



**H₂eriburg-Scooter -
a revolutionary vehicle for the way from our school
to a fellow school**



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H₂eriburg-Scooter

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1. Abstract

It's necessary to do something against climate change now and a traffic turnaround is needed. Traffic causes high CO₂ emissions. The "H₂eriburg-Scooter" is created, because the students of the Heriburg-Gymnasium work together with the Gymnasium Nepomucenum and need to travel fast. Our scooter drives like every other scooter, but hydrogen is used because hydrogen is better for the environment than batteries. This makes the scooter very efficient, the production is also environmentally-friendly.

The charging station is at the Heriburg-Gymnasium. We will create kind of a bus stop at our school, where photovoltaics are placed on the top to charge the scooters. The students would be traveling much faster between the schools and have more time for friends or to eat a snack. It is possible to realize this project with the remaining resources of the CIRO-project.

2. Introduction H₂eriburg-Scooter

The CIRO project deals with the problems and effects of the climate crisis and tries to find a way to stop or reduce these emissions. Our group searched for a vehicle to travel faster but without producing carbon dioxide, because it is the main emission produced by cars, busses, planes, ships or industry.

Our scooter drives like every other scooter, but it is powered by the energy of hydrogen not by the power of muscles. During the process of electrolysis, water can be separated into oxygen (O₂) and hydrogen (H₂) and this process produces chemical energy which is stored in the hydrogen gas. Basically, there will be a kind of charger on the scooter so it can be plugged into the charging stations. In those stations the electrolysis takes place which creates hydrogen for the scooter.

Our school, the Heriburg-Gymnasium¹ in Coesfeld works together with another gymnasium, the Nepomucenum which means, that students from grade 10 to 12 need to travel from school to school between their classes. The only negative thing about this cooperation is, that they don't have much time in one break, so they really need to hurry and here our scooters could make it way easier. Students can borrow the scooter and travel from school to school in a few minutes.

¹ A German "gymnasium" is a secondary school that prepares students for university.

This is only the first step, if we can produce more of these scooters they can be used literally everywhere, in the city, at school, and also in daily life. This scooter is very efficient because there are no emissions. The production is environmentally-friendly and the H₂ tank can be ordered from a company in Germany² and the emissions of the transportation are very low and just water.

The process of building the charging station is without any emission because our group builds it itself. The usage of the scooter is also environmentally-friendly and one of the main advantages is, that it can be used anywhere by everyone. For example, you can travel shorter distances in the city or some longer distances in villages. To sum it up, this scooter, the production and the usage creates almost no emissions and its compatible with every landscape.

3. Why is it necessary to act now?

a. Why is it called “Climate crisis”?

The term “climate crisis” is used to describe global warming and the consequences of it, but also to make it sound more dangerous and to make more people think about it, because “climate crisis” sounds worse than just a “climate change” which might be a change for the better.³

b. Why do we have climate change?

We have to differentiate between the natural greenhouse effect and the man-made greenhouse effect. The natural greenhouse effect is portrayed as a good thing, because without it, it would be around -18°C. When the sun sends solar radiation to the earth, it goes through the atmosphere. As soon as it gets absorbed by the surface of the earth, it is transformed into infrared radiation. When the IR-radiation is reflected by the earth's surface and goes out into space, it can hit a CO₂ molecule. When the IR-radiation hits a CO₂ molecule, it is sent back and warms the earth.

² Zoz Wasserstoff-Technologie – Zoz GmbH. This company is located in Germany, which deals with hydrogen technology. <http://gmbh.zoz.de/wp-content/uploads/Zoz-Portrait-I-Phone>.

³ Climate crisis Wikipedia: https://en.wikipedia.org/wiki/Climate_crisis

On the other hand, there is the man-made greenhouse effect, which is a bad thing. Humans started to burn fossils, heat their houses, built industries and started to drive cars which produces much carbon dioxide (CO₂) by burning gasoline. Solar radiation enters the atmosphere and gets absorbed by the earth. When the earth sends it back into space in the form of IR, the IR-radiation hits a CO₂ molecule which sends the IR-radiation backs to earth. This happens, because there are too many CO₂-molecules in the atmosphere. Humans produce too much greenhouse gases and the IR-radiation can't be sent into space anymore and is reflected back to earth. When more IR-radiation is sent back to earth, the earth heats up.⁴

c. Climate crisis and the impact on Coesfeld

Here in Coesfeld you can feel that something is happening with the climate. The years 2018, 2020, 2014 were the hottest years since the start of the weather recording in 1881, under the top 13 hottest years since 1881 are eight years from the last decade.⁵

The heat is a big problem for farmers because if the temperature is too hot then some plants die and the harvest is very bad, then they don't have enough food for their animals and can't feed them. But not only the heat and the resulting droughts are a big problem, in the last year we had several storms here. One was almost Hurricane called "Sabine" which destroyed many forests and even some houses in this region. This storm was probably caused by climate change.

4. Traffic turnaround

a. Why do we need a traffic turnaround?

Many people speak often about a traffic turnaround, but why do we need one? We need a traffic turnaround because traffic has very high CO₂ emissions. In 2019 traffic had the 3rd highest emissions after the energy industry and the industry in general with 20%.

⁴ The three slides presentation by Thomas Seilnacht and Christine Uphues.

⁵ Hottest year in Germany <https://de.statista.com/statistik/daten/studie/164050/umfrage/waermste-jahre-in-deutschland-nach-durchschnittstemperatur/#:~:text=Das%20bislang%20w%C3%A4rmste%20Jahr%20in,von%2010%2C5%20Grad%20Celsius.>

The biggest traffic emissions come from the street with more than 90%.⁶ So we need to change our traffic which has CO₂ emissions to traffic which has no CO₂ emissions.

b. Which alternatives are there and which are the best?

There are many alternatives to traffic without emissions but the alternatives are very different and some create new problems.

One alternative is electricity. At the moment it is the most popular emission-free car with 310.000 car in Germany in 2020.⁷ But it has some problems. There are not enough charging stations but in the near future many of them will be built. One other big problem is that the batteries are very bad for the environment as it is very hard to dispose of them.⁸ Some batteries do not have a wide range but if you buy a new car it is the most time not a big problem. Another problem of the electric car is that in some cars, if your battery is empty, it takes a very long time to charge the battery.

A better alternative is hydrogen as fuel. But in Germany there are at the moment only 507 hydrogen cars that are only 0,001% of all cars in Germany.⁹ The strengths of a hydrogen car are that it does not need to refuel a long time because hydrogen is very fast to refuel not like electricity and the range of a hydrogen car is very wide, too, it needs ca. 1 kilogram per 100 kilometres.¹⁰ But that does not play a big role because it is very fast to refuel.

The biggest flaw at the moment is that there are only 100 filling stations for hydrogen in Germany so you cannot drive without planning ahead at the moment but for the future it is a very good alternative. The motor is very easy to dispose of because there are no bad things for the environment.

⁶ <https://blog.naturstrom.de/mobilitaet/verkehrswende-warum-brauchen-wir-sie-und-wie-kann-sie-gelingen/>

⁷ <https://de.statista.com/statistik/daten/studie/265995/umfrage/anzahl-der-elektroautos-in-deutschland/>

⁸ [https://gsiwaste.com/battery-recycling-is-important-for-environmental-health/#:~:text=1\)%20Improperly%20disposed%20batteries%20contribute%20to%20water%20and%20air%20pollution.&text=When%20depleted%20batteries%20are%20tossed,contaminate%20groundwater%20and%20surface%20water.](https://gsiwaste.com/battery-recycling-is-important-for-environmental-health/#:~:text=1)%20Improperly%20disposed%20batteries%20contribute%20to%20water%20and%20air%20pollution.&text=When%20depleted%20batteries%20are%20tossed,contaminate%20groundwater%20and%20surface%20water.)

⁹ <https://www.spiegel.de/auto/wasserstoff-autos-diese-modelle-gibt-es-in-deutschland-zu-kaufen-a-088cffed-f8c5-4fdc-a773-cbf5e18749d>

¹⁰ <https://www.auto-motor-und-sport.de/tech-zukunft/alternative-antriebe/wasserstoffauto-brennstoffzelle-co2-neutral-batterie-lithium/#:~:text=Der%20hohe%20Druck%20macht%20die,400%20Kilometer%20weit%20kommen%20soll.>



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c. Why we choose hydrogen for our scooter project

For us was very important that we choose the best for our planet and hydrogen is much better than electricity for the environment because it is very bad for the environment to use batteries. Hydrogen does not take a long time to charge and electricity takes a long time that was another very important point for us because if the scooter charges too long nobody can use it. You do not need much hydrogen for a scooter which is very good, too. We do not need many charging stations so it is not a problem for a hydrogen or electric scooter because we do not want to drive a long time. There are many electric scooters already so it would be very easy to build one and nothing special but there are not many hydrogen scooters to be found on the internet at the moment. In Coesfeld there is no scooter-rental so we would set a higher standard and more people would learn about the potential of hydrogen through our project.

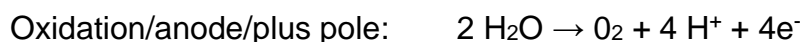
5. Electrolysis and the PEM fuel cell

In this part of the text we are going to explain electrolysis and how our scooter works. First of all, we are going to explain the normal electrolysis inside a fuel cell. In

¹¹ <https://www.tuvsud.com/en/-/media/global/images/press-and-media/2019/february/19019-lbst-is-germany-2019.jpg?la=en&hash=3C2AA9E7A5D5A323BEA1DE62A90D9DAC>

general electrolysis is a chemical decomposition produced by passing an electric current through a liquid or a solution containing ions.

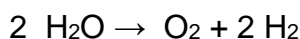
Now we will focus on the electrolysis in a PEM-cell (which we plan to use in our scooter). At the anode water is added and split into oxygen which vanishes in form of bubbles, 4 protons and 4 electrons. The protons then pass through the PEM-membrane (=Proton Exchange Membrane) which leads them to the cathode, but the electrons are not able to go through. The electrons use an electric circuit to get to the other side:



When the electrons reach the cathode, they start to react with the protons which arrive through the membrane and the result of that reaction is hydrogen.



The combination in the redox equation says:



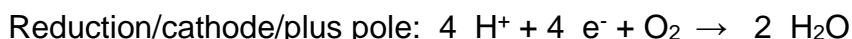
PEM fuel cell:

The construction of this cell is the opposite of the electrolysis cell though the device that we use is the same one. The reason is that now the minus pole is now the anode and the plus is the cathode. In a model car you only have to switch the cables. The electrons use the electric circuit and the protons use their membrane.

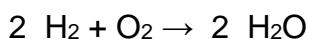


On their way through the electric circuit the electrons release energy which can be used to start engines, lighten lamps and power anything which needs electricity.

Then the electrons start to react on the side of the cathode.



Balanced redox equation after cancelling anything that is common to both sides:¹²



Our model is operated by a fuel cell which powers a motor and then powers a gear and through that gear the wheels of our scooter start moving. The wheels, the motor and the circuits of our scooter were taken from a model hydrogen car.

¹² Asselborn, W., Jäckel, M. et al. *Chemie heute III Gesamtband*. Schroedel-Verlag 2010. pages 198, 225.

6. Distance Heriburg to Nepomoceum

In the following picture you can see the distance students have to travel by walking in only one break. That is because the Heriburg and the Nepomoceum cooperate because sometimes some subjects are not chosen often enough for an extra class but at both schools together enough students chose it, so the schools collaborate and some students need to go to the other school for their courses.

On the map below it says you need six minutes by walking but in real life, with a full backpack of schoolbooks, you need more time and once you have arrived, you only have a few minutes left so you can barely eat, talk to some friends or prepare for the next lessons.



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What also is difficult to see on the map, all the way there is a little incline and especially on hot summer days it is exhausting to walk up there. And all of the named problems could be solved easily just with the usage of the scooter.

At each school there will be a stop for the scooter where the students, who rent a scooter, can get one. The students can take one and then drive to the other school and put it back in the stop there. After each ride the scooter can be refilled so it is already prepared for the next student. The hydrogen is produced by a PEM cell which is powered by photovoltaic system on the roof of the scooter stop because the stop will be at a sunny place. The PV system always produces electricity when the sun shines. The electrolysis therefore

¹³ www.google-maps.de (starting point: Heriburg-Gymnasium Coesfeld; aim: Nepomoceum Coesfeld)

starts when the sun shines. The hydrogen produced in the electrolysis is collected in a metal hydrid tank and waits for the next scooter to be filled. Each scooter needs its own smaller metal hydrid tank which is filled at the scooter stop at Heriburg.

To sum it up, the students would travel faster, traveling would be easier because they don't need to carry their backpacks for so long and they still got time to eat, talk and prepare for the lessons.

The production and the usage is environmentally-friendly so it fits in both of the schools concepts and it can be used without any CO₂ emissions. Because of the shortness of the distance, not much energy is used and more students can travel with only one charging process.

And one of the other advantages is, that the students can travel more safely because they don't need to hurry and got the ability to watch the traffic a bit better. This scooter is a kind of allrounder and makes many things easier and helps the climate crisis in a positive way.

Also, the awareness for hydrogen-powered vehicles would increase a lot because of the CIRO project, which basically is our main goal, so many vehicles are powered by hydrogen and could be used in an environment-friendly way.

7. Our model or buying a ready-made scooter

We were unable to build a scooter that really transports a person though we really wanted to. We only built a small model for dolls which we hope to present in the presentation part of the CIRO competition. But we know of a company in Wenden Germany, called ZOZ, that has successfully built a prototype of a hydrogen scooter.¹⁴ We contacted them by phone and mail to ask if we could rent the hydrogen scooter but unfortunately, this is impossible because they do not yet have an official permission to use this vehicle on public streets. But they have applied for that.

We spoke about the problems we have to overcome a lot. And at least, we have a picture of our model and of a scooter which was built by a company in Wenden (Germany):

¹⁴ <http://gmbh.zoz.de/wp-content/uploads/IsigoH2.0-E-2001.pdf>

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isigo® H2.0

H2-electric kickboard powered by H2Tank2Go®
demonstrator of Power to Gas to Fuel - P2G2F®

refueling at home or replacing at any home-depot / tank vending machine
Nanostructures for Zero Emission Future Transportation & Energy

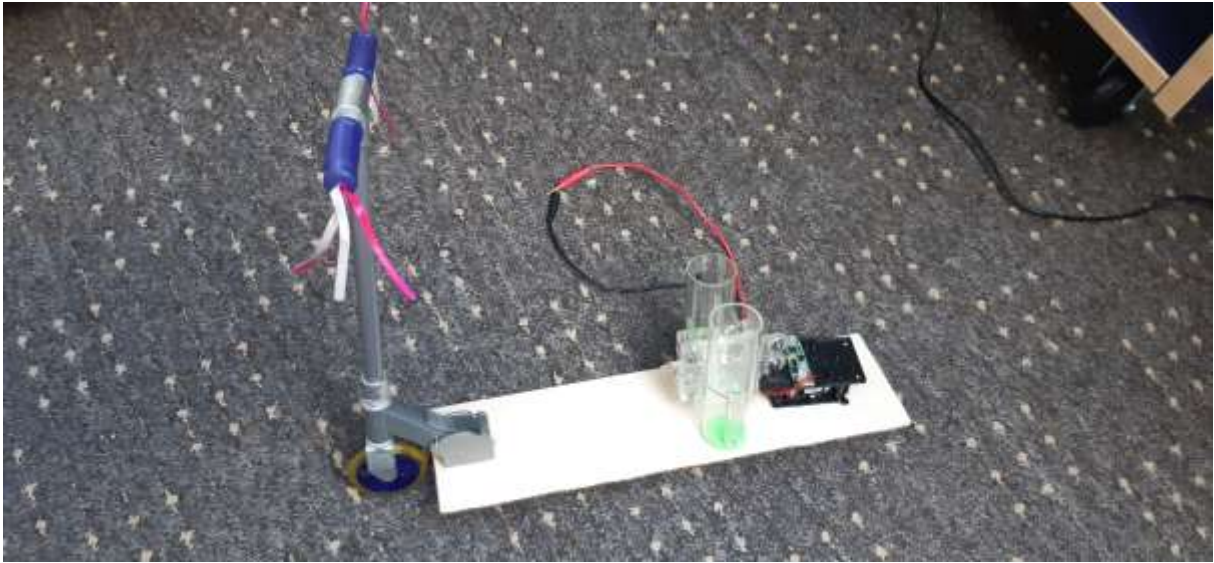
isigo® H2.0	at a glance
 The image shows two views of the isigo H2.0 electric kickboard. On the left is a close-up of the motor and fuel tank assembly. On the right is a full view of the kickboard, showing the deck, handlebars, and front wheel.	<p>isigo®H2.0 electric kickboard represents the 2nd generation of hydrogen driven vehicles demonstrating super safe Zoz-Hydrogen solid-state Storage-Technology.</p> <p>Based on the conventional battery-driven isigo®1.0, this kickboard comes with two Hydrolium® based H2Tank2Go®-cartridges and a 320W PEM fuel-cell. At ideal conditions, it offers up to 120 km driving range, refueling in seconds, all zero emission.</p>

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When we decided to build a model, we considered how to build it. We took a normal toy scooter and changed it. The scooter was very small, so we had to consider where we applied which thing. After that we searched on the internet for a motor which is big enough that it moves the scooter. We searched on the internet but we found nothing so we decided to take one of our hydrogen cars by Horizon, dismantle it and take this motor. We took the motor of it, so we could finally start to build our model. As we had a good motor and a toy scooter, we had no idea where we had to place the motor and how.

Hereafter we took the foot plate of our toy scooter and replaced it with a part of wood. We did this, because the scooter was made of plastic and we could not drill a hole into it because the material would break. Then we took the part of wood and drilled a hole into it so that we could apply the motor into it. After this we took the fuel cell and stuck it onto the part of wood. You must know that at the far end there is a hole with the motor inside. Under the motor is a little wheel which will drive the complete vehicle. In the middle is the fuel cell which is pasted on the deck with an adhesive material.

¹⁵ <http://gmbh.zoz.de/wp-content/uploads/IsigoH2.0-E-2001.pdf> (upper part of the file)



8. Realisation of our project

We might be able to realize the project when the remaining resources of the CIRO-project are used. As soon as the ZOZ-company or any other company that develops such a revolutionary vehicle is allowed to sell their scooters so that they can be used on public streets we could buy some of them. It won't be easy or cheap to realize the project, but it's possible with the right resources. Maybe it will just remain a dream.

9. Bibliography

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<https://de.statista.com/statistik/daten/studie/265995/umfrage/anzahl-der-elektroautos-in-deutschland/>

[https://gsiwaste.com/battery-recycling-is-important-for-environmental-health/#:~:text=1\)%20Improperly%20disposed%20batteries%20contribute%20to%20water%20and%20air%20pollution.&text=When%20depleted%20batteries%20are%20tossed,co%20ntaminate%20groundwater%20and%20surface%20water.](https://gsiwaste.com/battery-recycling-is-important-for-environmental-health/#:~:text=1)%20Improperly%20disposed%20batteries%20contribute%20to%20water%20and%20air%20pollution.&text=When%20depleted%20batteries%20are%20tossed,co%20ntaminate%20groundwater%20and%20surface%20water.)

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<http://gmbh.zoz.de/wp-content/uploads/IsigoH2.0-E-2001.pdf>