



The greening of the chemical industry – An opportunity to create sustainable value

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The chemical industry has been dealing with environmental concerns for decades. So how should it approach the current appeals to go green? This article examines what being green means for chemical companies, how going green can be a successful strategy, and sets out specific steps executives can take to put green behaviour into practice.

Green is all the rage. Whether one regards it as the latest buzzword or a way for companies to respond to the sustainable development agenda, a short look at the news headlines reveals increasing appeals to industry to “become greener” or do “green business.” In Europe and Japan, governments move to “green sourcing,” NGOs such as Greenpeace are ranking consumer industries on their greenness, and in the US Dell has set itself the goal of becoming the greenest technology company.

These are just a few examples. It is clear that green is an issue on the corporate agenda. Less clear is what green exactly means for the chemical industry, as it lacks a direct link to the end consumers who are driving the process. Furthermore, the subjective and dynamic nature of green does not sit well with the chemical industry, which is known for its tight control of operations and numbers.

It is instructive to compare green to sustainability, a term which the industry is using more often. Sustainability is more encompassing than green, comprising safety and risk reduction, energy efficiency, emission reduction (in the broadest sense of the word) and ethical business. Green is a subset focusing specifically on emissions (waste, harmful materials) and energy efficiency (to reduce greenhouse gas emissions).

At the same time, more than any other industry the chemical industry has experience of societal appeals. In past decades the industry has dealt with many (reasonable as well as misinformed) claims of unsafe or polluting behaviour. In response the industry has tightened safety and emission standards with programs such as Responsible Care®. Emissions have fallen sharply and, according to the American Chemistry Council, its safety record exceeds that of other industries. There has been a strong business case behind these activities. In addition to maintaining a “licence to operate,” companies have reduced production

costs through a more efficient use of raw materials and by running safer operations.

How should executives approach the more recent “green appeal”? Is it only a matter of better communicating what has been achieved, or does green go further? In this article we set out the what, why and how of green:

- What green means for chemical companies in practical terms, and what they should try to achieve by being green;
- Why embracing green is a strategy that can create sustainable value for chemical companies;
- How executives at chemical companies can put green behaviour into practice.

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What’s green for chemicals?

Green is not an easy term for the chemical industry. The term is subjective and intuitive, which is less compatible with the chemical industry’s mindset of engineering, science and control of costs and operations. Furthermore, the industry’s recent history is one of rationalisation and efficiency improvements. This has left little creative, out-of-the-box thinking, and green requires precisely such thinking to come up with innovative business and product concepts. Finally, green is a relative concept, not an absolute one. It is a moving target that can best be compared with the drive for quality: what is considered state-of-the-art today is an entry requirement tomorrow. Some companies are greener than others, and one is the greenest – at least today.

But there is no a priori reason why green cannot apply to the chemical industry. The industry contributes significantly to a greener lifestyle, for example through insulation materials, reducing energy demands for heating and cooling; through plastics, which allow reduced weight and hence lower transportation fuel demands; or through water treatment chemicals, to clean up waste water. Converting oil into a usable material must be a whole lot greener than burning it to generate CO₂.

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Comparable industries such as manufacturing and aviation have not shied away from using the word “green” in their communications. General Electric CEO Jeffrey Immelt, for example, says: “Green is now becoming pervasive. It is becoming universal.” Airbus CEO Louis Gallois proudly promotes the company’s new A380 “Gentle Green Giant” as “the greenest aircraft flying today”. Its competitor Boeing has launched its first “green dream jet”, the 787 Dreamliner, yielding improvements in environmental-quality measures such as fuel consumption and noise. Down the chain, Virgin CEO Richard Branson has bought 15 Dreamliners and is further pursuing greenness with an investment of \$1 billion in alternative fuels.

As far as the chemical industry is concerned, there are various useful frameworks to come to terms with green (see box on next page). They can guide executives in determining what they want to achieve through green.

In each framework, there is a strong emphasis on waste reduction, something with which the chemical industry has ample experience. Over the past decades reaction yields have been upped, energy demand reduced and side streams reused. Much of this has been enshrined in law, and discarding any remaining unused waste now comes at a cost, providing further incentive for reuse. The development has gone so far that in developed nations the general public has even come to expect that industries do not pollute.

As safety and risk reduction are regarded as baseline requirements, society is more and more focusing on green, i.e. the upstream and downstream impact of products. The “Crystal Faraday partnership” set up by the British government’s Chemistry Innovation Network, writes: “In the developed world, it is recognised that only 7 per cent of production materials used in a process end up in the final product and that 80 per cent of products are discarded after a single use. It is essential, therefore, that we seek to reduce material resources and ensure that any materials released to the environment are not toxic, harmful or persistent.” This could be an excellent description of what green could try to achieve in the chemical industry.

Three frameworks defining green for the chemical industry

A. The twelve principles of green chemistry

The Twelve Principles of Green Chemistry issued by the American Chemical Society is an extensive and prescriptive list, providing a useful guide to benchmark products and businesses:

1. Prevention - It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy - Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product.
3. Less Hazardous Chemical Syntheses - Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Designing Safer Chemicals - Chemical products should be designed to effect their desired function while minimising their toxicity.
5. Safer Solvents and Auxiliaries - The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. Design for Energy Efficiency - Energy requirements of chemical processes should be recognised for their environmental and economic impacts and should be minimised. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. Use of Renewable Feedstocks - A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. Reduce Derivatives - Unnecessary derivatisation (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimised or avoided if possible, because such steps require additional reagents and can generate waste.

9. Catalysis - Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Design for Degradation - Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. Real-time Analysis for Pollution Prevention - Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. Inherently Safer Chemistry for Accident Prevention - Substances and the form of a substance used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosions, and fires.

B. Cradle-to-cradle model

The cradle-to-cradle thinking put forward by McDonough and Braungart proposes to design business in terms of biosphere versus technosphere. Every product released into the biosphere should be 100 per cent biodegradable, providing healthy food for other organisms. Non-biodegradable materials such as metals belong to the technosphere and should be continuously recycled. Everything that cannot be biodegraded or recycled should be phased out.

C. Economic framework

The economic framework views any form of waste as an opportunity to reduce costs. Such costs come in two forms:

- (a) endogenous costs, which can be reduced by using the material more efficiently during manufacturing;
- (b) exogenous costs, when the waste degrades the environment or life, and/or causes clean-up costs afterwards.

Certainly, the above constitutes a tall and complex agenda. But chemical companies are highly capable of dealing with complexity. In the past decades, chemical companies operating in the developed world have faced ever-tightening safety and emissions standards, and ever-increasing demands for financial returns. In the process they have acquired some strong new competencies:

- Innovating products and processes that generate less waste (whether through efficiency improvements or complete process overhaul);
- Negotiating often contradicting demands of society, governments and investors;
- Balancing cash generation and return on investment with long-term growth and innovation requirements.

A case-in-point is Akzo Nobel's rapid ascent to the top of the Dow Jones Sustainability Index (see box).



Akzo Nobel's rise to the top of the Dow Jones Sustainability Index

The DJSI was launched in 1999 to achieve an objective sustainability benchmark of companies based on economic, environmental and social criteria. When Akzo Nobel first participated informally in 2004, 1,000 companies were already being benchmarked. In that first year, Akzo Nobel obtained an above-average score on such issues as HSE management and product stewardship. In 2005, in its first real participation Akzo Nobel ended up in the global top ten of best-performing chemical companies. Its strengths were, among others, its corporate citizenship and a strong cradle-to-cradle awareness. Following a step-up in a.o. product evaluation, in 2006 Akzo Nobel reached a shared number one position with DSM, also based in the Netherlands. Finally, in 2007 it achieved an undisputed global leadership position, out of around 80 companies in the worldwide chemical industry segment.

The case for green in chemicals

There are some strong business and economic incentives to pursue greenness:

Innovating towards greener alternatives reduces the risk of losing out and offers opportunity for early movers to gain a strategic and competitive advantage by defining the term in their favour.

a. Appropriate the first-mover advantage. Attack is the best defence. Innovating towards greener alternatives reduces the risk of losing out and offers opportunity for early movers to gain a strategic and competitive advantage by defining the term in their favour. This can allow them to set new industry standards which can exclude new entrant firms or serve new niche markets with innovative products and services. Greener alternatives also may command a price premium, or – when more expensive – generate a higher absolute profit at the same profitability margin.

For example, US-based Cereplast has been working hard to develop fully biodegradable, plant-based plastics to replace oil-based plastics. Just in time, it turns out, given the recent scare about toxic components in children's toys. The company will provide plant-based plastic resin and polylactic acid (in partnership with NatureWorks LLC, owned by Cargill) for a new line of children toys marketed by Green-Toys™. Similarly the market for renewable packaging is booming as retailers such as Walmart and Tesco try to establish their green credentials. DuPont, looking to expand in this area through proprietary innovations and partnerships, has entered into a development, marketing and branding agreement with first-mover Plantic, an Australia-based company that has been developing renewable packaging materials based on corn starch. Netherlands-based Purac is also investing in new lactides and technology aimed at the green packaging market.

b. Ensure customer and investor loyalty. The costs of keeping less green alternatives on the market are rising due to legislation such as the European law on Registration, Evaluation and Authorisation of Chemicals (REACH), and increasing attention to chemicals used in end products. Such costs concern the obvious testing and certification, but increasingly they also come from investors. In the wake of costly litigation, product sales bans and reputational damage, investors are becoming increasingly wary of toxic chemical risks – in products, in supply chains, and in their

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own portfolios. The number of companies facing shareholder resolutions dealing with toxic product risks jumped from three in 2004-2005 to 17 in 2006-2007, including such leading US corporations as Apple, Sears, CVS, Dow and DuPont. These shareholders get the attention of CEOs, not by expressing their concern about toxic chemicals per se, but about the companies' financial performance as customers may abandon product lines over their concerns, whereas liability litigation and government enforcement may further undermine bottom lines and reputations.

c. Up the ante for competitors. The additional "green" requirements effectively amount to an entry barrier for competitors that are less able to navigate these seas. This is particularly relevant for incumbent players facing competition from, for example, China and India. Instead of competing head-to-head on problem-ridden commodities, sophisticated players use green to tilt the playing field in their favour. For example, Great Lakes Chemicals (now Chemtura) phased out penta-BDE, a common but environmentally suspect flame retardant for polyurethane foam. The company received an endorsement of its proprietary alternative from the US EPA, gaining substantial market share in the process. In this light the dynamic nature of green now becomes an advantage. As soon as competition catches up with your level of greenness, you up the ante by adding a few more features.

In short, savvy companies can use the green push to build sustainable value, using their experience with Responsible Care® and similar programs to create competitive advantage.

Putting green chemical behaviour into practice

We distinguish four green chemical behaviours that can create sustainable value for industry and society.

Minimise production-related emissions

Sticking to your emission permit is expected behaviour, an entry-level requirement. Green is ensuring that companies are increasingly expected to display an absolute and proactive commitment to minimise production-related non-greenhouse gas emissions, even when permits have

been issued. A case in point is the recent upheaval about mercury emission into Lake Michigan by a US BP refinery. While the company had all required permits and the emissions were very minor, it ended up in the spotlight, receiving little or no mercy.

Use greenhouse gas (GHG) reductions proactively

Green behaviour is further exemplified by a commitment to GHG reductions beyond the obvious win-win of cost reductions from reduced energy usage. It looks at the business opportunities that are offered by green. There are a number of examples already. Brazil-based Braskem is the first producer of “certified Green Polyethylene”, using sugarcane-based ethanol as the feedstock. Dow Chemical Co. is following closely, recently announcing a cooperation with Crystalev, a major ethanol producer, to produce polyethylene in Brazil using sugarcane-based ethanol as the feedstock. Going even further Ben & Jerry’s approach of offering climate-neutral ice cream could be an inspiration for the chemical industry (see box).

Lessons from climate-neutral ice cream

One example of a company making business out of GHG reduction is Ben & Jerry’s. The company’s aim is to provide the best possible ice cream in the “nicest” possible way, socially and environmentally. It is now the first company in the world to offer climate-neutral ice cream. According to HIER, a Dutch climate-neutral promotion campaign, their production chain has a zero impact on our climate.

Starting the production chain, milk comes from cows which are specially fed, so they release less methane, a greenhouse gas with 18 times more impact than CO₂. All the company’s dairy farms use green energy as Ben & Jerry’s has invested in on-site renewables like bio-gas, solar and wind turbines. Transportation is accomplished in a sustainable manner: air freight is never used and delivery routes are changed in order to cut transportation miles. Furthermore, packaging is made from renewable material and is recyclable. Lastly, the ice cream is frozen in special refrigerators. Where technology does not provide a solution, Ben & Jerry’s compensate for the remaining GHG emissions through the purchase of emission reduction certificates. The whole process is certified by an external auditor, which has awarded the climate-neutral certificate.

For the chemical industry, given its technological know-how, experience with certification and supply-chain thinking, applying a similar approach to develop and offer green, climate-neutral chemicals must certainly be feasible.

Raise the greenness of your business, product and technology portfolio

There are various ways to make your portfolio of activities more green:

- a) Forgo business that is not green. For example, during 2005 Infineum declined to participate in bidding to supply customers with metal-based additives for diesel fuels. In another example, BASF's Expert Services Sustainability initiative includes a case study showing that in the short term it reduced the quantity of products sold to customers, but it gave BASF a long-term competitive advantage when renegotiating supply contracts. And, as part of its strategy development, one of our clients specified which business segments it would retreat from.
- b) Develop alternative business models that provide green benefits. For example, Ecover is experimenting with retail drug stores to offer in-store refilling of polyethylene bottles with shampoos, shower gel, etc. Although they do not consider the bottles problematic, reusing the bottles will help reduce customer packaging waste.
- c) Develop and offer non-toxic and/or climate-neutral products. For example, the GreenToys™ plastics provided by Cereplast are also claimed to be phthalate-free and not to contain any heavy metals. Rohm and Haas are developing additives to improve the properties of polylactic acid as a green packaging material. One company we worked with is also investigating the possibility of marketing climate-neutral versions of its products, using a combination of energy savings, biofuels and carbon emission certificates.
- d) Acquire alternative, green technologies. For example, Ashland recently created a joint venture together with Cargill to develop and produce bio-based chemicals. Ashland believes that "the chemical market has reached a tipping point where bio-based and petroleum-based options are both desired by the market and practical to produce. To be in a position where Ashland can offer bio-based specialty chemical products in the future, we need to help foster the creation of bio-based basic chemicals now".

Create partnerships with external stakeholders

Even if chemical companies want to go green, they will realise they cannot do so alone. Every company acts in a complex setting of stakeholders, each imposing sometimes opposing demands on the others. All actors in turn are influenced by society, but society itself has no voice. Society's needs are articulated in different ways. For example, societal demands for a clean environment are vocalised by protest campaigns of NGO action groups or by the questions posed by pension funds. These in turn may be contradicted by the need for cheap products vocalised by the market: any green solution that comes at a cost more than 10 per cent higher than the incumbent product will be hard to introduce except into small niches; for general, large-volume sales it will require legislation or market pressure to succeed.

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In response to these challenges, a new model is forming in which business and NGOs cooperate to develop and bring to market green solutions. A striking example concerns an alliance of the World Wildlife Fund (WWF), Toyota, BP, the Dutch and Swiss governments, the UN Foundation, the World Economic Forum and the University of California at Berkeley to draw up global standards for biofuel production and processing.

This development is showing up in chemicals too. DuPont has formed the Nano Risk Framework with Environmental Defense, to evaluate and address the potential risks of nano-scale materials. Climate Savers, a business initiative organised by the WWF in concert with the Center for Energy & Climate Solutions, mobilises companies to cut emissions of carbon dioxide. And Shell has formed partnerships with Chinese NGOs such as Friends of Nature and Global Village of Beijing to raise awareness of environmental concerns. One objective is to make sure that Shell's competitors in China will be subject to the same standards the company faces because of its developed world history. Arthur D. Little is actively helping companies to identify such opportunities. In each case the NGO's objective is to bring greener business into the marketplace by co-opting the businesses that are willing to develop it. In the process, the NGOs help companies by bestowing credibility on actions, thereby acting as referees and external auditors of the industry's behaviour.

Granted, partnerships are not easy to form, generally taking months of intensive contract negotiations with a high chance of failure. For example, less than one quarter of all cooperation attempts with WWF actually come to fruition. Most NGOs will not be willing to associate themselves too intimately with chemical companies, stating that “the chemical industry has an image problem.” They want to see the desired green behaviours spelled out before lending their credibility to any cooperation. But, if designed well, these partnerships can be true win-win situations for business, NGOs and society at large.

Insights for the Executive

A green chemical industry will not happen overnight. It took the industry two decades of Responsible Care® to get to where it stands today, and it is now vastly different from what it once was. Greening the industry will be a similarly lengthy, maybe even more difficult process.

Success will be based on looking for opportunities to further reduce plant-based emissions and reviewing the business and product portfolio to identify areas of exposure and where to focus green efforts. This involves developing new and better alternatives and developing new ways to bring them to market.

At the same time, the chances of success have increased – you can create competitive advantage through proactive engagement with regulators; you can get investor endorsement for your plans, or create investor pressure on your competitors; or you can gain support from NGOs. All of these will make your business more complex, but given the capabilities that chemical companies have acquired from dealing with societal appeals for decades, they should be able to navigate these waters while creating more sustainable value.

*Further links and references can be downloaded on our website:
www.adlittle.com/chemicals_2007.pdf*

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