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Motorsport and Sustainability

Case Study of MXStar Team's Environmental Impact Optimization

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Abstract

Given paper discusses motocross as a part of motorsport from the viewpoint of sustainability and considers continuously growing impact of human activity on the environment.

The theoretical framework of this paper is based on the concepts which position motorsport in a context of sustainability at both global and team levels within the borders of systems theory.

Training and racing activities of the MXStar team based in Uppsala (Sweden) are described in the paper from the environmental perspective. Changing of the team's technical performance as well as their behavioural models has certain driving and restraining forces that are analyzed in particular in the discussion part of the paper. Recommendations for the MXStar team have been developed in accordance with the results of detailed analysis of the team's environmental impact.

The authors concluded that environmental performance of motocross racing composes from technical and behavioural inputs of each participating team. In order to optimize the environmental impact of the motocross each team member has to be innovative in both perspectives.

Keywords: environmental impact assessment, ecological fuel, motocross, MXStar team, sustainable development, SWEMO, Yamaha.

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1. Introduction

Motorcycle sport plays a significant role in the social and economic life of industrialised societies. At the present time interest in this sport is rapidly growing, planners as well as competitive teams stand in front of a great challenge: they must address the increasing demand for tracks land, cars/bikes, fuel and other facilities in order to run the competitions. The challenge of sustainable development calls on investors and race planners to balance on three pillars: environmental, economic and social. The task of decreasing environmental impact of motorcycle sport is daunting and can be approached in the best way by the case study on the case basis. By doing a case study team's specific problems can be described and specialized solutions can be found. The case study illustrates difficulties in the implementation of the proposed solutions without compromising team's power and efficiency.

Great importance of the environment combined with the phenomenon of climate change caused by human activity at the global scale, emphasizes the necessity of looking at various human activities differently. Energy resources maintenance, energy production and use are issues that are widely discussed nowadays by the governments, representatives of commerce and average citizens. Motocross as a part of motorcycle sport is not an exception. It is widely discussed in mass media all around the world but very little academic research has been done on the relationships between motorcycle sport and sustainability. Given research analyses these relationships.

This paper is mainly aimed at finding ways for decreasing the environmental impact of the motocross team based in Uppsala (Sweden) in order to meet the requirements of SWEMO (Swedish Organization of Moto and Snowmobile Sport) during preparation and racing periods. Environmentally friendly solutions in a long-term perspective are expected to increase environmental awareness of other teams participating in Swedish and European Championships as well as to initiate further research in this area.

However, in order to provide more general perspective on motorcycle sport this study investigates information about the sport from the environmental point of view: impact assessment of motocross racing including fuels, tracks, noise pollution, water and land use. The analysis will include the case study of MXStar team's activities during training period, maintenance of their garage (including waste management and washing), logistics and competition itself. Following the "Case study" and "Theoretical framework" chapters, the discussion part will be built on relevant theories, development and examination of the ideas for sustainable solutions, discussion of other environmental activities applied earlier in this sport. The discussion part will provide a powerful background for establishing practical and effective solutions applicable for MXStar team in Uppsala.

Using both qualitative and quantitative methods, particularly described in the "Methods" chapter, the study will provide clear understanding of the relationships between motocross racing and the sustainability. Our research will also introduce effective solutions to maintain these relationships for future development and improvement.

1.1. Background

The background provides a broad to specific profile of motocross, which is a part of motorcycle sport. Since this sport is rapidly developing nowadays, the level of its environmental performance becomes crucial. This growth is not supported enough by the academic society and thus more research is required.

Surprisingly, The Fédération Internationale de l'Automobile (FIA), the global governing body for motorsport, does not provide us with a definition of motorsport in its International Sporting Code, 'Statutes' or 'Regulations' (Dingle, 2009). Since this term is widely used in the paper, the definition offered by Angus, Aylett, Henry and Jenkins (2007) will be applied: "*We define motorsport broadly as competitive racing by equivalent machines on a frequent basis, on designated tracks and circuits. These machines include... motorcycles, motocross, karts, historic cars, drag, open-wheel, single-seat, sports, GT, Formula Ford, touring cars, rallying, sports compact, CART, IRL and Formula One*". Authors also mention: "series, championships, events and meetings arranged by promoters, circuits and racing clubs at all levels (professional race and amateur sport)" (Angus et al, 2007). Furthermore, in the context of the motorsport industry, the term 'motor' refers to the "provision (construction and preparation) of cars and bikes", when the term 'sport' refers to the "infrastructure including clubs, circuits, promotion, insurance etc. that is needed to participate in or view the sport". Besides this, authors suggest that motorsport is a part of the "leisure and entertainment industry" (Angus et al, 2007).

Angus et al defines the main characteristics of motorsport industry in 2005:

- In average, 52 million viewers followed Formula One Grand Prix;
- Approximately 600 race circuits (excluding kart tracks) were constructed and used for competitions;
- It was worth approximately £50 billion and represented 0.23% of global Gross Domestic Product (GDP).

Considering that the data given above is relatively old and in six years these numbers have probably increased up many times, we can surely describe motorsport as a one of the global industries with significant economic, social and environmental dimensions.

Mentioned definition of motorsport is too broad compared with research goals of the given paper. However, motorcycle sport and motocross itself are types of motorsport as a whole. Motorcycle sport is a broad field that encompasses all sporting aspects of motorcycling. Alongside with classical racing it includes disciplines that are not timed-speed events, but depend on the various riding skills of competitors. Considering different types of motorcycles and tracks there are several types of motorcycle sport: Dragbike, Enduro, Hill climb, Ice racing, Minimoto, Motocross, Road racing, Snowmobile, Speedway, Supermoto and Trail.

The term motocross addresses research goals more specifically and thus will be applied further on. Motocross is a form of motorcycle sport or all-terrain vehicle racing held on enclosed off road circuits. Through its history, it has evolved from trials, and was called scrambles, and later motocross, combining the French "Moto" with cross-country.

Motocross is one of the world's most widely spread types of motorcycle sports. It is possible to define three main motocross series; the FIM's Grand Prix, the World Championship series, and the AMA's American National Championship.

Together with Belgium, Sweden is the leading nation in the European motocross history. The history of Swedish motocross championship dates back to the 60's. There was a great variety of different brands, which made it more interesting for the audience. Alongside with Czech producers, Swedish Husqvarna was a dominating force in motocross and the only brand at the top. After some time Japanese actors came into the industry hence it became harder for European actors to compete. Rolf Tibblin, Sten Lundin, Bill Nelson and others were the Swedish pioneers in motocross racing. Håkan Carlquist perhaps was one the most famous Swedish motocross stars after his 500cc title in 1983. After him, Marcus Hansen achieved the world title 500cc in 1994 and Peter Johansson's success was recognised in the year 2000.

MXStar motocross team is an active participant of Swedish and European Championships. Being one of the biggest teams in Sweden, they are based in Uppsala and are given support by the Yamaha Motor Scandinavia AB in cooperation with Yamaha Store in Västerås. High quality motorcycles and spare parts are provided for the team as a result of such cooperation. As for tires, one of the world's largest manufacturer Bridgestone supplies MXStar.

As it was mentioned before, the Swedish Motocross Championship is regulated by SWEMO. It means that all competing teams as well as tracks need to meet the standards that are improving annually and follow the rules that are set by this organization. Since the team needs to have a good environmental profile, they are willing to decrease environmental impact of their activities. In order to achieve this goal, the research on the reducing of the environmental impact of MXStar team needs to be done.

1.2. Goal and objectives

The goal of the case study is to reduce/optimize environmental impact of the MXStar motocross team during preparation and racing periods. In order to achieve the goal, two levels of analysis will be applied. Motocross as a whole will be studied generally, while MXStar's case will be investigated particularly. In the long term, the project aims to popularize environmentally friendly solutions for logistics, racing, training and bikes service among the participants of Swedish and European Motocross Championship.

The main objectives of the study are:

- to evaluate direct environmental impact of motocross and consider its possible side-effects;
- to define and analyze environmental performance of MXStar team;
- to develop recommendations in order to reduce environmental impact of the team;
- to make conclusions based on the case study about relationships between motocross and sustainability.

The exercise of doing a case study in an interdisciplinary group is one of the best practices applied in sustainable development research.

2. Methods

Given research is based on both primary and secondary data. Methods for data collection can vary dramatically and include a set of various data gathering techniques, which differ depending on the nature of information and research aims. Both qualitative and quantitative methods will be applied at the same time in order to achieve the main goal of the research.

Qualitative research aims to understand the research object's behaviour deeply and the reasons that preceded such behaviour. Denzin and Lincoln wrote that "the qualitative method investigates the why and how of decision making, not just what, where, when". Qualitative methods produce information only on the particular cases, which have been research objectives, furthermore general conclusions are no more than suggestions. (Denzin and Lincoln, 2005).

Quantitative methods of the research refer to systematic empirical (e.g. observation and experiments are the main sources of data) defining of the properties. Since "measurement" is essential in quantitative methods, it provides necessary connection between empirical and numerical expression of the relationships. Moreover, qualitative methods produce information only on the particular cases, where conclusions are hypotheses. Quantitative methods, basically, are applied in order to verify which of the hypotheses is true (Creswel, 2003).

By using such methods as interviews and observational research primary data will be collected. It is planned to interview MXStar team members and other related stakeholders. Observations will be conducted in the garage and during the competitions. Interviews and observations will be conducted in a semi-structured way that will allow finding the necessary data alongside with providing a space for unexpected data to arise (by putting open questions).

Secondary data will be gathered through the documentary search together with other data sources such as articles, databases, professional journals, theme analytical reviews and websites. Since the research objectives vary it is convenient to use both qualitative and quantitative data.

Analysis, as one of the most widely used methods of scientific research, will be applied in the following paper. Primarily, classical analysis aims to break a complex topic or substance into smaller parts to gain a better understanding of it. In order to build logical and conceptual discussion in this study as well as to produce effective and applicable solutions for the case study, different types of analytical methods will be used. Link analysis and brainstorming, as a part of intelligence analysis, will help to define connections between all possible stakeholders: fans, team members, sponsors and organisers and how these connections can affect the environment (Ritchey, 1996). Life cycle and failures analysis, as parts of engineering analysis, will provide more sufficient information for recommendations and conclusions.

During the discussion part of the research a force field analysis will be mostly applied. According to the goal of the paper it is planned to formulate a range of recommendations on

decreasing/optimizing of environmental impact. Thus, there is a need for a method, which will allow conducting the evaluation of the proposed measures.

Force Field Analysis is a method for listing, discussing, and assessing the various forces for and against a proposed change. Kurt Lewin wrote that “an issue is held in balance by the interaction of two opposing sets of forces - those seeking to promote change (driving forces) and those attempting to maintain the status quo (restraining forces)”. Thus, given method will contribute to the final decision of the enrolled stakeholders.

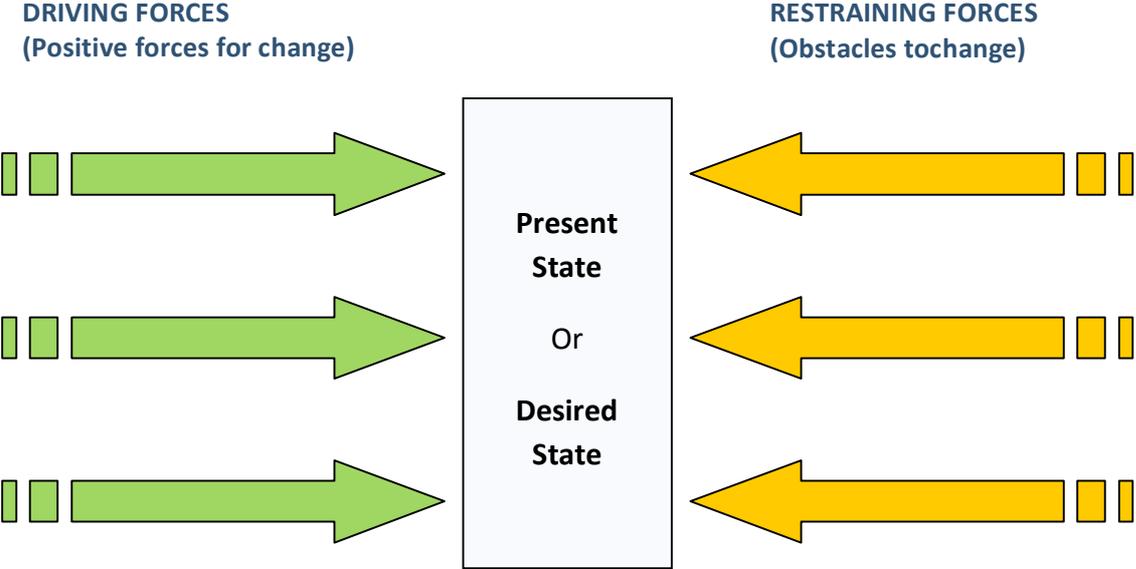


Figure 1. Force Field Analysis (Fisher, 2008).

Applying both qualitative and quantitative methods is essentially important in order to perform the research that achieves its aim to a full extent and satisfies all research goals.

3. Theoretical framework

Optimization of environmental impact is a complicated task. According to the goals and objectives stated in the previous chapters it is evident that given research has an interdisciplinary nature and consequently requires a suitable theoretical framework.

Another peculiarity of this project is the direct involvement of research subject. Research objectives were to a great extent determined by the needs of the MXStar team and this affected the whole structure of the project. Thus, a specific research approach needs to be applied.

Under these circumstances participatory research approach has a range of advantages and allows fulfilling research objectives. Generally, participatory research is aimed to generate knowledge and produce action, similar to other forms of action-oriented research, which, unlike academic research, are driven by practical outcomes rather than theoretical understanding (Park, p.143, 1999). However, participatory research most clearly distinguishes itself from other forms of action-related research by the fact that it issues from the felt needs of a community (Park, p. 143, 1999).

According to Pain (2003) participatory approaches did not originate as a methodology for research, but as processes by which communities can work towards change. It is typical for a participatory research to begin with people's problems and be initiated by the people themselves (Park, 1999). Another important tenet of participatory research is that the people themselves engage in the research process to the fullest extent possible (Park, p.144, 1999).

These statements correspond with the preconditions for the given research and match with its goal. Thus, participatory research approach creates a valid theoretical basis for reducing/optimizing MXStar team's environmental impact.

When it comes to sustainability an integrated and holistic systems approaches are required (Blackstock, 2005). Furthermore, sustainability requires institutional and personal transformation of understanding and practice, thus it relies on enhancing social capital and the collective capacity to respond positively to sustainability challenges (Blackstock, 2005). In response to this need for a change in practice, practitioners of 'sustainability science' advocate participatory and collaborative approaches to environmental decision making (Kates et al., 2001).

In the given project a research framework suggested by Blackstock (2007) will be applied. Overall outline of the participatory research process is illustrated in the figure 1.

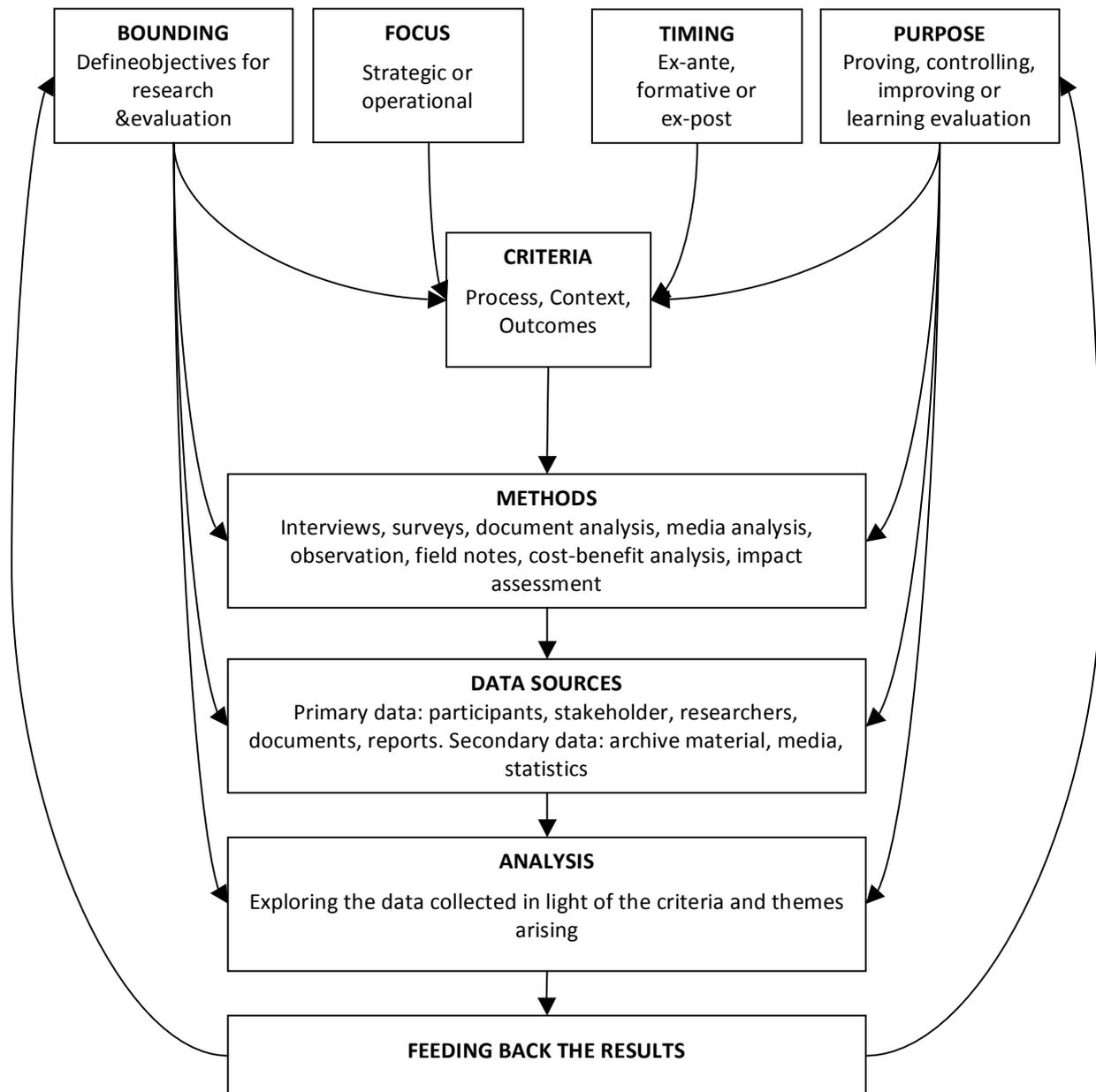


Figure 2. Participatory Research Process (Blackstock, 2005).

Alongside with general participatory research approach a range of minor theories will be applied specifically for various research tasks.

These theories are called to create a theoretical basis for further analysis of systems approach, relationship between sustainability and motorsport, team internal sustainability, intangible assets of the sustainability team and external stakeholders' relations.

3.1. Systems theory

The idea behind systems theory constitutes that it is a way to analyse various natural, social and economic phenomena. These phenomena are considered as integral systems that require holistic thinking in order to be analysed properly. Such approach is grounded on two basic components: elements of the system (measurable things that can be linked together) and

processes (changes of the elements' forms and states). According to Bertalanffy (1968) a system can be defined as a complex of interacting elements.

Usually a system consists of several elements, which are interacting in one or more processes. Thus, another fundamental component of the systems theory is a notion of system "boundary". The critical question is which elements should be considered as a part of the system and which factors belong to its environment (Olsson, 2004). When it comes to the analysis of complex multiple-factor systems, a boundary can be set in accordance with the research aims.

It is also possible to separate two types of systems: opened and closed. The distinction refers to the relation between system and its external environment. A closed system is totally isolated from its environment and the interaction between the agents of the system is all that matters (Olsson, 2004). On the other hand an open system exchanges matter and/or energy with its environment.

Depending on the way of organization there are two types of systems: static (changes can only come from external input) and dynamic (changes are generated by the system itself). Positive and negative feedback mechanism can be embedded in the system.

Control function can be implemented in the system in order to stabilise an unstable system, increase or decrease the sensitivity to external influences, obtain a desired system's state/characteristic or improve system properties in many other ways.

One can also distinguish stochastic systems from deterministic ones depending on the nature of the processes taking place under the system's boundaries. Similarly it is possible to separate linear and non-linear systems. At the same time mixed systems also exist.

A particular type of the system will be applied for research purposes in the given paper. The general model is illustrated in the diagram below:

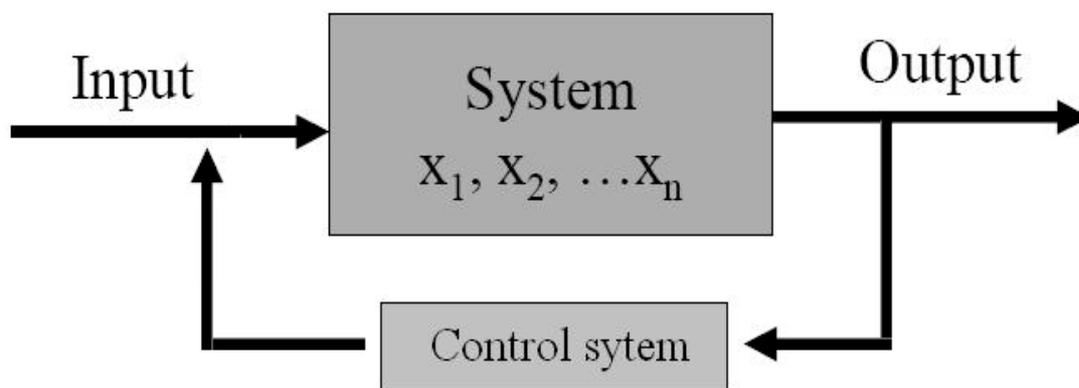


Figure 3. Open System Model (Olsson, 2004).

Picture above represents an open system that has a range of interacting elements, which function under a certain boundary. There is number of inputs that are taken from the external environment and are released back to it in the form of outputs after the operation process. At the same time, it is a static system that does not have a feedback mechanism; however there is an embedded control function.

3.2. Relationship between motorsport and sustainability

Relationship between motorsport and the sustainability were recognized not so long time ago in both sport and environment circles.

In order to examine relationships between motorsport and sustainability it is appropriate to define the concept of sustainability itself. There are a great number of definitions. Dingle in his article “Sustaining the race...” (2009) tells about American conservationists, including Rachel Carson (author of “Silent Spring”), John Muir and Aldo Leopold, who influenced environmental movement by the idea of sustainability as a link between the welfare of the environment and ethical behaviour of people. Around twenty years after Carson’s “Silent Spring” the Report of the Brundtland Commission in 1987 “Our Common Future” defined sustainability (sustainable development) as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. Meadows (2004), simplifying definition of sustainability, says that this term refers to the capacity of our society “to persist over generations” and at the same time the author gives a definition to “sustainable society” as one “farseeing enough, flexible enough and wise enough not to undermine either its physical or social systems of support”.

One more significant figure in development of the concept of sustainability is Sara Parkin, the co-founder of Forum for the Future in the UK. She talks about sustainability as “capacity for continuance”. As a consequence: “*Sustainability is therefore a quality. It is an objective, not a process. Something either has or has not got the quality of sustainability – the intrinsic capacity to keep it going more or less indefinitely. We want the environment to have it, so it can support life*” (Parkin, 2000, p.7). Parkin also sees sustainability as a result of close interaction of three dimensions: environmental, social and economic, where the environmental dimension is a “bottom line” and physical constraints of water, air, land and ecological systems are the limits in which social and economic dimensions can function (Parkin, 2000). The table below shows interaction of the dimensions though flows of benefits and five sorts of capitals, which represents available resources for human progress.

Sustainability Dimension	Sorts of capital	Description	Flow of Benefits
1. Environment	1. Natural	Soil, water, ecological systems	Energy, food, water, climate, waste disposal
2. Social	2. Human	Health, knowledge, motivation, spiritual ease	Energy, work, creativity, innovation, love, happiness
	3. Social	Governance system, families, communities, organizations	Security, share goods, inclusion
3. Economy	4. Manufactured	Existing tools, infrastructure, buildings	Living places, access, material resources

	5. Financial	Money, stocks, bonds	Means of valuing, owning and exchanging the other four capitals
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Table 1. The Five Capitals (Parkin, 2000)

Analysis of such models as in the Figure 3 might be very helpful for the sports managers and the teams in order to understand the relation between environment and sport events: degradation of the environment caused by the sport events. As a result, such analysis opens new perspectives for sports organizers including motorsport managers in the implementation of more sustainable solutions in their activities (Dingle, 2009).

A sport that is more sustainable has an insignificant environmental impact and brings more positive outcomes for social and economic welfare of the society while minimal amount of resources is used, little pollution is made and ecosystems are less disrupted. Taking into account these factors some sports can be more environmentally friendly (more sustainable) than the others: surfing, climbing, walking use less resource and produce zero emissions (Tranter and Lowes, 2009). At the other extreme, Tranter and Lowes are talking about motorsport: “requires the use of fossil fuels in the manufacture of the equipment and the racing circuits, produces local pollution as well as greenhouse gas, and involves a major transformation of the landscape wherever it is held”.

Motorsport influences environment in a short-term perspective at the local level (e.g. water/air/soil pollution) and in a long-term perspective at the global scale (e.g. peak oil and global warming) (Tranter & Sharpe, 2007). Besides, spectators’ choices and behaviour are influenced by the environmental issues of motorsport (Tranter and Lowes, 2009). Authors are explaining: “this not only includes transport to the events but also includes the encouragement of behaviours that have adverse environmental consequences, including increased use of cars”.

The literature about connection between sustainability and motorsports events sometimes focuses on available technological solutions in order to reduce the environmental impact of this sport. The approach is often referred to the ecological modernization theory, which is based on the statement “ecological issues will be solved through modernization of technologies” (York & Rosa, 2003). This theory is applicable for bio fuels, hydrogen or electricity to run cars and bikes. All international organizations strongly support this concept following their main goal to make motorsport more sustainable.

3.3. Internal sustainability theory

Nowadays motorsport market’s strategy requires a balance between natural environmental issues and organizational actions (Pfahl, 2010). Due to increasing pressure from stakeholders, environmental issues are inherently strategic and interwoven into every competitive team and racing organizations: from the easiest daily activities to strategically important planning processes.

For many managers in the sport including team members, addressing sustainability issues is not a part of the job description or personal skills and experience (Fineman, 1997). However,

the need to address sustainability issues is driven by growing concerns about environmental impact that have been caused by materials consumption and increasing of the connections among people, usually facilitated by the best available communicative technologies (Hart & Milstein, 2003).

Available resources often constrain strategic planning in terms of sustainability as well as limiting individual awareness about environmental issues within the team. Integrating sustainability issues into the strategic planning process in motorsport, considering statements listed above is a great challenge. Nevertheless, it can be possible by establishing cross-functionality in the competitive teams.

Cross-functional teams have been a part of organizational studies for decades (Alderfer & Smith, 1982). The actual sustainability issues in motorsport are often addressed through the use of cross-functional teams, however, lack of necessary knowledge and skills on behalf of team members and their sponsors stand in the way of cross-functional teams' development and management (Pfahl, 2010). In order to implement environmental activities in everyday life, racing organisers as well as teams are working to comply with guidelines and standards (Rigby & Tager, 2008). Cross-functional teams can be assigned for several possible strategic actions (e.g., tuning teams) and usually constrained by internal and external resource elements (Denison, Hart, & Kahn, 1996).

Sustainability teams are planning and making their own policies that are strictly coordinated with standards and rules. It influences internal team activities (e.g., being "green", different rewards for environmentally friendly behaviour, etc.) and the external factors, e.g. stakeholders (Pfahl, 2010). However, Hart emphasizes that "the internal dynamics of the sustainability team become critical to the success of any environmental initiative". Leaders are in charge of team policies' development. Since in this process strategic planning is very significant, operating environmental issues can be used as an instrument that helps to facilitate success in short term and long term. Considering different environmental experiences of racing organizers and current resources available, a sustainability team enacts a strategic plan simultaneously with its actual creation (Hart, 1995).

Resources available is one of the most important issues, which can be crucial for the cross-functional team during policy making and strategic planning processes as well as taking part in races, training, logistics and other activities that defines the team as a "motorsport" team or "competitive team".

Judge and Douglas define organizers' and sustainability teams' resources as a "functional coverage across the team (i.e., representation of organizational areas), resources provided (i.e., time, talent, financing), environmental issues integration into strategy, financial performance (e.g., cost savings, electricity use reduction), and environmental performance (e.g., different certifications and rewards)" (Judge & Douglas, 1998). In addition, the stakeholders' integration, team size, managing actions can also be utilized for decreasing environmental footprint (Judge & Douglas, 1998). Generally, all available resources are physical assets and operations (often refer to pollution management practices) of the team itself and external stakeholders input.

3.4. Intangible assets of the sustainability team

The intangible assets of a team and other organizational members are resources to improve environmental efforts. Talent and environmental education within the team together with the skills of team leaders and racing organizers are main recourses for strategic planning in sustainability teams. Since the standards are contentiously becoming higher, team leaders as well as other stakeholders must improve their intangible assets (Hart, 1995). Referring to these standards a good motivation to build sustainability team operations can be established. In addition, major professional motorsport teams can use the power of their organizational brand to promote environmental change among the other competitive teams during the championships, their own efforts towards it and to acquire a certain reputation (Hart, 1995). Besides, such powerful team assets like reputation can provide local contacts and establish good relationships with the community, which is extremely important in order to organize championships on the best territory available.

3.5. External stakeholders' attitude

The motorsport is a relationship-oriented industry because it provides a product-service in coordination with other stakeholders (e.g., tuning companies, sponsors, fans). These relationships are inherently human-focused. This is a plus for resource advantage because the stakeholders are able to provide more resources (Hillman & Keim, 2001). Usually a resource based view of the team allows starting, developing and improving year by year its sustainability activities and operations.

Stakeholders have their own environmental impacts and sustainability strategies. Including these groups into strategic environmental planning and tactics would offer not only a competitive advantage, but also work to strengthen the already existing coordination between fans and sports organizations (Hillman & Keim, 2001).

4. Environmental impact of motocross racing

Environmental impact of motorsport has been a widely discussed topic in the literature during the last ten years. Some authors like Smith and Westerbeek (2004) acknowledged that the sport is “a threat to the environment” through emissions and land issues on the global and local scales. Furthermore, they emphasized other examples of environmental degradation caused by motocross:

- the use of fossil fuels;
- habitat destruction through the facilities construction;
- unsustainable manufacturing processes;
- the lack of “clean” logistics during training and competition periods;
- the use of significant amounts of water and chemicals;
- ozone depleting caused by air pollution (Smith and Westerbeek, 2004).

Chermushenko et al in “Sustainable Sport Management” (2005) further developed the list of the environmental impacts of sport events and facilities, which were defined as an “ecological footprint”:

- consumption of natural resources like water, wood, paper etc., and especially usage of non-renewable resources (fuels, metals, etc.);
- pollution from fuels, cleaners, solvents, etc.;
- air pollution from increased vehicle traffic;
- noise and light pollution;
- soil and water pollution by pesticides during construction of fields and tracks;
- soil erosion during construction, maintenance and actual event;
- generation of greenhouse gases (by electricity consumption and transport) (Chermushenko et al, 2005).

Considering facts listed above Lowes and Tranter (2007) made an observation that environmental impacts vary depending on type of sport. They refer to the Australian Conservation Foundation (ACF), which ranks sports according to the level of damage caused:

1. Sport activities that are generally ecologically sustainable, but some issues can be improved;
2. Sport activities that are largely ecologically sustainable, but which may be significantly improved in terms of sustainability because their core activity is not inherently unsustainable;
3. Sport activities that can never be ecologically sustainable, nor made significantly more sustainable, due to the inherent nature of their core activity (ACF, 2007).

ACF is not defining exactly which type of sport can be fit into the categories listed above. It remains as a subject of discussions and further research.

Since this chapter provides detailed information about the environmental impact of motocross racing as a whole, such analysis requires systems approach that was described above in the theoretical framework chapter.

According to the theoretical guidelines it is necessary to determine the basic components of the system (elements, processes, inputs, outputs, boundary and the environment) in order to construct a holistic model of a phenomenon. In the given paper the phenomenon is motocross. Since the general aim of the paper is searching for an effective way of coping with environmental impact, the design of the model will correspond to this particular aim.

When it comes to the choice of the analysis' unit, development of a clear definition of the motocross from the environmental point of view becomes challenging. As any other sport it has numerous connections with the supporting industries and this fact broadens a system's boundary almost infinitely. In order to solve this problem a motocross race will be considered as the central unit of analysis instead of motocross as a general concept.

A motocross race takes place in a certain environment and exchanges matter and energy with it. According to the systems theory, a system having a range of inputs and outputs can be classified as an open one. Detailed illustration of the system is presented in the figure below.

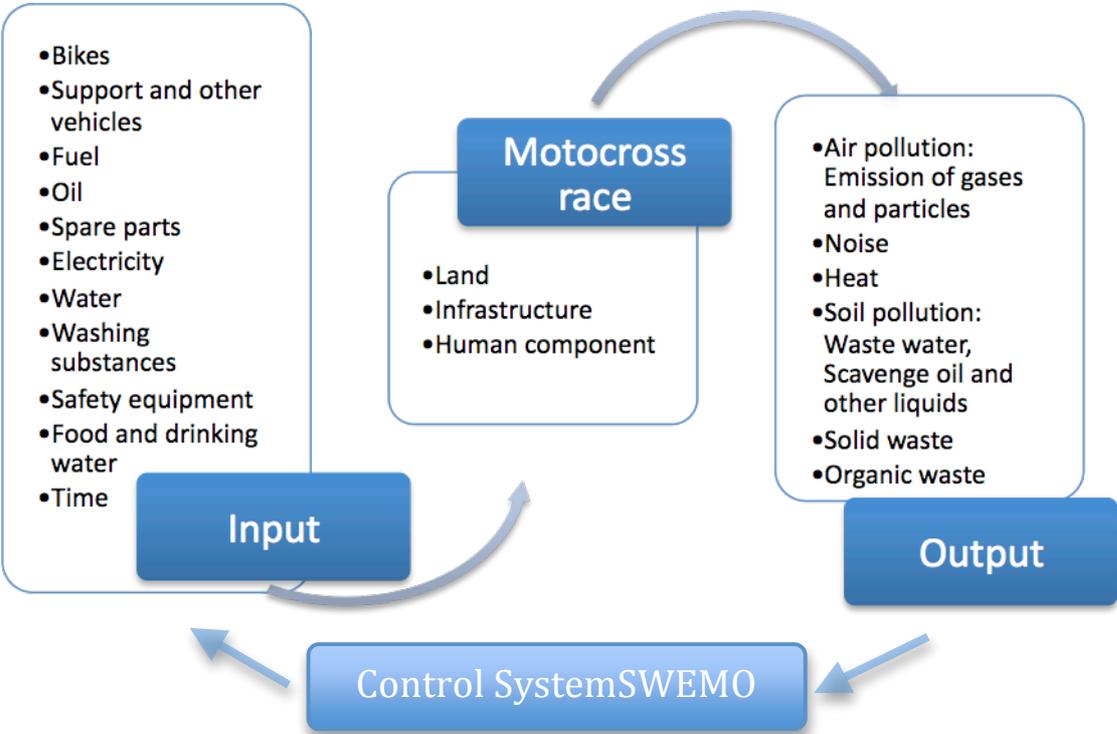


Figure 4. Systems Model of Motocross Race.

The resources that are necessary for conducting the race represent inputs of the system, while outputs are mostly represented by the factors that affect the environment. The process of transforming inputs to outputs is a “race” itself, which is the heart of the model. It is defined by the human component, amount of land, which has been used for tracks and other facilities including infrastructure. The latter one includes tents, repair shops, washing facilities and track guards for competitive teams plus parking space, tribunes, food tents, washrooms and lavatories for spectators. Human component includes activities of both external and internal stakeholders.

In the given system environment is an area beyond the race. It serves as a source of inputs and

a final destination for outputs. In reality, local environment is different at any particular race since there are numerous arenas where the competitions are held. However, in the given research the differences between local environments are not considered as crucial ones due to the fact that they are all located in Sweden and consequently are organized under the unified rules established by SWEMO. Thus, the environment is considered to be homogeneous in all cases.

According to the picture there is no embedded feedback mechanism in the system (neither positive nor negative). It means that the system is not looped back within itself. Consequently, it can be concluded that it is a static system.

At the same time an external control function is represented in the system. This function is mainly performed by SWEMO and is aimed at the stabilization of the system when it is necessary. An example of such stabilization is a constant improvement of the environmental norms and standards that individual racers and race clubs have to fulfil in order to be allowed to participate in the race. The control function regulates interactions and coherence between inputs and outputs and in this way a desired system's state or characteristics can be obtained.

The element of chance in the system's processes is insignificant, thus the system can be described as deterministic. Due to the various natures of the processes that take place during a race the system can be classified as mixed, which operates both linearly and non-linearly (depending on the inputs).

Given approach puts the motocross race in the middle of attention. In other words, most of the research efforts are given to the processes that take place within the boundaries of a race. However, this does not mean that the interest of the environment is not considered. On the contrary, the analysis is done in order to decrease/optimize negative environmental impact of the motocross on the area beyond the boundaries of the race. The environment is a final beneficiary of the recommendations developed as a result of such analysis.

4.1. Elements of the system

As it was mentioned above land, infrastructure and human component represent the motocross race itself. They are constants, presence of which is essential in every race or during any training period. These components constitute the centre of the systems model of race and create a base for transformation of inputs of the system into its outputs.

Land

Every motocross race starts with an amount of land used for its construction and maintenance (Appendix 1, figure 1.1.). The exact area of any track varies depending on the purpose (training or racing) and amount of riders including spectators, who are taking part in the motocross event. Drainage is a very important issue considering tracks' land use. Generally, using the land in low lying areas such as valleys, dips, bottoms of hills will not be efficient due to the possibility of filling them with water and turning into swamps unless there is an adequate drainage. Another very important issue is a type of soil. Ideally, it should be clay based which can bind and compact in order to provide a long lasting solid track for all competitive riders (Dirt Bike, 2011).

Location is extremely important as well. From one side, the track landscape of the land must contain some slopes and hills. From the other side, the racing area must be located near human habitat areas for comfortable logistics, although, spectators' behaviour, noise and air pollution can cause inconvenience for local residents.

Significant amount of hectares are used for tracks construction while they could be used for other productive purposes. Pollution by wastewater, scavenge oil, fuel and some other liquids causing damaging impact for the land are the results of motocross activity. Soil pollution will be particularly described further.

Infrastructure

Infrastructure itself includes tents for competitive teams, repair shops, washing facilities and track guard plus parking space, tribunes, food tents, washrooms and lavatories for spectators (Appendix 1, figure 1.2.). Each of these components has environmental impact in a light of lifecycle; however land use is a common impact for all of these facilities together. It is a well-known fact that the facilities listed above are usually produced from non-degradable materials. European Motorcycle Union (further EMU) offers: "during the circuit building and the preparation of the areas for promoters, sponsors, hospitalities, show-room etc, it would be necessary to increase the use of natural materials like wood, fabric, ropes, etc." (EMU, 2009). Natural materials could be a solution for spectators' tribunes and track guards. Food stands can serve food and water specially packed in easily recyclable and/or biodegradable materials like paper or cardboard for bottles glass, dishes, waste bins, etc. for the spectators and competition participants (EMU, 2009).

Providing spectators and racing participants with lavatories and washing rooms is one of the most important and at the same time very challenging tasks considering both environmental and participants' comfort. EMU represents the standards for WCs quantity for male and female spectators: "1 WC per 100 or fewer females anticipated to attend; 1 WC per 100 or fewer males anticipated to attend; 1 WC per 100-500 males anticipated to attend; 1 additional WC for every additional 500 males anticipated to attend; 1.5 meters long urinal facility for every 500 males; 1 basin for every 5 sanitary facilities; 1 of the facilities should be suited for wheelchair users" (EUM, 2009). However, racing planners must plan the location of these facilities efficiently considering minimum amount of permanent structures as the best solution (EUM, 2009). Wastewater treatment, as a direct environmental impact from washing facilities and lavatories, will be discussed further in detail.

Human Component

The internal and external stakeholders of the motocross event represent human component. Hillman & Keim (2001) defined internal stakeholders as the racing teams and event organizers, while sponsors, fans, sport federations, tuning and manufacturing companies as external ones. Such differentiation can be further discussed, however, in order to explain the model from an environmental point of view the authors of given paper prefer to use the current one. UM represents a list of activities that prevent stakeholders from the generating environmental impact during competition. At the same time compliance with these actions will lead to the increase of the spectators', local residents' and motocross teams' comfort and

safety.

Racing teams should reduce their environmental impact using the best available technologies and make sure that the required environmental equipment is available during the race. Team leaders or riders themselves must control energy and water use, scavenge oil and solid waste in order to be more environmentally friendly and meet the requirements set by sport federations (EUM, 2009).

Event organizers need to control actions of the teams and spectators and make sure that both have all necessary equipment and follow the rules. By printing different materials and brochures organizers need to promote reduction of the environmental impact by specifying spectators and teams' behaviour (EUM, 2009).

External stakeholders are providing internal stakeholders with all the necessary facilities: tracks, bikes, etc. Depending on the technologies that have been used, their professionalism and behaviour (in case of spectators), race performers can decrease their impacts and at the same time organizers have possibility to create safer and more comfortable environment. Only cooperation and professionalism of the "human component" during the establishment, maintenance and closing motocross racing events can make the sport more sustainable and popular.

4.2. Outputs of the motocross race

The following section provides a description of the outputs – the work of the system exported back to the environment after its transformation within a system. The description is performed from the environmental perspective and thus represents only the outputs that have negative impact on the environment. The common feature for all output items is their direct relation to inputs. Given paper does not provide separate subchapter for the inputs; they will be instead discussed in the light of outputs.

4.2.1. Air pollution

According to the systems approach to motocross, air pollution takes place during different stages of the race. Emissions are already generated during the track construction process, its exploitation and maintenance or reconstruction. However, due to the research goals of the given paper only the emissions generated during one separate race will be investigated while other stages will be left beyond the system's boundaries.

Motocross is closely associated with vehicles and consequently with the emissions produced as a result of internal combustion. A significant part of these emissions is released to the atmosphere in the form of exhausts that mostly consist of various gases and particulate matter. At the same time there are other activities besides fuel combustion that also lead to the air pollution (see Appendix 1, figure 1.4.). Thus, under the frame of the race it is possible to differentiate between direct and indirect air pollution.

In order to clarify this difference it is necessary to elaborate on system's inputs. On the one hand such elements as bikes, fuel and oil largely contribute to the direct pollution, which is generated as a result of internal combustion. Alongside with bikes there are support and other vehicles (i.e. track maintenance cars, private vehicles and public transport) that do not

participate in the race directly but take part in its organization, maintenance and create additional facilities for riders and public (see Appendix 1, figure 1.11.). On the other hand electricity is widely used in order to supply the arena with light, water, fresh air and other facilities. Consequently, the emissions required to produce electricity also have to be taken into account as an indirect source of air pollution.

Direct air pollution generated by the bikes' internal combustion during each race varies significantly depending on such factors as engine displacement (D), length of the race (L) and number of participants (N). These factors are in direct proportion to the total amount of emissions (E) and thus the general equilibrium can be presented in the following way:

$$E = D \cdot L \cdot N \quad - \quad \text{formula (1)}$$

Pollution generated by support vehicles depends on the type of the track and the number of facilities, which have to be provided. Thus, such factors as size of the track and number of the involved vehicles determine the total exhaust values. Similarly, other vehicles (primarily private ones) that are used by the spectators generate pollution depending on the size of the audience and the logistics of the area.

As for indirect air pollution resulting from the use of electricity, there is a range of factors that determine its scale: size of the track, time when the competition is held, technology that is used, number of various facilities which have to be provided, etc.

Thus, the major difference between direct and indirect pollution is the place where emissions are generated. In the case of direct pollution the exhausts are released at the track, while in the case of indirect pollution the emissions are generated at the power plant.

This difference determines the composition of the emissions. Pollution generated by the internal combustion at the track usually includes such elements as carbon dioxide (CO₂), carbon monoxide (CO), hydrocarbons (C_xH_y), nitrogen oxides (N_yO_x), water vapour (H₂O) and particulate matter (mostly soot). Indirect pollution from the electricity can take various forms depending on the production method.

Another important input into the system, which has a significant impact on the air pollution, is time. Being invested into the race by riders, spectators and the organizers time input determines the length of the race and consequently the amount of emissions (see Appendix 1, figure 1.6.). It is obvious that the time of the race itself cannot be limited, thus the notion of time here applies rather to the layout of all internal and external roads at the circuit. In other words the way in which logistics of the race is organised is a crucial factor determining the amount of direct air pollution from the support and other vehicles.

The elements and compounds released into the air can lead to different consequences. The most obvious and "popular" externality of internal combustion is the emission of greenhouse gases that in turn leads to the global warming. In the case with motorsport it is hard to find any significant influence of racing on the climate change, since the amount of emissions is not that crucial. However, taken together with other industries and activities, motorsport makes some contribution to the global warming and thus this influence needs to be minimized.

On the other hand, emissions rather affect the environment on the local level than on the global. Soot and some other oxides (mostly CO and NyOx) are released at the track during the race and can influence local ecosystem health of the participants and spectators.

4.2.2. Noise pollution

Motorsport is well known for its racing shows when bikes compete not only in speed but also in sound (see Appendix 1, figure 1.5.). Loud noise produced by the engine is intuitively associated with high amount of horsepower and ability of the bike to ride fast.

As a physical phenomenon noise can be characterized as successive fluctuations of the pressure around atmospheric pressure. These variations can differ in intensity (difference between the pressure of the wave and the mean one measured in decibels, dB) and frequency (rapidity in which they follow each other measured in Hertz, Hz).

Vibrations cause noise, which in the case with motorcycles are represented by combustion gases that leave the exhaust. Vibrations are also produced and propagated by the cylinder wall, cooling fins and other revolving parts of the engine. Thus, each time when the engine runs, combustion gases leave the exhaust, the air is set in vibration and a certain amount of noise is produced.

From the point of systems analysis, noise is an output that is generated in the system and is exported to the environment. It originates from several input sources, but bikes generate most of the noise. At the same time speakers that are used at the race can also produce significant noise pollution.

Unlike air pollution generated by the internal combustion, noise pollution is not proportionally related to the source of emission. It is rather a non-linear relationship, where the laws of acoustics play a crucial role. Thus, such factors as the amount of bikes and speakers do not solely determine the amount of noise produced during the race, while other factors like landscape, position of the track, weather conditions and existence of natural or artificial barriers for noise significantly affect the final amount of produced noise pollution.

Inanimate nature can tolerate high levels of constant noise. However, wild animals are very sensitive to noise because their survival totally depends on the ability to focus on the sounds. Thus, noise pollution from motorsport bears potential risks for the natural habitats of numerous wild species that are located closely to the racing tracks.

As for humans, it was proved that constant unwanted sound could damage physiological and psychological health. Noise pollution can cause annoyance and aggression, hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects. Thus, racing tracks that are located near settlements can influence health condition of its inhabitants by uncontrolled noise pollution.

4.2.3. Soil pollution

Soil pollution is one of the main environmental problems of every motocross event. During tracks and bikes maintenance oil, fuels, wastewater and some other liquids can be dispersed into the ground (see Appendix 1, figure 1.3.).

Motorcycle servicing pollutes soil with fuel, oil and other liquids coming from the motorcycle's parts during reparation or examination. In order to reduce this impact, teams must cover the ground with an "environmental mat" that is aimed to absorb the liquid (see Appendix 1, figure 1.7.). EUM introduces the following minimal characteristics for mats:

- absorbing capacity: 1 lit/m²
- dimension: 160x100 cm;
- thickness: 5 mm (EUM, 2009).

It is strongly recommended to use larger mats or use several of them in the area of contact to make a continuous carpet. There is also a possibility to find a mat with higher absorbing capacity. For example, the result of recent research in this area is the environmental mat with absorbing capacity up to 5 lit/m² (FIM-Afrika, 2011). Using, washing and utilizing such carpets create environmental impact itself. Teams and racing organisers need to consider this fact and to control it.

Another important issue for the soil is the impact of motorcycle cleaning. In case of permanent circuits, individuating an area in the paddock is quite easy. It should be fitted with gutters to collect wastewater, linked to the main sewerage unit or to a waterproof reservoir to be emptied every time when it becomes full. However, when the circuits are provisional, the process of motorcycle cleaning is more complicated. Usually absence of main sewerage creates necessity to use natural slope and build a reservoir from the waterproof material and connect cleaning space with this reservoir using environmental mats. Obviously, in case of provisional tracks total recovery of water cannot be achieved, but partial recovery is better than dispersing liquids straight into the ground. For both types of circuits it is important to build the floor from the solid materials (EUM, 2009).

Oil collection becomes very challenging, considering chemical and physical characteristics of this liquid. In order to avoid oil dispersing into the ground, it is fundamental to collect it into special containers and transport to the factories for digestion. Containers can be metallic, plastic, etc, but most important is that it is free of leakage, located under a roof to avoid rain filling. Filling such containers must also be not complicated. Specific containers for oil soaked filters should be installed as well (EUM, 2009).

Wastewater from the vehicles standing in the paddock is usually taken care off by the well-dimensioned system of sewerage with a sufficient number of sump pits linked to an oil-water separator. The system is connected to a main sewerage waste water system from the lavatories and washing rooms, which are in turn connected to the main sewerage unit and cause no environmental impact on the soil in the area of motocross event (EUM, 2009).

4.2.4. Solid and organic waste

Establishment of solid and organic waste system that will decrease the pollution is a very difficult task for motorcycle event planners, starting from the most obvious issue - waste bins. Its amount and placement plays an important role in waste reduction (EUM, 2009). It is an interesting fact that people often consider the distance from the bin as an excuse for not behaving properly. Furthermore, efficient and continuous service of emptying of all bins during the event helps to maintain the amount of waste as well.

A key concept in solid and organic waste management is differential collection considering different types of waste: glass, plastic, metal, organic waste, paper, etc. Containers usually have different colours for each type of waste with labels written in the local language and at least in the one of the European official languages (EUM, 2009).

Considering other solid waste such as tires, different spare parts, medicines, batteries, etc. special containers are provided for the reason that these types of waste are highly dangerous for the environment and need to be taken care of in special ways (see Appendix 1, figure 1.8.).

4.2.5. Heat

From the physical point of view heat is a form of energy that occurs when some work is being executed. According to the laws of thermodynamics, objects with higher temperature always tend to equalize with the temperature of the environment. On the other hand objects with lower temperature tend to gain energy from the environment and increase the temperature in order to reach the equilibrium.

In the motorsport it is possible to separate two types of heat produced: useful heat and side-effect heat. Useful heat represents heat that is intentionally produced in order to increase the temperature of the track (in the case with closed arenas), garage, premises and other buildings. Side-effect heat is produced unintentionally during other processes taking place during the race, mostly as a result of internal combustion (Perrot, 1998).

Thus, from the systems perspective, heat is an outcome of the system. It originates from two groups of inputs: electricity or hot water in the district heating system (for the intentional heating) and bikes, other vehicles and fuel (for the side-effect heating).

Consequently, both sources of the heat create air pollution. However, environmental impact of the release of heat depends on the type of the heat produced. In case with the side-effect heat it is impossible to avoid it, since it is not produced intentionally. At the same time the environmental impact of this heat is obvious. In the case of heat that is produced intentionally it is possible to control it and thus race organisers have more tools to control the pollution.

Even though environmental impact of heat is not obvious on the first sight, it has been proven that large releases of this pollutant cause some changes. In a large perspective, heat pollution directly contributes to global heating (Henderson, 2006).

4.3. SWEMO

Since motocross as a sport is a non-natural phenomenon and is organised by people, the pollution resulting from it can be classified as man-made. Consequently, nature does not have an adequate capability to absorb the emissions in a way that will not disturb the balance in the ecosystems. Thus, an intervention from people is required in order to decrease the negative environmental impact of the motocross or ideally make it equal to zero.

From the perspective of systems analysis such an intervention can be included in a system in the form of a control function, which can adjust the system and make it function in a desired way. Particularly, the control unit is supposed to check the outputs of the system and make a decision as for the necessary changes. After the decision is made the adjustments to the inputs of the system are undertaken and consequently the nature and amount of outputs also changes.

In the case of motorsport, control function is represented by the SWEMO organization (see Appendix 1, figure 1.9.). As it is described in the background, SWEMO is an organization that among other things executes environmental supervision of the motorsport by direct participation in races organization. Alongside with organization, SWEMO is responsible for environmental policy development, providing racing teams with education on the environmental issues, informing racers about actual standards and norms, designing of the championships' regulations and other activities.

Since motorsport race as an open system exchanges matter and energy with its environment, SWEMO executes an important role of the systems control mechanism. By measuring levels of different outputs, SWEMO creates recommendations for inputs. In this way the system remains in a certain balance and has a potential to increase its environmental performance in order to level the negative impacts on the ecosystems.

5. Case study - MXStar team

The MXStar motocross team is an active participant of Swedish and European Championships. Being one of the biggest teams in Sweden, they are based in Uppsala and are given support by Yamaha Motor Scandinavia AB in cooperation with Yamaha Store in Västerås for spare parts. Tires are supplied by one of the world's largest manufacturers Bridgestone. Four riders represent the team: Kim Lindström from Nyköping (age: 19), Sebastian Lorenz from Västerås (age: 17), Emmy Wallberg from Uppsala (age: 17) and the captain Tomas Petersson from Uppsala as well (age: 31).

The team is highly concerned about decreasing their environmental impact. Main goals of the team from the environmental perspective are testing different types of fuels in order to decrease GHG emissions, managing solid waste, reducing of energy consumption and resources use, treatment of scavenge oil and other liquids and waste water treatment. Current research is a tool for the team in order to achieve these goals.

5.1. Bikes

Being a source of the numerous inputs into the motocross race, bikes take a special place in the whole system. They are not simply involved in the race and subsequent generation of outputs, but simultaneously shape the way in which other inputs behave. Such inputs as fuel and oil perform differently depending on the model of bike and thus the choice of the bike is crucial for both speed and environmental characteristics.

MXStar team members use 2 types of bikes: Yamaha YZ250F and Yamaha YZ450F (see Appendix 2, figure 2.1.). Their choice is determined by two factors: speed characteristics of the bikes and sponsorship from the Yamaha Company in Sweden. Since a significant investment is required in order to purchase a racing bike, the team cannot afford changing bikes frequently. Thus, it is the most long lasting input in the motocross race.



ENGINE	
Type	449cc liquid-cooled DOHC 4-stroke; 4 titanium valves
Bore x Stroke	97.0 x 60.8mm
Compression Ratio	12.5:1
Fuel Delivery	Yamaha Fuel Injection (YFI), Keihin® 44mm
Ignition	CDI
Transmission	Constant-mesh 5-speed; multiplate wet clutch
Final Drive	Chain Drive

Figure 5. Yamaha YZ450F and Engine Characteristics (Yamaha Official Website, 2011).

5.2. Support and other vehicles

In the previous chapter the necessity of support and other vehicles for the motocross race in general was explained in detail. The exploitation of support vehicles by MXStar team in particular is similar to the other teams.

The task, that has to be solved before and after every race is bikes' delivery (see Appendix 1, figure 1.10.). Since the race is always organized at different tracks in various geographical

regions it is important that all the participants are equipped with their vehicles. For this reason MXStar team members use their own vans in order to transport their bikes to the points of destination. Each van can contain two or more bikes and in this way racers decrease their cost.

Another occasion for using a van is training races, which are conducted more often than the actual competitions. Each time the training race takes place the racer together with his/her bike moves to the special training track. It is necessary to highlight that there are no facilities for keeping bikes at the racing place. This means that if a rider trains every day at the same place he or she has to carry the bike instead of keeping it and using public transport in order to get to the track.

5.3. Fuel

Motocross is a sport where speed characteristics play an essential role and thus a high quality fuel is required. As it was mentioned above fuels perform differently and their characteristics vary according to the bike model. For this reason MXStar team members as well as their rivals put a special effort into the racing fuel choice.

Statoil 98 is most widely used for racing. It is a high octane fuel, which matches racing demands of the team and allows them to participate in the competitions and trainings. Statoil 98 is commonly recognised as an acceptable fuel for motocross and other branches of motorsport, therefore is quite popular among racers. This fuel is easy to find on any gas station and is used by the MXStar team most frequently.

VP MS109 is a racing fuel, which is also used by the MXStar team. It is an extra high octane fuel designed specifically for motorsport. The fuel is supposed to improve bike's racing characteristics and give additional power to the engine. The fuel is more expensive than Statoil 98 and is used by the team on the important races.

Another fuel option available for the team is Aspen 4. It is positioned in the market as an ecological fuel, which can be used in different machines, including bikes. The fuel is much more expensive than Statoil 98 or VP MS109. At the same time it is not popular among the other riders and does not have the high octane number. Thus, it is hardly ever used by the racers. However, the team is informed about their negative environmental impact and considers this fuel as an option if it gives adequate speed characteristics and brings significant decrease of gases emission.

Fuel test

When it comes to the environmental impact of the three fuels mentioned above - there are several advantages and disadvantages for each of them. A fuel test was undertaken during the research in order to present a clear picture of the fuels behaviour during the combustion in the YZ450F bike and show emission rates. It was assumed that data for YZ450F is also valid for YZ250F. The results of the test are presented in the Table 2.

The process of internal combustion is described in the following way:



It means that fuel while mixing with oxygen and is burned in the engine. Under the perfect conditions the emissions should include only water and carbon dioxide. However, due to the

Fuel	CO (%volume)	CO Cor. (%volume)	O ₂ (%volume)	CO ₂ (%volume)	HC Hexane (ppmvol)	λ value
Idle speed						
Statoil 98	5,08	5,72	5,3	8,2	124	1,093
VP MS 109	5,33	5,50	3,01	9,2	145	0,969
Aspen 4	5,56	6,45	4,9	7,4	165	1,050
Half engine speed position						
Statoil 98	7,64	7,64	3,54	8,1	200	0,899
VP MS 109	7,33	7,33	2,99	8,1	277	0,897
Aspen 4	6,84	7,53	5,0	6,8	210	0,993

technological imperfection the combustion is never perfect and thus there are other undesirable gases in the exhausts (mainly CO, Hexane and NO_x).

Table 2. Fuel Test Results.

The test was performed using the exhaust gas analyzer AVL DiGas 4000 Light (see Appendix 2, figure 2.5.). It is a special instrument that is widely used for testing the exhaust values of cars, bikes and other machines with internal combustion engines. The testing process is quite simple. The gas analyser has a special tube that should be inserted in the exhaust pipe of the bike (see Appendix 2, figure 2.6.). When the bike's engine starts the tube begins to inhale the exhausts. The detectors in the gas analyser evaluate the amount of different gases and present this information visually on the screen. After the test is done for one type of fuel, the bike's fuel tank should be emptied and filled in with next fuel.

According to the table there are six parameters that determine the characteristics of the exhausts. CO, CO₂ and O₂ present the amount of respective gases in percent of volume. HC Hexane gas value is presented in parts per million of volume (1ppm = 0,0001%).

λ value is a coefficient that represents the proportion between fuel and air in the air-fuel mixture. The optimal combination is assumed to be 14.7 kg of air and 1 kg of fuel (Fyrgasmättning, 1999). This proportion results in the most efficient combustion and makes λ value equal to 1. Lower coefficient stands for a rich mixture and higher coefficient indicates lean mixture.

CO cor. is the coefficient that proves the validity of data. It is calculated by the following formula (Fyrgasmättning, 1999):

d those that are slightly different, so the data can be characterised as a generally reliable, with minor variations.

When it comes to the analysis of emitted gases, it is possible to describe each gas in particular. Table 2 shows that the amount of carbon dioxide is higher compared with other emitted gases. It is quite reasonable, taking into account formula (2), which states that under the perfect combustion the only emitted gas is CO₂. Even though the combustion is not perfect in the given case, the amount of CO₂ still dominates in the emissions mix.

According to Figure 6, the highest value of CO₂ is produced by the VP MS109 fuel, since it is a racing fuel with an extra high octane value (Fyrgasmättning, 1999). The lowest amount of

CO₂ is produced by the Aspen 4, which can be explained by the lower octane number. At the same time there is a clear tendency of CO₂ values to be higher on the idle speed compared with the half engine speed, which is explained by the efficiency of combustion. Since on the half speed the engine is running quite fast, it leads to the intensified supply of fuel, which gives less time for the fuel to burn properly. This reduces the efficiency of combustion overall, which in turn results in the lower CO₂ values and higher values of monoxides.

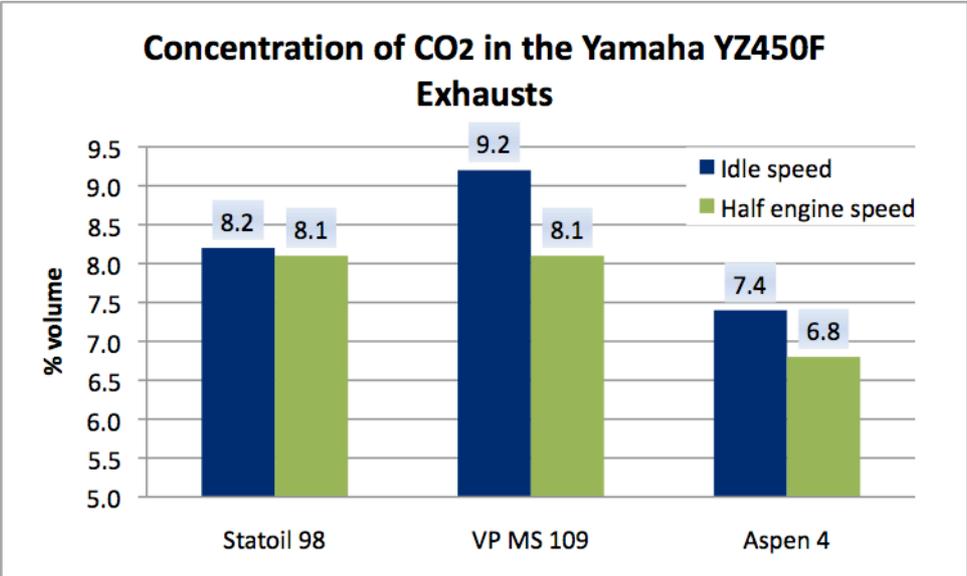


Figure 6. Concentration of CO₂ in the Yamaha YZ450F Exhausts.

The conclusion made for the previous figure is supported by the data from the Figure 7. It is obvious that the amount of CO is almost 1.5 times higher on the half engine speed than on the idle speed, which is a result of the inefficient combustion. It is also important that CO is not a greenhouse gas, but is highly toxic for humans and animals. CO concentrations are short-lived and eventually oxidize to carbon dioxide through natural processes in the atmosphere (Eoearth.org, 2011).

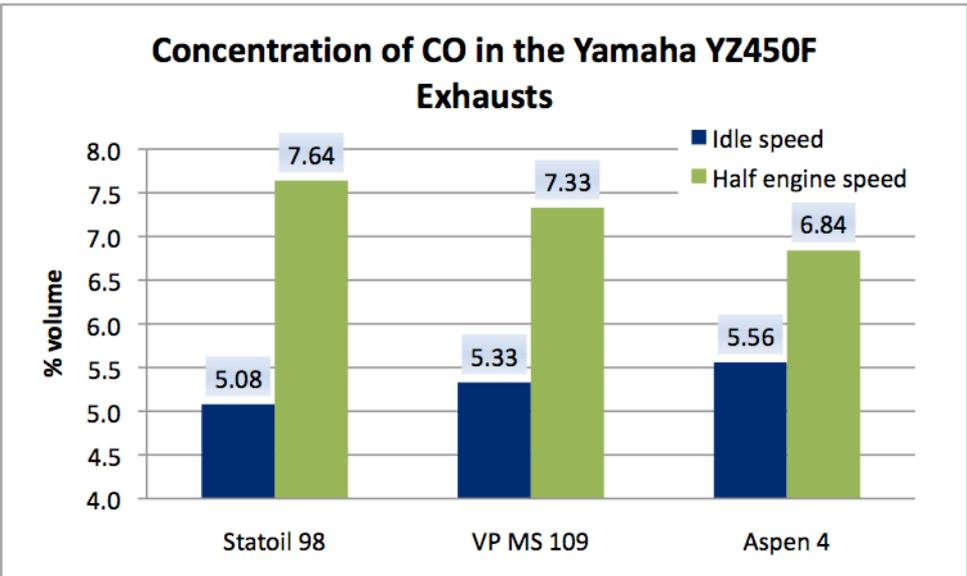


Figure 7. Concentration of CO in the Yamaha YZ450F Exhausts.

Since CO and CO₂ are interrelated, the comparison of fuels based on total emissions of both gases would be more reliable. These values is calculated and presented in the following table.

Fuel	CO+CO ₂
Idle speed	
Statoil 98	13,3
VP MS 109	14,5
Aspen 4	13,0
Half engine speed position	
Statoil 98	15,7
VP MS 109	15,4
Aspen 4	13,6

Table 3. Total Amount of CO and CO₂ in the Exhausts.

According to the data in the table, the total amount of emissions is higher on half engine speed compared with idle speed. In both cases Aspen 4 generates lower amount of the gases and proves its environmentally friendly label according to these parameters.

Figure 8 illustrates concentration of O₂ in the exhaust. This parameter can be by mistake characterised as a positive one since oxygen is a gas that is naturally present in the atmosphere (about 20.9%) and thus the 5% concentration of it in the exhausts will not do any harm for the environment. But the presence of O₂ in the exhausts indirectly detects inefficient combustion (i.e. not all the oxygen reacted with the fuel). For example high octane VP MS109 fuel burns much oxygen and consequently has higher CO and CO₂, while Aspen 4 burns less intensive and thus has higher O₂ concentration in the exhaust and lower CO and CO₂ value.

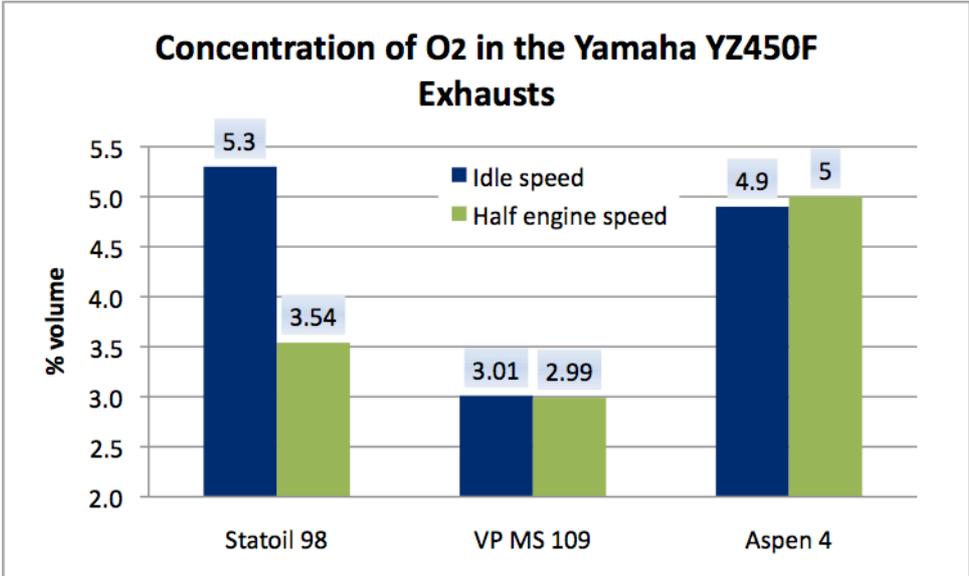


Figure 8. Concentration of O₂ in the Yamaha YZ450F Exhausts.

The presence of hexane in the exhausts is another sign of inefficient combustion. Hexane originates from the oil and fuel particles, which had not burned properly before they were emitted. Figure 9 illustrates that the amount of hexane is significantly higher for all fuels on

the half engine speed compared with idle speed. This tendency coincides with the trend of CO values and has the same explanation (Fyrgasmättning, 1999).

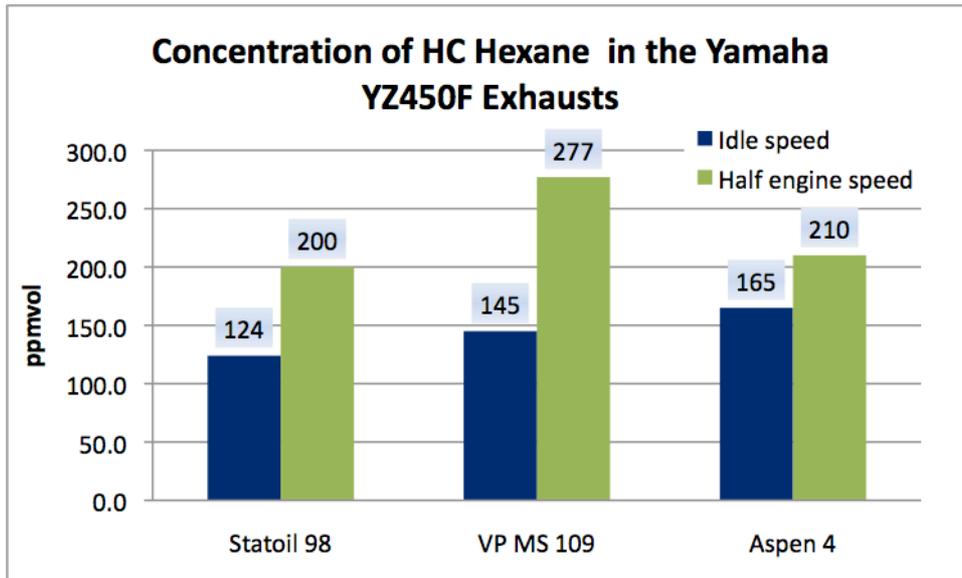


Figure 9. Concentration of HC Hexane in the Yamaha YZ450F Exhausts.

Finally, as it was explained above, λ value shows the proportion between fuel and air in the air-fuel mixture. Taking into account that the optimal value is 1, it is clear that the most optimal mixtures are generated when Aspen fuel is used. VP MS109 shows values below 1, standing for rich mixtures, which is obvious taking into account extra high octane number. The trend in figure 10 illustrates that on the half engine speed fuel mixtures are richer, which correlates with the data from Figures 7 and 9 (where the emission levels for the half engine speed are also higher).

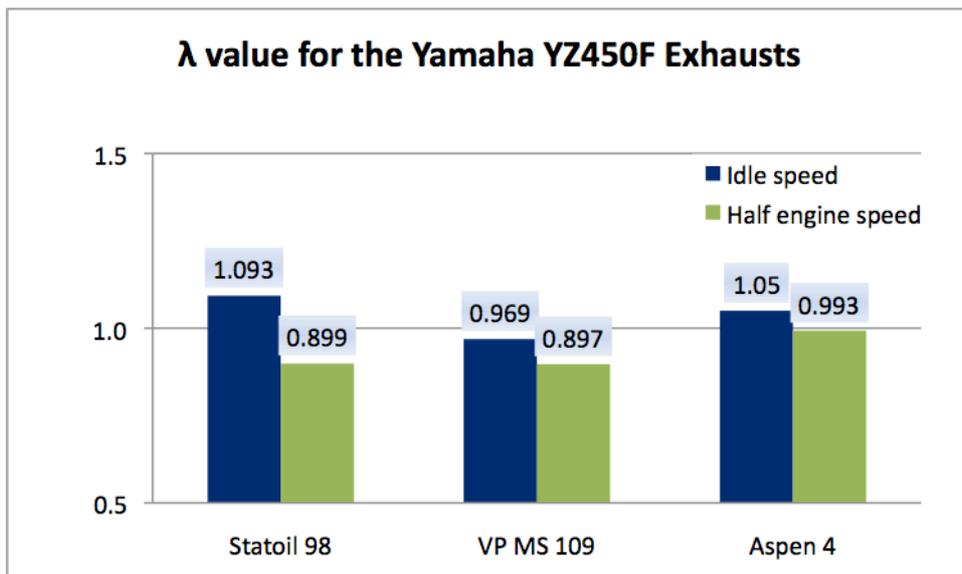


Figure 10. λ value for the Yamaha YZ450F Exhausts.

According to the data presented above it is clear that there is no absolute leader among the three fuels from the environmental point of view. Aspen 4 shows better performance when it comes to CO and CO₂ emissions. At the same time it allows to have a proper air-fuel mixture.

When it comes to the hexane emissions Statoil 98 performs best both on idle and half engine speeds. VP MS109 is not leading in any of the emission parameters except for O₂ concentration. This is a sign of a better combustion and depends on extra high octane number.

5.4. Oil

One of the constant inputs in the system is oil which is used by the team for bike oiling. Since there are no internal combustion engines that can function properly without sufficient oiling, oil becomes an unavoidable impact into the motocross.

MXStar team uses oils produced by Yamalube. This is reasoned by the fact that the bike producer Yamaha recommends Yamalube oils as such that perfectly suit engines of Yamaha bikes. At the same time the team gets sponsorship from Yamaha, which includes different Yamalube products including oil.

However, when it comes to other needs than oiling the engine there is more room for free choice. For example, the air filters installed on the bike require cleaning and oiling in order to filter the air properly. Since Yamalube does not produce any product for these purposes, team members use other oil for it. According to them in this case they try to choose an environmental brand presented on the market.

When it comes to the oils negative environmental impact it is possible to differentiate two stages of the oil use. First is the participation of oil in the internal combustion. This takes place both during the race and training period. It results in oil burning with consequent emissions and ash. This stage is hard to influence and it is similar for all the oil types. A major part of the oil is consumed by burning.

The second stage is the utilization of scavenge oil that has remained after the first stage. There are different ways of taking care of the scavenge oil, for example reusing it (oiling other less sensitive mechanisms), using it in the production of other materials (mainly ferroconcretes) and burning. Of course many people do not utilise oil in the environmentally friendly way so it pollutes soil or water. Utilization is an area of responsibility of every rider.

MXStar team members and other people in their garage collect all the scavenge oil in a big barrel standing in the garage (see Appendix 2, figure 2.2.). When the barrel becomes full they give it to a person who uses scavenge oil for heating his house (he applies a special furnace that burns oil). It is worth to say that the degree of ecological compatibility of such way of utilization totally depends on the technical characteristics of the furnace and the efficiency of burning in it.

5.5. Electricity

Electricity is used at all stages of the race. It is necessary in the garage, during the actual race and while transporting a bike. MXStar team consumes energy mostly in the garage. Since there are no windows the amount of electricity used does not depend on the time of the day.

There are two major reasons for electricity use: maintenance of the bike and illumination of the premises. Noteworthy is that no energy saving lamps are used in the garage. It depends on the fact that electricity expenses are included in the rent of the premises and thus there are no financial incentives for the team to decrease their energy consumption.

During the race the team does not use much electricity themselves, but benefit from the indirect use of it. It applies for both maintenance and illumination needs. Thus, the team has a little room for change in their way of energy consumption during the race.

Another aspect is the way of energy use by the race organizers. For example we have mentioned that during the race the lamps on the track were turned on both before and after lunchtime, which does not seem to be the most efficient way for electricity use.

5.6. Garage

Garage is a building or part of a building, designed and used for storing a vehicle, necessary equipment and different spare parts, which can be used for repairing and maintenance of the vehicle. Due to the fact that team members live in different cities, each member has own place for bike and spare parts storage. For instance Tomas Petersson (the team leader) rents a garage close to the Uppsala city centre together with 6 other riders, which are not part of the MXStar team. They are responsible for cleaning and waste management in the garage together. It might create certain difficulties in the communication and decision making about the garage maintenance in terms of environmental management.

The garage consists of two big rooms: one is used for keeping bikes, tires, scavenge oil container and some spare parts, another is storage for racing cloth, safety equipment and shoes. Most of the motorcycles are placed on the environmental mats, the purpose of which was discussed in the previous chapter. The place is mostly cleaned by water under pressure together with detergents.

In several months Tomas Petersson and the other riders who are renting the same garage are moving to another place. Currently, all 6 riders share the rent of 2500 kroner per month including water and electricity, however, the owner of their new garage will charge the riders rent and services separately which will increase the necessity of efficiency in water and electricity use.

5.7. Spare parts

Maintenance of the motorcycle spare parts is a very important issue during racing and training periods. Keeping clean, saving and utilizing tires as well as metal parts of the motorcycle has its own environmental impact; therefore, this process should be managed thoroughly.

First of all, the tires are kept in the garage on a special shelf close to the roof of the construction since it takes lots of space (see Appendix 2, figure 2.2.). For instance, 40 or more tires are kept in the Uppsala garage due to the amount of bikes and tire sets. Furthermore, depending on the season of the year and the type of motorcycling, the tires can be of winter or summer type. Besides this, a special tires type with metal inclusions is used for riding on ice. Usually all riders prefer to use different sets of tires for training and for racing. It is worth to mention that the price for one set of winter tiers is around five thousand Swedish kroner, when the summer ones is around one thousand Swedish kroner. The ice tiers can be even more expensive since they are handmade.

Utilization of the tiers is a very complicated process. All team members in Uppsala, Västerås and Nyköping are supposed to send their used tiers to the Commune Utilization Service thus

the local plants process them. Usually each rider uses the set of winter and the summer tiers for one racing and a training season.

Storage and utilization of metal spare parts is an easier process than the tier maintenance. The team members do not usually store many spare parts but buy and install them immediately. They sort this type of waste with other metal household waste in any city container.

5.8. Waste water and washing detergents

Handling waste water becomes a crucial problem considering the possibility of soil pollution during garage maintenance alongside with racing itself. In order to follow the requirements of SWEMO the team tries to handle these issues in the environmentally friendly way.

At the moment all members of MXStar team are keeping their motorcycles together with spare parts and all necessary equipment in garages with solid floor in and out. The floor of the storage contains special gutters to collect wastewater, which are linked to the main sewerage unit. Such construction of the floor is essential for keeping the storage clean from oil, fuel and other liquids. Besides during a competition period riders usually bring the bikes for washing back to the garage. In order to clean dust and pieces of dry mud, the riders usually use water under high pressure (pressure washer) and detergents for washing off oil, gasoline and other liquids. For instance, Tomas Petersson uses Yamaha lubricants (Yamalube), which are bought from the sponsors.

5.9. Safety equipment

Safety equipment and clothing is usually stored in the garage together with motorcycles and other equipment (see Appendix 2, figure 2.4.). Every rider of the MXStar team needs new uniform, which is represented by boots, pens, shirt and gloves, every year or every second year depending on the amount of competitions and trainings. The uniform must be bright, clean and look new considering the fact that motocross race is a show for spectators and good-looking uniforms is a part of it.

Rider's uniforms are made of non-natural materials such as polyester. The boots are usually made of leather including some other textile materials like cotton and polyester. The MXStar team is usually reusing their racing uniforms during the training period, however, they need to buy a new one every year for the reason that was described above. The team utilizes their uniforms by using community garbage containers.

Helmets are extremely important for riders' safety thus each riders of the MXStar team has to buy a new one after each accident even when it was not very serious. Tomas Petersson is explaining the reasons by the small cracks that could appear on the top or inside the helmet during a fall. These cracks cannot be easily seen by the owner of the helmet, which is the reason for changing a helmet every time after an accident for better safety. Used helmets are utilized by the community garbage system.

5.10. Food and drinking water

Food and drinking water is supplied by the sponsors or can be bought around the racing area. All responsibility is lying on competition organizers thus the MXStar team cannot influence transportation, utilization or any other issue considering food and drinking water. However,

they are supposed to follow main rules of the waste management, which are already defined by the authorities.

6. Discussion

The discussion part will be based on the Force Field Analysis previously described in the chapter “Methods” and Team Internal Sustainability theory. All possible driving and restraining forces for a positive change of MXStar team’s environmental impact will be discussed in order to provide the team with necessary recommendations. Definition of a motocross race as an open system with its essential elements and system’s inputs that can be directly influenced by the MXStar team will be followed. Inputs into the system will be discussed from the point of its change: driving forces - seeking to promote change and restraining forces - attempting to maintain the status quo will be highlighted.

6.1. Technological changes

The first group of inputs into the system includes such factors that have common technological nature. Thus, by changing technological components of the equipment the MXStar team can directly influence their environmental impact and improve their performance and compliance with SWEMO’s requirements.

6.1.1. Bike

As it was previously described in the case study chapter the team is currently using two models of bikes: Yamaha YZ250F and Yamaha YZ450F. Even though they are in a very good condition and meet all requirements set by SWEMO, there is an option to change these two bikes to more modern models or even change their sponsor Yamaha. Applying force field analysis it is possible to observe the following driving forces.

Firstly, purchase of new bikes might have a positive effect on the racing results. Buying a modern bike with better speed characteristics can improve racing performance of the team members and increase their winning probability. This is a very important aspect, since team performance is a crucial indicator for sponsors and racers themselves.

Secondly, new bikes potentially can have better environmental performance while having similar speed characteristics. This advantage corresponds to the aim of the team to decrease their environmental impact. At the same time it is possible to expect that SWEMO will increase the environmental standard in the future and by having better bikes the team will prepare themselves to the new conditions in advance.

Finally, buying a new bike will decrease the maintenance costs for the team since the new bikes will require less spare parts or repair. However, this effect will appear only in the short run and will not last long (depending on the intensity of racing and quality of maintenance).

At the same time there is a number of restraining factors, which keep team members from changing their bikes. Probably the strongest reason is the fact that the current bikes still are in a good condition and were produced not so long time ago. Consequently the bikes are not far behind the modern models and their speed characteristics are comparable.

When it comes to environmental performance the argument presented above is also valid. There are no modern models, which have significantly higher environmental performance, and thus there is no gain in changing the bike.

The strongest argument against changing the bike is the lack of investment. As it was described in the case study chapter the team has Yamaha Company in Sweden as their sponsor and the current bikes were purchased with their financial support. Thus, a change in a bike will most likely entail changing the sponsor, which is undesirable.

Shifting to the Electric Bike

The world progress of alternative fuels development gives us a possibility to consider another solution for bikes with combustion engines. Improving environmental impact is the main challenge for all team members, thus replacing fuel bikes with electric ones could be considered as a solution.

The strongest argument for purchasing an electric bike is zero level carbon dioxide and other GHGs emissions, which combustion engines produce in high volumes. This fact will increase the MXStar team's environmental performance in times. However, the power of electric engines is much lower compared with usual ones. The team has to change the racing category since electric bikes are not allowed to participate in the classical motocross races with fuel bikes. Team members consider this option as a possible or even a desired one, but in order to proceed in this direction SWEMO needs to be initiative and establish racing category for electric bikes.

6.1.2. Fuel

According to the analysis presented in the previous chapters, fuel is one of the most significant elements when it comes to the race and environmental performance of the bike and team as a whole. Thus, changing a fuel is an important decision, which can be grounded on the results of the force field analysis.

The term “sustainable fuel” usually refers to the one that has the smallest environmental impact on all stages of the life cycle. Alternative types of energy sources for vehicles like biofuels, sun energy, hydrogen, etc. can be considered as sustainable ones. These types of fuels are not applicable for motorsport racing because of their inability to produce high amount of horsepower, thus the MXStar team uses normal gasoline with high octane number: Statoil 98 and VP MS109.

A more environmentally friendly fuel can have several advantages for the MXStar team. Firstly it will significantly decrease environmental impact, which is an important goal for the team. It implies not only the decrease in the amount of emissions during the race itself, but also indirect minimization of negative impacts on the all stages of fuel production and distribution.

Secondly, environmentally friendly fuel promotes “green racing”. Considering this fact the team will positively influence other racers and SWEMO. At the same time SWEMO's requirements are dynamic and it is expected that a new environmental standard will be

accepted soon. Thus, by shifting to another fuel now MXStar team will be able to meet SWEMO's continuously growing standards.

However, there is a range of restraining forces, which keep the team from shifting to another fuel. First of all, by shifting to a more ecological fuel (for example Aspen 4) the team risks to lower their racing performance, especially when it comes to speed. It can be a serious disadvantage especially in the situation when the rest of the riders will use usual racing fuel. Currently there is no such an environmental fuel that can adequately substitute racing fuel (VP MS109). One of the best substitutes is suggested by the Aspen Company and is called Aspen R - fuel for motocross championships. This product is a high-octane (rating RON 102/MON 89) and extra clean specialised fuel that is assumed to produce cleaner exhaust gases with less smoke and soot. It is virtually free from aromatic hydrocarbons, polyaromatic hydrocarbons, benzene and olefins. Besides, this fuel reduces the risk of knocking.

Another important restraining factor is the price of a new fuel. Paying more for a better environmental performance can be considered as an option by the team, but it leads to high expenses especially during the training races, which are conducted almost every week, or even several times per week. The price of Aspen 4 per litre is 31 kroner. Statoil's petrol A-98 costs around 15 kroner per litre (Statoil Official Site, 2011) and the racing fuel that is often used by the MXStar team, VP MS 109, costs 19 kroner per litre (Alaska Motorsport Forum, 2011). Obviously, higher-octane rate and ecological compatibility lead to a higher price. Financially the team hardly can afford to use Aspen 4 and especially Aspen R for the training and competition period without significant sponsors' support. Since there is no crucial difference in the amount of direct emissions produced by Aspen 4, wide application of it seems controversial.

Taking a broader perspective on environmental impact it is also important to take into account the way of fuel production and its side-effects. For example, production of standard petrol (including Statoil 98 and VP MS 109 racing fuel) is proceeding of oil fractions in different ways and further mixing them together. This process itself and its final product contain plenty of different harmful substances (Speight, James G.1999). However, alkylate petrol is adapted to have comparably good environmental performance by using certain gases from the crude oil refinement. The final product in this case contains around ten substances that exclude sulphur, aromatic hydrocarbons and olefins. It is delivered in environmental packages (Aspen Official Site, 2011).

On the other hand Aspen is an alkylate petrol that contains comparably low amount of benzene, lead, olefins, sulphur and aromatic hydrocarbons. It means that alkylate petrol fumes influences humans health and environment significantly less (Aspen Official Site, 2011) compared with standard petrol that is produced by refining crude oil. Due to the pureness of Aspen petrol we can assume that it ensures the machine's high performance and can be stored without suffering deterioration in quality.

Alternative fuels

Since it is quite hard to select a fuel that would give good racing characteristics and at the same time satisfy both ecological and economic criteria, it is reasonable to take into account an option of using an alternative fuel.

Biodiesel

Biodiesel differs from petroleum diesel through its absence of petroleum products. A renewable hydrocarbon fuel is produced from animal fat and vegetable oils. The process is called transesterification, where vegetable oils and animal fats react with alcohol (ethanol or methanol) and a catalyst. In the process, glycerol is separated from the oil to form ethyl and methyl esters (Eemsonline Web Site, 2011).

Two common products are biodiesel based on rapeseed oil (Rapeseed Methyl Esters, RME) and fat (Fatty Acid Methyl Ester, FAME) respectively. Other types of oils being used include soya oil, palm oil, jatropha and olive oil (Eemsonline Web Site, 2011).

Biodiesel can be blended with petroleum diesel in different proportions (example B20 = 20% bio, 80% petroleum diesel) to be used in various diesel engines. If the appropriate modifications are made, it can also be used in its pure form (B100) (Eemsonline Web Site, 2011).

Power capacity and necessity of engine medications could be the restarting factors for using this type of biofuel during motocross championships. More research and tests need to be done in order to draw conclusions about this issue.

Bioethanol

Bioethanol is a high-octane, water-free alcohol. It is produced in the process of sugar or converted starch fermentation. This fuel is a colourless clear liquid. Usually it is used for blending with gasoline for combustion engines (Website of the Philippine Department of Energy, 2011).

Ethanol's high octane rate is natural and therefore it prevents premature detonation under load. Burning process of ethanol is clearer comparing to normal gasoline since it contains more oxygen, which affects amount of monoxide emissions. Besides, this fuel extends the time of engine use due to the fact that it burns slightly cooler (Website of the Philippine Department of Energy, 2011).

An important issue about ethanol fuel usage is the possibility to blend it with gasoline after basic engine modifications: for example, a 10% blend requires no engine modification while reduce carbon monoxide and dioxide emissions. However, blending more than 10% requires some engine modification (Website of the Philippine Department of Energy, 2011).

Participants of motocross championships in England and some other European countries have the experience of blending ethanol with gasoline. However, considering power capacity of such blends and necessity of engine modifications, ethanol fuel is on the testing stage and standard racing fuels are still widely used nowadays.

6.1.3. Oil

There are several ways of managing environmental impact, which is caused by the intensive use of oil in motocross. When it comes to the MXStar team there is an understanding of the problem and some actions are organised by the team and aimed at the reduction of negative environmental impact. However, there is a room for further change in the oil use. For example it can be special places for washing bikes or new ways of scavenge oil utilization.

So, the strongest driving force is in decreasing direct pollution resulting from oil use. It implies a more responsible attitude to the scavenge oil both in the racing track and garage. It is also possible to decrease the indirect oil pollution by shifting to a more environmentally friendly oil brand.

Another aspect responsible oil use is meeting SWEMO's requirements. Currently, a special environmental mat for the bike parking during the race is the only requirement for the racers and teams.

According to force field analysis, the strongest restraining force for the change in the oil use is the lack of facilities. It might be challenging to have enough space in the garage for storing the scavenge oil. Moreover it is almost impossible to wash the bike in the garage. When it comes to the race there is a similar lack for scavenge oil storage facilities, but some tracks are equipped with bike washes.

Another restraining force is lack of substitutes to Yamalube oil. It is strongly recommended by the bike producers to use particularly this oil in order to keep the Yamaha engine in a good condition and reach desired racing characteristics. Moreover the team is sponsored by the Yamaha and purchases Yamalube oil with discounts.

6.1.4. Electricity

Every rider concerns about optimization of resources use in the garage, which is directly connected to the improvement of environmental performance. The driving force for an environmentally friendly way of garage maintenance is saving natural resources, for example water, electricity and heat, which is directly proportional to the costs of garage maintenance. In this case electricity use plays the most significant role.

Even though motocross is not associated with high electricity consumption (in contrast to fuel consumption) it is still possible to implement some changes in the ways of electricity consumption in order to reach higher level of environmental performance. This improvement can be reached by optimization of illumination and application of energy saving technologies.

The primary driving force in this direction is natural resource saving. By lowering the amount of consumed electricity the team will indirectly decrease fossil fuel exploitation and lower emissions. At the same time lower energy consumption will lead to the cost reduction (especially when it comes to the garage maintenance).

On the other hand, implementation of energy saving technologies requires some investment. Depending on the scale of investment the amount of saved energy can vary, but in any case the total gain in efficiency will not be significant.

6.1.5. Spare Parts

Spare parts maintenance and utilization create a significant impact on the environment. It is represented as an impact to the motocross race, which is described as an open system in the Chapter 6. Spare parts management is under full responsibility of the MXStar team members, thus, the team coordinates this process directly.

Environmental impact optimization is the main goal of effective spare parts use and utilization. Furthermore, it has driving and restraining forces according to field force analysis. One of the driving forces is characterized by the necessity of decreasing environmental impact in order to meet annually increasing requirements of SWEMO. There are two main options in this case: reducing the number of tires used for training/racing periods and improving tiers alongside with other metal spare parts utilization process. Another driving force is cost saving.

The restraining force in this case is very important to consider since using fewer tires means decreasing the amount and intensity of trainings or races. It strongly affects team's performance, which makes it a significant restraining force taking into consideration the goals of motocross racing.

6.1.6. Waste Water

Waste water treatment is a key concept in motocross racing for both sides: competing team and racing organizers since it directly affects soil and water. Soil pollution is one of the main environmental problems of any motocross event. During bike maintenance oil, fuels, wastewater and some other liquids can be dispersed into the ground by the team members during reparation or examination.

Reducing the amount of waste water and improving a system of effective waste water management is a driving force for the MXStar team due to current legislation and standards. The restraining force in this case is inability of the team to influence the city sewerage unit. Team members can reduce the amount of detergents or change their types or brands to more environmentally friendly, which will directly affect the level of water and soil pollution.

Such actions are driving forces for the team because they can optimize their environmental impact. However, from the other side changing or reducing the amount of detergents usually leads to a decreasing quality of washing and in some cases increasing of expenses (prices for environmentally friendly products and solutions are much higher). This fact can be considered as a restraining force for the team in case of changing detergents and other washing liquids.

Saving Water

Water saving is an important issue of the team's everyday activities since most of the times they bring bikes to the garage place for washing. For example, around 100 gallons of water (approximately 378 liters) are required in order to wash a car at home (Dictionary.com, 2011). We can assume that washing a motorcycle after the race in the garage by using a pressure washer demands approximately the same amount of water as car wash. Such type of washing also produces a runoff that becomes waste water (Green-ct.org, 2011).

Here is a diagram of water consumption for different types of car washing based on the report of International Carwash Association:

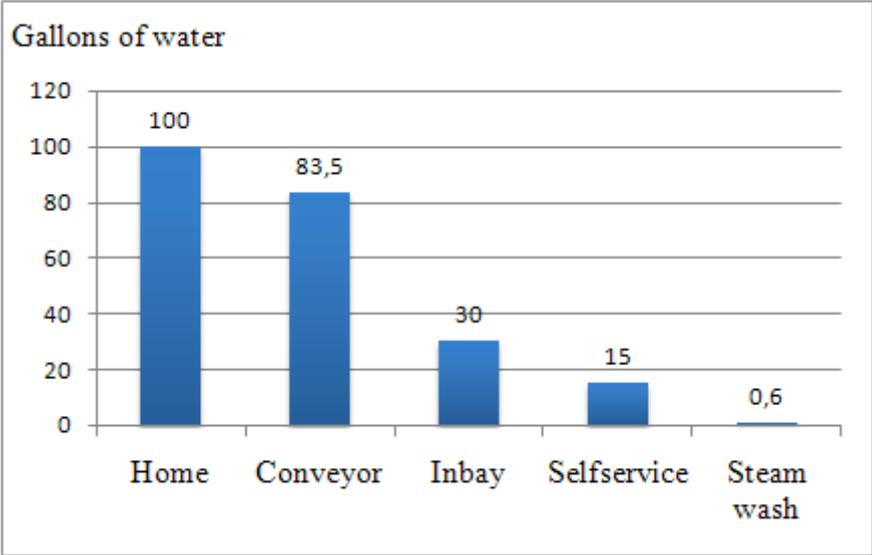


Figure 8. Water Consumption Rate by Car Wash Type (Sjecorp website, 2011).

From the figure above we can conclude that home wash is the most water consuming type of car wash, while steam wash demands the smallest amount of water. In order to save more water the MXStar team needs to modernise their motorcycle wash.

Driving forces for more efficient water management system are decreasing amount of waste water, cost saving in a long-term perspective and optimization of the team’s environmental impact. The restraining force is a current lack of investment.

6.1.7. Clothing and Helmets

Every rider uses a high number of shoes, helmets and clothes for each racing period. Non-natural materials that are used for making numerous riders’ uniforms, shoes and helmets are the reason for finding better ways to utilise or reuse them.

Driving forces for reusing uniforms and shoes are cost saving and decreasing amount of utilized items. This can positively influence the level of environmental impact if the old uniforms and shoes are sold or reused. Restraining forces are the necessary in attractiveness of the uniform during a competition since a motocross race is a spectators’ oriented sport. Reusing uniforms can also negatively affect the safety of the rider.

The driving force for utilising helmets is optimization of environmental impact; hence, the restraining force is inability of the team to choose the way of utilization according to the limitations in the city’s infrastructure. Reusing helmets is impossible due to safety issues described in the previous chapter.

6.2. Behavioural changes

The second group of inputs into the system includes such factors that have common behavioural nature. Thus, by changing behavioural models and habits, the MXStar team can

directly influence their environmental impact and improve their compliance with SWEMO's requirements.

6.2.1. MXStar's team internal sustainability

Environmental issues are inherently strategic and interwoven into every competitive team and racing organizations: from the easiest daily activities to strategically important planning processes. Such planning process assumes implementation of sustainability principles in everyday activities of the MXStar team.

Fineman (1997) wrote that addressing sustainability issues is not part of personal skills and experience team members, however, Hart & Milstein (2003) emphasize that the need to address sustainability issues is driven by growing concerns about environmental impact that have been caused by material consumption and increasing of the connections among people.

Tomas Petersson, MXStar team's leader, is concerned about environmental issues since his team needs to meet annually increasing standards of SWEMO, thus, he is trying to integrate sustainability issues into every activity of the MXStar team. Usually it can be gained by using best available technologies, but it is very challenging. Lack of investment, limited ability to affect a process of championships organization or city waste management options, relationships between internal and external stakeholders are some of the restraining forces, which could affect team's wiliness and possibility to improve their environmental impact.

According to Pfahl (2010), teams are planning and making their own policies that are strictly coordinated with standards and rules, which influence internal team activities. For instance SWEMO has an environmental award and encourages activities that make teams more "green". By implementing sustainability issues the MXStar team besides meeting environmental standards can also gain money awards, sponsors attention and positive reputation among internal and external stakeholders. Tomas Petersson as a person who is in charge of environmental strategies clearly realises these possibilities.

Intangible assets of the team become very important in a process of implementing sustainability principles. Talent and environmental education within the team together with the skills of the team leader are main recourses for strategic planning in the sphere of environmental protection. The MXStar team leader and each member of the team are highly aware of sustainability principles. Besides, they are motivated for positive change of environmental impact and ready to invest their time and talent into this. It creates a solid foundation for achieving team internal sustainability.

Furthermore, Hillman & Keim (2001) underline one more important concept in team internal sustainability – external stakeholders' attitude. Motorsport is a relationship-oriented industry because they provide coordination with tuning companies, sponsors, and spectators. As it was mentioned above this is beneficial for resource advantage because the stakeholders are able to provide more resource (e.g. awards, reputation and sponsors' attention).

In addition, major professional motorsport teams like MXStar, can use their achievements in optimization of environmental impact to promote environmental change among other competitive teams and influence spectators behaviour during the championship. This

decreases environmental, social and economic consequences of the motocross racing event at any level.

6.2.2. Team's attitude

As it was described in the theoretical chapter, participatory research approach is applied in the thesis in order to include MXStar team members in the research process and engage them to the fullest extent possible. During the research it became clear that their personal attitude to the problem of environmental impact of motocross is crucial both for the research process and practical implementation of the research results.

Particularly, it is possible to summarise that the research was initiated by the team members themselves and many initiatives in the environmental field are constantly undertaken by the MXStar team. In other words, team members are personally interested in environmental organization of their sport activities and thus the change in their attitude towards the environment has already taken place. It is possible to expect that the team will continue their efforts aimed at the further decrease in pollution and promotion of environmentally friendly motocross.

6.2.3. System's model of sustainable motocross

According to systems theory motocross race is a static and open system with its interacting elements, inputs, outputs and control function. The MXStar team can directly influence most of the inputs by the implementation of innovative technologies and development of completely new managerial strategies.

Field force analysis gives a clear picture of strengths and weaknesses of the proposed changes that potentially can lead to the optimization of the environmental impact. These changes are represented as inputs that can be influenced by the MXStar team directly.

Proposed changes can be theoretically divided in two main groups: technical and behavioural. In order to optimize the environmental impact, team members have to be innovative in both technical and behavioural perspectives. Such differentiation is essential for successful implementation of the environmental initiatives at the team level.

When it comes to the technical innovations such elements as bikes, other vehicles, fuel, oil, tires, electricity, equipment, spare parts, food and drinks are meant. These elements are direct inputs into the race and significantly influence MXStar team's environmental performance. The team has direct control over the mentioned elements and thus has the necessary instrument for the further improvement. However, the main threat to most of the technical environmental initiatives is the lack of investment, since eco-friendly solutions usually are more expensive.

Team's internal sustainability, stakeholders' attitude, intangible assets and resource-based view are behavioural changes that have a potential to bring improvement to the team's environmental performance. Considering the fact that team members themselves initiated current research and many environmental initiatives have already taken place it is possible to conclude that the MXStar team has a positive attitude towards environmental initiatives. Their behavioural initiatives create a great potential for the further eco-friendly development. The

major threat is that the team's behaviour does not solely depend on the team members, while the opinions of other stakeholders have to be taken into account. This causes certain risks for the further environmental initiatives.

Environmental performance of motocross racing composes from technical and behavioural inputs of each participating team. Sustainability of motocross race is a concept that considers environmental, economic and social aspects, thus technical and behavioural innovations create a solid ground for it. SWEMO, as a control function of the system, controls all inputs and outputs of motocross racing in Sweden. Technical issues are regulated by standardization and producing regulations for races, while behavioural ones are managed by organising environmental awards and prices.

7. Recommendations

Given chapter will follow the structure developed in the discussion. Recommendations are divided in two groups, each standing for separate set of factors: technological and behavioural. By implementing the recommended improvements MXStar team is supposed to decrease environmental impact and keep the high level of racing performance.

Technological Recommendations

1. Due to the intensive training schedule it is often required to go to the training arena several times per week. Thus, in order to decrease general environmental impact of the team it would be efficient to keep the bike at the place of training or have a mini-garage there.
2. Take part in races in the category of electric bikes. In case the new racing category for electric bikes will be opened by SWEMO a purchase of an electric bike will be reasonable. The MXStar team can promote green initiatives by taking part in this category, which will contribute to their public image. Besides, the sponsors and SWEMO can support such initiatives.
3. Being the most expensive fuel Aspen 4 did not show a crucial difference in environmental performance and thus it would be reasonable to continue using Statoil 98 for the training sessions and VP MP109 for the important races. However, a more detailed test combined with engine tuning and involvement of alternative fuels is strongly recommended.
4. Collect all the scavenge oil and pay more attention to the process of its utilization. Burning the scavenge oil for heating purposes is an acceptable way of its utilization, however other ways of utilization can also be applied (for example using municipality infrastructure)
5. Implement energy saving technologies in the garage. This applies for both types of equipment: illumination and bike maintenance. Energy saving lamps can bring significant increase in lighting efficiency and cost saving. Try to economize the general amount of electricity used.
6. Follow the latest innovations about motorcycle spare parts and environmental solutions. This especially applies to mufflers, which can significantly decrease noise pollution.
7. Consider the possibility of selling used spare parts as metal scrap, which can return some investments that were spent on the purchase.
8. Reuse racing tires for trainings. Consider the possibility to sell them to non-professional riders, who do not need to fulfil SWEMO's requirements or achieve high speed characteristics (if applicable).
9. Due to the high energy content of scrap tires as well as the high homology of the material they form an excellent secondary fuel for cement kilns and tire power plants. Besides the energy content, the steel and the silica in the scrap tires are also a material source for the production of cement. Thus, team members can contact cement factories around Uppsala region and tire power plants.

10. Consider the possibility of investment in steam washer and use natural detergents like soda.

11. Wash spare parts before utilization on the environmental mats.

12. Reuse clothing or resell to non-professional riders. It could be interesting to open a special section on the website where MXStar could post advertisements about things that are no longer needed. This applies not only for clothes, but especially for tires and other spare parts.

Behavioural Recommendations

1. Develop cross functionality in the team. Every team member needs to be assigned for some environmental duty. In this way team members will share responsibilities, which will contribute to a common sense of the “team” and at the same time promote the image of the MXStar as an environmentally responsible team.

2. Resource based view allows starting, developing and improving sustainability operations year by year both in terms of team’s motivation and relations with external stakeholders.

3. Inform other teams and riders about environmental improvements undertaken by the team through MXStar’s website and personal contacts. This will lead to the further promotion of environmentally friendly racing and spread the idea of sustainability in motocross sport.

8. Conclusions

Motocross is a form of motorcycle sport or all-terrain vehicle racing held on enclosed off road circuits and is one of the world's most widely spread types of motorcycle sports. Sweden is among the Europe's leading motocross nations. SWEMO is an organization regulating motorsport activities in Sweden.

The MXStar motocross team is an active participant in Swedish and European Championships. Being one of the biggest teams in Sweden, they are based in Uppsala and are given support by the Yamaha Motor Scandinavia AB in cooperation with Yamaha Store in Västerås. Since the team is concerned about their environmental profile, they are willing to decrease environmental impact of their operations.

During the research environmental impact of the motocross in general and MXStar team in particular were investigated. The primary goal of the study was to reduce/optimize environmental impact of the MXStar motocross team during the preparation and racing periods. In order to achieve the goal a range of research activities were undertaken: direct environmental impact of motocross was evaluated considering side effects; environmental performance of MXStar team was defined and analysed and key recommendations aimed at the environmental impact optimization were developed.

Given research has an interdisciplinary nature and thus participatory research approach and systems theory were applied. The research is based on both primary and secondary data. Methods for data collection varied and included a set of data collection techniques, which differed depending on the nature of information and research aims. Both qualitative and quantitative methods were applied at the same time and served as a base for force field analysis that constituted discussion chapter.

Motocross sport is defined as “sustainable” when it has low environmental impact and brings more positive outcomes for social and economic welfare of the society compared with the amount of resources it uses. Furthermore, available technological solutions alongside with cross functionality in the teams are the tools, which are applied in order to make this sport more sustainable.

However, motocross still causes environmental degradation by the extensive use of fossil fuels, significant amount of land, water, chemicals and the lack of “clean” logistics during training and competition periods. Thus, in order to perform the analysis of motocross race from the environmental impact perspective, an open system model was built and included a range of inputs and outputs. Most of the research efforts were given to the processes that take place within the boundaries of this system.

One of the major achievements of the research is the conduction of the fuel test that allowed analysing advantages and disadvantages of each fuel from the environmental point of view. Particularly, different concentrations of gases in the exhausts were presented and served as a base for further discussion. The controversial issues of fuel production and distribution

processes were also taken into account. The complexity of this question resulted in considering biofuels as an option for future research and analysis.

Sustainability of motocross racing is a concept that considers environmental, economic and social aspects, thus technical and behavioural innovations create a solid ground for it. Environmental performance of motocross racing composes from technical and behavioural inputs from each participating team. Summarising the recommendations it is necessary to emphasize that in order to optimize their environmental impact team members have to be innovative in both technical and behavioural perspectives.

Research limitations

Given research project and its results have certain limitations. Firstly, the system boundaries determine the scope of the research and thus the issues investigated in the thesis have a case study character and do not include the broad spectrum of nuances beyond the race boundary.

Secondly, since the major research attention was given to the emission sources, which are dependent on the MXStar team's activities, there is a range of other factors that are not included in the research – those that do not depend on the team directly but still contribute to the emissions. Further analysis in this direction requires more detailed investigation of external stakeholders and SWEMO.

Time frame and finance for the research are the factors, which has limited the amount and diversity of fuel tests. Those fuel tests that were conducted are limited in terms of equipment that was applied and did not allow measuring certain indicators (mainly NO_x oxides, particles and speed characteristics).

Finally, the lack of scientific literature on the relations between motorsport and sustainability determined the lack of theoretical models for the research. Thus, interdisciplinary theoretical models were applied.

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Appendix 1



Figure 1.1. General view of the racing track, parking place and other territory.



Figure 1.2. Infrastructure for race participants and guests.



Figure 1.3. Condition of the soil after the race.



Figure 1.4. Start of the race.



Figure 1.5. Protection from the noise pollution.



Figure 1.6. Count down before the start.



Figure 1.7. Bike standing on the special mat in order to prevent soil pollution.



Figure 1.8. Different wastes that were generated during the race.



Figure 1.9. Information board from the race organisers.



Figure 1.10. Trailer used in order to bring the bike to the racing place.



Figure 1.11. Support vehicle during the race.

Appendix 2



Figure 2.1. Tomas Petersson and Yamaha YZ450F motorcycle.



Figure 2.2. Shelves for keeping tires and several motorcycles under them.



Figure 2.3. Scavenge oil container in Tomas Petersson's garage.



Figure 2.4. Separate room for keeping racing and training uniforms in the garage.



Figure 2.5. Emissions measuring tool AVL DiGas 4000 Light



Figure 2.6. Measuring emissions from the Yamaha YZ450F (idle speed).