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Thank you, Chairwoman Castor, Ranking Member Graves, and distinguished members of the select committee, for inviting me to testify and for your leadership in focusing on climate change. My name is Cate Hight, and I am a principal at Rocky Mountain Institute (RMI). Founded in 1982, RMI is an independent, nonpartisan, charitable nonprofit dedicated to transforming global energy use to create a clean, prosperous, and secure low-carbon future. I am grateful for the opportunity to speak with you today about RMI's work to decarbonize industry, including the challenges present in this harder-to-abate sector, as well as the many opportunities we have to bring about transformative change.

I was invited here today to provide RMI's perspective on decarbonizing industry, as well as more specific information on how hydrogen may be used as a critical, low-carbon fuel in industrial processes. First, I'll share our wider perspective on this complex sector. At RMI, we think of industrial decarbonization in terms of the whole value chain, which means we consider the process from start to finish, thinking through how goods and services are designed, produced, sourced, and then ultimately delivered to consumers.

Consumer goods are formed through a set of industrial activities, starting with the sourcing of raw materials, either through recycling or virgin extraction. Those raw materials then undergo energy-intensive processes to refine and transform them. Next, the product is manufactured, generally in a large, energy-intensive factory, and finally, it is shipped to the end consumer, typically on a ship, plane, or truck that uses fossil fuels.

Although few of the activities in this chain are consumer facing, they play an important role in our everyday lives. They are essential to creating and delivering the things we use every day, from the cars and bicycles we use to get around, to the phones and laptops we use to connect to the world, and the cement, steel, and bricks we use to build houses. These products all require raw materials, along with energy, usually in the form of fossil fuels, to create and transport them. Not surprisingly, these activities also contribute a significant share of global greenhouse gas (GHG) emissions each year. If you include the emissions from the generation of electricity (Scope 2 emissions), the industry sectors represent more than 40% of the global GHG footprint today.[1] In addition to their contribution to climate change, these emissions create

[1] https://www.ipcc.ch/sr15

daily risks to our food and water, our health, our homes, and our economy. And industrial emissions are on the rise as economies around the world continue to grow, to a point where heavy industry alone will consume more than two times the remaining carbon budget for limiting global warming to 1.5 degrees Celsius.[2]

The main challenges in decarbonizing industry are not necessarily expensive solutions or the need to develop unknown technology. The main challenge is that we have to overcome three fundamental market forces that work against the energy transition: (1) maintaining the status quo to de-risk investments in long-life assets, (2) commoditizing the traded products to enable global competition and reduce the cost to consumers, and (3) siloing capital in asset classes, which isolates the processes that are in dire need of investments in low-carbon technology.

Overcoming these forces will take a combination of market, financial, and policy solutions. Today I will speak about how federal policy may be used to address each of these barriers by deploying more hydrogen into the industrial sector. When produced using renewable resources, hydrogen can play a critical role in decarbonizing this sector by replacing many of the fossil fuels the world relies on to power the economy. And we have the technology available today to produce large quantities of this clean energy source.

In fact, the US produces and uses hydrogen in its industrial economy today. Each year, we manufacture about 10 million metric tons of hydrogen, which is equal to about 15% of the global total. Most of this hydrogen is manufactured using natural gas and steam as inputs. Nearly three quarters of the hydrogen we produce is used in our domestic petroleum refining industry; the remainder is primarily used in fertilizer production.[3] There are hydrogen production facilities in almost every state in the US. However, scaling hydrogen production and use to the level we need to truly decarbonize industry will require intervention from policymakers, consumers, and the financial sector.

How much more hydrogen do we anticipate we will need to decarbonize industry? According to expert analyses by the International Energy Agency,[4] the Energy Transitions Commission,[5] and Shell,[6] this pathway requires the world to produce and use about 600 million metric tons of hydrogen per year by 2050. This is almost ten times the amount of hydrogen produced today. And to reach this level, production needs to steeply increase in the next decade and then continue to grow at a steady rate.

For hydrogen to play an essential role in decarbonizing industry, policymakers must focus on providing conditions that (1) stimulate rapid and wide-scale hydrogen production and its uptake

[2] https://rmi.org/insight/the-next-industrial-revolution/
[3] https://www.hydrogen.energy.gov/pdfs/16015_current_us_h2_production.pdf
[4] https://www.iea.org/etp/publications/etp2012/facts/widerbenefitsof2ds/
[5] http://www.energy-transitions.org/mission-possible
[6] https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html

as the primary fuel source for major industrial fuel consumers, including heavy manufacturers and heavy transport; and (2) enable a transition from fossil fuel-based hydrogen production to production that is based on renewable energy sources.

As mentioned earlier, right now most hydrogen is produced for use in the petrochemical sector, and most of it is produced using natural gas as a feedstock in a process called steam methane reforming (SMR). Unfortunately, SMR also produces a lot of carbon dioxide emissions. So, while there is capacity to ramp up production at these facilities, without carbon capture and storage (CCS), this production pathway cannot play a long-term role in industrial decarbonization using hydrogen.

SMR can, however, be part of the hydrogen story in the near term, in much the same way that our current fossil fuel-dominated power grid is part of the story for electric vehicles (EVs). EVs currently run on power provided by a mix of sources. The market for EVs is rapidly developing as more and more consumers demand them; simultaneously the electricity grid is becoming cleaner, and therefore EVs are running on greener power. In much the same way, SMR production can get more hydrogen to market and increase its uptake by driving down prices, while at the same time lower-emission hydrogen production methods displace SMR hydrogen production.

Currently, the commercially available alternative to SMR is hydrogen produced through electrolysis: grid-based electricity is used to split water molecules into hydrogen and oxygen. Just like EVs that run on grid-based power, this hydrogen is as "clean" as the electric power used to produce it. The more renewable electricity available to power hydrogen production, the more quickly the industrial sector can move into a decarbonized, hydrogen-based future.

To scale up hydrogen production as quickly and broadly as needed, federal policymakers can play a key role in stimulating the growth of the market by (1) reducing the risk associated with investment in large hydrogen production operations, and (2) helping kick-start regional hydrogen markets. Policy solutions could include the following:

- Policy or financial incentives/mandates for low-carbon hydrogen production, including natural gas-based production that includes CCS;
- Government procurement policies that require sourcing of hydrogen to power government operations;
- Policy or financial incentives/mandates to increase hydrogen uptake by industrial users, ensuring that SMR-based production includes CCS;
- A shift of federal subsidies away from oil exploration and development and toward investment in hydrogen infrastructure, which includes hydrogen production facilities and the transportation and distribution infrastructure needed to expand delivery routes to industrial users;
- Investment in infrastructure or investment loan guarantees for hydrogen transportation and distribution infrastructure to expand delivery routes to industrial users;

- Feed-in tariffs and tax credits to stimulate hydrogen production and deployment of more renewable electricity sources to the electricity grid;
- Investment support programs to reduce the costs associated with fuel-switching at industrial facilities;
- Safety regulations governing hydrogen production, transport, and use, similar to those for fossil fuel markets;
- Investment in research and development for new, sustainable hydrogen production pathways;
- Policy or financial disincentives for industrial facilities to use carbon-intensive resources such as coal or natural gas;
- Policy or financial disincentives for investment in carbon-intensive electricity generation; and
- Border adjustments for imported products in energy-intensive, trade-exposed industries that are manufactured using carbon-intensive pathways.

In summary, federal policymakers have a number of tools in the toolkit to reduce investment risk in hydrogen production and grow the market to the scale necessary to decarbonize industry. And the good news is that many of these tools have been applied to great effect in similar markets. For example, the solar investment tax credit has enabled that industry to expand at an annual growth rate of 50% since 2006, which has brought the price of solar power down dramatically and facilitated deployment of thousands of megawatts of clean electricity onto our nation's power grid. Today, we have the same opportunity with hydrogen. If we are truly serious about decarbonizing industry, hydrogen will be a critical part of the solution.