Sustainable Business International Journal

JUNHO DE 2016 - ISSN 1807-5908

SUSTAINABILITY IN THE CHEMICAL INDUSTRY IN BRAZIL

Carolina Cabral Netto
Chemical Engineer graduated from the Federal University of Sao Paulo and currently working at BASF. Has experience in corporate sustainability, including both environmental and social responsability.
KM 18 Via Anchieta,
09605-000 - São Bernardo do Campo – SP
Telefone: +55 11 4177-6509
carolina.netto@basf.com

Lívia Gabriele Azevedo Garcia
Chemical Engineer graduated from the Federal University of Sao Paulo. Has experience in quality laboratory, physicochemical analysis, R&D cosmetics and stability routines.
Telefone.: + 55 (11) 3699.0245
liviagabriele@gmail.com

Simone Georges El Khouri Miraglia
Professor Simone Miraglia is PhD and currently works at Universidade Federal de São Paulo as a researcher and professor. She has experience in environment research, including sustainability evaluation, air pollution effects and environmental valuation.
Rua São Nicolau 210 - 4º andar
Cep 09913-030 - Diadema - SP
Telefone: (5511) 3319-3592
simone.miraglia@unifesp.br
Skype: simone_miraglia

Resumo: Ao longo das últimas décadas, a indústria química tem mostrado uma alta taxa de crescimento, resultando em maior consumo de matérias-primas, recursos naturais e também maior geração de resíduos. Neste contexto, uma atitude mais sustentável foi adotada e os resultados de tais esforços publicados nos Relatórios de Sustentabilidade. O objetivo deste estudo é apresentar, através da análise de relatórios de sustentabilidade de dez empresas previamente selecionadas e por seus indicadores econômicos, sociais e ambientais, o nível de aplicação quantitativa e qualitativa da sustentabilidade nos processos, políticas e cultura da indústria química. Os relatórios foram analisados por meio de planilhas do Excel elaboradas com base em diretrizes da GRI. Para a análise qualitativa, as empresas foram agrupadas, possibilitando o desenvolvimento e análise de indicadores relativos, bem como a realização de avaliação dos níveis de aplicação da GRI. A análise permitiu-nos compreender e medir o nível de sustentabilidade em todos os setores e concluir que a sustentabilidade na indústria química nacional está em um estágio inicial, concentrando sua atenção sobre

os aspectos de consumo de energia, água e emissões. Novos progressos na área requerem maiores investimentos em pesquisa e desenvolvimento de processos mais limpos e com menos resíduos.

Palavras-chave: Indústria Química; Sustentabilidade; Sustentabilidade – indicadores.

Abstract: Over the past few decades, the Chemical Industry has shown a high growth rate resulting in higher consumption of raw materials, natural resources and also higher waste generation. In this context, a more sustainable attitude was adopted and the results of such efforts are published in Sustainability Reports. The objective of this study is to present, through the analysis of sustainability reports of ten companies previously selected and by their economic, social and environmental indicators, the level of quantitative and qualitative application of sustainability in the processes, policies and culture of the chemical industry. The reports were analyzed by means of Excel Spreadsheets that were elaborated based on GRI guidelines. For the qualitative analysis, the companies were grouped enabling the development and analysis of relative indicators. It was also performed an assessment of the GRI application levels. The analysis allowed us to understand and measure the level of sustainability across industries and conclude that sustainability in the national chemical industry is at an early stage, where the industry is currently focusing its attention on aspects of energy consumption, water and emissions. Further progress in the area requires greater investments in research and development of cleaner processes and that result in less waste.

Keywords: Chemical Industry; Sustainability; Sustainability - indicators

1. INTRODUCTION

Not only has sustainability been growing as a research field but its application has also been seen lately in the chemical industry, whose activities shave long been held responsible for environmental impact.

In this context, the main purpose of this paper is to present a methodology of analysis and comparison to assess the sustainability performance in the chemical industry. Ten companies were selected whose reports have been based on the GRI guidelines (Global Reporting Initiative – non-governmental organization that provides the guidelines for the preparation of sustainability reports), allowing the authors to adopt them for analysis.

The GRI guidelines provide a range of economic, social and environmental indicators, besides information related to governance and size of the reporting company. The indicators may be classified as core or additional and are created or revised at every new document release by a stakeholder council.

The proposed methodology consists in creating new relative indicators (based on those previously reported) and comparing them between each company amongst similar industries, thus allowing for quantitative conclusions regarding their respective sustainability performance.

The quantitative analysis is directly linked to the veracity and quality of each company's reported information and the respective ease of access to this data since many companies choose to publish such information online on their websites.

The provided social indicators were put through quantitative analysis regarding their respective presence in each report and their impact to the company's image, reputation and the actual sustainability compliance in each company.

The paper's main objective is to demonstrate the actual quantified and qualitative level of application of sustainability concepts in the processes, policies and culture of the chemical industry by analyzing ten previously selected sustainability reports from different companies in the sector.

2. ASUMPTIONS

The growing importance of the concept of sustainability in production processes, policies and company culture and the lack of academic work involving a performance evaluation methodology for sustainability have influenced the choice of the subject of this paper. The development of such methodologies is also very relevant

in the evaluation of the influence of sustainable development in each company's financial and economic performance, providing opportunities of improvement in the production processes performance as well as lowering unneeded losses, whose savings can be redirected to further investments.

3. REVIEW OF LITERATURE

Global warming, the depletion of nonrenewable resources, water contamination, air pollution are amongst the many problems we currently face that directly resulted from the inadvertently usage of natural resources during decades solely focused on economic and technological development. Consequently, sustainable development has acquired global attention from the 20th century onwards (MOHAMAD, REPKE, WOZNY, & HUANG, 2010).

Sustainability became a frequently used word possessing many implicit concepts. Due to its positive implications many companies began publishing sustainability reports in order to demonstrate their respective sustainable performance. It's assumed that such behavior should became a common practice, as suggested by global initiatives such as the GRI and the "Agenda 21" (SACRAMENTO-RIVERO, 2011).

The aforementioned definition promotes the three pillars of sustainability: Economic, Environmental and Social (triple bottom line). Although these are specific elements the concept of sustainability implies the observation that interconnecting elements must support and reinforce each other in a reciprocate relation (VOS, 2007).

Chemical processes provide a wide array of products and materials with high aggregated value, essential to modern societies/economies ranging from healthcare to

food processing however each process demands a high quantity of nonrenewable natural resources and generates significant amounts of waste and emissions to the environment (TORRES, GADALLA, MATEO-SANZ, & ESTELLER, 2011).

Considering this complex scenario the companies are looking for a decision support mechanism that could assist reach all triple bottom line objectives. Arising from this complex equilibrium many decision makers faces sustainability development dilemmas which can be addressed, for instance, using management tools like muti-criteria analysis, which provides an adequately answer to needs and goals of different stakeholders involved (De Brucker *et al.*, 2012).

Reaching sustainable development will require changes in industrial processes, in the type and amount of consumed resources, in waste disposal as well as emissions control. In order to ensure that the level of sustainability in the industry is correctly measured and reported it's necessary to use appropriate indicators (KRAJNC & GLAVIC, 2003).

The chemical industry has demonstrated significant effort towards reaching higher levels of sustainability by means of developing and applying cleaner technologies, recycling and reusing, reduction or elimination of waste, reduction of greenhouse emissions, avoiding the use of hazardous substances and reducing the amount of energy used in their processes. During the past few decades a wide range of methodologies and indicators were suggested to assess the evolution of sustainability in the chemical processes (ZHENG, LOU, GANGADHARAN, & KANCHI, 2012).

The application of sustainability in the chemical industry can be exemplified by initiatives such as the ones from BASF, whose adopted eco-efficiency indicators

assist in the choice of alternative processes which aim in providing improvements in the economic and environmental performance. The American Institute of Chemical Engineers (AIChE) also propose an array of indicators that may be applied in industrial processes. In the corporate level GRI proposes guidelines for companies that want to report their sustainability capabilities. The Institute of Chemical Engineers (IChemE) also proposes a complete list of indicators for industrial operation grouped in 5 categories. Although this may be applied to a specific process or to the whole plant the list is too long for a systematic application (MARTINS, MATA, & COSTA, 2007).

This way by creating an indicator one should take into consideration that it evaluates the current status concerning the predetermined targets and objectives, warns about potential risks of the process and predicts future trends. The indicators must also allow for the identification of the most sustainable options by comparing similar products, different production processes for the same product, performance between two different plants inside the same company but also in different companies. And lastly evaluate the growth of sustainable development in a specific company or even an entire industry (KRAJNC & GLAVIC, 2003).

Recent applied study revealed that integrated sustainability metrics offer a more advanced method for product and supply chain sustainability measurement and assessment which could be useful for manufacturers (Ingwersen *et al.*, 2016).

The main purpose of the sustainability report is to demonstrate risks and opportunities, ensure reputation and brand loyalty, help stakeholders to better understand the impacts of sustainability, influence in the company's strategy and

policy, act as a benchmark, allow for compliance evaluation (Global Reporting Initiative, 2006).

4. METHODOLOGY

The data for the analysis of the sustainability of the chemical industry in Brazil were obtained after selection of sustainability reports from ten industries that have chemicals processes along its supply chain. These industries belong to the petrochemical, agrochemical, food/beverage, consumer goods (cosmetics, cleaning products, etc.) and basic chemical industry.

Taking as reference the G3.0 and G3.1 guidelines provided by the Global Reporting Initiative, a guide for the report data analysis was elaborated. For information intrinsic to the structure of the report it was evaluated whether or not attending to the criteria and, where appropriate, comments were included to complement the analysis reviews. For economic, environmental and social indicators it was verified whether or not attending to the requirements of the GRI guidelines.

The indicators provided by GRI are divided in three main groups – economic, social and environmental –and may be core or additional.

Economic Indicators: The economic dimension of sustainability concerns the organization's impacts on the economic conditions of its stakeholders and on economic systems at local, national and global levels (Global Reporting Initiative, 2006).

Environmental Indicators: The environmental dimension of sustainability concerns the organization's impacts on both living and non-living natural systems, including ecosystems, land, air and water (Global Reporting Initiative, 2006).

Social Indicators: The social dimension concerns the impacts an organization has on the social systems within which it operates (Global Reporting Initiative, 2006, s.d.).

After the detailed analysis of each previously selected report, the companies were clustered by market sectors and/or processes similarity. The groups created for comparison purposes are described below: Alcoa and Vale, BrFoods, Nestlé and Unilever, Bunge and Syngenta, Natura and Unilever, Braskem and Petrobras. The relative indicators elaborated are described in the Table 1 and were applied in each comparison group according to the data availability in the analyzed reports. The Relative Indicators (IR) were developed in order to illustrate different comparisons from those commonly addressed in sustainability reporting.

Table1 – Indicadores relativos e respectiva descrição.

Indicator Identification	Indicator	Description
IR1	EN3/Net Revenue	Direct Energy by Net Revenue (GJ/R$)
IR2	EN4/Net Revenue	Indirect Energy by Net revenue (GJ/R$)
Indicator Identification	**Indicator**	**Description**
IR3	(EN3+EN4)/Net Revenue	Total Energy by Net Revenue (GJ/R$)
IR4	EN3/Production Volume	Direct Energy by Production Volume

		(GJ/produced ton)
IR5	EN5/Production Volume	Energy Saved by Production Volume (R$.year/boe)
IR6	EN8/Net Revenue	Total water withdrawal by source by Net Revenue (m^3/ R$)
IR7	EN8/Production Volume	Total water withdrawal by source by Production Volume (m^3/produced ton)
IR8	EN10/Production Volume	Water recycled and reused by Production Volume (m^3/produced ton) and for Petrobras (m^3.year/boe)
IR9	EN16/Net Revenue	Total direct and indirect greenhouse gas emissions by weight by Net Revenue ($tonCO_{2e}$/R$)
IR10	EN16/Production Volume	Total direct and indirect greenhouse gas emissions by weight by Production Volume ($tonCO_{2e}$/produced ton)

Indicator Identification	**Indicator**	**Description**
IR11	EN18/Production Volume	Initiatives to reduce greenhouse gases missions by Production Volume ($tonCO_{2e}$/produced ton)
IR12	EN19/Production Volume	Emissions of ozone-depleting substances by Production Volume (ton O_3/produced ton)
IR13	EN21/Net Revenue	Total water discharge by Net Revenue (m^3/R$)

IR14	EN21/Production Volume	Total water discharge by Production Volume (m^3/produced ton)
IR15	EN22/Net Revenue	Total weight of waste by Net Revenue (ton/R$)
IR16	EN22/Production Volume	Total weight of waste by Production Volume(ton/produced ton)
IR17	EN23/Production Volume	Total number and volume of significant spills by Production Volume (m^3/produced ton) and for Petrobras (m^3.year/boe)
IR18	EN27/Net Revenue	Percentage of products sold and their packaging materials that are reclaimed by category(ton/R$)
Indicator Identification	**Indicator**	**Description**
IR19	EN29/Net Revenue	Greenhouse gas emissions due to transportation by Net Revenue (tonCO_{2e}/R$)
IR20	EN30/Net Revenue	Total environmental protection expenditures and investments by Net Revenue (R$/R$)

*boe: barrelof oil equivalent

*CO_{2e}: CO_2 equivalent

After the conceptual elaboration of indicators based on data extracted from reports and additional information as Net Revenue and Annual Production Volume extracted from other sources (financial statements and reporting companies websites),

there were comparisons between groups and illustrative charts containing relative indicators on common among the ten companies were prepared, allowing to obtain conclusions about the level of implementation and sustainability performance among the various chemical industries.

The social indicators were analyzed qualitatively through a critical analysis regarding the presence or absence of indicators in the reports and their impact on image, reputation and level of implementation of sustainability in companies.

The last analysis was a qualitative evaluation of the GRI application levels. Taking as reference the GRI guidelines, for each report it was verified the amount of requirements for each application level examined in which the report was framed. Where applicable, it was suggested a new application level.

5. RESULTS AND DISCUSSION

The results presented below were obtained through analysis of sustainability reports of the following companies:

- Alcoa Alumínio S.A.: the world's leading producer of primary and fabricated aluminum, as well as the world's largest miner of bauxite and refiner of alumina. Braskem: operates in the chemical and petrochemical markets, focused on the production of thermoplastic PE, PP and PVC resins in addition to chemicals.
- BRFoods: leading producer of cold and frozen foods. Has 61 plants in Brazil, 5 in Argentina, 2 in Europe (Plusfood) and has 118,859 employees.

- Bunge Brazil: operates in the production and sales of fertilizers, purchasing and processing grain, food production, sugar production and bioenergy. Has 150 plants and 19,000 employees.
- Natura: operates in the personal care, perfume and cosmetics market. Has 15 plants in Brazil and 1 in Argentina. Has 7,000 employees.
- Nestlé: the world's leading nutrition, health and Wellness Company. Has 30 plants in Brazil, 141 brand, generates more than 20,000 direct jobs and 220,000 indirect.
- Petrobras: leader in the petroleum sector in Brazil, operates as an integrated energy company in exploration and production, refining, trade and transportation of oil, natural gas, petrochemicals, distribution of oil derivatives, electricity, biofuels and other sources of renewable energy. Operates in 28 countries and has 81,918 employees.
- Syngenta: its portfolio includes solutions for crop protection, lawn and garden, seed care and pest control. Operates in 90 countries and has more than 26,000 employees.
- Unilever: one of the largest companies in the world in the production of consumer goods. Operates in 180 countries with 13,639 employees.
- Vale: world's largest producer of iron ore and pellets, the second largest nickel producer, active in logistics, steel and energy sectors. Has 187,700 employees.

The previously selected companies adopt the GRI guidelines for preparing their sustainability reports. All companies publish their annual reports in electronic

and printed format. The companies have at least one previous report to the ones analyzed in this paper, except for Nestlé which first published a report adopting the GRI guidelines.

Regarding stakeholders only Nestlé and Unilever do not report which channel is used to get in contact with their main partners. The other eight companies that report their communication channels relate to their stakeholders primarily through electronic channels (email, websites, blogs), SAC, ombudsman, regular investor meetings, visits and participation in projects and / or organizations / government entities and non-governmental entities.

Concerning the adequacy of the principles proposed by the GRI, the reports, in general, presented the company's performance in a broad context of sustainability, developed a materiality matrix with its stakeholders in order to report relevant issues ensuring good coverage, while the reports proved to be balanced since both positive and negative aspects are included along the reports.

All companies have a statement in the beginning of its reports the most senior decision maker of the organization about the relevance of sustainability to the company and its strategy. Regarding the organizational profile, the information was provided in a clear and transparent way, including the identification of impacts, risks and opportunities.

Regarding the parameters of the report only Nestlé and Syngenta do not match the item that is related to the external audit for the Application level of its report.

Items regarding governance, commitment and engagement are complete only for Bunge, BRFoods, Braskem, Petrobras and Natura.

The report that was less satisfactory in terms of profile, parameters and items related to governance, commitment and engagement was the Syngenta's, since it does not meet most of the items required by GRI in the context quoted. Subsequently to the profile analysis proceeded the analysis of the Environmental, Economic and Social performance indicators.

Environmental Indicators: By analyzing the reports of each company, all or most of them show the environmental performance indicators relating to: Materials- EN1,Energy - EN3, EN5, Water - EN8, Biodiversity - EN11, Emissions, Effluents and Waste - EN16, EN18, EN23, Products and Services - EN26, Overall- EN3.

The environmental indicators are better represented in the reports. Petrobras, Natura, Bunge, Vale and BRFoods report these indicators with clarity, transparency and abundance, providing an overview of the specific consumption of materials, amount of recycled materials, water consumption, recycled/reused water, spills, emissions of greenhouses gases, initiatives to reduce utilities consumption and emission reduction, protected areas and targeted investments to environmental protection.

Although Nestlé, Alcoa and Syngenta presents fewer environmental indicators those contained in the reports are important indicators as EN5, EN8, EN16, allowing an analysis of the performance in terms of water consumption, energy, energy saving initiatives and emissions reduction.

Unilever has few environmental indicators, but in its report it is stated that the content is available on the internet, however, only a few have been located and are not presented clearly or are reported partially.

Economic Indicators: The economic performance indicators are reported in different ways by each company. It was noted that the private companies (Alcoa, Nestlé and Unilever) do not provide most of the data relating to economic indicators, just filling some key indicators. Different behavior of publicly-held companies that expose their data required by economic indicators.

The companies BRFoods, Bunge, Natura, Petrobras and Vale present all indicators of economic performance and those that are not reported are justified. Bunge, despite reporting all economic indicators, does not expose them clearly and not in figures, only displays comments or goals.

Although having all economic indicators, Natura does not report important data from the EC1 indicator, such as direct economic value generated and distributed, including revenues, operating costs, employee compensation, donations and other community investments, retained earnings and payments to capital providers and governments.

Unilever doesn't present their data with clarity in the complete online version of its report, making it difficult to access their information. Although it is self-declared application level A+, many of its core and additional indicators were not found.

Braskem despite not having presented all the key economic indicators (level B+), showed clarity and ease of access to data related to those indicators that were reported along its report, ensuring reliability of the provided information.

Social Indicators: Most analyzed companies show the social indicators relating to:

Employment- LA1, LA2, Labor/Management Relations-LA4, Occupational Health and Safety - LA7, Training and Education - LA10, Diversity and Equal Opportunity- LA13, LA14, Non-Discrimination (HR4), Child Labor - HR6, Forced or Compulsory Labor - HR7, Indigenous Rights – HR9, Diversity and Equal Opportunity- LA13, LA14, Corruption - SO2, Public Policy – SO5, Customer Health and Safety - PR1.

Nestlé presented few social indicators covering only a few areas, omitting important indicators such as the one's concerning human rights (HR1, HR2), cases of violation of indigenous rights (HR 9), measures taken to abolish child labor (HR6), cases of discrimination and actions taken (HR4), justifying their application level C +.

Syngenta, despite a greater number of indicators, reports some incomplete (justifying its application level C).

Unilever has many indicators listed in its index, however major difficulties were encountered during the search of these indicators, since the content was not clearly stated on the company website.

The social indicators from Alcoa e Vale, despite not having all, are clearly presented and easy to understand. It is noteworthy that Alcoa doesn't report all the essential social indicators (application level B+) different from Vale that has all core and some additional.

In contrast BRFoods, Bunge, Petrobras and Natura feature all the social indicators and report information with high quality, transparency and clarity.

Note that Bunge has great social indicators, but economic and the environmental indicators with little clarity and compliance. BRFoods, Bunge and Unilever clearly mention in LA14 indicator that there is no wage difference between men and women. Any differences must be aspects such as experience in the position, qualifications, competence and performance.

Application Levels: After the analysis of all indicators and the content of reports, you can declare the application level that each company reached with your reports. Each company can self-declare their level following the GRI guidelines. Bunge, BRFoods, Natura, Petrobras, Unilever and Vale have declared themselves level A +, being audited by consultants, whose verification includes adherence to GRI methodology, assurance of information about items in profile, management approach and performance and the statement of application level. Note that Bunge and Unilever have the full content only in online form. In the case of Unilever the online availability of data generated great difficulty and lack of clarity in information, preventing that many indicators were found, generating questions about whether or not the omission of data from stakeholders and the general public.

Braskem is self-declared level B+, verified by DNV audit (leading provider of sustainability services). Although it is a clear, full of data and impartial, doesn't report all essential indicators and doesn't explain the reason for the omission. However given its category B, attends a minimum of 20 Performance Indicators, including at least one from each of the areas of performance required by the GRI.

Alcoa is self-declared level B, as it attends to a minimum of 20 performance indicators, all profile indicators, governance and engagement and all forms of

management. Compared with the previous version, Alcoa chose to publish this year, an edition with fewer indicators, more objective and without submit it to an audit process since they consider this a model of transition to the next report, which will be based on a process of consultation with stakeholders and will be more consistent, substantial and profound.

Nestlé despite being considered, worldwide, the first company in the food and beverage industry to get "A +" level, the highest classification of the reports in standard GRI, publishes its first national version of the sustainability report under the GRI format. Is self-declared level C. answering a minimum of 10 performance indicators, including at least one of each area: social, economic and environmental.

Syngenta doesn't self-declares what level it was reached, only mentions in its Global report "Global Syngenta, based in Switzerland, publishes its Sustainability Report in accordance with the guidelines of the Global Reporting Initiative (GRI), in its third version, reaching the level A + with external consultants conducted by Price Waterhouse Coopers. Syngenta Brazil, based in Sao Paulo, follows the same methodology in its Sustainability Report". But a complete analysis of the report and its indicators showed that the company reaches level C, attending to a minimum of 10 performance indicators, including at least one of each area: social, economic and environmental.

Relative Indicators: Relative Indicators were elaborated by the authors for comparison purposes between companies of the same sectors of the market. Were developed with the help of performance indicators and some economic data such as net revenue and total production volume, for each company.

Initially Alcoa and Vale were compared, which are two large companies' leaders in mining. The environmental performance indicators that have been adopted was EN3, EN4, EN8, EN16 and EN30.

Table 2 – Relative Indicators comparing Alcoa and Vale.

	ALCOA			**VALE**	
IR1	GJ/R$	0,02	IR1	GJ/R$	0,002
IR2	GJ/R$	0,01	IR2	GJ/R$	0,0004
IR3	GJ/R$	0,03	IR3	GJ/R$	0,002
IR4	GJ/produced ton	72,67	IR4	GJ/producedton	0,59
IR6	m^3/R$	0,02	IR6	m^3/R$	0,004
IR7	m^3/producedton	78,38	IR7	m^3/producedton	1,38
IR9	ton CO_{2e}/R$	0,001	IR9	ton CO_{2e}/R$	0,0002
IR10	ton CO_{2e}/ produced ton	5,55	IR10	tonCO_{2e}/produced ton	0,06
IR20	R$/R$	0,60%	IR20	R$/R$	1,30%

The relative indicators presented in Table 2 explains that Alcoa has more costs both with direct and indirect energy and also with water, than Vale, which was expected, because the process of transformation of bauxite into alumina and subsequent treatment of alumina require a high amount of energy and water.

Through the analysis of relative indicators relating to emissions per production volume is noted that ALCOA emits more GHG (Greenhouse Gases) than it produces and also spend greater amount of their revenue from GHG emissions that Vale.

When analyzing the data on investment income is noted that Vale invests more in environmental protection that Alcoa.

Companies in the agribusiness, food and bioenergy: Bunge e Syngenta. The environmental performance indicators that have been adopted was EN3, EN16, EN2, EN22 and EN30.

Table 3 – Relative Indicators comparing Bung and Syngenta.

	Bunge			**Syngenta**	
IR1	GJ/R$	0,001	IR1	GJ/R$	0,0002
IR8	m^3/producedton	0,40	IR8	m^3/producedton	0,03
IR13	m^3/R$	0,0007	IR13	m^3/R$	0,0003
IR14	m^3/producedton	0,73	IR14	m^3/producedton	0,0300
IR15	ton/R$	1,54E-06	IR15	ton/R$	5,34E-06
IR16	ton/producedton	3%	IR16	ton/producedton	3%
IR20	R$/R$	0,20%	IR20	R$/R$	0,20%

By the analysis of the indicators for energy per net revenue is noted that Bunge spends more with energy than Syngenta. For water recycled and reused by production volume it is noted that Bunge recycles more water per volume produced than Syngenta. For total water discharge by Net Revenue it is noted that Bunge drops more water per volume of production than Syngenta. Regarding the volume of production of the two companies, 3% are waste of all classes. The values are identical for both organizations, which shows that the generation of waste by production volume presents the same ratio between the companies analyzed. The two companies commit 0.2% of their revenue to investments and spending on environmental protection.

The companies BRFoods, Nestlé and Unilever are part of the food market.

Sustainable Business International Journal

JUNHO DE 2016 - ISSN 1807-5908

Table 4 – Relative Indicators comparing BRF, Nestlé and Unilever.

	BRF			Nestlé			Unilever	
IR1	GJ/R$	0,002	IR1	GJ/R$	0,001	IR1	GJ/R$	n/a
IR4	GJ/producedton	7,58	IR4	GJ/producedton	8,50	IR4	GJ/producedton	0,89
IR9	ton CO_{2e}/R$	0,00002	IR9	ton CO_{2e}/R$	0,00001	IR9	ton CO_{2e}/R$	0,00001
IR13	m^3/R$	0,002	IR13	m^3/R$	0,0002	IR13	m^3/R$	0,00013
IR14	m^3/producedton	7,96	IR14	m^3/producedton	3,07	IR14	m^3/producedton	n/a

The value of 8.5 GJ/t for Nestlé demonstrates that this company has a largest energy consumption per ton of product produced than Unilever and also BRFoods. For the relative indicator of GHG emissions (Greenhouse Gases – IR9), both companies emit the same amount of GHG by net revenue. The two companies have almost the same value for this relative indicator (IR13), which specifies the amount of water discharged by net revenues. The BRFoods has a water disposal largest Nestlé by production volume.

Consumer goods companies are represented by Natura and Unilever.

Table 5 – Relative Indicators comparing Natura and Unilever.

	Natura			Unilever	
IR9	ton CO_{2e}/R$	0,00005	IR9	ton CO_{2e}/R$	0,00001
IR18	ton/R$	0,000000024	IR18	ton/R$	9,05E07
IR19	ton CO_{2e}/R$	7,66E-06	IR19	ton CO_{2e}/R$	1,26E-06

For both companies the amount of GHG emissions by the net revenue is the same. For both companies the amount of packaging recovered to revenue is negligible. Allowing the conclusion that very few packages are retrieved for a net revenue of the

size of these companies. For both companies the environmental impacts of transporting products and other goods by revenue is very small in relation to net revenue.

The last comparison was made between the two companies operating in the petrochemical sector. Braskem is focused on the production of thermoplastic PE, PP and PVC resins, plus basic chemicals and Petrobras is the leader in the petroleum sector in Brazil.

Table 6 – Relative Indicators comparing Braskem and Petrobras.

	Braskem			**Petrobras**	
IR1	GJ/R$	0,006	IR1	GJ/R$	0,003
IR4	GJ/ton produzida	13,4	IR4	GJ/ton produzida	1,000
IR8	m3/ton produzida	0,97	IR8	m3/boe*	0,03
IR9	ton CO_{2e}/R$	0,0003	IR9	ton CO_{2e}/R$	0,0002
IR10	ton CO_{2e}/produced ton	0,61	IR10	ton CO_{2e}/producedton	0,08
IR17	m^3/ton produzida	8,33E-07	IR17	m^3/boe*	3,44E-07
IR20	R$/R$	1%	IR20	R$/R$	1%

*barrel de oil equivalent

This indicator demonstrates that Braskem has a much higher power consumption compared to its volume of production, contrary to Petrobras. Petrobras, in relation to Braskem has a smaller total volume of water recycled in relation to its volume of production, represented by the relative indicatorIR8. Analyzing the data from the indicators for energy consumption is noticed that Braskem consumes more energy per volume of production and net income of Petrobras. In both companies the volume of spills on the volume of production is negligible. The two companies have an investment in environmental protection corresponding to 1% of their net income.

The development of the relative indicators, reported in the tables above provides a range of possibility of analyzes of data, allowing comparisons between two or more sustainability reports, as emissions of greenhouse gases by annual production volume, percentage of investment spending the environment corresponding to net income, among others. From the comparisons and analyzes of these relative indicators from sustainability reports of the companies in question, it was noted that some companies have shown better performance compared to others in the same industry and have allocated greater investment in environmental protection and sustainability projects . For example, Vale uses less energy and water when compared to Alcoa, as shown in Figure 2. Syngenta discards a small amount of water and reuses more water in the process by production volume compared to Bunge. From the comparisons and analyzes of these relative indicators from sustainability reports of the companies in question, it was noted that some companies have shown a better compared to others in the same industry and have allocated greater investment in environmental protection and sustainability projects. For example, Vale uses less energy and water as compared to Alcoa, as shown in Figure 1 and 2. Syngenta discards a smaller amount of water and reuses more water in their processes by production volume when compared to Bunge.

In addition to comparisons between companies, and analysis of consumption, emissions, investment volume of production or net revenue, another interesting analysis that can be performed is, for example, recycled material by production volume. For Natura and Unilever, it was noted that the amount of packaging recovered to revenue is negligible, explaining that very few packages are retrieved for a net revenue of the size of these companies. Another case is also of Petrobras and Braskem,

since both companies have an investment in sustainability and environmental protection areas corresponding to 1 % of its net revenue. Therefore the indicators as well as comparisons, provide the size of the share of investment of these companies relative to annual revenues. So the indicators are an additional analysis tool, complementing the study of performance indicators and providing options for better understanding of the data provided by companies in their annual sustainability reports.

Figure 1 – Comparison between companies through the relative indicator IR4.

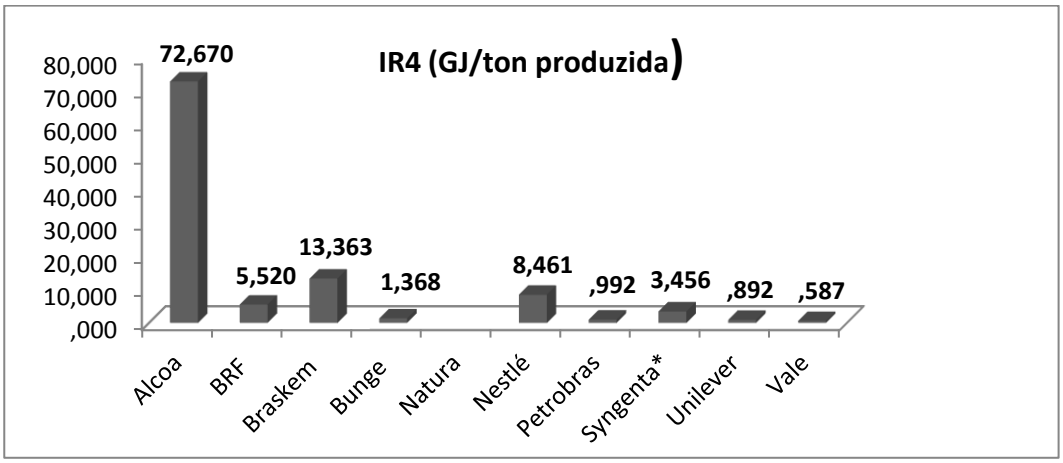


Figure 2 – Comparison between companies through the relative indicator IR7.

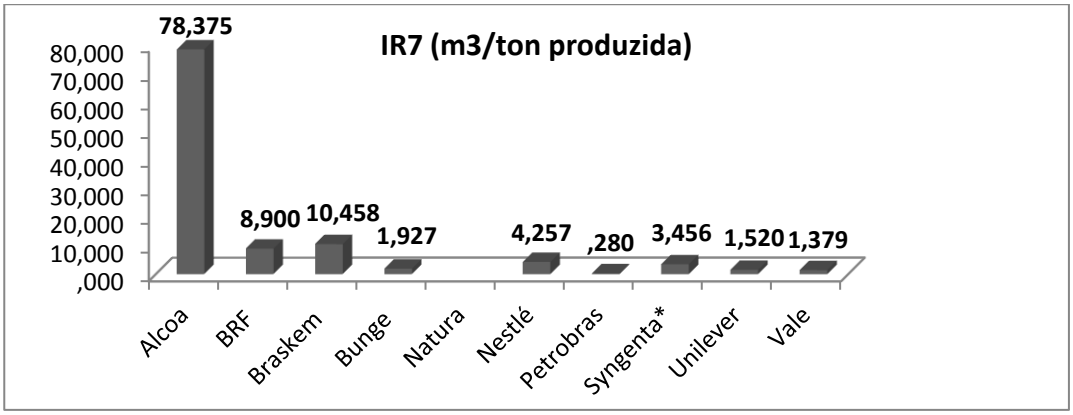


Figure 3 – Comparison between companies through the relative indicator IR10.

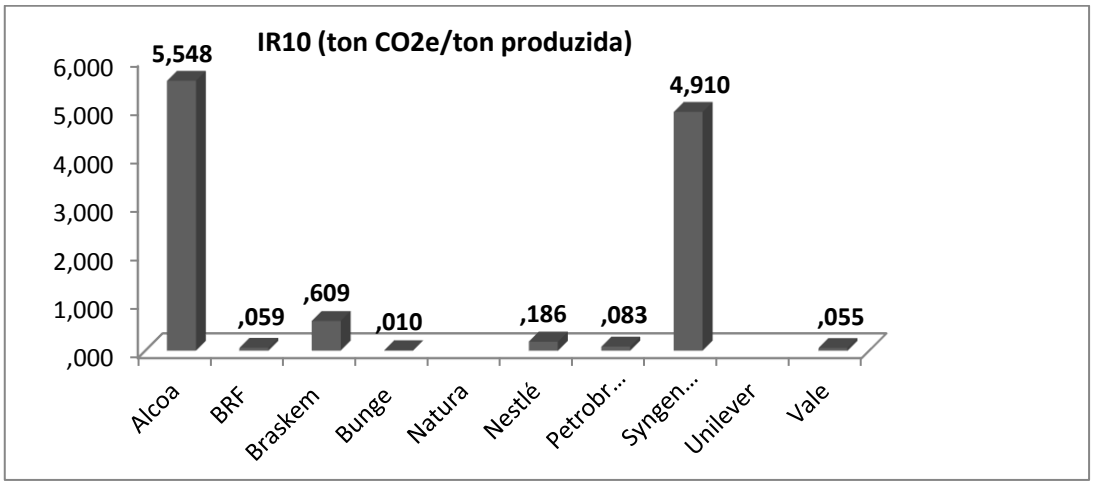
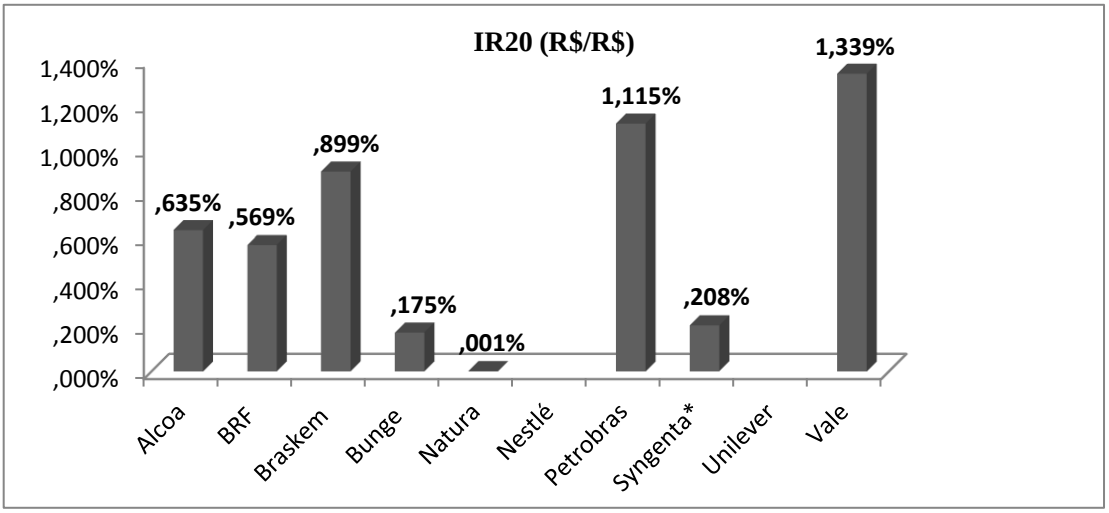


Figure 4 – Comparison between companies through the relative indicator IR20.



By analyzing only the indicators provided in the reports is not possible to measure the impacts of these companies, since they only allow comparisons between years, the reduction or increase of a parameter, while the relative indicators represent the extent of the impact of each parameter the volume of production or financial performance of the company, allowing comparison of data of companies of different sizes and different markets.

In the comparison scenario among the ten industries studied it was possible to identify, by means of relative indicators developed during this analysis, which company has better sustainability performance, while the details of how this was achieved performance is obtained by analyzing the actions implemented by each company.

By analyzing the Figures 1, 2, 3 and 4, which represent the relative indicators common to ten companies, it is possible to identify companies that have the best performance. In order to validate the information explained in graphs, some initiatives taken by the best performing companies were listed.

Among the best performances observed, Vale applies sustainability in its process through investments (US$ 100 million in 2011) in actions for sustainable improvements in performance. Regarding the reduction of energy consumption, the measure adopted was the investment in self-production and search for specific solutions for each operation, resulting in reduced direct energy consumption by 10.1% compared to 2010. Although it has a high water consumption, Vale reuses 70% of the water consumed, which was achieved through optimization projects on water consumption in each transaction contemplated within the sustainability action plan of the company. There was also a 15% reduction in emissions of greenhouse gases through a program of diversification of energy sources with increased use of renewable energy.

Petrobras aims its investments (US$ 1.2 billion distributed in the period 2011-2015) to research and development projects to reduce energy consumption and

emissions of greenhouse gases. There was a 5% reduction in energy consumption compared to 2010, generating savings of R$10 million.

The indicators were effective in analyzing how sustainability is applied in the chemical industry, since those who had higher performance were companies with more effective initiatives. Sustainability is mainly applied in actions for reducing consumption of energy, water and emissions of greenhouse gases and investments aimed at environmental protection, explained by common indicators among the ten companies (IR4, IR7, IR10 and IR20).

After the analysis of sustainability indicators reported by selected companies and the development of indicators, it was found that perspective of sustainability in national chemical industry mainly runs through the following environmental aspects: consumption of water, energy, waste generation (gas, liquid and solids), emission of greenhouse gases, water reuse and material spills (accidents) and the amount invested in environmental protection. Fundamental aspects where Chemical Engineering could act and, which was found an insipid action, is the issue of reverse logistics in relation to packaging, lack of investment and innovation in the use of alternative materials and cleaner chemical processes.

In terms of financial performance, corporate sustainability index ISE-Bovespa stands as an indicative auxiliary tool. The ISE is a tool for benchmarking the performance of companies listed on the BM&F BOVESPA under the aspect of corporate sustainability based on economic efficiency, environmental balance, social justice and corporate governance. Also broadens the understanding of businesses and groups committed to sustainability, differentiating them in terms of quality, level of

commitment to sustainable development, equity, transparency and accountability, nature of the product, besides the business performance in the economic and financial dimensions social, environmental and climate change. The companies analyzed in this study, Braskem, Natura and Valley part of the ISE-Bovespa.

In order to have a larger panorama of driving sustainability in businesses, a deepening of this study would be a prospecting companies in order to identify opportunities in their processes of innovation in processes and materials.

6. CONCLUSION

Sustainability in national chemical industry is in early stage and currently focuses his attention on aspects of energy, water and emissions. Alternative chemical processes and more sustainable materials should be the focus of future attention on corporations, since there are no examples of projects/actions related to the development of cleaner processes. Investments in research and development are mandatory for the national chemical industry to become reference and differentiate in terms of corporate sustainability. The companies analyzed constitute different sub-segments of the chemical industry and exhibit similar behavior in their initiatives and implementing their business sustainability actions. The development of the relative indicators showed the stage where the businesses are. The concept of sustainability, in the qualitative point of view, is inserted in the analyzed companies and is explained in the reports, featuring a breakthrough in the domestic industry.

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