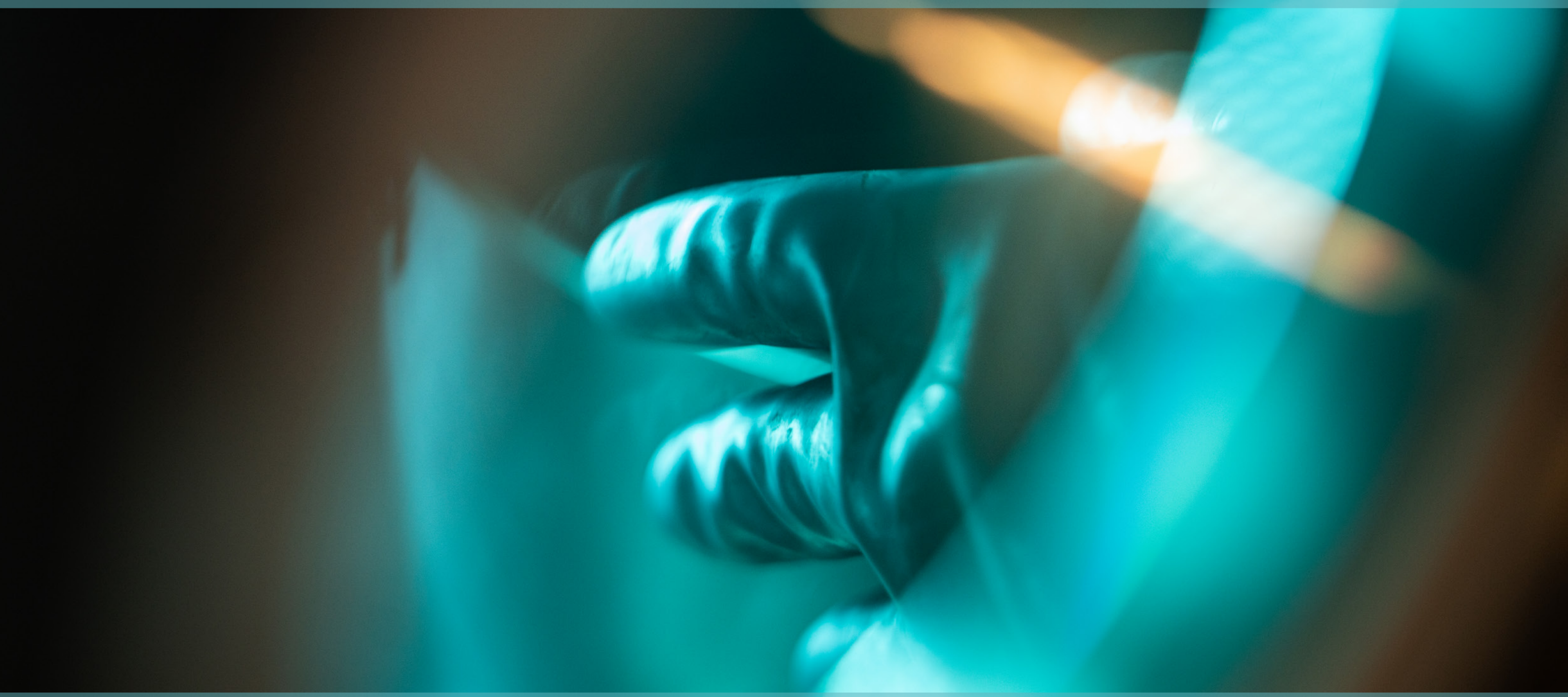
AVOIDED EMISSIONS ASSESSMENT



Life cycle assessment done by Nysnø Climate Investments,
in collaboration with Cenate, of Cenate's to-be industrialized
silicon-based anode materials in a large-scale factory

OSLO, March 2024

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LIFE CYCLE ASSESSMENT

With the replacement of 5-7 kg of conventional battery anode materials by using only one kg of Cenate's materials, the majority of CO_2 emissions from production of anode materials will be avoided. Additionally, the substantial benefits from using Cenate's materials making batteries smaller, lighter, cheaper and cleaner will accelerate the transitioning from ICE vehicles to EVs, thereby avoiding significant emissions from vehicles also in the use phase.

For documenting these significant avoided CO_2 emissions, Cenate engaged Nysnø Climate Investments to carry out a climate footprint analysis of Cenate's to-be industrialized silicon-based anode materials in a large-scale factory.

BACKGROUND AND EXECUTIVE SUMMARY

The predominant anode material for electrical vehicle (EV) battery technology today is graphite, and the large majority of this material is synthetic graphite. Graphite, comprising 25% to 30% of a battery (Carbonscape, 2022), is one of the largest carbon dioxide emitters in the lithium-ion battery value chain, and Tesla recently estimated that 18% of their CO_2 contribution in their nickel-based batteries stems from graphite.

Synthetic graphite is made from coke – the carbon that's left over from oil and coal refining – and this fossil fuel is heated to 2500-3000°C in a hugely energy intensive process, with massive CO_2 emissions. Most of the synthetic graphite in today's EV batteries is made in China where the electricity source used during the high temperature processes is fossil based, leading to even higher CO_2 emissions.

In contrast, Cenate's products are based on silicon – an abundant and non-toxic material. Cenate's production process is executed in a highly efficient and scalable way, growing a nano composite of silicon and carbon together in one process step. This stands in stark contrast to several competitors relying on a stepwise process that first constructs a carbon structure at high temperatures before incorporating silicon under high pressure– a much more energy-intensive approach that translates to increased costs and emissions.

With the successful development of a new and more attractive silicon-based anode material, Cenate is scaling up and preparing for the commercial phase with the construction of large-scale production plants on two continents. For documentation of the environmental footprint of Cenate's materials, Nysnø Climate Investments has been engaged to carry out a climate footprint analysis of Cenate's to-be industrialized silicon-based anode materials in a large-scale factory.

Nysnø's analysis concludes that a conversion from today's typical synthetic graphite to Cenate's new material in EV batteries will directly lower the CO_2 emissions during production of the battery with as much as 93% for the active anode material being replaced. This substantial gain is mainly attributed to the fact that each kilogram of Cenate's material replaces 5-7 kilograms of graphite, and that the production of graphite is currently associated with elevated emissions from petroleum-based tar and low yields. In practice, this means that for every kg of Cenate's products that are used in an EV to replace synthetic graphite, there is a direct reduction in CO_2 emissions of 151 kg. For a 10,000-ton Cenate manufacturing plant, this CO_2 saving amounts to 1.5 mill. ton/yr.

Furthermore, it is noteworthy that Cenate's materials not only contribute to more affordable EV batteries but also enhance the energy density and driving range of EVs, thereby expediting the electrification of the transport sector and leading to an additional CO_2 avoidance. However, these actual and additional EV conversions are not under Cenate's control, so the indirect CO_2 reductions are more difficult to quantify with certainty compared to the direct emission avoidance.

For the first large-scale Cenate production plant, with an annual output of 10,000 tons delivering anode material to 1.5 million new cars every year, the report predicts a direct CO_2 avoidance exceeding 15 million tons of CO_2-equivalents over the initial ten years of production. The indirect savings due to a faster electrification of cars due to the increased attractivity of EVs with Cenate materials, are estimated to potentially be more than 22 million tons over a ten-year period and come in addition. For comparison, the total CO_2 emissions in Norway in 2022 were 32.1 million tons.

"This extraordinarily large gain is mainly attributed to the fact that each kilogram of Cenate's material replaces 5-7 kilograms of graphite

Dr. Erik Sauar
Chief Executive Officer

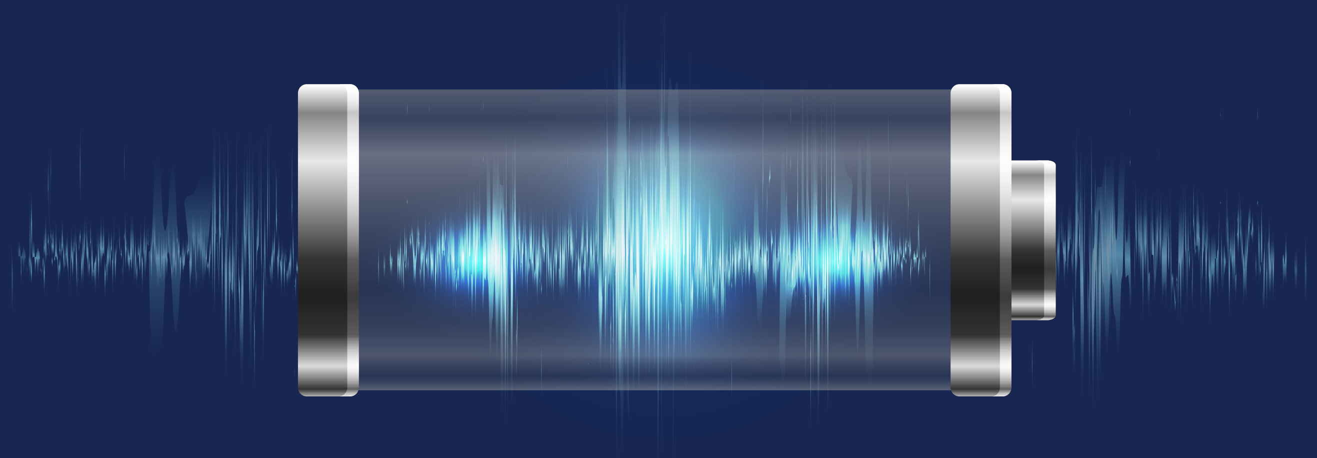
INTRODUCTION

The road transportation sector is directly responsible for around 15% of the global emissions just by fuel consumption. Therefore, substitution of fossil fuels with clean electricity, generated by renewables sources, represents a major part of the route towards a zero-emission society.

However, to truly establish a sustainable EV road transport, also the materials required to make the EV batteries need to have a low carbon footprint. Synthetic graphite (the currently dominant anode material), made from petroleum tar in China with the use of coal power, does not represent such a low carbon footprint material.

The electrification of the transportation sector has challenges regarding energy storage. Current electric vehicle (EV) batteries are heavy, expensive and the driving range, or distance that an EV can go without recharging, is often less than wanted for an acceptable price. The driving range typically varies between approximately 300 and 650 km.

The total avoided emissions over a ten-year period enabled by the solution are more than 37 million tons of CO_2-eq



Battery innovations, such as the one by Cenate, can help overcome these challenges.

Cenate's solution aims at increasing the energy storage of EV batteries and reducing their weight and cost by using an alternative anode material. If the solution becomes globally spread, the impacts both in direct Greenhouse Gas (GHG) avoidance and increased adoption of EVs can be substantial for global emission reductions.

Cenate's product emits approximately 6 tons of CO_2 per ton during its production phase when the energy source is renewable energy.

Almost all of this comes from the production of metallurgical silicon. Synthetic graphite from China, which Cenate primarily replaces (mostly used in EV batteries due to fast charging properties), has typically an emission of 17 tons of CO_2 per ton, and one will need 5-7 times as much material as with Cenate's nano silicon anode materials. Cenate's material will therefore largely compare 6 tons of CO_2 with 6x17 tons from the existing value chain. The enabling effects, such as improved EV adaption, come in addition.

Cenate's solution will significantly increase the storage capacity of EV batteries

DEFINITION OF THE PROJECT

THE CENATE SOLUTION. HOW IT WORKS

Current EV batteries are normally lithium-ion batteries with graphite anodes. These batteries require a large mass of graphite to be able to store the energy required to move the car. Cenate has developed a method for replacing graphite anodes with Silicon Nano Composite anodes, which exhibit a significantly greater storage capacity at a ratio of approximately 6:1.

THE BENEFITS OF CENATE'S NEW SOLUTION ARE ESTIMATED BASED ON:

- Emissions reductions due to the material change. The emissions associated with the production of Silicon Nano Composites are considerably lower compared to the manufacturing process of anode-grade graphite.
- Contribution to faster transitioning the global car fleet from ICE cars to EVs. Studies conducted in Norway suggest that there is a certain level of price elasticity in the case of EV's, therefore the contribution to cost reduction and increased driving range can help accelerate the adoption.

METHODOLOGY

The methodology that is used in the current report is based on a life cycle assessment of the technology's impact on climate gas emissions and following the indications and parameter definitions published in the report "Study on principles for avoided emissions accounting" (Requena Carrión, 2020).

MAIN PARAMETERS OF THE STUDY

The parameters of the study are the main data points that will define the result of the study. Except in the definition of the boundaries, the rest of the parameters are assumptions made on this specific assessment and this fact should be taken into consideration when comparing with solutions similar in nature.

SCOPE OF THE STUDY

The scope of the study is the quantification of the avoided emissions potential for Cenate's solution, both in terms of direct emissions through the reduction of required emissions to manufacture the battery component; and enabling emissions, or how they can help other parts of the system, mainly consumption patterns, to become more sustainable.

To ensure emissions in the entire value chain are captured and for transparency in the project's emission calculations, the assessment includes CO_2 emissions associated with the raw materials metallurgical grade silicon (MGS) and silane in addition to the silicon nanocomposite production. However, it is important to note that this approach may result in double-counting emissions within the value chain. As for the baseline, the emissions from synthetic graphite production are likely understated. The lower reference value is maintained to uphold transparency.

Substantial environmental impact

SYSTEM BOUNDARIES

The assessment takes on a full life cycle approach. However, and due to lack of information, the emissions generated by the building of the facilities for manufacture, the use of energy in the offices and the end-of-life phases have been excluded from the analysis.

FUNCTIONAL UNIT

The functional unit is the number of tons silicon anode material produced, and how many batteries/vehicles this will contribute to manufacturing for the enabling effect.

ENABLING EFFECTS

- Enabling effects: contributing to the production of EVs with longer driving range and lower cost will contribute to reducing the number of ICE cars on the roads.
- Fridstrom & Ostli (2018) indicate a 0.99 price elasticity of demand, and Cenate expects a USD 100-150 influence of price reduction for the end users (competition in cell manufacturing leads to that the end-user captures a large share of the benefit). Based on this, the sales increase due to price elasticity of demand (average) is estimated to 0.29%.
- The secondary effects are cumulative over the years as there will be an increasing number of EVs rolling on the streets every year.

GEOGRAPHICAL BOUNDARIES

The manufacturing of the silicon anodes in this report is assumed to be Norway. Changing the location will not make a major impact as long as the main power supply is from renewable energy sources. Considering that the market is dominated by few actors, Cenate can have a global outreach with established commercial relationships with the relevant actors.

TIME FRAME

The temporal limit of this assessment is ten years.

BASELINE

There are two baselines for the current assessment: Both baselines are in this case assumed to be static for the next decade.

- The baseline for the directly induced effects or direct avoided emissions is the graphite anode, which is the technology that Cenate aims at substituting.
- In the case of the enabling effects due to EV adoption, the baseline is reflecting emissions from combustion vehicles, which is the technology to be displaced by EVs.

PRODUCTION FORECAST

The market study has for simplicity reasons assumed that all the manufacturing capacity in any given year will reach the market and be sold.

EMISSION FACTORS CONSIDERED

The emission factors that have been used in the analysis come mainly from the database Ecoinvent 3.71, open sources provided by Morescope.com and industry reports (*Carbon Footprint Report. Volvo C40 Recharge, 2021; IEA, 2019; Kane, 2021; NVE, 2021*). The geographic definition to choose these factors has been global or averaging between markets, since the solution has a clear global reach. Other sources of information include industry reports and academic articles.

LIMITATIONS

The nature of this forecast implies the existence of certain limitations. The main ones are:

DATA LIMITATIONS

The the current level of development of the technology, as well as the uncertainties regarding market adoption, market development and related aspects necessarily lead to less accuracy in the data. A very important factor, but also difficult to forecast, is the adoption acceleration of EVs, and the possibility that the price elasticity changes over time. Therefore, and to reinforce this and future assessments, control of the actual outcomes in the process are important. See section 5.

ASSUMPTIONS

To be able to provide a quantitative value to the avoided emissions, some gaps in the data have been overcome with assumptions. In this specific case, the main assumptions are:

- Emissions related to electricity consuming during baseline manufacture will be assumed to take place in northern China.
- Emissions related to electricity consumption during manufacture will be assumed to take place in Norway.
- Emissions related to electricity consumption during the use phase are assumed will be global and therefore we will be using the European energy mix emissions intensity.

RESULTS

As can be concluded from our calculations, the direct avoided emissions over a ten-year period enabled by the solution are more than 15 million tons of CO_2-eq within the described parameters. The result summary can also be seen in Table 1 below.

This includes both direct avoided emissions, which come from the reduction in emissions motivated by the change of material, from graphite to nano-silicon, as per the first baseline; and the enabling emissions motivated by the increase of EV sales in detriment of the ICE cars.

The aggregated direct avoided emissions by the change in anode material in the EV batteries, is estimated to 15 million tons of CO_2-eq accumulated over ten years. These direct avoided emissions represent a 93% reduction by producing Cenate's silicon anode materials compared to conventional anode materials production – for every kg produced of Cenate's materials, 151 kg of CO_2 emissions can be reduced (only from production).

The aggregated enabled avoided indirect emissions where ICE vehicles are the baseline (baseline 2), is estimated to be more than 22 million tons of CO_2-eq accumulated over ten years. The indirect CO_2 avoidance from increased transitioning from ICEs to EVs due to the reduced prices on EVs is found to represent an even larger reduction in CO_2 emissions over time and will continue as long as the EVs produced are in operation (the sales increase due to price elasticity of demand included in this assessment is 0.29%, and the price reduction for end users is estimated at 100-150 USD per car). Since this effect continues every year the EVs are in use, meaning the effect is cumulative, it creates a substantial CO_2 avoidance over time (as can be seen from the table below). For simplicity, the table below stops after 10 years, but the enabling effect in year 11 will be equally large as in year 10 and continue to be large for another 10-15 years even if Cenate should for any reason halt its production.

Table 1. Result summary

Year	Cumulative manufacture forecast. Tons of nano-silicon	Yearly emission avoidance with baseline 1. Direct avoided emissions (tons of CO_2eq)	Yearly emission avoidance with Baseline 2. Enabled avoided emissions (tons of CO_2eq)	Total
1	10 000	1 517 100	413 858	1 930 958
2	20 000	1 517 100	827 717	2 344 816
3	30 000	1 517 100	1 241 575	2 758 675
4	40 000	1 517 100	1 655 433	3 172 533
5	50 000	1 517 100	2 069 292	3 586 391
6	60 000	1 517 100	2 483 150	4 000 250
7	70 000	1 517 100	2 897 008	4 414 108
8	80 000	1 517 100	3 310 867	4 827 966
9	90 000	1 517 100	3 724 725	5 241 825
10	100 000	1 517 100	4 138 583	5 655 683
TOTAL	550 000	**15 170 997**	**22 762 207**	**37 933 205**

ALLOCATION

Due to the early stage in the development of the solution and lack of knowledge about its entire value chain, the entire quantity of avoided emissions is allocated to Cenate.

CONCLUSIONS

The innovation proposed by Cenate is an important step in the electrification of the transportation sector. The need for lighter, cheaper, and more efficient batteries are important parameters for increased market penetration of electric cars.

As seen in the previous section, Cenate can significantly decrease the manufacturing emissions of the battery component for electric vehicles. This has a two-fold positive consequence: on one hand, the actual decrease in the emissions takes society closer to its net zero goals; on the other hand, it prevents EVs from a steep increase in price in potential carbon-pricing policies.

OTHER POSITIVE IMPACTS OF THE SOLUTION

This solution enables, in addition to a reduction of emissions, an increase in air quality around the plants that today produces synthetic graphite as well as for the people living in the areas where the cars are used, due to the reduction of other toxic and dangerous substances in the atmosphere, such as particulate matter. This is related to many sustainability aspects, but it is directly addressed in the UN Sustainable Development Goal 3: Good Health and Well-Being.

Cenate's product is so far the only silicon anode product that has a first cycle efficiency equal to or higher than graphite.

"

It's about making a difference – for your business and our world. Creating sustained outcomes that drive value and fuel growth, whilst strengthening our environment and societies.

In practice, this means that batteries made with our material require less of the rare and costly cathode materials. As there is a limited resource of lithium, nickel, cobalt and manganese, this product benefit has both a high commercial and environmental value.

To conclude, and as PwC puts it, ESG investments are more than ticking boxes: "*It's about making a difference – for your business and our world. Creating sustained outcomes that drive value and fuel growth, whilst strengthening our environment and societies.*"

CONTROL

The results of this report should be confirmed yearly through the reporting of the company after having entered into production.

If the actual results are very different from the results provided by this report in two years' time, this assessment should be updated with actual data.

A general report five years after the publication of this one should confirm or reject the forecast hereby presented and should lead to a new assessment considering the changes that the system might have undergone and contemporary forecast of market effects, considering, if necessary, the apparition of new competition.

USE OF THE RESULTS OF THIS REPORT

This report calculates avoided emissions, and as stated in the Avoided Emissions Framework, avoided emissions will always be reported separately from the Corporate GHG Emissions Report. These results will not be used in corporate standard emissions reporting along where Scope 1, direct emissions, and Scope 2, indirect emissions, are included. This responds to the requirements of the Greenhouse Gas Protocol Corporate Standard (GHG Protocol) as well.

In the cases in which the results are communicated, the admission of double counting should be acknowledged. Double counting takes place when the emissions reported by one company can also be reported by another, which in this case might happen if the transportation company decided to study the avoided or reduced emissions of its own operations. There would be an overlap. This is allowed but it is required acknowledgement to avoid confusion if results are aggregated.

In addition to that, it is important to acknowledge that the avoided emissions have been allocated 100% to the analyzed solution as mentioned in the results section. However, this is just an assumption used for clarity, and it does not mean that the rest of the players in the value chain have no responsibility over it. It is simply that the level of responsibility over the emissions has not been analyzed in this specific case.

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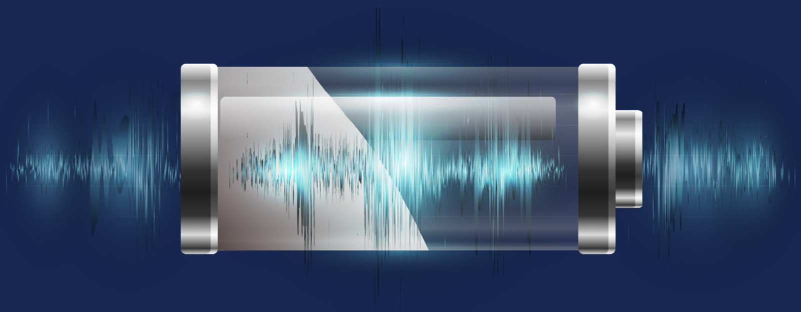

DELIVERING THE KEY TO YOUR SILICON ANODE

Cenate is a Norwegian company dedicated to the development and production of silicon-containing anode materials for immediate application in present-day lithium-ion batteries.

The nano-fenced silicon composite materials offer a substantial increase in energy density and almost completely eliminate carbon emissions during production compared to traditional anode materials.

One kilogram of the anode materials, can replace 5-7 kilograms of graphite.

The company is engaged in collaborations with some of the world's foremost battery producers and leverages Norway's rich heritage in silicon industrial expertise.

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