We create chemistry

R&D Webcast
Sustainability Starts in Research – Speech

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[Title Slide]

Ladies and gentlemen,

A warm welcome to this year's R&D Webcast. This is my first in the role of Chief Technology Officer. I am passionate about research and our innovations. As it is my first interaction with investors and analysts, I hope this comes across in this virtual format. I look forward to the Q&A session with you following my presentation.

[Slide 2: We live in a time of tremendous challenges…]

The Earth's average temperature has already risen by 1.1 degrees Celsius compared to the pre-industrial era. We are quickly approaching 1.5 degrees Celsius. Global climate change is human-induced, states the Sixth IPCC Assessment Report.

It is becoming increasingly clear: Climate change is the greatest challenge of the 21st century. Quick and decisive action is needed now. That is the only way to reach the goals of the Paris Agreement. We are aware of our responsibility. We at BASF support the Paris Agreement target of limiting global warming to less than 2 degrees Celsius.

The international community needs to address many issues simultaneously: climate protection, the use of limited resources and providing the growing global population with food, water and energy. These are all tremendous challenges.

[Slide 3: …and we live in a time of groundbreaking innovations]

At the same time, we live in an age with many groundbreaking innovations.

The energy transformation is progressing faster and faster – thanks to technological advances in solar and wind energy generation as well as in the use of electrical energy. The per-kilowatt-hour costs of solar or wind

electricity are falling. There are very rapid improvements in battery technology, such as in electric vehicles.

Another field of research also puts me in an optimistic mood: quantum computing. It will launch a chain of disruptive innovations that will fundamentally change the chemical industry in the long term. We will be able to develop new products much faster. This technology makes it easier for us to model chemical reactions and molecular properties. And in future, we will also be able to better study larger molecules. That is why BASF has joined the Qutac Consortium. Quantum technology is the way of the future. And we want to use this technology in industrial applications.

[Slide 4: Innovation is the key enabler for the sustainability transformation]

At BASF, innovations have always been the key to success. They enable us to transform our company and offer our customers products that are more sustainable – supporting their differentiation in their specific markets.

For us, innovations begin in research and development. The know-how of our highly qualified staff is our most valuable resource and the foundation of our innovative strength.

We focus on developing sustainable solutions for our customers. To help them to reduce their carbon footprint, use resources more efficiently or manufacture products in a more eco-friendly way enabling a circular economy. This is how we safeguard our competitiveness in the long term. And make our contribution to society.

[Slide 5: We operate the industry-leading innovation platform]

We have a unique research and development landscape. Worldwide, we have around 10,000 employees working in research and development, many of whom are based in Ludwigshafen. We have continuously

expanded our presence in the regions in recent years. This enables us to react faster to regional growth trends. We invest around 2 billion euros per year to develop new products, new fields of technology and competencies. We generated annual sales of around 10 billion euros with products launched on the market in the past five years that stemmed from R&D activities.

[Slide 6: New setup to benefit our customers and support the transformation towards sustainability]

To secure long-term success, we must further strengthen our customer proximity and leverage the advantages of our Know-how Verbund. By this, I mean our technologies and the broad knowledge of our employees. To become even better, we will be reorganizing our global research activities next year.

Business-related research units which previously belonged to one of the three group research divisions will be embedded into the operating divisions. This will put them in an even better position to cater to the needs of our customers. Our aim is to further shorten the time to market for new products and to accelerate the company’s organic growth.

Many of our customer industries have very specific requirements, for example, in the automotive or personal care industries. New solutions from the laboratory and their application testing are very closely linked in these business areas. This integration will help us to react even more quickly to trends in these fast-moving markets.

Research activities that are relevant to several operating divisions will be bundled in a central research division headquartered in Ludwigshafen. This division will keep a global footprint with a presence in all regions.

It will be aligned with our focus areas. As a result, we will create synergies and a strong foundation for market trends. Developing new competencies

is an ongoing task for us. For example, when it comes to further reducing our carbon footprint, developing concepts for biodegradable plastics, or using digital tools more effectively.

[Slide 7: Our purpose leads the way: We create chemistry for a sustainable future]

Ladies and gentlemen,

We are – and want to stay – the innovation leader in the market. I have told you how our organizational realignment will contribute to this.

Our corporate purpose – We create chemistry for a sustainable future – guides our actions. We have set ourselves an ambitious goal for 2030: We want to reduce our absolute CO_2 emissions by 25 percent compared to 2018 levels. And by 2050, we aim to achieve net zero emissions at BASF. At the end of November, we announced that we are stepping up our efforts with a new project organization and the establishment of a unit called “Net Zero Accelerator.” This powerful structure will support us in our transformation.

We have also set ourselves ambitious goals for our Circular Economy Program. By 2025, we want to process around 250,000 metric tons of recycled raw materials each year. And we aim to increase our sales of circular solutions to 17 billion euros by 2030. That is double the current figure.

An important steering instrument for our product portfolio is the Sustainable Solution Steering method, which is based on the sustainability performance of our products.

In the following, I will give you one research example for each of these focus areas: climate protection, circular economy, and our Sustainable Solution Steering.

[Slide 8: Methane pyrolysis – process innovation to reduce CO_2 emissions]

Chemistry requires vast amounts of energy. This energy currently comes primarily from fossil fuels. We have continuously further developed our plants and processes and have nearly exhausted the potential for CO_2 reduction. We are reaching the technical limits. That is why we need completely new technologies and processes. One of these technologies is methane pyrolysis. When powered by green electricity, it is the key technology for CO_2-free hydrogen in the coming decades.

At our R&D Webcast in 2019, we first told you about our research into splitting methane into carbon and hydrogen. At that time, we had just tested an entirely new reactor concept at lab scale. We talked about the challenges related to electrical heating.

We took the next major step in the pandemic year 2020/21: the construction and commissioning of our test plant in Ludwigshafen. This plant is now running in trial operations. This is a milestone for us. I want to say thanks to the very dedicated BASF team. They have done a fabulous job in challenging times!

There are now two challenges to overcome: The first is mastering the process technology – with the electrical heating and the use of novel materials with high temperature resistance in this reactor. The reactor can reach temperatures of up to 1,400 degrees Celsius. The second challenge is the right process control. This means finding out what the right operating window is for this reactor.

CO_2-neutral methane pyrolysis will contribute to sustainability and will be economically viable. We are convinced of this. And it will help to combat climate change. But until we get that far, we still have hard work to do and

some hurdles to overcome. Our next milestone will be the scaleup. We want to achieve industrial application before 2030.

[Slide 9: Gas fermentation for carbon-neutral and circular products]

Our climate is changing and one of the crucial questions is: Will it be possible to develop the urgently needed technologies to keep carbon – an important raw material – in circulation? The aim is to transform the carbon contained in industrial off-gases into valuable chemicals. Together with partners, we have already achieved a first success.

Today, industrial off-gases are primarily incinerated or thermally recovered to produce electricity and steam. In both cases, CO_2 is emitted. Our goal is to avoid these emissions and to recycle the main components of the off-gases so they can be used in chemical production. Our researchers have been working on this since 2018 with the American startup LanzaTech.

This year they made a breakthrough: With the help of special bacteria, they were able to produce n-Octanol for the first time from carbon monoxide and hydrogen. The alcohol n-Octanol is used in cosmetics, for example. Normally, microorganisms cannot produce n-Octanol because it is toxic to them. But with biotech methods, LanzaTech was able to program the organisms in such a way that they can produce and tolerate n-Octanol during gas fermentation.

In parallel, our researchers developed a process that enables n-Octanol to be continuously separated and purified. We have successfully put this into practice in the lab.

[Slide 10: New biodegradable chemistry – significant acceleration of development through digitalization and automation]

For a successful Green Deal, we want to and must achieve climate-neutral production in the future. But not only that. The E.U. goals will not

be reachable without the chemical industry. Because we offer innovations for a more sustainable life.

I would like to give you one example from our research in the area of biodegradable and bio-based materials. This is an example of innovative solutions that contribute to the Green Deal agenda.

The circular economy and sustainability are increasingly important, including for our customers. For example, in the detergents and formulators industry. That is why teams at BASF are working on the question of how to best combine strong cleaning performance and good environmental compatibility. The focus is on new ingredients made from bio-based raw materials, which can biodegrade at the end of their productive life cycles. This requires new approaches in research and development.

Together with academic partners, we are pursuing various projects to develop a fundamental understanding of how biodegradation processes occur under different conditions. To this end, we are synchronizing the results of laboratory and field research. With the additional integration of new digital tools as well as faster screening and test methods, we can reduce our development times and develop high-performance, environmentally sound ingredients. This is true not only for cleaning products, but also for cosmetics and industrial applications such as agrochemicals.

[Slide 11: Chemical industry as enabler for the reduction of CO_2 emissions in other sectors]

The chemical industry plays a central role in the transformation towards a climate-neutral society: One reason is because the industry currently emits relatively large amounts of CO_2. Another reason is that its innovative products will be especially needed in the future. These include materials

for solar cells and wind turbines, battery materials for e-mobility, insulation materials and robust materials that protect against increasingly extreme weather. Chemical products are also indispensable in other areas of daily life, for example, in pharmaceuticals or agriculture.

At the Research Press Conference this morning, our experts presented innovations from two areas – electric mobility and agriculture. This afternoon, I would like to focus on e-mobility as the examples nicely complement the insights we shared with you during the recent Investor Update.

[Slide 12: The transformation of the automotive industry towards electric mobility is in full swing – with significant opportunities for BASF]

The automotive industry is undergoing a massive shift owing to the transformation of the powertrain and the transition from internal combustion engines to e-mobility. We expect that by 2030 around 30 percent of all cars produced worldwide will be either fully electric vehicles or plug-in hybrids. This share will continue to increase significantly after 2030.

For BASF, this offers major opportunities because the chemical content per vehicle will increase substantially. We anticipate that it will rise by a factor of 2.5 in a fully electric vehicle as compared to a car with an internal combustion engine. The largest share of this added value will be in the battery.

This transformation is very important for our company because the automotive industry is our key customer industry. Around 20 percent of BASF Group’s sales are currently associated with the automotive industry.

In recent decades, we have proven that we are a strong solution supplier for the automotive industry. And we want to continue to be.

[Slide 13: BASF innovations enable electric mobility in various applications]

The battery is the heart of every electric vehicle. We use an extensive toolbox of different methods to improve the performance, reliability and sustainability of batteries. Markus Kamieth presented our activities in battery materials during the Investor Update on September 27. Therefore, I will now focus on plastics, coolants and coatings.

Plastics are indispensable in e-mobility. Plastics play a role in lightweight construction, heat conductivity, heat management and, of course, safety. The share of plastics will also increase amid the transition to fully electric powertrains.

In addition, BASF is developing new engine coolants. A battery electric vehicle will require roughly twice as much coolant as a car with an internal combustion engine. There is one particular challenge with electric vehicles: The formation of flammable hydrogen must be prevented in the event that coolant comes into contact with high-voltage battery components, as could happen in the case of an accident. Lowering the electrical conductivity of the coolant is the key to success here.

And one more important topic: corrosion protection. With the help of digital simulations, we have developed a cathodic dip coating tailored to the specifications of electric vehicles. It protects the car body from corrosion and at the same time helps to lower CO_2 emissions in production. This is good news for sustainable mobility.

I will now present the selected innovation examples from our Performance Materials, Performance Chemicals and Coatings divisions.

[Slide 14: Enabling safe handling of high-voltage components – a portfolio of durable orange-colored polyamides]

Given the nature of electric vehicles, high-voltage transmitting components enable safe distribution of power. In electric cars, these components must be highlighted in bright orange – as you can see the connector on the slide. This is an important visual cue for car drivers and mechanics to help avoid accidental short circuits or electric shocks.

The automotive industry requires that this color remain stable after being exposed to 140 degrees Celsius for 1,000 hours. Considering the heat these components must endure during the lifetime of a car, this makes sense.

Polyamides are one of the standard materials used for high-voltage connectors in electric cars and charging infrastructure. However, the chemical nature of polyamides leads to a severe discoloration when the material is exposed to heat over a long period of time. On the right side, you can see the variations of color with a standard polyamide and how it will turn brown at elevated temperatures over time.

Our scientists have found a way to achieve long-lasting color durability at elevated temperatures. They developed a new formulation based on polyamides and thermally stable pigments. This breakthrough represents the next level of color stability in polyamide formulations.

In a nutshell: Our durable color Ultramid® portfolio supports safe handling of high-voltage components – by car owners and mechanics.

[Slide 15: Ensuring passenger safety – a new vehicle architecture requires new safety concepts]

Let’s look at safety from the driver’s and passenger’s perspective.

Battery-powered vehicles tend to have shorter frontends. The heavy battery needs to be protected. Furthermore, the weight and impact mass

of an electric vehicle is higher overall compared to a conventional car. This all requires new safety concepts.

Our R&D teams have contributed many solutions, including plastic frontends with especially high energy absorption. They are made of polyamide and glass fiber. The absorbers serve two purposes: They take up momentum in the event of a crash and channel the impact energy into the designated areas of the vehicle. When developing the absorbers, our researchers applied our digital simulation tool Ultrasim® to model the best material composition and component design.

Our scientists have also developed structural parts in car bodies made of polyamide particle foam. OEMs can produce these in complex three-dimensional shapes using standard particle foam molding processes. The polyamide foams keep their form even under high temperatures. This allows them to be attached in the car even before the dip coating. This effectively reduces the need for an additional process step afterwards, which helps the OEMs save time and resources.

Pultruded polyurethanes and thermoplastic profiles are extraordinarily stiff and help keep the frame around the battery intact in case of an impact. They are also stiffened with glass fiber.

These BASF innovations enable the next safety level for electric vehicles in the event of a crash. And the plastic materials are a lot lighter than metal, for example. This helps minimize the weight of the vehicle while maintaining high safety standards.

[Slide 16: Thermal management of the battery requires increased volume of liquid coolant]

Let’s move on to coolants.

The battery is the highest value part in an electric vehicle and is the key driver of its performance. A robust, finely tuned thermal management

system is required to help protect the battery and ensure its longevity. This is where coolants come into play.

I mentioned earlier that the chemical content in electric vehicles is higher than in conventional cars. This also holds true for coolants. We are talking about a two-fold increase in terms of volume here. The reason is simple: In contrast to an internal combustion engine, where the area that needs to be cooled is rather small, the battery extends across almost the entire underside of an electric vehicle. In addition, the electric engine needs to be cooled.

This means: To achieve optimal operation of the vehicle, car manufacturers need to ensure specific temperatures across a large area. A network of cooling plates or pipes ensures that the coolant can reach all relevant parts of the battery. These are the basic requirements for thermal management of an electric vehicle.

[Slide 17: Coolant's electrical conductivity is a key determinant in minimizing risk associated with hydrogen generation]

There is another crucial aspect related to coolants in battery-powered vehicles. If the coolant comes into contact with high-voltage battery components, for example, after a crash, there is a risk that hydrogen will be generated. Essentially, the water in the coolant may be split into hydrogen and oxygen by the electric current from the battery components. This is one of the most memorable chemistry experiments in high schools – the production of oxyhydrogen, a gas mixture that self-ignites. And this is something you want to avoid.

The trick is to decrease the electrical conductivity of the glycol water system that makes up the coolant. If you look at the left side of the slide, you see how the new BASF coolant, Glysantin® Electrified™, compares to a conventional coolant.

An automotive OEM would ideally want a coolant to reach the maximum performance in all categories. This means it would reach the outermost boundary in all corners of the graph. Conventional coolants perform very well in terms of low flammability, low viscosity, high thermal capacity and conductivity and excellent material compatibility. The term material compatibility refers, among other things, to how well the coolant protects the coolant circuit from corrosion. However, conventional coolants perform poorly when it comes to electrical conductivity – meaning they show very high electrical conductivity, therefore transmitting electrical current at a rate that is too high.

Glysantin® Electrified™ is markedly less conductive for electricity. And it still performs very well in all other categories. This is not easy because tweaking the coolant impacts its other favorable characteristics. Getting there was the result of thorough R&D work. Our experts achieved the low electrical conductivity by using non-ionic additives and a lower polarity solvent, which simultaneously ensures that the coolant circuit is well protected from corrosion.

With Glysantin® Electrified™, our researchers could significantly reduce the risk of hydrogen generation: by an impressive 98 percent – as you can see on the right of the slide. The Performance Chemicals division introduced Glysantin® Electrified™ to the market this year.

With this innovation, we help improve the safety of the battery and contribute to reducing the risk of dangerous situations like overheating, fires or explosions if an accident occurs.

[Slide 18: New BASF e-coat technology meets OEMs' demand for one paint solution for all platforms and fulfills high sustainability standards]

Moving on to the examples from our Coatings division.

Every car owner wants protection against rusting and corrosion. This is also important for the structural stability of the vehicle and a key determinant of its lifetime.

Unsurprisingly, the requirements for battery-powered cars can also differ here. For safety reasons, their rocker panels and sills – essentially the base of the vehicle – can feature thicker metal than in conventional vehicles. This has implications for the process in which the corrosion protection is applied. During this process, the car frame is dipped into a cathodic electrocoat or e-coat. Afterwards, the metal of the chassis is heated up to ensure the crosslinking of the various e-coat components on its surface. This is crucial to achieve the full level of corrosion protection.

Thicker metal takes longer to heat up. If you were to simply apply the corrosion protection used for conventional cars, this could lead to uneven protection of the electric car's individual parts. In this context, it is important to know that car manufacturers apply dip-coating for all types of vehicles on the same manufacturing line. The challenge for our R&D team was to offer one paint solution that works for all vehicles. Employing smart tools, they ran several digital simulations to help accelerate the development.

We can now offer customers our new CathoGuard® technology featuring increased reactivity. This means that the crucial crosslinking happens at lower metal temperatures. This has been achieved by optimizing the dispersion and the pigment paste components of the product. In addition – and this is an important achievement – there is no compromise when it comes to the industry's high sustainability standards.

[Slide 19: Meeting novel requirements: A broader baking window enables reduction of energy consumption]

Our new CathoGuard® technology offers an additional sustainability benefit. Due to its higher reactivity, OEMs can reduce the oven temperature for the dip-coating process by 20 degrees Celsius. The baking process can also be shortened. When you compare the left and right graphs, you can see that our technology works at a much broader range of temperatures.

The areas highlighted in orange indicate the upper range of temperatures at which the technology can still work, but must be tested on the OEM's manufacturing line. The shaded area at the bottom indicates the area meeting the specifications for corrosion protection in the interior of the vehicle. The requirements here are different since these car parts are not as exposed to the environment as the exterior of the vehicle.

Please note that these graphs show the temperature of the metal. The temperature in the oven will be about 15 to 20 degrees Celsius higher. Today, metals are usually heated up to 155 to 160 degrees Celsius. Our CathoGuard® technology enables the process to be run with a metal temperature of only 140 degrees Celsius.

We are thus offering a lever to reduce the energy required in the process, with a positive impact on CO_2 emissions. With this technology, CO_2 emissions can be reduced by up to 35 percent per unit in this process step, depending on the curing temperature and time.

Our teams are already working on a new concept that would further increase the reactivity and further reduce the required energy.

[Slide 20: Pipeline of selected solutions for electric mobility]

This slide shows a selection of products and solutions we have in our pipeline specifically for electric mobility. As you can see, we have already launched new products in 2021. Over the next years, more of the innovations I presented today will become available. And there will be more solutions to come.

As the largest chemical supplier to the automotive industry, our expertise and networks enable us to anticipate new trends and have a head-start when it comes to developing new industry standards.

This is a key driver for growth, together with the battery materials business we are continuously expanding.

[Slide 21: BASF's R&D team is committed to helping our customers become more sustainable]

To conclude my speech, I would like to return to my opening statement: Tremendous challenges have to be mastered simultaneously. And time is of the essence. This means we must now boldly tackle the transformation of the economy and society, rely on innovations and be open to new technologies. This is the path we are taking. Resolutely and systematically. Research and development is the core of BASF. We have an incredible team. This makes me very optimistic.

And now I look forward to taking your questions.