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TECHNISCHE UNIVERSITÄT MÜNCHEN
INSTITUT FÜR INFORMATIK

An Assessment Technique for Sustainability: Applying the IMAGINE Approach to Software Systems

Alejandra Rodriguez, Birgit Penzenstadler

TUM-I1218

Technische Universitäts München
Software and Systems Engineering
Guided Research Requirements Engineering

Technical Report

An Assessment Technique for Sustainability: Applying the IMAGINE Approach to Software Systems

by Alejandra Rodríguez

Author: Alejandra Rodríguez

Supervisor: Birgit Penzenstadler

München, 2012

To ...

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Chapter 1

Introduction

1.1 Motivation

In a company whether small, medium or big, it is necessary to have clearly defined objectives that the strategy intends to fulfill and the activities needed to transform the desire into facts. The realization of many of the different tasks assigned is derived in the optimal case from an established process in the company developed through the experience in the field or maybe extended and adapted from a public standard available. Examples of such standards are the information management frameworks or methodologies offered by a particular vendor. Until now almost the totality of the strategic objectives in the companies have turned around economic aspects such as revenue, profit, and production. Some special agencies such as NGOs have also considered the social aspects, the rights of the employees and the service offered to the community, however, it remains insufficient to consider one of these elements alone or even the two of them, when sustainability becomes one of the goals to be integrated into the company strategy.

Sustainability requires the simultaneous treatment of its three aspects* and as any goal, it needs to set a particular ideal scenario, define the steps to be followed to achieve the expected results, and finally be able to determine the current status and monitor the evolution. This lifecycle should be supported by a reference standard, a well defined process, and mechanisms to realize carry it out in a real scenario, but currently there is no out of the box framework available to assess the sustainability in a company.

*Economic, Social and Environmental

Nowadays the term sustainability and its concept is more popular than in former years. The immense population density in all continents, the massive consumption, the unrestricted use or maybe abuse of natural resources had caused a significant change in our planet and to its equilibrium, and now that we are experimenting some of the effects (e.g. global warming, water contamination, energy shutdowns, biodiversity reduction and extinction of species) a change of mentality is taking place. We are more conscious that although we cannot reverse what we have done, at least we can adopt a more rational position and contribute to reestablish a sustainable environment, society and economy.

This work adopts a framework from the environmental studies used to appraise the sustainable development of a set of industries, and adapts it for the use in contexts of IT and Software supported projects; we refer to the Imagine approach. To exemplify all the activities conducted and analyze the obtained results, this research selected a Car Sharing system operating in Germany since 2011 as an example, and each step of the Imagine approach is hence conducted on the light of this particular system.

The process and the results are documented in this report, which is structured as follows: first the Imagine approach is explained in Section 2. Section 3 presents possible instruments described in the Corporate Sustainability Management Guide of the German Ministry for Environment, Nature Protection and Reactors Safety. Section 4 explains the purpose of this research and research questions considered are introduced in Section 5. Section 6 give an introduction to the context of sustainability and our car sharing system example. In the remaining sections: Section 7, 8, 10, 11, and 12, the Imagine steps are carried out and discussed, lastly a conclusion is presented in Section 13.

Chapter 2

The Imagine Approach

The Imagine approach evolved originally from a SSA (System Sustainability Analysis) within a project context focused on the coastal management [5]. The initial procedure for performing a SSA as originally devised in 2002 consists of 5 steps, namely: (1) Identification of stakeholders, (2) Identification of the main SI, (3) Identification of the band of equilibrium, (4) Development of the AMOEBA diagram, and (5) Evolution over time.

An updated and revised version of the SSA, basis for the Imagine approach, consists as well of five steps with a slight change, the resulting Imagine Approach is depicted in Figure 2.1.

1. STEP 1: Understand the context - identify the stakeholders and the system.

2. STEP 2: Identify the main Sustainability Indicators (SI) - SIs are subjective and dependent upon the stakeholder group and the dominant viewpoint of the group - identify the band of equilibrium (i.e. reference condition) and agree upon the main SI.

3. STEP 3: Develop the AMOEBA diagrams and scenario making.

4. STEP 4: Conduct a review and engage in meta-scenario-making.

5. STEP 5: Publicize and market the message.

As a structuring help for the sections explaining each step we will make use of a convention that we will explained next.

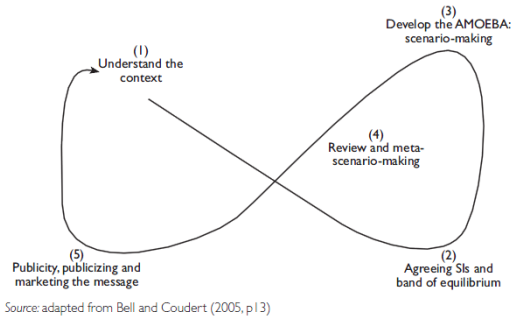

Figure 2.1: The five steps of the Imagine Approach. From [5]

Figure 2.2: Step mnemonics

2.1 Steps mnemonics

The mnemonics of each part from sections 7 to 13, use the Figure 2.2 diagram to help the reader recognize the Imagine step considered. Each step is divided into three sub-steps, namely (1) the procedure we use to fulfill the tasks of the step, (2) the results obtained from this procedure, and (3) the discussion arisen from the analysis. Each sub-step is later highlighted in green to indicate the current sub-step conducted.

2.2 Instruments

To accomplish the tasks of each step and as part of the discussion, we extracted 17 instruments out of 37 instruments listed in the Corporate Sustainability Man-

Figure 2.3: Instruments mnemonics

agement [13] guide that could support the information gathering, implementation and monitoring of the Imagine step. The sub-sections where the instruments are linked to the imagine approach are signalized with the mnemonics in Figure 3.

These 17 selected instruments as an overview are next listed and related with the Imagine step, as well as subsequently described, pointing out the ecological and social challenges of each one.

2.3 Instrument List and Description

The list of instruments is organized in the vertical axis and the Imagine steps on the horizontal axis. Each symbol in the cell refers to the support provided for each instrument in each step.

1. Controlling: this area supports the figures based steering of the company. Some functions can be distinguished, such as: information supply, success oriented steering, coordination function and rationality assurance. Ecological challenge: an ecological oriented controlling approach entails the gathering and steering of environmental effects of economic activities. The broad unidimensional measure considered is the ecological load and can be obtained from multiple instruments such as: Eco-balance, Indicators, Eco-Compas, Accounting, Reporting.

2. Corporate Social Accounting: accounting systems that provide information about the social benefit and costs of operational functions. The social balance measures and documents the contribution of a company to social problems and also to their solution. The preparation of a social balance which is usually published later, helps the management to be aware of the correlation between new and old factors in the company. At the same time it stimulates the improvement of the efficiecy of the social dimension by identifying weaknesses, and introducing rectification and counter measurements to remove them.

Instruments		Imagine Approach Steps				
	Instrument	STEP 1	STEP 2	STEP 3	STEP 4	STEP 5
1	Controlling			X	X	
2	Corporate Social Accounting					X
3	Corporate Volunteering				X	
4	Cross-impact analysis			X	X	
5	Dialog instruments	X			X	
6	Early Detection	X	X		X	
7	Eco-design/Design for environment (DfE)	X	X	X	X	
8	Environmental Shareholder Value	X	X	X	X	
9	Indicators		X	X	X	
10	Mission Statement	X	X		X	
11	Reporting			X	X	
12	Scenario analysis				X	
13	Sponsoring				X	
14	Suggestion system	X			X	
15	Supply Change Management (SCM)	X	X	X	X	
16	Sustainability Balanced Scorecard (SBSC)	X	X	X	X	
17	Total Quality Environmental Management (TQEV)	X	X	X	X	

Table 2.1: List of instuments

Social challenge: the limitation lie in the difficult measurements that can be determined for many social factors, such as employees motivation, well-being, and social development. These factors have impacts in the business and the consequences can be evidenced in profit cuts; but the relation is hard to establish due to the complexity generated by the combination of the monetary and not monetary factors.

3. Corporate Volunteering: corporate volunteering is understood as the voluntary engagement of a company to provide personal and material resources for a diversity of activities with environmental and social aims. The personal resources refer to employees voluntarily participating through the company in such labours.

4. Cross Impact Analysis: is a prediction instrument for identification and evaluation of fundamental relations between current and future situations. The analysis presents the adaptations needed to attain the expected scenarios. It is carried out in three steps: (1) The relevant business areas, company departments,

and range of products are listed, (2) the relevant fields to consider (e.g. legal, R&D, clients, press, etc) are listed and the given trends or expected developments are described, (3) the impacts and their direction are indicated numerically in a matrix, afterwards the rows and columns are summed to determine the global impact (e.g. positive or negative).

5. Dialog instruments: offer a platform for communication between the members that facilitates getting to know people better. Tools and spaces such as community advisory panel, Risk- Benefit dialog and networks have gained significant relevance. (1) Community Advisory Panel (CAP): forums initiated from the company side and in particular a specific location with its neighbors, where opinions and demands on a variety of topics, can be communicated avoiding the bureaucracy and situations that when scaled can become a difficult problematic. (2) Risk- Benefit Dialog: presents an instrument where potentially concerned social groups (e.g. neighbors, specialists, unions) debate in a deep dialog, with the objective of discussing the benefit, risks and acceptance of the matter in discussion, (3) works as a platform to exchange ideas and information, the contents published in the information pool can be used by any member, where all the actors can interact autonomously and which doesn't impose to restrictive formal rules.

Ecological and social challenge: all these instruments require trust, openness, a joint problem solving intention, and an extensive use of communication and cooperation means. The acceptance of the solution brings with itself the acceptance of the company for the different actors, nevertheless the development of the systems and information gathering can affect negatively the eco-/social-efficiency increase.

6. Early detection: instrumente that supports the company on the early awareness, early detection, and early recognition of specific aspects that enables the early coordination of the strategic company planning when the environment in the company suffers a change. The subsequent task is to trace and collect, process and forward important information along with a concluding prediction of the effects. Risks and chances can be as well identified through early detection.

Ecological and social challenge: the ability of the early detection to make statements about the future is restricted by the unpredictability of the future. The costs of simulations and prediction mechanisms can be very high playing against the ecological aspect.

7. Eco-design/Design for environment (DfE): deals with the integration of environmental relevant enquiries in the product planning, development and design.

The goal of the designers and product developers is to conceive the products (old and new) in an easily disposable constitution and configuration. For the evaluation of the existing products the environmental impacts are measured along the complete product lifecycle ("Life Cycle Thinking") and aligned with the social, economic, technical and legal surrounding conditions. Supporting instruments are: eco-balance, checklists, eco-compass, and upstream analysis such as requirements analysis and substantiation options to be compared among them.

Ecological challenge: for the reduction of the impact on the environment, the early consideration of future consequences is required and analysis of all production stages with sustainability questions, and consideration of usage instead of ownership.

8. Environmental Shareholder Value: links the measures of the environmental management with shareholder value approach, defined as the market worth of the own capital of a company that arises from the capital value of the expect free cash flows. The goal is to identify the measures of the environmental management that are ecologically effective and increase the shareholder value as well. For this the measures are analyzed with respect to the effects if possible in a quantitative way against the risk assumed and value gain.

Ecological challenge: the eco-effectiveness can be indirectly considered and from there realize in the long term the environment protective actions that are economically beneficial and that have a positive ecological effect.

9. Indicators: are comprised representations of qualitative ascertainable circumstances, and they can denote absolute or relative information with respect to one or many reference values. Indicators and indicator systems are operative management instruments that can be applied in the planning, steering, and controlling processes.

Ecological and social challenge: the indicators alone can be misleading and have rather a low expressive power, they need context, temporal and spacial characterization, and the consideration of the relations with other elements in the system/process/company. Another basic problem is that specially environmental and social indicators have a very low change rate, and many of them can only be slighlty quantifiable when not unmeasurable at all.

10. Mission Statement: with the help of the mission statement a company presents in written form the essential aspects its the desired situation, and it establishes the principles and basic points for the activities, without needing to

characterize a specific goal scenario. The mission statemenent builds the foundations of the company culture (also with respect to sustainability or a particular dimension), the employees can sensibilized through moral concepts and norms, therefore influencing the collective behavior.

Ecological and social challenge: without the correct mechanisms to implement the mission statement with respect to any factor, the company can lose its credibility and guide the employees and proceses in an opposite direction.

11. Reporting: environmental report, eco-report, environmental statement, social report, business oriented report, sustainability report. Written information and documentation of corporate internal and external facts, the objective is the improvement of the company image, trust and credibility through transparency. A periodic reporting help to increase the employees' awareness about the sustainability impacts

Ecological and social challenge: the measurement reported should be communicated transparently, and should be careful communicating the advance related to long term goals, due to the long periods of time needed to show results (e.g. environmental goals). Credibility must be built and maintained everyday and along all publications; the information provided must be of interest for the consumers and must describe the real situation.

12. Scenario analysis: scenarios give advice about the possible chances and risks, from which consequences for current measures and strategies are derived (e.g. corporate management and governance, technology management, product development and location), they support the decision making of the strategic management. They propose a picture over a time span (5, 10, 15, 20 or more years) from the current point in time, and enable the contrast of different developments that promote thinking in different alternatives. They are not thought to solve the uncertainties of the future, but to structure the intended ideal path and end.

Ecological and social challenge: identification of chances and risks that shape the activities of the employees that can lead to pioneering tasks that improve the ecological and social areas within the company. The scenario analysis is an adjacent long term, work-, time-, personal- and cost- intensive process which demands a methodical and technical previous knowledge. The final decision of which scenario to choose can be one out of three options: 1) Selection of a robust strategy which successful is guaranteed by taking over agreements, 2) orientation towards the strategy with maximum likelihood, 3) oriented adoption of resources for the arrangement of an desirable scenario.

13. Sponsoring: disposition of money and/or material expenses or services provided by the company for the execution of ecological and social projects. These resources are intended for the improved achievement of the ecologic and welfare goals and have a positive effect on the corporate culture and communication, and boost the trust between company and employees. Opposite to a donation or contribution, the sponsoring grants the company space for marketing and advertisement, and a sponsoring philosophy must be introduced, that adhere to: advice for the pursued goals, definitions of the target audience, key topics that the sponsoring fosters, and sponsoring forms, justification and indication of the company with the particular environmental problem, advice for an own ecological and social behavior, relationship with the image of the company, and clear limit of the contribution amount.

Ecological and social challenge: in the frame of sponsoring the thematic variety is unlimited, and the intended objectives are more easily tracked and attained. But it is very important to build and maintain the trust and project transparency through extensive and precise communication internally and to the outside, and collaborate with distinct organizations that have a completely different thinking structure and conducts , that can lead to misunderstandings and conflicts, that jeopardize the sponsoring activities, but if successful it can be translated into more value added for the brand.

14. Suggestion system: this system for the encouragement, survey, acknowledgement, implementation, and reward of suggestions for improvement by employees outside their working area. This business information system serves the streamlining and economic improvement of operating processes and products as well as for stimulating the motivation and creativity of employees, which channels the potential for innovation in ideas without additional research effort.

Ecological and social challenge: the systems propose improvements in processes which directly or indirectly contribute to the reduction of environmental impact and on the contrary increase the eco-efficiency. The openly exposure of the sustainability thematic in the suggestion system doesn't instantly raise the number of proposals or recommendations, but in increases permanently with the time and familiarization. The social topics must however be treated carefully, on one hand further development and identification of the employee with his working place can be enhanced, on the other hand conflicts, bullying and problems in the working place can affect negatively the social effectiveness progress.

15. Supply Change Management (SCM): management of the logistics chain, the clear analysis of the processes over the limits of the company, the goal is

the optimization of the internal and corporate business processes. The main motivations for performing SCM are: the improvement regarding quality of the products, processes, and delivery; the streamlining of the organization and reduction of negative ecological impact and the realization of the cost benefit. It requires of good information and communication systems inside the supply chain, and a modular composition. Instruments such as: Checklists, mass flow analysis, process costs, or material flow cost accounting (supply chain costing), or indicators; can be used to support this concept.

Ecological and social challenge: broader consideration of ecology that includes more functional areas, and the complete product or service life cycle (raw material, production, and waste disposal), that can be improved through planning and resource allocation). Also the controlling procedures and surveillance can be provided by some agent in the complete chain or build intrinsically by originated from self-organizing patterns. The weakness lies on the interdependencies that can arise.

16. Sustainability Balanced Scorecard (SBSC)): it is a concept of the strategic sustainability management that extends the traditional balanced scorecard including social and ecological aspects. This instrument expresses the business strategy in coarse grained operative terms and supports the realization of such concerns. The SBSC includes: the identification of the ecological and social success factors, the causal relationships, indicators and measures and the controlling and execution of the decisions taken.

Ecological and social challenge: the SBSC offers different non-monetary perspectives besides the economic point of view and the anchoring of relevant factors that bring the business forward in the three aspects in a triple win situation, integrated in the core competences of the company. The weakness lies in that the SBSC mostly considers final goals and not intermediate ones.

17. Total Quality Environmental Management (TQEV)): ist a combination of Environmental management and Total Quality Management (TQM), it embraces besides the process, product, and service quality, also the quality with respect to the concerns of the employees and the company, and the increase of the environmental quality. It is based on four elements, respectively: client/stakeholder identification, continuos improvement, make the work right from the first time, and systematic approach.

Ecological and social challenge: the integration of all the aspects requires the adherence to a very systemic approach.

All these instrument can support the tasks needed in each step and will be pointed out in the description of each step in the following sections.

Chapter 3

Research

Having presented our structure and the elements to document our research, we proceed with the explanation of the goal and the questions intented to be solved.

3.1 Research goal

As previously indicated, there is no sustainability framework to be used as is on a specific company project and that makes the introduction of sustainability as a goal a harder task, although many of the companies use this word when describing their mission. The main reason why sustainability is so complicated to assess stems in the lack of measurable indicators and reference values that allow to identify the current and future scenarios.

But even if they were available, what can be sustainable for one company can be unsustainable for another, i.e. a precise conception of sustainability varies depending upon who is using it and in what context [6]. For this reason the aim of this research is to extend and validate the use of an existing methodology in the contexts of software supported systems, without losing generality, given that the basis are identified at the starting point and the further steps refering to the baseline are standard.

3.2 Research Questions

1. Is the imagine methodology suitable for IT and Software supported systems?

2. Can it be extended to make it more beneficial under such context?

3. Does it provide insights to the stakeholders about the sustainability in the company and how to achieve it?

4. Can a standard framework for IT and software supported systems be developed from it?

How these questions are to be solved is explained in the section below.

3.3 Methodology

In order to answer each one of the research questions, we start by identifying and describing the context of our study. We used a car-sharing system to apply and validate the methodology, each step conducted is explained, describing the set of tasks performed to obtain the expected results, followed by a short discussion for the analysis, finally the findings are consolidated and we give some advice for future actions towards the attainment of the expected results.

3.4 The Imagine approach

Imagine is based on some premises[5] that serve as the foundations for deriving the method and they are:

- Sustainability can provide a qualitative measure of the integral nature and wholeness of any given system.
- Subjectivity on the part of the stakeholders in any given system (including researchers) is unavoidable.
- Subjectively derived measures of sustainability are useful if the subjectivity is explicitly accepted and declared at the outset, and if the method for deriving the measures is available to a range of stakeholders.
- Measures of sustainability can be valuable aids for future planning, forecasting and awareness-building.
- Rapid and participatory tools for developing our thinking and modeling concerning measures of sustainability are of value to a wide range of stakeholders within the development policy.

These premises are important assumptions for the derivation of the method, and gives in a certain degree the rationale to the design of every step and the tasks performed in each. The steps of the Imagine approach are:

1. Stakeholders and system identification

2. Sustainability Indicators (SI) identification
3. Band of equilibrium identification (i.e. the reference condition)
4. AMOEBA diagram creation
5. Publicizing, Publishing and Marketing the Messages

In this research for each step we gather data from different sources mainly literature, published reports, press, and interviews. Later we depict and structure our results with the corresponding diagrams or lists that ease the organization while maintaining the understandability of the recorded information, and conclude with an analysis and discussion on the obtained results.

One of the main structuring criterion is the definition of sustainability on the light of the Triple Bottom Line (TBL), this guideline is then applied on our Car Sharing System. But understading the meaning of the TBL is not enough, the contextual knowledge is needed for the comprehension of the whole research; therefore all of the concepts used are following clarified.

Chapter 4

Background

4.1 Definitions of "sustainability"

The concept of sustainability arises from the integration of three perspectives: (1) economic growth, (2) social progress, and (3) environmental stewardship; all three together are known as the three bottom line (TBL)) [14]. The (1) economic growth focuses on initiatives promoting the growth of the company, such as: innovation, capital efficiency, risk management, margin improvement, growth enhancement and total shareholder return. The emphasis of (2) environmental stewardship is the management of physical resources, like: clean air, water and land, emissions reduction, zero waste, releases and spills, and biodiversity. The (3) social progress viewpoint considers: diversity, human rights, community outreach, indigenous communities, and labor relations. The concept is depicted in Figure 4.1.

There exist many other different definitions people use when referening to sustainability. We didn't conceive a new meaning for sustainability, but rather show a couple of the existent definitions that express the same idea and reflect strong common understandings, altough they are described in different terms.

Our basic definition of sustainability is taken from the World Commission on Environment and Development (WCED) document often called the Brundtland report after the name of its chair, Gro Harlem Brundtland. This report (1987) [14] essentially began the global discussion of sustainable development, recognizing there are limits to the earth's ability to absorb the impacts of human activities, and addressing world poverty as one of the most significant problems in today's world. The Brundtland commission pointed out that equity is an essential ingredient of sustainability.

Figure 4.1: Triple Bottom Line (TBL). From [10]

The Brundtland definition states that "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [14]. In [12] they described it as, "Having your cake and sharing it, too". Sustainable Seattle [3] explains the term as a linkage of three important spheres of life: "Sustainability is the long-term social, economic, and environmental health of our community". Other groups would add a fourth sphere, either "cultural," or "civic". Gilman [7], states it as "Sustainability is equity over time.": "As a value, it refers to giving equal weight in your decisions to the future as well as the present. You might think of it as extending the Golden Rule through time, so that you do unto future generations as you would have them do unto you". Another definition by Hawken, [9], expresses sustainability as the intention to "Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do." At last Meadows [11], uses a sustainable society to describe sustainability as, "A sustainable society is one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or its social systems of support".

And as indicated by [12] we adopt their characteristics to define sustainability:

1. Asset-based: Begins by considering existing assets, then addresses deficien-

cies;

2. Engages diverse stakeholders in respectful, mutual, flexible and open decision making processes;
3. Express values that have been formally adopted;
4. Integrating: illuminates linkages among multiple issues;
5. Forward-looking: focuses on long-term future change, not evaluation of the past; and
6. Distributional: works toward equitable distribution of resources and wealth, not only for the current generation but also for future generations.

Now that we have a definition for sustainability it is important to also explain the system where our approach will be used to discuss the obtained the results afterwards, and draw some conclusions also for the future. Our system is a Car Sharing initiative, already launched and deployed in Germany, which intends to expand not only its geographical location, but also its services and coexist with other providers making incursion in this field.

4.2 Car-Sharing

Different interpretation have been given to the term 'Car-Sharing' initially many people specially employees within a company thought that Car-Sharing was about letting other people to borrow their vehicle, what didn't appeal them much. With the time the concepts have been spread in the community and the definition became clearer. Car-Sharing refers to the situation where two or more people travel by car together, for all or part of the car trip, it can be available for close communities such as employees or it can be available for everybody.

In general Car-Sharing can be described in a formal or more informal way, respectively: an organized scheme that allocates drivers and passengers together who make otherwise not come together to share car journeys, or the agreement among family, friends or colleagues to share car journeys on an ad hoc or on a more regular basis.

4.2.1 Start of Car-sharing

The program started in Switzerland in 1987, Germany followed the initiative one year later and subsequently other European countries, the United Kingdom and United States adopter it afterwards. Today, a little longer than 20 years on 600 cities worldwide have introduced Car-Sharing schemes.

A Car-sharing system has two basic ways of operation. The firsts consists on members using a booking system to share a car, involves a larger group of people and a smaller number of cars. This option works best for people that don't need a car every day, and instead use other transportation systems, such as public transportation, bicycles, or walk instead, and only in particular occasions need a car for a particular purpose.

The second way involves people owning a car, but not using it the whole day long or having empty places that can be occupied. By driving other people that fill the empty seats and collecting a fee among them, the owner can share the running costs of the ride. This alternative on the other hand is suitable for people that also need to drive to the same final destination or an intermediate point on the way, it can indeed be very convenient for those who live and work in the same area and share a regular journey.

Until now we described our motivation, purpose, methodology and tools along with the context were this research situates, in the subsequent sections the real contribution and hypothesis acceptance or rejection begins, starting with the stakeholder identification and understanding of the system.

Chapter 5

Stakeholders

"Imagine" depends on participation and inclusion of the groups of interest and relevant actors in the development of the process. It is important that identification include all the stakeholders present, who can participate most usefully in all deliberations.

5.1 Stakeholder Identification

The complete list of stakeholders for our Car-Sharing system is large, due to the possibility to contact all of them and their availability, only three individuals were interviewed for our research. However they represented three main groups corresponding to: the owner group (management side), the beneficiaries group (user side), and the external analyst group, acting in the role of a non-governmental regulator (e.g. competence, other regulatory entities).

The participatory technique used was a semi-structured interview, with the aid of a designed questionnaire (see A), and a duration between half and one hour and a half. For each one of the interviews a protocol was made and later all the answers were analyzed, compared, structured, and finally the results prioritized.

The questionnaire was designed in a general section, plus five more sections focused on finding the drivers, pressures, states, impact and responses also known as DPSIR Indicators[4]. DPSIR stands for (Driver-Pressure-State-Impact-Response), and is a participatory technique to gather information by identifying 5 elements: the Drivers(D) to design the system, the Pressures(P) to use unsustainable products of practices, what aspects of the current State(S) might seem afflicted by

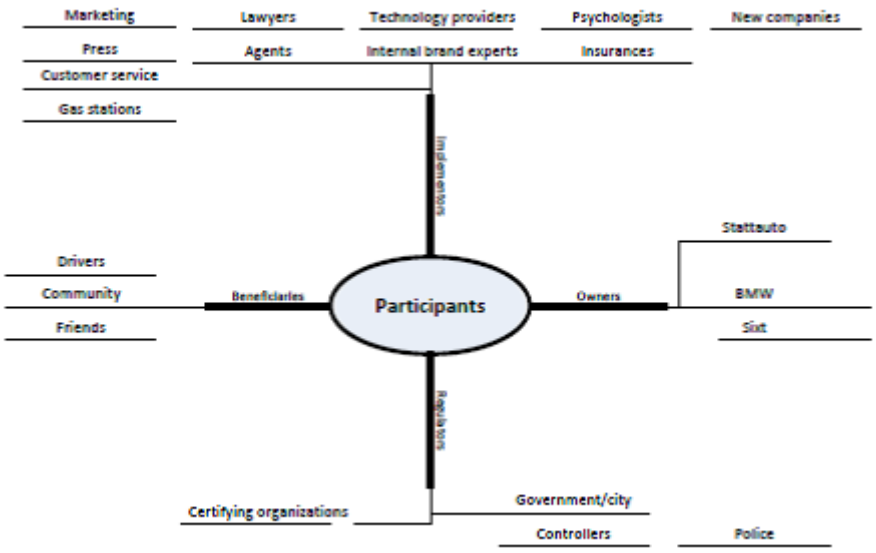

Figure 5.1: Participants

the introduction of the system, which Impact(I) and level of severity is expected, and what are the Responses(R) of the environment and users to the system regarding sustainability. Each one of the components in the DPSIR are implicit in the answers given by the interviewee. These DPSIR indicators were further used in step 2.

The following were the consolidated results from the interviews.

5.2 Car Sharing System Stakeholders

The participants in our system can be segmented into implementers, owners, beneficiaries and regulators. A list of them can be found in Figure 5.1. For our research only stakeholder from the beneficiaries group, the owners group, and (external) regulators were considered, due to the capability to interview them.

5.3 Observations

As a familiarization with sustainability and Car-Sharing systems, relevant literature was read, the system understand and an original list of stakeholders

identified. From this list with four main groups identified, we consider three of them were covered by our interviewed stakeholders, the members of the main groups were extended after the interviews with the new information provided.

Due to the use of a semi-structured interview all of them covered fairly equivalently the same concerns. Later with the protocol documented for each interview the system was better scoped and more insights were gained regarding how it works, the results were analyzed, categorized and structured with respect to the DPSIR.

Instruments

The possible instruments applicable for this step are: Dialog instruments, Early Detection, Eco-design/Design for environment (DfE), Environmental Shareholder Value, Mission Statement, Suggestion system, Supply Change Management (SCM), Sustainability Balanced Scorecard (SBSC), Total Quality Environmental Management (TQEV).

Chapter 6

Sustainability Indicators

For the identification of relevant indicators for our stakeholders, users and company representatives were interviewed, nevertheless this task cannot be asked in a direct way, therefore the DPSIR[4] technique was employed as an alternative and included in the questionnaire design in the previous step, in which the drivers, pressures, state, impacts and response were made explicit, lastly sustainability indicators were derived from the important elements.

Based on the structuring of the results of the step 1, according to the DPSIRs, the elements of each category were refined to afterwards derive the Root Definitions.

6.1 Sustainability Indicators Elicitation

First the DPSIR identification enabled the categorization of the elements to abstract them into more generic concerns in form of topics, topics which correspond to the TBL dimensions and two additional ones, Human and Technology respectively; to end up with five topics: Environmental, Social, Human, Economic, and Technology. For each one of the dimensions a general catalogue of Sustainability Indicators (SI) with its description and possible measures was produced and only a core set of representative and measurable SIs (between 10 and 30) that applied to our Car-Sharing system were chosen.

The root definitions explaining the rationale of the product and paraphrasing it into one sentence, were generated. The root definitions include all the BITAOC

elements - Beneficiaries, Implementors, Transformation, Assumptions, Owners, and Constraints.

The prioritization of subtopics was done with the aid of a company sustainability report, press publications and users feedback in the network, emphasizing our goal of transforming the current system into "an environment friendly Car-Sharing system".

6.2 SI Selection

6.2.1 Drivers-Pressures-State-Impact-Response indicators (DPSIR)

The drivers for the creation of the system depend on the stakeholder. For the users is more important to satisfy their daily needs, while for the company is important to obtain profit after providing the service. Thus for the user the main drivers found were the offering of a mobility service for not owners of a car as a massive community offer. For the company the main drivers were the extension of its market by offering another approaches to use cars, different from the regular purchase and ownership of them; in parallel enter into the market to consolidate as a mobility service provider of premium quality, what in turn enhances the brand, generates revenue, helps making the business sustainable and makes part of its continuous improvement. The sustainability incentive was also involved into the idea conception, and the main drivers to provide a Car-Sharing conform to all of the aforementioned drivers. The aim behind the system seek for the reduction of the amount of cars on the streets, helping so the sustainability efforts with respect to climate change, by reducing the amount of CO2 emissions, as well as for the cooperation with the government to offer alternatives to the current offer pool of mobility services.

In order to succeed in the aim some pressures have been introduced, which on one hand moves us towards the end purpose, but on the other hand is affecting the sustainability aspects, examples of these are the comfort of using a car, the easiness of the service as a decisive factor for the users to acquire the service, the flexibility to make use of the cars, keep low prices that makes the offer attractive and affordable while still making profit, attract new customers through publicity whether with printed material or through online press alternatives, keep a balance of the availability between the cars in use, in repair, parked and the amount of users demanding them, it is essential to ensure a responsible use otherwise the system cannot be implemented, provide customer support and maintenance, keep the system quality at a high level by introducing new technologies that improves

the service, offer an integral service and monitor the customer satisfaction, and dispose specialized businesses to take care of the operational tasks. Each of these pressures can be related to other pressures such as the need for trust to offer an easy access, or the plan and research in advance, to ensure the profitability of the initiative. Figure 6.1 depicts the DPSIR elements of our Car-Sharing system.

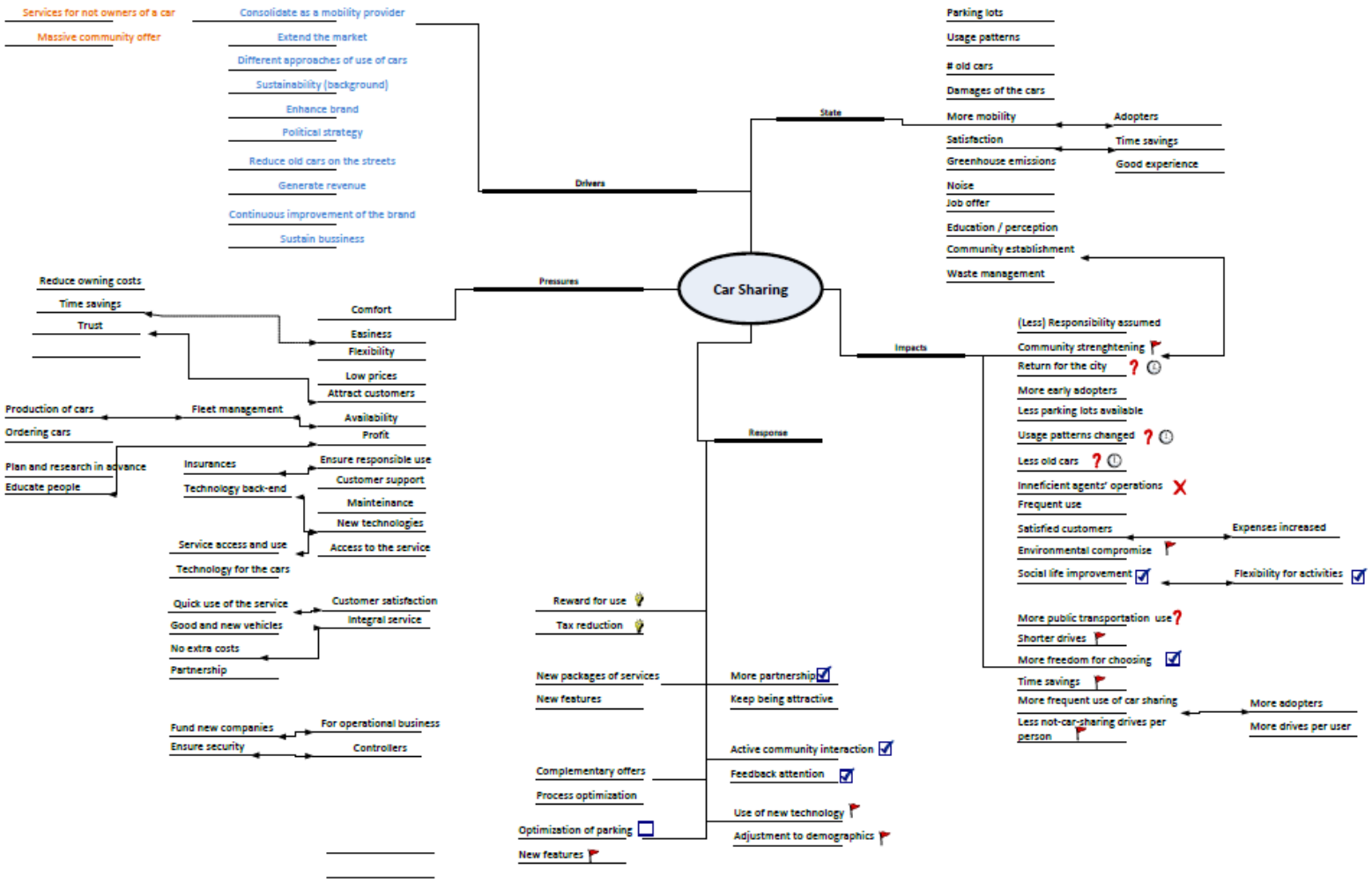

Figure 6.1: DPSIR Indicators

After introducing Car-Sharing system the state of the environment is expected to change and be observable, for instance the density of occupancy of parking lots, the modification of usage patterns, the number of old cars on the streets, the number of adopters, the customer satisfaction, the greenhouse gas (GHG) emissions, the noise, the number of new jobs offered, the education and perception of people of the sustainability concept, the establishment of communities, and the waste management.

Also the introduction of the system generates certain impacts, whether a reduction or an increase. Some of them are already verified whereas some others still need to be monitored. Within the monitored ones we find the strengthening of the community, the environmental compromise, the reduction of distance and time of drives, and the number of not car-shared drives per person. As verified ones we find the social life improvement of the users, and the freedom for using the service. As part of the ones that need to be monitored but the running systems also require some more time, we find the return for the city, the change of usage patterns, and the reduction of the number of old cars on the streets. Other expected impacts are the reduction of the degree of responsibility assumed by the users compared to the ownership of a car, the return for the city in monetary terms and regarding the distribution of spaces, the number of early adopters when introducing the system in other cities, the number of available parking lots (opposite to the initial aim of raising, it they were reduced), and the frequency of use of a car and car-sharing cars.

The response to the system experimented from the environment and society in the moment has been that the brand keeps staying attractive, the process has been optimized and complementary options, new features, and packages of services were offered. Positive responses are also the intensification of partnerships, the active community interaction, and the attention to the users' feedback. Some responses under monitoring are the adjustment to demographics, to new features and use of new technologies. Additional ideas as an incentive to use the system and rewards for usage are for instance tax reductions.

6.2.2 Root Definitions

A root definition is a structured description of a system and a clear statement of activities which take or might take place in the context of our system. A properly structured root defnition comprises three elements namely What the aim of the system is, How that aim is to be achieved, and whY the activity is carried out w.r.t. a long-term aim. This is stated as A System to do W, by means of H, in order to achieve Y".

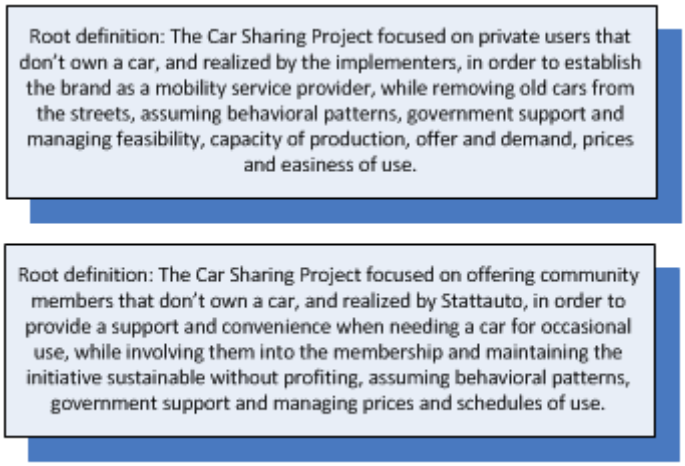

Figure 6.2: Root Definitions

From the interviews and an analysis the following two root definitions were defined:

1. The Car Sharing Project focused on private users that don't own a car, and realized by the implementers, in order to establish the brand as a mobility service provider, while removing old cars from the streets, assuming behavioral patterns, government support and managing feasibility, capacity of production, offer and demand, prices and easiness of use. Figure 6.2 left side.

2. The Car Sharing Project focused on offering community members that don't own a car, and realized by Stattauto, in order to provide a support and convenience when needing a car for occasional use, while involving them into the membership and maintaining the initiative sustainable without profiting, assuming behavioral patterns, government support and managing prices and schedules of use. Figure 6.2 right side.

6.3 Observations

Many of the matters of the DPSIR are a proof of the achievement of a goal, others are under monitoring, but no result is been delivered yet, some others still need time to give meaningful results when evaluated, various still lie on the clouds and are ideas or proposals from stakeholders that also need a process for

planning and studying feasibility of the implementation in order to become real, and for this system specifically only a handful are not considered by at least two of the stakeholders simultaneously.

The Car Sharing System is intended to reduce the use of a car individually and instead share rides and promote active mobility options to cause less impact in the environment. Opposite to claims there are currently more cars on the streets, we must concede there are more shared cars, but until know the conversion rate from drivers to car-sharing drivers or passengers is very low. More time is needed to evaluate whether the goal was achieved or not, and how the behavioral patterns of the users changed. In particular the environmental and social indicators are hard to measure and require long periods of time to show alterations, for the social dimension explicit feedback from the users in form of a survey or open suggestions and opinions is a better approach to obtain realistic values.

Instruments

The possible instruments applicable for this step are: Early Detection, Eco-design/Design for environment (DfE), Environmental Shareholder Value, Indicators, Mission Statement, Supply Change Management (SCM), Sustainability Balanced Scorecard (SBSC), Total Quality Environmental Management (TQEV).

Chapter 7

Sustainability Topics, Subtopics and Indicators for a Car-Sharing System

7.1 Mobility

The streets of the capital cities and big cities in the whole world face the problem of mobility of the citizens, the problem does reach other sustainability issues such as energy, politics, cultural habits and behaviors. Because mobility is involved into the daily activities of every person like going to school or work, buying groceries, running errands; some effects on the city and a larger extent that crosses geography come into place. From traffic congestion, passing by noise level, to air pollution and climate change.

Hence mobility is not only a major need of the current society, but is influenced by the development of technology and adoption of new means and modalities of transportation, like vehicles allowing for individual and massive transportation. With the introduction of such apparatus the society has experienced many changes in different aspects: socio cultural values, consumers' behavior, urbanization tendencies, multi-modular transport, economic models (ensuring an integrated transportation system), values, infrastructures of communication, and attitudes are concerned with the matter. For the sustainability consideration it does not suffice to consider only the final use of the transportation systems, behind them stay the productions systems, technological needs, team works, material processing; that represent the capability and improvement on the outcomes of manufacturing and distribution. In parallel but always attached we find the

economic aspect, which is in its own one of the major if not the main rationale of the product fabrication and service provision, the goal is to reach a high profitable margin by means of effective channels from the fabrication, through the sell and final usage.

As it can now be inferred, mobility finds its place in a society with multiple and varied participants within geographical and political boundaries. The activity and development of the place requires a conscious planning what makes the capacity of foreseeing a relevant skill required in the field, that will allow us to identify the trends of the industry, equip our team with production systems and different models of organization, and establish relations with external partners (e.g. suppliers and subcontractors) all of them mostly dictated by the urban structures available and present.

For the politics and urban development plans, there is the need to consider the emergence of new social actors and their integration in institutionalization, along with the common factors like social and demographic structures. But the effect impacts both sides, and the industry also needs to integrate the social areas when planning, designing and building new features, products and and services (these areas can be more decisive than technical specifications) but in certain extent should remaining isolated from them (creative process).

As an example of mobility as a main concern, the task is not only responsibility of the automotive industry; it is also embedded in discussions in aeronautics, railways sector, and information and communication technology. Mobility is related with other elements such as interfacing between community and transportation, multi-modularity of transports, what leads to solving new architectural problems, urban solutions, that in turn must intend to take advantage of the different transport networks. As mentioned before this strategies must go together with financial growing of the different sectors (e.g. aeronautic, railways, logistics, communication systems, construction, and automobile industry).

The fact that mobility plays an important role in the development of social and financial structures for the following at least 20 years, entering more and more into the protection of the environment field as a way to introduce sustainability and contribute to it, is an important piece of the big solution puzzle that still needs to be discovered in a high degree, and assembled.

In the research field of automobile whether in Europe, Japan, or USA, everywhere mobility is in the list of top ten priority interests of the industry, even it is so for the communications industry. Many framework programs for research are

loooking for innovative, easy, integrated, alternative proposals that contribute to the solution of the main addressed problematics such as energy, climate change, and of course transportation and mobility.

The Horizon framework research program [1] is for instance a framework program from the EU where one of the emerging themes is precisely "Mobility: individually attractive and socially sustainable". Within this thematic three subtopics were considered important:

Individual mobility versus public mobility

- "Tele-office in the backpack": mobility in movement?
- Germans "favourite child" - the new role of automobile

The Internation Motor Vehicle Program (IMVP) [2] also engaged in research in relation to the mobility theme, where sub-themes like the global reach, enabling and disruptive technologies and the organisational learning and knowledge management are analyzed on the light of items such as: "Green" drive train technology, New materials, recycling and environment management, and Mobility solutions.

In conclusion, mobility is and outstanding social need that is currently managed in some countries and cities, but what yet requires attention. There are needs for individual mobility and also needs for transportation of goods and services. It is important to remark the cultural questions related with the possession and exhibition of individual mobility goods (i.e. cars), but also questions related with the isolation of the individuals that resort to the individual commodities as a mean of personal valorization. Hence the importance of the massive transportation means has suffered a marginalization with respect to the collective use, urban planning (e.g. residential, industry, leisure spaces) that integrate fundamental activities of the society: labor, cultural, familiar and consumption dimensions.

7.2 Topics Identification

"Indicators are one way of building consensus around our long-term goals, and evaluating the impact of our local action...".

"We were so busy writing our plans and accomplishing our goals we lost track of how it all fits together, or where we were heading in 50 years. Nothing in the NRP planning process encouraged us to look at the linkages between issues. We can't afford to work in such a disconnected way in the future."

7.3 Topics and subtopics

Following the Imagine approach from the DPSIR analysis and the root definitions, topics and subtopics grouping similar concerns were defined and the sustainability indicators for the priority concerns of the stakeholders were derived. For this research the prioritization was not done since it highly depends on the stakeholder, therefore in order to keep generality indicators all the topics and subtopics were considered.

Taking as a base the TBL we defined the topics: Environmental, Social, and Economic, and extend them aggregating the human topic that resembles to the social topic, but entails only individual aspects whereas the social entails community and society; and the Technical topic, which embraces all the elements of feasibility and plausibility.

For each topic, subtopics were identified, respectively:

1. Environmental: conservation and efficiency, fossil resources, waste and pollution, quality and treatment, and resource management.
2. Social: landscape planning and design, transportation, demographic change.
3. Human: mobility.
4. Technical: capacity, demographics, support, technology.
5. Economic: business and economics.

7.4 Indicators

For each topic and subtopic the indicators where defined and described together with its measure and units.

Environment Dimension

Topic	SubTopic	Indicators	Description	Classification
Environmental	Conservation & Efficiency	Energy consumed	Consumption of energy in units (kWs) in a period of time (e.g. month, quarter) (Historical data)	Background indicator
	Fossil Fuel Resources	Price of crude oil (per gallon)	Price of the crude oil, indicates the scarcity or abundance of the resource (Historical data)	Background indicator
		Price of gasoline at local pumps (regular unleaded - per gallon)	Price of the gasoline, indicates also political and demographic circumstances (Historical data)	Background indicator
	Waste Pollution	GHG saved	Reduction of greenhouse gas emissions (MTCE - Metric tons of carbon equivalent)	
		CO2 annual savings per member	Reduction of individual CO2 emissions, due to the activities of each person (MTCO2E - Metric tons of carbon dioxide equivalent)	
		Reduction of traffic pollution	Concentration of pollution in the atmosphere (e.g., micrograms/m3) (Measured by simulation then validated with monitored measurements, or manually measured)	
		Lead content in (neighborhood) soils	Amount of lead present in the soils (e.g. g/cm3, mg/cm3)	

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Topic	SubTopic	Indicators	Description	Classification
		Toxins released by nearby industrial firms	Amount of toxic chemicals released to air, water and land as well as off-site transfers to sewage plants, recyclers , incinerators, deep well injection, and landfill for recycling or disposal (Company report - Toxic release inventory TRI, 650 chemicals)	
	Quality & Treatment	Air quality at nearest collection point	Presence of contaminants in the air (Carbon monoxide-CO, Nitrogen dioxide-NO2, Ozone-O3, Particulate matter-PM2.5 and PM10, Sulphur dioxide-SO2, Hydrogen Sulphide-H2S) (ppb: parts per billion, ppm: parts per million, g/m3: micrograms per cubic meter)	background indicator
	Resource Management	Users and stations interactions	Frequency of user of a particular station (# rents of a car in a particular station, #returns in a particular station)	background indicator
		Periods of use	Use and dead hours (hours and periods during the day)	
		Cars saved	Reduction of the numbers of private cars(# private cars not on the streets, # car shared cars used)	

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Topic	SubTopic	Indicators	Description	Classification
		Unavailability	To implement a complete maintenance procedure including preventive maintenance and to improve the management of material and human resources at medium term, the availability of the cars remains the problem to solve (# agents operations, duration of tasks, process inefficiency/efficiency, duration in maintenance, # available cars)	
		Estimated total consumption by all households in neighborhood	(1) Food items, (2) non-food items, (3) consumer durables, (4) housing, over a period of time (e.g year)	background indicator

Table 7.1: SIs for the Environment Dimension

Social Dimension

Topic	SubTopic	Indicators	Description	Classification
Social	Landscape Planning & Design	Stations distribution	Amount of stations per area (# stations/km2)	
		Parking density	Proportion between parking lots for the residents and visitors and occupancy during the day (Parking occupancy rate in peak hours and average hours during the day, number of parking lots per cars in the neighborhood)	
		Friendly spaces	Area of friendly spaces within a delimited zone (m2/km2)	

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Topic	SubTopic	Indicators	Description	Classification
	Transportation	Trip complexity	Complexity of trip chains for active population segments (# stop overs, # deviations, duration of the trip, unavailability periods)	location dependent
		Duration of peak periods	Duration of the peak periods of traffic during the day (# hours/day)	
		Saturation of some transit route segments	Level of congestion of the highly used routes (level of saturation per route/# of main routes)	
		Car occupancy	Percentage of car occupancy (# passengers/car, # cars in a level of occupancy/# total cars)	
		Accessibility	Level of accessibility to the service by population and age sectors (# users able to access the service/# residents)	
		Car ownership (community)	Car ownership level of the residents (# cars /person)	
		Mobility (community)	Need for transportation and mobility level of the residents (#trips/#residents, #km travelled/#residents, frequency of use, # different destinations (geographical location), # residents working outside the city/# total residents, average travel time of the residents)	Time period
		Bicycle-Car proportion	Proportion of the number bicycles traveling on key routes compared to number of cars (# bicycles/# cars)	

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Topic	SubTopic	Indicators	Description	Classification
	Demographic Change	Ageing	Percentage of each age sector (# residents within an age range/# total residents)	Emerging, background indicator
		Residence habitation	Percentage of residences that are vacant and/or boarded with respect of the total amount of residences within the city limits (# inhabited residences /# total residences)	background indicator
		International migration	Percentage of immigrants arriving and leaving the city (# immigrants arriving or leaving/# total residents)	Emerging
		Household	Number of households (# households)	background indicator

Table 7.2: SIs for the Social Dimension

Human Dimension

Topic	SubTopic	Indicators	Description	Classification
Human	Mobility	Active transportation use	Share of active transportation (Amount of time walking, cycling, # of activities performed by walking, cycling)	
		Mobility (individual)	Need for transportation and mobility level of the individual (#trips, #km travelled, frequency of use, # different destinations (geographical location), average travel time to work)	Age dependent, Location dependent

Continued on next page

Topic	SubTopic	Indicators	Description	Classification
	Community Interaction	Resident mobility rate	Level of mobility from the residents on a daily basis for the common activities (e.g. going to work, shopping, leisure)	background indicator
		Share of motorized modes	Use of shared motorized modes (frequency scale)	Age dependent
		Dependency towards motorized modes	Level of dependency to motorized modes (cars, motorbike)(Dependency scale)	
		Car ownership	Car ownership level of the individual (# cars)	
		Stabilization of transit share	Conversion rate from private to shared modes and duration of this conversion (# converted users x duration as converted user)	
		Transport flexibility (modes)	Transportation options and modes to choose by the individual (# transportation means x # modes)	
		Interdependency of transportation sustainable modes	Level of interdependency between the sustainable transportation modes (Interdependency scale)	
		Participation	Active citizenship, active social work, participation and engagement	Emerging
		Access	Legal or organization constraint to using the service (no valid (-European, American-) driver's license)	Emerging

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Topic	SubTopic	Indicators	Description	Classification
		Identity	Social and individual identity as an affiliation and acceptance to a population sector and community groups (social identity scale, individual identity scale, regional identity scale, cultural identity scale)	Emerging
	Sense of belonging	Sense of Place	Identification of the place as own	Emerging
		Culture	Cultural values (Hofstede's measures)	Background indicator
		Education and skills	Level of education and cultural values of the residents (Education level scale)	Emerging
	Security	Safety	Normative and perceived safety level of the users using the service, and the users who feel safe by the others using the service (# accidents/period of time, # individual injuries, # car damages)	Emerging
		Security	Normative and perceived security level of the users using the service, and the users who feel secure by the others using the service (# crimes/ period of time)	
	Welfare	Well-being	PQLI - Physicial Quality of Life Index. Livability (Economist Intelligence Unit's quality of life index, Mercer's quality of living reports)	Emerging

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Topic	SubTopic	Indicators	Description	Classification
		Happiness	Mental or emotional well-being state of positive and pleasant emotions (Subjective happiness Scale (SHS), Positive and negative Affect Schedule (PANAS), Satisfaction with Life Scale (SWLS))	Emerging
		Quality of life	Economic well-being (leisure, wealth, non-market activity, unemployment, insecurity). GDP (consumption, net investment, depreciation, net income going to foreigners, regrettables) (GDP - Gross domestic product). Individual living conditions (environment, health, inequality, education)	Emerging

Table 7.3: SIs for the Human Dimension

Technical Dimension

Topic	SubTopic	Indicators	Description	Classification
	Capacity	Capacity	Capacity of cars running on the city (Max. number of cars running pro period of time)	
		Estimated market value, tax capacity, and taxes payable for residential	Derived from tax capacity the probability of somebody buying or renting a car	Background indicator

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Technical

Topic	SubTopic	Indicators	Description	Classification
Demographics	Demographic capacity	Number of residents that the city can host (Max. number of residences, max population, max number of families, max number of single residents)	Background indicator	
	Support	Government support	Industry activity and government supporting the offering of the service (Agreements and support from the government)	
		Customer support	Infrastructure and resources disposed for attending customer requests either physically or via internet (Call center, chat, contact forms, FAQ)	
		Self-service	Platforms for using the service in an individual and independent basis (Communities, website, online services)	
	Technology	Technology availability	Availability of technology contributing to sustainability issues (Technology characteristics and features)	
		Technology access	Access to the technology and equipment needed to operate it (Technology appliances and applications)	Target audience dependent
		Extension/Integration	Services with complementary alternatives to enhance the experience of the user with the system (Integrated applications and accessories)	

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Topic	SubTopic	Indicators	Description	Classification
	Communication	Green IT	Use of green IT technologies and techniques (Adoption of mobile solutions, virtualization of infrastructure and services)	
		News	Use of communication mechanisms to inform the customer about news of the service (Rate of press publications, new offers, partnerships)	
		Coordination	Use of collaboration mechanisms to coordinate tasks and resources involved in the service provision process (Platforms for requests, automatic notifications, monitoring, scheduling)	
		Feedback	Spaces for receiving feedback from customers and partners (Available means, surveys, contact forms)	

Table 7.4: SIs for the Technical Dimension

Economic Dimension

Topic	SubTopic	Indicators	Description	Classification
	Business & Economics	Supply/demand balance (saturation)	Balance between the products manufactured and the demand of them by the customers	
		Economic development	Utility of the economic activity (Profit in a period of time)	

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Economic

Topic	SubTopic	Indicators	Description	Classification
		Affordable housing	Proportion between house prices or rent prices with respect to the net income of an individual or families	Background indicator
		Affordable and available food	Proportion between the prices at what the aliments are sell to the residents, the availability of them and their incomes	Background indicator
		Users (new, old, leaving, returning)	Number of users and segmentation between new, old, leaving and returning users (# old, # new users, # leaving users, # returning users, # total users)	
		Usage	Frequency level of use of the service in a period of time (# times service used/period of time)	

Table 7.5: SIs for the Economy Dimension

7.5 Observations

The prioritization of indicators in a neutral position is not an easy task even maybe unfeasible, since it is highly dependent upon the stakeholders, for this reason and to avoid the bias that can take place in this analysis we based our selection in the Figure 10 matrix, which relates the concerns of both the owners and the beneficiaries stakeholder groups. This way considering the goals that are relevant for both of them simultaneously and considering some highly relevant SI individually.

Some of the indicators might have relationships with others and therefore are immediately selected by inclusion.

Instruments

The possible instruments applicable for this step are: Controlling, Cross-impact analysis, Eco-design/Design for environment (DfE), Environmental Shareholder Value, Indicators, Reporting, Supply Change Management (SCM), Sustainability Balanced Scorecard (SBSC), Total Quality Environmental Management (TQEV).

Chapter 8

Band of Equilibrium: Future Scenarios

8.1 Transforming a regular Car-sharing into an environment friendly Car-sharing

The development of a Car-Sharing system concept has several objectives that belong to one dimension, but which of them is more important varies the stakeholder being asked. The information with respect to the economic objectives is highly confidential, therefore difficult to obtain and be publicized. All together agreeing on the importance of one or another factor is rather complicated, for that reason we stated the transformation of the Car-Sharing system into an environment friendly one, our main purpose in this research.

8.1.1 Impact of cars in the environment

On one hand cars have lots of advantages in terms of mobility to their owners, in spite of this the owner incurs into extra costs, and can also find it frustrating and stressing when the streets are flooded with cars hence making the travelling time a long and tense wait. On the other hand the use of cars although aimlessly has a big impact in the environment, respectively is responsible for a significant percentage of the CO2 emissions that cause the climate change.

8.1.2 Vehicle lifecycle stages and their contribution to the climate change

The lifecycle of a vehicle can be seen in four main stages, starting from the extraction and processing of raw materials, going through the assembly, selling and

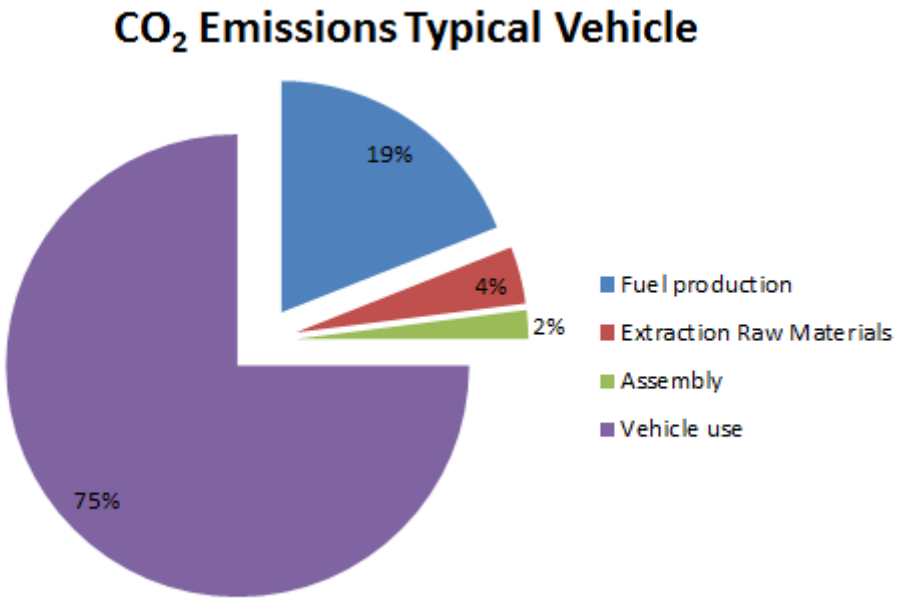

Figure 8.1: CO2 Emissions from the Lifecycle of a typical vehicle. Data from [15]

distributing the vehicles, use and destruction. In Figure 8.1, only three of them are considered, additionally the contribution of the fuel production is considered separately from the extraction of raw materials. There we can see that the stage within the lifecycle of a vehicle contributing the most to the climate change is the daily use, the combustion of gasoline and diesel fuels allocate the greatest proportion of CO2 emissions (75%); other activities like raw materials transformation and assembly only correspond to 4% and 2% of the total emissions. It's then in the use where we can find a leverage for the reduction of CO2 emissions.

Table 8.1 presents a comparison of the CO2 emissions reduction in previous implemented car-sharing programs in different countries. In general there was a reduction above 15%.

8.1.3 Context of our Car Sharing System

About Munich

The current situation of the city where the system was introduce, provide some important contextual information that must be considered together with the facts, to understand why do we obtain these results and no others.

C-S provider or country	Specific CO2 emissions of C-S fleet	Number of vehicles in C-S fleet	Specific CO2 emissions of the national vehicle fleet	% lower consumption	Comparison year	Source
Mobility, Switzerland	151g/km	2200	183g/km	17.5% (total 1510t in year)	2008	Mobility 2009
Various, Germany	148g/km	1042 (included in the study)	176g/km (new cars only)	16%	2003	Knie, Canzler 2005
Cambio, Germany	129g/km	575	165g/km (new cars only)	21.2%	2009	Cambio Journal 19/2009 German Federal Bureau of Statistics
Cambio Belgium, Belgium	117g/km (Flanders) 120g/km (Brussels) 122g/km (Wallonia)	248 (included in the study)	155g/km (new cars only)	21.3-24.5%	2008	Taxistop
4 providers, Italy	127g/km	236			2008	Momo survey
Various, Great Britain	110g/km		171g/km (assuming replacement of personal cars after 6 years)	36%	2007	Carplus 2007

Table 8.1: Results of implemented Car-Sharing Programs

The city of our example is Munich, in Germany. Its current population raises up to 1'419.781 inhabitants. 41% of the citizens use the public transportation system on their way to work. The percentage of people that don't live in the city but have daily activities or guests such as tourist or business people that have assignments for short periods of time in the city, and that use the public transportation increased in comparison to 2011 in a 2.2% resulting in 633.2 million people. The total number of vehicles in the city during the 2011 exceeded the

600.000 vehicles.

The number of traffic accidents registered in 2010 was of 39.440 resulting in 5.613 persons injured.

8.1.4 Main goal - an environmentally friendly Car-sharing

The fuel consumption of each car is the highest contributor to the GHG emissions in their lifecycle and the impact is magnified by the number of cars running on the streets. This number increases as every individual wants to go to a particular place by driving his own car, hence occupying in many cases only one or two seats from the five available in the car.

8.1.5 Types of Eco Friendly Cars

- Hybrids: These work by capturing the energy that is created when the car breaks. This energy is stored in batteries, then used as fuel until it is gone, at which point the car switches automatically to the gas engine. Hybrids are quieter than conventional cars and don't require special facilities for fueling. In California or Arizona, people can get the added bonus of being able to use the carpool lane any time they wish.

- Biodiesel: This fuel is a blend of vegetable oil and conventional diesel fuel. Any existing engine that uses diesel fuel (most trucks, for instance) can use biodiesel with no equipment conversion or other extra measures, although you might wish to change your oil filter slightly more often. You can also switch back and forth between biodiesel and regular diesel if you don't have a steady supply.

- Biodiesel is a great way to make driving more eco-friendly with the already owned car, or with a used one. Diesel engines can be modified to run on straight vegetable oil (SVO), although fueling with SVO entails more work for the consumer.

- Ethanol-based - This type of fuel additive is usually made from wheat, corn, or barley. The most common fuel made from ethanol is called E85. E85 is a blend of 15 percent conventional gasoline and 85 percent ethanol. Ethanol is eco-friendly because it reduces emissions. As a bonus, it also costs less than conventional gasoline in most locations.

Some of the aims of Car-sharing are the reduction of the traffic congestion by filling the empty seats and shrinking the amount of cars on the streets, while covering the same journey for less fuel, saving costs and facilitating the traffic

flow, due to the cars running more efficiently without wasting time and fuel sitting in traffic jams.

Many people use the scheme not only as means for saving money, but to contribute to the decrease of carbon emissions. In some cities the program is governmentally supported by the provision of information, advertisement of the communication through websites and the agreements and parking deals for the use of car sharers.

8.1.6 User conversion - prerequisites for becoming a user

The service is a good option to substitute old cars, save money and reduce the use of a car individually. However this might imply some adjustments in the lifestyle of the users, urban dwellers with access to public transportation for daily journeys are highly compatible users towards green travelling. When car is not the most convenient option anymore, people will automatically optimize the trips, avoiding unnecessary journeys.

8.2 Development of Future Scenarios

With the prioritized SI and information about boundary values of specific measurements gathered from standards, regulations, press publications, detailed descriptions of the concept, and our position of obtaining an environmental friendly car-sharing, the boundaries for each indicator and a goal value was elicited.

For the boundaries we have two values, namely the upper bound which is for us the Maximum sustainable value the indicator can have, and the lower bound, for us the Minimum sustainable value for the indicator. Any value above the Maximum sustainable is unsustainable by excess, and any value below the Minimum sustainable is unsustainable by lack.

8.3 Results

In order to balance the priorities for car producer and the priorities for the users, considering the laws established by the regulatory entities are mandatory and have the highest priority, we used the priority matrix made public in the sustainability report of the owner company [8].

In 2010 the company held an intern meeting where the following priorities where identified from two different points of view, respectively stakeholders and the company. The following topics were identified:

1. energy supply and renewable energies
2. climate change and co2 emissions
3. alternative propulsion technologies or technologies for the engine and electromobility
4. LCA products, components and product safety
5. environmental and social standards in the distribution chain
6. sustainability management
7. consumer safety
8. product recycling
9. employee's health
10. traffic safety
11. continuously growing usage of raw material
12. environmental friendly production and mobility concepts
13. fight against corruption and demographic change
14. corporate engagement
15. water
16. arrangement family and work
17. diversity in the company
18. biodiversity

From these topics the 5 with the highest priority for stakeholders and both parties in decreasing order of importance were: (1) energy supply and renewable energies, (2) climate change and co2 emissions, (3) alternative propulsion technologies or technologies for the engine and electromobility, (4) LCA products, components and product safety, (5) environmental and social standards in the distribution chain.

Differing a little from the major concerns of the company which were in decreasing order of importance: (2) climate change and co2 emissions, (3) alternative propulsion technologies or technologies for the engine and electromobility, (1) energy supply and renewable energies, (5) environmental and social standards in the distribution chain, (9) employee's health.

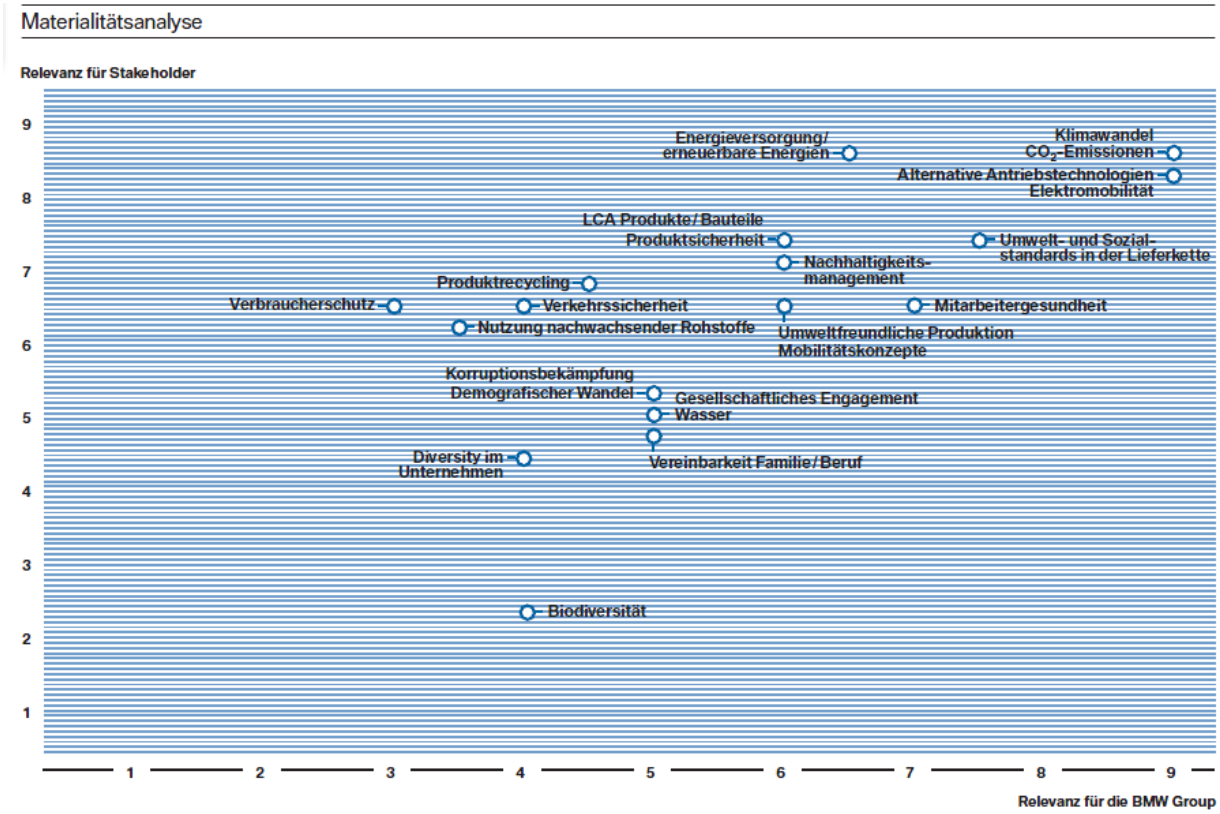

Figure 8.2: Prioritization of concerns. From [8]

Figure 8.2 depicts the prioritization of the concerns for the company in relation to its stakeholder.

8.3.1 Current situation

To date, vehicles with particularly low emissions or climate-friendly drive systems have been introduced into Car-sharing fleets in only a few cases. Some of the reasons alternative drive systems haven't been used more often in Car-sharing to date are:

- The often significantly higher purchase cost of vehicles with alternative drive systems are difficult to reconcile financially within the Car- Sharing fee structure (lower fees for smaller cars) given the relatively short lifespan of vehicles used in Car-sharing. Without financial project support, the relatively tight budgets that most Car-sharing providers work within don't allow them to act as testing grounds for not-yet-fully-developed vehicle technology, thereby taking over the manufacturers' financial and availability risks.

- Alternative drive systems may be seen as barriers by inexperienced Car-sharing customers who may fear being billed for any mistakes they make (for example in tanking up/recharging). This constraint exists even if fears are not based in fact but only the customer's perception.

- Cost transparency decreases distances driven: The high initial costs of a personal vehicle seriously - and understandably - reduce the willingness of car drivers to choose the most appropriate mode of transport for each individual journey. The depreciation of a new (or like-new) vehicle is seen as unavoidable, leading to the attitude: "since I've paid for the car, I should use it as much as possible". Such an attitude blinds car owners to the specific strengths of other modes of transport for certain journeys at certain times and inhibits an optimized and efficient use of all transport modes.

8.3.2 Particular future perspectives of Car-sharing

The goals of the Car-sharing system of the company of our research when thinking on the implementation of the project were:

1. Extend the portfolio with a sustainable (zukunftsfhige) mobility offer (e.g. sub brand BMW i) "Wir bleiben Automobilbauer, ergnzen aber das Portfolio um Mobilittsangebote."

    - Cover the always heterogeneous preferences and mobility requirements of users
    - Access and develop a new target groups, mobility products, services and marketing concepts
    - Use car sharing as an element to develop the new mobility, linked with electrification of the engine
    - Develop the key market for electroCar-sharing (by 2015 there should be 80000 charging stations within Europe)

2. To offer a modern mobility concept

3. Start in Munich and then implemented it in Berlin, and in more cities afterwards (short term goal)

4. Deploy to other European metropolis in the following years (medium term goal)

5. Introduction to other continents (long term goal)

6. Introduction of electric cars in the fleet (e.g. reduce co2 emissions, no date defined yet for this)

7. 1 Million members by 2020 (long term goal)
8. Provide parking assistance systems
9. Replace under used, old and inefficient cars
10. Reduce traffic load (this maybe requires more strict regulations)
11. Cooperation with other businesses (e.g. flinc) and government (we might think of partnerships and agreements with the other providers/competitors)
12. For flinc: integrated Social Mobility Network
    - Cooperation and integration with navigation information providers and navigation solutions
13. Emission free production (i.e clean production, in the long term this will be necessary to be competitive)
    - Resource management
    - Waste management
    - Introduction of renewable energy in the plants (sustainable mobility can only be instantiated in sustainable structures)

8.4 Complementary options

8.4.1 Cleaning tasks optimization

Owning a car implies maintenance and periodical cleaning activities, like washing. Washing the car therefore can be done in a eco-friendly way, that is possible because they employ recycled water, optimize the use of water (often 50% less than a traditional wash in the driveway of the owner), and the water is drained into sewer systems so that it gets treated.

8.4.2 Saving fuel consumption

- Quickly accelerating to the cruising speed (more efficient than slowly accelerating)
- For every 1 MPH you drive above 55 MPH, you will lose almost 1 MPG (primarily due to aerodynamic drag).
- Try to keep your speed below 42 MPH (this will prevent the engine from running)
- Use a fuel efficient model (it has the biggest aggregate potential reduction in greenhouse gas emissions at 31.4 millions of metric tons of carbon a year).

- Offer/use carpooling when possible
- Use active mobility means (e.g. cycle, walking)
- Travel planning (e.g. gps route, current traffic information, carpooling, company bus route) o
  - Achieve carbon reduction and other environmental gains by promoting and adopting more sustainable modes of transport
  - Help the local community by reducing traffic on roads and helping to improve public transport services
  - Provide financial savings by reducing the need to travel using single occupancy car journeys
  - Contribute towards a healthier workforce by promoting active travel and less stressful modes of travel
  - Contribute towards a more productive workforce by reducing the need to travel and providing the opportunity to work whilst on route to a destination.
- Use of active, cycle, public transportation, and Car-sharing in an integrated way
- Make use of remote flexible-working practices when possible (e.g. remote access, home office, video conferencing)
- Community and neighborhood engagement (e.g. land planning - a nice example of positively re-purposing land can be seen in the southern German city of Freiburg. In a newly-developed neighborhood, residents made a conscious decision not to own personal cars but to use Car-sharing instead. There, car-free households can meet the legal requirement of one parking space per newly-built flat through the purchase of a property share. While car-owning households must purchase a car parking space in a central community garage, the land of the carfree households is green space and play areas that are used by all residents of the neighborhood)
- Steepen the "learning curve of Car-sharing participation" (e.g. effect of optimizing the mobility due to not owning a car. For those who rarely use a car anyway, Car-sharing can serve as an assurance of mobility that largely supports an environmentally-friendly attitude to transport and ensures that being car-free isn't seen as a limitation to mobility).

8.5 Observations

Instruments

The possible instruments applicable for this step are: Controlling, Cross-impact analysis, Eco-design/Design for environment (DfE), Environmental Shareholder Value, Indicators, Reporting, Supply Change Management (SCM), Sustainability Balanced Scorecard (SBSC), Total Quality Environmental Management (TQEV).

Chapter 9

AMOEBA

An graphicall representation for the selected SI in step 2, and the future scenarios in step 3 was obtained, namely our AMOEBA diagram. In it diverse information is presented simultaneously, such as the band of equilibrium expressed in terms of minimum sustainable, maximum sustainable, the goal, the current values, and the extent of the dimensions considered.

9.1 Development of the AMOEBA Diagram

The AMOEBA diagram is similar to a radial diagram which consists of concentrical circles of increasing radios that represent an value in a determined scale and present information on various axes simultaneously. For each serie the values for each axis are graphically marked and for the same serie the points are linked through lines, creating the shape of an amoeba. In our case the the axes are the selected SI, the series represent the current scenario, the goal scenario, the maximum sustainable boundaries, and the minimum sustainable boundaries, and the values are give by the pair indicating the SI and the series.

We develop two diagrams with the same values, a first one depicting the current and goal values for each indicator, as well as the boundary values (i.e. mininum and maximum), all of them as surfaces than ideally should overlap making a similar shape in the same orientation, that signifying we are reaching our desired state. The SI must be grouped by dimensions to obtain equal shapes in the two diagrams. All the values of the goal scenario should be contained above the minimum sustainable and below the minimum sustainable, and in the best case all the values of the current scenario as well, whenever they are far apart from

the goal value, corrective actions must be applied to move this value towards the goal.

The second depicts the current and goal scenario of our system are depicted, also the boundaries for the indicators, all of them as functions, and an overposed surface indicating the distribution with respect to the dimensions (i.e. environment, social, human, technical, and economic) of the SIs. In this diagram ideally all dimensios are equitative distributed, i.e. the system covers all the dimensions in equal proportion, or sustainably.

9.2 AMOEBA

For each SI the four values corresponding to the boundaries, and the current and goal scenario are depicted in the AMOEBA diagram as aforementioned. Figure 9.1 shows the first type of our AMOEBA diagram.

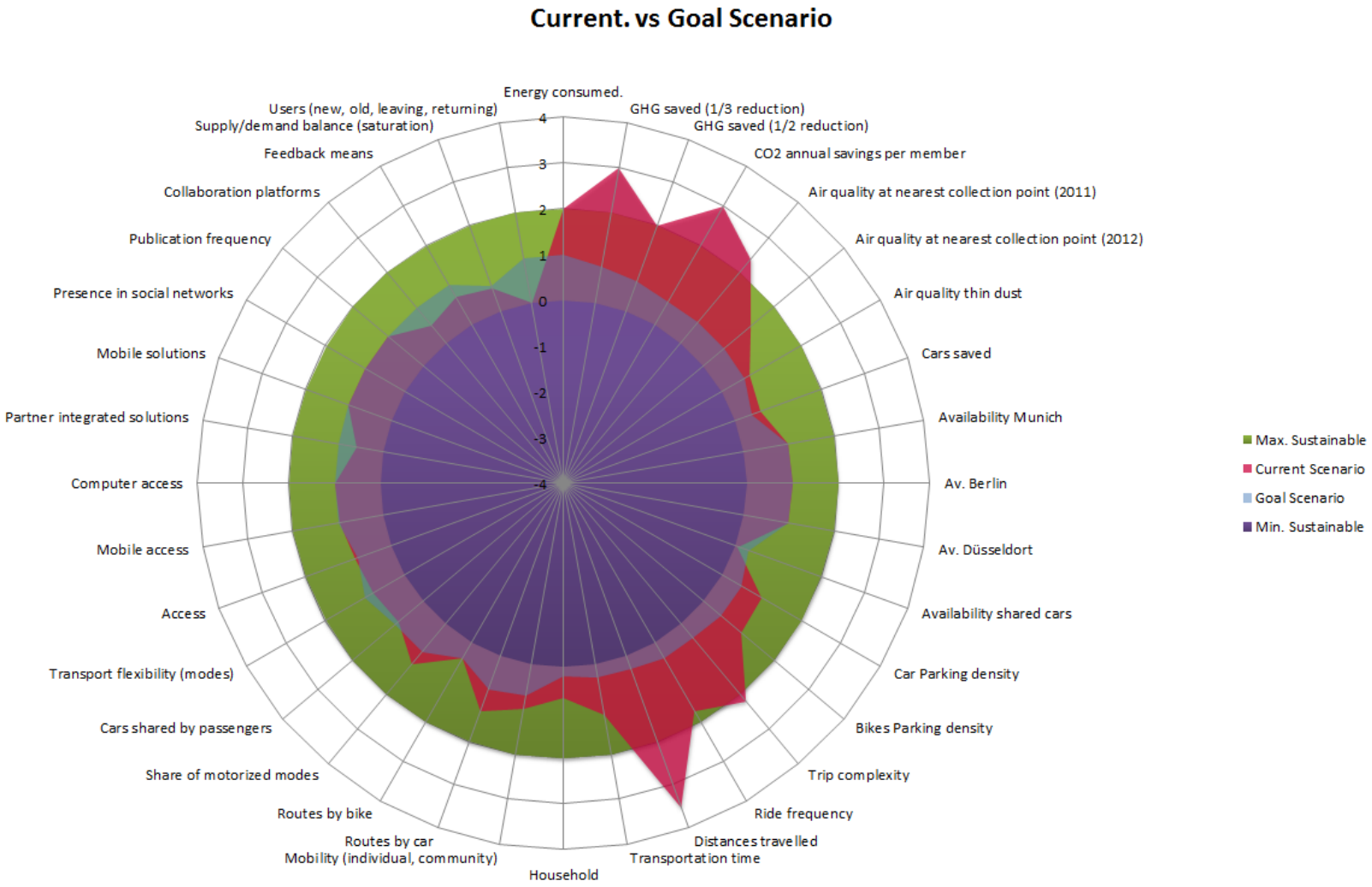

Figure 9.1: Current Vs. Goal Scenarios

The SI are grouped by dimension and is denoted by an overposed surface for each group. Figure 9.2 shows the second type of our AMOEBA diagram.

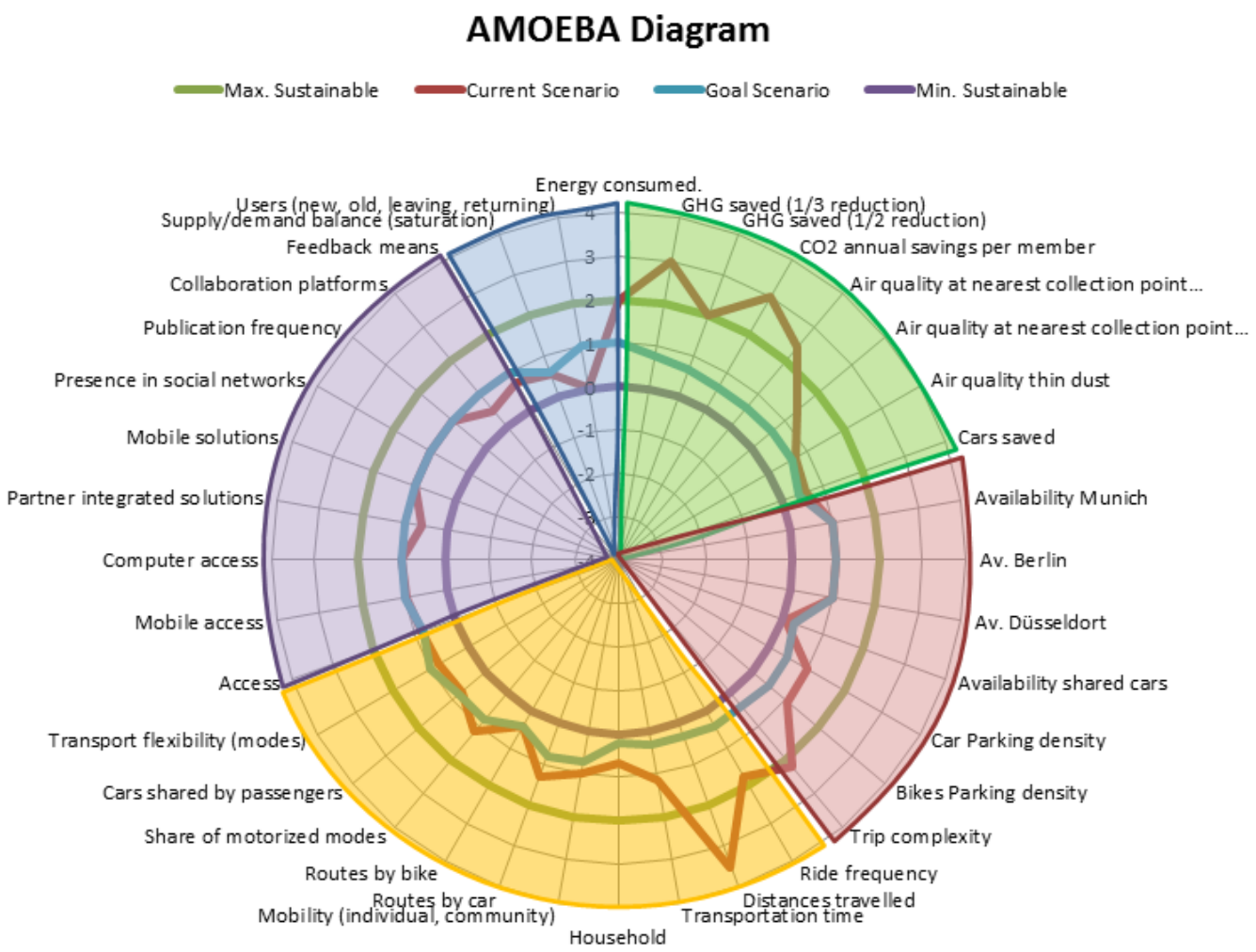

Figure 9.2: AMOEBA Diagram

9.3 Observations

According to our AMOEBA diagram and the band of equilibrium, currently 40% of the indicators are unsustainable, all of them my exceeding the maximum sustainable boundary, and 41% of these indicators greatly exceed this limit. 6% are currently in the minimum sustainable, and need remain the same or at least increase its value to not cross the border and become into an unsustainable by minimum indicator. The remaining 50% lies between the boundaries, but only 33% have reached the goal. It means an approximately 67% need to move towards the goal value, which implies a high potential for improvement, and a committed action looking for a change.

Instruments

The possible instruments applicable for this step are: Controlling, Corporate Social Accounting, Corporate Volunteering, Cross-impact analysis, Dialog instruments, Early Detection, Eco-design/Design for environment (DfE), Environmental Shareholder Value, Indicators, Mission Statement, Reporting, Scenario analysis, Sponsoring, Suggestion system, Supply Change Management (SCM), Sustainability Balanced Scorecard (SBSC), Total Quality Environmental Management (TQEV).

9.4 Conclusion

The extension of the Imagine approach has been successfully applied in this industrial case study with a system that has been online for a year, supported by IT and with a focus on sustainability in its roots. The developed indicator catalogue is available for use in other assessments in related application areas.

The first two steps are mainly used to scope the right problem and therefore the participation of several stakeholders from each group enriches the result. The third step provides succinct information and an overview of the current system status, as well as it provides insights and indications of strenghts, weaknesses and potential for improvement. The fourth step is there to enable exibility and make possible an evolutionary assessment over time. This information can later be used for informed and precise decision making relating to sustainability matters.

For the future work remains a complete toolset to support the execution of the whole approach, which eases the current and historic information management, and the review step in posterior revisions. This work can be integrated to be part of a broader sustainability quality model and established as a state of the practice standard for assessing sustainability in any context.

9.4.1 Advice for improvement

Is important to always evaluate the feasibility of the goal scenario and to ensure the right measurements are implemented and the changes perceived by the people involved. The last with the purpose of maintain the attention and collaboration of the participants. The use of the following instruments might help in the realization of the defined actions towards change.

- Controlling
- Corporate Social Accounting
- Corporate Volunteering
- Cross-impact analysis
- Dialog instruments
- Early Detection
- Eco-design/Design for environment (DfE)
- Environmental Shareholder Value
- Indicators, Mission Statement
- Reporting
- Scenario analysis
- Sponsoring
- Suggestion system
- Supply Change Management (SCM)
- Sustainability Balanced Scorecard (SBSC)
- Total Quality Environmental Management (TQEV).

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Appendices

Appendix A

Appendix 1

A.1 DPSIR Questionnaire

OVERALL STRUCTURE

1. DRIVERS: Where did the idea come from? In response to which needs did the initiative originate?
2. PRESSURES: Which interventions/actions were needed to address these needs? How do we solve the problem?
3. STATE: How did the environment/social/economy/technology previous state change? What did change after the solution to the problem was used?
4. IMPACT: What exactly changed? How did the state change (improvement, worsening)? Which risky/undesirable or desirable impacts did the solution cause? What where the consequences of applying the "solution"?
5. RESPONSE: What were the policies/actions implemented to counteract the undesired impacts or mitigate the risks? How could be the current situation adapted and transformed into a desired one (what actions)? How effective was it?

DRIVERS - What does the Project intend to solve or improve?

1. Where does the initial idea of a Car Sharing come from? Was there any existing problem that the Car Sharing system tried to solve?
    - Economic objective
    - Environmental objective

- Social objective

2. What were the objectives of building a Car Sharing system?

   - Economic objective
   - Environmental objective
   - Social objective

3. Is the Car Sharing System Project relevant to the countries' development objectives?

4. Is the Car Sharing System Project relevant to the company's development objectives?

   - Economic development objective
   - Environmental development objective
   - Social development objective (legislation, certification, etc.)
   - Technological development objective

5. What was the audience intended to reach? How would you segment this audience?

6. What are the needs of the target users? Does the Project address these needs? How does it address them?

7. Why is the Project relevant in light of users/partners/government?

8. How are the objectives of the Car Sharing System intended to be achieved? When are they considered to be achieved?

PRESSURES - How are the solutions to solve the problem?

1. What actions were needed to achieve the Car Sharing System objectives (activities)?

2. What resources were used to achieve them (physical and economic resources)?

3. Which external interventions where needed to achieve them (government, international organizations, etc)?

4. What were the areas of focus or priority issues to solve?

STATE - What aspects of the environment, society and economy changed with the solution?

1. What changes were observed in the environment after Car Sharing was introduced?
    - Quantitative/Qualitative
2. What changes were observed in the society after Car Sharing was introduced?
    - Quantitative/Qualitative
3. What changes were observed in the economic aspect after Car Sharing was introduced?
    - Quantitative/Qualitative
4. Were there any unplanned direct or indirect effects discovered? Which?
5. What improvement/worsening did the Car Sharing initiative cause?
    - Economic improvement/worsening
    - Environmental improvement/worsening
    - Social improvement/worsening
6. Which measures were applied to gain more of these improvements/ reduce the worsening (Management actions, consumer actions, policies or laws, marketing, campaigns, system's changes, governmental intervention, institution cooperation, international agreements/standards)?
7. Was the Car Sharing System rolled out in another country? What was affected, different to the case of Germany?

IMPACTS - How did the solution impact the environment, society and economy?

1. How did the previous state of the environment, society and economy changed after the Car Sharing System was introduced and used? What did improve, in which extent? What did worsen, in which extent?
2. Was the Car Sharing System Project effective in achieving its expected outcomes? Which objectives were effectively attained? Which objectives were not met?
3. What priorities and challenges of the targeted users were not addressed?
4. Which risks did occur after the Car Sharing System's rollout?

RESPONSE - What measures were taken to achieve the unattained objectives and to counteract the undesired effects?

1. What results deviated from the initial plan after the rollout?
2. How was risk and risk mitigation managed?
3. What undesired effects happened? Were they considered previously? Which actions were applied to correct them?
4. What changes could have been made (if any) to the design of the Car Sharing System in order to achievement more of the expected results?
5. To what extent were partnerships/ linkages between institutions/cooperation with other organizations/ government collaboration agreements, encouraged and supported to achieve more objectives? Which partnerships/linkages were facilitated? Which one can be considered sustainable?
6. Did the Project take into account local capacity in design and implementation of the Project?

SUSTAINABILITY - Are the initiatives and results of the Project allowing for continued benefits?

1. Is the capacity in place at the national and local levels adequate to ensure sustainability of the results achieved to date?
2. Are the activities and results being replicated elsewhere and/or scaled up?
3. What are the main challenges that may hinder sustainability of efforts? What are priority and must be directly and quickly addressed?
4. Is there evidence that Project partners and government will continue their activities beyond Project support?
5. Are laws, policies and frameworks being addressed through the Project, in order to address sustainability of reforms?
6. Which focus areas/arrangements under the Project show the strongest potential for lasting long-term results?

ANY OTHER COMMENTS?

List of Symbols and Abbreviations

Abbreviation	Description	Definition
CAP	Community Advisory Panel	
DfE	Design for environment	page 7
DPSIR	Driver-Pressure-State-Impact-Response	page 21
GHG	Green House Gas	page 29
NGO	Non-Governmental Organization)	page 1
R&D	Research and Development page 7	
SCM	Supply Change Management page 10	
SBSC	Sustainability Balanced Scorecard	page 11
SI	Sustainability Indicator	page 25
SSA	System Sustainability Analysis	page 3
SVO	Straight vegetable oil page 52	
TBL	Triple Bottom Line	page 17
TQEV	Total Quality Environmental Management	page 11
WCED	World Commission on Environment and Development	page 17

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