



SOLVAY

asking more from chemistry®

SUSTAINABLE PORTFOLIO MANAGEMENT • GUIDE

Driving long-term sustainable growth



SPM
SUSTAINABLE
PORTFOLIO
MANAGEMENT

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This SPM Reference Guide is an easy-to-use guide for applying the SPM tool, improving your sustainability performance and creating more value for your business.

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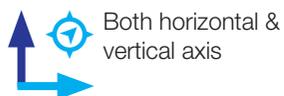
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Jean-Pierre Clamadieu



Peter Bakker

“Our sustainable **Solutions** reached **43%** of Solvay sales in 2016 while our **Challenges** decreased to **8%**.”

Jean-Pierre Clamadieu

“Sustainability is one of the essential driving force of Solvay strategy. The “SPM” or Sustainability Portfolio Management tool is like a compass. It makes our strategy more robust and adds value in the key business, innovation and investment decisions. This SPM guide helps to demystify the tool, show its strengths and its limitations. We explain simply how we evaluate for each product/application both the impact of its production on the environment and the benefit or challenge to the planet and the society. The scientific approach, rigorous analysis and systematic external references are the guarantees for excellence and neutral evaluations.

We are proud of the current momentum. Best Solutions reaching 43% of our sales in 2016 while our Challenges decreased to 8%. Let us continue the journey to a better world, developing sustainable and differentiated offer using SPM as an asset

Jean-Pierre Clamadieu
CEO, Solvay

“The business case for sustainable development is strong: it opens up new business opportunities, big efficiency gains and it drives innovation. The Business & Sustainable Development Commission research shows that achieving the Sustainable Development Goals could be worth an estimated 12 trillion USD every year by 2030 in business savings and new revenue, creating 380 million jobs in the process. In order to make the right decisions in their business processes, companies need to adopt robust, reliable and practical tools. WBCSD is engaged with leading chemical companies, in particular Solvay, to develop a common framework and methodology to steer companies’ product portfolios to higher sustainability standards.”

Peter Bakker
President, WBCSD
<http://www.wbcd.org/>

The SPM global and systematic assessment helps alert the business to sustainability market signals, even weak ones, to anticipate their impact and develop the right answers in a timely way. It enables value to be captured in emerging eco systems and helps business to grow its portfolio by leveraging on opportunities and turning challenges into solutions.

The Sustainable Portfolio Management (SPM) is a **fact based and robust compass** to steer Solvay's portfolio toward better business because more sustainable.

SPM is designed to boost Solvay's business performance and deliver higher growth.

With SPM, decision-makers are **informed on** the contribution of Solvay's products to sustainability considering both:

-  • Their **environmental manufacturing footprint** and its correlated risks and opportunities – vertical axis – quantitative assessment by 19 impact indicators.
-  • How in their **applications** they bring **benefits or faces challenges in a market perspective** – horizontal axis – qualitative assessment by 60 questions on social and environmental topics.

Over the last three years, Solvay's products have experienced significantly different annual revenue growth rates depending on whether customers and consumers are seeking out Solvay's products to match their unmet social or environmental needs.

SPM category Solutions (unmet needs to achieve higher social or environmental standards) shows an annual growth rate of +9% while Challenges (sustainability concerns or roadblocks) ends up at -3%.

Measuring sustainability in business terms:

SPM is a key tool to integrate the sustainability dimension in strategic and operational decisions of key business processes: strategy, research and innovation, investment, marketing and sale, merger and acquisition.

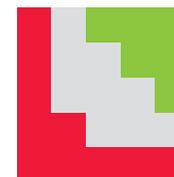
A tool to help GBU contribute to the Group's ambition:

Within Solvay, Global Business Units (GBUs) are accountable for delivering the ambitious Group target for sustainable business performance: by 2025, realize € 1 of revenue out of every € 2 in sustainable solutions.

“SPM is instrumental at Solvay to take robust decisions by integrating sustainability in its business growth ambition. SPM is a key tool to understand the operational and market-induced risks and opportunities related to the environmental impact of our facilities against the contribution of our products to the planet and society. We are engaging in open innovation and dialog with our key partners and are committed to sustainable growth.”

Pascal Chalvon Demersay

Chief Sustainability Officer, Solvay



Overview

1.1 SPM TOOL INTEGRATED IN THE SOLVAY *Way* THE SUSTAINABLE DEVELOPMENT AMBITION OF THE SOLVAY GROUP

The Solvay Way is the continuous improvement approach which integrates social, societal, environmental and economic aspects into the Company's management and strategy, with the objective of creating value. It takes into account society's changing expectations, requiring industry to develop technology, processes, products, application and services that are in line with the objectives of sustainable development.

The **SOLVAY Way** is an exceptional onboarding tool to deliver our ambition and commitments towards our six main stakeholder groups:



The Group has set ambitious extra-financial objectives by 2025 positioned in three circles:

1. How we contribute to society beyond our responsibility as a chemist (societal actions)
2. How we bring Sustainable Solutions to the market through innovation (SPM)
3. How we act responsibly (with main indicators on safety, people engagement and environmental footprint)

The SPM tool clearly addresses all the characteristics of the Circular Economy which is at the heart of our vision to create more value for the future through the development of sustainable solutions.

<https://www.ellenmacarthurfoundation.org/circular-economy>

1.2 KEY DECISION-MAKING TOOL

SPM tool aims to integrate sustainable development into strategic and operational level decision-making covering a wide scope of management processes:

- Portfolio management decisions and differentiation strategy
- Strategic project-related decisions in Research and Innovation (R&I), capital expenditures (CAPEX) and Mergers and Acquisitions (M&A)
- Product footprint improvement

From 2016, within Solvay, the methodology is applied in:

- More than 80% of the existing product portfolio in a consistent way (i.e. total sales revenue)
- All R&I projects
- All CAPEX projects for requests above 10 million EUR
- All M&A projects

Since **SPM is a pragmatic decision-making tool**, it is adapted to different information needs, time and resources available.

The SPM tool combines **pragmatism, adaptability, scientific justification and process reliability** and leads to more value creation through a robust and more differentiated strategy.

“What is unique about Solvay's sustainable solutions? They make money – we do not need to make a choice between sustainability and profitability. SPM is like a compass, steering us towards the right investments, research projects and portfolio decisions.”

Roger Kearns

Member of the Executive Committee, Solvay



2.1 METHODOLOGY IN A NUTSHELL

The SPM tool in Solvay is often referred to as a camera as it takes a snapshot of product's sustainability risks and opportunities in their business environment. It develops a dynamic vision of sustainability market signals and their potential impact on portfolio and strategic projects helping the business:

- Take the right decisions to address successfully sustainability needs of the marketplace
- To meet customers and stakeholders expectations both today and tomorrow.

The SPM snapshot is projected on a heat map matrix where products in their applications are plotted according to three attributes (see figure below):

 **1. Operations Vulnerability (vertical axis)** is  the ratio of monetized environmental footprint of products over their sales value. In other words, it is the monetized environmental manufacturing footprint per 1 EUR of revenue.

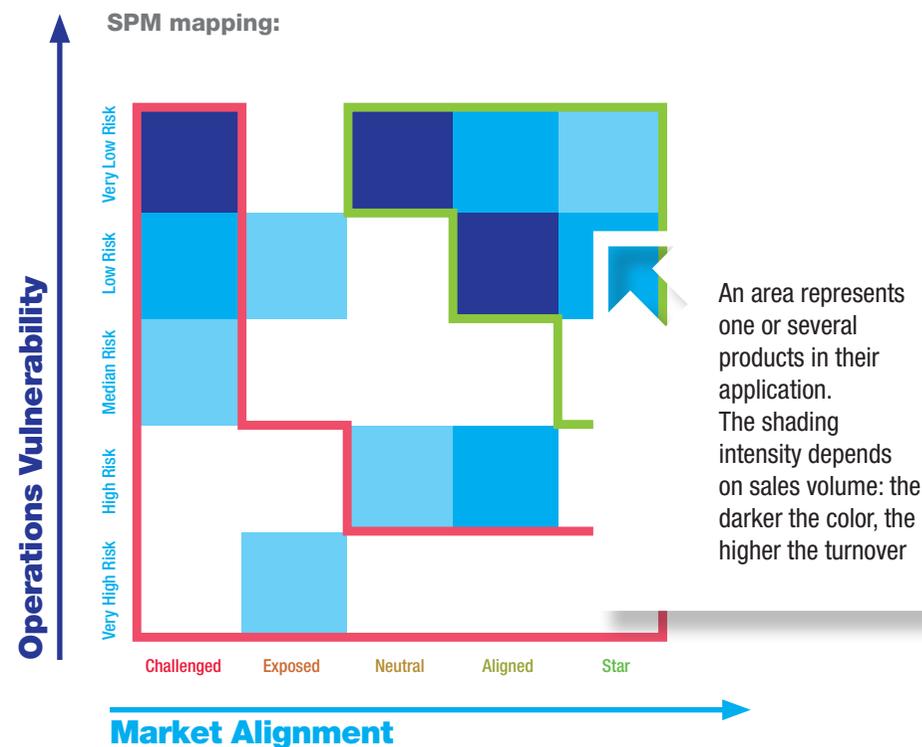
The higher the ratio, the higher the risk for Solvay of losing business to more sustainable solutions.

The lower the ratio, the higher the probability to displace a less environmental-friendly competing technology.

 **2. Market Alignment (horizontal axis)**  of products in their application analyzes the market signals of sustainability benefits and roadblocks and categorizes products on a five-scale spectrum from 'challenged' to 'star potential'.

It analyzes whether one product in a given application is part of the sustainable development solution or part of the problem from a consumer and market perspective.

3. Sales volumes are also taken into account and represented in the SPM Heat Map with the darker shading representing the revenue at stake.

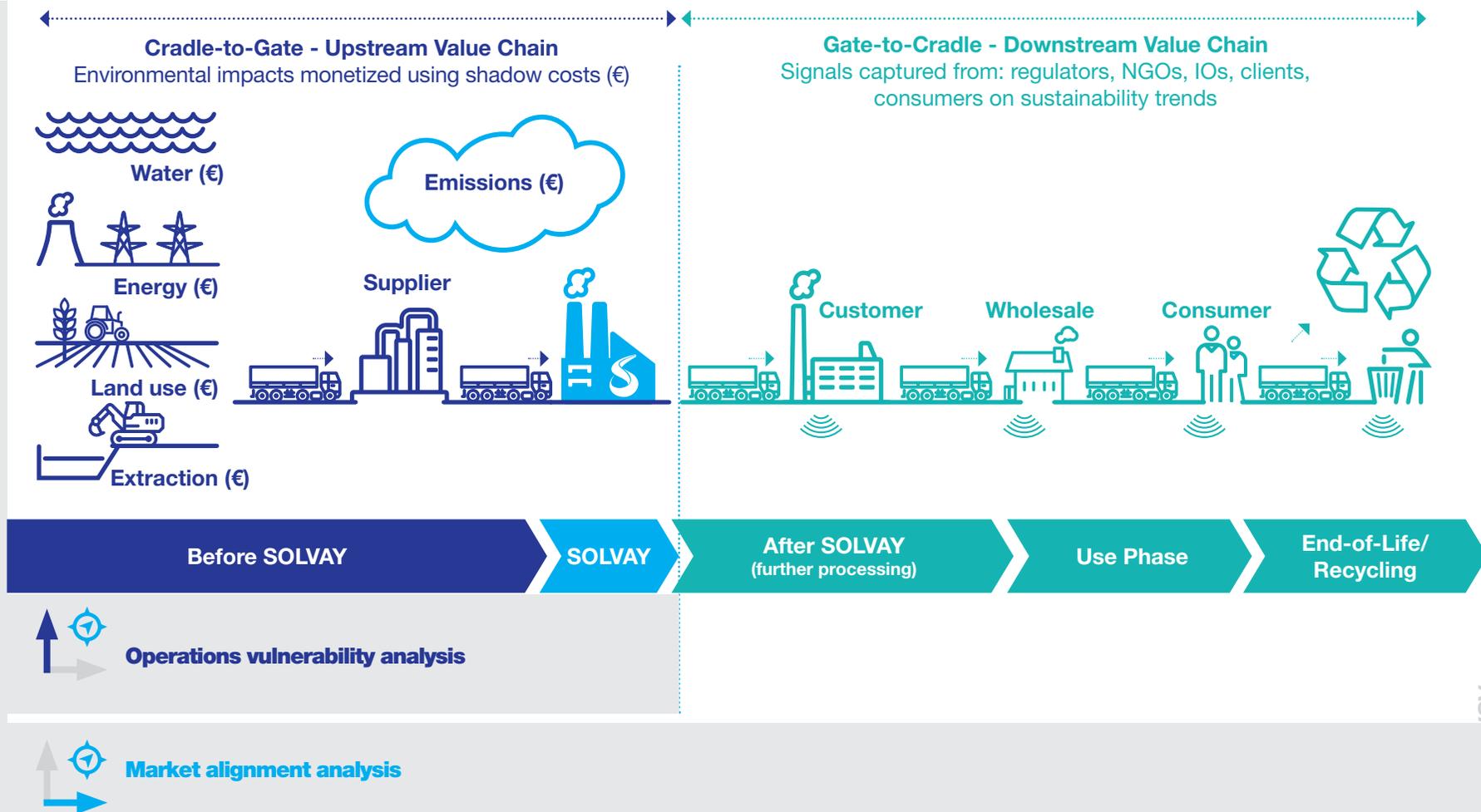


The SPM assessment is performed in close cooperation with Business Units with strict quality control and external expert review. The results are recorded in a global SPM Database and are fully auditable.

2.2 SCOPE OF SPM

The SPM tool covers:

- ↑
→
1) Operation vulnerability: the upstream, cradle-to-gate scope of the value chain to define sustainability-related business risks and opportunities based on a quantitative LCA. 19 product impact points analyzed, monetized and compared to sales value using LCA methodology.
- ↑
→
2) Market alignment: the entire value chain (up and downstream), cradle-to-grave to pinpoint sustainability benefits and roadblocks in the product portfolio applying evidence-based analysis of market signals.



2.3 OPERATIONS VULNERABILITY: THE VERTICAL AXIS

Operations Vulnerability is the quantitative element of the SPM analysis. It evaluates any potential financial risk and opportunity posed by the environmental footprint of products according to the 'polluter pays' principle.

A unique approach combining scientific analysis with risk assessment.

Operations Vulnerability calculation steps:



Step 1:
Impact Assessment



Step 2:
Impact Valuation



Step 3:
Operations Vulnerability

1. Calculation of a product's ecoprofile. We calculate the ecoprofile of a product using a Life-Cycle Assessment (LCA) performed by our in-house experts in line with the ISO 14040 and ISO 14044 standards.

With this procedure, we create an inventory of impacts on surrounding ecosystems e.g. resource consumption, emissions to soil, air and water, including human toxicity potential, of a product occurring upstream from extraction, through production, until it leaves Solvay's premises (in a cradle-to-gate approach). 19 indicators of impacts are used.

2. Monetization of negative impacts. We use 'shadow costs' drawn from authoritative scientific sources to define what it would cost to remedy or prevent negative impacts.

These are costs which Solvay does currently not incur, i.e. they have not been internalized yet. The impact valuation defines the financial risk of internalizing these negative impacts.

3. Financial risk of negative impacts (externalities). The risk of losing business or the opportunity of gaining new business depends on the balance between the economic value and the damage that is created.

The absolute financial value of the potential impacts of one kg of product is insufficient to inform the decision-maker. That is why we calculate the implications of the financial impacts by dividing the value of the impacts by the sales value of the product. The result is the Operations Vulnerability ratio expressed as a percentage, which can range from 2% to over 200% of the sales value for some products. This ratio is plotted on the vertical axis of the heat map.

2.4 MARKET ALIGNMENT: THE HORIZONTAL AXIS

Qualitative, evidence-based collection of sustainability-related market signals



Consumers and stakeholders across the value chain (manufacturers, wholesale and retail) are putting more and more emphasis on sustainability.

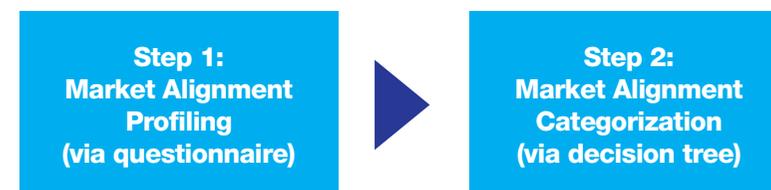
In order to understand the risks and opportunities arising in the value chain, the right signals have to be captured from different stakeholders.

Similar approaches from Solvay's peers, such as AkzoNobel, BASF, Clariant, DSM and Evonik among others, have shown that a qualitative or semi-quantitative analysis is best adapted to interpret signals¹.

Full cradle-to-cradle Life-Cycle Analysis is not material for Solvay as it is limited to environmental impact assessment, while SPM analysis also addresses social issues such as healthcare, ageing population and healthy living. We defined these questions based on the analysis of a number of different authoritative sources to understand what sustainability means for a chemist and for chemical products. The result is a questionnaire with 60 questions.

We analyze products in their end-user applications, based on **Product-Application Combinations** or **PACs**. One product can have several PACs.

The Market Alignment analysis of PACs consists of two steps:



Step 1: Market Alignment Profiling: To identify the sustainability signals for each PAC, a Working Group of the SPM expert and Business Unit answer the 60-question questionnaire on environmental and social issues to collect information on obstacles, concerns, benefits, high-growth (Star) potential and amplifiers.

Step 2: Market Alignment Categorization: The information gathered is applied to a decision tree, which positions the product on a 1-5 scale of Challenged (1), Exposed (2), Neutral (3), Aligned (4), Star (5).

¹ Our benchmark shows that quantitative, e.g. monetized analysis of impacts occurring in the entire value chain requires lengthy and costly procedures that are difficult to use in fast-paced strategic corporate decision-making cycles, as well as in operational decisions on allocation of future spending such as innovation projects.

2.4 MARKET ALIGNMENT: THE HORIZONTAL AXIS

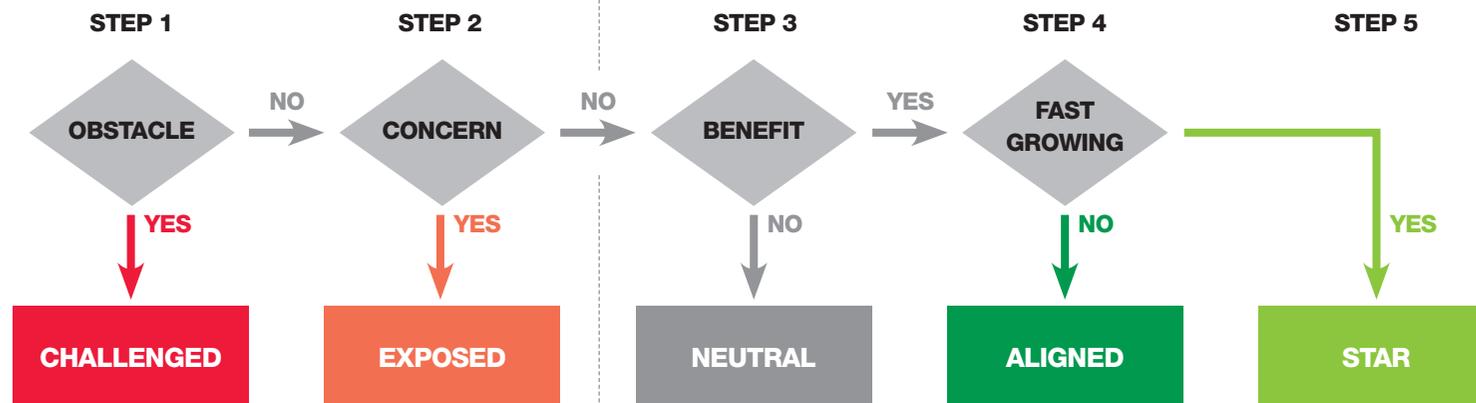
Qualitative, evidence-based collection of sustainability-related market signals



All the sustainability signals assessed using the questionnaire are run through a decision tree. This defines the exact positioning of the Product-Application Combination or PAC. First, we look at Obstacles and Concerns (Steps 1 and 2). Any Obstacle identified will immediately rank the PAC as **Challenged** and anything raising Concern as **Exposed**.

Then we turn our attention to the positive signals (Steps 3-5). If we find no negative and no particularly positive impacts, we categorize the PAC as **Neutral** (Step 3). If the PAC analyzed demonstrates a direct, significant and measurable benefit to the market, impacting positively upon at least one of the sustainability benefits assessed, we list the product as **Aligned** (Step 4). If in addition, we register double-digit growth potential in sales forecasts, the PAC is categorized as **Star** (Step 5).

Fast track SPM Market Alignment decision tree:



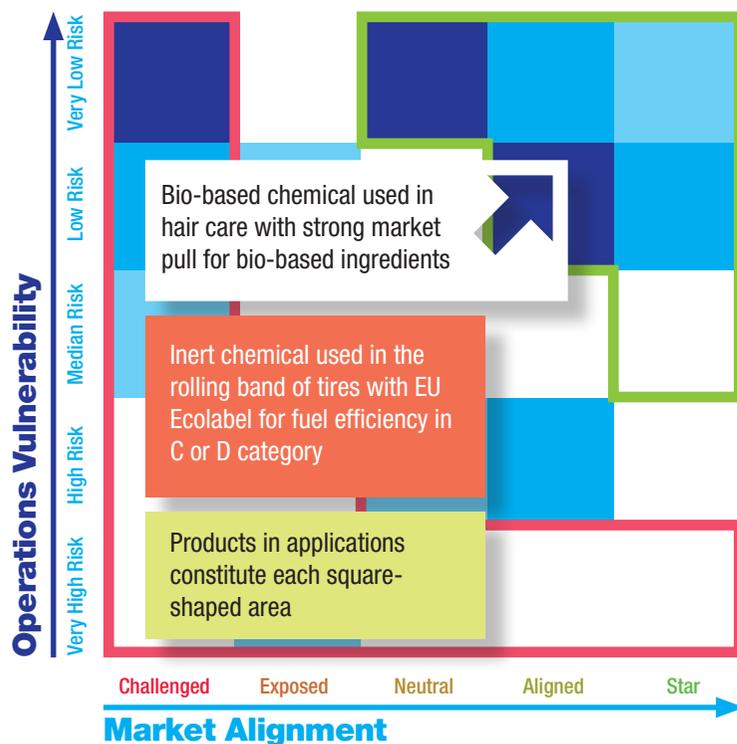
All the answers are also recorded in the Global SPM Database and are fully-auditable. Reviews of the Market Alignment methodology application are conducted on a regular basis by Arthur D. Little (ADL). The % of the product portfolio assessed and the % of sustainable solution published in Solvay's 2016 annual report have been reviewed by Deloitte (reasonable assurance).

2.5 MAPPING RESULTS – SPM HEAT MAP

Results of the **Operations Vulnerability** and **Market Alignment** assessments are plotted on a heat map which shows how risky the PAC is for Solvay.

Business Units receive a drilled-down report which allows them to analyze the PAC's position on the heat map and suggest actions to maintain or improve performance and reach Group-level targets.

Product applications on the SPM Heat Map:



The heat map is the highest-level portfolio steering instrument of the SPM assessment. It categorizes products and PACs in three higher level categories

- **Solutions:** PACs with an **outstanding sustainability contribution** to Solvay customers and value chain, combined with a favorable balance between value and environmental impact.
- **Neutral:** PACs which do **not have outstanding sustainability performance**, if any. Low Operations Vulnerability is not combined with favorable sustainability drivers in the marketplace. These are products that consumers need, but which do not contribute to environmental footprint reductions.
- **Challenges:** PACs for which there are **either strong negative** signals resulting from sustainability drivers in the marketplace, **or serious operations vulnerability challenges**. These are products where there may be a significant negative impact on revenue over time and where products may eventually disappear.

Over the last three years, Solvay's products have experienced significantly different annual revenue growth rates depending on whether customers and consumers are seeking out Solvay's products to match their unmet social or environmental needs.

Annual growth rate per SPM category:

- Solutions (unmet needs to achieve higher social or environmental standards): +9%
- Challenges (sustainability concerns or roadblocks): -3%

(based on turnover with same product, same application and same SPM ranking over the last 3 years representing 45% of Group revenue).

SPM global and systematic assessment involves an evaluation of the portfolio for a given year (Y) based on the turnover of the previous year (Y-1). Changes in the business perimeter during the year are taken into account in the scope of the year (Y) SPM.

2.6 AUDITABILITY FOR RELIABLE DATA

In order to integrate the results of the SPM assessment to strategic and operational planning, we developed a sustainability assessment framework which could be audited by third-party accounting and sustainability assessment experts.

1. Dedicated data management module for SPM

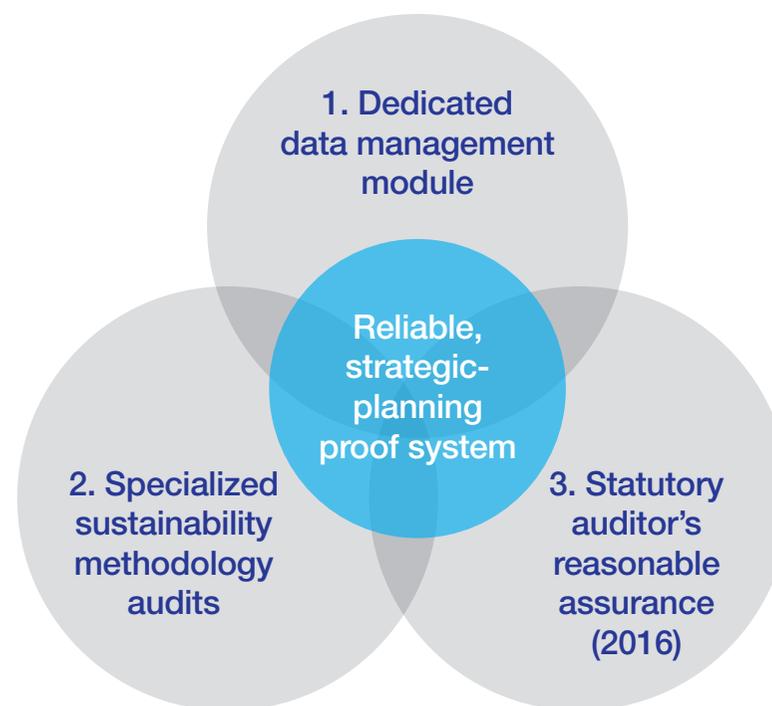
Data from both axes of the SPM assessment are documented and recorded in Solvay's Global SPM Database. A user-friendly module developed in-house and hosted in the SAP system allows around 1,500 SPM assessments (PAC) to be carried out per year.

2. Specialized sustainability methodology audits

Third-party verification of the Market Alignment assessments is carried out by Arthur D. Little (ADL) at PAC level. Every year ADL screens all the PACs in the database and selects 150 PACS for deeper review, 100 with higher value for Solvay based on multiple criteria and 50 on a random basis. In addition, Solvay submits 50 PACs per year to ADL for review. All the PACs in the database will be reviewed every five years at the latest.

3. Statutory auditor limited to reasonable assurance

Each year, we report Group-level turnover breakdown following the SPM Heat Map categories (Challenges, Neutral and Solutions). The % of the product portfolio assessed and the % of sustainable solutions published in Solvay's 2016 annual report have been reviewed by an independent third party (reasonable assurance).



2.7 EXTERNAL RECOGNITION



“Solvay’s Sustainable Portfolio Management approach received a ‘Highly Commended’ award in EFQM’s Sustainability Good Practice Competition. The Jury recognized that the tool represents a paradigm shift in the way organizations consider sustainability as part of their strategic planning process and the potential for this tool to be adapted and applied in other organizations and sectors.”

Matt Fisher
COO, EFQM

Award	Recognition	Promoted as Best Practice	Partnerships
EFQM ‘Highly Commended’ 2011 Sustainable Portfolio Management	<ul style="list-style-type: none"> • European Commission, DG Enterprise & Industry • SusChem, European Technology Platform for Sustainable Chemistry • Kohlberg Kravis Roberts (KKR) - global investment firm • CIRAIG (with whom Solvay also embarked on a high-level research platform on LCA methodologies) • Umicore • ArcelorMittal (as a buyer of Solvay products in our value chain) • The Conference Board 	<ul style="list-style-type: none"> • CSR Europe http://www.csreurope.org/solvay-sustainable-portfolio-management-spm#.WEfkXeZNBw • The World Business Council for Sustainable Development (WBCSD): Collaboration, innovation, transformation - ideas and inspiration to accelerate sustainable growth - A value chain approach; 2011, page 14 and 15 • ICIS Article: https://www.icis.com/resources/news/2017/01/25/10073070/insight-multiple-benefits-from-drive-for-sustainable-innovation/ 	<ul style="list-style-type: none"> • TNO to advance scientific research • WBCSD to advance sectoral Portfolio Steering Assessment (within the framework of Action2020 – Business Solutions on safe products)

‘ASK NEW QUESTIONS, GET NEW ANSWERS!’

SPM is a compass to help key business processes integrate the sustainability dimension.

‘Ask new questions, get new answers!’ is the SPM motto to help the business differentiate and create more value.

At Solvay, the SPM tool is the compulsory analytical tool to be applied before decisions are made in Strategy, Research & Innovation (R&I), Marketing & Sales, Capital Expenditure (CAPEX) and as an element of due diligence in Mergers and Acquisitions (M&As).



3.1 STRATEGY

Strategic projects are key to achieving Group-level targets in general and the business portfolio-related targets in particular. SPM helps deliver on the non financial target that 50% of Solvay's revenue should come from products which offer sustainable solutions and therefore the SPM approach is fully-integrated in the strategy process that each Business Unit has to undergo during its annual Business Strategic Review (BSR).

SPM in Projects

The SPM tool is therefore applied to strategic projects in a similar logic to make sure that they are heading toward business solutions to support growth and value creation. Fast track assessments are used especially in the early stages of projects where it is not practical or not possible to commit more resources to in-depth analysis due to time and/or financial constraints. It allows to integrate sustainability dimension among others from the beginning of the project.

The SPM logic around project assessment is to:

- Prepare an SPM snapshot of the starting point and the anticipated end-point of any project and continuously review the latter as the project evolves
- Position the project within the BU/GBU portfolio where it belongs
- Position the projects in the corresponding Solvay Way practice and maturity level and link them to Group targets

All SPM snapshots are taken by the SPM team and are linked to financial performance bridges in a similar way as in the Business Strategy Review process. (explained above).

“SPM is an unmatched tool when Novincare is making portfolio decisions. It enhances our ability to align our strategies and practices that contribute to providing sustainable solutions, while simultaneously supporting our customer approach.”

Emmanuel Butstraen

President GBU Novincare, Solvay

“GBU Specialty Polymers started applying the SPM tool in 2009, speeding up its sales growth when the economy rebounded in 2010. Since then, repeatedly reassessing our sales and R&I investments with SPM has given us a better alignment and focus on fast-growing sustainable emerging markets.”

Augusto Di Donfrancesco

President GBU Specialty Polymers, Solvay

3.2 RESEARCH & INNOVATION (R&I)

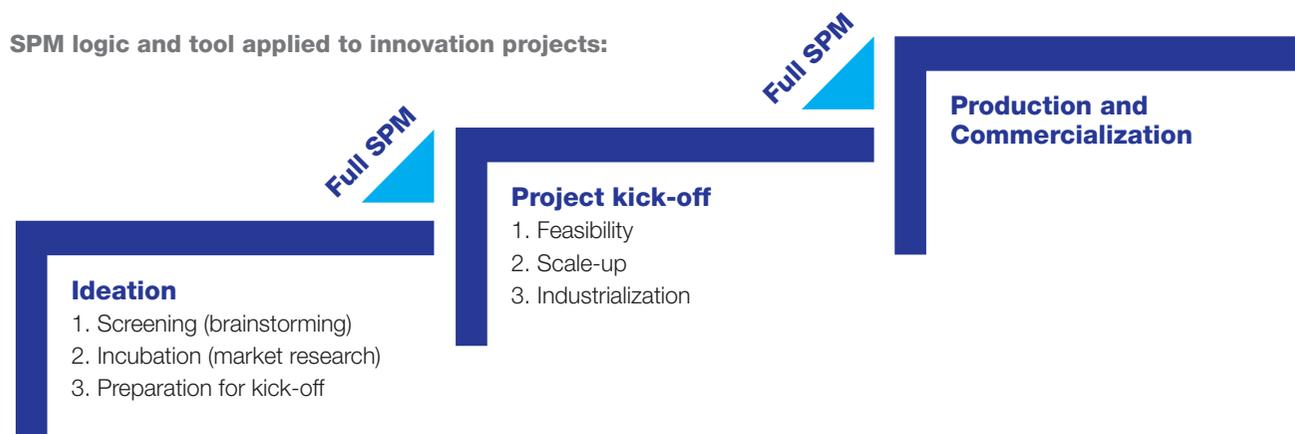
As of 2013, 100% of R&I projects are analyzed with the SPM tool. Using SPM logic, a product is analyzed in a so-called stage-gate process starting already at the ideation phase with the use of version of Fast track version of the SPM tool within each phase.

The Fast track SPM version is a list of six SPM impact indicators² assessed for the existing or reference product and the desired future target. The reference product can either be a Solvay product or a competitor's product. The executive summary of the SPM analysis is uploaded to the innovation workflow management system.

Every time a project steps into another phase, i.e. passes a gate, full SPM analysis is applied to the future product and the data is stored in the SPM Database.

The innovation pipeline is a key element in achieving the 2025 target of realizing 50% of Solvay's revenues from sustainable solutions.

SPM logic and tool applied to innovation projects:



² Climate Change, Non-renewable resource consumption, Human health, Ecosystem quality, Water management, Social impacts.

3.3 CAPITAL EXPENDITURES (CAPEX) PROJECTS

Planned CAPEX projects are also subject to SPM analysis. Different organizational levels and functions use the results of the SPM assessment depending on the value of the planned investment.

The SPM team works directly with the Business Units, the Investment Committee and the Executive Committee, providing the analysis required integrating long-term, sustainability-driven signals into investment decisions.

3.4 DUE DILIGENCE ON MERGER & ACQUISITION (M&A) PROJECTS

An M&A project will initially be evaluated with a Fast track SPM assessment to analyze the feasibility of the investment according to the Sustainable Portfolio targets and a full SPM is done as the merger progresses.

3.5 MARKETING & SALES

SPM can position sales revenue on a heat map at customer level and help identify sustainability topics. Connecting with customers on sustainability helps both differentiate and create value for Solvay and the customer and helps deliver the company's sustainable solutions target.

This approach helps the company better understand and build a dynamic vision of our customers' sustainability challenges and anticipate trends in order to continue to deliver business solutions.

3.6 SPM TOOLKIT

The SPM tool is flexible and can be adapted to the needs and maturity level of projects in the different key business processes (Strategy, R&I, CAPEX, Marketing & Sales, M&A...).

The Fast track SPM assessment can be applied to screen projects from R&I, CAPEX, Marketing... so that we ensure the sustainability dimension is taken into account at an early stage in the selection of the projects.

While the SPM Heat Map reports the 2 axes of Operations Vulnerability (vertical axis) and Market Alignment (horizontal axis) in a single matrix, those complementary assessments can be done independently showing the operational flexibility of the SPM tool in its implementation.

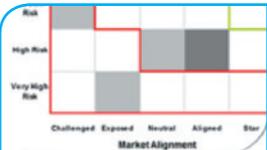
Stages of SPM and LCA:



SD scorecard

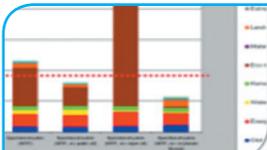
SPM Fast Track

- **Scoring** based on SD expertise and expert intuition
- **Resource requirements:** 10 products in applications: 1 hour (run by SPM team)



Full SPM

- **Thorough assessment,** auditable and fact-based (x axis: questionnaire, y axis: based on ecoprofile)
- **Resource requirements:** 10 products in applications: 1 day (run by SPM team)



Full LCA

- **Fully quantitative assessment,** auditable, full (cradle-to-grave) data needed
- **Resource requirements:** 1 product in applications: 3 months (run by LCA expert team)

The SPM toolkit and LCA approach are complementary.

When a deeper analysis is necessary, an additional full cradle-to-grave LCA can be performed for a specific product in specific applications.

This is a sound and longer lasting scientific examination that can be considered to complement the SPM assessment either to confirm environmental benefits along the full value chain or to compare to competing products/solutions in the market e.g. to benchmark better technical performance resulting in lower energy consumption or lower pollutant emissions during the use phase.

4.1 INTRODUCTION - THE PROCESS

The SPM assessment process takes place year-round and involves both Corporate Functions (Strategy, Marketing & Sales, R&I, Sustainable Development) and Business Units (Management Teams, Strategy, Marketing & Sales, R&I, Production, Business Development etc.). SPM assessments require close collaboration between the Corporate SPM Expert and the Business Unit SPM Correspondent.

The **SPM Correspondent** is typically the Marketing Strategy Manager of the Business Unit:

- They coordinate the SPM assessment with the support of the Corporate SPM team to ensure the right expertise is brought in
- Clarify expectations on both sides. Product and market experts from the Business Unit are key contributors in defining the relevant Product-Application Combinations (PACs) and in going through the process effectively.

The **Corporate SPM team** provides a comprehensive executive report of the assessment to the Business Unit management team.

The SPM Corporate Expert ensures that the results and learnings are embedded in the decision-making process and action plans of the Business Unit at the strategic and operational level.

SPM global and systematic assessment involves an evaluation of the portfolio for a given year (Y) based on the turnover of the previous year (Y-1). Changes in the business perimeter during the year are taken into account in the scope of the year (Y) SPM.

A Fast track version of the SPM tool is used to assess early-stage R&I, CAPEX, M&A, Marketing & Sales etc. projects, through simplified modules to ensure that projects are developed while integrating the sustainability dimension using SPM approach.

4.2 PREPARATION FOR THE SPM ASSESSMENT

In order to achieve the SPM tool's dual goal of being **robust and lean** in execution, thorough segmentation of products is of vital importance.

Solvay's organizational structure is built around **product lines** managed by **Global Business Units** reflecting the markets where the company operates and **not around geographical segmentation**.

In SPM, the segmentation and assessment follows the same logic so a product and application segmentation is carried out first.

For each axis of the SPM Heat Map, a segmentation analysis is done with the relevant Business Unit experts:

-  • For **Operations Vulnerability**, we work with industrial experts from the Business Units and LCA practitioners
-  • For **Market Alignment**, we work with the market experts from the Business Units

Although the segmentation and assessment is carried out by market, the risks and potential negative impact of products and applications are considered from a global point of view, not based on a geographical selection, as this could hide certain negative effects of products.

For example, if a product is banned in two OECD countries, but not in others, SPM will rank that product as Challenged in every country and not only in the countries where it is banned.

Assessment for practitioners

4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

Analyzing the business risks of sustainability

4.3.1 The Product Segmentation

In the **product segmentation**, we assume that the criteria (inventory threshold, characterization model, mid-points etc.) for establishing an ecoprofile have already been defined.

In order to define a product segment and assess its environmental impact, the following 3-step approach is undertaken at Business Unit-level:

1 Analysis of existing products and production processes (LCA perspective)

The SPM expert, the LCA expert and the Business Unit representative analyze the ecoprofiles of existing products, where one product can be manufactured in many different factories, using different raw materials, or using different energy sources etc.

The analysis looks for similarities or significant differences in the cradle-to-gate value chain processes and raw material supply, which may allow several products to be merged in the SPM analysis into the products segment.

2 Identification of differentiating factors in ecoprofiles (LCA perspective)

Ecoprofiles are compared and differentiating factors examined to determine if the differences are material enough to justify a more granular approach and therefore a separate SPM product assessment.

If the differences are material, the procedure is repeated with the next product in the family.

If the differences are not material, the procedure is repeated to check if the reference product could be integrated in a product segment at a higher level in the value chain.

3 Revenue segmentation to identify SPM products (Financial perspective)

Within the product segment, the identified revenue per product line is plotted (at the lowest level of financial reporting).

Products are selected to cover at least over 80% of the annual external revenue of the Business Unit portfolio. Potentially problematic e.g. hazardous products are added to the selection to ensure all risks are addressed. Internal sales are out of scope.



Assessment for practitioners

4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

Quantitative, monetized analysis of the potential business risk and opportunity for Solvay and products' cradle-to-gate environmental footprint.

4.3.2 The Operational Vulnerability Assessment

Operations Vulnerability calculation steps:

Step 1:
Impact Assessment

Step 2:
Impact Valuation

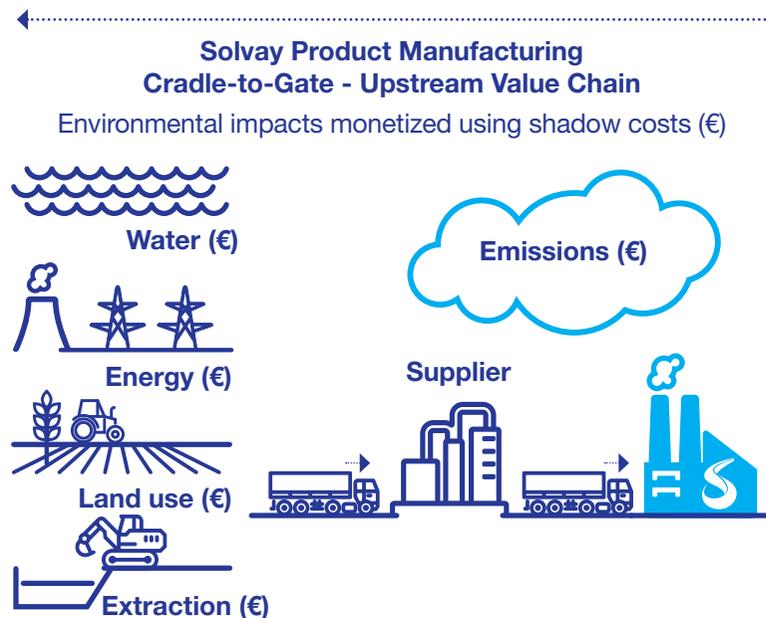
Step 3:
Operations Vulnerability

Step 1: Impact Assessment: calculation of a product's ecoprofile

We calculate a product's ecoprofile using a Life-Cycle Assessment (LCA) procedure performed by LCA practitioners in conformity with the ISO 14040 and ISO14044 standards using publicly-available and Solvay-specific scientific data.

This allows us to create an inventory of all the environmental impacts of a product (resource consumption, emissions to soil, air and water) including human toxicity in a 'cradle-to-gate' approach, from raw material extraction to production until it leaves Solvay's premises.

Cradle-to-gate scope of the ecoprofile:



4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

4.3.2 The Operational Vulnerability Assessment



The impact assessment element of the Operations Vulnerability calculation:

Step 1:
Impact Assessment

Material & Emission
Inventory (kg)



Impact Equivalents
(equivalent/kg)



Impact
(equivalent)

LCA practitioners calculate the environmental footprint of one kilogram of product. This includes:

1. Establishing a Life Cycle Inventory (LCI) of substances exchanged with nature (withdrawals and emissions), as well as of land surfaces transformed and occupied for the production of one kilogram of product.
2. Classifying and characterizing the impacts into 19 impact indicators, depending on the specific features of the substances. For emissions, the physical, chemical and toxic characteristics are considered, for resources, energy content as well as depletion rate are considered. This classification is done by applying the corresponding impact characterization methods.

The characterization method proposes - for each substance i involved in the impact j - a characterization factor $CF_{i,j}$ to express the intensity of the contribution of substance i to impact j , compared to a reference substance impact j .

$$CF_{i,j} = \frac{Impact_{i,j}}{Impact_{ref,j}} \left(\text{in } \frac{kg \text{ ref}_{eq.}}{kg \text{ i}} \right)$$

3. Third, for each impact j , summing up the contributions of all involved substances:

$Impact_j = \sum_i CF_{i,j} \times m_i$; m_i mass of substance i emitted by the considered system

The computation of the environmental footprint of product manufacturing can be summarized as follows:

The 19 indicators of environmental impact – also called mid-points – take into account inputs and outputs in the form of emissions to soil, air and water, as well as energy consumption and human toxicity (see table below for a list of indicators and their description). See Annex 1.1 p 47 for the detailed list.

For most of the ecoprofiles, the quality is estimated by an LCA expert mixing completeness of primary data input, complexity to access robust secondary data, ease to build the proxies, age of the data versus relevance of the technology,...The quality is defined on a 5-level scale: Very Good, Good, Fair, Poor, Very Poor. In the framework of SPM analysis, the quality level of the ecoprofile is not a critical parameter but needs to be defined according to the criticality of the SPM position on the vertical axis. Nevertheless, in order to ensure a consistency across SPM assessments, the minimum quality level recommended for the ecoprofile is “Fair”.

Solvay considers an ecoprofile valid as long as the production technology, including the effluent treatment, utility management and emissions control remain unchanged. If no change, an ecoprofile should then be revised about every 10 years.

As today, LCA experts use LCA software Simapro to calculate the ecoprofile for SPM assessment purposes. Simapro relies on existing databases: Ecoinvent V2 and V3, ELCD, Agrifootprint, Industry data 2.0.

The ecoprofile of a product is reported in a table and the data is stored in specific software used by the expert team and also in Solvay's SPM Database. For a sample of an ecoprofile reporting table, see Annex 1.2 p49.

4.3 OPERATIONS VULNERABILITY THE VERTICAL AXIS

Step 2: Impact Valuation: monetization of negative impacts

Impact Valuation assigns a monetary value to very different impact measurement categories following the 'polluter pays' principle. Such monetization outlines the financial cost for Solvay if the externalities had to be paid based on the shadow costs calculation.

4.3.2 The Operational Vulnerability Assessment



A **shadow cost** is an estimation of the 'cost for the planet', a theoretical monetization (in euro) of each environmental impact (scientifically called mid-point) of the ecoprofile in order to consolidate and compare them. Monetization can be seen as the cost for society at large, which no-one is currently bearing. The shadow cost is calculated based on what it would take to prevent environmental or human toxicity damage (avoidance cost route) or to remediate the damage caused (repair cost route). A range of values is defined for both routes and each ecoprofile indicator for the year 2020, resulting in an average, a minimum and a maximum value to be used in sensitivity analysis. Detailed examples of how we define shadow costs are included in the Annex 1.3 p50.

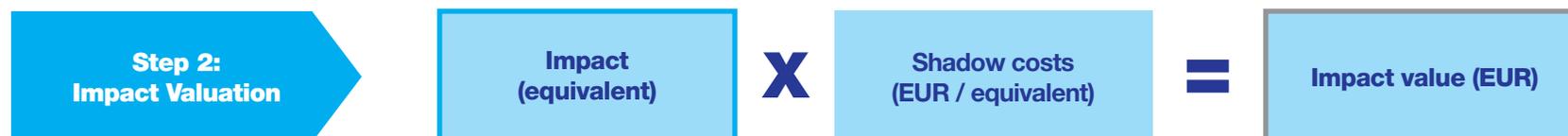
Shadow costs are not yet available in standardized databases for all environmental impacts so Solvay and the consultancies supporting the development of the SPM tool had to find and reference authoritative research and sometimes make in-house analysis and decisions on monetary figures. For Solvay, the shadow costs estimation should not be considered as an objective as such but as a tool to integrate the environmental costs in business decisions, to reflect on how to reduce them for existing products or minimize them at an early stage for new product development projects. This is why the option was taken to keep the shadow costs for 5 to 10 years for comparison purpose to measure the progress versus the initial assessment. In addition this does not prevent to use minimum, maximum value or other databases value to carry out a sensitivity analysis of the business model.

The time horizon used in the SPM methodology is 10 years – currently to 2020 – with a revision of the data planned every 2-3 years.

Calculation

Once **impact equivalents** have been determined, we multiply them by the shadow costs to arrive at the monetized value of external environmental impact per kg of product:

The Impact Valuation element of the Operations Vulnerability calculation:



Finally, we add the **monetized impact values** to the product's ecoprofile for each impact category, adding the value of all categories to give the total external environmental impact value for one kg of a product.

4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

4.3.2 The Operational
Vulnerability Assessment

Monetized ecoprofile of a Solvay product:

Impact Category	Element	per kg of product	Unit	External costs (in €/kg)
Climate change	GWP 100a	1,90	kg CO ₂ eq.	0,14
Climate change	Biogenic CO ₂ Emissions	-0,68	kg CO ₂ eq.	-0,05
Human Toxicity	Human Toxicity [HTP]	0,89	kg 1,4-DCB eq.	0,07
Ecotoxicity	Freshwater Aquatic Ecotoxicity [FAETP]	1,20	kg 1,4-DCB eq.	0,05
Ecotoxicity	Maritim Ecotoxicity [MAETP]	680,00	kg 1,4-DCB eq.	0,01
Ecotoxicity	Terrestrial Ecotoxicity [TETP]	0,39	kg 1,4-DCB eq.	0,50
Water	Water	0,17	m ³	0,17
Energy	Renewable Energy Resources [Renewable]	24,00	MJ	0,00
Energy	Primary Forest Energy [Primary Forest]	2,60	MJ	0,00
Energy	Nuclear Energy [Uranium]	3,20	MJ	0,00
Energy	Coal Energy [Coal]	4,70	MJ	0,02
Energy	Crude Oil Energy [Oil]	8,20	MJ	0,15
Energy	Natural Gas Energy [Gas]	9,00	MJ	0,07
Abiotic Depletion	Depletion of abiotic resources	0,011	kg Sb eq.	0,00
Land Use	Quantitative Land Use [Land Use]	0,69	m ² y	0,06
Acidification	Acidification	0,0088	kg SO ₂ -eq.	0,04
Eutrophication	Eutrophication	0,011	kg PO ₄ -eq.	0,10
Ozone Depletion	Ozone Depletion	0,00000036	kg CFC-11 eq.	0,00
Photochemical Oxidation	Photochemical Oxidation	0,0021	kg ethylene eq.	0,00
Total of external costs (in €/kg)				1,33

4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

4.3.2 The Operational Vulnerability Assessment



Step 3: Operations Vulnerability calculation: financial risk of negative impacts (externalities)

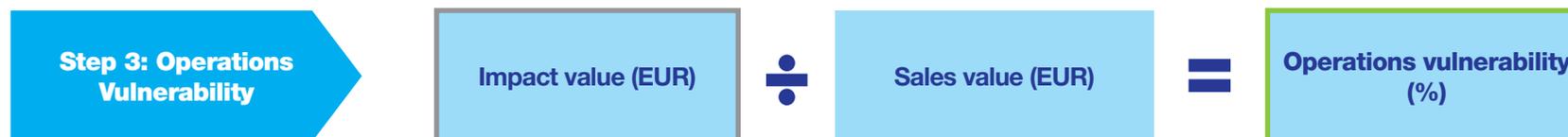
The Risk of losing business or the opportunity to gain additional business depends on the balance between the economic value and the environmental damage created. The absolute financial value of the potential impacts of one kg of product is not sufficient to inform the decision-maker. This is why the implications of the financial impacts are calculated by dividing the value of the impacts by the sales value of the product. The result is the Operations Vulnerability ratio expressed as a percentage which can range from 2% to over 200% of the sales value of the product.

While monetization of the environmental footprint brings sustainability considerations closer to decision-makers, to ensure the externalities are taken into consideration in strategic and operational decisions, our products' environmental footprints are compared to the value added of our activities.

The best approximation of this comparison is to use the products' sales price against the monetized environmental footprint of the products. The calculation is a simple division of the Impact Value expressed in EUR and the annual average of the product sales value (to mitigate the impact of price fluctuations). This gives the **Operations Vulnerability** rate. The higher the rate, the higher the sustainability risk of the particular product. The lower the ratio, the higher the opportunity to displace a less environmentally-friendly competing product.

On the one hand, the rate compares the environmental footprint to the value added to society at large. The best approximation of the latter is the sales price offered on the market. On the other hand, the rate also expresses how risky environmental footprints can be if buyers on the market are looking for intermediary products with a low environmental footprint. **Operations Vulnerability** expresses whether a product presents a long-term risk or opportunity in sustainability-oriented markets.

Operations Vulnerability calculation

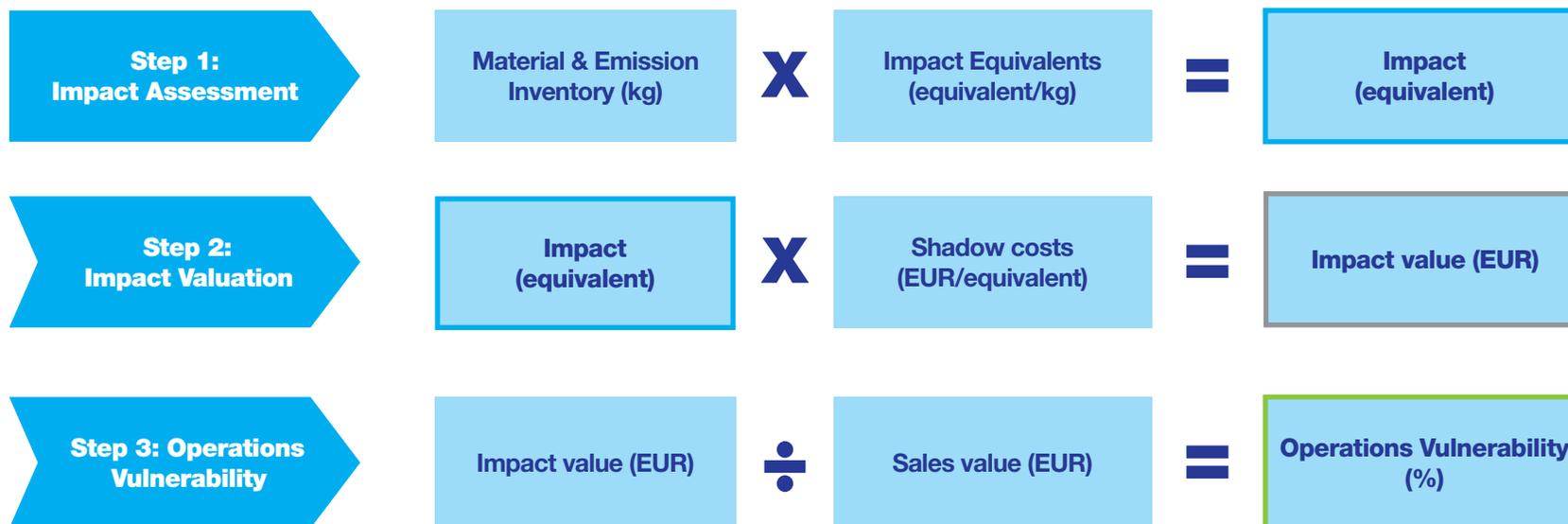


4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

4.3.2 The Operational Vulnerability Assessment

This concludes the 3-step Operations Vulnerability calculation process, which we summarize below.

3-step process of Operations Vulnerability calculation:

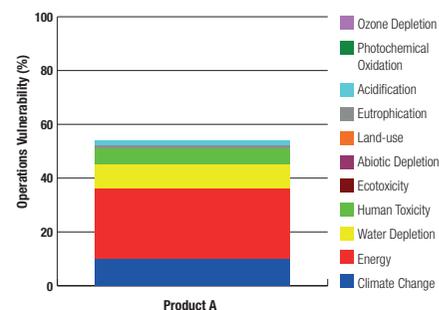


Assessment for practitioners

4.3 OPERATIONS VULNERABILITY - THE VERTICAL AXIS

4.3.2 The Operational Vulnerability Assessment

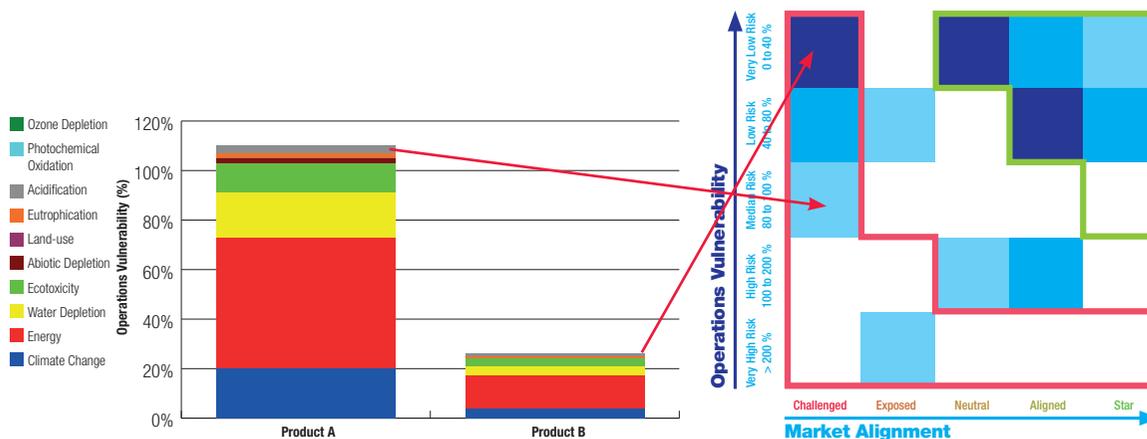
The **Operations Vulnerability** of a product is represented on a chart, detailing the monetized contribution of each impact category. Note that the ratio can be higher than 100% **if the cost of impacts exceeds the sales value**. The same presentation can be built for a group of products (e.g.: BU's portfolio), aggregated according to their turnover.



Operations Vulnerability broken down into impact categories



Operations Vulnerability is projected on the vertical axis of the SPM Heat Map:



Advantages of Operations Vulnerability approach:

- Quantitative
- Analyzes one product in one application over one fiscal year
- Scientific Life-Cycle Assessment based on ISO standards
- Cradle-to-gate to ensure feasibility of calculations and reasonable leverage
- Comprehensive: takes into consideration air, water, soil emissions, human toxicity and energy consumption
- Monetization based on authoritative academic sources
- Auditable
- LCA-expert review

Assessment for practitioners

4.4 MARKET ALIGNMENT - THE HORIZONTAL AXIS

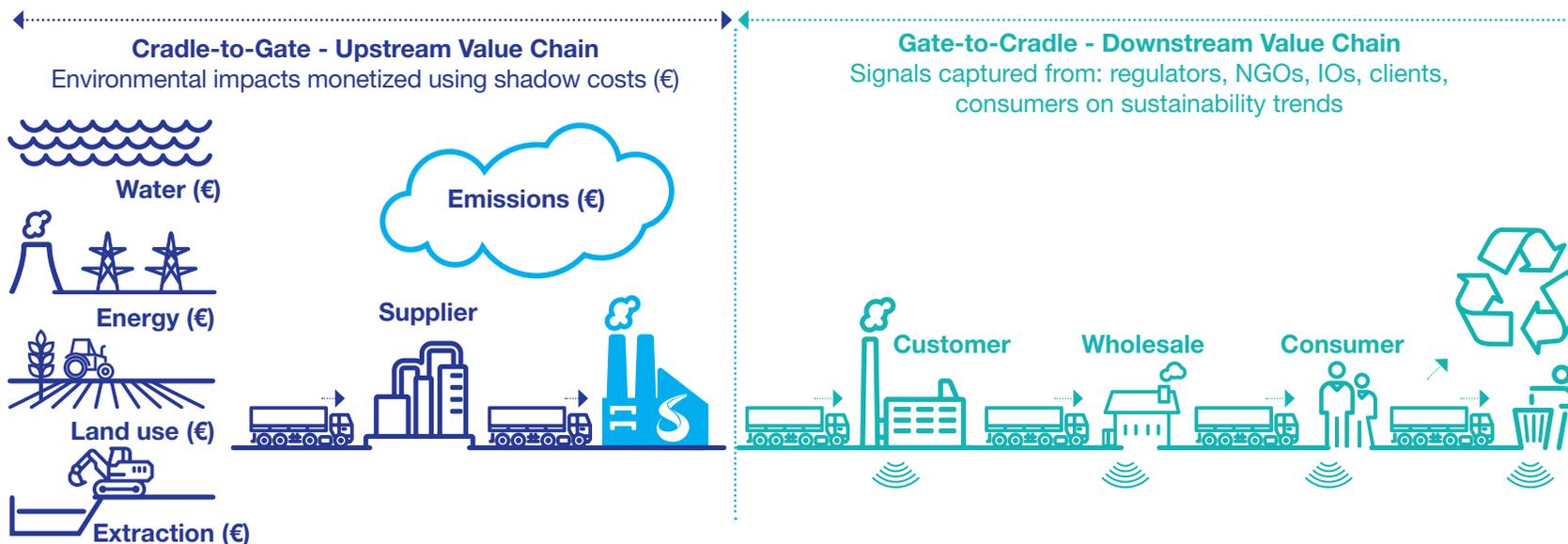
Qualitative, evidence-based collection of sustainability-related market signals

Consumers and value chain stakeholders (manufacturers, wholesale, retail) are putting ever more emphasis on sustainability. In order to understand the risks and opportunities arising from the value chain, the right signals have to be captured from different stakeholders.

Benchmarking against our peers, companies like AkzoNobel, BASF, Clariant and DSM, has shown that a qualitative or semi-quantitative analysis is best adapted to interpret market signals³. Furthermore, full cradle-to-cradle Life-Cycle Assessment is not material for Solvay as it is limited to environmental impact assessment, while our analysis also addresses social issues such as healthcare, ageing population or healthy living.

Detecting early signals in market allows us to act in a timely fashion and make the necessary changes in the portfolio by anticipating the future of a product in its application in terms of environmental, health, economic and social sustainability.

The scope of the market alignment analysis is cradle-to-cradle:



³ Our benchmark shows that quantitative, e.g. monetized, analysis of impacts occurring in the entire value chain would take too long and be too costly and not be practical for application in a fast-paced strategic corporate decision-making environment.

4.4 MARKET ALIGNMENT - THE HORIZONTAL AXIS

Solvay's products are not sold direct to the consumer but consumers' purchasing decisions impact our business. It helps us to understand the applications for our products and their potential to reduce consumers' environmental footprint. The Solvay leadership internalized this trend and set the ambitious goal that by 2025, 50% of revenue should be generated by sustainable solutions.

In order to define the right application segment to focus on, the following steps are taken at Business Unit-level and per product segment:



a) For a product processed or used in the downstream value chain, close to the consumer, we look at internal commercial reporting (at financial consolidation level) with a market expert from the relevant Business Unit.

b) For products processed or used higher up the downstream value chain, further from the consumer, we use market reports from authoritative sources to identify market/application segmentation.

The application level derived from both previous steps, a) or b), is unlikely to mirror sustainability drivers in the market and further segmentation is required, based on expert considerations.

For a product segment, applications accounting for more than 80% of annual external revenue are selected, and possibly problematic products (e.g. products blacklisted in the downstream value chain) are added to the selection.

Application segmentation is done from a global point of view. Further application segmentation according to regional characteristics is only acceptable when there are positive market signals for Solvay which may increase the relevance of the solutions in the market.

However regional segmentation should not be used for negative signals as global regulation or corporate rules generally supersede the regional approach. For the regional approach, we are guided by the World Business Council for Sustainable Development (WBCSD) approach.

4.4.2 Product Application Combination (PAC)



4.4 MARKET ALIGNMENT - THE HORIZONTAL AXIS

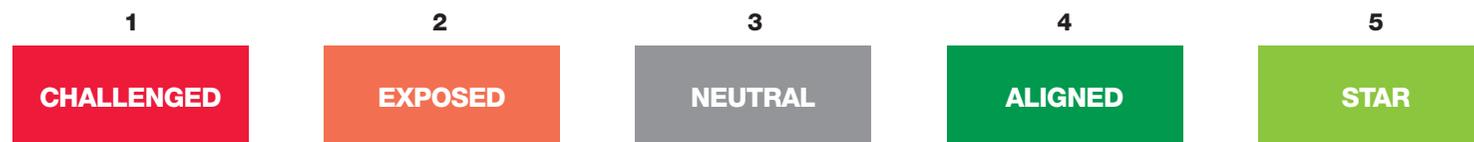
We analyze products in their end-user applications, based on Product-Application Combinations (PACs). One product may have several PACs.

4.4.2 Product Application Combination (PAC)

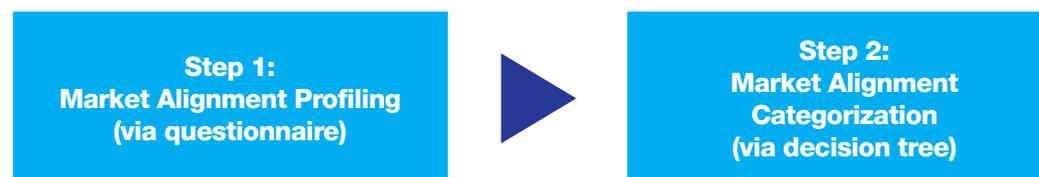


- 1) **Market Alignment Profiling:** Identifying sustainability signals for each PAC by answering the 60-question questionnaire on environmental and social issues to collect information on obstacles, concerns, benefits, high-growth (Star) potential and amplifiers.
- 2) **Market Alignment Categorization:** The information gathered is applied to a decision tree which positions the product on a 1-5 scale as Challenged (1), Exposed (2), Neutral (3), Aligned (4), Star (5). This category is then added to the SPM Heat Map.
- 3) We look for positive and negative sustainability signals on the **Product Application Combinations (PACs)** taking the entire value chain into consideration in a 'cradle-to-grave' approach, from raw material extraction through product use and disposal, or even taking a 'cradle-to-cradle' when the product is recycled at the end of life.

Market Alignment categories:



Market Alignment analysis steps:



4.4 MARKET ALIGNMENT - THE HORIZONTAL AXIS

The Market Alignment questionnaire mirrors sustainability market trends which can act in favor of or against the demand for Solvay products. It is the lens through which the SPM experts assess a PAC.

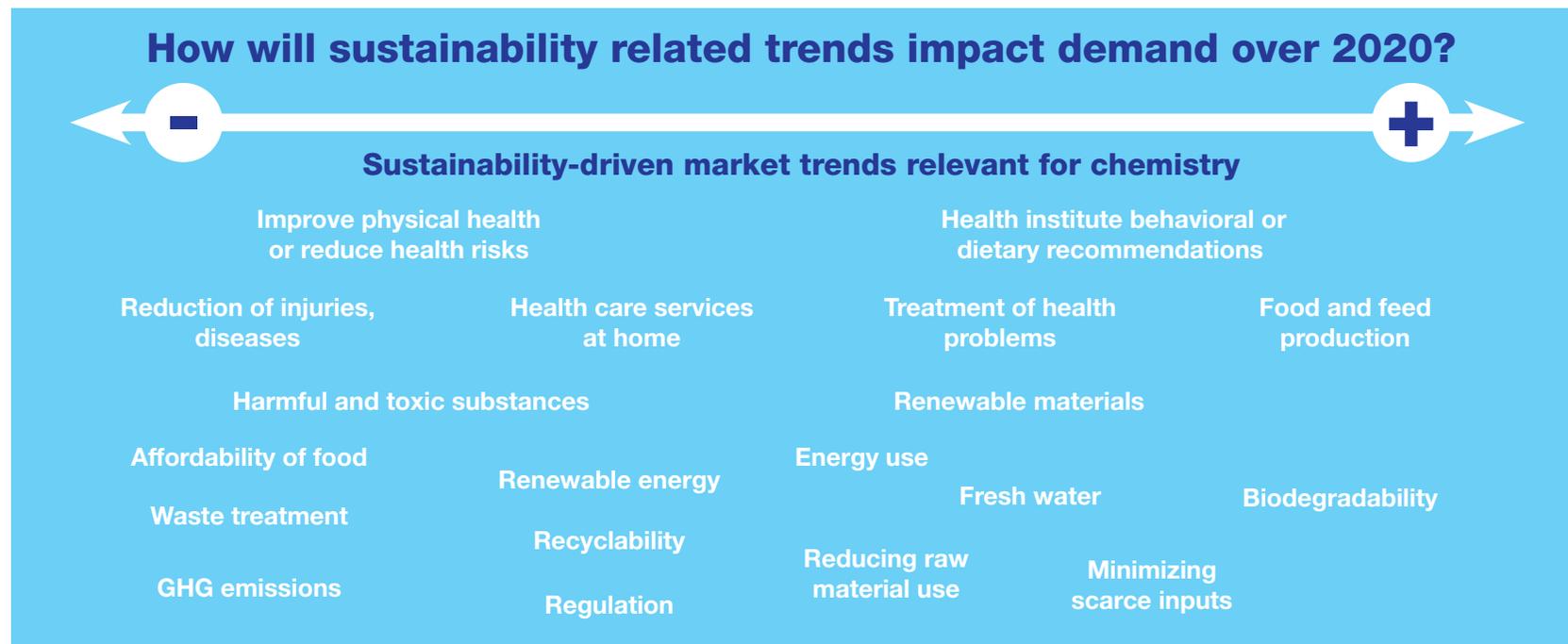
The list of sustainability trends linked to the decision-making layers of the SPM lens was established in 2009 in cooperation with Arthur D. Little and Dutch research organization TNO. Studies from eleven of the most reputed institutes⁴ were consulted to map the most material potential sustainability impacts in the chemical industry.

The Market Alignment questionnaire formulates 60 questions assessing the applicability of each trend to a specific product in its application.

Questions are grouped in four 'families' which are addressed in the decision tree later on (Star Potential, Benefits, Obstacles, Concerns). An additional set of questions on negative and positive 'Amplifiers' were added to benchmark PACs against competitors and fine-tune the positioning in the final SPM report.

This analysis resulted in a list of sustainability trends which were categorized according to their potential impact on product demand (see Figure below).

Sustainability-driven market trends assessed by Arthur D. Little and TNO:



⁴ Rocky Mountain Institute, Worldwatch Institute, WWF, Greenpeace, United Nations Environment Programme, Wuppertal Institute, World Business Council for Sustainable Development, International Institute for Sustainable Development, London School of Economics, Sierra Club and Öko Institut.

4.4 MARKET ALIGNMENT - THE HORIZONTAL AXIS

The Market Alignment questionnaire formulates 60 questions assessing the applicability of each trend to a specific product in its application. Questions are grouped in four ‘families’ which are addressed in the decision tree later on (Star Potential, Benefits, Obstacles, Concerns). An additional set of questions on negative and positive ‘Amplifiers’ were added to benchmark PACs against competitors and fine-tune the positioning in the final SPM report.

4.4.3 Market alignment questionnaire and categorization



Market Alignment question families:

Question families	Description	Used in decision tree	Benchmark Used
Star Potential	Is double-digit growth driven by sustainability anticipated?	YES	Turnover forecast
Benefit	Does the product help consumers or any stakeholder in the downstream value chain to directly, significantly and measurably address their own sustainability needs or challenges?	YES	Stakeholder expectations
Obstacle	Is there a strong negative sustainability-related signal (national customer ban, scientific results on toxicity etc.)?	YES	Stakeholder expectations
Concern	Is there a weak negative sustainability-related signal (toxicity, less widespread ban, buyer signals etc.)?	YES	Stakeholder expectations
Amplifier	Are there other positive or negative signals with lower influence (comparison in impacts to competitive alternatives, regulations, subsidies and ecolabels, NGO scrutiny etc.)?	NO – fine-tunes positioning within the 5 categories	Competitor/stakeholder expectations

Questions are formulated simply, e.g. for a question on a PAC’s energy efficiency benefit:

‘Does <product> in <application> (help consumers or stakeholders in the downstream value chain to) directly, measurably and significantly reduce energy consumption?’

An *obstacle*-type question on a product ban is strict:

‘Is (<product> in) <application> banned or restricted for use in the application by 2 OECD countries or by 2 key stakeholders in the downstream value chain or application by 2 health institutes on behavioral or dietary recommendations?’

A *concern* of the same category is less strict:

‘Is (<product> in) <application> banned or restricted for use by 1 OECD country or by 1 key stakeholder in downstream value chain or 1 health institute?’

The corresponding *amplifier* will compare energy efficiency potential to that of a competing product:

‘From the standpoint of energy efficiency, from cradle-to-grave, and in comparison with its next best comparably-priced alternatives, the <product> in <application> is anticipated to lead to: [less/more/equal energy efficiency]?’

The full list of market alignment questions is in the Annex 1.4 p51.

Assessment for practitioners

4.4 MARKET ALIGNMENT - THE HORIZONTAL AXIS

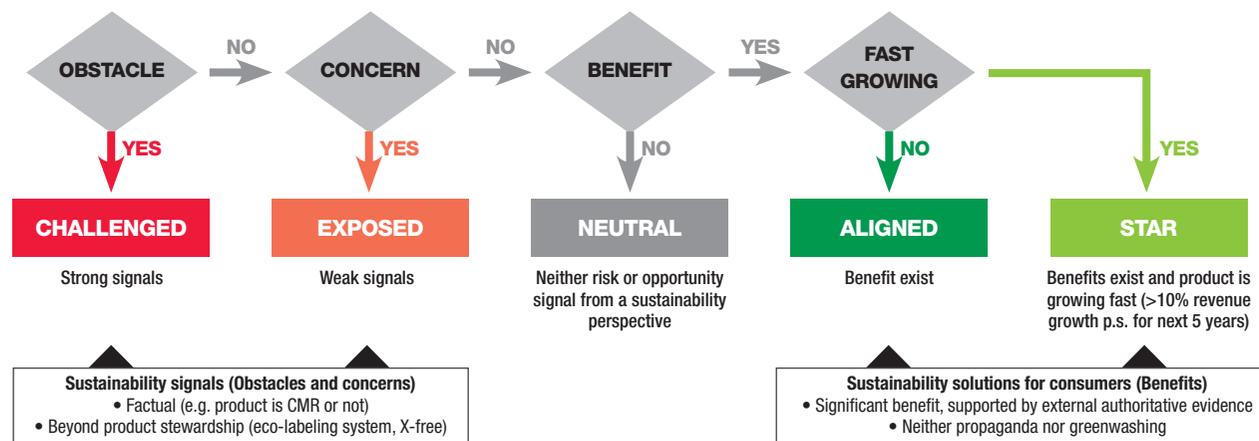
Market Alignment Categorization

The decision tree guides the SPM expert in plotting the PAC on the horizontal axis of the SPM Heat Map, based on the answers collected to the questions in the market alignment questionnaire. One 'Yes' or 'No' answer is sufficient to move to the next stage in the decision tree. As explained in the Product Segmentation sub-chapter above, Solvay does not compromise on negative signals. If an obstacle is identified then the product is classed as **Challenged** or if a concern is found it will be classed as **Exposed**.

4.4.3 Market alignment questionnaire and categorization



Market Alignment decision tree in detail:



Market alignment categories can be summarized as follows:

- **Challenged:** PAC with strong negative signals resulting from sustainability drivers in the marketplace. These are products whose revenue could experience a significant negative impact and eventually disappear.
- **Exposed:** PAC with weak negative sustainability signals. These are products which might be negatively impact or have difficulty growing due to sustainability drivers.
- **Neutral:** PAC with neither positive nor negative signals resulting from sustainability drivers in the marketplace. These are products that consumers need but which do not contribute to environmental footprint reductions.

- **Aligned:** PAC with positive sustainability signals where the revenue is expected to grow moderately from sustainability drivers, but where the growth is curbed by competing solutions from the existing market leader. These are products that customers want to buy because they contribute to decreasing their own environmental footprint.
- **Star:** PAC with positive sustainability signals, with revenue expected to grow substantially from sustainability (double-digit growth). The PAC comes from a fast-growing sustainability-driven market e.g. wind energy and where the Solvay product outperforms the leading alternative.

Once the product's **Market Alignment** category is defined, 'Amplifier' questions on benefits and drawbacks help position the PAC. This set of questions is a good instrument to cross-check answers to other questions and drive ecodesign. The SPM team assesses the signals for each PAC with the related businesses.

Any answer must be agreed between the Business Unit and the SPM expert to ensure both 'business knowledge' and 'methodological integrity' are taken into consideration. In case of disagreement between the business representative and the SPM Expert, the answer of the business is recorded, with a comment explaining the different point of view of the SPM Expert.

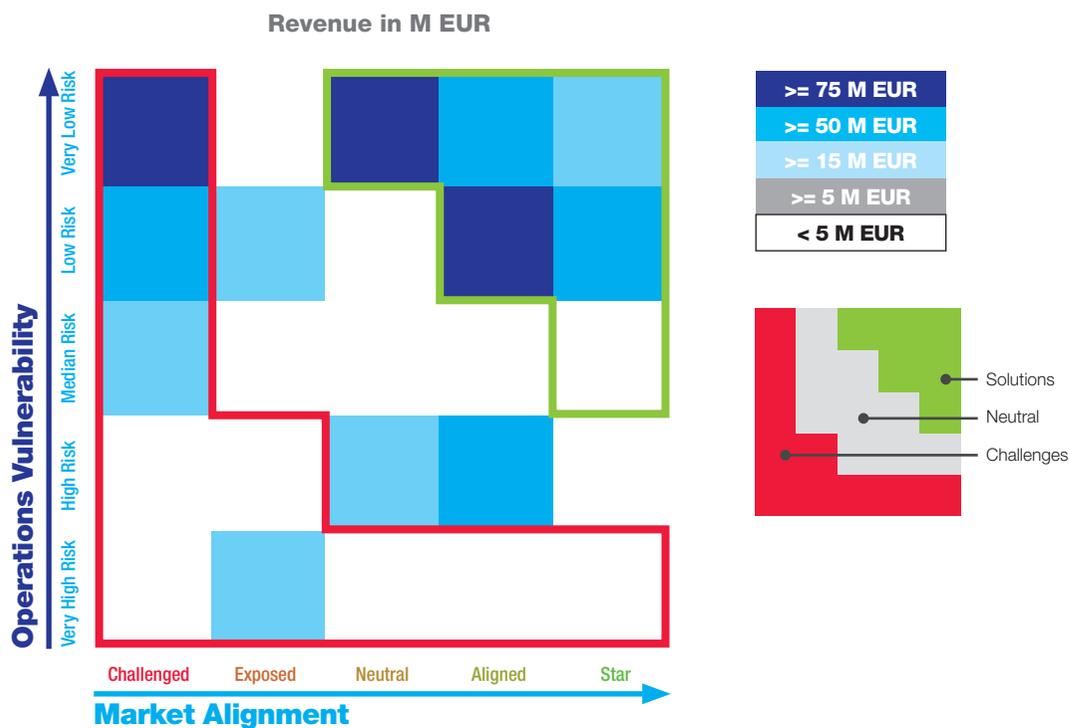
4.5 MAPPING OUT RESULTS – SPM HEAT MAP

In the SPM assessment, the process is as important as the output, e.g. mapping results for selected products' Operations Vulnerability and for selected PACs' Market Alignment. The process helps sensitize business experts to the importance of sustainability in marketing and the results allow senior executives to make strategic decisions on a portfolio level, while practitioners identify improvement areas related to single products.

The SPM Heat Map

The single most important output of the assessment is the SPM Heat Map, which shows business risks related to environmental footprint and sustainability-related market opportunities or challenges through the lens of Solvay's turnover.

The SPM Heat Map:



The heat map is the highest-level portfolio steering instrument of the SPM assessment. It categorizes products and PACs in three higher level categories

- **Solutions:** PACs with an **outstanding sustainability contribution** to Solvay customers and value chain, combined with a favorable balance between value and environmental impact.
- **Neutral:** PACs which do **not have outstanding sustainability performance**, if any. Low Operations Vulnerability is not combined with favorable sustainability drivers in the marketplace. These are products that consumers need, but which do not contribute to environmental footprint reductions.
- **Challenges:** PACs for which there are **either strong negative signals** resulting from sustainability drivers in the marketplace, **or serious operations vulnerability challenges**. These are products where there may be a significant negative impact on revenue over time and where products may eventually disappear.



4.5 MAPPING OUT RESULTS - SPM HEAT MAP

The SPM Heat Map is a pragmatic benchmarking tool which constantly evaluates a group of PACs to represent market-related sustainability risks and opportunities in a single matrix. It supports decision-making on a strategic portfolio level. It identifies challenges and spurs action.



“We have designed SPM to be as ‘light’ as possible for Business Unit Managers to use. It is meant to be a tool to help managers think about and discuss the sustainability context. It is not a reporting tool but it aims to visualize sustainability issues in a rigorous and systematic way. The value of SPM is to ensure that sustainability becomes an integral part of the business planning process and that management is able to quantify the choices made.”

Dominique Debecker

Sustainable Portfolio Management, Project Manager, Solvay

The SPM tool is flexible depending on the organizational and functional level using it within the company.

The **GBU Management Committee** will use it to map the entire GBU for strategic review. Furthermore, in particular cases, for example a special homecare product line, the matrix can forecast sales in that segment.

It can also be used by **key account managers** to show clients the differentiating sustainability factor a Solvay product can bring to their product. In short, SPM can be adapted to the scope of the discussions it needs to inform.

Nonetheless, Business Unit (BU) directors and managers use other representations of the SPM results to help them identify areas for improvement in a product’s environmental footprint. Such representations are for example, stack charts on the SPM-related evolution of the Business Units (BUs) over time, financial bridge charts on BUs or PACs which need explanation (where year-on-year changes in certain areas are significant) or stack charts on the positioning of products within a GBU according to a monetized environmental footprint compared to unit sales value (EUR/kg) etc.

Such representations help cascade SPM thinking to the strategic and operational level of the Business Unit.

5.1 SODIUM CARBONATE IN DOUBLE GLAZING – IMPROVING INSULATION AND ENERGY EFFICIENCY

Introduction

Solvay is a global leader of Soda Solvay® anhydrous sodium carbonate production using two different processes: the traditional Solvay ammonia process and the refining of a primary source of Sodium Carbonate, the Trona. The production of Sodium Carbonate has grown continuously to address population growth and increased purchasing power challenges. Sodium Carbonate is used mainly by the glass and detergent industries. Soda ash is another name used by the industry to name Sodium Carbonate.

Product Segmentation

Sodium Carbonate is produced by different factories and processes. From an LCA perspective these factories and processes use different energy levels and sources (coal or natural gas or oil) which means they will have a different environmental impact.

From an SPM perspective, it is important to segment products with almost similar impacts into one SPM product assessment and differentiate those that have significantly different impacts into separate SPM product assessments.

In the case of Sodium Carbonate, a synthetic dense sodium carbonate differs from a natural Trona-process sodium carbonate which uses naturally-extracted Sodium Carbonate that halves overall impact compared to the synthetic sodium carbonate. Therefore, SPM will require two separate impact assessments.

Impact assessment

1 kg of Sodium Carbonate has a cradle-to-gate impact of 1.1 kg of CO₂ equivalent (based on European Soda Ash Producers Association

2016 figure), 655 kg of 1.4 DCB equivalent (regarding human and ecotoxicity), 15 MJ of energy consumption (coal, gas, oil), 0.07 kg of SO₂ equivalent (acidification) and 0.02 m³ of water consumption.

Impact Valuation

Sodium Carbonate's potential externality costs amount to 0.31 EUR/kg with Global Warming Potential, human toxicity, acidification potential, water consumption and eutrophication potential making up 88% of the total cost.

Operations Vulnerability

Sodium Carbonate's Operations Vulnerability analysis shows that its production has potential externality costs in the order of 0.31 EUR/kg with Global Warming Potential, human toxicity, acidification potential, water consumption and eutrophication potential making up 88% of the total shadow cost. Compared to the revenue of this product segment, this result amounts to a 'High' Operations Vulnerability risk.

Application Segmentation

Sodium Carbonate is used in the manufacturing of the most prevalent type of glass (90% of glass), soda-lime glass, which is relatively inexpensive, chemically-stable, reasonably hard and extremely workable. Soda-lime glass can be resoftened and remelted numerous times, so is also the best choice for glass recycling.

Further downstream the value chain, glass can appear in many different applications, i.e. consumer products (flat glass in mirrors, windows with a clear trend to double/triple glazing, glass in photovoltaic panels etc.).

5.1 SODIUM CARBONATE IN DOUBLE GLAZING – IMPROVING INSULATION AND ENERGY EFFICIENCY

If we do not know the sales breakdown of our product among further downstream applications, market studies as the IHS Chemical Economic Handbook are used.

Market Alignment

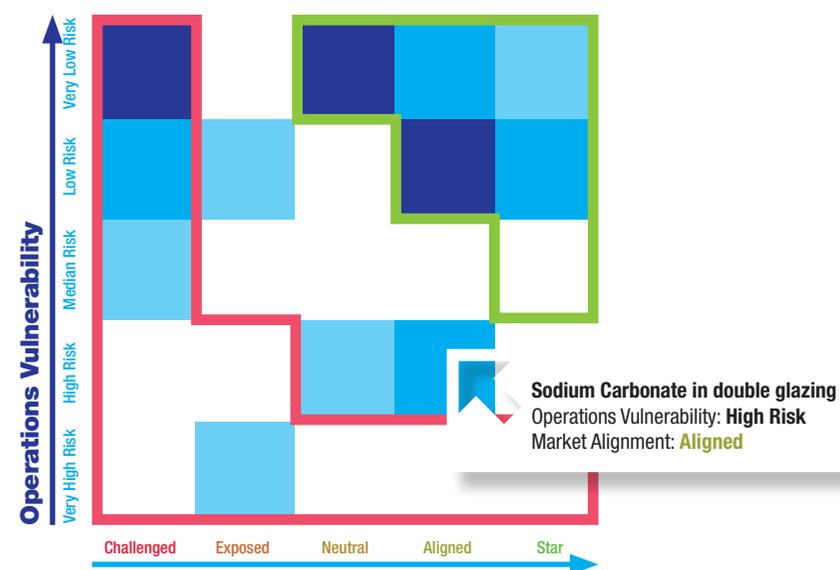
Sodium Carbonate massively reduces the energy required to melt glass by lowering the melting point from 1723°C down to 850°C.

In addition, the highest positive impact of glass is in insulation, which can contribute significantly to lowering consumers' energy consumption and therefore their CO₂ emissions. From this perspective, flat glass for windows is the main application of Sodium Carbonate.

SPM evaluates Sodium Carbonate in three applications: in single glazing windows, double glazing windows and triple or more glazing windows.

The use of Sodium Carbonate halves the energy need in glass manufacturing and the glass itself saves energy in housing. Until it is recycled, the emissions of millions of tons of CO₂ will have been avoided during the lifetime of double and triple glazing windows (source: TNO-034-DTM-2009-01990 by TNO Built Environment and Geosciences, Delft, The Netherlands. "...More than 100 million tons of CO₂ could be avoided annually if all Europe's buildings were fitted with advanced energy-saving glass").

The Market Alignment analysis shows that soda ash has no market-level obstructions or concerns and it has a very solid energy efficiency benefit that differentiates it from competing products. However, the installation of double glazing, even if not yet the norm everywhere, is not increasing very rapidly. Soda ash is therefore categorized as 'Aligned' in Market Alignment.



Soda Ash positioning in SPM Heat Map

On the SPM Heat Map, Sodium Carbonate will be positioned in the 'Neutral' quadrant of the matrix and even if it does not directly contribute to Solvay's 2025 goal, it remains an important sustainable and revenue-generating product.

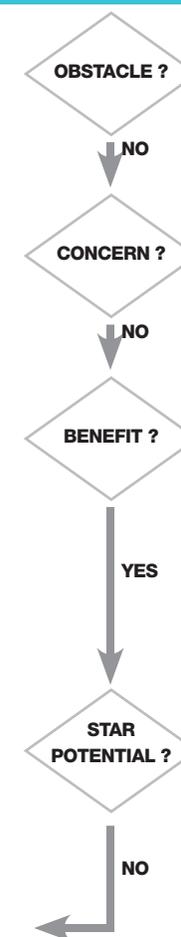
As of today, associated benefits linked to the use of Sodium Carbonate are not taken into consideration on the Operations Vulnerability vertical axis.

5.1 SODIUM CARBONATE IN DOUBLE GLAZING – IMPROVING INSULATION AND ENERGY EFFICIENCY

QUESTIONNAIRE

DECISION TREE

Obstacles	None
Concerns	None
Benefits	
Energy Efficiency	
Question:	Does Sodium Carbonate in double window glazing (help consumers or actors in the downstream value chain to) directly, measurably and significantly reduce energy consumption?
Answer:	<p>"YES To reduce the melting point of silica, it is necessary to add a flux; this is the purpose of Sodium Carbonate (soda ash), which makes available the fluxing agent sodium oxide. By adding about 25 percent of sodium oxide to silica, the melting point is reduced from 1,723 to 850°C.</p> <p>Evidences: Rapport of US Environmental Protection Agency (page 54): http://www.energystar.gov/ia/business/industry/Glass-Guide.pdf Encyclopedia Britannica : http://www.britannica.com/technology/glass</p> <p>Other benefit in the final application: Increased glazing thickness in windows, especially for double glazing, leads to better insulation performance, which in turn decreases energy use. Reference: http://archive.defra.gov.uk/environment/business/products/roadmaps/documents/windows0909.pdf</p>
Star Potential	
Sustainable Star	
Question:	<p>"Is the revenue of Sodium Carbonate in double window glazing anticipated to experience 10% growth or more per year, in average, in the next 5 years thanks to:</p> <ol style="list-style-type: none"> Better sustainability profile than the leading solutions in the market segment Serving a fast-growing market segment because of favorable sustainability megatrends?"
Answer:	<p>"NO Market definition: Materials used for windows Identified market leader: Glass is the most common solution for windows and other constructions Since glass is the market leader, sales are not anticipated to be accelerated. Its market share is already high and is not expected to grow faster than GDP. Flat glass is the most commonly used type of glass for the application windows. Global demand for flat glass will rise 5.5 percent annually through 2012, spurred by a healthy building construction environment and rapid growth in newer flat glass technologies. Conclusion: Sodium Carbonate in flat glass for windows is not considered to be a Sustainability Star PAC References: http://www.freedoniagroup.com/World-Flat-Glass.html</p>
SPM Category	ALIGNED



5.2 OPTALYS® IN GASOLINE DEPOLLUTION

Introduction

OPTALYS® performance materials help make the world a cleaner and healthier place by boosting the performance of automotive catalytic converters, minimizing emissions of gaseous pollutants from an ever-growing number of vehicles.

Vehicles are major contributors to air pollution. The largest part of combustion gas is neither toxic nor noxious: Nitrogen (N₂), water vapor (H₂O), and carbon dioxide (CO₂) although the latter contributes to global warming. A relatively small (but still too high) part of combustion gas (about 1%) is noxious or toxic: Carbon monoxide (CO), unburnt Hydrocarbons (HC), Nitrogen oxides (NOx) and Particulate Matter.

Solvay's OPTALYS® products comprise Cerium (a rare earth element) and Zirconium oxides which enhance the destruction of those pollutants in three-way catalytic converters.

Product Segmentation

Product segmentation is not required as Optalys® has no variants within the Solvay Group from a production process and ecoprofile point-of-view.

Impact Assessment

1 kg of OPTALYS has a cradle-to-gate impact of 25 kg of CO₂, 87,206 kg of 1.4 DCB equivalent (regarding human and ecotoxicity), 79,368 megajoule (MJ) of energy consumption (gas, coal, oil, uranium and renewables), 123 MJ of gas and 1.4 m³ of water.

Impact Valuation

The assessed impacts of OPTALYS® altogether have a potential externality cost of 15 EUR/kg, mainly due to (in the order of potential costs' magnitude) human toxicity, energy consumption (oil), Global Warming Potential, water consumption and eutrophication potential.

Operations Vulnerability

The Operations Vulnerability analysis shows that the production of OPTALYS has a potential externality cost of 15 EUR/kg, mainly due to human toxicity, energy consumption (oil), Global Warming Potential, water consumption and eutrophication potential. Compared to the revenue of this product segment, this result amounts to a 'Low' Operations Vulnerability risk.

Application Segmentation

OPTALYS® in gasoline depollution.

Internal combustion engines cannot be optimized for highest fuel efficiency and lowest emissions at the same time. The operating conditions of modern cars' engines are optimized for fuel efficiency and air pollutants are neutralized in three-way catalytic converters where OPTALYS® products play their part in improving exhaust gas quality by reducing the release of noxious exhaust gases into the atmosphere without compromising the car's performance.

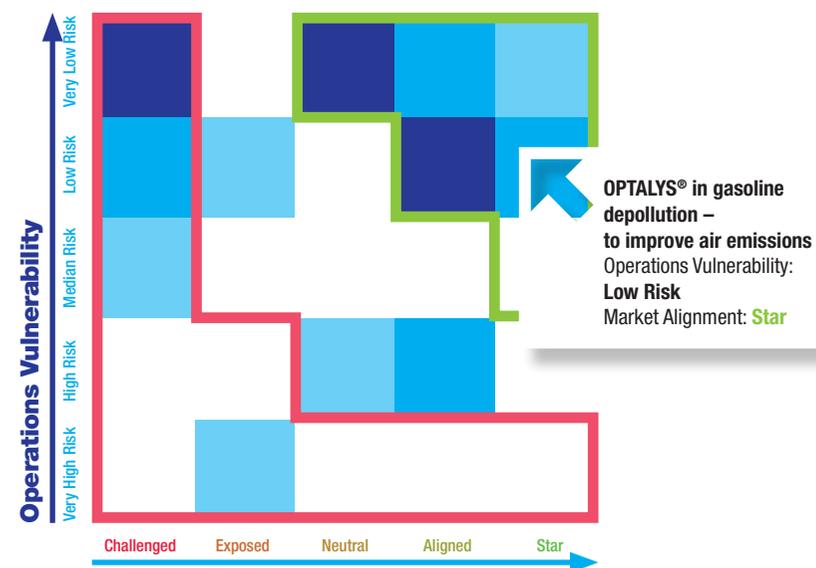
Case studies

5.2 OPTALYS® IN GASOLINE DEPOLLUTION

Market Alignment

The Market Alignment analysis shows that OPTALYS® has no market-level obstructions or concerns and even falls within the ‘best available technology’ category as Three-Way Catalytic (TWC) converters enable limiting CO, HC and NOx emissions to legal levels. Since the main regulatory trend worldwide is to curb emissions, OPTALYS® is well-positioned to deliver on this as a solution with favorable sustainability attributes. OPTALYS® is therefore categorized as a ‘Star’ in Market Alignment.

In addition, its performance allows precious metals or less well-performing metals to be replaced.

**OPTALYS positioning in the SPM Heat Map**

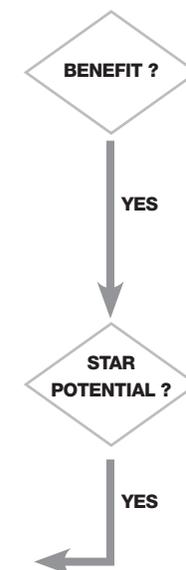
On the SPM Heat Map, OPTALYS® will be positioned in the ‘Solutions’ quadrant of the matrix and will contribute to meeting Solvay’s 2025 goal of generating 50% of its revenue from sustainable solutions by 2025.

5.2 OPTALYS® IN GASOLINE DEPOLLUTION

QUESTIONNAIRE

DECISION TREE

Benefits	
Regulation	
Question:	Does <product> in <application> (help consumers or actors in the downstream value chain to) directly, measurably and significantly comply with regulations having a strong sustainability focus and in force for less than 10 years?
Answer:	<p>"Numerous regulations exist on limits for pollutants emitted by diesel engines.</p> <ul style="list-style-type: none"> - EURO directive: http://en.wikipedia.org/wiki/European_emission_standards - Tier 2 tier 3 in the USA - SULEV and LEV 3 in California: http://en.wikipedia.org/wiki/Super_ultra-low_emission_vehicle - Clean Air Act in the USA: http://www.catf.us/diesel/policy/federal/ - European Air Quality requirement»
Water & Air Quality	
Question:	Does <product> in <application> (help consumers or actors in the downstream value chain to) directly, measurably and significantly increase the quality of water and air available to consumers?
Answer:	Yes: the application is aiming at improving the quality of air, mainly in urban areas. Three-Way Catalytic (TWC) converters enables to limit emissions of CO, HC and NOx to levels at the same time.
Star Potential	
Sustainable Star	
Question:	"Is the revenue of <product> in <application> anticipated to experience 10% growth or more per year, in average, in the next 5 years thanks to: <ol style="list-style-type: none"> 1. Better sustainability profile than the leading solutions in the market segment 2. Serving a fast-growing market segment because of favorable sustainability megatrends?»
Answer:	"Yes. Sales are anticipated to increase by 10% pa in volume between 2013 and 2018. Roadmap committed, confirmed by the GBU»
SPM Category	STAR



5.3 PROMOTING A SUSTAINABLE SALMON INDUSTRY WITH PARAMOVE®

Introduction

Hydrogen peroxide (H₂O₂) is mainly used by the paper industry to bleach pulp. Its properties are also of interest in other markets like chemicals, food, textiles and the environment. As world leader in this technology, the Business Unit Peroxides develops innovative applications and processes for these market segments.

In the salmon farming industry, the main threat to production is parasitic disease like sea lice. Solvay's hydrogen peroxide-based solution PARAMOVE® helps control this problem.

With the global population expected to reach 8 billion by 2025, one of the biggest challenges society faces is to feed more people with limited resources. To meet the growing demand for food, many consider aquaculture to be a sustainable way to produce animal protein. Around half of the fish consumed in the human food chain today is grown in fish farms and this figure is expected to grow to 75% by 2025.

Solvay contributes directly to food security with PARAMOVE® Hydrogen Peroxide (H₂O₂), a solution for controlling two parasitic diseases and therefore enhances the yields in salmon farming.

Product Segmentation

From an SPM perspective, PARAMOVE® is a product that has no variants within the Solvay Group from a production process or ecoprofile point-of-view.

Impact Assessment

1 kg of Hydrogen Peroxide (H₂O₂) has a cradle-to-gate impact of 1.1 kg of CO₂ equivalent, 20 MJ of energy consumption and 0.14 kg of 1.4 DCB equivalent (regarding human and ecotoxicity).

Impact Valuation

The potential externality cost of PARAMOVE® is 0.26 EUR/kg and the main source of this is energy consumption (gas) and Global Warming Potential, which together make up 84% of the total.

Operations Vulnerability

The Operations Vulnerability analysis shows that the production of H₂O₂ has a potential externality cost of 0.26 EUR/kg coming mainly from energy consumption (gas) and global warming potential, which together make up 84% of the total monetized ecoprofile. Compared to the revenue of this product segment, this result amounts to a 'Very Low' Operations Vulnerability risk.

Application Segmentation

PARAMOVE® (H₂O₂) is used in salmon farming by providing a more sustainable, less toxic solution.

Market Alignment

The main benefits of PARAMOVE® are that it quickly removes the parasites and leaves no residue in the fish. The active ingredient hydrogen peroxide breaks down leaving only water and oxygen in the environment.

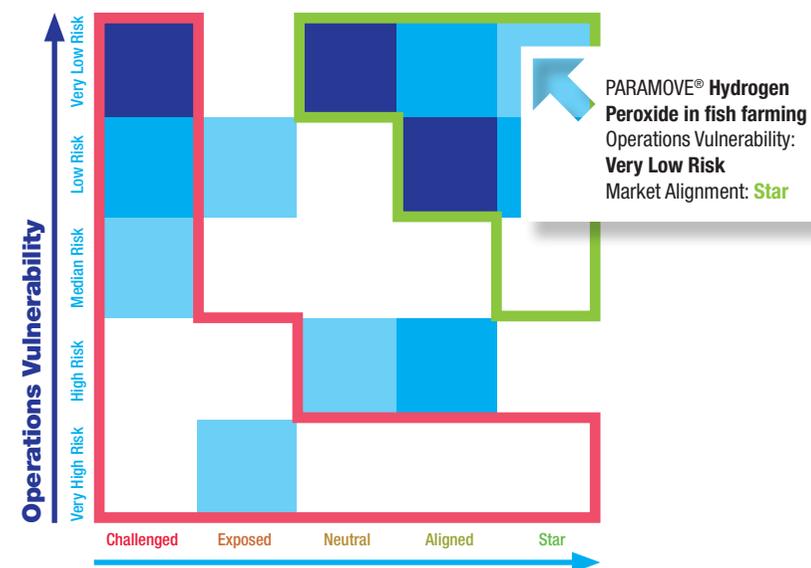
Case studies

5.3 PROMOTING A SUSTAINABLE SALMON INDUSTRY WITH PARAMOVE®

The product answers a market need and a solution to replace fish treatment which presents some toxicity.

Aquaculture Stewardship Council (ASC)-certified farms can apply PARAMOVE® as part of an integrated treatment program against parasites. Salmon-producing companies covering more than 50% of global production have already committed to become ASC-certified by 2020 through the Global Salmon Initiative (GSI).

Solvay's own sales growth from the product and the projected growth in Atlantic salmon farming signals that this market is expected to provide high sales potential in the future. PARAMOVE® is therefore categorized as 'Star' in the Market Alignment assessment.



PARAMOVE® positioning in SPM Heat Map

On the 2015 SPM Heat Map, PARAMOVE® will be positioned in the 'Solutions' quadrant of the matrix and will contribute to fulfilling Solvay's 2025 sustainable solutions goal.

5.3 PROMOTING A SUSTAINABLE SALMON INDUSTRY WITH PARAMOVE®

QUESTIONNAIRE

DECISION TREE

Obstacles	None
OECD Countries (2 or more)	
Question:	"Is PARAMOVE Hydrogen Peroxide in salmon farming banned or restricted for use by at least two OECD countries, California and one OECD country or one Supranational Institution? Reference: http://www.oecd.org/general/listofocedmembercountries-ratificationoftheconventionontheoecd.htm "
Answer:	"NO New salmon farms are allowed in Scotland, Norway, Ireland and USA, provided they comply to very strict regulations. No countries presently ban fish farming.»
Major Customer Ban (2 or more)	
Question:	Is PARAMOVE Hydrogen Peroxide in salmon farming banned or restricted for use by at least two significant actors in the downstream value chain?
Answer:	"NO Big distributors, with a clear orientation in sustainability as Mark & Spencer, Walmart have in their catalog «»Farmed Salmon»», but respecting strict production rules: > Mark & Spencer : (Turnover 2015: 13 000 M€) http://help.marksandspencer.com/support/products-services/salmon_lochmuir > Walmart: (Turnover 2015: 427 000 M€) Walmart policy : they required wild and farmed fish to be certified : MSC (Marine Stewardship Council) for wild fish and BAP (Best Aquaculture Practices) for farmed. http://corporate.walmart.com/global-responsibility/environment-sustainability/sustainable-seafood > Target is a retailer active in USA and Canada. Turnover 2014 : 64 000 M€. Target is the 3rd retailer in USA in 2012. "Target is the first major retailer to eliminate farmed salmon, converting our entire salmon assortment to Marine Stewardship Council-certified wild-caught Alaskan salmon". (Press release in 2010). But on the Target site, on Dec 2013, they mention that they collaborate with FishWise to select their suppliers but they do not mentionned they ban «»Farmed Fish»». On the FishWise site, they assess both fisheries and fish farm. That let suppose that Target today does not ban the farmed fish but work with FishWise certified farms.»
Concerns	
Ecolabel	
Question:	Is (PARAMOVE Hydrogen Peroxide in) salmon farming ranked in a bottom category in any ecolabel system from the list compiled by SPM team?
Answer:	"NO But several fish farms get ecolabels. The MSC (Marine Stewardship Council) does not cover the certification of fish farm but only wild capture fisheries.»



NO



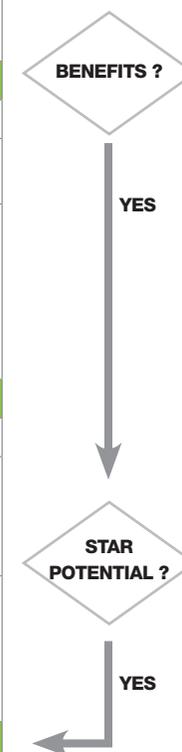
NO

5.3 PROMOTING A SUSTAINABLE SALMON INDUSTRY WITH PARAMOVE®

QUESTIONNAIRE

DECISION TREE

Major Customer Ban (at least 1)	
Question:	Is (PARAMOVE Hydrogen Peroxide in) salmon farming banned or restricted for use by at least one significant actor in the downstream value chain?
Answer:	"NO Walmart policy: they required wild and farmed fish to be certified: MSC (Marine Stewardship Council) for wild fish and BAP (Best Aquaculture Practices) for farmed. Walmart is surely one of the most strict in this area. No other ban or restriction on the horizon.»
Benefits	
Food & Feed Production	
Question:	Does PARAMOVE Hydrogen Peroxide in salmon farming (help consumers or actors in the downstream value chain to) directly, measurably and significantly increase the yield of food & feed production?
Answer:	"YES Hydrogen Peroxide is effective in fighting sea lice, therefore increasing food production of an aquaculture. Fish farming is a major contributor to human foodstuff with a significant increase in the last 20 years. Evidence: http://www.earth-policy.org/plan_b_updates/2013/update114 See also the FAO document 2012 or the role of aquaculture in the world food supply: http://www.fao.org/docrep/016/i2727e/i2727e00.htm »
Star Potential	
Sustainable Star	
Question:	"Is the revenue of PARAMOVE Hydrogen Peroxide in salmon farming anticipated to experience 10% growth or more per year, in average, in the next 5 years thanks to: 1. Better sustainability profile than the leading solutions in the market segment 2. Serving a fast-growing market segment because of favorable sustainability megatrends?»
Answer:	"YES Evidence: - Solvay's sales growth of 156% achieved in this product segment between 2009 and 2012 - Worldwide growth in Atlantic salmon farming Evidence: http://www.earth-policy.org/plan_b_updates/2013/update114 »
SPM Category	STAR



Annex 1: Methodology

ANNEX 1.1 THE 19 INDICATORS (MID-POINTS)

	Impact Category/ Mid-point	Description	Characterization method and Equivalent measurement unit
1	Greenhouse gas emissions	Reports the potential contribution to climate change, through the greenhouse effect of gases. It is the sum of the individual contributions of each greenhouse gas emitted, the 'Global Warming Potential (GWP)' (characterization factor) multiplied by the emitted quantity. The GWP is the ability of the gas to absorb or reflect UV radiation, integrated over a given time horizon (100 years according to the Kyoto Protocol: GWP100) in the atmosphere, compared to (divided by) GWP100 of CO ₂ .	Method: IPCC 2007, 100 years Unit: kg of CO ₂ equivalent (kg CO ₂ eq.)
2	Biogenic CO₂ uptake	A complete assessment of CO ₂ exchange with the atmosphere takes into account CO ₂ uptake from the atmosphere from plants growing during the photosynthesis process, in the case of bio-sourced products. As a consequence, on a cradle-to-gate basis, bio-sourced products establish a trap for CO ₂ until their destruction into CO ₂ again (total oxidation). The CO ₂ uptake is computed from a theoretical biogenic CO ₂ content in the product under consideration.	Method: theoretical computation Unit: kg of CO ₂ equivalent (kg CO ₂ eq.)
3	Human Toxicity Potential	The human toxicity potential (HTP) reflects the potential harm of a unit of chemical released into the environment. It is based on both the inherent toxicity of a compound and its potential dose to which humans are exposed after the emission of a unit of that substance in a given compartment (or sub-compartment). The potential dose is calculated using a generic fate and exposure model which determines the distribution of a chemical in a model environment and accounts for a number of potential exposure routes. Toxicity is represented by the cancer potency for carcinogens and the safe dose for non-carcinogens.	Method: CML 2007 Unit: kg of 1,4-dichlorobenzene equivalent (kg 1,4 DCB eq.) Although the reference pollutant (1,4-dichlorobenzene) is the same for both human toxicity and ecotoxicity, impact pathways are obviously not the same and thus the characterization factors are different.
4	Freshwater Aquatic Ecotoxicity Potential (FAETP)	Ecotoxicity refers to the damaging effect of toxic substances on ecosystems such as heavy metals or chemical substances. This can lead to reduced growth of flora and fauna, as well as diminishing species. For biomass production, ecotoxicity is mainly related to plant protection products (PPP). Ecotoxicity is expressed for different media, viz. marine aquatic and sediment ecotoxicity potential (MAETP and MSETP), freshwater aquatic and freshwater sediment ecotoxicity potential (FAETP and FSETP) or terrestrial ecotoxicity potential (TETP). The term potential refers to the fact that the emission has a potentially toxic effect which is assessed by the global dispersion and exposure model USES.	
5	Marine Aquatic Ecotoxicity Potential (MAETP)		
6	Terrestrial Ecotoxicity Potential (TETP)		
7	Water Use		The impact category on water scarcity is accounted for by measuring the amount of freshwater withdrawn from ground and surface water sources presently available in life-cycle inventory databases.
8	Energy – renewable	Solvay analyzes energy consumption by its origin or primary source. All energy sources are accounted for to be able to identify the cost of the externality. Primary energy sources are divided into renewable and non-renewable resources. For determining the energy content of resources, the method considers the fundamental material input and the net calorific.	Method: Cumulative Energy Demand Unit: megajoule (MJ)
9	Energy – primary forest		
10	Energy – nuclear		
11	Energy – coal		
12	Energy – oil		
13	Energy – gas		

Annex 1: Methodology

ANNEX 1.1 THE 19 INDICATORS (MID-POINTS)

14	Abiotic Depletion Potential	Abiotic resources are natural resources such as ores, minerals or other resources which are regarded as non-living. Abiotic depletion reflects the speed of decrease in the total reserve of resources. For each substance, the rate of extraction (in kg/yr) is considered, as well as the quantity of the ultimate resource. The reference substance is Antimony (Sb), one of the substances that will disappear first and for which ultimate resource data is robust. Note that for fossil substances, the ultimate resources are considered, based on their energy content (Higher Heating Value HHV).	Method: CML 2007 Unit: kg Sb eq.
15	Land Use	Land use involves the management and modification of natural environment or wilderness into built environment such as fields, pastures and settlements. It has also been defined as "the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it" ⁶ . Land use may have a large impact on the services of ecological systems and the natural capital stocks that produce them and which are critical to the functioning of the Earth's support system. Examples of ecosystem services are: nutrient cycling, soil formation, recreation, water regulation and supply, climate regulation, habitat, flood and storm protection, food and raw materials production, genetic resources, atmospheric gas balance and pollination. The method used simply inventories the land occupation for the production of 1 kg of the product: surface area multiplied by the time of occupation.	Method: CML 2007 Unit: m ² /yr
16	Acidification Potential	Some acidic substances (Sulfur Dioxide (SO ₂), Nitrogen Oxide - NO _x , Ammonia) emitted to the air fall back to the soil or water in the rain (the well-known acid rain phenomenon), disturbing the development of certain living species. The acidification potential indicator not only considers the intrinsic acidity of the substance but also its lifecycle in the atmosphere after its emission, based on the RAINS-LCA model (transportation over regions and probability for deposition in a given region depending on its geographical point of emission). An average is then calculated to get a global characterization factor.	Method: CML 2007 Unit: kg SO ₂ eq.
17	Eutrophication Potential	Eutrophication is defined as the enrichment of water and soil in nutrients (Nitrogen and Phosphorous), as a result of human intervention. Oxygen depletion is a possible consequence of this enrichment. The method used takes account of the emission of nitrogenous and phosphorous substances in three compartments: air, water and soil. It is based on the ability of a substance to contribute to the profusion of algae (biomass potential).	Method: CML 2007 Unit: kg PO ₄ —eq.
18	Ozone Layer Depletion Potential	Ozone molecules in the stratosphere absorb large quantities of UV radiation coming from the sun, thus removing the life-threatening UV-C radiation and reducing the harmful UV-B radiation. The destruction of the stratospheric ozone layer (particularly over the Poles) is mainly due to a catalytic destruction of ozone by atomic Chlorine and Bromine. The main source of these halogen atoms in the stratosphere is photo dissociation of chlorofluorocarbon (CFC) and bromofluorocarbon compounds. These compounds are transported into the stratosphere after being emitted at the surface of the earth, mainly due to human activity. Characterization factors are established according to the effective destruction of the ozone layer attributable to the annual emission of a given substance, as compared to the effective destruction attributable to the annual emission of CFC-11.	Method: CML 2007 Unit: kg CFC-11 eq.
19	Photochemical Oxidation Potential (or Photochemical Ozone Creation Potential)	Under certain climatic conditions, air emissions from industry and transport can react in a complex manner under the influence of solar radiation and lead to photochemical ozone formation responsible, in particular, for possible respiratory problems. As a measure for estimating airborne substances' potential for forming atmospheric oxidants, POCP (Photochemical Ozone Creation Potential) values are used. The POCP value of a particular hydrocarbon is a relative measure of how much the ozone concentration measured at a single location varies if emission of the hydrocarbon in question is altered by the same amount as that of a reference hydrocarbon, usually ethylene. The POCP value is not a constant, but can vary over distance and time, since formation of oxidants along the path of an air pocket is determined by the composition of the prior mixture and the meteorological conditions, which can also vary spatially and chronologically.	Method: CML 2007 Unit: kg C ₂ H ₄ eq.

⁶ IPCC Special Report on Land Use, Land-Use Change And Forestry, 2.2.1.1 Land Use

Annex 1: Methodology

ANNEX 1.2 EXAMPLE OF AN IMPACT ASSESSMENT TABLE

Impact Category	Element	per kg of product	Unit
Climate change	GWP 100a	1,90	kg CO ₂ eq.
Climate change	Biogenic CO ₂ Emissions	-0,68	kg CO ₂ eq.
Human Toxicity	Human Toxicity [HTP]	0,89	kg 1,4-DCB eq.
Ecotoxicity	Freshwater Aquatic Ecotoxicity [FAETP]	1,20	kg 1,4-DCB eq.
Ecotoxicity	Maritim Ecotoxicity [MAETP]	680,00	kg 1,4-DCB eq.
Ecotoxicity	Terrestrial Ecotoxicity [TETP]	0,39	kg 1,4-DCB eq.
Water	Water	0,17	m ³
Energy	Renewable Energy Resources [Renewable]	24,00	MJ
Energy	Primary Forest Energy [Primary Forest]	2,60	MJ
Energy	Nuclear Energy [Uranium]	3,20	MJ
Energy	Coal Energy [Coal]	4,70	MJ
Energy	Crude Oil Energy [Oil]	8,20	MJ
Energy	Natural Gas Energy [Gas]	9,00	MJ
Abiotic Depletion	Depletion of abiotic resources	0,011	kg Sb eq.
Land Use	Quantitative Land Use [Land Use]	0,69	m ² y
Acidification	Acidification	0,0088	kg SO ₂ -eq.
Eutrophication	Eutrophication	0,011	kg PO4-eq.
Ozone Depletion	Ozone Depletion	0,00000036	kg CFC-11 eq.
Photochemical Oxidation	Photochemical Oxidation	0,0021	kg ethylene eq.

Example of an impact assessment table expressed for 1 kg of a manufactured product

Annex 1: Methodology

ANNEX 1.3 SHADOW COST VALUATION IN SELECTED IMPACT CRITERIA

Impact category	How is the shadow cost defined?	Shadow cost
Water	<p>We are measuring the impact of water scarcity in this impact category. Simply put, we are pricing the quantity of water used in industrial processes which can therefore not be used for other purposes.</p> <p>Currently, no clear consensus exists on the definition of water scarcity, while different methods converge on using a fraction of water footprint analysis to define the impact. We therefore base the impact category for water scarcity on high-quality freshwater consumption from ground and surface water sources presently available in the LCI databases.</p> <p>The price of fresh water was the main indicator we followed to define the shadow cost. Large differences exist in water prices in developed countries since prices vary between 0.40 USD/m³ and 1.91 USD/m³ (UNESCO, 2003).</p> <p>Water treated in desalination plants can be seen as the maximum price for freshwater.</p> <p>Given the uncertainties and local circumstances, we concluded that the shadow cost of (high quality ground and surface) freshwater is in the order of 1 EUR/m³.</p>	1 EUR/m ³
Land Use	<p>In order to define the potential externalities caused by land use one needs to understand and value ecosystem services that are limited by land use. Ecosystem services contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet.</p> <p>Costanza et al. (1997) estimated the (then) current economic value of 17 ecosystem services on a global scale. Current valuations are mostly based on this 'ecosystem services approach'.</p> <p>The ILCD Handbook (2002) recommends using the Potentially Disappeared Fraction of species (PDF) concept as an indicator for calculating the damage caused to the natural environment.</p> <p>For valuing land use, Kuik et al. (2007) developed an approach which allowed a 0.47 EUR per (PDF/m²/y) price tag on externalities derived from land use. However, this approach does not reflect specific local conditions and is highly-sensitive to population density, area size and the amount of change inherent to the calculation.</p> <p>After examining several other calculation methods, TNO came to the following conclusions regarding the different approaches to account for the externality costs of land use:</p> <ul style="list-style-type: none"> • Agricultural land prices reflect many socioeconomic developments. • The shadow cost based on ecosystem services used in CML is higher than the market price of land. • Damage estimates using Potentially Disappeared Fraction (PDF) result in an even higher shadow cost. The scale of this shadow cost is partly explained by sensitivity to factors such as population density, area size and the amount of change. <p>Based on other considerations including crop differentiation potential, the experts recommended using the shadow cost for land use impact category in CML 2000, which is somewhat limited in gauging ecosystem services, but transparent in its calculation method, which is an important factor for auditing the methodology.</p>	0.094 EUR/m ² /y
CO₂	<p>Solvay followed a scientific logic to define a reasonable long-term estimation. Sources such as the 2006 EU RECIPE Study suggest that to maintain average global temperature rise within +2°C compared to pre-industrial levels, greenhouse gas emissions should be priced between 50-100 EUR per ton of CO₂ equivalent. We decided to take the median between the two extremities and defined 75 EUR per ton of CO₂ equivalent as the shadow cost in our calculations. This figure went through sensitivity analysis before being deployed. Such a measurement can drive the development of new products which can contribute to reducing CO₂ emissions.</p> <p>Other companies and trading schemes are also using internal carbon pricing. However, in the corporate world, these prices are very volatile e.g. ranging from 2.25 EUR to 109 EUR in the Materials sector where Solvay puts the third highest price tag on one ton of CO₂ emissions⁷. In 2014, the average price of 1 ton of CO₂ in trading schemes was 7 EUR⁸, while the European Trading Scheme (ETS), in the current period, is valuing one ton of CO₂ at around 6 EUR.</p> <p>The International Energy Agency (IEA) is projecting in its 450 scenario that the price of carbon emissions may rise to as high as 140 EUR/ton in OECD countries by 2040 when policymakers become serious about reaching the 2oC goal⁹.</p>	75 EUR/metric ton of CO ₂

⁷ Source: CDP <https://www.cdp.net/CDPResults/carbon-pricing-in-the-corporate-world.pdf>

⁸ Source IEA <http://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf>

⁹ Ibid.

Annex 1: Methodology

ANNEX 1.4 MARKET ALIGNMENT QUESTIONS

OBSTACLES

- Does the product in the application cause **exposure of over 0.1% of a compound**?
 - Considered **carcinogenic, mutagenic** or **reprotoxic** (CMR) categories 1A or 1B?
 - Considered (very) **persistent**, (very) **bioaccumulative** or **toxic** (PBT or vPvB)?
 - On the ECHA list of **substances of very high concern** (SVHC)?
 - On the **SIN list (Substitute It Now!)**
 - Is the product in the application?
 - Banned or restricted for use in the application by **2 OECD countries** or by **2 key actors** in downstream value chain or application by **2 health institutes** on behavioral or dietary recommendations?
 - Not compatible with the **EU Ecolabel requirements**?

CONCERNS

Does the use of the product in the application?

- Cause human **exposure** of **harmful** or **toxic substances** (CMR I, SVHC, SIN list) during normal use (even if **below 0.1%**) when an **alternative** is available?
- Cause emissions into the environment of **harmful** or **toxic substances** (PBT, vPvB) during normal use (even if **below 0.1%**) when an **alternative** is available?
- Significantly decrease **air/water quality**, which could be avoided by switching to an **alternative** product?
- **Receive a bottom quartile** sustainability ranking in any government-sponsored sustainability **labelling code**?
- **Is the Product in the application?**
- Banned or restricted for use by **1 OECD country** or by **1 key stakeholder** in downstream value chain or **1 health institute**?
- Restricted for use by **strategies** implemented by at least **2 major stakeholders** in downstream value chain to improve their sustainability?

Annex 1: Methodology

ANNEX 1.4 MARKET ALIGNMENT QUESTIONS

BENEFITS

Does this product in this application help consumers and/or customers to **directly, significantly and measurably**?

- Reduce the **emissions of Greenhouse Gases (GHGs)?**
- Reduce exposure to **harmful** or **toxic substances** (human or environment)?
- Reduce **energy consumption**?
- Increase availability of **freshwater** (in production and supply chain) or decrease its demand?
- Reduce consumption of **non-renewable resources** e.g. increasing lifespan?
- Reduce the consumption of **scarce raw materials**?
- Increase the production of **renewable energy/materials** or make it more competitive?
- Increase the yield or supply chain efficiency for **food/feed** production?
- Increase **recycling**?
- Increase the production of **biodegradable materials** or make them more competitive?
- Comply with **regulations** with a strong sustainability focus?
- Increase efficiency of **waste** supply chain or decrease waste generation?
- Support **treatment of health** problems through medical equipment, tools, etc. inc. **chronic diseases**?
- Reduce physical limitations from **ageing**?
- Increase supply of **healthcare services at home** vs. in hospitals/institutions?
- Increase **quality of air/water** available to the consumer?
- Prevent injuries and exposition to germs (**safety and prevention**)?
- Increase **healthy nutrition/habits** or make it more competitive?
- Improve physical health or reduce health risks through **topical solutions**?

Annex 1: Methodology

ANNEX 1.4 MARKET ALIGNMENT QUESTIONS

AMPLIFIERS

Does the use of the product in the application?

- Cause human exposure of a compound which is considered **CMR 2 (over 0.1%)**?
- Compete with sources of **food**, feed, or **freshwater** also used for human consumption?
- Use certain **scarce** raw materials?

How does the product in the application compare to its next best alternatives?

- From the standpoint of **energy** efficiency?
- From the standpoint of **water** efficiency?
- From the standpoint of **GHG** emissions?
- From the standpoint of **raw materials** (resource) efficiency?
- From the standpoint of **renewable** materials and energy?
- From the standpoint of **recyclability, biodegradability** and other **end-of-use** solutions?

Is the use of the product in the application favored or not favored by?

- Regulations, taxes, subsidies (OECD country level), ecolabels, NGO scrutiny or active communications on sustainability issues (based on e.g. LCA)?

STAR POTENTIAL

Is the revenue of the product in the application anticipated to experience 10% growth or more per year, in average, in the next 5 years?

- Driven by a better sustainability profile than the leading solutions in the market segment, or serving a fast-growing market segment, because of favorable sustainability megatrends?

Annex 2: Q&A

Journey

Why did Solvay develop a proprietary tool to manage its portfolio in a more sustainable way?

The CEO and top management of Solvay wanted to understand how sustainability trends impact the profit and loss account of the company. The question was raised by Christian Jourquin, CEO of Solvay in 2006 and the SPM tool was launched in 2008 to become a strategic management tool in 2015 under new CEO, Jean-Pierre Clamadieu. At the time when Solvay started developing the SPM tool, there were no ready-made sustainable portfolio assessment methodologies available which combined scientific robustness with the specifics of the corporate financial decision-making processes.

Methodology

Is the environmental manufacturing footprint more acceptable when the product value is high?

SPM works with acceptable environmental footprints to make the methodology viable in present-day context. The ‘Solutions’ category of products, however, will not tolerate Operations Vulnerability below median risk and Market Alignment below Neutral. Solvay’s strategy moves in the direction of favoring Solutions over Neutral PACs, or those with Challenges.

Why not doing a full LCA analysis (cradle to grave) on Product Application Contribution (PAC) ?

For the SPM tool to be robust enough for decision-making on strategic and operational levels, we drew on scientific knowledge as much as possible, especially on Life-Cycle Assessment (LCA). With such a goal in mind, we needed to ensure a good balance between the reliability and time-efficiency of the analysis.

On the vertical axis (Operations Vulnerability) of the SPM Heat Map, a cradle-to-gate scope of the value chain is covered, because this is where we have control over raw materials and production processes. On this axis a quantitative LCA based calculation resulting in a ecoprofile is carried out.

However, on the horizontal Market Alignment axis, a full cradle-to-grave LCA would:

- Be excessively time-consuming as detailed information on application and end-use phases is often not available
- Not cover important elements such as healthcare
- Be less focused on elements that are material for Solvay e.g. toxicity and ecotoxicity

In addition the time needed to complete such cradle-to-grave LCA will come out of the timeframe of business decision-making process and therefore become not relevant anymore.

Such decisions cannot be put on hold for several months for a full LCA to be carried out. This challenge prompted us to use an LCA-minded approach to assess relevant sustainability trends from a consumer and market perspective on the horizontal axis.

Annex 2: Q&A

Decision-making

Why is Solvay not conducting a comprehensive, quantitative and monetized Life-Cycle Assessment of products from cradle-to-cradle?

Full-scale, cradle-to-cradle Life-Cycle Assessment (LCA) is a thorough, yet time-consuming scientific examination of a product in its different applications along the value chain. Therefore we limit the assessment to the manufacturing phase cradle-to-gate. It helps to confirm and ascertain the environmental benefits of a single product compared to competing products in the market. These benefits could come from better technical performance, lower energy consumption or lower pollutant emissions during the use phase.

The SPM tool relies on qualitative thinking in the Market Alignment phase to complete the LCA-snapshot and make sure that other material topics (e.g. healthy living) are addressed in the analysis, which LCA does not cover.

Why is the Market Alignment analysis not quantified and monetized?

Monetizing market signals and impacts without reliable scientific data gives significant uncertainty about the reliability of the calculations. Basing long-term strategy on such numbers would be even more difficult and risks getting stuck in discussions on the validity of the analysis. Also, the monetization of the entire value chain on a long-term horizon would be very time-consuming, Solvay opted for a qualitative analysis of market signals. This analysis is robust, rigorous and auditable.

On the horizontal Market Alignment axis, a full cradle-to-grave LCA would:

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Annex 2: Q&A

Are authoritative sources changing at the same pace as the revision of tool, or are there compromises to be made on that front?

Solvay is continuously scanning authoritative sources, particularly during the annual reviews of the SPM snapshots. If strong signals are received on a changing trend which would significantly affect the validity of the tool, a review process cycle is activated to update the tool, which also implies changing all snapshots. However, the sustainability megatrends we have taken into consideration have not changed so far and we do not expect them to change significantly before 2020. Signals on volatility in e.g. commodity prices, legislative behavior etc. are continuously collected and funneled into the Market Alignment analysis.

How does SPM contribute to the UN Sustainable Development Goals (SDGs) mapping and integration in our non financial targets?

The chemical industry manufactures intermediate products used in a wide variety of applications around the world. In essence, it is the industry of industries. As such, the chemical industry is at the heart of whether global sustainable development challenges are impacted negatively or positively. These global issues are well known and captured in the UN Sustainable Development Goals (SDGs) launched in 2015, and can be summed up as:

- Climate Change
- Increasing global population
- Scarcity of raw materials
- Scarcity of water
- Geopolitical environment changes
- Human development gaps
- Biodiversity stress

SPM contributes particularly to the following SDGs:

- 2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- 3) Ensure healthy lives and promote well-being for all at all ages
- 6) Ensure availability and sustainable management of water and sanitation
- 9) Ensure access to affordable, reliable, sustainable and modern energy for all
- 11) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Annex 2: Q&A

12) Ensure sustainable consumption and production patterns

13) Take urgent action to combat climate change and its impacts

14) Conserve and sustainably use the oceans, seas and marine resources for sustainable development

15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss

For Solvay, as a leading and responsible chemical company, we need to understand the business meaning and impact of sustainability trends underlying such global issues. In the long-term, these trends are key elements of risk mapping and the drivers of business growth.

The Solvay Group is continuously analyzing stakeholder expectations related to these global issues. We are building our sustainability strategy and toolbox, the Solvay Way, around these expectations. In general, we see the following:

- Customers increasingly ask for products and services with sustainability benefits, which can decrease their impact on the Planet and on other citizens.
- Institutional investors, hedge funds and responsible, Environmental-Social-Governance (ESG)-minded investors¹⁰ are increasingly considering and requiring proof of the link between addressing sustainability challenges and business performance, especially in relation to climate change.
- Corporate responsibility for and management of sustainability are moving beyond companies' own operations and into the entire value chain.
- Legal instruments targeting corporate sustainability are on the increase. Transparency requirements are present in countries on all continents and are especially on the rise in Europe.
- Circular economy business models and moving towards cradle-to-cradle thinking and reducing waste is gaining ground in all sectors (governments, civil society and corporate).
- Corporate improvement goals related to sustainability are becoming factors of market competitiveness, as more and more companies are using them.
- NGOs, rating agencies, governments are scrutinizing companies on their commitments and performance.

¹⁰ These are investors who consider and analyze ESG factors as a means to potential long-term financial performance advantages.

Annex 3: Glossary

BU

Business Unit.

Corporate Social Responsibility (CSR)

CSR is defined in the European Commission's Communication on CSR (A Renewed EU Strategy 2011-14 for Corporate Social Responsibility, October 25, 2011) as:

"The responsibility of enterprises for their impacts on society... [which involves] having a process in place to integrate social, environmental, ethical, human rights and consumer concerns into their business operations and core strategy in close collaboration with their stakeholders, with the aim of:

- Maximizing the creation of shared value for their owners/shareholders and for their other stakeholders and society at large
- Identifying, preventing and mitigating their possible adverse impacts."¹¹

Cradle-to-gate Assessment/Lifecycle assessment

The assessment of a partial product lifecycle, starting from extraction/harvesting of raw materials (cradle) and ending at the factory gate (before transport to the consumer).

Cradle-to-grave Assessment/Lifecycle assessment

The assessment of a full product lifecycle, starting from extraction/harvesting of raw materials (cradle) to the use phase and end-of-life (grave).

Cradle-to-Cradle Assessment/Lifecycle assessment

Same as cradle-to-grave assessment but used when the product is recycled at the end of life.

¹¹ A Renewed EU Strategy 2011-14 for Corporate Social Responsibility, p.6
(http://ec.europa.eu/enterprise/policies/sustainable-business/corporate-social-responsibility/index_en.htm).

Ecological Footprint

An ecological footprint is the measure of human demand/load on the Earth's ecosystems and natural resources.

Ecoprofile

A 'cradle-to-gate' study for a product, taking into account materials and energy inputs and outputs in the form of emissions to land, air and water and energy consumption.

Executive Committee

The Executive Committee (COMEX) is responsible for Group strategy, ensures that objectives are realized and optimizes the allocation of resources among the different Global Business Units. Acting as a collegial body, the Executive Committee is collectively responsible for overall performance and for protecting the Group's interests. On 31 December, 2015, the COMEX consisted of five members, each with oversight of a number of GBUs, Functions or/and Zones.

External costs

Theoretical valorization of the 'environmental' costs for 1 kg of a product. This valorization is based on the ecoprofile (impacts by kg of the product) and the shadow costs (value by impact).

GBU

Global Business Unit, there are 15 GBUs in Solvay, each comprising several Business Units (BUs).

Annex 3: Glossary

Greenhouse Gas (GHG)

A gas that contributes to the natural greenhouse effect. The Kyoto Protocol covers a basket of six greenhouse gases (GHGs) produced by human activities: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Annex I Parties' emissions of these gases taken together are to be measured in terms of carbon dioxide equivalents on the basis of the gases' global warming potential. An important natural GHG that is not covered by the protocol is water vapor. Source: European Commission. Climate change: Glossary of common terms and acronyms.

http://glossary.eea.europa.eu/EEAGlossary/G/greenhouse_gas

Ideation phase (in R&I)

A phase of product research comprising 1) Screening (brainstorming), 2) Product incubation (with market research and SWOT analysis), 3) Preparation kick-off through which the new product enters into the feasibility and production.

Kyoto Agreement Scope 1

Scope 1 emissions: Direct emissions from GHG sources owned or controlled by the reporting organization. From the Carbon Disclosure Project Supply Chain Report 2010 - CDP.

Kyoto Agreement Scope 2

Scope 2 emissions: Emissions that do not physically occur from within the organization's reporting boundary and are therefore 'indirect' emissions. Scope 2 emissions are caused by the organization's consumption of electricity, heat, cooling or steam brought into its reporting boundary. This category is often called 'purchased electricity' because it represents the most common source of Scope 2 emissions. From the Carbon Disclosure Project Supply Chain

Report 2010 - CDP.

Kyoto Agreement Scope 3

Scope 3 emissions: An organization's indirect emissions other than those covered in Scope 2. They are from sources that are not owned or controlled by an organization, but which occur as a result of its activities. From the Carbon Disclosure Project Supply Chain Report 2010 - CDP.

Mid-point

The direct measure of an externality expressed with an indicator, as opposed to the damage caused by an externality, which is called an end-point.

Operations

All the production processes and related activities executed to manufacture a product. (In SPM, we define Operations as covering the cradle-to-gate phase).

Operations Vulnerability

The potential financial risk (vulnerability) of a product based on the environmental shadow costs. The measurement is the ratio of external costs by kg/commercial net sale price by kg and is expressed in percentage (%). It is the relationship between the value created and the environmental costs. The lower the ratio, the higher the business resilience to costs from sustainable development. The higher the ratio, the higher the vulnerability of the business.

PAC (Product Application Combination)

The combination of a product and one of its market applications as seen by the final consumer (e.g. Sodium Carbonate in double glazing). The PAC is the key element of the Market Alignment assessment.

Annex 3: Glossary

Product

A product is in essence a product family (e.g. soda ash, Na_2CO_3). If different products have several production processes which can lead to significant differences in environmental impacts or in energy consumption, several products will be registered and analyzed with the SPM tool, and named with the following formula 'product + production process'. E.g. ' Na_2CO_3 synthetic dense' and ' Na_2CO_3 natural Trona-process').

R&I

Research and innovation, both a Group- and business-level function.

Rare earths

Rare earth elements are a series of chemical elements found in the Earth's crust that are vital to many modern technologies, including consumer electronics, computers and networks, communications, clean energy, advanced transportation, healthcare, environmental mitigation, national defense and more.

Because of their unique magnetic, luminescent and electrochemical properties, these elements help make many technologies perform with reduced weight, reduced emissions, and energy consumption, or give them greater efficiency, performance, miniaturization, speed, durability and thermal stability.

<http://www.rareearthtechalliance.com/What-are-Rare-Earths>

Shadow costs

The shadow costs are the conversion factor (in EUR per unit of impact) for monetizing the overall cost for the community of individual impacts on the surrounding ecosystems e.g. for ozone depletion in EUR/kg CFC11 equivalent.

SPM snapshot

As an assessment tool, SPM defines the practical risks and opportunities of the 'sustainable development' dimension of product and innovation portfolios, with an accurate profile of the portfolio at a particular point in time.

Sustainability

Products and processes that meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

Sustainability Trends/Megatrends

Megatrends are long term processes of transformation with a broad scope and a dramatic impact. They are considered to be powerful factors which shape future markets. There are three characteristics in which megatrends differ from other trends:

- 1) Time horizon: megatrends can be observed over decades. Quantitative, empirically unambiguous indicators are available for the present. They can be projected, with high probabilities, at least 15 years into the future.
- 2) Reach: megatrends impact comprehensively on all regions, and result in multidimensional transformations of all societal subsystems, whether in politics, society, or economy. Their precise features vary according to the region in question.
- 3) Intensity of impact: megatrends impact powerfully and extensively on all actors, whether it is governments, individuals and their consumption patterns, or corporations and their strategies."

(Source: "20 most important megatrends", Zpunkt, 2007)