Environmental Assessment
- Sustainable Cards Europe

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VI HAR FÅTT STÖD AV TILLVÄXTVERKET

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Abstract

Jegrelius - Institute for Applied Green Chemistry are managing the project Show Rooms for Products of Tomorrow with the aim to support small and medium enterprises to achieve the competitive advantages that environmentally driven markets can offer. One of the elements to achieve this is to assess and verify the environmental performance of the participating companies products. In this report we therefore provide, an assessment of the environmental performance of Sustainable Cards Europe's wooden multifunctional cards compared to the market-dominating cards made of plastic such as PVC, polystyrene and PETG.

The assessment of the environmental performance has been performed through a life cycle assessment (LCA), sustainability analysis and chemical assessment.

The performed Cradle to Grave LCA demonstrates that the total environmental impact during the cards life cycle is lower for the wooden cards compared to the plastic cards. Environmental impact in form of climate change effects and fossil depletion are more dominating for the plastic cards than for the wooden cards. This difference is mainly due to the fossil origin of the raw materials but also due to that the wood based cards have a lower energy demand combined with a greater proportion of renewable energy sources.

The sustainability assessment clearly shows that the plastic materials have some great issues to deal with in order to fit in a sustainable society. PVC and polystyrene are in the assessment identified as materials not feasible in a sustainable society due to hazardous components and material recycling issues. PETG plastic cards on the other hand, might comply with sustainability, but due to the fossil raw material, a technical recycling loop is a necessary step for reaching sustainability.

The wooden cards from Sustainable Cards have several advantages due to the raw materials origin from renewable resources, but there are some critical challenges such as threats towards the biological diversity. To ensure the sustainability of the forestry some kind of third party certification is necessary. The FSC-certification system is identified as the best system available and expected to improve in a sustainable direction due to a credible and transparent organization.

The assessment of the chemicals used in the production of the wooden cards did not identify any priority substances or any specific chemical risks.

Our conclusion is that Sustainable Cards wooden cards are from an environmental perspective, preferable to the studied plastic cards. The wooden cards have a lower total environmental impact and are closer to a sustainable society than the plastic cards.

Within the group of wooden cards, the Northern Light and the Scandic PLA cards are the most preferable in a sustainability perspective due to the high degree of raw material from renewable resources.

1 Introduction

1.1 About Jegrelius – Institute of Applied Green Chemistry

Jegrelius - Institute of Applied Green Chemistry is an public non-profit organization that works with consumers, businesses and the public sector to stimulate demand and production of toxic free products. The vision is to contribute to a safer environment in our everyday life. The Jegrelius Institute supervises companies in chemical issues, run projects and support local governments in innovation procurement. The Jegrelius Institute is a part of the Regional Council of Jämtland in Sweden.

1.2 The project: Show Rooms for Products of Tomorrow

The project *Show Rooms for Products of Tomorrow* is managed by Jegrelius - Institute of Applied Green Chemistry. The project was started 1 July 2010 and runs for three years. The project aims to support small and medium enterprises to achieve the competitive advantages that the environmentally driven markets offer.

In the project the Jegrelius Institute makes, as an independent player, an environmental assessment of the participating companies' products in comparison with selected market-dominating competing products.

The project is funded by the European Regional Development Fund, Swedish Agency for Economic and Regional Growth, Jämtland County Administrative Board and the Regional Council of Jämtland.

1.3 Sustainable Cards wooden card products

The company Sustainable Cards Europe AB manufactures and sells wood based cards. The cards can function as hotel key cards, gift cards, member cards etc. and be applied with magnetic strip or bar codes. The cards core is made from Finnish birch veneer with a layer of paper backer glued on both sides of the veneer. The card core can the be printed on or applied with a magnetic strip and finally based on the type of card, main function and customers demand, the card are sealed with a layer of lacquer or a plastic overlay.

Sustainable Cards produce at this point two card types; Scandic PETG with a PETG-plastic overlay and the Northern Light with a thicker veneer and a layer of lacquer. A new card with biobased PLA-plastic overlay is ready for market introduction under the name Scandic PLA. The wooden core can also be applied with a PVC-overlay if customers make that demand and the card is in that case named Scandic PVC.

The card market today is dominated by plastic cards of different types, such as PVC, polystyrene and PETG. In this study we will perform an environmental assessment of the Sustainable Cards wooden cards and compared the environmental aspects cards made of PVC, polystyrene and PETG.

2 Method

2.1 The Jegrelius Model for Environmental Assessment

In order to perform assessment of the environmental performance, we work according to the Jegrelius Model for Environmental Assessment[1] which defines and describes our values and the methods and tools we use.

A fundamental part of our approach is to base our evaluation on three types of environmental analyses:

- Life Cycle Assessment (LCA)
- Sustainability Analysis
- Assessment of Chemicals

The LCA approach gives us a good scan of different environmental impacts during a products whole life cycle. Many of the environmental impact parameters are quantitative, such as energy consumption, greenhouse gases, resource depletion etc. The way these impacts are evaluated between each other and what priority they are given are subjective and depend on the method used.

Sustainability Analysis is a suitable way to deal with more dynamic processes from present to a certain time in future and is suitable to handle non quantitative aspects as biodiversity, chemical risks, social justice etc. A Sustainability Analysis is not sensitive for differences in inherent and adjustable problems such as changes in electricity supply and routes for transportation.

In both the LCA and the Sustainability Analysis, chemicals and chemical use during the products life cycle are assessed. With the Assessment of Chemicals approach we look closer at the individual chemicals included in the final product with a risk for exposure to the users.

2.2 Life Cycle Assessment (LCA)

LCA is a method used as a tool to get an overview of the total environmental impacts associated with a process, product or activity. This LCA has been performed according to the ISO 14040 series standards and is here only described briefly. For a more comprehensive method description please see full report[2].

ISO 14040: 1997—Principles and framework

ISO 14041: 1998—Goal and Scope definition and inventory analysis

ISO 14042: 2003—Life Cycle Impact assessment

ISO 14043: 2003—Interpretation

A major part of the environmental impact of a product depends on choices taken during the product development phase, e.g. materials, processes, functionality etc. The basic principles for abatement come from the discipline of cleaner technology, is defined in the concept of Integrated Product Policy (IPP). The method includes four iterative process phases that in combination produce strategic information about the environmental aspects of a product life cycle.

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[1] Jegreliusmodellen – vårt sätt att arbeta med hälso- och miljöbedömningar. Unpublished report Jegrelius 2010
[2] Life Cycle Assessment, Sustainable Cards, Marcus Wendin, Pär Andersson, Miljögiraff 2011

An LCA is used to scan which part or parts of the life cycle of a product that has environmental impacts that have to be considered. It does not give an absolute figure of environmental loads. The result of the inventory is used to detect potential impacts to the environment. Each parameter, e.g. emission of carbon dioxide is characterized by potential environmental effect e.g. global warming potential (GWP). The importance and magnitude of this effect is weighted to other effects such as resource depletion. The characterization and weighting are subjective and depend on the method used.

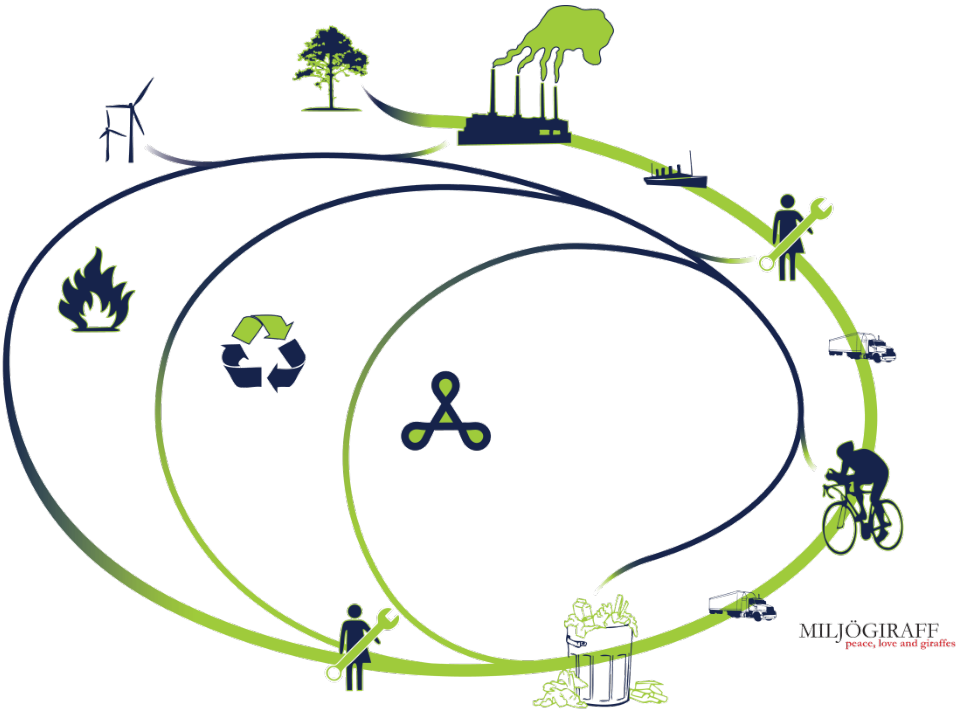

Figure 1: The concept of Life Cycle Assessment

Moreover, the indices that are used to evaluate the environmental impacts are based on subjective consideration. These depend on how society today priorities the environmental issues and what is on the political agenda. An example is substances contributing to global warming which are given a very high value for environmental impact. This will reflect on the result in such manner that for example use of oil and natural gas is very negative. Other issues that have a more local impact are not given equal priority and therefore may not be accounted for as accurately.

The life cycle scenario is compiled of a number of operations. Some are solely used in the production of the products, while some are used in many other processes such as electricity from the grid. These are referred to as ―external processes outside the factory fence or ―infrastructure related production. Environmental impacts from external processes are allocated to the core chain of production. Some issues become very peripheral and it is not always relevant to take into account of all these impacts.

2.3 Sustainability Analysis (SA)

The sustainability analysis of the wooden and the plastic cards was performed by *Hedenmark Ecoprofits*[3] and integrated in this environmental assessment. During an environmental assessment it is important to ask whether it is a step towards a sustainable society and whether it is a flexible platform for further improvement.

In a sustainable society there are four Basic Principles of Sustainability (System Conditions, SC 1-4) that should be fulfilled[4]:

1. Substances extracted from the earth's crust must not systematically accumulate in the environment.
2. Society-produced substances must not systematically accumulate in the environment
3. The physical conditions for production and diversity within the ecosphere must not become systematically deteriorated
4. The use of resources must be efficient and just with respect to meeting human needs

The Sustainability Analysis includes a four step ABCD program.

A-step: It begins with an overview of the whole system, considering all issues in the life cycle that are in conflict with Basic Principles of Sustainability (System Conditions, SC 1-4):

In the A-step, we undertake training to share the framework, including the funnel metaphor representing the sustainability challenge, the process of backcasting, and the four system conditions. These are the conditions for sustainability towards which we are working to comply in the long term. This is actually the fundament of the SA. Our initial point in this report is that the reader is already introduced to this step. Otherwise we refer to existing literature[5,6].

B-step: In this step, the SA corresponds to a LCA (baseline analysis) whereby sustainability issues can be assessed with respect to the goal of sustainability using the sustainability principles above. It helps to tell us our starting point and what we need to address from a sustainability perspective.

C-step: Creating a vision within the constraints of the sustainability principles is necessary to establish a more specific direction and set of goals to work towards.

D-step: Finally, the conclusion of the potential to achieve sustainability can be analyzed by considering the gap between B and C (where we are and where we want to be in the future) in the D-step. Three questions need to be addressed:

1. Is the discussed action a significant step towards D?
2. Does the action give enough flexible platform for following steps?
3. Does the action give pay-back enough, as being seen as a realistic initiative within existing market situation?

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[3] Hedenmark Ecoprofits http://ecoprofits.se/

[4] Azar, Holmberg & Lindgren 1996, Socio-ecological indicators for sustainability, Ecological Economics, Vol 18, pp 89-112

[5] Holmberg J, Robe`rt K-H. Backcasting from non-overlapping sustainability principles — a framework for strategic planning. Int J of Sust Dev and World Ecol 2000;7:1–18.

[6] Robe`rt K-H. Tools and concepts for sustainable development, how do they relate to a framework for sustainable development,and to each other? The Journal of Cleaner Production 2000;8(3):243–54

2.4 Assessment of Chemicals

When it is possible our aim is to perform a simplified risk assessment based on the hazardousness of the chemical, the specific exposure, how the product is used and the exposed people’s vulnerability.

We are also convinced that there are a large number of chemicals that should be phased out from our society. Many of these are included on various lists of priority substances. Examples of some of such lists are: ChemSecs SIN List, ECHAs Candidate List of Substances of Very High Concern and the Swedish Chemicals Inspectorate's database PRIO. For substances with CMR and PBT properties not included on these lists, we base our evaluation on the same criteria.

The Jegrelius institute believes that in many occasions it is essential and in some cases an obligation to use the precautionary principle. Our criteria for substitution can be expressed as: *If there is a scientifically based suspicion of serious negative effect from chemical A, but not from chemical B, then substitution should be made provided that the function is otherwise satisfactory.*

3 Result

3.1 Life Cycle Assessment

A comparative and prospective Life Cycle Assessment according to ISO 14040 has been performed for the wooden card laminated with a PETG, called Scandic PETG. In order to see how the environmental impact changes and if any environmental benefits could be found three other product varieties have also been assessed:

Northern Light: Without PETG covering, and thicker veneer and lacquer instead.

Scandic PLA: Use of PLA plastic instead of PETG plastic for covering.

Scandic PVC: Use of PVC plastic for covering instead of PETG plastic.

The environmental effects during the life cycle from these cards have also been compared to the most common types of plastic cards on the market today. High impact polystyrene (HIPS), PETG, and PVC-cards.

Each wooden card have a weight of 3,3 g and the weight of the plastic cards have been generalized to 5 g. All data are presented per functional unit (FU) of 1000 cards.

Below we present the main results from the performed LCA. For a complete inventory analysis and results please se the full LCA-report2.

<u>Environmental impact during the life cycle.</u>

Quantitative environmental impact parameters such as energy consumption, greenhouse gases, resource depletion etc. has been weighted against each other according to the ReCiPe Endpoints method, and the total environmental impact can then be presented as endpoints.

In Figure 2 the ReCiPe Endpoints for all the studied products are presented. The plastic cards have an overall higher environmental impact than the wood based cards. Within the plastic cards HIPS based cards have the highest impact and PVC cards the lowest. The wood based cards have rather equivalent impact but with the Northern Light having the lowest impact due to the absent of a plastic layer.

The total environmental impact is the sum of the weighted impact categories noted in the bottom of Figure 2. For the plastic cards the three dominating impacts are connected to climate change and depletion of fossil resources confirming the dominating environmental issue concerning plastics from fossil resources. These impacts have also a dominating part of the environmental impact from the wooden cards. Those impacts are the result of fossil fuel use for energy production and transports. The wooden cards have an additional impact category named agricultural land occupation. That impact is due to the forestry’s occupation of land and reflects the loss of land availability that could have been used for cultivating food crop as an alternative livelihood.

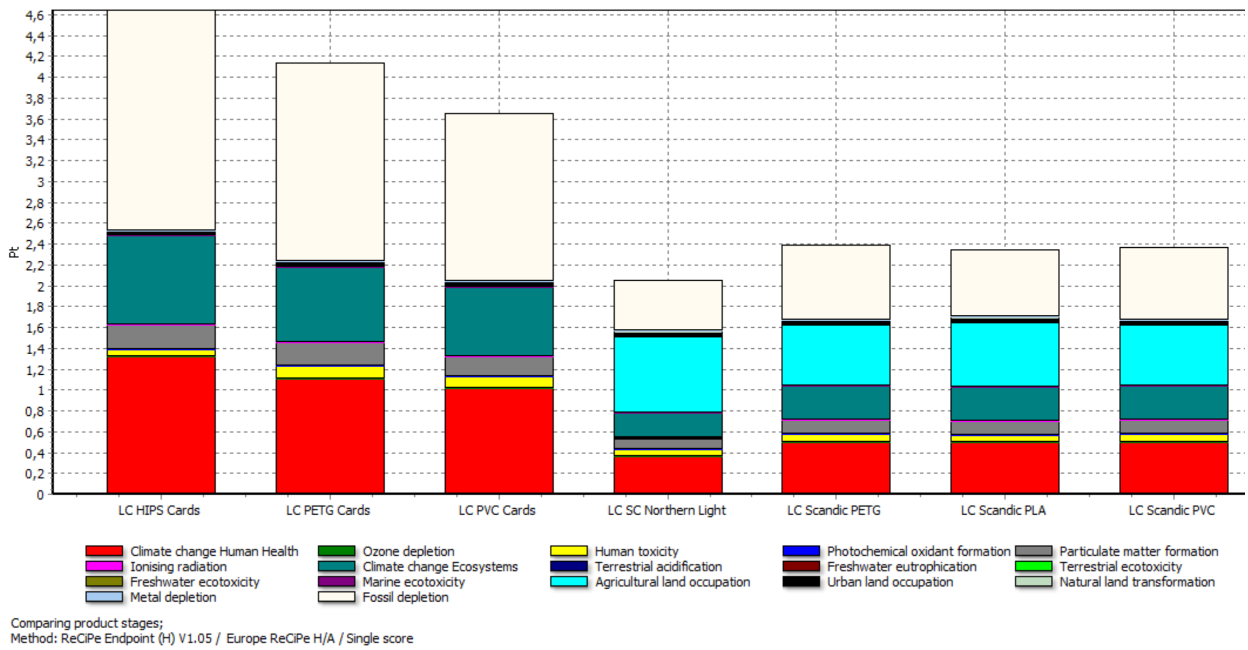

Figure 2: An overall comparison of the environmental impact presented as ReCiPe Endpoints during the life cycle of studied products.

In order to get a better understanding of the difference in environmental impact between the plastic cards and the wooden cards it is useful to look at the different phases in the cards life cycle. Figure 3 show the environmental impact allocated on the life cycle phases; raw material, manufacturing, usage and disposal.

The plastic cards have a higher environmental impact in all four phase. The impact from raw material and manufacturing is for the plastic cards mainly attributed to the energy consumption with fossil origin. The energy used for the wooden cards is to a higher degree non fossil based with a lower environmental impact. During the raw material phase for the wooden cards, the impact from agricultural land occupation contributes to more than half of the total impact.

The usage phase describes the transport of cards to the end user. The environmental impact is mainly the result of that 26 % of the cards are sent one by one by air mail around the world. The weight of letters and personal information are excluded so the environmental impact are only due to the weight of the cards and the difference between plastic and wooden card is due to the lower weight of wood cards 3,3 g compared to 5 g for plastic cards. If the Scandic PETG card should have the same weight as the plastic ones the environmental impact would be approximately 12 % higher.

The disposal phase shows a fundamental difference between the materials in the cards. The plastic cards based on fossil sources are generating fossil carbon dioxide when incinerated affecting the climate and the wooden cards are mainly generating biogenic carbon dioxide.

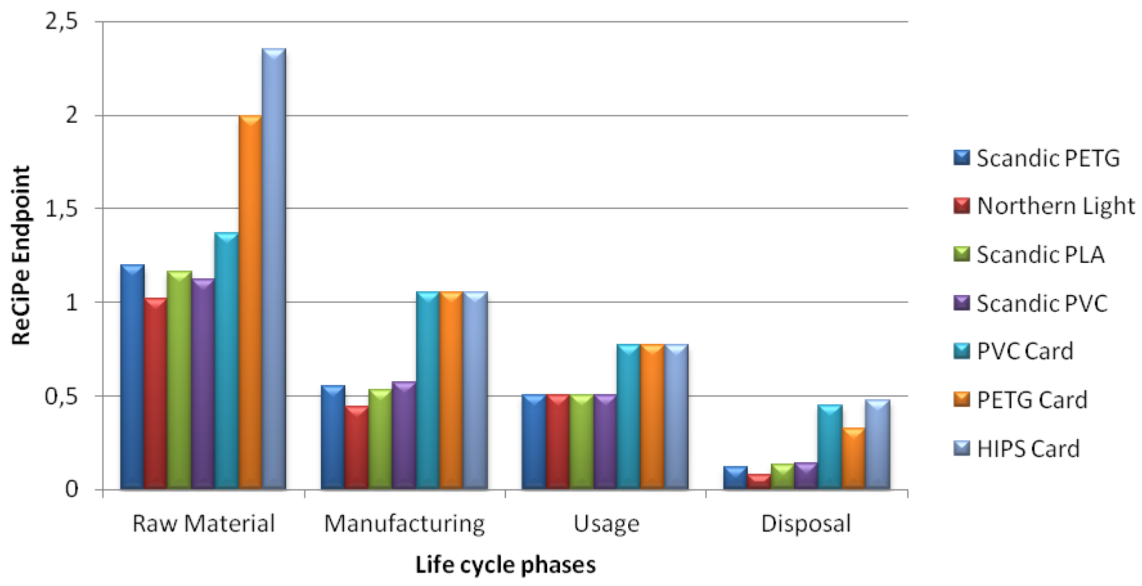

Figure 3: The environmental impact as ReCiPe Endpoints allocated on the different phases in the products life cycle

Energy demand, green house gases and water depletion

In order to take a closer look on some of the quantitative data identified in the life cycle assessment we have chosen to present data for energy demand, green house gases and water depletion in Table 1. The energy demand is somewhat higher for the plastic cards (700-800 MJ) compared to the wooden cards (500-600 MJ). The difference is more pronounced for the green house gases where the plastic cards emit more than twice the amount of carbon dioxide equivalents.

Table 1: Energy demand, green house gases and water depletion for wooden and plastic cards during the life cycle

	Energy demand [MJ]	Greenhouse gases [kg CO_2 eq]	Water depletion [Litre]
Scandic PETG	579	17,8	205
Northern Light	500	13,1	175
Scandic PLA	570	17,7	204
Scandic PVC	580	17,8	208
PVC Card	707	36,5	164
PETG Card	766	39,6	155
HIPS Card	819	47,3	139

Water is a scarce resource in many parts of the world, but also a very abundant resource in other parts of the world. A products life cycle can be global and the water used in different life cycle phases can thereby affect water resources in different ways in different places. There is at this point no PeCiPe Midpoint to facilitate the comparison of water consumption so instead we look at the actual water consumption data in liter. The water consumption is greater for the wooden cards (175-208 Liter) compared to the plastic cards (139-164 Liter). For both wood and plastic cards the greater part of the consumption take place in the life cycle phases; raw material and manufacturing.

3.2 Sustainability Analysis

The following sustainability analysis on wood and the plastic cards was performed by *Hedenmark Ecoprofits*[3]. Sustainable Cards offer a wood card for exchange of individual digital data, e.g. keycard on hotels, credit card, member card etc. The mission is delimited from recycling activities and is expected to be discarded as garbage and end up in dumps or incineration plants.

The sustainable solution, the C-vision

A card with an intended function as described above could theoretically be handled both within a technical recycling loop or a biological loop without breaking the system conditions. A card made of fossils is, however, dependent on a technical loop for being justified within the constraints of sustainability. It will otherwise, more or less, conflict to System Conditions number 1(SC1).

A card made of renewable material should on the other hand be cultivated with sustainable methods in order to keep up mainly with SC3, but also all other SC's as well (keeping up with biodiversity, deforestation, fertilizers, pesticides, GMO, indigenous people)

Since the card also consists of other materials, as the magnetic stripe, these must also fit in a biological composting or incineration process. Involved elements should therefore not be unusual within the earth's crust in order not to systematically increase in concentration and keep up with SC1 and/or 2.

Critical views on wood as card material

Wood based materials have several advantages, due to its origin from renewable resources. There are, however, some critical challenges. The threats towards the biological diversity might even be a bigger issue than climate change. This problem is, however, varying in different parts of the world. Deforestation is a critical issue in tropical forests, but not in boreal forests in the Nordic countries. The boreal forests have, on the other hand, problems with decreasing areas of old forest, key biotopes, monoculture etc. Moreover, 20% of the climate change is due to unsustainable forest management[7]. 25% of the forest trade is estimated to be illegal according to the WWF.

Since forestry is much more complicated to asses, compared to eg plastics, it is necessary to refer to relevant certification systems. Sustainability of forestry is not delimited to only ecological concerns, it is very much other social values as well as human rights for workers, indigenous people, outdoor people, long term economy for local societies etc. In order to assess the forestry, we have to assess the certification system.

There are two global certification systems: the FSC (Forest Stewardship Council) and PEFC (Program for Endorsement of Certification Systems). The basic difference of PEFC and FSC consists of the organization of interested parties. While FSC is ruled by all three sectors (economic, ecological and social) with equal influence, the PEFC is ruled only by economic interests even if the other sectors are invited for dialogue.

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[7] Intergovernmental Panel on Climate Change (IPCC). 2000. Land use, land-use change and forestry. Cambridge, UK, Cambridge University Press

In collaboration with the World Bank, WWF developed the Forest Certification Assessment Guide[8] (FCAG) in 2006, to assess the quality and credibility of forest certification schemes. This guide was 2008 used to review the credibility of the two certification systems: the FSC and PEFC[9]. Some of the result is illustrated in Table 2 and it shows that there are considerable differences between the FSC and PEFC. Of these two global certification systems the FSC system is the best system available and expected to improve in a sustainable direction due to a credible and transparent organization.

Table 2: The table provides a visual summary of the assessment by presenting the percentage of fulfilled indicators per criteria for PEFC and FSC at international level as well as the national schemes[9].

Criteria	PEFC	FSC
Compliance with international frameworks for certification, accreditation and standard setting	80 %	80 %
Compatible with globally applicable principles that balance economic, ecological and equity dimensions of forest management and meet Global Forest Alliance requirements	68 %	91 %
Meaningful and equitable participation of major stakeholder groups in governance and standard setting	22 %	72 %
Based on objective and measurable performance standards that are adapted to local conditions	100 %	100 %
Transparency in decisions making and public reporting	36 %	100 %
Reliable and independent assessment of forest management performance and chain of custody	47 %	89 %
Delivers continual improvement in forest management	50 %	100 %
Accessible to and cost-effective for all parties	75%	100 %
Voluntary participation	25 %	100 %

Critical views on plastic as card material

In order to assess the sustainability of different plastic materials used in plastic cards a range of both quantitative and non quantitative aspects must be viewed and evaluated. In the literature there are some examples and different attempts to summarize and rank plastic material against each other. In this analysis we focus on the polymers most common in plastic cards; PVC, polystyrene (PS), high impact polystyrene (HIPS) and PETG or PET.

There is a rating of different polymers and their environmental impact issues by Lars Pedersen[10] (in Danish). The method used is a kind of a qualitative LCA, followed by an environmental classification considering mainly content of health or environmental hazardous substances, energy consumption and waste treatment. With his methodology both PET and polystyrene is categorized in the second best category and hard PVC in the second worst category (Table 3).

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[8] The FCAG is available at: http://assets.panda.org/downloads/fcagfinal.pdf

[9] Summary of the report by Martin Walter: Analysis of the FSC and PEFC Systems for Forest Certification using the FCAG 2008, publ 2009. http://wwf.panda.org/what_we_do/footprint/forestry/news/?150601/FSC-still-the-best

[10] Pedersen, L.B. (1999). *Plast og Miljø*. Teknisk Forlag.

Table 3: Ranking of plastic according to Pedersen (1999)[10]. The least problematic polymer are categorized as Cat. 1 and the ones poses greatest risk to the health and environment are categorized as Cat. 4.

Cat.	Description	Polymer
1	Substances added or generated during the life cycle do not require any special precautions or result in significant health or environmental impact. Energy consumption is relatively low while the energy generated by incineration is high	Polypropylene – PP Polyethylene – PE Cellulose acetate – CA Poly (isobutylene) – PIB Ethylene vinyl acetate – EVA
2	Contain health or environmental hazardous substances crucial for the manufacturing or for the properties. Use or disposal phases might have health or environmental impacts. Category 1 polymers but with large energy consumption and/or relatively low levels of energy upon incineration.	Polyamide – PA or Nylon **Polyethylene terephthalate – PET** Phenolformaldehyd – PF **Polystyrene – PS** Silicone Styrene co-polymer and ter-polymer – SAN and ABS
3	Contain particularly health or environmentally hazardous substances. Some substances added or generated in the production may require special end-of-pipe precautions or protective equipment.	Polyvinyl chloride not plasticized with DEHP – PVC (soft) **Polyvinyl chloride – PVC (hard)** Polyurethane foam – PUR foam Polycarbonat – PC Epoxy – EP
4	The polymer materials regarded as particularly hazardous to health and environment. Category 1-3 polymers which contain additives considered as hazardous to health and environment.	Polyvinyl chloride plasticized with DEHP – PVC(soft) Halogenated additives Additives with heavy metals Fire-retardant based on bisphenols or diphenyl

Greenpeace has developed a guidance tool to assist people making material selection, to avoid PVC use presented in Figure 4. The guidance focuses on the toxic characteristics of the potential alternative materials. It provides a qualitative ranking based on environmental and health problems of polymers, addressing the production, additives, emissions during use, disposal and recycling.

It does not include raw materials and energy inputs and therefore does not address all criteria of a life cycle analysis. It provides guidance for interim steps on the route to clean production.

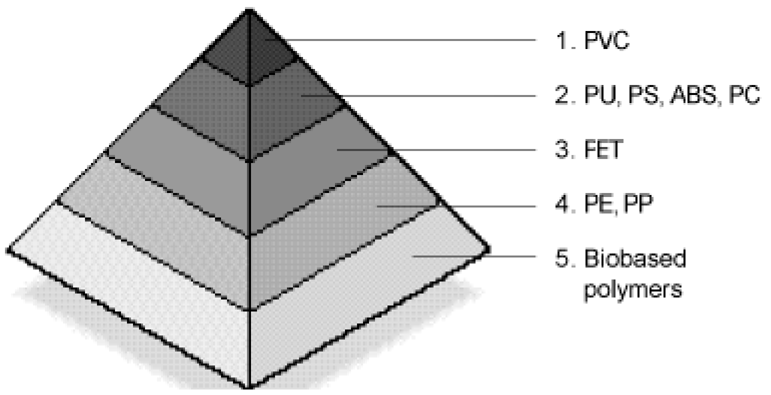

Figure 4: Ranking of plastic according to Greenpeace. The most problematic polymer are placed at the top of the pyramid and the least polluting in the pyramid's base. PVC = Polyvinyl chloride and other halogenated plastics, PU = Polyurethane, PS = Polystyrene, ABS = Acrylonitrile-butadiene-styrene, PC = Polycarbonate, PET = Polyethylene-terephthalate and PE and PP = Polyolefins.

Greenpeace's main argument for phasing out Polyvinyl chloride (PVC) is the materials unique composition of high chlorine and additives content, which makes it an environmental poison throughout its life cycle. Vinyl chloride is a known human carcinogen. PVC releases dioxin and other persistent organic pollutants during its manufacture and disposal and cannot be readily recycled due to it chlorine and additive content. Furthermore, additives are not bound to the plastic and leach out.

The production of polystyrene (PS) involves the use of known (benzene) and suspected human carcinogenic substances (styrene and 1,3-butadiene). Styrene is also known to be toxic to the reproductive system. PS can be technically recycled, but recycling rates are low, although still higher than for PVC.

Polyethylene-Terephthalate (PET) is made from ethylene glycol and dimethyl terephthalate. And in some applications it can contain additives such as UV stabilisers and flame retardants. PET recycling rates are high compared to other plastics.

Bio-based Polymers Biodegradable plastics from renewable sources (bio-based) are seen as a promising alternative for plastic products which have a short life cycle or are impractical to recycle, such as food packaging, agricultural plastics and other disposables.

Another hazard ranking model for plastic polymer types has been developed by Lithner *et al.* (2011)[11]. The hazard ranking is based on the hazard classification of the monomers that the polymer is made of. This can be motivated from risk point of view, since monomers always will be exposed to the environment, either via residues in the product (up to 4%) or via emission from production. In the study, over 40 polymers were ranked and rigid PVC with a very high hazard score was ranked as the sixth most hazardous plastic, HIPS were ranked as number 15 and PET as number 36 (Table 4).

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[11] D. Lithner et al. (2011) Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition, Science of the Total Environment, 409:3309-3324

Table 4: Ranking of plastic polymer types based on hazard classification of monomers (Lithner *et al.*, 2011)[11]

Rank	Polymer	Monomer
6	Polyvinyl chloride (PVC), rigid	Vinyl chloride (100%) Carc. 1A, Hazard level V
15	High-impact polystyrene (HIPS)	Styrene (92%), Acute tox. 4, Irrit. 2, Hazard level II 1,3-butadiene (8%), Carc. 1A, Muta. 1B, Hazard level V
36	Polyethylene terephthalate (PET)	Ethylene glycol (37%) Acute tox. 4, Hazard level II Terephthalatic acid (63%) Not classified
> 37	Polylactic acid (PLA)	Lactide (100%) Not classified

According to the definition of sustainability, there are certain unsustainable substances that should be phased-out. Such substances correspond well to the criteria for SVHC (Substances with Very High Consern) according to REACH. PVC is made of vinyl chloride monomer which is classified as carcinogenic. Moreover, PVC production involves EDC-tar including chlorinated POPs. Production and waste management inevitably contributes to the formation of dioxins/furans.

PS is made of styrene, benzene and 1,3-butadien. The two latter are classified as CMR1 (Carcinogenic, Mutagenic, or toxic to Reproduction) and the first one is at least scientifically suspected as a CMR.

There is no such science based suspicion of SVHC within PET/PETG as a polymer, but there have been raised some questions of heavy metals or other additives that might be present in various applications. But PVC/PS/PET are made of fossils, and cannot comply with the constraints of sustainability as long as a technical loop is excluded. If the situation will change, PET is the best option among the fossil cards.

Bioplastic is however another option. The dominating bioplastic originates, at least partly, from corn. Critical challenges towards sustainability are GMO and use of the persistent herbicide Atrazine.

Conclusion Sustainability

From sustainability point of view there are two types of cards that quickly disqualify due to inevitably and inherent properties. PVC and PS consist of several SVHC that can be exposed to humans and the environment during the lifecycle.

The PETG plastic card might comply within sustainability, but since it is made of fossils a technical recycling loop is a necessary step for reaching sustainability. Without a functional recycling system for PETG cards the use of these cards are not a step towards a sustainable society.

The renewal materials as bioplastic and wood are the only remaining materials, but have some significant challenges as GMO and persistent pesticides for bioplastics and forest management for the wood card.

The FSC system is strongly recommended for wood products. Even if the FSC might be criticized for some flaws, it is the best system available and expected to improve in a sustainable direction due to a credible and transparent organization.

3.3 Assessment of Chemicals

In this chemical assessment part we want to identify and evaluate the chemicals used in the production of the wooden cards and substances ending up in the final product. With the main purpose to assess the differences between wooden cards and the plastic cards that are dominating the market today, we will focus on the materials and production steps that are specific for producing wooden cards.

The wooden cards with plastic laminate on the surface Scandic PETG, Scandic PLA and Scandic PVC have a similar production step as the conventional plastic cards when a plastic film are laminated on the core of the card. All cards can then be printed on with different techniques and magnetic strips can be applied.

The main difference between the types of card are that the cards from Sustainable Cards all have a core of birch veneer covered with a thin layer of paper on both sides. The card Northern Light has also a layer of thin lacquer instead of a plastic layer. It is especially the chemicals in the glue which attaches the paper to the veneer and in the lacquer on the Northern Light cards that is important to assess.

Paper adhesive

The paper used to laminate the veneer is prepared in Germany with a water based adhesive. Only a minimum of information about the adhesive has been received describing it as a *dispersion of polyvinyl acetate copolymer and acrylic acid* and that the polyvinyl acetate (PVA) is the main component. PVA is a common water based adhesive made from the monomer vinyl acetate. PVA can then be copolymerized with acrylic acid to change performance properties[12].

The polymer PVA is regarded as an inert and safe adhesive and the monomer building blocks vinyl acetate are only classified as flammable. Acrylic acid on the other hand is classified as very toxic to aquatic organisms, skin corroding and acute toxic to humans[13].

Based on the information that PVA is the main component and the assumption that the copolymerization with the acrylic acid is complete without leaving any free acrylic acid, the adhesive should not possess any risk to workers handling the paper. For the final customer the adhesive is in addition sealed behind either a layer of lacquer or a plastic film.

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[12] Rolando, T.E. (1998) Solvent-Free Adhesive, Rapra Review Reports, vol 9

[13] CLP/GHS-data base, European Chemical Substances Information System

Lacquer on the Northern Light card

The lacquer used to seal the Northern Light card is a water based acrylic carpenter lacquer. According to the manufacturer none of the components give rise to any classification regarding health and the environment. We have had the possibility under confidentiality to evaluate majority of the components and none of them where classified on the basis of CMR or PBT properties. Nothing in the available information about the lacquer product indicate any risk for workers or the final customer.

Water free offset printing

The wooden cards manufactured at Sustainable Cards are printed with water free offset printing technique. The printing technique is not specific for the wooden cards and is a probably also used for many of the plastic cards on the market.

Pigments and chemicals used in offset printing can consist of substances potential hazardous to the environment or health. Two of the pigments used by Sustainable Cards are classified as hazardous to the environment. But owing to the water free technique non of the chemicals enters the wastewater system and the residues can be handled as hazardous waste and transported to appropriate destruction facility.

4 Summary of the assessments

In this report we have tried to evaluate the environmental impact and the risk to human health for wooden cards from Sustainable Cards compared to some of the market-dominating cards made of PVC, polystyrene and PETG. This has been done by highlighting and evaluating the cards with three different approaches:

- Environmental impact during the whole life cycle
- Assessment from a sustainability perspective
- Assessment of chemicals

The overall presentation of the total environmental impact during the cards life cycle gives a clear picture that the wood based cards are from an environmental point of view preferable to the plastic based cards. The life cycle assessment also highlights the fundamental difference between the cards, the difference between fossil and biogenic origin of the raw material. The environmental impact in form of climate change effects and fossil depletion are much more pronounced for the plastic cards compared to the wooden cards. This difference is mainly due to the raw materials but also due to that the wood based cards have a lower energy demand combined with a greater proportion of renewable energy sources.

Sustainable Cards wooden cards were less preferable than the plastic cards regarding two aspects; water depletion and agricultural land occupation. Both of these impacts are mainly a result of the raw material production and manufacturing, both taken place in northern Scandinavia. In this study, data for the forestry and the veneer production are generic data. If more geographic specific data had been used it would had been possible and suitable to discuss if water depletion actually is a problem in the specific area and if the land really could have been used for cultivating food crop as an alternative livelihood.

The sustainability assessment clearly shows that the plastic material have some great issues to deal with in order to possibly fit in a sustainable society. The two plastic material PVC and polystyrene are in the assessment identified as materials not feasible in a sustainable society. PVC is not feasible due to its composition of high chlorine and additives content giving rise to exposure of hazardous substances and risk of dioxin formation and polystyrene consists of very hazardous monomers. None of these materials are optimal for material recycling. PETG plastic cards on the other hand, might comply with sustainability, but since it is made of fossil raw material, a technical recycling loop is a necessary step for reaching sustainability.

Wood based cards have several advantages, due to its origin from renewable resources, but there are some critical challenges such as threats towards the biological diversity. To ensure that the wood in the cards meet these challenge it is suitable to use some kind of third party certification. The FSC-certification system is identified as the best system available and expected to improve in a sustainable direction due to a credible and transparent organization.

The assessment of the chemicals used in the production of the wooden cards did not identify any priority substances or any specific chemical risks.

5 Conclusion

Based on this environmental assessment we can conclude that Sustainable Cards wooden cards are from an environmental perspective, preferable to the studied plastic cards. The wooden cards have a lower total environmental impact and are closer to fit in a sustainable society than the plastic cards.

Within the group of wooden cards, the Northern Light and the Scandic PLA cards are the most preferable in a sustainability perspective due to the high degree of raw material from renewable resources. We strongly recommend FSC-certification as the most suitable way to ensure sustainability.

Even though the Scandic PETG card is closer to sustainability than the plastic cards, it is necessary with material recycling of the PETG-plastic for reaching sustainability.

Sustainable Cards product line does not today contain the PVC-version of the Scandic card. Our recommendation to the company is not to proceed with such product development, due to the environmental and sustainability issues regarding PVC.

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