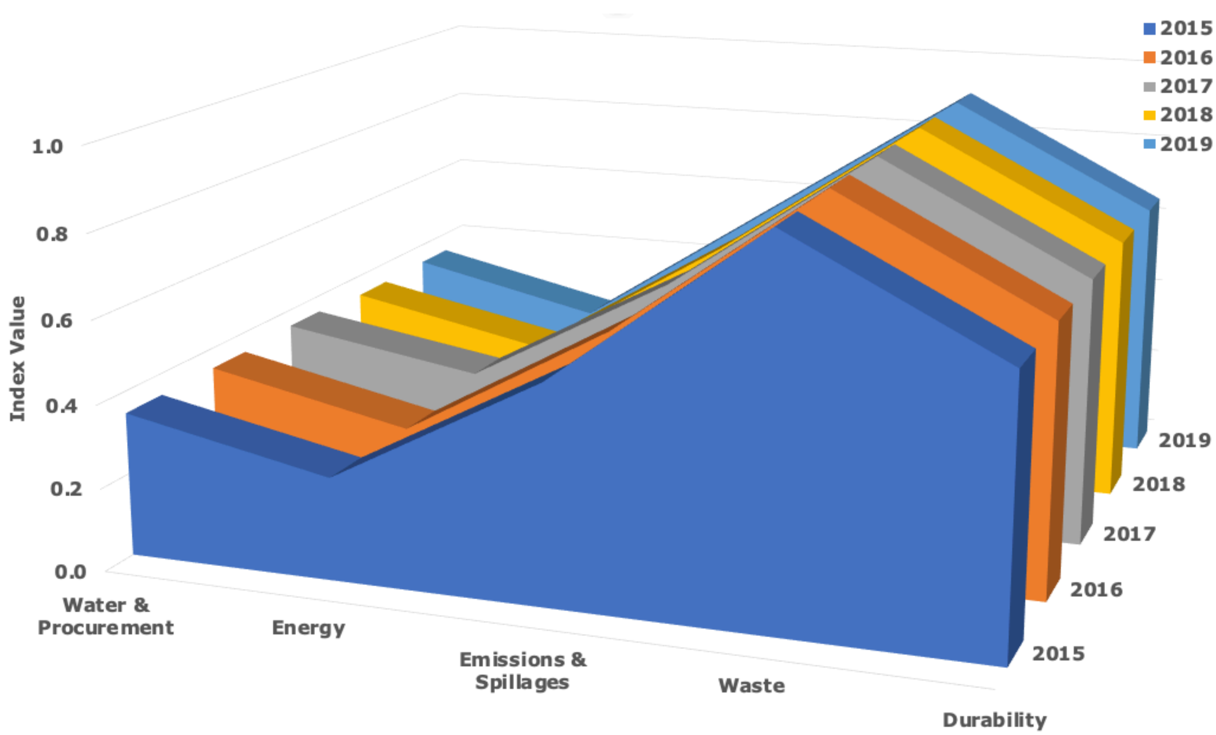


Figure 30 BMW's CE Progress –3D Area

Because of the filled area, it is shown which sector needs more attention and improvement. In the first column, "Energy" has the least filled area underneath, which means that they need to focus on it to improve their circularity. A weakness about the visualization is that the filled in data from the earlier years can cover the data from the most recent years, as it is shown under "Emissions & Spillages" from 2015 to 2019.

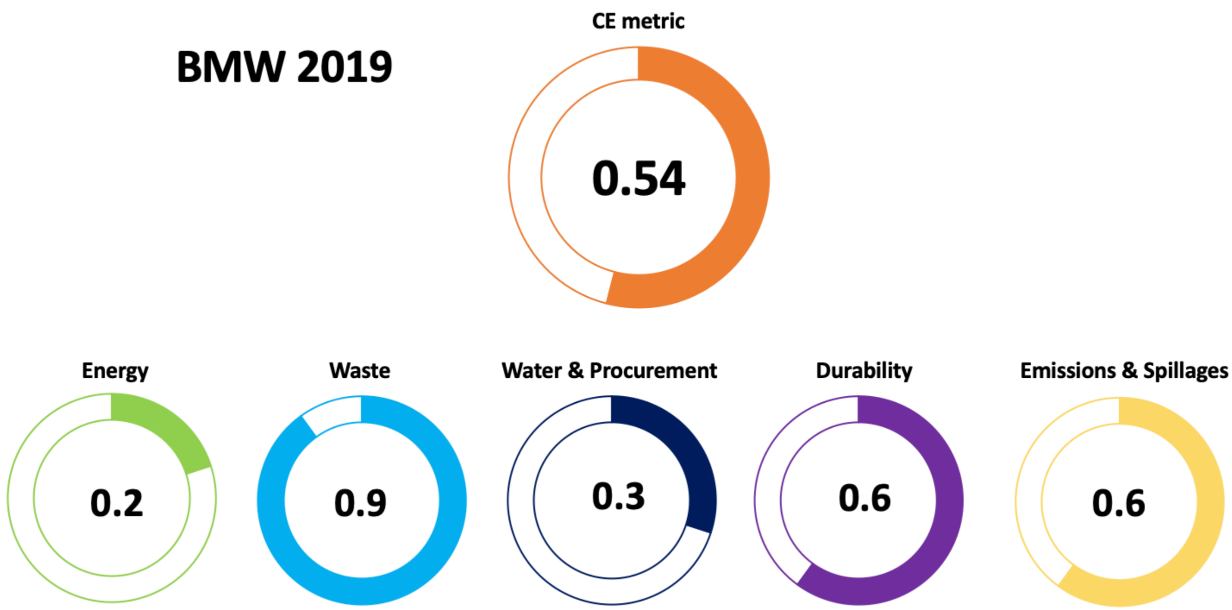


Figure 31 BMW's CE Progress –Doughnut

Unlike the previous visuals where all of the years were incorporated in one visual, the doughnut visualization focuses on presenting their performance one year at a time. Figure 31 shows BMW's circularity performance for 2019. This visualization helps companies see their score for each CE indicator along with the overall performance. However, a weakness about the Doughnut visualization is that it does not show a clear comparison to the previous years.

4.6. Nestle Circular Economy Evaluation

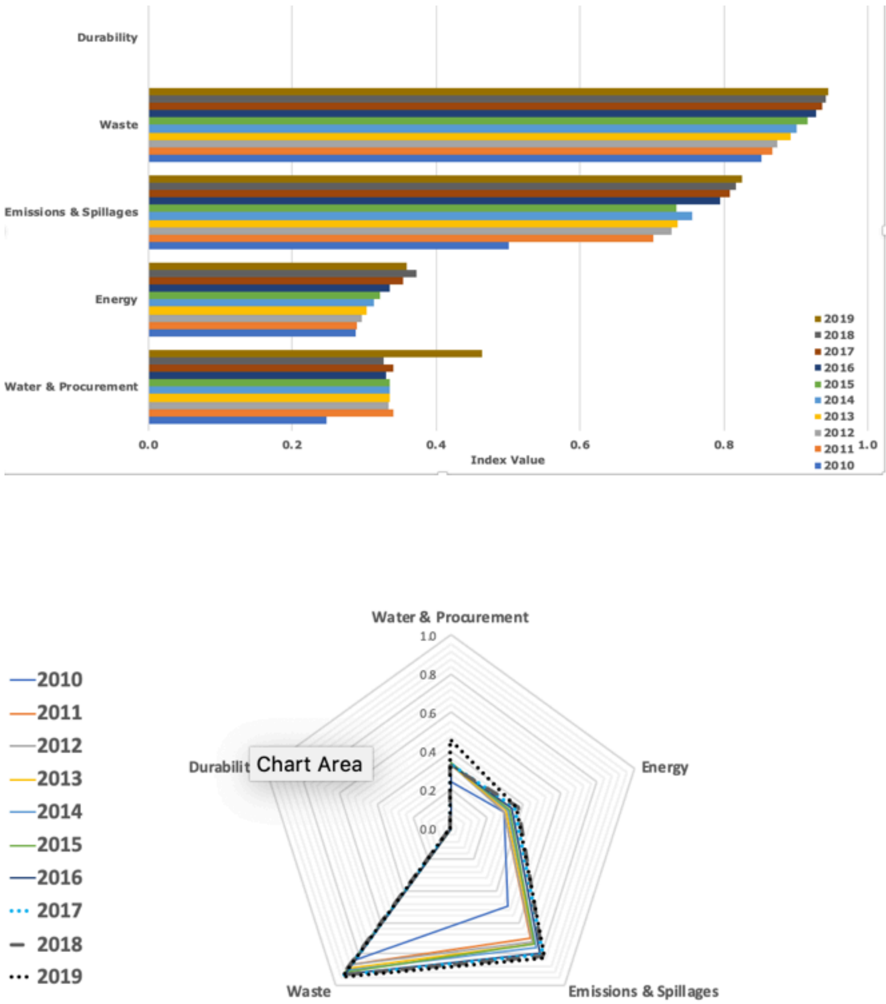


Figure 32 Nestle: CE Progress 2010-2019

Based on the visualizations, it is shown the sector that needs attention to improve their progress towards circularity: "Energy". Similar to BMW, Nestle has not had much significant improvement, but they have improved as the years progress. However, where we do see significant progress towards CE under "Water & Procurement" from 2018 to 2019. It is also shown the improvement under "Waste" as the years progress. Although Nestle's transition towards CE is advancing, they can focus more on "Energy" and "Water

& Procurement”. Based on the reported data, there was not data for reposted for “Durability”.

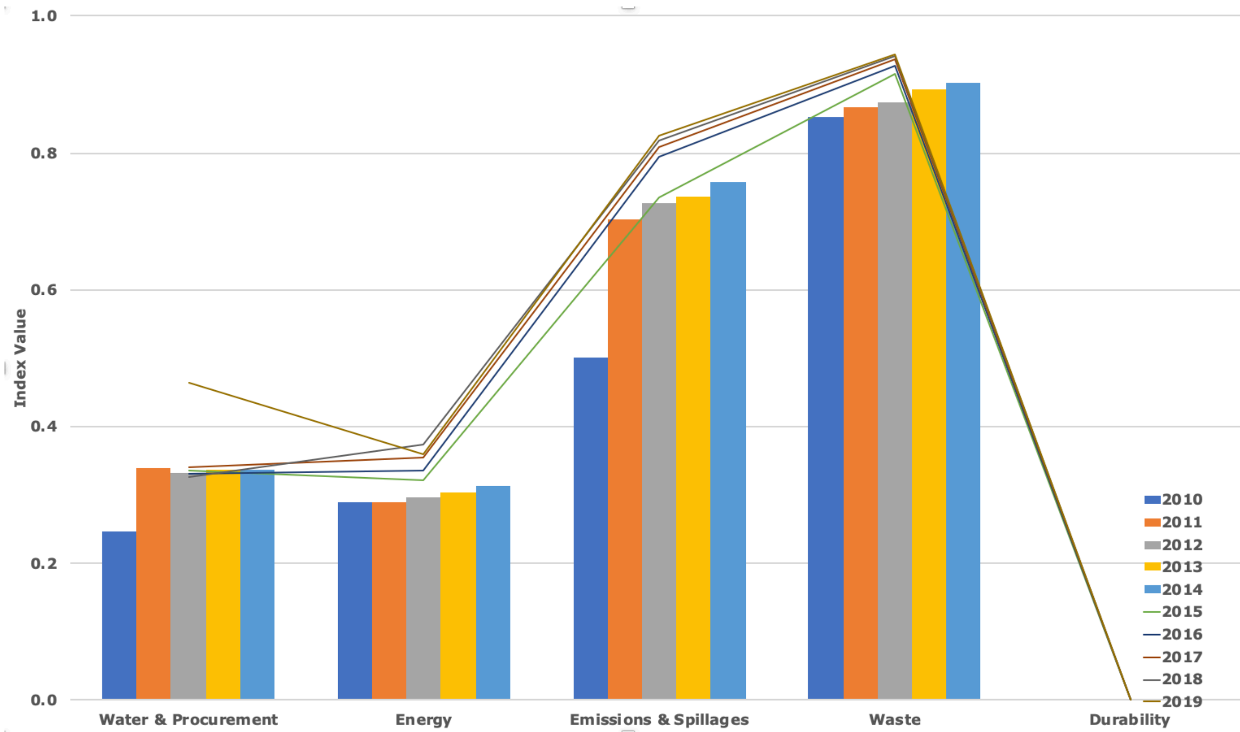


Figure 33 Nestle’s CE Progress –Combo Visualization: Clustered Column –Line

The combo visualization demonstrates the most recent years in the line chart and the clustered columns being the earlier years. The purpose of this visualization is for companies to have a quick glance of their circularity. Based on Figure 33, Nestle has improved over the years as the lines (2015 to 2019) are above the columns (2010-2014) for all four sectors: Water and Procurement, Energy, Emissions & Spillages, and Waste.

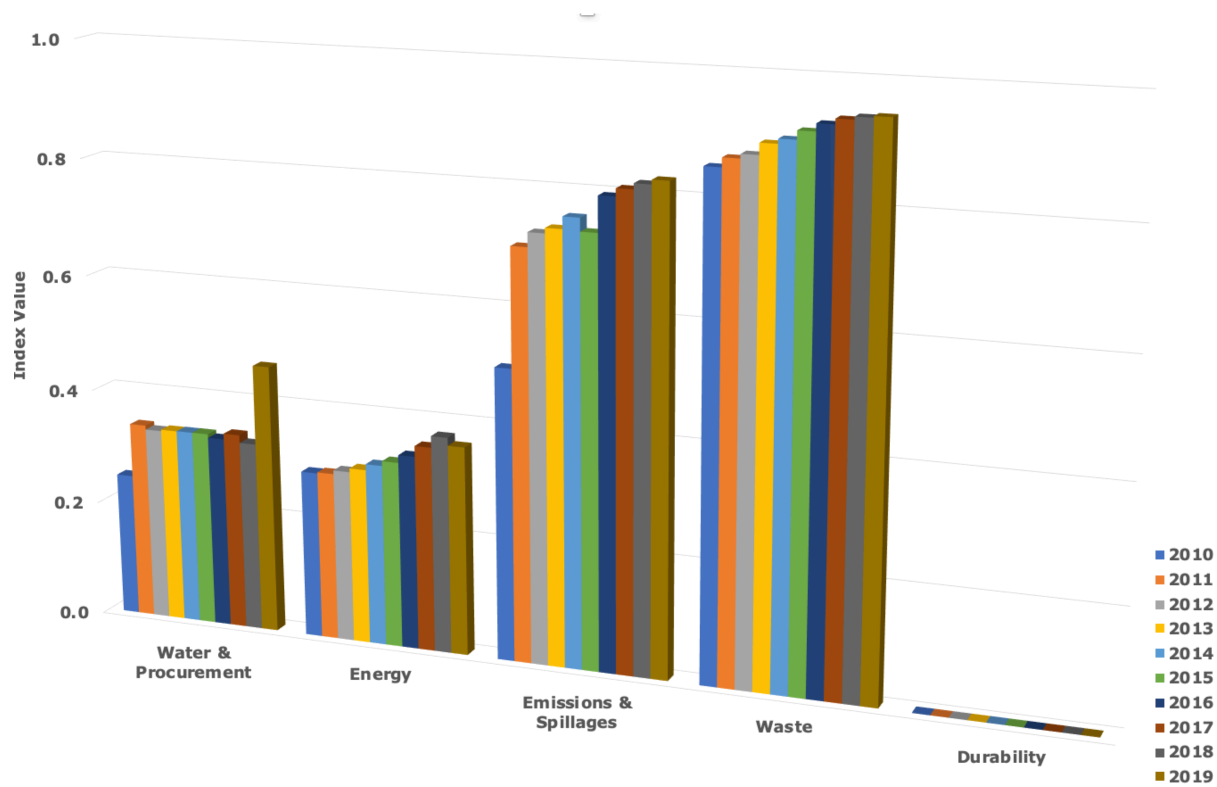


Figure 34 Nestle's CE Progress—3D Clustered Column

The 3D Column visualization shows a more detailed view of the progress throughout the years. There is not a significant difference from 2010 to 2019 but there has been improvement across all four sectors. Unlike the previous visualizations where instead of the columns being next to each other, they are right behind one another, they are next to each other. Because of a weakness of this visualization is that the most recent years can be cover by the earlier years, this is presented next to each other to see all of the reported years.

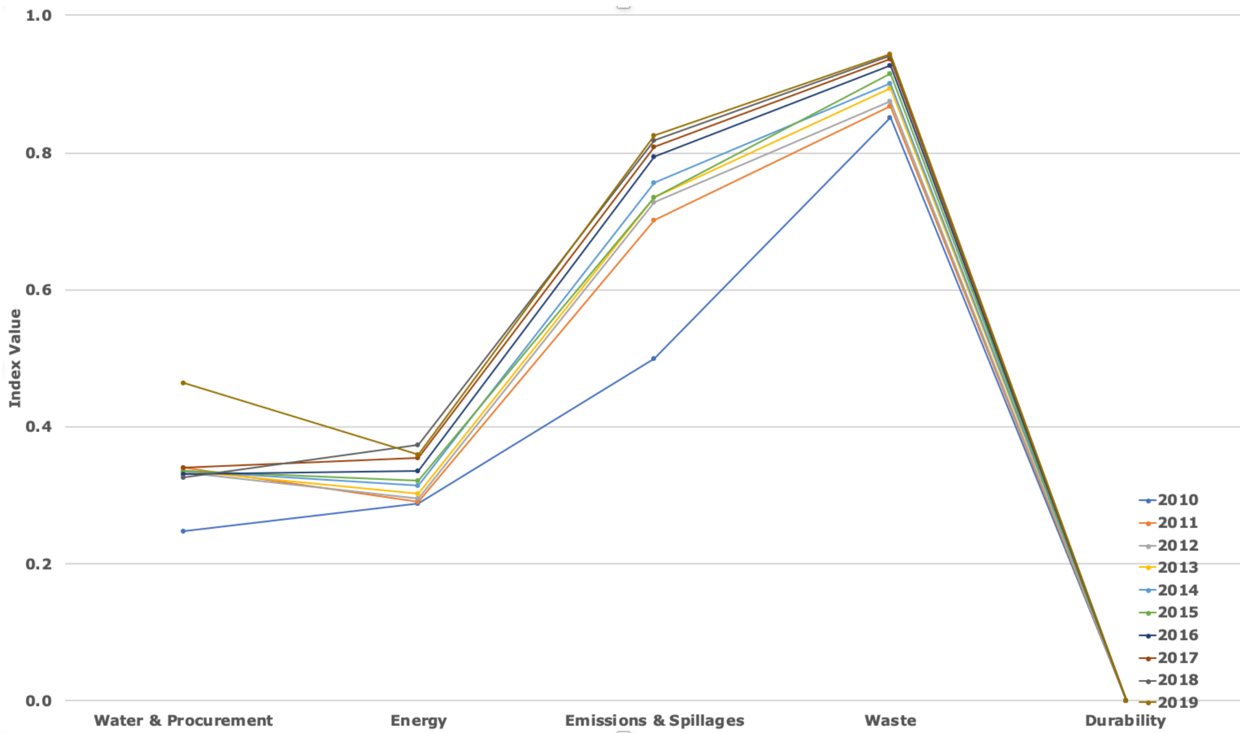


Figure 35 Nestle's CE Progress—Line with Markers

The Line with Markers chart is not as detailed as the 3D column, but with the markers above each sectors, it is shown exactly where their index values are. Figure 35 connects the all of the reported data by the year. As mentioned earlier, there are not significant improvements towards circularity as the years progress, but there is noticeable improvements.

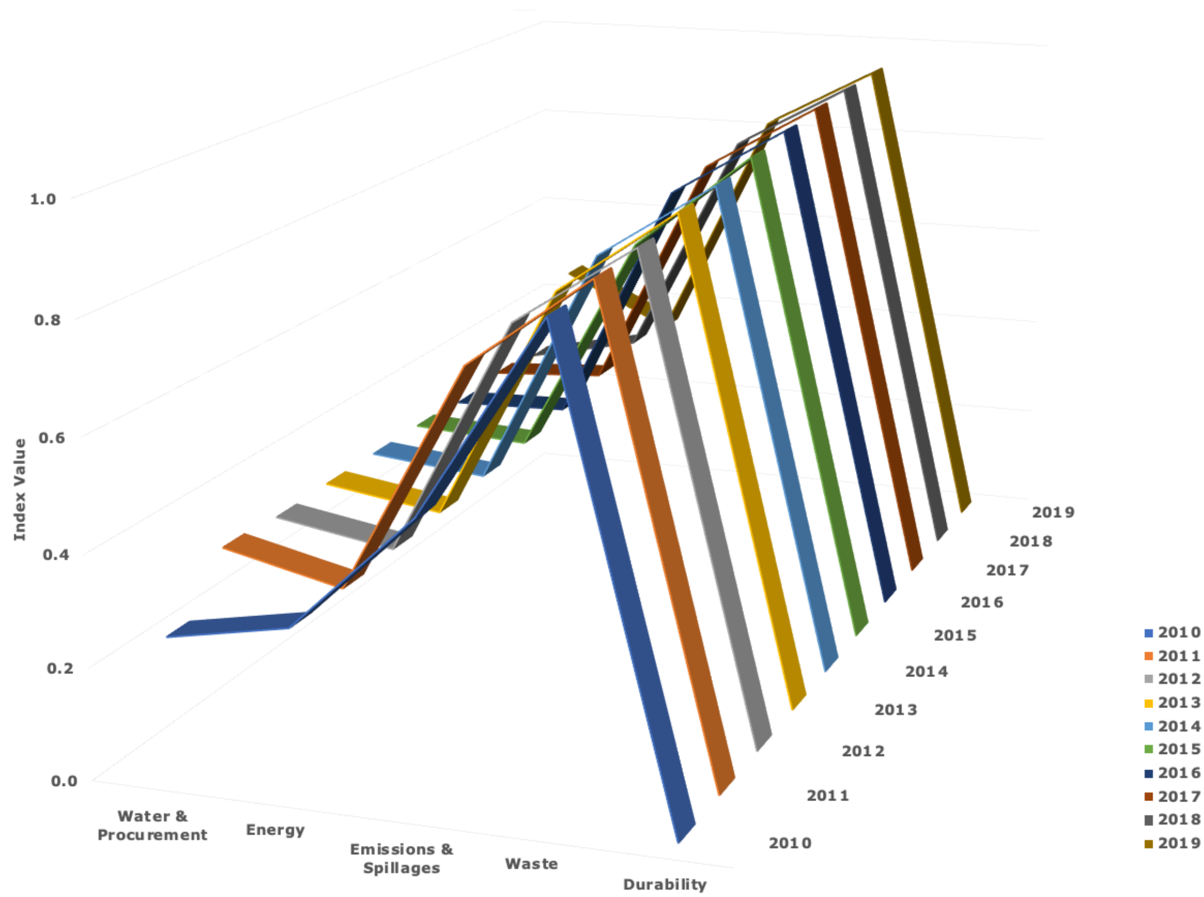


Figure 36 Nestle's CE Progress—3D Line

3D Line connects all the reposted data with a line, but instead of the data being presented on vertically (on top or below one another), it is presented behind one another. However, it can be difficult to see the exact progress there was under "Emissions & Spillages" between 2010 to 2019 whereas other types of visualizations greatly distinguish the difference such as Figure 35.

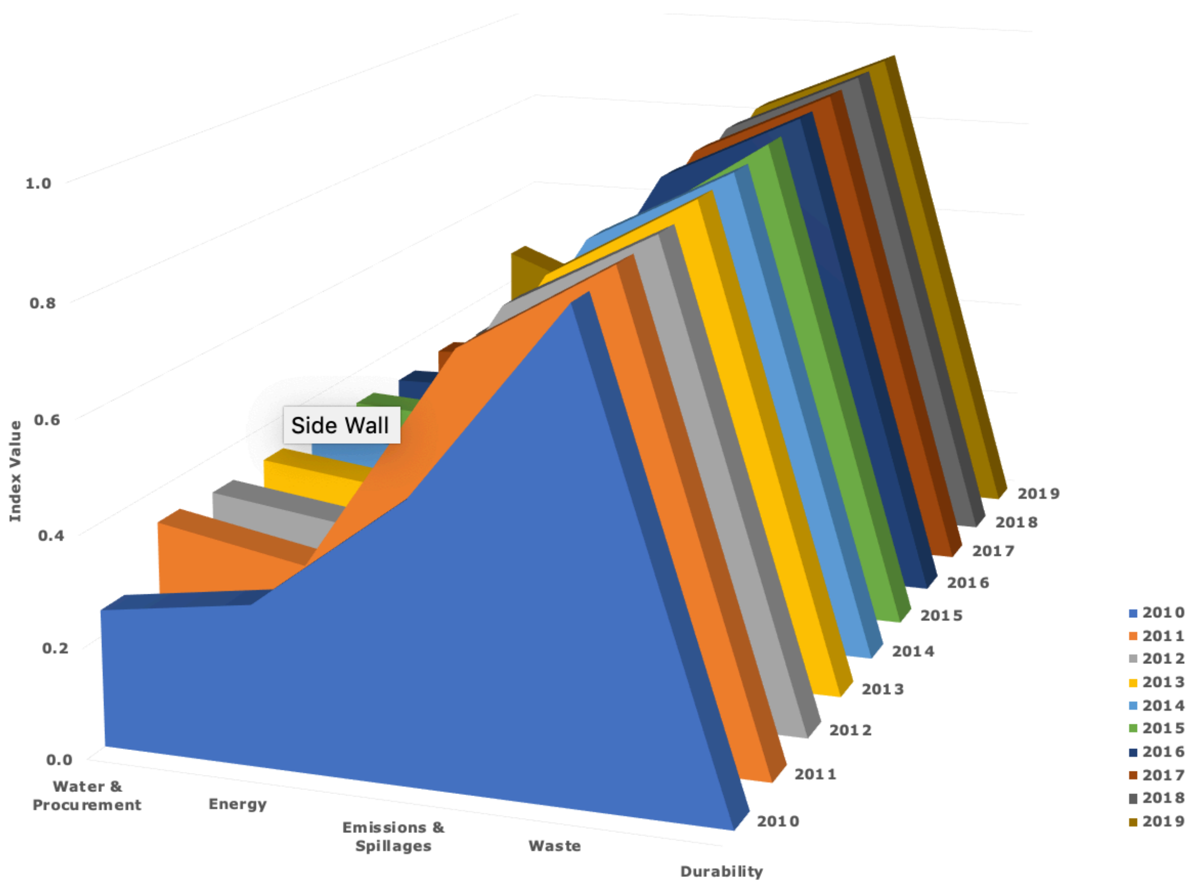


Figure 37 Nestle's CE Progress—3D Area

Because of the filled area, it is shown which sector needs more attention and improvement. In the first column, "Energy" has the least filled area underneath, which means that they need to focus on it to improve their circularity. A weakness about the visualization is that the filled in data from the earlier years can cover the data from the most recent years, as it is shown under "Energy" from 2010 to 2019.

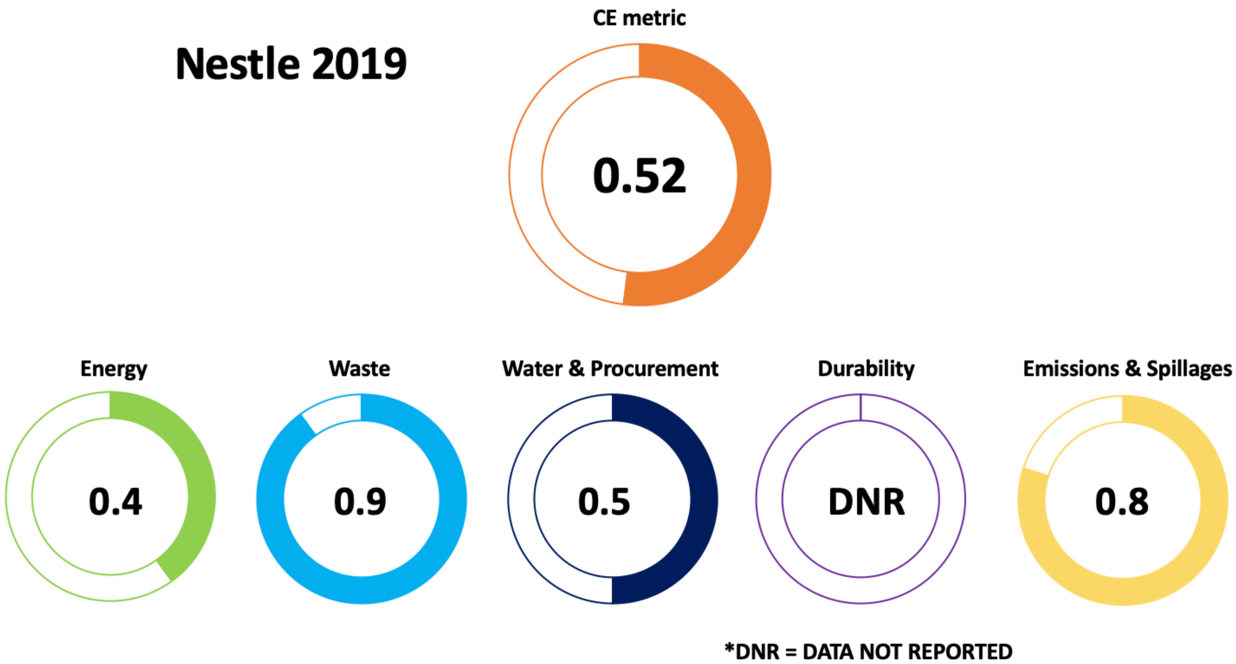


Figure 38 Nestle's CE Progress –Doughnut

Unlike the previous visuals where all of the years were incorporated in one visual, the doughnut visualization focuses on presenting their performance one year at a time. Figure 38 shows BMW's circularity performance for 2019. This visualization helps companies see their score for each CE indicator along with the overall performance. However, a weakness about the Doughnut visualization is that it does not show a clear comparison to the previous years. Because Nestle did not report any data over the packaging materials that were reclaimed or recovered, the missing data lowered the score for the overall performance in 2019. If the CE metric score did not take into consideration the missing data, then the CE metric score would have been 0.65 instead of 0.52. However, it is important to consider the entire data, whether reported or not, to have a more accurate evaluation.

5. FUTURE WORK

Although the main focus was on large companies, it is important to also consider the smaller companies to include all size scales for companies. However, an issue with current tested companies is that they do not report all of the necessary data to complete a full evaluation. Instead of relying on the GRI report, it is recommended to figure out different ways to collect the missing data. A possible solution to address this issues is to reach out to the companies directly to collect the missing data—the data not reported in their GRI reports. However, there is a probability that the companies may take too long to respond or they may not respond at all. Gathering the complete data provides a full CE evaluation for the company, which will allow comparisons with other companies in the same industry.

The current indicators to measure CE primarily focus on the energy, waste, water consumption, and GHG emissions; however, the assessments lacks information over the economic aspect. It is important for companies to see how much investment is needed to improve their circularity. Additionally, it will also be beneficial for companies to see how much money they are saving by transitioning to CE. The economic aspect can be incorporated more in the CE indicators and characteristics. A finance tab can be included in the CE indicators where it will integrate their total expenditures on their current energy use, the total needed to transition to renewable energy sources, and the total amount that companies will save after transitioning.

After working with the different CE indicators and characteristics and inputting different companies' data into the template, it was observed that there is a double counting in metrics when measuring energy. Under "Energy" and "GHG Emissions", both indicators are essentially measuring the energy that does not have renewable energy. This results in penalizing the company twice for not using renewable energy, and it ultimately lowers the company's overall CE score. Double penalizing a company catalyzes an inaccurate

CE evaluation, but this issues can be addressed by recording both sets of data but not including both when calculating the overall CE score.

6. CONCLUSION

Circular Economy focuses on benefiting the economy, businesses, societies, and environment by aiming for a green, recurring use of energy recourses. It also concentrates on reusing products by extending their life cycle. With CE goals in mind, the attention was focused to companies and their sustainability reports. Although the companies' sustainability report had data for the energy input and GHG emissions, they were still missing data over the circularity of their products—procurement for packaging and production and durability. This data is needed for a complete CE evaluation as it measures the life cycle of a product—having a longer use of a product can cause an increase in value, which effect the economy.

There were companies that reported sufficient data to fully evaluate their circularity. With these companies, there were additional visualizations added: the combo Visualization: Clustered Column –Line, 3D Column, Line with Markers, 3D Line, 3D Area, and Doughnut visualizations. Each visualization has its own strengths and weaknesses with different purposes.

The Clustered Column—Line The purpose of this visualization is for companies to have a quick glance of their circularity. It also helps demonstrate the areas that need improvement through a column and line chart; the lines are the most recent 5 years of collected data while the columns show earlier years. The 3D Column visualization shows a more detailed view of the progress throughout the years. Instead of the columns being next to each other, they are right behind one another, which can help get a detailed view of how much it is improving by the height of the columns. The Line with Markers shows exactly where their index values are, which can help with more accuracy. 3D Line connects all the reposted data with a line, but instead of the data being presented on vertically (on top or below one another), it is presented behind one another. However, it can be difficult to see the exact progress for the most recent years as they are in the back being covered by the earlier years. 3D Area displays a clearer view of the indicators that need improvement along with the indicators that do not by looking at the filled area. The least filled area underneath means that they need to focus on it to improve their circularity. The doughnut visualization focuses on presenting their performance one year at a time but it is unable to compare the previous years before. Although all of these visualizations help companies demonstrate their transition towards circularity, the 3D Column does not only demonstrate the areas that need improvement but also tracks the progress from the previous years and displays it. However, for a detailed view of a certain year is best visualized with the Doughnut chart as the scores are clearly visible and it gives an overall score for the entire company.

Overall, most companies are improving their transition towards circularity by emitting less CO_2 and increasing the amount of reported recyclable waste. However, the reports did not include information on recyclable packaging and the renewable packaging materials used. Similar to packaging and product materials, the reports lacked information on the fresh and other water withdrawn along with the amount of water that was recycled or reused, which is needed to make a full circularity evaluation. In addition to lack data, many companies did not report the numbers that could have negatively affect their report. There were some companies that reported the percentage they increase/decreased but not the actual data numbers. Although many companies find it useful to keep track of their circularity, it will not have a fair judgment to compare their circularity to other companies within their industry. This also gives a biased evaluation for CE because while the reported numbers demonstrated the company improving, the entire actual numbers could give a different result of their circularity progress. It is important to report all of the data regarding the company's circularity to not just track their circularity progress but to reduce carbon emissions and to fight climate change. On top of the shortage of nonrenewable energy sources, they have a negative impact on the environment. Helping track a company's progress towards circularity will help transition to a low carbon, regenerative economy.

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APPENDIX A

TOOLS TO MEASURE C.E. UNDER ENERGY, MANUFACTURING, AUTOMOTIVE, AND SERVICES INDUSTRIES

GRI CODES	**Definition**
Energy Sector	
Organization	
GRI-201-1	The direct economic value generated and distributed; this includes revenues and operating costs, employee wages and benefits, etc.
GRI-203-1	Infrastructure investments and services supported
Energy	
GRI-302-1	Energy consumption within the organization *Fossil Fuels: a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms. *Non Fossil Fuels: a hydrocarbon chemical that was not sourced from a geological deposit. Examples: Solar, wind, and biofuels.
GRI-305-1	Direct (Scope 1) GHG emissions • Direct emissions from sources that are owned or controlled by the organization ▪ It includes on-site fossil fuel combustion and fleet fuel consumption .
GRI-305-2	Energy indirect (Scope 2) GHG emissions • Indirect emissions from sources that are owned or controlled by the organization ▪ It includes emissions that result from the generation of electricity, heat or steam purchased by the organization from a utility provider.
GRI-305-5	Reduction of GHG emissions *Greenhouse gases (GHG) are gases in Earth's atmosphere that trap heat and absorb infrared radiation.
GRI-305-6	Emissions of ozone-depleting substances (ODS) *Ozone-depleting substances (ODS) are chemicals that destroy the earth's protective ozone layer.
GRI-305-7	Nitrogen oxides (NOx), sulfur oxides (Sox), and other significant air emissions Other significant air emissions = persistent organic pollutants (POP), Volatile organic compounds (VOC), Hazardous air

	pollutants (HAP), Particulate matter (PM), Other standard categories of air emissions identified in relevant regulations
Water	
GRI-303-1	The amount of water withdrawal by source
GRI-303-4	Total water discharged • A breakdown of total water discharge to all areas in the two categories: Freshwater and Other Water. *Freshwater is water with concertation of total dissolved solids equal to or below 1,000 mg/L
GRI-303-3	Water recycle and reused
Waste	
GRI-306-3	These are significant spills and the impacts it has had. More specifically, it is asking for the amount of waste generated in the two following categories: hazardous waste and non-hazardous waste. *Hazardous waste: waste with properties that make it dangerous or capable of harming effect on human health or the environment.
GRI-306-4	Transport of hazardous waste. More specifically, it is asking for the waste from disposal that was either reused, recycled or recovered.
GRI-307-1	Non-compliance with environmental laws and regulations. More specifically, the environmental fines that the organization was charged.
GRI-306-4 **OG6 (2016)**	*******
GRI-306-4 **OG6 (2016)**	*******

Table 5 Energy industry with GRI description

Manufacturing Sector

Organization	
GRI-201-1	The direct economic value generated and distributed; this includes revenues and operating costs, employee wages and benefits, etc.
GRI-203-1	Infrastructure investments and services supported
GRI-301-3	Reclaimed products and their packaging materials
Energy	
GRI-302-1	Energy consumption within the organization *Fossil Fuels: a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms. *Non Fossil Fuels: a hydrocarbon chemical that was not sourced from a geological deposit. Examples: Solar, wind, and biofuels.
GRI-305-1	Direct (Scope 1) GHG emissions • Direct emissions from sources that are owned or controlled by the organization ▪ It includes on-site fossil fuel combustion and fleet fuel consumption .
GRI-305-2	Energy indirect (Scope 2) GHG emissions • Indirect emissions from sources that are owned or controlled by the organization ▪ It includes emissions that result from the generation of electricity, heat or steam purchased by the organization from a utility provider.
GRI-305-5	Reduction of GHG emissions *Greenhouse gases (GHG) are gases in Earth's atmosphere that trap heat and absorb infrared radiation.
GRI-305-6	Emissions of ozone-depleting substances (ODS) *Ozone-depleting substances (ODS) are chemicals that destroy the earth's protective ozone layer.
GRI-305-7	Nitrogen oxides (NOx), sulfur oxides (Sox), and other significant air emissions Other significant air emissions = persistent organic pollutants (POP), Volatile organic compounds (VOC), Hazardous air pollutants (HAP), Particulate matter (PM), Other standard categories of air emissions identified in relevant regulations
Water	
GRI-303-1	The amount of water withdrawal by source
GRI-303-4	Total water discharged

	• A breakdown of total water discharge to all areas in the two categories: Freshwater and Other Water. *Freshwater is water with concertation of total dissolved solids equal to or below 1,000 mg/L
GRI-303-3	Water recycle and reused
Waste	
GRI-306-3	These are significant spills and the impacts it has had. More specifically, it is asking for the amount of waste generated in the two following categories: hazardous waste and non-hazardous waste. *Hazardous waste: waste with properties that make it dangerous or capable of harming effect on human health or the environment.
GRI-306-4	Transport of hazardous waste. More specifically, it is asking for the waste from disposal that was either reused, recycled or recovered.
GRI-307-1	Non-compliance with environmental laws and regulations. More specifically, the environmental fines that the organization was charged.
Procurement	
GRI-301-1	Materials used by weight or volume. More specifically, total amount of non-renewable and renewable materials used to produce and package the company's products/service. *Renewable: a substance of economic value that can be replaced or replenished in less time than it takes to draw the supply down. Examples: biomass, wind, solar, hydropower, etc. *Non-renewable: a natural substance that is not replenished with the speed at which it is consumed. Examples: oil, natural gas, coal, and nuclear energy.
GRI-301-2	Recycled input materials used. This includes the percentage of recycled input materials used to manufacture the company's product/service.
GRI-301-3	Reclaimed products and their packaging materials. More specifically, this is total percentage of the reusable, compostable or recyclable packaging materials.
Durability	
GRI-306-2	Waste by type and disposal method. This refers to collecting, reusing, or recycling products and their packaging materials at the end of their useful lives.

Table 6 Manufacturing industry with GRI description

Automotive Sector

Organization	
GRI-201-1	The direct economic value generated and distributed; this includes revenues and operating costs, employee wages and benefits, etc.
GRI-102-7	Scale of organization
GRI-203-1	Infrastructure investments and services supported
GRI-301-3	Reclaimed products and their packaging materials
Energy	
GRI-302-1	Energy consumption within the organization *Fossil Fuels: a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms. *Non Fossil Fuels: a hydrocarbon chemical that was not sourced from a geological deposit. Examples: Solar, wind, and biofuels.
GRI-305-1	Direct (Scope 1) GHG emissions • Direct emissions from sources that are owned or controlled by the organization ▪ It includes on-site fossil fuel combustion and fleet fuel consumption .
GRI-305-2	Energy indirect (Scope 2) GHG emissions • Indirect emissions from sources that are owned or controlled by the organization ▪ It includes emissions that result from the generation of electricity, heat or steam purchased by the organization from a utility provider.
GRI-305-5	Reduction of GHG emissions *Greenhouse gases (GHG) are gases in Earth’s atmosphere that trap heat and absorb infrared radiation.
GRI-305-6	Emissions of ozone-depleting substances (ODS) *Ozone-depleting substances (ODS) are chemicals that destroy the earth’s protective ozone layer.
GRI-305-7	Nitrogen oxides (NOx), sulfur oxides (Sox), and other significant air emissions Other significant air emissions = persistent organic pollutants (POP), Volatile organic compounds (VOC), Hazardous air pollutants (HAP), Particulate matter (PM), Other standard categories of air emissions identified in relevant regulations
Water	
GRI-303-1	The amount of water withdrawal by source
GRI-303-4	Total water discharged

	• A breakdown of total water discharge to all areas in the two categories: Freshwater and Other Water. *Freshwater is water with concertation of total dissolved solids equal to or below 1,000 mg/L
GRI-303-3	Water recycle and reused
Waste	
GRI-306-3	These are significant spills and the impacts it has had. More specifically, it is asking for the amount of waste generated in the two following categories: hazardous waste and non-hazardous waste. *Hazardous waste: waste with properties that make it dangerous or capable of harming effect on human health or the environment.
GRI-306-4	Transport of hazardous waste. More specifically, it is asking for the waste from disposal that was either reused, recycled or recovered.
GRI-307-1	Non-compliance with environmental laws and regulations. More specifically, the environmental fines that the organization was charged.
Procurement	
GRI-301-1	Materials used by weight or volume. More specifically, total amount of non-renewable and renewable materials used to produce and package the company's products/service. *Renewable: a substance of economic value that can be replaced or replenished in less time than it takes to draw the supply down. Examples: biomass, wind, solar, hydropower, etc. *Non-renewable: a natural substance that is not replenished with the speed at which it is consumed. Examples: oil, natural gas, coal, and nuclear energy.
GRI-301-2	Recycled input materials used. This includes the percentage of recycled input materials used to manufacture the company's product/service.
GRI-301-3	Reclaimed products and their packaging materials. More specifically, this is total percentage of the reusable, compostable or recyclable packaging materials.
Durability	
GRI-306-2	Waste by type and disposal method. This refers to collecting, reusing, or recycling products and their packaging materials at the end of their useful lives.

Table 7 Automotive industry with GRI description

Services Sector

Organization	
GRI-201-1	The direct economic value generated and distributed; this includes revenues and operating costs, employee wages and benefits, etc.
GRI-102-7	Scale of organization
GRI-203-1	Infrastructure investments and services supported
GRI-301-3	Reclaimed products and their packaging materials
Energy	
GRI-302-1	Energy consumption within the organization
GRI-305-1	Energy consumption within the organization *Fossil Fuels: a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms. *Non Fossil Fuels: a hydrocarbon chemical that was not sourced from a geological deposit. Examples: Solar, wind, and biofuels.
GRI-305-2	Direct (Scope 1) GHG emissions • Direct emissions from sources that are owned or controlled by the organization ▪ It includes on-site fossil fuel combustion and fleet fuel consumption .
GRI-305-5	Energy indirect (Scope 2) GHG emissions • Indirect emissions from sources that are owned or controlled by the organization ▪ It includes emissions that result from the generation of electricity, heat or steam purchased by the organization from a utility provider.
GRI-305-6	Reduction of GHG emissions *Greenhouse gases (GHG) are gases in Earth’s atmosphere that trap heat and absorb infrared radiation.
GRI-305-7	Emissions of ozone-depleting substances (ODS) *Ozone-depleting substances (ODS) are chemicals that destroy the earth’s protective ozone layer.
Water	
GRI-303-1	The amount of water withdrawal by source
GRI-303-4	Total water discharged • A breakdown of total water discharge to all areas in the two categories: Freshwater and Other Water. *Freshwater is water with concertation of total dissolved solids equal to or below 1,000 mg/L
GRI-303-3	Water recycle and reused
Waste	

GRI-306-3	These are significant spills and the impacts it has had. More specifically, it is asking for the amount of waste generated in the two following categories: hazardous waste and non-hazardous waste. *Hazardous waste: waste with properties that make it dangerous or capable of harming effect on human health or the environment.
GRI-306-4	Transport of hazardous waste. More specifically, it is asking for the waste from disposal that was either reused, recycled or recovered.
GRI-307-1	Non-compliance with environmental laws and regulations. More specifically, the environmental fines that the organization was charged.
Procurement	
GRI-301-1	Materials used by weight or volume. More specifically, total amount of non-renewable and renewable materials used to produce and package the company's products/service. *Renewable: a substance of economic value that can be replaced or replenished in less time than it takes to draw the supply down. Examples: biomass, wind, solar, hydropower, etc. *Non-renewable: a natural substance that is not replenished with the speed at which it is consumed. Examples: oil, natural gas, coal, and nuclear energy.

Table 8 Service industry with GRI description