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Chemical and Process Industries Beyond Gross Domestic Product

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In the past, a lot of research has been carried out about eco-innovation, sustainable development (SD) and the associated indicators but this research has rarely been taken into practice. Economic indicators such as Gross Domestic Product (GDP) were never designed to be comprehensive measures of prosperity and well-being. RIO+20 discussions have resulted in the call for development of a possible set of indicators to measure progress on Sustainable Development Goals. The EU Beyond GDP initiative is about developing indicators that are as clear and appealing as GDP, but more inclusive of environmental and social aspects of progress. We need adequate indicators to address global challenges of the 21st century such as climate change, poverty, resource depletion, health, and quality of life. The Beyond GDP initiative will have a profound influence on the chemical and process industries (CPI), the biggest consumer of raw materials and energy. Therefore, they have to prepare for this future evolution. The climate change speed-up, the increasing list of critical raw materials, extinction of fossil fuels, and species extinction require vast and long reaching reactions. A critical review of sustainability measurement using methods, tools and indicators for CPI is presented. Possible responses are investigated in the paper, reaching from short-term ones like resource efficiency and circular economy, via medium-term ones like renewable energy and material sources, to long-term ones like adopting to changing consumption patterns by the products portfolio of these industries and their volume of production.

1. Introduction

Sustainability oriented indicators, indices, tools and methods have undergone a series of improvements in the past two decades, from the beginning in 1992 when experts in the Earth Summit recognized their important role. This recognition was articulated in Chapter 40 of Agenda 21 which called on countries at the national level, as well as international, governmental and non-governmental organizations to develop and identify indicators of sustainable development (UN SD, 1992). Agenda 21 specifically called for the harmonization of efforts to develop sustainable development indicators (SDI) at the national, regional and global levels, including the incorporation of a suitable set of these indicators in common, regularly updated and widely accessible reports and databases. Therefore, many indicators or sets of indicators have been developed to objectively assess a progress in a sustainability field.
Sustainability measurement is a term that denotes the measurements used as the quantitative basis for the informed management of sustainability. The metrics used for the measurement of sustainability (involving the sustainability of environmental, social and economic domains, both individually and in various combinations) are still evolving. They include indicators, benchmarks, audits, indices and accounting, as well as assessment, appraisal and other reporting systems. They are applied over a wide range of spatial and temporal scales (Bell and Morse, 2008).

1.1 Indicators

Data are the basic component of indicators scheme but most data cannot be used to interpret change in the state of the environment, economy or society. Indicators are considered as superior to data in several ways – providing decision-makers and other target groups with enough knowledge to formulate responses and decisions. Indicators are qualitative or quantitative measures signaling for some condition, for a

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decision to be taken, to give an early warning, and/or to show the results of a certain action or process. Headline indicators represent few, well-selected, easily understandable and communicative indicators.

SDI are measures of sustainability. Evidently, indicators have been accepted as a base for sustainability assessment and management highlighting key areas to improve the social, ecological and economic dimensions of sustainable societal development. This is a complex task: the EU sets comprise dozens, if not hundreds of indicators, some of them overlapping, some of them being supplementary. Therefore, we shall follow the bottom-up approach in this overview – starting with indicators, we shall than proceed to the possible indices, tools and methods for sustainability assessment.

Similar observations can be used for another EU flagship initiative – A resource-efficient Europe (European Commission, 2011a) which supports the shift towards a resource-efficient, low-carbon economy to achieve sustainable growth. It includes policy agendas for climate change, energy, transport, industry, raw materials, agriculture, fisheries, biodiversity and regional development. The Roadmap to a Resource Efficient Europe (European Commission, 2011b) sets out a framework for the design and implementation of future actions. It outlines the structural and technological changes needed by 2050, including milestones to be reached by 2020. A Table in its Annex shows interlinks between sectors (energy, food, chemicals, pharmaceuticals, textiles, pulp and paper, and water supply), and resources (fossil fuels, materials and minerals, water, air, land, soils, biodiversity, marine resources, and waste). Together with policy initiatives it offers a matrix with 45 cross cutting-areas, and in each of them several indicators are needed; some of them are not yet defined, or not well developed. Eurostat uses a set of SDI to monitor the EU's Sustainable Development (SD) Strategy and also works in the context of the European Commission's initiative "GDP and beyond, measuring progress in a changing world" (European Commission, 2009).

Besides the EU, United Nations (UN) and The Organisation for Economic Co-operation and Development (OECD) are very active in the field. UN Conference on SD RIO+20 has called for expanded use of key environmental indicators that allow the measurement and monitoring of progress towards the environmental sustainability of selected product chains, building on a limited number of Life Cycle Assesment (LCA) based key environmental indicators with the involvement of potential and current decision makers in governments, private sector and the academia. The 134 UN national indicators for SD were prepared by the Commission on Sustainable Development (CSD) (UN, 2007). UNEP (UN Environment Programme) is preparing measurement framework for its Green Economy initiative (UNEP, 2011).

1.2 Beyond GDP indicators

RIO+20 discussions have resulted in the call for development of a possible set of indicators to measure progress on SD Goals (SDG). A need of new metrics, i.e. new indicators for new goals has been agreed. A circular flow model expressing the relationship between firms and households (flow of goods and services through economy) was found imperfect by some economists as supply of goods and factors of production occur like a perpetual motion machine, without a link to ecosystem.

GDP is the sum of the market value of all final goods and services produced in a country in a given period. GDP per capita has traditionally been used to illustrate a country's material standard of living, but recently its usage is meeting rising criticism. To avoid double-counting, GDP is based on the "value added" principle and, therefore, leaves out the value of goods and services which are used in the production of other products. GDP also does not include the value created by households. Enlarged GDP indicators start from GDP (or other figures from the System of National Accounts) but adjust for some of its shortcomings to deliver a more comprehensive overview of a country's wealth or well-being. Economic growth that comes at the expense of environmental degradation, resource depletion or higher income inequality, for example, does not give an accurate picture of a country's prosperity. By considering such matters as costs, enlarged GDP indicators provide a more accurate indication of a country's actual economic, environmental and social performance (European Commission, 2012).

The EU Beyond GDP initiative is about developing indicators that are as clear and appealing as GDP, but more inclusive of environmental and social aspects of progress. In 2007, the European Commission, European Parliament, Club of Rome, OECD and WWF (World Wildlife Fund) hosted the high-level conference "Beyond GDP" (European Commission, 2007). The objectives were to clarify which indices are the most appropriate to measure progress, and how these can best be integrated into the decision-making process and taken up by public debate. Two years later the European Commission released the EU roadmap with five key actions to improve indicators of progress in ways to meet citizens' concerns and make the most of new technical and political developments (European Commission, 2009). The Genuine Progress Indicator (GPI) adds up the positives of economic growth and subtractes from them the clear negatives such as resource depletion, pollution, and long-term environmental damage.

Parallel to these initiatives, political interest in producing a Green GDP (Stiglitz et al., 2008) to take into account at least the cost of pollution and natural capital depletion has grown. China has announced the

2010 Green National Accounting results (also called Green GDP Accounting) showing that the country's ecological and environmental degradation cost reached 248 billion USD, accounting for about 3.5 % of its GDP for 2010 (CleanBiz.Asia, 2013).
European Environment Agency (2015) has developed a tool for finding information on indicators and fact sheets on the Europe's environment. About 180 items are enclosed in the database. The search can also be performed according to different topics: sectors, pollution groups, natural or human environment. The OECD issued Your Better Life Index, and a set of indicators for its Green Growth Strategy (OECD, 2011).

1.3 Indices

Indices are obtained if two or more indicators are combined into a messenger. They are considered as superior to data and indicators in several ways: they provide decision-makers and other target groups with enough knowledge to formulate responses and decisions.
The UN Development Programme (UNDP) is regularly reporting on the three-dimensional Human Development Index (UNDP, 2014). Foundations and civil society organizations have developed national indices such as the Ecological Footprint and Sustainable Society Index. Academia has developed Happy Planet Index, Environmental Sustainability Index (now the Environmental Performance Index), Genuine Progress Indicator, and the Index of Sustainable Economic Welfare. Bhutan developed a Gross National Happiness Index to measure the well-being of its citizens.

1.4 Sustainability evaluation of companies

Dow Jones Sustainability Indices (DJSI, 2014) are a family of indices evaluating the sustainability performance of the largest 2500 companies listed by the DJ Global Total Stock Market Index. Corporate Sustainability is a business approach that creates long-term shareholder value by embracing opportunities and managing risks deriving from economic, environmental and social developments. DJSI are based on RobecoSAM's internationally recognized Corporate Sustainability Assessment methodology, taking into account five general criteria (corporate governance, tax strategy, social and environmental reporting, human-capital development, labor practice and human rights) in addition to industry-specific criteria.
FTSE4Good Index Series has been designed to objectively measure the performance of companies that meet globally recognised corporate responsibility standards. The index is maintained by the FTSE Group, a joint venture between the Financial Times (FT) and the London Stock Exchange (SE). It is designed to measure the performance of companies demonstrating: environmental (climate change, water use, biodiversity, pollution and resources), social (health and safety, labour standards, customer responsibility, human rights and community) and governance (anticorruption, tax transparency, risk management, and corporate governance) practices in the whole supply chain (FTSE, 2014).
The Global 100 is including top 100 large-cap companies in the world, selected from 4000 developed and emerging market stocks, and based on their integrated sustainability ratings from the world's largest sustainability research consortium, The Global Sustainability Research Alliance (GSRA). It is based on 12 key performance indicators: energy, carbon, water, and waste productivities, innovation capacity, tax fraction paid, CEO to average worker pay ratio, pension fund status, safety performance, employee turnover, leadership diversity, and clean capitalism pay link (Corporate Knights, 2014).
A model for designing a composite sustainable development index depicting company performance along all sustainability dimensions – economic (cash flow, R&D expenditure, exploration cost, environmental and safety penalties cost), environmental (oil products used, GHG emissions, hazardous waste, and spills), and societal (employees, societal and community investments, fatalities and injuries for employees and contractors) has been developed (Krajnc and Glavič, 2005). Indicators were weighted by pair-wise comparison techniques using Analytic Hierarchy Process, and normalized.

2. Sustainability management tools

Sustainability tools include management standards, sustainability assessment, and indices (sets of indicators). Company management methodology should integrate areas of sustainability into the traditional business phases which, when understood and effectively addressed, can reduce negative environmental impacts while maximizing opportunities to manage sustainability and finite resources.
The globally accepted standards for professional management are the "books of knowledge" for project managers. The PRiSM (Projects integrating Sustainable Methods, 2011) project incorporated a framework of activities derived from ISO standards focusing on specific areas and incorporating best practices:

- ISO 9001 (2008)**,** quality management system standard, ensures that an organization or product can be considered to have four main components of quality: planning, control, assurance and improvement. It shall be achieved in everything an organisation does including its: customers, strategy, leadership, people, partners, society, processes, products and services.
- ISO 14000 (1999–2009) is a family of standards related to environmental management that help:

a) organizations to minimize how their operations, processes, products, services negatively affect the environment, i.e. cause adverse changes to air, water, or land;
b) comply with applicable laws, regulations, and other environmentally oriented requirements,
c) and continually improve in the above.

- ISO 21500 (2012), Guidance on project management, can be used by any type of organization – ,public, private or community, and for any type of project, regardless of complexity, size and duration.
- ISO 26000 (2010) offers guidance on socially responsible behaviour and possible actions; in contrast to ISO 14000 series standards it does not contain requirements and is not certifiable.
- ISO 50001 (2011) supports organizations in all sectors to use energy more efficiently, through the development of an Energy Management System (EnMS). Using energy more efficiently helps organizations save money as well as conserve resources and tackle climate change.

Sustainability assessment has become associated with the family of tools including Environmental Impact Assessment, Strategic Environmental Assessment, or EU Sustainability Impact Assessment. Sustainability assessment is defined as “a tool that can help decision- and policy-makers decide which actions they should or should not take in an attempt to make society more sustainable.” LCA (Life-Cycle Analysis) is a technique to assess environmental impacts associated with all the stages of a product life from-cradle-to-grave, i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, to recycling or disposal (Finnveden et al., 2009).

3. Sustainability management methods

Sustainability methods include circles of sustainability, reporting, voluntary approaches and they are using sustainable development methodology. They provide decision-makers with an evaluation of global to local integrated nature-society systems in short and long term perspectives to assist them in determining which actions should or should not be taken in an attempt to make society sustainable.

Circles of Sustainability (CI, 2011) is a method for assessing sustainability and managing projects directed towards socially sustainable outcomes. It is intended to handle 'seemingly intractable problems'. Treating the social domains of ecology, economics, politics and culture, it provides the empirical dimension of an approach called ‘engaged theory’ (Magee et al., 2013). Developing CI is part of larger project called 'Circles of Social Life' conducted by the UN Global Compact Cities Programme, which is using the same four-domain model to analyse questions of resilience, adaptation, security, and reconciliation.

The Global Reporting Initiative (GRI, 2014) promotes sustainability reporting as a way for organizations to contribute to sustainable development. The guidelines include four categories: economic (performance, market presence, indirect impacts, and procurement practices), environmental (materials, energy, water, biodiversity, emissions, effluents and waste, products and services, compliance, transport, overall supplier environmental assessment, and environmental grievance mechanism), and social with four subcategories (labour practices and decent work, human rights, society, and product responsibility), and 30 aspects, e.g. 8 in the first subcategory are including employment, labour/management relations, occupational health and safety, training and education, diversity and equal opportunity, equal remuneration for women and men, supplier assessment for labour practices, and labour practices grievance mechanisms).

Integrated Pollution Prevention and Control (IPPC, 2008). The European Union defines the obligations that industrial activities with a high pollution potential must comply. It establishes a procedure for authorising these activities and sets minimum requirements to be included in all permits, particularly in terms of pollutants released. The aim is to prevent or reduce pollution of the atmosphere, water and soil, as well as the quantities of waste arising from industrial installations to ensure a high level of environmental protection. The European IPPC Bureau has been founded to organize the necessary exchange of information; it produces Best Available Techniques (BAT) reference documents (BREF) which Member States are required to take into account when determining BAT generally or in specific cases.

Responsible Care (2006) is a global, voluntary initiative developed autonomously by the chemical industry. It runs in 52 countries whose combined chemical industries account for nearly 90 % of the global chemical production. The signatory chemical companies agree to commit themselves to improve their performances in the fields of environmental protection, occupational safety and health protection, plant safety, product stewardship and logistics, as well as to continuously improve dialog with their neighbours and the public, independent from legal requirements. As a part of Responsible Care initiative, the International Council of Chemistry introduced the The Global Product Strategy (2006).

4. Results and conclusions

Today, typical sustainability criteria for the chemical industry are including economic (28 %), environmental (35 %), and social (37 %) dimensions (Ricci, 2012):

- Economic: corporate governance, risk and crisis management, codes of conduct, compliance, corruption and bribery, customer relationship management, and innovation management
- Environmental: environmental reporting, policy/management system, operational eco-efficiency, product stewardship, climate strategy, genetically modified organisms
- Social: social reporting, labour practice, human capital development, talent attraction/retention, corporate citizenship and philanthropy, standards for suppliers, occupational health and safety.

Materials, minerals, ores, biomass and other non-renewable depletion is becoming critical. Packaging has to be reduced and recycled. Fossil fuel based energy is being substituted by renewable hydroelectric, solar, wind, geo-, bio-, and nuclear one. Energy intensity is decreasing; energy recovery, co- and poly-generation is growing. Waste water treatment and recycling rate are badly needed. Fresh drinking water and ground water table are more and more important. Stricter regulation is affecting the management of:

- Air quality (SO_x, ozone depletion, CFCs, particulate matter and other pollutants)
- Pollution prevention (toxic chemicals, heavy metals, POC, VOC, BOD, noise)
- Waste (water, air, solids, organic, radio-active, hazardous, biodegradable), waste minimization, waste to energy, and zero-waste instead of landfills.

Future development of CPI will be determined by global trends in sustainable development. Consumption and production patterns will be changing with lifestyle transformation. Aging of population and migration rates will have a profound effect on the European CPI. Global markets will increase demands on added value per employee, productivity, competitiveness and profitability. Shrinking reserves of minerals and ores will require rapid introduction of circular economy (zero waste, industrial ecology, and cascading) to reduce, recycle, reuse/redistribute, refurbish/ remanufacture, repair, rethink, redesign policy, increase resource and process efficiency, resource conservation, process intensification, and product durability. Eco-design will include re-usability, suitability for recycling and take-back policy reducing physical production and move employment from production to services. Fossil fuels will be substituted by renewable energy sources, energy intensity will be reduced, and usage of co- and poly-generation increased. Human and social capital will become much more important. Customers' healthy life, well-being, equal opportunity, food security and quality, suppliers' assessment for impacts on society, labour practices, human rights, social security, employees' satisfaction, wages, occupational health and safety will gain importance. Welfare, quality of life and social inclusion will be more important than consumerism.

The most drastic changes will occur in the environmental pillar. Because of the pressing hunger, land use, biodiversity and habitat will be critical for survival. Ecological footprint, and footprint/bio capacity ratio will be carefully monitored and reduced to the Planet absorbing capacity. Agriculture, fisheries and marine will become of utmost importance. Use of fertilizers, pesticides, and water will have to be reduced to keep eutrophication, and soil degradation to an acceptable level. Principles and metrics of green chemistry and green engineering will gain importance in CPI. GHG emissions (CO_2, CH_4, NO_x) causing climate change, global warming, and acidification are to be captured and reused in chemical synthesis.

Good corporate governance and management will comprise accountability, innovative business models, and leadership. Modern analyses and assessment tools will be including new methods in:

- Analyses (relevance, scoping, impact), in particular comparative, associative, and political
- Economics (cost/benefit analysis, modelling, integration, multiparameter optimisation, scenarios)
- Environmental care (LCA, material flows, resource accounting, the National Accounting Matrix including Environmental Accounts, NAMEA, and ecological footprint)
- Social (sustainable livelihoods, human and social capital measurement, participatory processes)
- Science, technology, innovations, eco-design, ICT, integration, and multi-criteria optimisation
- Good manufacturing practice using ISO standards (9001, 14000 series, 21500, 26000, 50001)
- Quality control, risk management, disaster preparedness, and security
- Tax transparency, anti-corruption, ethical values, child labour prohibition
- Capacity building, talent attraction and retention, and long-life learning
- Institutional and legislative activities, integrated decision-making, compliance
- International conventions and cooperation, collaboration with stakeholders.

Education, research and technological development, innovations and entrepreneurship will take the lead.

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