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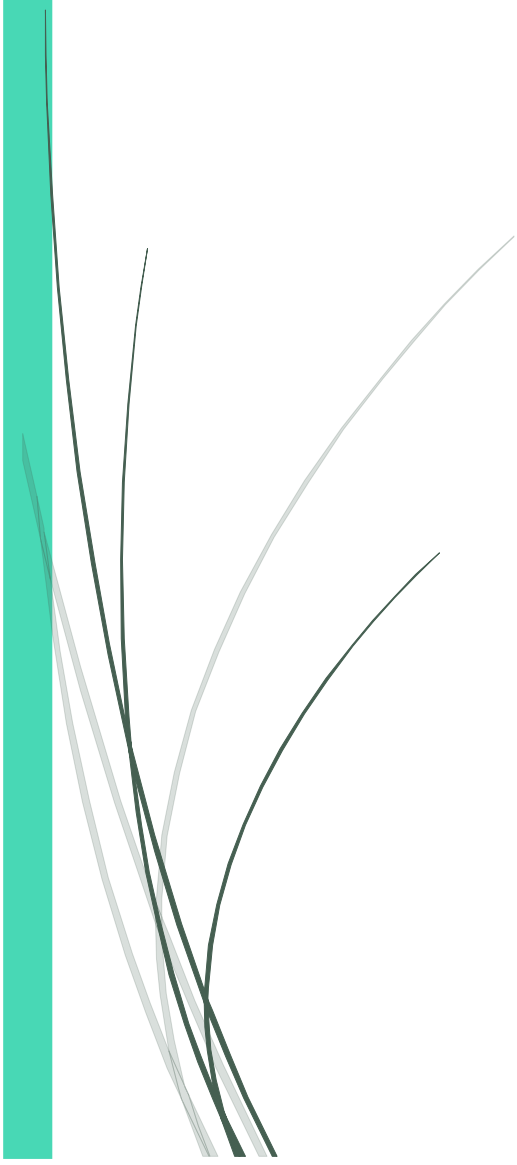
Advisory Report

Bicycle Street of the Future



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Minor Smart Solutions – Bicycle street of the future

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INTRODUCTION

In this report the advice that will be given towards 'Stichting Fiets op 1' regarding the bicycle street of the future can be found. The Project group 'In Tandem' has researched different aspects that the 'Bicycle Street of the Future' should contain in order to become more attractive towards the local communities and tourists.

The advice has been divided into different parts. These parts coincide with the research questions created during the problem analysis. The questions that have been set up are answered by a team member with the suitable knowledge and expertise.

The subjects are:

- How the bicycle street can attract tourists
- What technologies should be considered for the bicycle street
- How the local entrepreneurs can benefit from said bicycle street
- How Sustainable Development Goals (SDG's) fit into the future design of the street

When these components are combined an answer to the research question can be formulated.
As the research question states: *"How can Dieren attract more tourists by becoming a leading cycling village when creating a bicycle street with innovative technologies which can be realized before the 22nd of February 2022."*

This advice report should be clearly structured in order to answer the research question. The first part of the document will recite all the research that has been conducted in the previous set up the 'problem analysis' and the 'literature review'. Secondly, the desired methods will be defined and explained. Additionally, the results of the research related to the research questions will be explained. Finally a conclusion and advice will be given towards the client.

SUMMARY

The preliminary research from previous documentation has been shortly exemplified. This is done in order to create a clear foundation as a base for the document. The preliminary Investigation contains the conclusion of the problem analysis which is the base of this project. In this phase are the main and sub-research questions created. The research questions are of great importance in the research phase because these force the team to research specific areas. Eventually these questions create value for the bicycle street and are the base for the project. Each technology that has been found has been explained shortly and the exact source can be found in Appendix (1)

After the Preliminary investigation it is possible to create some methods on which the document is based. It explains the method on how the research questions can be answered. Every research question is a slightly different because of the context in which it lives but the grand scope can be applied to all. It follows these basic steps:

I. Research question
II. Result or answer to the question using the literature review or other means.
III. Recite the sources (if required) and then substantiate them.

After defining the methods it is possible to apply those to the research results and find the answers to the sub-questions.

When using technologies to substantiate the research questions, the stoplight or traffic light method has been used. Which means:

	Ability to be implemented in a design before 22-02-2022
	Ability to be implemented in the near future after 22-02-22
	Ability to be implemented in the far future with no timespan

Table 1, Stoplight methodology

The first sub question is regarding improving the safety of the bicycle street. This can be done by using a new technique, whereby the street lights up itself. Light is a very important feature when looking to improve the safety of the street. Furthermore, all the technologies have been labeled, so the information can be seen at glance.
It's also possible to make the street signs smarter by using sensors and systems to smartly influence the street features.

Another important component of this project is the use of the sustainable development goals (SDG's). These goals are a framework of objectives that new projects can adhere to. Eventually these goals make the final product more sustainable and better for nature and people. Not all the goals can be implemented immediately but those which could be implemented have been researched and are labelled with the stoplight prioritization methodology.

The next sub question that has been answered is how the local shop owners can create value out of the bicycle street. The local entrepreneurs have been researched in order to make the 'Bicycle Street of the Future' attractive. The two Kamer van Koophandel (KVK) Pillars can make the bicycle street more attractive for shop owners since the street will create an increase in people or tourists going through a street and will therefore automatically bring more revenue to shop owners with minimal effort required by them.

Another aspect that has to be considered is the future of the street. How can the street stay innovative in the future and what can be done to keep it fresh and interesting? A brainstorm session has been held to discuss unusual, futuristic and new idea, which led to some interesting results. One of the more achievable ideas is the one that there is a drive-through for tourists at the Gazelle factory, which can be sponsored by Gazelle, and give tourists a glimpse on how bicycles are produced.

Finally, the ability to attract more tourists to the street and to Dieren should be answered. The trends and developments regarding cycling vacations have been researched with a result that good infrastructure is one of the primary ways of attracting more tourists. This can be done by letting the street participate in the official and national cycling itineraries and junctions. Furthermore, a marketing plan should be created in order to make people aware and enthusiastic of the existence of the street. This is possible through the use of folders and advertisement at campsites and resorts near the Veluwe. Furthermore a collaboration with 'Landelijk Fietsplatform' and the VVV offices is recommended.
In order to create a clearer image on who would actually use the bicycle street a persona has been created that might be the best fit with the tourists that would possible visit the new bicycle street of the future.

Finally the advice and conclusion can be given. Which means:

- Implement technologies prioritized using the stoplight method. Making the street attractive and safer.
- Marketing has to be done to make people aware of the existence of the bicycle street.
- Local entrepreneurs are possible to make extra profit because of the bicycle street.
- Implement the SDGs using the stoplight method making the street more sustainable and environmentally friendly.
- The ideas from the brainstorm make the street future proof.
- Connect the bicycle street with the network of national cycling routes.

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1 PRELIMINARY INVESTIGATION

1.1 PROBLEM ANALYSIS

After analyzing the problem which Fiets op 1 has given, the following conclusion has been stated: Research has been conducted throughout the analysis report and have led to several outcomes. Firstly, has the outcome of the survey held amongst 102 individuals regarding the 'Bicycle Street of the Future' and the tourism in Dieren shown that most respondents cycle often or occasionally, with only a small amount that never cycles. Moreover, does the majority of the tourist goes cycling on a holiday and would see benefits when designing a bicycle street with new technologies.

Secondly, did most respondents answered not to adjust their holiday destination for an innovative bicycle street. Even though they would like such a project as an addition to their holiday, but only if they would already have the destination planned.

Lastly, can be concluded that Dieren is a city with a certain amount of qualities, improving the destination as a city to live. The central location, surrounded with nature, forests and 'National Park De Hoge Veluwe' along with Hanseatic cities Doesburg and Zutphen nearby, positively influences the development of the Bicycle Street of the Future.

1.1.1 RESEARCH QUESTIONS

In order to formulate a proper advice towards Fiets op 1 the following research questions were created.

Primary statement:

- How can Dieren attract more tourists by becoming a leading cycling village when creating a bicycle street with innovative technologies which can be realized before the 22nd of February 2022.

To answer the primary statement, research questions were formulated. Research has been done to build a steady foundation in order to answer the research questions. By answering these research questions the primary statement can be answered as accurate as possible.

Sub-statements:

- What futuristic technologies can be applied to the bicycle street of the future to make it more future proof?
- How can the Sustainable Development Goals be implemented into the bicycle street of the future?
- How can the safety of the bicycle street be improved compared to the current situation?
- How can the Bicycle street become attractive for business opportunities of the surrounding entrepreneurs?
- How can the bicycle street of the future attract more tourists to Dieren and the surrounding area?

1.2 RESEARCHING TECHNOLOGIES

1.2.1 TECHNOLOGICAL CONTEXT 1-13

1. STREET ENERGY RECOVERY

The street energy recovery system is quite interesting for the 'Bicycle Street of the Future' as it provides energy for road lightning but it is also a way for vehicles to be slowed down. The pressure plate needs to stick out of the road like a traditional speed-hump. After a car makes contact, the surface of the hump will compress a spring and generate kinetic energy that will be collected by a battery. Due to the dimensions and compressing motion the cars will need to move slower which is comparable to speed humps and will therefore add more safety to the street. The recovered energy can be collected at a nearby power station, this can be used to power the street lights during the evening or at night. A single plate generates about 37800 joules, a modern LED street light needs about 70 watt of power, so one plate could roughly power one high brightness LED light.

2. LIGHT "EMITTING" CONCRETE

This concrete is infused with aligned glass fibers and has the characteristic of being opaque. It is possible to place lights behind the concrete to emit a see-through effect. It might be possible to use this material in pavement or roads to dynamically change signaling or to show a dangerous road situation to motorists, cyclists or pedestrians.

3. SMART STREET LIGHTS FOR CYCLISTS

This technology makes use of small windmills in order to power street lights and signals. In combination with an app, the street lights and signals are used dynamically and therefore can the software be useful for a futuristic bicycle street.
Apart from the fact that this is technology is better for the environment, the cyclists will feel safer while cycling on the bicycle street which is positive. In the winter it becomes dark earlier and people are less likely to go outside by bicycle if they do not feel safe. By creating a safe atmosphere customers whom are travelling by bicycle will approach the shops sooner. This contributes to financial value creation for the surrounding entrepreneurs.

4. "SMART" TRAFFIC LIGHTS AND SIGNALING

This technology is similar to the third article [3] but this system is a more dynamic integration of the entire city infrastructure with a futuristic view on traffic. As the article states: "Smart traffic systems are a revolution because they can have a dramatic effect on traffic flow and congestion at a small fraction of the cost of building a new road. More importantly, they address the root of the problem—regulating traffic patterns, improving public transport and effectively balancing private and public transportation."

5. SOLAR AND WIND POWERED STREET LIGHTS

Also similar to the third article [3], this article dives into the technical aspect of realizing solar and wind powered street lights. In conjunction with the first article [1], this could make the lighting system of the bicycle street of the future completely autonomous and carbon-neutral. These small turbines are usually used for highways but could easily be adapted for usage in a more urban environment. This technology is already available and is being used in China.

6. MAKING ROADS SMARTER

These are steps that could be taken to improve an obsolete road, and therefore make the street safer and modern. The bicycle street of the future might need to undergo the steps mentioned in the article in order to be able to modernize the street. It describes "stripping" the road of all unnecessary features that might have accumulated over the years of upgrades and changes.

As mentioned before, also this technology will create customer value since it created a safer environment. In addition, rebuilding this road will result in an innovative cycle path for tourism. This will create financial value for the surrounding entrepreneurs.

7. ROAD LIGHTING TO IMPROVE SAFETY

This is not really an article but a showcase of an art/engineering prototype already implemented into a Dutch road. Already showcased during a FietsOp1 presentation but reviewed by the project group to see if the benefits valuable. In conclusion this prototype is very promising to be implemented into a road in the near future. The materials are relatively cheap, easily implemented and actually useful for road users. This technology is also useful for possible power outages, where street lighting might not work.

8. SMART ROAD TECHNOLOGY: PAVING THE WAY TO THE FUTURE

A cumulative set of articles by HERE mobility that showcases 7 different kinds of futuristic technologies that might be used by governments all around the world. Some are more realistic then others but certainly worth to have a look at. One of the more interesting technology is number 5, where electric cars can be charged using induction charging. But what if it's not only cars that can be charged but bikes instead. It could be possible to embed induction coils into bicycle tires and charge electric bikes whilst on the move.

9. THE USE OF CYCLING SPEED INDICATORS

Cycling speed indicators might improve road safety in combination with anticipation other road users like cars or motorcycles. This technology was already presented in Utrecht around 2018 so it already exists and might be useful for the bicycle street of the future.

10. EMBEDDED LED ROAD LIGHTING

An embedded LED technology that uses radar and lidar sensor technology to detect cyclists. When a cyclist is detected by the LED's in the road, the lights will light up with a warning for the driver of the car that a cyclist is approaching. This is not an indication that the driver has to stop but might prove itself very useful for signaling motorists for oncoming traffic and possibly avoid a dangerous situation in the future.

11. THE USE OF BLOW IN THE DARK PAINT ROADS

Instead of using LED or glow in the dark strips on the road, the road and road signaling might be painted with a glow in the dark paint. This paint will make road signals and lines better visible, especially at night where visibility mostly is lower. A disadvantage might be abrasion, where the paint is stripped off due to traffic and has to be reapplied regularly.

12. INTERACTIVE SMART STREET CROSSINGS

This system called STARLING (**ST**igmergic **A**daptive **R**esponsive **L**earn**ING**) is used for interactive crossings and to monitor real time road conditions. It's high tech and futuristic but might prove useful in the period after the Bicycle street of the future has been implemented.

13. AUTOMATIC BICYCLE PARKING GARAGE

Automated Bicycle parking is nothing new but might prove very useful in persuading citizens to use their bicycle instead of the car. These parking locations are safe and only use little space above ground.

2 METHODS

This chapter will provide the relevant methodology that will be used to structure this document. Since this is an advisory report a standard structure will be used.

First the context will be determined. Then the methodology will be used that fits with the context. And eventually an end product will be decided upon.

2.1 CONTEXT

To determine what methods will be used, the context will need to be brought forward. The context is the following documentation:

- Project plan
  In the initial stages of the project 'Stichting Fiets Op 1' approached Saxion. Fiets Op 1 want to transform the Wilhelminastraat in Dieren into a futuristic bicycle street before 2022. It was not clear what the problem was for Fiets Op 1 so a Problem Analysis (PA) had to be done. The project plan contained general rules and agreements for the project itself.

- Problem analysis
  The PA determined the problems in a clear manner and a set of research questions are formulated moreover, some requirements were formulated. Next to the primary products two questionnaires were held and therefore useful information is gathered.

- Literature review
  The problem is now clear to the 'In Tandem' team. In the Literature review (LR) research has been conducted in order to answer the research questions that have been set up in the PA. Results were eventually aggregated in that document. All the research questions have not been concretely answered so that step can be done in the advisory report.

It is important to know that the Design Thinking methodology has been applied during this project which means that this Advisory Report (AR) is built upon an iterative way of working which means that it can go through multiple cycles of improvement to add more information or products.

2.2 METHODS

For the design approach, the deliberative approach has been used. Deliberative
means that the design for the end product is created by consulting between different parties. In addition, the criteria stated at the beginning of the project were quite unclear and had to be discussed together with the product owner and Saxion.

The method that best fits this advisory report is to write down the research questions in its own separate chapter. The various sources that have been researched will be used to try and answer the question. Important to know that each research question might have a different method of being answered but all of the questions have the same general structure. The structure is:

I. Research question
II. Result or answer to the question using the literature review.
III. Recite the sources (if required) and then substantiate them.

When a technology is used it has to be labelled either red, yellow or green (requirement [B5] from the problem analysis). Fiets Op 1 preferred that this prioritization scheme be used as it coincides with Fiets Op 1's internal method.

So:

	Ability to be implemented in a design before 22-02-2022
	Ability to be implemented in the near future after 22-02-22
	Ability to be implemented in the far future with no timespan

Table 1, Traffic Light Prioritisation

after all research sub-questions are able to be answered. The main research question "How can Dieren attract more tourists by becoming a leading cycling village when creating a bicycle street with innovative technologies which can be realized before the 22nd of February 2022." Is able to be answered as well and an advice can be given towards Fiets Op 1.

A chapter in conclusion is added to add additional results that do not fit directly in any other chapters.

2.3 DESIRED PRODUCTS

The desired product for this document is clear: An answer to the main research question and an advice towards Fiets Op 1.

Next to the main desired products it is possible that a few sub-products are delivered or made. This has to do with the Design Thinking Methodology where extra resources can be used to improve or add features to the desired product.

3 RESULTS

3.1 SAFETY

3.1.1 CONTEXT

Safety is one of the issues that was brought to light during the Initial stages of the project. One of the product owner deemed that the street was not safe, or safe enough for road users. The project group has created a research question and have tried to answer it and find a solution for the unsafe street. All the information gathered from the previous documentation regarding safety will be aggregated.

The research question states:
"How can the safety of the bicycle street be improved compared to the current situation?"
It is important to know that innovative technologies play a crucial part in this project, as this has to be a bicycle street of the future. So the solutions that have to be found need to be unconventional and futuristic.

Firstly it has to be made clear what the current situation is. During the problem analysis it was deemed useful to go to Dieren and look at the current situation of the street in question.

Figure 1, Blind Corner(s)

Figure 2, Narrow road and wide sidewalk

Figure 3, complicated intersection

The Wilhelminaweg (as shown in the pictures above) is a fairly normal street. Some interesting features are the very wide sidewalks and narrow street. There are some blind corners (figure 1) that might form safety hazards. Also, the intersection as shown in figure 3 is complex and might cause confusion to its road users.

In the literature research the group has looked at different innovative technologies that might be useful to increase the safety around the Wilhelminaweg.

3.1.2 RESULTS

The following technologies have been found:

I. STREET ENERGY RECOVERY SYSTEM. [1]

	Ability to be implemented in the near future after 22-02-22

The street energy recovery system might prove useful for slowing down vehicles that are driving on the street. This is done through the pressure plates that act like speed humps whilst also recovering energy to power street lights and other electrical features.
Example of the prototype is shown below:

Figure 5, Single Waydip plate on a road

Figure 4, Waydip Plate

This product already exists but is still a prototype and not widely used yet and therefore it needs to be tested first. It might be possible to implement this technology before 22-02-2022 but this depends on the existence of the prototype or even a finished product. If not the technology could possibly be implemented after 22-02-22.

II. LIGHT EMITTING CONCRETE. [2]

Ability to be implemented in the design before 22-02-2022

This technology is already used as a consumer product called Litracon©, it can be used for indoor or outdoor environments. This material is very useful in an urban setting where the situation of the road can change very quickly. It is possible to mount a light grid under the concrete to create shapes or images that are useful for road users.

Because this is a product already it's possible to be implemented in some form before 22-02-2022. Example is shown below.

Figure 6, Translucent Litracon concrete

III. SMART STREET LIGHTS, SMART TRAFFIC LIGHTS, SMART STREETS. [3] [4]

Ability to be implemented in the design before 22-02-2022

IV. MAKING ROADS SMARTER. [6]

Ability to be implemented in the near future after 22-02-22

V. STARLING INTERACTIVE SMART STREET CROSSING [12]

Ability to be implemented in the far future with no timespan

These technologies will be aggregated under smart technologies. These technologies try to provide the same features but in a different context. Smart technologies are the gateway to smart cities. A smart city is a city where it is services are inter-connected with each other and work together. Technology driven would be a good description of a smart city in a general sense. These inter-connected services can make day-to-day tasks of its citizens easier. Like commuting to work or finding a restaurant to eat at in the evening. For example, during rush hour there might be sensors in the city that measure how busy the streets are. This data is aggregated an processed and then shared to its citizens.
All these smart technologies need to be tested or implemented on a smaller scale. The bicycle street of the future can be a primary example of this. The only problem is the effort and experience that is required to set up such a system.
One of the biggest challenges when making a smart city is figuring out a way to make all the services work together. Traffic lights have vastly different technical protocols and signals then a security

camera. Another problem is who the exact owner is of the infrastructure. The telephone poles are owned by a different company then the traffic lights. Not everyone is going to give the municipality complete control over the digital infrastructure without making a profit. Also, how are you going to serve this data to its citizens. What are you going to do with the data? It might be illegal to track people in the city. Where is all this data going to be saved? Maybe use a cloud provider? But cloud providers are really expensive when you're using so much data. And building a massive data center in the city is very inconvenient. These are all questions that don't really have any clear answers yet. Standards have to be developed and in my opinion a standard for data is step number one.
The use of "smart" has gone on a tangent and can be taken out of context a lot.

As said before, it is useful to try and make the bicycle street of the future a testbed for smart services that others can learn from. And in the end it will make a massive difference in the safety of the road users. And bring lots of other advantages with it as well. Because of the effort required a single smart technology might be able to be made before 2022. And it can be expanded upon after that.

VI. ROAD LIGHTING AND THE USE OF GLOW-IN-THE-DARK PAINT [7] [10] [11]

	Ability to be implemented in the design before 22-02-2022

The use of innovative sources of light in streets is not widely used yet. Even though it can be very useful for the safety of the street. A prototype has been set up by Studio Roosengaarde which many people have seen. But it was an art exhibit. Another step needs to be taken to implement is into a real life traffic situation. The bicycle street of the future is a good candidate for this. Research that has been done has shown that passive sources of light can be very useful in certain road situations. (Wood, 2019) There are also active sources of light that can be used. Like LED lights that are mounted into the street that signal road users when a cyclist is coming around a blind corner. [10] the passive light sources are very easy used and places and some active sources are also very usable in the near future. Thusly, these have been labeled green.
If these technologies are implemented then the road safety will improve.

Figure 7, Example of embedded LED lighting

3.2 THE USE OF THE SUSTAINABLE DEVELOPMENT GOALS

How can the Sustainable Development Goals be implemented into the bicycle street of the future?

As mentioned in the literature review, multiple SDG's could be implemented during this project. A table at the end of the paragraph will indicate if the SDG's could be implemented at a short-term or at the long haul.
Below the SDG's that could be implemented are mentioned and elaborated:

GOAL 3: Good Health and Well-being: by promoting the street you are also encouraging people to go and start biking (more).

GOAL 6: Clean Water and Sanitation: next to the bicycle street of the future a tap with clean water will be placed, this can either be in one spot or in multiple. One seating spot will be created to rest and enjoy the view. In this spot it would be a good idea to certainly place a tap with clean water.

GOAL 7: Affordable and Clean Energy: the innovation implementation makes use of sustainable energy to avoid impact on climate change. Can also be covered by applying the solar panels which are described in Goal 12

GOAL 8: Decent Work and Economic Growth: by promoting the bicycle street more tourist will be attracted. When also promoting the shops which are down the street, tourists are more attracted to check out the stores as well which improves the economic growth.

GOAL 9: Industry, Innovation and Infrastructure: make use of 'give a way road markings' that light up when a cyclist is approaching from the other side, to make motorist aware of the cyclists.
Furthermore adding glow in the dark street markings will improve the road during the night.

Figure 8, Image of a glow in the dark strip

Retrieved from: (BBC, 2014)

GOAL 11: Sustainable Cities and Communities: partnering with local businesses in order to create new jobs.
When tourism and the economic flow increases more jobs can be created and are possibly needed to handle the growing demand. Businesses will become more attracted in opening their business along this street.

GOAL 12: Responsible Consumption and Production: sustainable and decent jobs with better quality of life for the local businesses. When implementing sustainable (eco-friendly) technologies. An example could be to make the Gazelle factory more sustainable by adding solar panels on the roof, to generate energy which could be used for powering the factory and the road markings.
The clean water from the tab could be rain water which is cleaned through filters.

GOAL 13: Climate Action: avoid impact on climate change, through corporate awareness by measuring the environmental impact and reduce ecological footprint. Again here, when implementing the idea of the solar panels from goal 12, this goal will be covered. Furthermore, an upcoming new technology could be useful, namely: the technology of the street engine recovery. A detailed description of this technology can be found in the paragraph technologies, 1a

GOAL 15: Life on Land: placing bird houses in threes which are on the route of the street. By placing these houses, more birds should be attracted.

GOAL 17: Partnerships to achieve the Goal: working together with Gazelle, gemeente Rheden, local businesses.
Working with Gazelle for the ecological improvements (SDG 12). Gemeente Rheden and local businesses for promoting the street to tourists (SDG 3 and 8) and gemeente Rheden for accomplishing goals 6, 7, 9, possibly 11, 12, 13, 15

In this table an indication of implementation of the SGD's can be found, with regards to the bicycle street.

Applicable	Short-term	Long-term
SDG 3	SDG 6	SDG 7
SDG 8	SDG 9 (partly already applicable)	SDG 12
SDG 11	SDG 13	SDG 13
SDG 15		
SDG 17		

Table 2, SDG's using the stoplight method.

To be able to implement certain SDG's certain technologies that have been found would be needed to realize this. Five SDS's could be directly implemented, which would give the street a sustainable and future proof meaning. This is not only beneficial for the street but also for the visitors, the surrounding companies and stichting Fiets op 1.

3.3 VALUE

To know how the bicycle street of the future becomes attractive to the entrepreneurs the project group did research about entrepreneurs. What motivates an entrepreneur to become entrepreneur and to start a business? The answer is value creation.

The research question states:
"How can the Bicycle street become attractive for business opportunities of the surrounding entrepreneurs?"

From research by the KVK (kamer van koophandel) and sources far back in time, something becomes interesting for entrepreneurs when value can be created with it. This can be value for the entrepreneur as well as for the customer. A survey by the KVK in 2019 shows that 47% of entrepreneurs look at the financial value that can be achieved for the company. In addition, 45% of the entrepreneurs see value creation for the customer as most important for the continuity of the business. In addition, 8% indicate that they consider value creation for society to be the most important. The KVK is of the opinion that social value is clearly the least important. (KVK, 2019)

It is therefore clear that there are two pillars that make it interesting for a large proportion of entrepreneurs. These are financial value creation and customer value creation. With these two pillars almost all entrepreneurs can be persuaded to participate in the project. It then adds value (Melsen, 2020). A large number of entrepreneurs are located on the street that will be converted into the bicycle street of the future. Think for example of a fishmonger or a baker. When they get a tourist attraction right in front of their doorstep, they can take advantage of this to increase sales. It is therefore also very interesting for businesses of this kind if an innovative bicycle parking facility can be placed close to the shops and terrace. People will park their bicycles and make use of the facilities. This is an opportunity for financial value creation for the companies that can offer something to the tourists who pass by to see the most innovative bicycle street. It can also work as a value creation for the regular customer. This has the possibility to store the bike in a proper way and pass the shops with peace of mind. So an innovative bicycle storage offers both financial and customer value creation for the already existing entrepreneurs in the street.

Campsites and holiday parks are located in and around Dieren. For these parks, a tourist attraction in the area is extremely attractive. Any reason for a tourist to choose a destination near such a holiday park or camping site is a direct opportunity for the entrepreneurs of these parks or camping sites to create financial and customer value. This allows for a wider range of activities in the area and for more visitors and therefore a financial plus. This means that the more innovative and attractive the street, the more interesting it becomes for the surrounding holiday parks and campsites.

As can be seen in the examples above, a value creation in the area of one of the two pillars creates a value creation in the area of the other pillar. By implementing the right innovative techniques at the right place in the street, values can be created for the surrounding entrepreneurs. By doing this with touristic attractive techniques, value can be created for entrepreneurs who are not directly located in the surrounding area. Advertising can also be considered for the techniques in the bicycle street. Think of those made possible by texts that make someone realize that a company has contributed to this street. By being able to show the right figures, it will be possible to poke the company for this as well. This has an effect on the financial value creation of that company.

3.4 THE FUTURE OF THE BICYCLE STREET

During the midterm evaluation there was another opportunity to talk to the client. The client made clear that there had to be some ideas or technologies that had the ability to be implemented after the initial opening of the bicycle street. There has also be stated that these ideas do not have to be feasible initially but are possible for future proofing the street.
The project group has researched articles and technologies where such ideas can be explained. However, it is very difficult to find futuristic ideas for bicycle streets. In order to be able to come up with good ideas for a future proof bicycle street, the project group held a brainstorming session. In order to allow a smooth process of the brainstorming, the network of the project group was consulted to allow an outsider to lead the creative process during the session. For this purpose a fourth-year student of the small business and retail management course was asked. This student supervised the session well and a lot of special, fun, sometimes unreasonable and crazy ideas came out of it. After completing the creative process, we looked at which ideas could be interesting and these are elaborated below.

Due to the nature of this research questions all the ideas are deemed:

	Ability to be implemented in the far future with no timespan

Another research question had to be set up to deal with the needs of the client. Eventually the following research question was made:
“What ideas can be used for the bicycle street of the future after the initial opening in 22-02-2022”

The ideas:

BICYCLE SUSPENSION BRIDGE OVER THE ROAD

By creating a bridge which the cyclist can enter and can be lifted over the road, the dangerous situation at the intersection near the railway tracks has will be solved. The cyclist no longer need to cross the road but will float over the dangerous part of the street.
Besides improving the safety the bridge can likewise become a new tourist attraction. This will be the first bridge of this kind in the Netherlands and probably even in the whole world. Which probably generates more visitors, that will become interesting for the surrounding entrepreneurs and can help to create financial value.

CYCLING BACK IN TIME WITH VR GLASSES

Cycling through the same street but see what it looked like in 1800. A lot is known about the streets of the old days. This makes it possible to recreate this into a virtual environment. When this is worked out well people can cycle through the past. A revenue model could be linked to this idea. This could generate extra income for one of the surrounding entrepreneurs and could create financial value. It will also attract tourists and add financial value for the other surrounding entrepreneurs.

BICYCLE DRIVE-THROUGH AT THE SURROUNDING SHOPS

The first bike drive-in in the Netherlands. All entrepreneurs who sell food can participate in the bicycle drive in the street. This will have the same concept as the MC drive the only difference is that this drive-in is created for cyclists and multiple companies. In this way the entrepreneurs can easily sell products to passing cyclists and create customer value and financial values creation. In addition, this will be the first bike drive-in in the Netherlands and will therefore attract tourists.

RETRACTABLE ROOF SO IT NEVER RAINS AND WHEN THE ROOF IS CLOSED A VIRTUAL SUN SHINES

By building a roof over the entire street, people never have to cycle in the rain. In addition, a virtual sun is built in which this is the only place in the meadow area where the nice feeling of nice weather is present. This will ensure more visitors and more crowds because this will create an unique situation. For all the surrounding entrepreneurs this will create customer value.

RIDING SAFETY BARRIER SO THAT THE CYCLIST CAN ALWAYS CYCLE SAFELY ON THE ROAD WITHOUT FEAR OF CARS

With this idea the cyclist is always protected but there are not always crash barriers on the road. It is a crash barrier that rides along with the cyclist. This ensures a safe situation but at the same time a normal street view. When the cyclist enters the road the crash barrier will come up and as soon as the cyclist leaves the road it will go down again. This creates customer value for the entrepreneurs because the customers can reach it more easily by bicycle.

STREET LOADING IN A VR ROOM. THIS ALREADY GIVES FUTURE TOURISTS AN IDEA OF WHAT THEY CAN EXPECT

By loading the street in a free space, people can remotely see what a special street this is for cyclists. This ensures that cyclists are triggered to visit the street and experience it for themselves. It could be used as a marketing tool for the bicycle street of the future.

CYCLE ROUTE THROUGH THE GAZELLE FACTORY SO PEOPLE CAN LITERALLY CYCLE ALONG THE PRODUCTION PROCESS

When the bicycle street of the future has been constructed, a cycling itinerary should be created. It would be a great idea to let the tourists cycle through the production process of a bicycle. By constructing a bicycle route through the factory in cooperation with Gazelle, the bicycle route will become interesting and innovative. The tourists can see how a bicycle is made or at least a part of this process. This will be very interesting for Gazelle and eventually create more brand awareness. This will eventually create financial value for Gazelle.

This research question can also be used in conjunction with the persona from chapter 6 of the literature review.

3.5 ATTRACTING TOURISTS

3.5.1 TRENDS AND DEVELOPMENTS OF CYCLING TOURISM

The travel industry requires many businesses to operate together as destinations might compete against neighboring countries. Therefore, is it important to make conscious decisions to attract tourists. Within the travel industry there are many types of tourists or tourism from which Bicycle Tourism is mostly unknown or misunderstood. It is therefore surprisingly that this type of tourism or bicycling in general is one of the fastest growing types of outdoor tourism and recreation worldwide. Besides contributing to billions of euros per year for the economy, bicycling also contributes to better health for communities and the environment. According to Path Less Pedaled (2020), Bicycle Tourism is defined as ''Any travel-related activity for the purpose of pleasure which incorporates a bicycle''. It is important for communities, decision-makers and businesses to understand how to attract the touring cyclist. A destination can be seen as a bicycle tourism destination when an individual wants to ride a bike during the holiday. The possibilities are endless, and the different types of bicycling need to be taken into account along with the visitors' preferences. However, the key to attract bicycling

visitors is to ensure that there is an enjoyable place to ride, in order to tackle the development and ensure benefits for the entire community.

The research question states:
"How can the bicycle street of the future attract more tourists to Dieren and the surrounding area?"

Within cycling there are different types of cyclers. Most common is *daily (commuter) cycling.* The bicycle is used as a means of transport to go to work, school, visit friends and relatives and more. The intention is to reach the destination as effortless, quick and safe as possible. An important type of cycling is *family cycling.* Families with children want easy and safe cycling trails and therefore have different wishes and needs. Whereas, *Tourist cycling* is a combination of several different types of cycling. Within this type of cycling the cyclers are tourists, both domestic and foreign, who want to experience natural beauties, cultural attractions and ethnological specialties.

For the development of cycle tourism, it can be concluded that infrastructure is the basis to attract tourists. In fact, to ensure appropriate infrastructure the best way to promote is a cycle route. When cyclers are enthusiastic about a route and experience no problems, worth of mouth will spread quickly. Moreover, do several preferences of cyclers influence the decision to visit a particular destination. Besides, the quality of the infrastructure is the quality of food and accommodation service preferred along with interesting paths and historical and cultural sights (Rotar, 2012). These preferences towards the tourism product will have a positive advantage on different stakeholders such as accommodation and food service.

Within the years cycling tourism has developed rapidly. The reason of this rapid change is the developments of trends within the bicycle and tourism industry. Currently various trends need to be taken into consideration by the supplier in order to attract the cycling tourist. Examples of these trends are:

E-BIKES

Electrical bicycles are a trend which already exists for a couple of years within the daily life cycling, yet it is only now becoming more popular in the tourism sector. The e-bike which has a small electric motor is very suitable for holidays since it helps the cyclists to ride longer distances per day trip and can support with uphill sections. Moreover the e-bike allows people which do not have the same level of fitness to enjoy a cycling activity together.

INCREASED CUSTOMIZATION

Currently, there is an increasing demand in customized cycling itinerates. This trend is valid for the more experienced cycler and for the mature tourism industry in western Europe. The tourist likes to have a tailored holiday with personal cycling routes in which the needs and wishes have been taken into consideration such as interests, level of fitness and budget.

FAMILY OR MULTI-GENERATIONAL TRIPS

Among the cycling tourists the family friendly trips are nowadays in high demand. A very popular type is the multi-generation holiday where grandparents, parents and children travel together. This trend is encouraged by the better physical shape of the aging seniors within Europe. Many of these seniors see these multi-generation holidays as an opportunity to create unforgettable moments and memories with their children and grandchildren. The e-bike trend makes the holiday even more suitable for the multi-generation.

CYCLING EXPERIENCE AS AN ADD-ON

The cycling experience becomes a bigger trends as an add-on activity to a holiday. Tourist have the interest to combine cycling with other activities such as wellness or cultural activities. Bicycle trips are also added increasingly to city-trips as a one-day activity or combined with cultural activities.

3.5.2 NATIONAL CYCLING ROUTE

As mentioned before, the best way to promote the infrastructure is a cycle route. This is therefore advised to do in order to promote the Bicycle street of the future towards potential tourists.
All over the Netherlands small signs can be found with a number and an arrow. This is a "fietsknooppunt" which means cycle junction. The numbered junctions are points where the routes from the recreational network intersect. This is an easy way for tourist to create their own itinerary to follow. Unfortunately, none of these cycling junctions are placed in the center of Dieren or the Wilheminaweg which can be seen below.

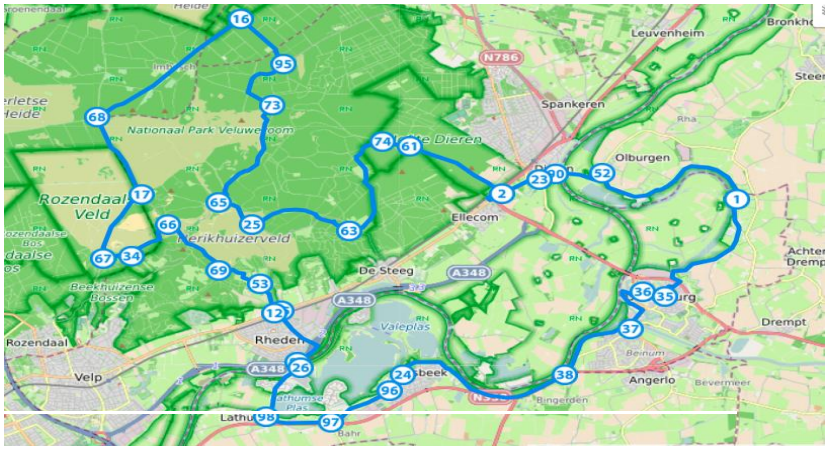

Figure 9, National cycling route

Figure 10, Wilhelminaweg that can be used in the national cycling route

As an advice, creating a collaboration with the "Landelijk Fietsplatform" and "Holland City routes" will promote this new national cycling route via
the Bicycle Street of the Future.

3.5.3 PERSONA

For cycling tourism, Europe is seen as a key source market. Small countries as the Netherlands and Denmark offer good opportunities as cycling is relatively popular. Therefore, cycling holidays could be center-based with the focus on good infrastructure and cycling-friendly accommodation.

The cycling tourist are:

- Slightly more often male
- Mostly aged between 40-60
- Generally well-educated with higher incomes
- Enjoy cycling for sports or physical exercise
- Often travel in couples or small groups

One of the trends and developments amongst cycling travelers is multi-generational travelling, where grandparents, parents and children travel together. The aging European population and better shape of seniors nowadays, encourages this new trend. Many seniors see travelling as unforgettable way to create memories with family and friends.

A persona is created in order to visualize the bicycle street user:

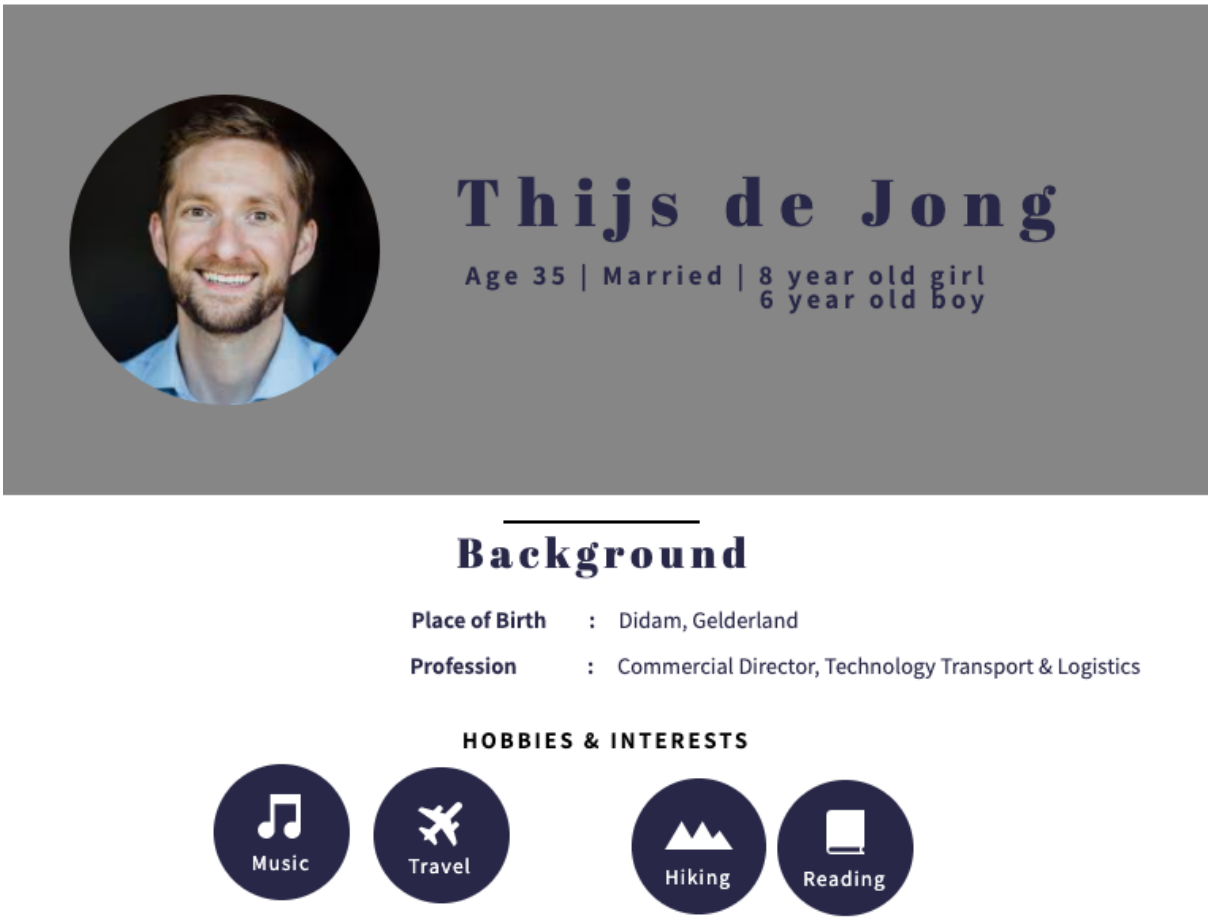

Figure 11, Persona

Mr. Thijs de Jong is a 35-year-old full time businessman who works as a commercial director. When at home, Thijs enjoys music, reading and prioritized his time with his wife and kids. He enjoys taking them out for dinner and walks in the weekend, experiencing and enjoying unique locations while spending time together.

Costs for Thijs when it comes to holidays, daily life and his household are not a big factor. Due to his income, he tries to enjoy life to the fullest when having the possibility to do so.

3.5.4 PERSONA IN 5 AND 10 YEARS

As a persona is the fictional representation of the bicycle street user, it is applied in both the early stage of the development along with the future changes. The persona 'Thijs de Jong' is vital for the success of the Bicycle Street of the Future. Design decisions of the common users need to be taken into account before the design has started, together with the future implementation of innovations and technologies after 2022. Therefore, it is advised to firstly understand the bicycle street users' goals and capabilities, while keeping up to date with the wishes and demands.

Especially for the Bicycle Street of the Future it is highly recommended to visualize the 'Bicycle Street User' yearly, in order to be able to implement new future technologies adjusted to needs and wishes. Moreover, does the persona give different stakeholders the opportunity to discuss all critical features of the future redesign. The persona can be used to walk several stakeholders through the common interactions and pain-points in order to clarify actual priorities of the bicycle street user over the personal wishes of stakeholders.

Secondly, since the persona is focused on the needs of the user, scenarios and placement of content can be determined. This will help the designers with the development of site architecture and wireframes and support the goal and development of the product. Moreover, will the ''face'' that is formed by the persona, create a story and understanding.

Lastly, is it advised to organise user interviews as they are most successful. Patterns that emerge from every respondent can be noticed and included in the personas profile. Together, with help desks calls and feedback through websites, important information could be received.

In conclusion, it is extremely difficult to create an overview of the persona of the Bicycle Street of the future as the street is not realized yet. Therefore, as mentioned above, does the persona need to be analysed yearly in order to adjust needs and wishes, especially when taking into account or implementing new technologies. Moreover, will wishes and demands of the persona change due to new technologies implemented by stakeholders, reshaping the bicycle street users' thoughts and standards. Moreover, does not only the 'main' persona need to be target and informed. The children of the persona will be the future and could therefore have a massive and important influence on the Bicycle Street of the Future users wishes and demands.

3.5.5 MARKETING OF THE STREET

The bicycle street of the future is under development. Marketing the street with matching marketing is of course part of this. However, the project group has not yet drawn up a concrete plan for this. This has been chosen because at this stage of street development it is more important to focus on other facets. Of course, the project group has different ideas about how this marketing can be used and what possibilities there are for collaborations.

First of all, the collaborations with surrounding holiday parks and campsites. In and around Dieren are a lot of places people can celebrate their holidays. These holiday parks and campsites are always eager for new activities in the area that attract tourists. This ensures that these holiday parks and campsites are happy to help market and publicise the bicycle street of the future. In the end, this will be an advantage for both parties. For example, by setting up a website on which the street can be seen and the associated activities, sharing will become easier for the holiday parks and campsites.
This website is the second idea the project group has. By building a website that shows what the street has to offer and putting the right online marketing behind it, there will be more publicity. This makes it immediately more interesting for entrepreneurs to advertise with, for example, the possibilities of advertising on the street that are shared in the technology ideas. The more awareness the street gets, the more can be asked for the advertising possibilities. This provides an income through which the street can be developed again and becomes more and more attractive for advertising opportunities. In addition, the website will help visitors to get a picture of what they can expect.

The street is of course aimed at cyclists. Most (fanatical) cyclists are familiar with the beautiful cycling routes offered in the Netherlands. As has been offered several times in the report, the area around Dieren offers many of these beautiful routes. The project group therefore advises to ensure that the bicycle street of the future is included in these routes. This will ensure many more visitors to the street and the brand awareness will grow rapidly as a result. By including the bicycle street in the cycle routes, local authorities Rheden will also have a better chance of becoming a bicycle municipality of the year. This, too, will make the street better known.

In many countries, tourists can contact tourist information offices for travel information. This is often information about the area where the tourist is currently located. The project group thinks it is very wise to conclude a cooperation with these VVV offices. It is very important that these offices know exactly what the street offers so that it can be put on the map and can be recommended as a fun activity. The VVV also provides overviews of activities for tourists online. It is essential that the bicycle street is included. This will once again ensure more name recognition and more visitors.
By combining this information and prescribing a good plan for it, the marketing will be more meaningful. However, this is still difficult because the idea is still in its infancy.

4 IN CONCLUSION

In the previous chapter the sub-questions have been answered and it is therefore possible to answer the previous set up main research question.

The main research question is:
"How can Dieren attract more tourists by becoming a leading cycling village when creating a bicycle street with innovative technologies which can be realized before the 22nd of February 2022."

As it can be concluded out of the research that has been conducted, various innovative technologies have major possibilities concerning the Bicycle Street of the Future which can be implemented before but also after the 2nd of February 2022. Furthermore, when implementing different technologies in and around the street the safety can be improved for both the cyclist and motorist. Which technologies are interesting and important will be explained in the advice further in the report.

Moreover, it can be concluded that tourism towards the innovative bicycle street can offer extensive opportunities for the region, city and the local businesses. It is therefore important to create various modifications regarding the marking of the city, region and the street towards both national and international tourists. Furthermore, it can be concluded that numerous Sustainable Development Goals can be implemented before and after the 2nd of February 2022 in the concept of this project.
The advice on how to implement these modification can be read in the advice part later in this report.

5 ADVICE

The reason for writing this advice is the question towards the students of Saxion University of Applied Sciences, to develop the Bicycle Street of the Future. This Bicycle Street is located on the Wilhelminaweg in Dieren, in front of bicycle manufacturer Koninklijke Gazelle.

For the Bicycle Street of the Future it is advised to implement several technologies realizable before 2022, the near future and beyond. This can be accomplished by coloring the technologies per category, where green can be implemented before 22nd of February 2022, yellow in the near future and red in the far future. Moreover, if Fiets op 1, implements the innovative technologies described in the advisory report, Dieren could become a bicycle city.

When considering the Sustainable Development Goals, 5 of these goals can be implemented before 2022, 3 in the near future and 3 in the late future. Sustainable Development Goals 3, 8, 11 and 17 are linked together, by promoting the bicycle street, resulting in a chain reaction by which these four goals could be accomplished. Moreover, is it advised to directly implement goal 15 by simply adding birds houses near the road.

For the near future, it would be recommended to implement goal 9 when the bicycle street is being updated/changed/renewed as this safes time, money and it will also cause less hazards for the users of the road since it only needs to be changed once. Depending on the money, cooperation of Gazelle and the municipality of Rheden, it is recommended to take into account the Sustainable Development Goals 13, 7 and 12 on necessity for the development as solar panels are a huge investment.

Besides the Sustainable Development goals are the surrounding entrepreneurs extremely important for the realization of the Bicycle Street of the Future. When more entrepreneurs participate in the project, it will become easier to realize. In addition, will more budget be generate resulting in possibilities for new innovative technologies that could be implemented. It is therefore advised to educate entrepreneurs on the value creation that can be achieved through the bicycle street. For example, the possibilities generated from tourism and the innovative technologies will show the entrepreneurs that it will be beneficial to participate in the project.

As tourism can support the development of the economy of a destination for both the local communities and economy of the country, it is advised to consider the following aspects in order to generate earnings from domestic and foreign visitors. Firstly, it is recommended to develop the infrastructure as research showed that this is the basis to attract tourists. In fact, is the infrastructure the best way to promote a cycling route. What will result in worth of mouth and spread quickly when cyclers are enthusiastic about the bicycle street. Moreover, it is advised to include ‘fietsknoopunten’ in other words cycle junctions on the Wilhelminaweg and the center of Dieren, to give tourists the possibility to create a personal itinerary to follow.

Secondly, does the rapid development of cycling tourism and trends and developments need to be taken into consideration along with promoting the bicycle street towards potential users. It is advised to make sure that the changes and developments are analyzed every year, in order to stay up to date and meet the needs and wishes of the bicycle street users. In order to be able to visualize this it is first advised to take into account the persona created for the current bicycle user before the design has started. Moreover, it is recommended to visualize the bicycle street user yearly. In order to be able to implement new future technologies adjusted to needs and wishes. This will give important stakeholders the opportunity to implement critical features for a possible future redesign adjusted with new technologies. Moreover, does not only the ‘main’ persona need to be target and informed.

The children of the persona will be the future and could therefore have a major and important influence on the Bicycle Street of the Future users wishes and demands.

Subsequently, is it advised to organize user interviews as they are most successful. Patterns that emerge from every respondent can be noticed and included in the personas profile. Together, with help desks calls and feedback through websites, important information could be received. Moreover, is it important and recommended to collaborate with surrounding stakeholders such as holiday parks and campsites. These stakeholders need to be implemented in the cycling routes as this will ensure more visitors while creating brand awareness.

Lastly, is it advised to collaborate with tourist information offices, the 'Landelijk Fietplatform' and 'Holland City Routes' in order to ensure name recognition and new visitors. When combining the information while prescribing a good plan, the marketing will become more meaningful and the new national cycling route via the Bicycle Street of the Future will be promoted.

Once the innovative bicycle street in other words 'Bicycle Street of the Future is realized, it is important that it must stay innovative. This can only be achieved when the bicycle street continues to implement, innovate and change. In order to be able to remain innovative it is advised to implement the future technologies described whenever possible. Moreover, is it important to include trendwatching, what will be done when taken into account trends and development while anticipate on them.

When all the advice given will be followed, the Bicycle Street of the Future will have the opportunity to remain future proof. Furthermore, it can be applied as a basis for future developers within universities or organizations.

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6 APPENDIX

6.1 APPENDIX (1) TECHNOLOGIES IN SCIENTIFIC NOTATION. CITED.

1	Title	Street energy recovery.
	APA reference	(Ferreira, Duarte, & Champalimaud, 2015)
	Scientific	Yes
	Main points article	Generating energy from depressible plates in a road.
	Relevant information	"This paper describes an innovative pavement energy harvest system, called Waynergy Vehicles, developed in Portugal by Waydip in partnership with the Pavement Mechanics Laboratory of the University of Coimbra. This system was installed in a university campus road pavement, which allowed the testing of a prototype. During a peak hour, between 1.00 p.m. and 2.00 p.m., the system was able to generate 37 800 J or 10.5 Wh. The electrical energy generated by several modules of the system located, for example, in speed humps and speed bumps, can be used not only to charge batteries for electric vehicles, but also for general consumption through injection into the electricity grid or direct use by electrical equipment, such as public lighting, traffic lights and outdoor advertising."

2	Title	Light "emitting" concrete.
	APA reference	(Asif, 2018)
	Scientific	Yes
	Main points article	The creation and usage of translucent concrete that can be used for roads, buildings or other infrastructure.
	Relevant information	The concrete currently used in the construction industry generally consists of at least cement, water and aggregates (fine or coarse). Traditional concrete has a greyish color, and its high density prevents the passage of light through it, which means that it is also impossible to distinguish bodies, colors and shapes through it. As can be imagined, concrete with the characteristic of being emitting will

		permit a better interaction between the construction and its environment, thereby creating ambiences that are better and more naturally lit. Along with the emitting characteristics, the paper also confides its area towards the reinforcement method of this type of concrete such that they can be practically implemented as a load bearing structure. This new kind of building material can integrate the concept of green energy saving with the usage self-sensing properties of functional materials. Emitting concrete is a concrete based building material with light emitting properties due to embedded light optical elements usually Optical fibers. Light is conducted through the concrete from one end to the other. Therefore the fibers have to go through the whole object. Emitting concrete is also known as the translucent concrete because of its properties

3	Title	Smart street lights for cyclists.
	APA reference	(Endendijk, 2015)
	Scientific	No
	Main points article	The use of technology to efficiently use street lighting for cyclists.
	Relevant information	Port of Amsterdam chooses smart street lighting, a DC grid and sustainable wind and solar energy on a bike path in the area. In this way it is able to save costs and energy. On the other hand Port of Amsterdam provides light to citizens when they need it. As soon as a cyclist is nearby he can adjust the lighting by himself to a 100% with the GeoLight app on his own smartphone. During his tour he will feel safe and comfortable. As soon as there is no activity the streetlights dim again automatically so energy will be saved.

4	Title	“smart” traffic lights and signaling
	APA reference	(HERE mobility, 2020)
	Scientific	No
	Main points article	The use of smart lighting to signal cyclists that cars might be coming around from a blind corner. Increases road safety

	Relevant information	In the twentieth century, the only way to improve traffic flow and reduce congestion was physical infrastructure. Adding or improving roads is a complex, expensive and disruptive effort, and offers only a partial solution. Smart traffic systems are a revolution because they can have a dramatic effect on traffic flow and congestion at a small fraction of the cost of building a new road. More importantly, they address the root of the problem—regulating traffic patterns, improving public transport and effectively balancing private and public transportation. Rather than just adding more capacity, while traffic volumes grow unchecked, smart traffic systems can actually reduce and contain the traffic problem. They can improve quality of life, reduce pollution, and even save lives, reducing the number of accidents by providing real-time information to drivers and helping cities regulate traffic on busy roads and intersections.

5	Title	Solar and wind powered street lights.
	APA reference	(Azzarello, 2014)
	Scientific	No
	Main points article	street lights powered by solar and wind energy
	Relevant information	designed for primary use in parking lots or over highways, hybrid street lights are more frequently seen in china. since they're grid connectable, the lights can send excess power from the wind turbines and solar panels back through the grid. the constantly moving turbine technology in the lights should last twenty years, requiring just an annual maintenance check-up, barring natural disasters or accidents. (not including the batteries) the LED lights and other parts within should endure as long as the turbines. The hybrid street lamps guarantee a stable supply of electricity even when it is cloudy. the lamp will automatically start lighting when the environment becomes dark through the use of an intelligent sensor system. the lamp is turned off by an automatic controller which can be set to a specific time as per your requirements with an average lighting time of 8-10 hours per day. so the whole system is virtually maintenance free and there are NO daily running costs totally off-grid.

6	Title	Making roads smarter.
	APA reference	(Giarratana, 2018)
	Scientific	No
	Main points article	Upgrading a road to make it safer, more energy efficient and better in general.
	Relevant information	If you have ever driven in rural areas, or with severe weather like snow or ice, then you know that roadways safety can be challenging to manage in those situations. In many circumstances, drivers can improve their chances of arriving at their destination safely if they have more data to help direct their efforts. As engineers and automakers continue to advance innovations with smart cars, autonomous technology, and vehicle communication systems, the one aspect of public transportation that has not been updated much over the years has been advancements in roadway technologies. There are many things that city planners and lawmakers can implement to help innovate and improve the driving experience while also increasing roadway safety.

7	Title	Road lighting to improve safety.
	APA reference	(studio roosegaarde, 2015)
	Scientific	No
	Main points article	Using ambient road lighting to help road safety in dangerous situations.
	Relevant information	The first GLOWING LINES have been realized after a trial period of 3 months in the Netherlands, and glows up to eight hours at night. The project exhibited for 3 years in Oss, NL. GLOWING LINES will further be developed and launched internationally. SMART HIGHWAY are interactive and sustainable roads of tomorrow by Daan Roosegaarde and Heijmans Infrastructure. Its goal is to make smart roads by using light, energy and information that interact with the traffic situation. SMART

		HIGHWAY consists of projects Glowing Lines, Dynamic Paint, Interactive Light, Induction Priority Lane, and Road Printer. VAN GOGH PATH shares the same vision, made of thousands twinkling stones inspired by 'Starry Night'. The path combines innovation with cultural heritage in the town of Nuenen NL, the place where Van Gogh lived in 1883. The collaboration between Roosegaarde and Heijmans is a true example of innovative industry. The design and interactivity by Studio Roosegaarde and the craftsmanship of Heijmans are fused into one common goal: innovation of the Dutch landscape.

8	Title	Smart road technology: paving the way to the future.
	APA reference	(HERE mobility, 2020)
	Scientific	No
	Main points article	Making roads “smart” to improve traffic flow and safety
	Relevant information	**1. SOLAR POWERED ROADWAYS** Photovoltaic cells are embedded within hexagonal panels made of tempered glass, which are used to pave roads. These panels contain LEDs, microprocessors, snow-melting heating devices and inductive charging capability for electric vehicles when driving. Glass is renewable and can be engineered to be stronger than steel, and to allow cars to stop safely even when traveling at high speeds. While this idea has gained widespread support, attracting over $2 million in crowdfunding, scalability is a challenge as it remains expensive. **2. SMART PAVEMENT** Specially engineered roadways fitted with smart features, including sensors that monitor and report changing road conditions, and WIFI transmitters that

provide broadband services to vehicles, homes and businesses. The smart pavement can also charge electric cars as they drive.

3. GLOW IN THE DARK ROADS

Glowing markers painted onto existing roadway surfaces use a photo-luminescent powder that absorbs and stores daylight. The 500m long strips glow for 8 hours after dark. This technology is still in the testing phase, and the glow is not yet consistent, but it could be more cost-effective than traditional road lighting.

4. INTERACTIVE LIGHTS

Road lights activated by motion sensors to illuminate a particular section of the road as a car approaches. The lights dim once the car passes. Suited for roads with less traffic, interactive lights provide night visibility as needed and reduce energy wastage when there are no cars. One design, developed by the Dutch Studio Roosegaarde, uses wind generated by passing vehicles to power lights.

5. ELECTRIC PRIORITY LANE FOR CHARGING ELECTRIC VEHICLES

Embedded cables generate magnetic fields that charge electric vehicles while driving. A receiver coil in the vehicle picks up electromagnetic oscillations from a transmitter coil embedded in the road and converts them to AC, which can then power the car. Inductive charging technology already exists for static cars, but future wireless technology could charge batteries while in motion.

6. WEATHER DETECTION

Networks of AI-integrated sensors detect weather conditions that impact road safety. Road Weather Information Systems (RWIS) in use today are limited because they only collect data from a small set of weather stations. A larger future network could use automated weather stations to collect atmospheric and weather data and instantly upload it to the cloud. Dynamic temperature-sensitive paint could be used to highlight invisible roadway conditions like black ice.

7. TRAFFIC DETECTION

Data that helps travelers plan their routes. Sensors lining highways monitor traffic flow and weight load, warn drivers of traffic jams, and automatically alert the authorities about accidents. Fiber-optic cables embedded in the road detect wear and tear, and communication between vehicles and roads can improve traffic management. For example, Rapid Flow Technologies uses artificial

		intelligence (AI) to manage traffic lights, which respond to each other and to cars.

9	Title	The use of cycling speed indicators.
	APA reference	(Evergreen, 2020)
	Scientific	No
	Main points article	Providing information about the desired cycling speed
	Relevant information	In practice, the bicycle traffic lights are subordinate. As a result, cyclists often have to wait (unnecessarily). By providing cyclists with information about the desired speed to get the green light far before the intersection, waiting is kept to a minimum and routes can be created with good traffic flow. In Utrecht is this technology presented in 2018. The system is linked to the traffic light and knows when the light turns green and red. Four symbols indicate how you should cycle. Haas is 'bicycle faster', turtle is 'bicycle slower', thumbs up is 'keep cycling like this' and the cow means 'you will not get the green light'.

10	Title	Embedded LED road lighting
	APA reference	(Heijmans, 2020)
	Scientific	No
	Main points article	Detecting a cyclist and warning drivers with LED light
	Relevant information	Motorists often see bicycles or scooters too late at a roundabout or an intersection. Various dangerous situations can arise from this. Often the cyclist is unaware of his or her own vulnerability. The technology which is called Bike scout improves the safety of cyclists at crossings by detecting them at an early stage and warning drivers in time by means of LED lighting in the road surface. This method is applied in Zuid-Holland

		

11	Title	The use of glow in the dark paint for roads.
	APA reference	(Vereniging voor Sterrenkunde, 2019)
	Scientific	No
	Main points article	Paint with technologies which gives light for 12 hours
	Relevant information	A paint has been developed using different technologies that gives more than 12 hours of light. This paint provides the basis for a fully-fledged, sustainable alternative to conventional lighting. The paint absorbs and retains UV light during the day. At night it is radiated in a dosed manner. Road contours are represented by the paint, lighting is provided by the vehicle's headlights. The cyclist can easily follow the course of the cycle path through the luminous paint, so that traditional lighting is unnecessary.

12	Title	Interactive smart street crossings.
	APA reference	(Hooijdonk, 2017)
	Scientific	No
	Main points article	Starling Crossing is a prototype interactive crossing being tested, that adapts to real-time traffic conditions and determines who has right of way at any given time.
	Relevant information	**ST**igmergic **A**daptive **R**esponsive **L**earn**ING** Crossing, or Starling Crossing, developed in collaboration with Direct Line, an insurance company. This super high-tech pedestrian safety system is a digital answer to the atomic age's painted stripes. Using two cameras to capture the space around the crossing, Starling uses machine learning and smart algorithms to identify the various

		objects it sees. It uses these cameras to predict pedestrian behavior and give drivers an impossible-to-miss warning, adapting to cyclists, playful children, and distracted adults. Example video: https://vimeo.com/237217992

13		Automatic bicycle parking garage.
	APA reference	(Berger-Schauer, 2015)
	Scientific	No
	Main information	Automated Bicycle Parking
	Relevant information	Train stations are real hot spots for cyclists. Legions of people descend on them during peak times, and it is difficult to find a free spot or to locate your bicycle. As a renowned technological pioneer, Japan has developed a practical solution. Kasai train station in Tokyo has set up an automatic parking area with space for 6,480 bicycles. Registered users can place their bike (fitted with a chip) into a machine, and a robotic arm will then store it away automatically in an underground storage area. They use a chip card to retrieve their bike, and they are back on the saddle within around 20 seconds.