

Product Innovation in the Automotive Industry:

- Incar Nature -

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Abstract

People tend to spend increasingly more time in cars, which is why it is inevitably important to develop concepts in order to increase drivers' comfort and wellbeing in their vehicles. This article addresses exactly this issue by introducing a new aspect in the automotive industry: Incar Nature. Since Incar Nature is a rather new and innovative aspect for the automotive industry, up to date no official definition has been introduced. In this context, Incar Nature is mainly understood as the integration of particular plant species into vehicles, fulfilling all the necessary analysed criteria.

In doing so internal as well as external risks were taken into account. This led to an economic, as well as biological approach. While different potential plant species got examined, this article also includes a market analysis and possible economic benefit. Besides the complete natural concept, also a more technical possibility is considered, which is referred to as an overall Incar Living approach.

The outcome delivers a solid first approach to this new topic. However, further research will be necessary in this field in future.

Introduction

Since the invention of automobiles in the 19th century they increasingly gained in importance for the human kind. They became an inevitable component of the way people travel and it is difficult to imagine the daily lives without cars. Therefore, it is no surprise that the amount of time people spend in cars constantly increases. According to a study, German employees spend 90 minutes on average in cars on every business day, which sums up to a total of 330 hours a year based on 220 days of work (Vieweg, 2011).

In addition to that, the increasing number of cars on the streets and the consequently higher traffic volume will lead to an even longer time span that people will spend in their cars. According to Jim Forsyth (2015), urban commuters are stuck in traffic for 42 hours a year on average in the United States. Furthermore Forsyth suggests that Washington D.C. itself has an even more dramatic number, since commuters waste 82 hours a year on traffic jams, which amounts to almost the double of the national average.

For this reason, car manufacturers are progressively researching and developing concepts in order to increase drivers' comfort and wellbeing in their vehicles. This field is also known as the so-called Incar Wellbeing.

Incar Wellbeing is an emergent aspect in the automotive industry and can be described as technologies that are implemented in cars in order to maximise the driver's wellbeing. It includes innovations with regard to the driver's health, wellness and comfort (Bödeker and Glanz, 2015, p.1). Incar Nature can be considered to be a branch of the Incar Wellbeing and generally aims at the integration of a natural environment into a vehicle.

More specifically, Incar Nature is a promising component of the health care aspect of Incar Wellbeing. Health care is generally a highly profitable sector and has therefore vast potential for the integration in the automotive industry. In addition to the profit opportunity, the health care aspect in relation to cars is constantly rising in importance, since many people spend a substantial amount of time in cars, as mentioned before. Incar Nature aims at a healthier air quality in cars, which can be seen as a rising business opportunity due to the general rise in awareness of health issues resulting from bad indoor air quality in buildings, schools, and hospitals, for instance.

Car drivers can suffer from internal as well as external risks affecting their health condition, which are often not immediately obvious or noticeable. Hence, Incar Nature is a promising possibility to address those specific health risks in cars in the near future and contribute to an overall improvement of car drivers' health condition. In the context of this thesis, a first concept for Incar Nature is provided. For this purpose, a biological, as well as an economic approach are taken into consideration.

Initial Position

In order to get an overview of the opportunities, it is important to describe the meaning of Incar Nature in a more precise manner. In addition to that, one needs to analyse and define the problems that are supposed to be addressed in order to consequently show the necessity and potential of the innovation. Moreover, it appears to be obvious to explain the role of Incar Nature in this context in more detail.

2.1 Definition of Incar Nature

Since Incar Nature is a rather new and innovative aspect for the automotive industry, up to date no official definition has been introduced. Therefore, automotive manufacturers are as far as possible free to define it within the scope of their products.

However, Incar Nature could possibly be defined as the integration of any natural component into a vehicle in order to achieve a more natural and healthier environment for the car driver. This can reach from specific single plant species placed in the interior of a car to improve the overall air quality and reduce certain toxics and chemical substances that are harming people's health, to the vision of a fully natural environment, relating to terms such as the feeling of a "flower field" in the car. This could include plants creating a certain pleasant smell, for instance, or also other natural components, such as certain kinds of rocks integrated in the car interior.

Even though at the moment the field around Incar Nature lacks a clear and official definition, the future introduction of natural components in cars and the respective development in this area will set a clearer definition for Incar Nature and outline more explicitly what elements are considered to be part of it.

In the context of this thesis, Incar Nature is mainly understood as the integration of particular plant species, fulfilling all the necessary criteria analysed in the following.

These criteria primarily include aspects such as the absorption of certain toxics and chemical substances by the plant, leading to cleaner air quality with higher oxygen levels and therefore also to a healthier environment in the car. This is constantly gaining in importance, since people tend to spend increasingly more time in their cars.

In addition to that, also survival criteria for the plants need to be taken into consideration, as cars are closed spaces, leading to difficulties for an appropriate living environment. This includes factors such as the water supply for the plants, as well as light conditions and temperature requirements that are necessary for the plants in order to survive in cars. However, those aspects will be further analysed at a later point in this thesis.

2.2 Problem Statement

In order to understand if and why there is a need for the innovation of Incar Nature, it is important to define a clear problem statement that shows the need for a reasonable solution approach. In this context, these problems are related to the health condition of car drivers that is affected from the inside, as well as from the outside of the vehicle.

Car owners are, often even unknowingly, confronted with two major risk factors with regard to their health. Those aspects are split up into internal and external factors. So on the one hand, there is an internal factor, which is directly related to the car itself and therefore affects the health condition of drivers from the inside out. On the other hand, the external factor describes all outside influences not directly linked to the vehicle and also needs to be taken into account, since it can have a serious negative impact on people's health, too.

2.2.1 Internal Factor

In this context, an internal factor is considered to cause health issues for car drivers from the inside of the car. This includes especially the materials used by car manufacturers, resulting in a poor air quality in the cars and possibly bearing a high medical risk. Generally, the production process of cars involves many different chemical substances and toxics. Even though often, especially in new cars, one can sense tangy smells, this does not necessarily mean that car owners always notice those existing and harming toxics. Moreover, cars that are heated up in the sun during summer times can

liberate more chemical substances that sometimes also result in tangy smelling, unhealthy air.

Studies have proven that certain toxics can indeed be found in cars. An article from the Chemical Sensitivity Network in 2009 states that there is a chemical pollution over the limit value in cars, leading to serious consequences for the state of health of car drivers. It shows that besides formaldehyde and benzene, there were over 50 other VOCs found in cars, often in deleterious concentrations, possibly also resulting in tangy smells especially in new cars. In addition to that, this article mentions cases, which prove that people can actually get physically sick because of pollutants and toxic substances in new cars. This included incidents of people being nauseous, as well as people suffering from oesophageal.

After those incidents the automotive industry tried to reduce especially the amount of benzene and formaldehyde used during the manufacturing processes. However, in 2012, The Ecology Center in Ann Arbor, Michigan, published a report about the chemical use in cars based on test data on 204, 2011-2012 new vehicle models. These compounds are usually found in coatings, leather, trims, and other materials used for the car interior. The report recognises chemicals such as PBDEs, as well as bromine (associated with brominated flame retardants), chlorine (indicating the presence of polyvinyl chloride and plasticisers), volatile organic compounds, lead, and heavy metals to be the ones of primary concern. According to the Ecology Center, those substances have been linked to a substantial amount of serious health issues, including allergies, cancer, impaired learning, liver toxicity, and birth defects, and therefore it is not surprising that the WHO (2016a) considers interior air pollution to be one of the major threats to human health.

Furthermore, the Ecology Center (2012) underlines regional differences in chemical use, differentiating between Asia, Europe and North America. According to this report, vehicles assembled in Asia demonstrated a significantly lower use of PVC in the components for the vehicles (Korea and Japan showed a 50% reduction). However, the number of used components was on average almost twice as much. On the contrary, vehicles assembled in Europe obviously struggled with the reduction in the use of PVC. The utilised PVC showed more than double the amount of vehicles assembled in other places, while the levels of BFR use are by far the lowest in Europe. Since the United

States have the weakest chemical regulatory systems, the vehicles assembled in the U.S. clearly lag behind European and Asian produced vehicles in PVC, as well as BFR reduction. So while the general outcome includes the fact that the elimination of important chemical hazards from vehicles is driven by progressive regulations in Europe and Asia, there is clearly room and also the necessity for further improvement. Moreover, the same report states that the concentration of VOCs does indeed decrease over time, since it off-gases. However, it warns about the fact that increased car temperatures can increase the VOC concentration, as well as sunlight exposure reaction products, that can also have harmful effects on human health (The Ecology Center, 2012).

Considering that certain toxics and chemical substances can get people physically sick opens the question of how this may actually also have an influence on the driving behaviour of people. Some of the substances proven in cars can not only cause serious and unpleasant headaches and other sicknesses, but also lead to somnolence, as well as to a reduction in concentration. Consequently, this means that the existing toxics and chemical substances in cars are not only hazardous to the people driving the cars, but can also be seen as a general danger for the road traffic.

Even though car manufacturers have been working on reducing hazardous and toxic substances, it still poses an extreme and underestimated danger for the health condition of car drivers, possibly even with regard to their driving behaviour. So generally, the problem arising from the internal factor is on one hand the strong and inconvenient smell for drivers, especially in new cars and heated up cars. On the other hand, and even more severe, those toxics and chemical substances in cars can have serious consequences on people's health condition and are widely underestimated.

2.2.2 External Factor

In this regard, an external factor can be seen as a cause from the outside of the car, including all aspects that are not linked to components of the car itself, such as air pollution from the outside, for example. Therefore, the general air quality within the car needs to be reflected again, considering this condition.

Besides the internal factors causing health hazards and poor air quality in the car, the sheer breathing in cars already has an effect, too. Since a car is a confined space, the longer people spend time in cars the worse gets the air quality due to the fact that the oxygen content is constantly decreasing. Car manufacturers tried to address this problem by introducing the air conditioning. With the so far existing technologies, a constant exchange with outside air is involved in the process. This means that the inside air reaches a quality level of the outside air. As a first approach to guarantee the quality of the air, car manufacturers offer certain filters, cleaning the air to a certain extent. This is further analysed at a later point. So generally, in rather rural areas and regions with an acceptable and lower degree of air pollution this happens to be a reasonable technology to overcome the problems of temperature regulation and air quality control in cars in a rather simple way.

On the contrary, one needs to take cities into account that suffer from an enormous degree of air pollution. This mainly applies to megacities, which are by definition metropolises with more than 10 million inhabitants (Umweltbundesamt, 2013). In order to analyse the air quality in cities, WHO (2016b) came up with a list of the average particulate matter concentration of different years, since the inhalation of PM is expected to have a negative effect on the health condition. This is the reason why the WHO recommends a minimum limit value of those, which is $20 \mu\text{g}/\text{m}^3$ as an annual mean. According to the WHO, the compliance with the guideline level could help to reduce air pollution-related deaths by around 15%. However, this list indicates that many cities exceed this value by far, especially the Asian continent and countries like India, Pakistan, Iran, Mongolia, and China struggle with problems regarding particulate matter. WHO states that Beijing, for instance, significantly exceeds this recommended minimum value with $108 \mu\text{g}/\text{m}^3$, while Mumbai struggles with $117 \mu\text{g}/\text{m}^3$ and Delhi even with $229 \mu\text{g}/\text{m}^3$. In comparison, Tokyo only slightly exceeds the guideline level with $28 \mu\text{g}/\text{m}^3$ and New York (including suburbs) even manages to stay below the guideline level with $16 \mu\text{g}/\text{m}^3$ (WHO, 2016b).

Taking Beijing, China, as an example, the list of WHO indicated the tremendous level of pollution in terms of PM and also the regular occurrence of smog is part of the life there. One major part of their problem includes the extreme traffic volume. The Umweltbundesamt (2013) states that the amount of cars on the street increased from 3 to 4 million between 2007 and 2009 alone. The report also claims that there were around 5.2 million cars in 2013 and

depending on the growth rate it is expected to reach a level of 8.9 to 10.4 million cars by 2030. This is a dramatic development for the traffic flow, which is already significantly influenced, but also in terms of the air quality issues and the resulting health risks this will lead to further problems in future.

Moreover, the author Annett Stein stressed a similar issue in an article for "Die Welt" (2014). She claims that some megacities happen to produce more exhaust gases than countries like Portugal. Again, it is pointed out that especially Beijing struggles enormously with the high degree of pollution. According to a group of Chinese scientist the city is nearly inhabitable and the number of people suffering from respiratory diseases constantly increases (Stein).

Besides the general air pollution problem in such cities, one also needs to consider the even more extreme exhaustion level that people are exposed to when they are stuck in traffic. As already stated before with the example of the U.S. and Beijing, the amount of cars on the roads is generally expected to even further increase in future, consequently resulting in more traffic issues.

Furthermore, an article by Julia Merlot (2015) cites the respiratory physician Joachim Ficker, who argues that a certain concentration of CO_2 indeed has a negative impact on our health condition and behaviour. He claims that there is a different individual reaction to it, but once it starts affecting people it can cause headaches and discomfort, as well as negatively impact the concentration. It can also lead to tiredness and people can even fall asleep when higher concentrations of CO_2 are reached.

Dale Walsh (2012) argues in a similar direction. He sees a connection between drowsy driving and CO_2 levels in cars. He observed that CO_2 levels rose dramatically, after spending an hour in the vehicle, windows closed and air conditioner on maximum power. This is illustrated in the following figure (see Fig. 1, Walsh, 2012).

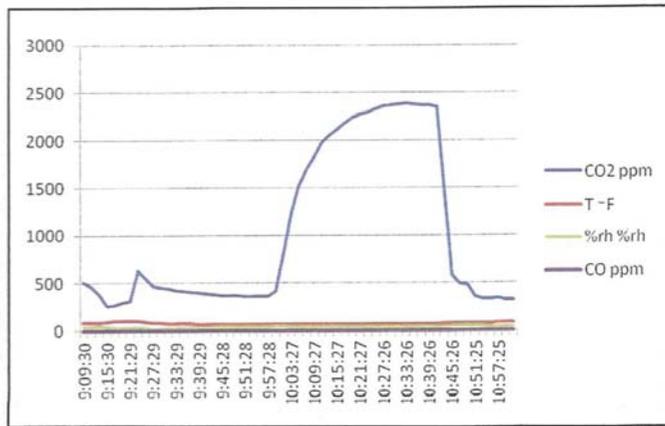


Figure 1: CO₂ levels in vehicle

Dale Walsh suggests in his report that 250-350 ppm are the normal outdoor level of CO₂, while 350-1,000 ppm is the “typical level that is found in occupied spaces with good air exchange”. A value of 1,000-2,000 ppm is “associated with complaints of drowsiness and poor air”, 2,000-5,000 ppm is “associated with headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention increased heart rate and slight nausea may also be present” (Walsh, 2012). So the level Dale Walsh measured in the vehicle was clearly high enough to result in drowsiness. He further observed similar results in another experiment in a car with the outside air intake turned on. The CO₂ level went up, when he was behind another vehicle, but dropped again after they separated. This leads to the assumption that especially in traffic jams or stop-and-go traffic, the concentration level of CO₂ can reach dramatic levels inside cars with air conditioner and outside air intake turned on.

This proves that moving in the traffic, especially in a city with enormous pollution levels consequently bears an extreme risk to health. Therefore, the need for an innovation addressing these specific issues can be clearly determined.

Moreover, also the bad air quality in cars that haven’t been moved needs to be considered. On one hand, condensation caused by air conditions and radiators can result in mildews in the car interior, also displaying a serious risk to health. Especially after a longer time the car has not been moved, a significant amount of those emissions in the car can be proven (Michulsky, 2012). Ventilating the car before driving can partly

eliminate this aspect, as well as the use of air conditioning when driving, however only to a certain extent. In addition, also the bad air quality people are exposed to in the mornings for example, after the car was parked in a garage, which can have high exhaustion levels, or on the street of cities with a high degree of air pollution, needs to be considered. This can be again partly addressed by the air conditioning when driving, or ventilating the car before driving. However, people are still surrounded by unhealthy conditions when entering the car after it hasn’t been moved over night, or an even longer period.

To briefly summarise the findings of the problem statement, two major problems have been identified, which both bear a high risk to health for people. The internal factor includes the toxics and chemical substances resulting from the production process of a car, possibly resulting in serious effects on the health condition. In addition to that, external factors consider the enormous air pollution, especially in megacities, affecting people in their daily lives there. They are exposed to tremendous air pollution when moving in the traffic. Moreover, the fact that bad inside air in cars negatively influences people’s health condition also allows the assumption that this can have a negative impact on the driving behaviour of people.

2.3 The Role of Incar Nature

The problem statement clearly identified some major issues concerning the health condition of people. Therefore, it should not be underestimated but rather be classified to have high importance. As already mentioned before, car manufacturers have tried to reduce the amount of chemical and toxic substances in their production process, however, only with limited success. The innovation of Incar Nature may provide new possibilities in this field as it aims at a healthier air quality and more natural environment within cars.

It is a matter of common knowledge that plants have the capability to turn CO₂ into oxygen. This happens to be a crucial and vital cycle for plants, as well as for the animals and people living on this planet. However, in some areas, for instance in big cities, the human kind disturbed this equilibrium by exhausting more particulates and CO₂ into the atmosphere than trees and plants can turn into oxygen. A high degree of air pollution and a constantly rising risk to health is the consequence, as already discussed in the

problem statement. Moreover, different plant species absorb different kinds of substances, including chemical and toxic substances. Therefore, it appears to be an obvious approach to analyse plants' characteristics according to the toxics that need to be addressed, while taking necessary conditions for a successful implementation in a car into account.

In more detail, this basically means that in order to address the internal factors it is necessary to analyse and identify plants that absorb those toxics that were mentioned before in the problem statement and are proven to be harmful to people's health. Furthermore, for the purpose of tackling the problems arising from external factors affecting car drivers' health condition, plants that are especially suitable for cleaning the air need to be identified. Integrating these special identified plants according to the stated requirements can contribute to ensuring a better and healthier air inside the car.

Generally, the idea of integrating certain plants into the car interior could support a solution for the identified problems in cars. This would not only help to address the serious health risks, but contribute to an overall better air quality and more natural environment, turning the car from a "toxic cocktail" into a healthier and more natural place, where people spend quite a considerable amount of time. Cleaner air and higher oxygen levels may also lead to a better state of mind of the driver, for instance with regard to concentration, as well as a decrease in tiredness. In the end, this innovation could therefore result in a safer way of driving.

To put this in a nutshell, the innovation of Incar Nature has the potential to at least partly tackle the identified problems with regard to the internal and the external factor. By integrating particularly analysed plant species in cars according to the substances that are supposed to get addressed, as well as considering the capability to contribute to an overall increase in the air quality, Incar Nature can possibly provide a reasonable solution approach to the mentioned problem statement.

3 Possible Concept for Incar Nature

After the identification of the problem statement, the need for an innovation in this field became obvious. Incar Nature has the potential to address the named issues by

integrating certain plant species into the car interior. In order to fully exploit the opportunities of Incar Nature, it is important to identify and analyse the already existing ideas, as well as present further possibilities for the implementation of this innovation, considering the problems of the internal and the external factors that were described before.

Generally, for the purpose of developing a valid concept for the innovation of Incar Nature the major necessary requirements for a realisation need to be identified. First of all, this includes the fact that the plant needs to be capable of surviving in a closed space, which basically means surviving under extreme conditions. Since cars are often parked in garages, those conditions contain the lack of regular daylight, which can only be compensated with artificially created light. The technological implementation also needs to ensure that this does not result in an inconvenient or distracting environment for the car driver.

Additionally, it is clearly beneficial, if the specific plants require an appropriate amount of water supply, since it must be possible for car manufacturers to integrate a mechanism that guarantees the regular water provision for the plant in the car.

Moreover, the plant needs to be attached properly in the car in order to withstand rapid movements, such as significant turns in the road or intense braking, without soiling the car interior. This can be addressed with a respective container, ensuring the solid attachment of the plant.

In addition to that, one needs to consider the extreme variation of temperatures that cars are exposed to. This can vary from extreme high temperatures during summer to rather cold or even freezing temperatures in wintertime, especially if the car is kept outside and not in a garage. This requires a technology that allows regulating the temperature in the container, but also the plant needs to be rather insensitive to temperature changes.

Also, the question of the plant size plays a significant role when planning to integrate it in a car. Obviously, the space in the car interior is very limited, and hence the plant must be able to survive not just generally in a closed space, but rather in a small container that can be integrated. The development of a respective container that fulfils all the necessary requirements is a crucial point for the innovation of Incar Nature, since it needs to ensure all the relevant conditions for the survival of the plant in a closed space.

So a possible plant for the concept of Incar Nature needs to address the identified toxics and has to survive under extreme conditions that are coming along with a closed and limited space like a car interior. Furthermore, there is the need to generate a small container that allows the regulation of crucial elements for the survival of the integrated plant, such as the light conditions, water supply, appropriate temperatures, and solid attachment.

3.1 Existing Ideas

In order to further develop a concept for Incar Nature, it makes sense to look at existing technologies that are going in a similar direction, as well as analyse first approaches to the innovation of Incar Nature.

3.1.1 Similar Technologies

There are already established innovations in the automotive industry that aim at a similar goal like Incar Nature. As already briefly mentioned before, car manufacturers introduced special filter systems, trying to improve the indoor air quality or even provide a solution for allergy sufferers. Ford offers a so-called “Cabin Air Filter”, which is supposed to keep pollutants and pollen out of Ford and Lincoln vehicles. Generally, it filters the outside air that possibly enters the car interior through air conditioning systems, for instance. According to the manufacturer, this filter removes up to 90 % of dust, pollen and spore particles that are larger than 3 μm (Ford, 2016).

This is a good first step in the direction of improving the inside air in cars, however, David Pennise from the University of California-Berkeley presents a distribution of several PM source emissions, showing that for instance around 90 % of the particulates of diesel truck exhaust are smaller than 1 μm , as well as over 80 % of the particulates of crude oil combustion are smaller than 1 μm . This means that the filter can help to increase the air quality to a certain extent while driving. Especially for allergy sufferers this can be a valuable first step.

Besides the example of a particulate air filter, active carbon filters are obtainable for almost every car model and are also aiming at better air quality in cars. The car manufacturer Audi (2016) states for example, that those filters do not only remove dust, pollen and other particulates from entering the passenger compartment, but also adsorb

exhaust fumes, benzene and ozone, for instance. Again, this active carbon filter seems to be a reasonable approach, however, generally, those filters do not provide a solution for bad air quality in a car that hasn't been moved, since they only work while the car is in operation. So if a car is parked in a garage over night, the air quality is bad in the morning, and cannot immediately be addressed with the filters.

Additionally, some car manufactures offer fragrances for a pleasant smell in the car. Mercedes-Benz, for instance, offers an Air Balance Package with a selection of high-class fragrances, aiming at a more comfortable ambiance inside the car, also covering unpleasant smells, which is presented in the following (see Fig. 2, Mercedes-Benz, 2016)



Figure 2: Mercedes-Benz Air Balance Package

The concept is very simple. According to Mercedes-Benz (2016), a container in the glove compartment is equipped with a glass flacon containing the different scent options (Nightlife mood, Downtown mood, Sports mood, Freeside mood). Moreover, the air quality is increased through ionising with oxygen, contributing to the driver's overall wellbeing. Right now, the Air-Balance package is offered solely for the upper class models (C-Class and higher), and the prices charged for it vary between 440,30 € (Germany) and 675 € (Ireland), for instance (Mercedes-Benz, 2016). However, generally, this technology seems to rather conceal the issues with the air quality even though it ionises the air with oxygen.

To put this in a nutshell, the fragrance offers by car manufacturers, such as the Air Balance Package of Mercedes-Benz, may contribute to the driver's comfort by providing a pleasant smell in the passenger compartment. However, besides an improvement in the oxygen level through ionising, they fail to actually address the factors discussed in the problem statement. The existing filter technologies are basically pursuing a similar goal like Incar Nature. Even though the filter systems do address the problem statement with regard to the external factor to a certain extent, they fail to tackle the issues arising from the internal factor, as well as the issue with the air in cars that haven't been moved. While filters seem to generally be a solid approach, they do not support a "natural environment" in cars. Therefore, Incar Nature can be a promising add-on or alternative to such existing technologies.

3.1.2 Plant Module

A first and very brief approach to this field has already been introduced. The presented idea is based on a concept of integrating a plant into a car interior with the aim of improving the overall air quality in cars. It pursues the vision of experiencing health inside the car and is a plant module. A transparent cover protects the plant from mechanic, as well as environmental influences. The creation of artificial light is similar to daylight and therefore ensures a pleasant visual perception. Air can flow through the root system and also the transparent cover into the car interior, increasing the quality of the inside air, since the plant is constantly generating oxygen (Innovationen Institut, 2015). The plant module is illustrated in Figure 3 (Innovationen Insitut, 2015).



Figure 3: Plant Module

3.2 Further Possibilities

3.2.1 General Idea

Besides the existing technologies for improving the air quality in cars, as well as the first approaches for the implementation of plants into car interiors, further possibilities can now be examined. NASA already conducted the study "Interior Landscape Plants For Indoor Air Pollution Abatement" in September 1989 in corporation with the Technology Utilization Division and the ALCA. The general idea behind this study is to analyse plants that specialised on the absorption of certain chemicals and toxics in order to improve the air quality in closed spaces, basically aiming at living space. The background of this study is the occurrence of workers' health problems during the late 1970s. This included itchy eyes, skin rashes, drowsiness, respiratory and sinus congestion, headaches, and other allergy-related symptoms and it was referable to the airtight sealing of buildings, as well as synthetic building materials, that are known to emit certain organic compounds. Depending on the used materials, specific office equipment was also considered to be a factor contributing to the serious health complaints. In addition, NASA looks towards finding a possibility to seal people in a closed environment, such as inside a space station, together with certain plants. This is the reason why this study also supports the evaluation of the ecology of such a closed space (Wolverton et. al., 1989, p. 2).

Moreover, the authors Wolverton, Johnson, and Bounds (1989, p. 1) point out that people themselves could be seen as a part of indoor air pollution, which becomes especially obvious when a larger number of people are present in a limited space, such as an airplane for instance. They claim that a life support system existing of an intricate relationship with plants and their microorganisms guarantees the existence of the human kind on this planet. The study also stresses that isolation from this ecological system by tightly sealed buildings is apparent to be problematic. This can also be linked to the issues with the indoor air quality in cars. Firstly, spending time in a car displays isolation to a certain extent, too. Secondly, the number of passengers in cars can then have a significant negative impact on the overall air quality in cars, as well.

The study is based on evaluating plants according to their ability to absorb chemical substances like benzene, trichloroethylene, and formaldehyde. Benzene is found in basic

items, such as gasoline, inky, oils, paints, plastics, and rubber and bears a great risk for people. It is known for irritating skin and eyes and there exists evidence that it contributes to chromosomal aberrations and leukaemia in humans, as well as repeated skin contact can lead to drying, inflammation, blistering, and dermatitis. It happens to be an interesting factor with regard to car drivers that the inhalation of a higher concentration of benzene has been reported to cause dizziness, weakness, euphoria, headache, nausea, blurred vision, respiratory diseases, and even tremors, irregular heartbeat, liver and kidney damage, paralysis, and unconsciousness can be a consequence. Furthermore, the study reveals that the chronic exposure to even only relatively low concentrations can indeed result in headaches, loss of appetite, drowsiness, nervousness, psychological disturbances, and diseases of the blood system, such as anaemia and bone marrow disease (Wolverton et al., 1989, p. 5).

The authors state that formaldehyde can be found in almost all indoor environments. It is proven to irritate the mucous membranes of the eyes, nose, and also throat and can cause possible allergic contact dermatitis. The most common symptom from an exposure to this substance on a rather high level are, amongst other things, irritation of the upper respiratory tract and headaches, as well as even more serious consequences such as asthma. In addition to that, the study reports of a research conducted by the EPA that indicates the possible cause of a rare type of throat cancer in long-term occupants of mobile homes (Wolverton et al., 1989, p. 5).

In terms of trichloroethylene the study observes that it is used in a variety of industrial processes. It is mainly used for metal degreasing and dry-cleaning, but also for printing inks, lacquers, adhesives and varnishes and is considered to be a potent liver carcinogen. As the problem statement included issues with similar substances, as well as some of the named materials are partly also relevant for car production processes, a direct relation can be established (Wolverton et al., 1989, p. 5).

Since there is generally a clear link between the indoor air purifying in buildings and in cars, the NASA study can be used to derive first approaches to find the appropriate plants for the concept of Incar Nature. All indoor plants are able to purify indoor air to some degree through their normal photosynthesis processes, however, the study helps to find first indicators for plants that have the special potential to possibly address some of the issues identified before.

In order to apply this study to the innovation of Incar Nature, the most interesting and relevant findings of the NASA study need to be considered. Generally, the outcome for the best indoor air purifying plants included English ivy (*Hedera helix*), Peace lily (*Spathiphyllum* "Mauna Loa"), Mother-in-law's tongue (*Sansevieria laurentii*), Ficus (*Ficus benjamina*), Janet Craig (*Dracaena deremensis* "Janet Craig"), Pot mum (*Chrysanthemum morifolium*), Green spider plant (*Chlorophytum elatum*), Golden pothos (*Scindapsus aureus*), Heart leaf philodendron (*Philodendron oxycardium*), and Aloe Vera (Wolverton et al., 1989, p. 9-14). Those plants were especially good at absorbing the named substances and are therefore expected to contribute best to an increase in the indoor air quality.

These findings allow a first overview of the potential plants for Incar Nature. However, also further aspects need to be taken into account. While buildings have quite some room for also rather larger plants, size plays an important role when it comes to the implementation in the car interior. Moreover, other requirements such as the temperature, light, and water supply conditions need to be considered. Therefore, the potential plants got further selected in the following, relating them more precisely to the necessary conditions discussed before. In addition, the plants are evaluated also in accordance to other aspects of the problem statement.

3.2.2 Main Findings

To briefly summarise the findings of the possible concepts of Incar Nature, three plants were identified to be especially interesting for this purpose, partly based on the NASA study, namely Golden pothos, Mother-in-law's tongue, and commonly known Aloe plant. While the Golden pothos shows some restrictions, Aloe Vera and also Mother-in-law's tongue seem to have promising characteristics. The data collected by the NASA proves to be extremely helpful in order to understand the capabilities of certain plant species to absorb chemical substances. However, one needs to consider that the final circumstances and conditions in car interiors will obviously differentiate to the conditions in the laboratories and therefore, also the measured values will differ from the original ones. Besides that, the identified plants indeed have the potential to address some of the named issues in the problem statement and contribute to a reduction of

certain substances and to an increase in the oxygen concentration, and therefore to the overall air quality.

As already mentioned before, a special container needs to be developed, which is equipped with the respective functions in order to guarantee the control over water supply, light conditions, and temperature. The containers are furthermore supposed to display such information, so the driver can always check on the status and condition of the plant. It would be especially helpful if the display also had the possibility to also inform the driver about the air quality. When considering the location of this innovation, different possibilities arise. However, aspects like safety concerns and technological backgrounds need to be taken into account

In conclusion, one can say that a first approach to the concept of Incar Nature is provided, however, there is still the need for further research in this field in order to achieve the intended goal with it. This includes the area of the suitable plants, the development of appropriate containers that are needed for a successful integration of plants into car interiors, as well as the correct final location for it in the passenger compartment. Generally, one can derive an interesting idea of Kamal Meattle's approach in New Delhi. Since filters, as well as plants have certain limitations, also with regard to the problem statement, the combination of air filters and certain plant species might be the best possibility to address the air quality issues.

3.3 Incar Living Approach

Besides the actual implementation of plants into a car, theoretically one can go even one step further by focusing rather on the technological application of nature in a vehicle. This basically means the technological implementation of natural resources with the vision to provide a healthy, or even health enhancing driving experience. The aim is to create the feeling of "an afternoon on a flower field".

This experience is supposed to include all senses. Therefore, lighting, the display in the car, air conditioning, background sound as well as taste need to be taken into consideration. Generally, Incar Nature, hence the positive energy of nature and the respective healing and recovery effect is to become perceptible in cars. These scenarios can vary in their features and are built upon already available technologies.

In order to further illustrate this approach one can look at different scenarios of such technological Incar Nature examples. A sundown in Capri, for instance, can be simulated by adjusting the temperature, providing the respective background sound, producing a salty and fresh air, and also considering the appropriate lighting in order to provide a unique sundown experience. Alternatively, there could also be a package "summer meadow in Bavaria" with the respective features, as well as the "Amazon rainforest" or a "fjord in Norway", especially for hot summer days for example.

Market Analysis

With regard to Incar Nature, two main points arise. Firstly, there is the necessity to evaluate if there exists a market for Incar Nature. Secondly, one then needs to assess more precisely what this market looks like.

Fundamentally, a market is driven by demand and supply for a good or service. Since Incar Nature is currently in the development phase and only consists of a concept, it is difficult to immediately determine the market. Incar Nature is aiming at improved health conditions of people. Thus, there is an apparent link to the health care industry, which makes it reasonable to have a look at the respective market. A successful integration of plants in cars requires different technological components, such as sensors for necessary measurements. Hence, it also makes sense to look at the relevant existing market for this. Furthermore, Incar Nature is a branch of Incar Wellbeing, so it is reasonable to consider the Incar Wellbeing market, as well. All of this can help to derive the market potential of Incar Nature.

4.1 Health Care Market

The health care industry is considered to include promotive, curative, preventive, rehabilitative and palliative care (WHO, 2016c). With aiming at healthier air quality in cars, Incar Nature is supposed to address health issues, such as respiratory diseases, arising from bad air quality in cars and can therefore be related to the preventive care section. The overall state of the health care market can help to understand future trends and the potential in this field and provide indicators for the Incar Nature market.

Generally, health care is one of the largest industries in the world and it is a constantly growing market with high profitability. While the global % of GDP spent on health care

is expected to decrease to 10.1 % by 2019, the health care expenditures vary around the world (Deloitte, 2016a). In the U.S. health expenditure per capita reaches \$9,146 and in Germany \$5,006, while China only has \$367 and India even less with \$61 (Deloitte, 2016b). It is expected that the health care spending is influenced by different factors such as economic uncertainty, the Eurozone crisis, but also currency devaluations. While the annual health care spending in Western Europe is expected to grow by 1.4 % by 2019, it has the potential to grow by 4.8 % in North America, and in the Middle East and Africa even by 9.3 %, for instance. This leads to an overall global growth of 4.3 % in annual health care spending (Deloitte, 2016b). Figure 8 sums up these findings on the expected average growth in annual health care spending (Deloitte, 2016b).

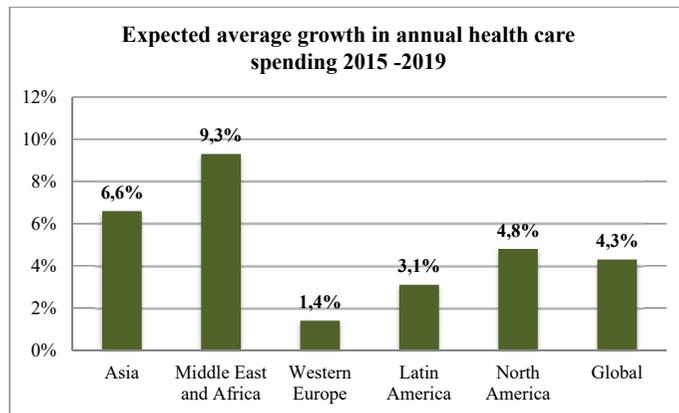


Figure 4: Expected average growth in annual health care spending 2015-2019

The expected drivers of growth include the general rise in wealth, aging population and lengthening life expectancy, as well as access to health care, population growth and an increase in chronic diseases. On the contrary, for the health care market also constraints to growth need to be considered, namely reforms, cost pressures, economic and political uncertainty, and price and value based care (Deloitte, 2016a).

In addition to that, cHealth has the potential to create possible new opportunities and sources of value for health care stakeholders. The combination of sensors, networks, augmented intelligence and consumer behaviour plays an important role in this field and includes four areas. Telehealth is generally aiming at people with chronic conditions and increases the ability for an independent live. With technologies such as home monitoring hospital readmissions can be reduced, for instance (Deloitte, 2016a).

The so-called mHealth makes use of the mobile networks and basically works as a communication channel to health care services. The applications can include basic functions, such as reports on daily calorie, sodium, fat, and carbohydrate intake, as well as intermediate functions, namely inhaler with a built-in asthma sensor in order to provide information on the air quality. Advanced functions include portable devices that are capable of measuring body temperature, heart rate, and blood oxygen levels, for example (Deloitte, 2016a).

Electronic medical records aim at the trend for people to be in control of their own electronic health and social care record, while wearables, such as watches, skin patches, implanted sensors under the skin, or even pills that are swallowed, may allow doctors in future to determine the reaction of bodies to drugs and adjust the dosage if necessary (Deloitte, 2016a).

While cHealth can especially be transferred to the overall concept of Incar Wellbeing, the trend towards electronic records and control over the own health and social care record can be directly linked to Incar Nature. Having control over the air quality and related health condition in cars, maybe even with a respective digital record, perfectly matches this field. Moreover, technological progress in terms of certain measurements with sensors can easily be related to Incar Nature, which also has the potential to integrate such components in cars in order to provide information on the health condition while driving. This may include aspects like keeping track of the oxygen level in the blood, helping to visualise the effect of improved air conditions through Incar Nature.

To briefly summarise the findings of the health care market, it is a highly profitable market with good future growth perspectives. Some trends of the health care industry may give indications for possible trends for Incar Nature. While the increasing awareness towards a healthier lifestyle plays an important role, especially the factors related to digital connected health are a promising aspect that implies great potential for Incar Nature.

4.2 Technology Market

Incar Nature happens to require certain technological components for the realisation of the integration of plants into cars. This includes the development of containers for the plants, which are capable of providing the plant with the necessary water supply and

light requirements. In addition, the realisation of Incar Nature needs sensors for different measurements, that involve engineering and electronics companies such as Robert Bosch GmbH for instance, in order to manage the plants' needs, as well as provide information on the air quality in the car in terms of temperature, humidity, and oxygen level. This means that the future development of Incar Nature is also dependent on the technology industry, which is why it makes sense to look at this market in more detail. The following figure shows that the gross profit margins are comparable or even higher in the technology industry compared to the automotive industry (Annual reports 2015: Robert Bosch GmbH, Schaeffler Group, DENSO Corporation, Magna International, AUDI AG, BMW Group, Daimler AG). This indicates a stable financial position of the operating companies, as well as a high potential for profitability in this market.

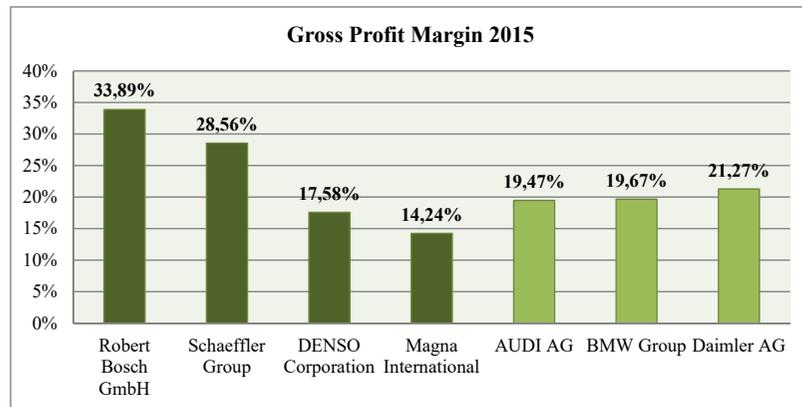


Figure 5: Gross Profit Margin 2015

In addition to the gross profit margins, also the growth rate in the electronics industry is promising, especially in Asia. Figure 10 shows the estimated growth rates from 2014 to 2016 for the global electronics industry (Statista, 2016b).

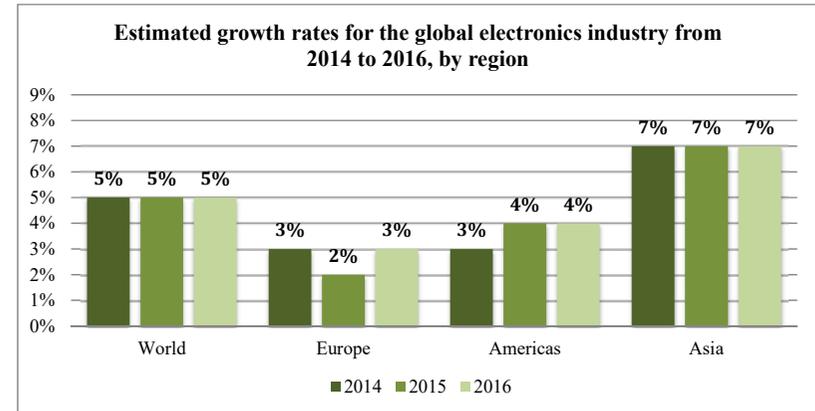


Figure 6: Estimated growth rates for the global electronics industry

Recapturing the main findings, the electronics market is a constantly growing market with positive future outlooks. Incar Nature is dependent on this market in terms of the technological parts that are necessary for realising the concept of a natural environment in cars by integrating natural components. The market for Incar Nature is therefore likely to develop in accordance with the quality and level of development in the technology market. Fundamentally, this also allows transferring certain trends from the technology market to the Incar Nature market.

4.3 Incar Wellbeing Market

Since the innovation of Incar Nature is directly linked to Incar Wellbeing it makes sense to also look at the identified market for this segment. Incar Wellbeing itself is obviously not just related to the health care market, but also to the wellness market, which is considered to be a big market with increasing volume, as well (Bödeker and Glanz, 2015). Generally, the fact that people spend increasingly more time in their cars, makes it likely that people would appreciate the opportunity to spend their time in cars more efficiently with regard to their wellbeing. At the same time this shows the necessity for making exactly this possible with appropriate innovations. This includes the wellness aspects for the overall comfort of car drivers, as well as factors, which contribute to an increase in the health condition of people. Since people's awareness for a healthier lifestyle constantly rises, the trend towards spending money on health and fitness is already given, as well as the willingness to pay for it is quite significant.

The following figure underlines the potential that is found in the field of Incar Wellbeing. The health care and wellness market bears a global market volume of over 8,000 billion €, of which around 10 % are expected to be suitable for an integration in the automotive industry (Innovationen Insitut, 2015).

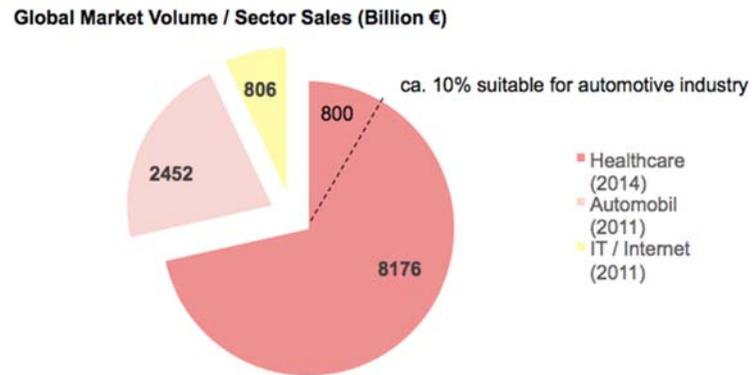


Figure 7: Global Market Volume / Sector Sales (Billion €)

As already mentioned before in the section of existing ideas, the example of the Air-Balance package from Mercedes-Benz shows the opportunities in this market. Recalling that right now, it is charged between 400 € and 675 €, while the production can be estimated to not include too high costs, it happens to be a simple, but profitable feature. The existing Incar Wellbeing technologies are mainly found in the premium segment of the automotive industry. As the example of Mercedes-Benz already indicated, the prices charged for such technologies are rather high, especially when people are forced to buy packages, which is quite common in the automotive industry. Yet, consumers seem to be willing to pay this amount for it. Of course, one needs to consider that those innovations will find their way into the mass market after some time, which will lower the prices to a certain extent. However, the profitability in this field is still expected to have a promising outlook (Bödeker and Glanz, 2015).

Furthermore, the fact that the individual supplementary equipment especially drives the prices of cars provides the Incar Wellbeing market with great opportunities. This means that customers are expected to carefully choose the technical features for their cars, which consequently results in the dependency of the Incar Wellbeing market on people's willingness to pay for health care and wellness features in their cars. The Incar

Wellbeing market is likely to develop in conjunction with the level of innovation progress in this field by the automotive industry (Bödeker and Glanz, 2015).

To put this in a nutshell, the Incar Wellbeing market is dependent on customers' spending on health care and wellness features, but is expected to have a promising and profitable future perspective, while developing in line with the quality of the innovation progress relating to Incar Wellbeing products. This can be transferred to Incar Nature, since it is part of Incar Wellbeing in terms of the health care features in cars and therefore, indicators and prospects for the Incar Nature market can be drawn.

4.4 Incar Nature Market

At present it is difficult to analyse the market for Incar Nature, however, it can be expected that it will be discovered and entered by first car manufacturers very soon. Generally, the market for Incar Nature can be considered to be composed of a combination of trends from the health care, technology and the Incar Wellbeing market. The basic trend towards a healthier and more conscious lifestyle is an important base for this field. Additionally, as already mentioned before, the fact that people spend such a significant amount of time in cars creates potential for innovations that aim at a healthier environment in cars, such as the concept of Incar Nature. The evaluation of the Incar Wellbeing market shows the potential of innovations in this field, also in terms of charging relatively high prices. This is the reason why it is also expected that car manufactures can charge a rather high price for Incar Nature features.

Similar to the Incar Wellbeing market the concept of Incar Nature is most likely introduced in the premium segment first. Again, the innovation can possibly make its way into the mass market in the longer term and therefore, prices might consequently decrease in this context. However, the profitability can be expected to remain on a high level, also in a longer term, which provides car manufacturers with promising future perspectives and not just with a concept on an interim basis.

As already mentioned before, Incar Nature is in an early stage of conceptualisation and development. Therefore, it may make sense to conduct more explicit research on the actual demand for Incar Nature innovations, as well as on the willingness to pay for such products with respective surveys. This would help to evaluate the overall potential laying in this field.

5 Economic Benefit

The introduction of Incar Nature innovations can contribute to an economic benefit by helping to reduce car accidents, which generate high expenditures every year, and add to an improvement of the general health condition of the driver and passengers. Moreover, an interesting business model with regard to insurance companies arises, based on existing systems of insurance companies.

5.3 The Role of Insurance Companies

Besides the economic benefits arising from the contribution to a reduction of car accidents and an improvement of the general health condition, the innovation of Incar Nature can be the origin of an interesting business model with regard to insurance companies. There is an interconnection in terms of health insurances, but also with car insurances. In order to fully understand this potential it makes sense to look at existing models including insurance companies first, before transferring this to a business model for Incar Nature.

5.3.1 Example of Health Insurances

Generally, health insurance companies are interested in minimising their expenditures. This is the reason why it makes sense for them to incentivise a healthier lifestyle in order to save unnecessary costs arising from a rather unhealthy living. There do already exist examples of insurance companies encouraging people towards a healthier lifestyle by promoting for instance fitness and health courses. In Germany, this includes bonus programs, health courses, preventative courses, and financial benefits through cooperation, for example.

One of the main health insurances in Germany, Barmer GEK (2016), subsidises health courses on exercise habits, balanced nutrition, stress management and consumption of addictive substances. Per year, up to two courses can be claimed and be subsidised up to a maximum of 75 €. In addition to that, Barmer GEK offers a bonus program, which allows the collection of bonus points through certain medical check-ups and health-promoting activities, such as actively participating in fitness studios. There are different conditions for adults, adolescents, and children. On its website it states that the collected bonus points can be exchanged for certain rewards, such as vouchers, but also items like scales, goal walls, or even barbecues or Bose sound systems.

Another main insurance in Germany, AOK (2016), states that statutory health insurances are not allowed to subsidise or even take over the costs of fitness studio memberships. However, similar to Barmer GEK, they provide benefits for their customers through cooperation with fitness studios.

IKK (2016) also provides a comparable bonus programme for 2016. The general idea is again to collect bonus points, however, they offer to pay out an amount up to 60 € or alternatively subsidise further health courses with an amount up to 120 €. It states that the customers can earn bonus points with certain medical check-ups and memberships in fitness studios including at least 24 training sessions a year, but also with blood donation and organ donor cards, for instance.

To briefly sum up the findings, health insurances actively encourage people to live a healthier life. Obviously, they also benefit from healthier customers and save costs, which is why it pays off to incentivise certain actions. Therefore, Incar Nature could also play a role when it comes to health insurances.

5.3.2 Example of Car Insurances

Similar to health insurances, also car insurances are interested in their customers to drive safely and take care of their cars in order to save costs. In addition to the already existing benefits provided by health insurances, car insurances offer benefits under certain conditions, too. In Germany, this starts on a low level with customers, who regularly park their cars in garages. This can lead to a reduction in the insurance rate. In addition, a safe driving training in cooperation with the General German Automobile Association ADAC can also help to reduce the rates (ADAC, 2016).

In the United States this goes even further. Through a data-monitoring device installed in their cars, people can save money on the car insurance, however, some also may pay more. It works similar like a black box in an airplane and basically collects data on the car's operation, which allows insurance companies like Progressive and Allstate to consequently reward safe driving with lower rates (Tanner, 2013).

Allstate offers so-called telematics devices, which are plugged in the vehicle's onboard diagnostic port. The company states that the installation can help to qualify their customers for car insurance discounts. The driver should avoid high speeds and hard stops, as well as fewer miles on vehicles per day also qualifies for discounts. Many

insurance companies even offer to track the data of the telematics device online, which contributes to a learning process of the customers (Allstate, 2014).

To put this in a nutshell, car insurances also aim at people taking care of their cars and driving safely in order to avoid costs. They incentivise certain actions to encourage people to go in that direction, and in the end it pays off for the customer with reduced insurance rates, as well as for the insurance company with reduced expenditures. Incar Nature can also contribute in this field, which is further elaborated in the following.

5.3.3 Link to Incar Nature

The two previous examples showed that insurance companies are interested in pushing people towards a healthier and safer lifestyle by providing incentives, such as bonus programmes and discounts on insurance rates. Since Incar Nature is also strongly connected to contributing to people's health, this could also be introduced in such a concept for insurance companies, for health insurances, as well as car insurances.

When it comes to health insurances one has to recall that Incar Nature has the vision to make driving a car healthier and maybe even safer. Therefore, health insurances may be interested in the fact that car driving can be healthier through the integration of plants in the car interior. Similar to the existing examples with health insurance, a verification of driving a car, which is equipped with Incar Nature could be added to the bonus programme. This means that customers could also collect the bonus points by driving a car with healthier and more natural air conditions inside. This is particularly interesting and relevant for customers, who drive long distances and spend a significant amount of time in their cars, since this has a paramount effect on their health condition, especially in the longer term. Alternatively, health insurances could offer subsidies for purchasing the Incar Nature package in their new car.

In addition, Incar Nature could possibly be a relevant aspect for car insurances, as well. One needs to consider the fact that better air quality does not only have positive effects on the drivers' health, but can also contribute to a higher concentration level, less tiredness and therefore, an overall safer driving behaviour of people. This could be considered in the insurance rates in different ways. On one hand, a similar approach to the data-monitoring devices, which are a common tool for insurance companies in the U.S., is possible. More precisely, driving a car with Incar Nature could bring financial benefits for the customer. On the other hand, also subsidies would be possible, meaning

that customers who drive cars with Incar Nature could receive a prescribed amount in order to be rewarded.

Generally, this concept can also be transferred to other Incar Wellbeing technologies, the Attention Assist, for instance. Since it helps to prevent accidents and therefore also personal injuries, it can be an interesting approach for car insurances but also health insurances, to subsidise such technologies, provide discounts on rates, or include them in the bonus programs.

Even though the examples only refer to Germany or the United States, a clear potential can also be seen for the Asian market. As already mentioned before, especially in megacities, such as Beijing or Tokyo, the pollution level is so high that people are actually starting to get physically sick from it, especially with regard to respiratory diseases. Therefore, the interest of Chinese or Japanese insurance companies can be expected to be even higher. Since people spend such a significant amount of time in their cars Incar Nature can help to prevent such respiratory diseases, and therefore, insurance companies may incentivise the respective equipment in cars. Additionally, also other Incar Wellbeing technologies are of course relevant in this context.

To briefly conclude on this aspect, Incar Nature can contribute to an interesting business model in relation with insurance companies, since it aims at a healthier and safer life, which is also on behalf of insurance companies, since they can save on costs. Therefore, the concept may be to incentivise people to buy the Incar Nature feature, either by including it to a bonus programme, or subsidise a certain prescribed amount. This aspect is also especially interesting for the Asian market because people in cities like Beijing suffer from respiratory diseases due to polluted air. Moreover, this concept can be transferred to other Incar Wellbeing technologies, consequently expanding the potential in this field even further.

6 Summary

Generally, Incar Nature can be seen as the integration of any natural component into a car interior and aims at achieving a healthier and more natural environment for the car driver. Both, a biological, as well as economical approach are taken into account. The

innovation of Incar Nature is supposed to address the issue of bad air quality in cars, due to internal as well as external factors. There is an increasing awareness for health issues resulting from bad indoor air quality in buildings, schools, and hospitals. Since people spend a significant amount of time in cars, as already mentioned before on average around two years, it becomes increasingly important to create an environment in cars, which does not negatively impact people's health, but rather contributes to the drivers' health condition and wellbeing. In combination with other innovations of Incar Wellbeing this may even result in achieving the vision of people being healthier after the car ride than they were before.

Incar Nature intends to address the issue arising from internal factors, namely toxics and chemical substances, which are used in the production processes of cars and can harm the health condition of people. Besides the internal factor, also the external factors are to be addressed. This aspect includes the bad air quality especially in cities and megacities, harming people traveling in the traffic. Incar Nature is supposed to approach the internal as well as the external factor of the problem statement by integrating certain plant species absorbing the respective substances and contributing to a healthier and more natural environment in cars.

Existing ideas in this field include air filters, as well as fragrances for the car interiors, such as the Air-Balance package of Mercedes-Benz, that have already been introduced by car manufacturers. These technologies aim at a similar direction like Incar Nature and provide a reasonable approach to the discussed issues with external problems. However, they do not tackle the internal factor, as well as the problem with bad air quality in cars that haven't been moved does not get addressed. Beyond that Incar Nature provides a natural add-on or alternative to the filter systems.

There exists a first proper approach to Incar Nature, namely the introduction of a plant module. For the purpose of this thesis further possibilities were analysed according to the necessary requirements for a successful integration into a vehicle. More specifically, this includes realistic conditions with regard to the size and the amount of water the plant needs, as well as the temperature and light conditions required in order for the plant to survive in a closed space. In addition, a certain container for the plant needs to

be developed that ensure exactly those requirements with water supply, artificial light creation and temperature regulation. Furthermore, a display function is needed to provide the driver with information on the air quality and the condition of the plant.

After taking different plant species into account, the main outcome includes amongst others the Mother-in-law's tongue and the Aloe Vera plant. They have the benefit of being a rather easy care plant, with the right size and the possibility to survive in closed space. They are able to absorb CO₂ and produce oxygen at night, which is an interesting point with regard to the air quality in cars after a night in the garage, for instance. Additionally, Aloe Vera also provides the benefit of being automatically linked to a healthier lifestyle, since it is already used in many different fields, always with a relation to an improvement in health. This aspects can also have a possible positive effect when it comes to the commercialisation of the innovation, since people immediately understand the positive and healthier effect, which is supposed to be achieved with Incar Nature. The Mother-in-law's tongue is also already commonly known for its capability to clean indoor air. This is underlined by the project of Kamal Meattle in New Delhi, who used this plant, along with filter systems and other plants, to provide healthy space for the people living in a highly polluted city as New Delhi. An interesting aspect with regard to Incar Nature can be derived from this. Kamal Meattle used the combination of filters, as well as certain plants to reach the best air quality possible. Therefore, it might also be the best solution to combine air filters and Incar Nature in order to achieve the highest possible air quality in cars.

Besides taking the biological background into account, also the market potential needs to be analysed. A link between Incar Nature and three main markets is found, namely the health care, technology, and Incar Wellbeing market. Since it is part of Incar Wellbeing with regard to improving the health of drivers, it makes sense to look at the health care market. The health care market is a constantly growing market with great potential and a trend towards cHealth. Since Incar Nature can be related, also possible trends for the innovation itself can be derived from this.

In addition to that, Incar Nature is strongly dependent on the developments and innovations of the technology market. Since an appropriate container for the plants is needed especially companies with expertise in terms of sensors play an important role,

such Bosch GmbH in order to guarantee the control over water supply, temperature, light, oxygen levels, etc. by respective measurements. The technology market is a promising market as well with slightly higher gross profit margins compared to the automotive industry. This generally indicates a stable market with profitable operating companies.

The Incar Wellbeing market itself is directly linked to health care and wellness, which has a global market volume of over 8,000 billion €. The suitability for the automotive industry is estimated to be around 10 %, leaving a market potential of around 800 billion €. Generally, there is a high willingness to pay in this segment, which is underlined by the example of the Air Balance package of Mercedes-Benz. However, the Incar Wellbeing market can only develop in accordance to the extent and quality of innovations on the health care and technology market. Since both markets are in a good condition and have promising outlooks, this can be transferred to the Wellbeing market. Since Incar Nature is situated in a very early stage of conceptualisation, the market for it can only be derived. However, all linked and relevant markets are promising, especially the case of Incar Wellbeing shows the potential laying in this field.

The innovation of Incar Nature can bring economic benefits in terms of a possible reduction of car accidents, increase in the overall health condition, and it also provides a potential business model including insurance companies. The expenditures arising from car accidents are generally enormous. In relation to car accidents, Incar Nature can contribute to a higher level of concentration, as well as less tiredness, and therefore an overall safer driving behaviour. The fresher and healthier air also results in an improvement of the health condition of drivers, namely less headaches and increase in the overall wellbeing. Since there are no valid numbers that proof the influence of Incar Nature on the reduction of car accidents yet, a combination with other Incar Wellbeing features is considered, in order to underline the potential. Under respective assumptions a total saving in social costs of around 350 million € would have been possible in 2015 in Germany. In addition, Dale Walsh puts focus on addressing drowsy driving. This results in the potential to prevent approximately 500,000 accidents per year in the United States.

Furthermore, the health condition of people, especially with regard to respiratory diseases and other health issues arising from bad indoor air quality, can be addressed.

Incar Nature can contribute to generating an economic benefit with an approach to cleaner and healthier air, since this can positively influence the health condition of people, in particular in areas with high pollution levels.

Incar Nature also provides an opportunity for an interesting business concept related to insurance companies. This includes health insurances, but also car insurances. In this context it is especially interesting to evaluate existing examples of insurance companies incentivising people towards a healthier, in terms of car insurances safer, lifestyle. In Germany, some insurance companies, such as Barmer GEK, AOK and IKK, offer bonus programmes, which reward the collection of bonus points through certain medical check-ups, participating health courses or certain fitness courses, but depending on the insurance company also blood donation or organ donation cards can lead to bonus points. The rewards differentiate from non-cash benefits, such as other courses or products like barbecues, etc. to actual cash payments. On the contrary car insurance offer small deductions on the insurance rates for parking cars in garages for instance. In the U.S. customers also have the possibility to make use of a so-called telematics device, which monitors the data of an operating car, rewarding safe drivers financially.

The examples can easily be transferred to the innovation of Incar Nature. The general idea is to provide benefits for customers with cars that are equipped with Incar Nature, possible on the level of health insurances as well as car insurances. For health insurances the benefit exists in healthier customers, and consequently saving costs. On the contrary for car insurances, the contribution of Incar Nature to an environment that allows a higher concentration level and less tiredness happens to be interesting. This means that people drive safer and therefore, avoid costs to a certain extent.

In the case of health insurances Incar Nature could be included in the bonus programme of the companies, while car insurances could subsidise car holders with Incar Nature with a prescribed rate or discount. Basically, the discussed opportunities can also be applied to other Incar Wellbeing technologies, increasing the potential for this concept even further.

Generally, only a very brief part of Incar Nature was discussed in this thesis. The outcomes allow the estimation of a very promising innovation for the future in the automotive industry. However, it also becomes obvious that a lot of research still needs

to be done in this field. On one hand, especially research on the plants is necessary and the respective technologies for a successful integration in a closed space like a car need to be fully developed. On the other hand, also the market for Incar Nature can so far only be derived from linked markets. Therefore, conducting a representative survey can help to analyse the full potential of this innovation, since only products that are also purchased and used, can generate profit for the companies and an overall economic benefit. So in conclusion one can say that besides the lack of research and development Incar Nature provides a promising approach to the stated problems and has the potential to be found in the cars of the near future.

7 Reference List

- ADAC (2016). *Preise, Zuschüsse und Vorteile*. Available at: <https://www.adac.de/produkte/fahrsicherheitstraining/preise/> [Accessed 18 Jul. 2016].
- Adminaite, D., Jost, G., Stipdonk, H., and Ward, H. (2016). *Ranking EU progress on road safety -10th safety performance index report*. [online] European Transport Safety Council. Available at: <http://etsc.eu/wp-content/uploads/10-PIN-annual-report-FINAL.pdf> [Accessed 18 Jul. 2016].
- Allstate (2014). *What is a Telematics Device?*. Available at: <https://www.allstate.com/tools-and-resources/car-insurance/telematics-device.aspx> [Accessed 06 Aug. 2016].
- AOK (2016). *Vergünstigungen bei Fitnessstudios*. Available at: <https://www.aok.de/inhalt/fitnessstudios-verguenstigungen-fuer-aok-versicherte/> [Accessed 08 Aug. 2016].
- AUDI AG (2015). *Audi 2015 Annual Report*. Available at: http://www.audi.com/content/dam/com/EN/investor-relations/financial_reports/annual-reports/audi-ar-2015.pdf [Accessed 17 Jul. 2016].
- AUDI AG (2016). *Staub- und Pollenfilter*. Available at: <http://www.audi.de/de/brand/de/kundenbereich/reparatur-und-service/komplettpreisangebote/audi-a4/staub--und-pollenfilter.html> [Accessed 18 Jul. 2016].
- Barmer GEK (2016). *Bonusprogramm im Überblick*. Available at: <https://www.barmer-gek.de/meine-barmer-gek/online-services/bonusprogramm> [Accessed 17 Jul. 2016].
- BMW Group (2015). *Annual Report 2015*. Available at: https://www.bmwgroup.com/content/dam/bmw-group-websites/bmwgroup_com/ir/downloads/en/2016/Annual_Report_2015.pdf [Accessed 15 Jul. 2016].
- Bödeker, F. and Glanz, A. (2015). *Incar Wellbeing: Innovations from Healthcare for the Automotive Industry*. [online] Innovationen Institut. Available at: http://www.innovationeninstitut.de/fileadmin/user_upload/White_Paper_Incar_Wellbeing.pdf [Accessed 08 Jul. 2016].
- Bühl, R, Gugenhan, E., Schweder-Schreiner, K., and Werner, H.A. (eds.) (1981). *Mehr Freude an Zimmerpflanzen – Das praktische Handbuch zur für Aufzucht und Pflege*. Das Beste GmbH, Stuttgart.
- Chemical Sensitivity Network (2009). *Innenraumluft von Neuwagen ist oft der reinste Giftcocktail – Gesundheit bleibt auf der Strecke*. Available at: <http://www.csn->

deutschland.de/blog/2009/05/15/innenraumluft-von-neuwagen-ist-oft-der-reinste
-giftcocktail-gesundheit-bleibt-auf-der-strecke/ [Accessed 03 Jul. 2016].

Daimler AG (2015). *Annual Report 2015*. Available at:
<https://www.daimler.com/documents/investors/berichte/geschaeftsberichte/daimler/daimler-ir-annual-report-2015.pdf> [Accessed 15 Jul. 2016].

Deloitte (2016a). *2016 Global health care outlook*. Available at:
<http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Life-Sciences-Health-Care/gx-lshc-2016-health-care-outlook.pdf>
[Accessed 11 Jul. 2016].

Deloitte (2016b). *2016 global health care sector outlook*. Available at:
<http://www2.deloitte.com/jo/en/pages/life-sciences-and-healthcare/articles/global-health-care-sector-outlook.html> [Accessed 11 Jul. 2016].

DENSO Corporation (2015). *Annual Report 2015*. Available at:
http://www.globaldenso.com/en/investors/library/annual_report/2015/pdf/financial_section.pdf [Accessed 15 Jul. 2016].

Ford Ltd. (2016). *Ford Parts, Cabin Air Filters*. Available at:
<https://www.fordparts.com/Products/Filters-CabinAirFilters.aspx>
[Accessed 13 Jul. 2016].

Forsyth, J. (2015). *U.S. commuters spend about 42 hours a year stuck in traffic jams*.
[online] Reuters. Available at: <http://www.reuters.com/article/us-usa-traffic-study-idUSKCN0QV0A820150826> [Accessed 08 Jul. 2016].

IKK Südwest (2016). *Bonusprogramm: IKK Gesundheitsbonus 2016*. Available at:
<https://www.ikk-suedwest.de/leistungen/ikk-gesundheitsbonus/>
[Accessed 26 Jul. 2016].

Innovationen Institut (2015). *Incar Wellbeing Innovationsthema für Audi*. PowerPoint presentation. Innovationen Institut, Frankfurt am Main.

Knapp, J. (2016). *15 houseplants for improving indoor air quality*. Available at:
<http://www.mnn.com/health/healthy-spaces/photos/15-houseplants-for-improving-indoor-air-quality/golden-pothos> [Accessed 21 Jul. 2016].

Koch, W. (2014). *Can Houseplants Really Clean the World's Smoggiest City?*. [online] National Geographic. Available at: <http://news.nationalgeographic.com/news/energy/2014/12/141230-can-plants-really-clean-indias-air/> [Accessed 19 Jul. 2016].

Luftanalysezentrum, (2016). *Schadstoffe im Autoinnenraum*. Available at:
<http://www.luftanalyse-zentrum.de/schadstoffbelastung-raeume/schadstoffe-autoinnenraum> [Accessed 10 Jul. 2016].

Magna International (2015). *2015 Annual Report to Shareholders*. Available at:
<http://www.magna.com/investors/financial-reports-public-filings/financialreports?rpt=annual> [Accessed 17 Jul. 2016].

Mercedes-Benz Ireland (2016). *Equipment packages – tailored luxury*. Available at:
http://www.mercedes-benz.ie/content/ireland/mpc/mpc_ireland_website/enng/home_mpc/passengercars/home/new_cars/models/s-class/w222/facts_/equipment/packages.html [Accessed 08 Jul. 2016].

Merlot, J. (2015). *Mythos oder Medizin: Macht stickige Luft müde?*. [online] Spiegel Online. Available at: <http://www.spiegel.de/gesundheit/diagnose/macht-stickige-luft-muede-mythos-oder-medizin-a-1025251.html> [Accessed 08 Jul. 2016].

Michulsky, N. (2012). *Gefahr durch Pilze und Bakterien: Experten empfehlen regelmäßige Wartung der Auto-Klimaanlage*. [online] Aachener Zeitung. Available at: <http://www.aachener-zeitung.de/news/auto/gefahr-durch-pilze-und-bakterien-experten-empfehlen-regelmaessige-wartung-der-auto-klimaanlage-1.434073> [Accessed 16 Jul. 2016].

Pennise, D. *Biomass Pollution Basics*. [online] University of California-Berkeley. Available at: <http://www.who.int/indoorair/interventions/antiguamod21.pdf> [Accessed 23 Jul. 2016].

Robert Bosch GmbH (2015). *Consolidated financial statements of the Bosch Group*. Available at: <http://annual-report.bosch.com/financial-statements/> [Accessed 17 Jul. 2016].

Schaeffler Group (2015). *Annual Report 2015*. Available at:
http://www.schaeffler.com/remotemedien/media/_shared_media_rwd/08_investor_relations/reports/2015_schaeffler_annual_report_en.pdf
[Accessed 17 Jul. 2016].

Statista (2016a). *Durchschnittlicher Schadensaufwand je Pkw-Unfall in Deutschland von 1995-2011 nach Art der Versicherung*. Available at: <http://de.statista.com/statistik/daten/studie/38507/umfrage/durchschnittliche-kosten-je-autounfall-1995/> [Accessed 19 Jul. 2016].

Statista (2016b). *Estimated growth rates for the global electronics industry from 2014 to 2016, by region*. Available at: <http://www.statista.com/statistics/268396/estimated-growth-rates-for-the-electronics-industry-by-region/> [Accessed 19 Jul. 2016].

Statistisches Bundesamt (2016a). *Verkehr 2015 - Fachserie 8 Reihe 7*. [online] Available at: https://www.destatis.de/DE/Publikationen/Thematisch/TransportVerkehr/Verkehrsunfaelle/VerkehrsunfaelleJ2080700157004.pdf?__blob=publicationFile [Accessed 15 Jul. 2016].

Statistisches Bundesamt (2016b). *Verkehr Mai 2016 - Fachserie 8 Reihe 7*. [online] Available at: https://www.destatis.de/DE/Publikationen/Thematisch/TransportVerkehr/Verkehrsunfaelle/VerkehrsunfaelleMonat/VerkehrsunfaelleM208070061054.pdf?_blob=publicationFile [Accessed 16 Jul. 2016].

Stein, A. (2014). *Megasmog verwandelt Megacitys in Todeszonen*. [online] Die Welt. Available at: <http://www.welt.de/wissenschaft/umwelt/article125797901/Megasmog-verwandelt-Megacitys-in-Todeszonen.html> [Accessed 07 Jul. 2016].

Tanner, A. (2013). *Data Monitoring Saves Some People Money On Car Insurance, But Some Will Pay More*. [online] Forbes. Available at: <http://www.forbes.com/sites/adamtanner/2013/08/14/data-monitoring-saves-some-people-money-on-car-insurance-but-some-will-pay-more/#3c31132d264a> [Accessed 10 Jul. 2016].

The Ecology Center, (2012). *Model Year 2011/2012 Guide to New Vehicles*. Available at: http://www.ecocenter.org/sites/default/files/2012_Cars.pdf [Accessed 09 Jul. 2016].

Umweltbundesamt (2013). *Feinstaub in Megacities – Ein Thema mit essentieller Bedeutung für Millionen Menschen*. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/420/dokumente/feinstaub_megacities.pdf [Accessed 18 Jul. 2016].

Vieweg, C. (2011). *Wenn das Auto zum neuen Lebensraum wird*. [online] Die Welt. Available at: <http://www.welt.de/motor/article12447504/Wenn-das-Auto-zum-neuen-Lebensraum-wird.html> [Accessed 08 Jul. 2016].

Walsh, D. (2012). *The Drowsy Driving Off Switch*. [online] The Synergist, January 2012, pp. 24-25. Available at: <http://www.americanasafety.com/associates/docs/publications/The%20Drowsy%20Driving%20off%20Switch.pdf> [Accessed 21 Jul. 2016].

Wolverton, B.C., Johnson, A., and Bounds, K. (1989). *Interior Landscape Plants for Indoor Air Pollution Abatement*. [online] NASA. Available at: <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19930073077.pdf> [Accessed 10 Jul. 2016].

World Health Organization (2016a). *Ambient (outdoor) air pollution database, by country and city*. Available at: http://www.who.int/entity/phe/health_topics/outdoorair/databases/WHO_AAP_database_May2016_v3web.xlsx?ua=1 [Accessed 15 Jul. 2016].

World Health Organization (2016b). *Children's environmental health*. Available at: <http://www.who.int/ceh/risks/cehair/en/> [Accessed 11 Jul. 2016].

World Health Organization (2016c). *Health financing for universal coverage*. Available at: http://www.who.int/health_financing/universal_coverage_definition/en/ [Accessed 04 Jul. 2016].