Life cycle sustainability based innovation: tools for an integrated approach

David Russell[1,*]

[1]Dow Europe GmbH, Sustainability & Life Cycle Assessment, EH&S Department, 8810 Horgen, Switzerland

[*]darussell@dow.com

Abstract Embedding the concept of sustainability into a company's culture is immensely challenging, but is likely to be critical to the long term viability of science and technology companies that rely on successful innovation to remain competitive. Moving to a more sustainable society can be expected to provide plenty of commercially viable business opportunities for forward thinking organisations and the combination of life cycle thinking with the enabling science of chemistry will be essential to successfully address world challenges such as the strain on resources caused by population growth and changing demographics. The Dow Chemical Company has been developing strategies and tools around holistic thinking for more than 20 years and since 2005 has used the concept of sustainable chemistry to deepen and broaden sustainability knowledge throughout the company with the intention of developing a culture that fosters sustainability based innovation. This talk will describe aspects of the current integrated approach being taken to embed sustainability into the Dow company culture and will review tools that have proved useful. In particular, a methodology to broaden sustainability knowledge and encourage life cycle thinking among innovators new to this area while providing insight into the sustainability of new product development will be described.

1 Introduction

The cover of The Dow Chemical Company (Dow) 1989 Annual Report was mostly plain [1]. It had one small picture of ducks flying over wetlands at sunset at Dow's Eastern Division manufacturing site in Joliet, Illinois in the USA and around this picture in bold writing was set the text, "One issue, more than any other, will affect Dow's prospects – in the '90s and beyond. That issue is the environment." In his introduction to the report, Frank Popoff, the CEO of Dow at the time, explained that the feature section of this annual report was devoted to explaining Dow's environmental commitment, a "work in progress". Later that

year, the company produced its first public report dedicated to environmental progress [2], beginning a rich history of public reporting on the company's sustainability related initiatives. Two years later, just before the Rio Earth Summit, the Cover Story of the International Business Week journal [3] quoted David Buzzelli, the then vice-president for environment at Dow, who said, "The question isn't, 'Have you achieved sustainable development?' The answer is always no. The question is, 'Are you moving toward it continuously?'"

Having the executives of a company understand and embrace the sustainability imperative and sanction dedicated public reports on their organisation's progress in this area is important, and probably essential, to making a company's operations, products and value chains more sustainable, but it is unlikely to be sufficient. Today, many company CEOs believe that embedding the concept of sustainability into a company's culture – making it part of how a company operates – is a business imperative [4]. This is immensely challenging. Nevertheless, it is in line with the position taken by many stakeholders in Dow's value chains, particularly brand owners and consumer facing businesses, which are showing an increasing interest in products that contribute towards sustainability. This alone creates a clear and immediate business driver for their suppliers to develop products and services that are increasingly more sustainable.

Since Dow's 1989 Annual Report statement about the business importance of the environment, the company has been building a suite of tools and initiatives, some strategic, such as Dow's corporate 10 year sustainability goals, and others tactical, such as product Life Cycle Assessment (LCA) expertise, to incorporate sustainability thinking into business strategy development, to support business decision making and to disseminate sustainability knowledge broadly amongst employees.

Dow communicates regularly with employees through internal news media and quarterly progress reports (also available to the public through Dow's website: www.dow.com/sustainability/pbreports), by hosting voluntary monthly internal webinars for employees, often with internal or external experts talking about aspects of sustainability, as well as by providing an employee intranet site to provide interested employees with information to help them integrate sustainability into their work or at home.

One key group of employees for a science and technology company such as Dow to target with sustainability information and tools is the research and development (R&D) community, where most new products are conceived and developed. While it is essential to provide R&D scientists and engineers with screening tools to evaluate the sustainability of their innovations, it is equally important to provide them with sufficient knowledge to enable them to integrate sustainability from the earliest concept stage of an idea. Based on the belief that people are likely to learn

best when they are actively and constructively involved in a new topic that they perceive as both useful and relevant to their job (a concept long recognised by educators [5-7]), a simple tool for use by innovators, The Dow Chemical Sustainability Footprint Tool©, was created for company innovators to use to evaluate the sustainability of their current projects, to suggest opportunities for improvement as projects are further developed into potential products or services and to stimulate more sustainable new project ideas.

2 The Dow Chemical Sustainability Footprint Tool©

2.1 Basis

With today's increasing focus on sustainability, the long term commercial success of R&D projects is likely to increase if:

- the economics of value chain service provision to end users is improved;
- society is enhanced;
- the bio-sphere is conserved;
- humans are not harmed; and
- resources remain available.

The intention of the initiative described in this paper was to create a tool that would indicate the extent to which an R&D project could contribute to a more sustainable world while simultaneously increasing the tool user's understanding of sustainability. Engaging busy focused employees in a topic that they may know little about and where they may not fully understand the relevance to their specific business was seen as challenging. Consequently, it was decided that the tool should have the following attributes:

- be self-explanatory;
- be easy and quick to use by R&D engineers or teams with limited knowledge of sustainability criteria;
- be applicable to all projects (including those with an internal focus; for example, manufacturing plant improvements);
- instantly communicate the sustainability advantages and opportunities in a visually engaging way;
- provide a record of what was considered when rating a particular sustainability attribute;
- be informative of sustainability criteria.

Also, the data from project evaluations should be easy to compile into reports that inform management about the sustainability status of a business's portfolio of development projects as well as which sustainability areas are well represented and which remain areas of opportunity.

2.2 Metrics

For convenience, sustainability metrics are often divided amongst economic, social, and environmental dimensions. These are frequently referred to as the business 'triple bottom line', a term first coined by John Elkington in 1994 and later described in detail in his book “Cannibals with Forks"[8] in terms of an organisation's relationship with people (fair, ethical and beneficial business practices), the planet (environmentally sound products from sustainable manufacturing) and profits (which, in this case, includes the economic benefits for the company, its employees, shareholders and its value chain).

In fact, many sustainability metrics are cross-cutting, contributing to two or sometimes all three dimensions of the triple bottom line. Ecological aspects can impact the social and economic dimensions of sustainability and the environmental dimension in particular is often given a broad definition that encompasses more than ecologically focused metrics. For example, resource depletion, such as of a particular fish species in a fishery, can affect not only the ecosystem of which the fishery is a part but also the viability of local communities and businesses that rely on the various services that the healthy ecosystem can provide. Understanding an organisations relationship with the services provided by ecosystems has become an important study area for business; for example, Dow's collaboration with The Nature Conservancy on how to incorporate ecosystem services into global business goals, decisions and strategies [9].

The Dow Chemical Sustainability Footprint Tool© examines sustainability through 23 questions, many of which involve comparisons of a project or new idea with an incumbent use of one or more products (the base case) that deliver an equivalent service to an end user. Projects can be scored higher or lower than the base case with lower being more sustainable (i.e., a smaller footprint). Where there is no existing product against which a comparison can be made, then the new idea is given the base case score of 5. Some of the 23 questions are absolute rather than relative and are scored based on a property of the new product/idea or the completion of an action by the project owner. To be pragmatic and to aid communication by providing a balanced view of key sustainability attributes each of the 23 questions is assigned to one of 6 dimensions and plotted on a radar

diagram (Figure 1). There are good reasons for the assignment of a particular aspect to a dimension but, because of the cross-cutting nature of sustainability aspects, alternative distributions of the metrics can be just as valid and may provide different perspectives.

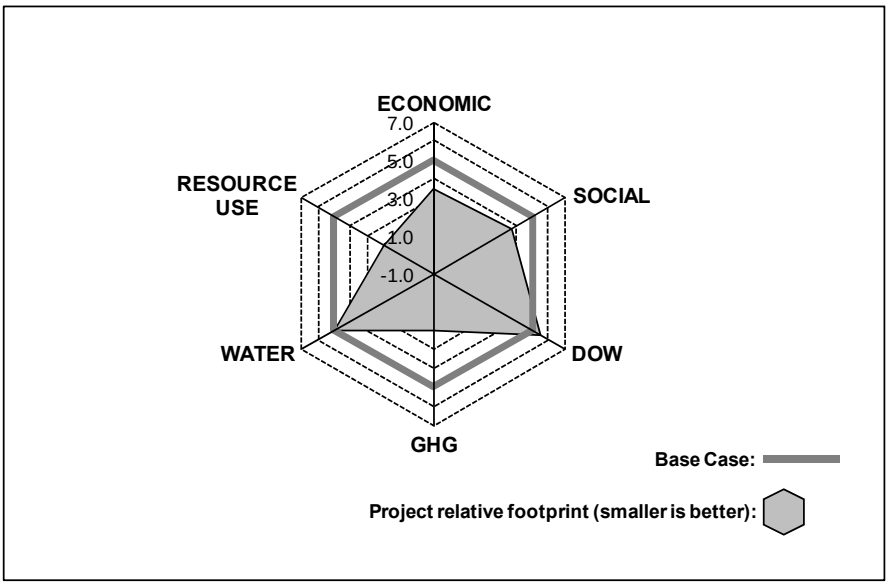

Fig.1: Radar plot summarising a hypothetical output of The Dow Chemical Sustainability Footprint Tool©

Of the six sustainability dimensions summarised by the tool, three focus on environmental aspects that have broad sustainability relevance: life cycle greenhouse gas (GHG) emissions, life cycle water requirements and life cycle resource requirements (a combination of the raw material requirements and energy consumption over the life cycle). There is one economic dimension, one social one and a Dow dimension. This latter dimension would not typically be singled out in a sustainability assessment, which, by definition, should take a full life cycle perspective but it is included here to provide both a focus on those aspects over which the company has direct control and to take account of purely internal projects, for example, manufacturing plant improvements.

As well as understanding the importance of a life cycle perspective when considering sustainability, innovators also need to appreciate that sustainability involves the long term perspective of human society as articulated by The World Commission on Environment and Development (the Brundtland Commission) in its report "Our Common Future" [10]: "Sustainable development is development

that meets the needs of the present without compromising the ability of future generations to meet their own needs."

2.3 Tool description

A chemical company such as Dow typically operates near the start of the value chains that deliver services to consumers. In considering sustainability it is important to think beyond the requirements of the direct customer in a value chain and to recognise the demands of the ultimate consumer whose needs and wants lead to the purchases that drive value chains. To encourage this life cycle thinking, innovators are first asked to describe who they consider to be the end user that ultimately benefits from their idea and to define a functional unit for the service that is delivered (usually by way of a new product) to that end user. With that functional unit in mind, tool users are primed to begin answering the 23 questions. Those questions that require the user to make a comparison are typically of the following form:

"As a consequence of the commercialisation of this work, the – sustainability aspect under consideration – is expected to, (a) decrease by >x%, (b) decrease by ≤x%, (c) remain the same, (d) increase, compared to the current product-service provided to the end user."

Whatever answer is chosen, the innovator is asked to give a short explanation of the reasoning that led to that choice. This provides both a historical record of the evaluation and an indication to a sustainability expert of the level of understanding of the innovator at the time of the assessment (see Figure 2).

In this tool, innovations that are considered to be more sustainable will receive a negative score that will reduce the default footprint score of 5. Scores for each question within a dimension are averaged according to a weighted key and then added to the default dimension score of 5 to determine the actual dimension score.

Sustainability Dimension	Criterion	Sustainability Question		Possible Scores
Economic				
Ec1	Value Chain Economic Benefit	As a consequence of the commercialisation of this work, annual value chain costs* per unit of product sold are expected to:		
			decrease by > 10%	-3
			decrease by ≤ 10%	-1
			remain the same	0
			increase	1
		… compared to the current product(s) providing an equivalent service to the end user.	*(Consider the whole life cycle)*	
		** Value chain costs are defined as the total cost incurred by all members of a value chain (over the whole life cycle from raw material extraction through end of life management) in delivering a product to an end user, but excluding the cost to the end user of using the product.*		

Criterion Score	Explanation of chosen criterion score
	Insert score for most appropriate case.
-1	This score is appropriate because converting the new Dow material into a finished product requires less energy than today's incumbent material and will reduce the customers' energy costs.

Fig.2: Example of a comparison question (and hypothetical answer) in The Dow Chemical Sustainability Footprint Tool©.

2.3.1 Economic dimension

For the Economic Dimension of the sustainability tool, innovators are asked to consider and score three aspects of the market for their idea and to fulfil one requirement:

1) **Value Chain Economic Benefit.** Important contributors to a project's commercial success are the economic benefits that accrue to the companies in the value chain. This is separate to the cost to the end user as savings or costs are not always passed on to the consumer (Figure 2).
2) **End User Economic Benefit**. Separately, but of similar importance, is the cost to the end user; a cheaper product that provides the same service, or a similarly priced product that provides extra benefits is more likely to be successful in the marketplace.
3) **Market Acceptance 1.** Even if the above cost pictures look promising, a project may not be successful if there are aspects of its product or its supply chain that are thought by the market to be undesirable or are

expected to have their use constrained by proposed regulations. The innovator is asked to consider substances that are being targeted for deselection by regulators, companies or non-government organisations (NGOs), including the raw materials required for manufacture and the products themselves.

4) **Market acceptance 2.** As innovators are not expected to be experts in regulatory compliance or toxicology (this relates to answering questions 8 & 9 below) it is important that they obtain sound advice at an early stage of a project to prevent wasting resources on an idea that may not be accepted by the market. This question requires the innovator to have reviewed their project with a Product Steward (someone who has the relevant expertise). There is a default penalising score for this question that can be changed to one that indicates a more sustainable approach by completing this product stewardship discussion.

2.3.2 Social dimension

For the Social Dimension six aspects are considered:

5) **Life Cycle Knowledge.** This requires the innovator to have defined the functional unit and (to the extent of their current knowledge) to list the main operational stages of the life cycle of their proposed product(s) together with the key inputs of raw materials and energy and outputs of products and wastes at each stage. The innovator is not expected to quantify these inputs and outputs. The idea behind this question is one of encouraging the innovator to look for sustainability opportunities over the whole life cycle of their idea.
6) **Potential to Address World Challenges.** This question, inspired in part by the United Nations Millennium Development Goals [11], allows the innovator to choose up to 4 aspects of the commercialised development of their idea that they believe will provide significant social benefit in the following areas: healthier drinking water, affordable housing, improved food production (e.g., agricultural productivity), improved personal/public health, improved (end user) safety and improved biodiversity. To obtain footprint reducing scores under this question, the innovator has to provide good explanations of how the commercialisation of their project will contribute to addressing a particular world challenge. In the next iteration of the tool three more areas will be added to the list: access to telephone networks and the internet, access to (renewables

based) electricity and access to markets (including improved transportation infrastructure).

7) **Development.** For this question, projects are automatically penalised unless two conditions are met. Firstly, the end user service enabled by the commercialisation of the idea must be relevant to the needs* of the citizens of emerging economies and, secondly, if marketed in such an economy the cost of the product or service is expected to be affordable (i.e., not prohibitively expensive) to the emerging middle class in that economy. *Needs in this case include those described in the U.N. Millennium Development Goals [10] as well as other development needs such as knowledge access, communications infrastructure and low environmental emission transport infrastructure.
8) **Toxicity.** In conjunction with their Product Steward, the innovator is asked to consider potential changes in the life cycle mammalian toxicity profile over the whole value chain that is needed to provide the service to the end user.
9) **Ecotoxicity.** In conjunction with their Product Steward, the innovator is asked to consider potential changes in the life cycle ecotoxicity profile over the whole value chain that is needed to provide the service to the end user.
10) **Value Chain Process Safety.** This question addresses the potential ability of a new product to improve safety in the value chain (other than the Dow manufacturing operations, which are addressed separately), for example by making a product easier to handle at a customer's facility.

2.3.3 Dow dimension

The next 9 questions make up the Dow dimension and concern those aspects of the life cycle that are bounded by the Dow fence line; in other words, those aspects where the company can have direct control:

11) **Dow Water Requirement.** This question examines the potential of the new project to influence the annual water intake of the relevant Dow business's manufacturing operations. Water intake includes all water (other than recycled water) required for the manufacturing process(es) except for cooling water that is returned to the same environmental location from which it was obtained (for rainwater this means the local watershed) in the same or an improved quality compared to when abstracted or captured. Currently, local aspects of water use such as scarcity or the quality of the water used are not addressed. This

represents an area where the tool may be further developed, for example, as a result of Dow's collaboration with The Nature Conservancy on how to incorporate ecosystem services into global business goals, decisions and strategies [9].

12) **Dow GHG Emissions.**
13) **Dow Energy Consumption.**
14) **Dow Resource Quality 1.** For a resource to be considered sustainable it must exist in sufficient, easy to obtain quantities and the resource must be well managed. Hence this two part question. The first part asks the innovator to consider the abundance of the major raw material(s) that will be used to produce their new product and asks if these resources are plentiful, limited or scarce.
15) **Dow Resource Quality 2.** This second part of the question asks if the resources are well managed, have average management or are poorly managed.
16) **Dow Use of Renewable and Recycled Raw Material.** Projects are automatically penalised in this question unless the raw materials used include renewable or recycled materials (post-consumer or post-industrial, but not within same process as this latter form of recycling is considered to be normal good manufacturing practice and is not seen as encouraging conversion efficiency). The benefit score depends on the amount of renewable or recycled material used.
17) **Dow Conversion Efficiency.** This question examines the weight percentage of raw materials input to the relevant Dow manufacturing processes that becomes waste rather than useful product.
18) **Dow Process Safety.**
19) **Chemicals Management at Dow.** This question rewards emissions reductions within the Dow business(es) involved.

2.3.4 Greenhouse gas, water and resource dimensions

The next two dimensions focus on environmental aspects with broad sustainability relevance and have one question each:

20) **Life Cycle Greenhouse Gas Emissions.**
21) **Life Cycle Water Requirements.**

The last dimension, Life Cycle Resource Requirement, also focuses on environmental aspects with broad sustainability relevance and is made up of two questions:

22) **Life Cycle Energy Consumption.**

23) **Life Cycle Raw Material Consumption.** For this question water and renewable or recycled materials use are excluded from the estimate of raw materials consumption. Recycled materials can include post-consumer or post-industrial materials, but not materials that are recycled within the same value chain manufacturing process that created them.

These last three dimensions take a life cycle view and can include aspects considered in other dimension such as the Economic Dimension or the Dow Dimension. Consequently, there can be double counting. This is not considered to be a problem in this assessment as it can serve to highlight the importance of sustainability aspects in multiple dimensions.

2.3.5 Caution

This sustainability assessment tool will not show that an evaluated project, product or service is, or is not, sustainable, but rather that the successful commercialisation of a project is expected to lead to a more (or less) sustainable service delivered (normally through the use of products) to an end user. The tool is designed to indicate incremental improvements (or worsening) in important dimensions of sustainability, highlighting those dimensions that remain the most challenging. It is not suitable for use as a screening tool amongst **dissimilar** applications. Also, if the product or service delivered by the assessed project is expected to be used in more than one end use application, the major application(s) should be individually assessed.

3 Discussion

Experience from 18 months of use has shown The Dow Chemical Sustainability Footprint Tool© to be self explanatory, easy and quick to use. Typically, Dow innovators have taken between 30 minutes and an hour to complete an assessment (excluding first time use, which takes longer). There has been a clear increase in the sustainability knowledge amongst those innovators who have used the tool. Also, the compiled results of these assessments are providing management with useful perspectives of their project portfolios that are allowing them to better track progress in addressing sustainability opportunities.

4 References

[1] Dow, 1989 Annual Report, The Dow Chemical Company, Midland, Michigan 48674, 1990.

[2] Dow Europe S.A., The Dow Europe Environmental Progress Report 1990, The Dow Chemical Company, 1990.

[3] Smith, E. T., D. Woodruff, & F. Templeton, Growth vs. Environment in Rio next month, a push for sustainable development, *International Business Week*, McGraw-Hill, May 11, 1992, No.3254-584, p.51.

[4] Lacy,P., T. Cooper, R. Hayward & L. Neuberger, *A New Era of Sustainability – CEO reflections on progress to date, challenges ahead and the impact of the journey toward a sustainable economy.*, Accenture - UN Global Compact, June 2010.

[5] Brown, J.S.; A. Collins, P. Duguid, Situated Learning and the Culture of Learning, *Education Researcher*, 18(1), 1989, pp. 32-42.

[6] Brown, A.L., D. Ash, M. Rutherford, K. Nakagawa, A. Gordon & J. Campione, Distributed expertise in the classroom, in G. Salomon (Ed.), *Distributed cognitions*, Cambridge University Press, New York, 1993, pp. 188-228.

[7] Elmore, R. F., P. L. Peterson, & S. J. McCarthey, *Restructuring in the Classroom: Teaching, Learning, and School Organization*, Jossey-Bass, San Francisco, CA, 1996.

[8] Elkington, J., *Cannibals with Forks: the Triple Bottom Line of 21st Century Business*, Capstone, 1997

[9] Dow and The Nature Conservancy Announce Collaboration to Value Nature <http://www.businesswire.com/news/dow/20110124006239/en>, (Last accessed 18.04.2011).

[10] United Nations World Commission on Environment and Development (WCED), *Our Common Future*, Oxford University Press, Oxford, 1987, ISBN 0-19-282080-X.

[11] United Nations Millennium Development Goals (MDGs) <http://www.un.org/millenniumgoals/>, (Last accessed 18.04.2011).