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ECONOMIC UPDATE

Number 19 • DECEMBER 2021

EXECUTIVE SUMMARY

AMERICAS: THE U.S. ECONOMY ADDED 210,000 JOBS IN NOVEMBER, but job openings surged by 11 million in October, suggesting a recent moderation in employment growth was due to a shortage of workers rather than ebbing demand. **The U.S. trade gap** plunged 17.6% in October as exports soared to a record high. Trade may contribute to GDP this quarter for the first time in more than a year. **U.S. import prices** climbed 1.2% as the costs of petroleum products and food spiked. **Production at U.S. factories** surged 1.2% to its highest level since March 2019. Output at auto plants rebounded 11.0% after declining for two straight months. **Consumer spending** rose 1.3% in October, while personal income increased 0.5%. **Consumer prices** accelerated 0.9% as Americans paid more for gasoline and food, leading to the biggest annual gain (6.4%) in 31 years. Prices for new vehicles jumped 9.8%. Gasoline prices shot up 50% from a year ago. **Durable goods orders** fell 0.5%, depressed by a 2.6% drop in orders for transportation equipment. Orders for civilian aircraft tumbled 14.5% after plunging 31.2% in September. **U.S. services industry activity** unexpectedly rose in November, hitting a fresh record high.

OVERSEAS: JAPAN'S ECONOMY SHRANK AT AN ANNUALIZED RATE OF 3% DURING THE 3RDQTR. Global supply chain disruptions and a resurgence in COVID cases cut spending by consumers and businesses. **Eurozone business activity** strengthened in November, but record inflationary pressures and surging COVID-19 cases weighed on the outlook. **India and South Korea** are experiencing shortages of urea, which is produced using coal, since China placed new restrictions on exports. Urea is widely used in India as a fertilizer and in South Korea to produce urea solution, which is used to reduce diesel emissions in vehicles and factories.

STEEL: TARIFFS ON JAPANESE STEEL AND ALUMINUM MAY BE EASED BY THE WHITE HOUSE. The administration announced a plan to start negotiations with Tokyo on easing the tariffs, with a goal to set up an arrangement to allow some Japanese metals to enter the U.S. tariff-free. **Stainless steel pricing** remains strong as buyers contend with a tight U.S. market. The base price announced in October has been fully accepted into the market and, combined with higher alloy surcharges, lifted all November prices more than 3%. Service centers have built some stainless inventory, closing October with 386,300 tons, up 11.6% from a year ago.

AUTOMOTIVE: GENERAL MOTORS IS SEEING A BETTER FLOW OF SEMICONDUCTORS, as its assembly plants in North America are now back to running regular production. **Ford** entered into a strategic agreement with U.S.-based semiconductor manufacturer GlobalFoundries to develop chips, a pact that could eventually lead to joint production. **Manufacturers of large trucks and commercial vehicles** are beginning to embrace hydrogen fuel cell technologies. Toyota, Kenworth and the Port of Los Angeles have begun testing hydrogen trucks to haul goods from ships to warehouses. Volvo Trucks and Daimler Trucks have announced partnerships too.

ENERGY: U.S. UTILITIES ARE FACING THE HIGHEST NATURAL GAS PRICES IN YEARS as they build stockpiles for winter. U.S. Henry Hub gas prices reached \$5.59/million BTUs, up from \$3 a year ago. **A record amount of renewable electricity** was added to energy systems globally in 2021, but it remains about half of what is needed annually to be on track to reach net zero emissions by 2050.

MEDICAL: GENERAL ELECTRIC PLANS TO SPLIT INTO THREE PUBLIC COMPANIES, the culmination of a years-long process of shrinking the company. GE Healthcare, which makes MRIs and other hospital equipment, will be spun off in early 2023. The global market for equipment for medical imaging—including ultrasounds, MRIs, X-rays and CT scans—was worth around \$22 billion in sales globally in 2020. **Johnson & Johnson** plans to spin off its consumer health division to focus on pharmaceuticals and medical devices.

INNOVATION: GLASS WITH INVISIBLE SOLAR PANELS THAT GENERATE ELECTRICITY was developed at South Korea's Incheon National University. Fully transparent solar cells can be integrated into windows, buildings or even mobile phone screens. Abundant and easily manufactured nickel oxide is playing a pivotal role. **Researchers at the Lawrence Berkeley National Laboratory** discovered that they could use a technique called cryo-forging to manipulate pure titanium on the scale of a billionth of a meter (a nanometer) at ultra-low temperatures to produce extra-strong "nanotwinned" titanium without sacrificing any of its ductility.

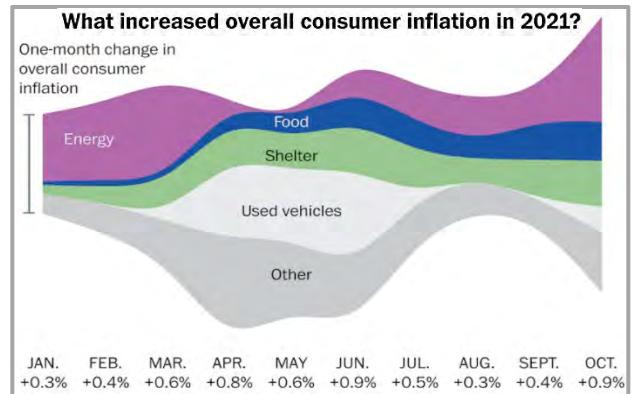
AEROSPACE: THE PENTAGON SELECTED NORTHROP GRUMMAN, LOCKHEED MARTIN AND RAYTHEON to research and develop a missile system that would be able to defend the U.S. against a hypersonic weapons attack. **American Airlines** said the Omicron variant is a threat to trans-Atlantic travel, indicating it will have less flights to Europe in January. Those routes are the most lucrative long-haul market, accounting for up to 17% of pre-pandemic passenger revenues for the major U.S. carriers.

COMMODITIES: CHINA APPROVED THE CREATION OF ONE OF THE WORLD'S LARGEST RARE-EARTHS COMPANIES to maintain its dominance in the global supply chain of the strategic metals as tensions deepen with the U.S. **The LME aluminum cash price** averaged \$1.20/lb in November, down from October's average of \$1.34. Traders reduced the MW premium to \$0.29/lb. Because of the decline in both the LME aluminum ingot price and the MW premium, mill products will decline by about \$0.20/lb in December.

THE AMERICAS

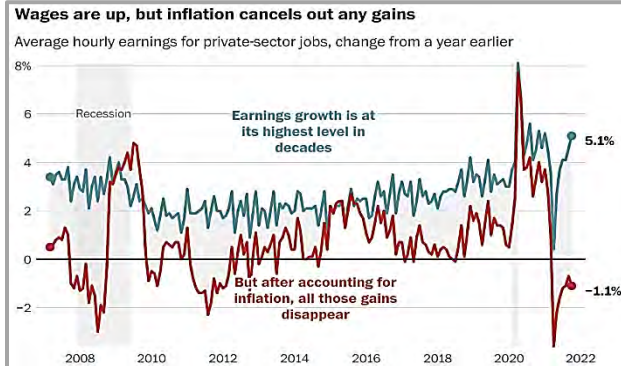
- **The U.S. government** posted a \$165 billion budget deficit for October, 42% lower than the \$284 billion shortfall a year earlier, as personal and corporate income tax receipts surged on the back of the rebounding economy.
- **U.S. producer prices** increased 0.6% in October, driven by surging costs for gasoline and motor vehicle retailing. The Federal Reserve restated its belief that current high inflation is "expected to be transitory" and started reducing the amount of money it is injecting into the economy through monthly bond purchases. In the 12 months through October, the PPI has increased 8.6%.
- **Durable goods orders** in October fell 0.5%, depressed by a 2.6% drop in orders for transportation equipment. Motor vehicle orders rebounded 4.8% after falling 2.2% in September. Orders for civilian aircraft tumbled 14.5% after plunging 31.2% in September. Boeing received only 10 aircraft orders compared to 27 in September. Orders for non-defense capital goods excluding aircraft rose 0.6%.
Key Update: Unfinished work continues to pile up at factories as manufacturers struggle with snarled supply chains. This, and strong demand for goods, should keep manufacturing, which accounts for 12% of the economy, humming.
- **The Index of Leading Economic Indicators** climbed 0.9% to 118.3 in October. The Conference Board said the sharp advance suggests the current economic expansion will continue into 2022 and may even gain some momentum in the final months of this year.
- **U.S. import prices** surged 1.2% in October as the costs of petroleum products and food spiked. Imported fuel prices soared 8.6%; petroleum prices advanced 8.1%. In the 12 months through October, prices jumped 10.7%. Prices of U.S. exports increased 1.5%. Prices for agricultural exports rebounded 1.0%, nonagricultural export prices were up 1.5%. Export prices were 18.0% higher YOY in October.
- **The U.S. trade deficit** plunged 17.6% to \$67.1 billion in October as exports soared to a record high, potentially setting up trade to contribute to economic growth this quarter for the first time in more than a year. Exports accelerated 8.1% to an all-time high of \$223.6 billion.
- **U.S. retail sales** jumped 1.7% in October, soaring 16.3% YOY. The broad increase in sales was led by motor vehicles, with receipts at auto dealerships advancing 1.8%. The rise reflects an increase in unit sales for the first time in six months as well as higher prices. Retail sales also received a boost from higher gasoline prices, with receipts at service stations increasing 3.9%.

- **Consumer prices** accelerated 0.9% in October as Americans paid more for gasoline and food, leading to the biggest annual gain (6.4%) in 31 years. Gasoline prices shot up nearly 50% from a year ago, putting them at levels last seen in 2014. Grocery prices climbed 5.4%, with pork prices up 14.1% from a year ago, the biggest increase since 1990. Prices for new vehicles jumped 9.8%. A 5.3% surge in restaurant prices marked the sharpest increase since 1982.



- **Consumer confidence** dropped to a nine-month low in November amid worries about the rising cost of living and pandemic fatigue, but that did not change expectations for stronger economic growth this quarter. The Conference Board survey showed consumers less enthusiastic about buying a house and big-ticket items such as motor vehicles and major household appliances over the next six months, likely because of shortages, which have boosted prices.
- **The U.S. economy** added 210,000 jobs in November, marking a slowdown in hiring amid new COVID-19 uncertainties, but a tight labor market showed an early sign of loosening as almost 600,000 people joined the workforce. The unemployment rate fell to 4.2% from 4.6%.
Key Update: U.S. job openings surged by 11 million in October, suggesting a recent moderation in employment growth was because of a shortage of workers rather than ebbing demand. Employers have been raising salaries and offering new benefits to entice new hires.
- **Production at U.S. factories** surged 1.2% in October to its highest level since March 2019. Production at auto plants rebounded 11.0% after declining for two straight months. Excluding autos, manufacturing output rose 0.6%. Capacity utilization for the manufacturing sector increased 0.9% in October to 76.7%. Overall capacity use for the industrial sector rose to 76.4% from 75.2% in September.
- **U.S. factory orders** increased 1.0% in October. Data for September was revised higher to show orders gaining 0.5% instead of 0.2% previously reported. Factory orders surged 17.1% on a YOY basis.

- **U.S. consumer spending** rose 1.3% in October, while personal income increased 0.5%. Consumers increased spending on goods, including big-ticket and smaller purchases, by 2.2%. Spending on services, hit hard by the pandemic, showed glimmers of improvement, growing 0.9%. Although wages are up to support increased spending, inflation has cancelled out any real gains.



- **October existing home sales** rose 0.8% to an annual rate of 6.34 million units, their highest level since January. Home resales dropped 5.8% on a YOY basis. The median existing house price increased 13.1% from a year earlier to \$353,900. New home sales increased 0.4% to an annual rate of 745,000 units. The median new house price soared 17.5% to \$407,700 from a year ago. Single-family housing starts dropped 3.9% to an annual rate of 1.039 million units. The fourth-straight monthly decline pushed housing starts to the lowest level since August 2020. Home construction costs jumped a record 12.3% YOY in October.
- **U.S. manufacturing activity** picked up in November amid strong demand for goods, keeping inflation high as factories continued to struggle with pandemic-related shortages of raw materials. All of the six largest manufacturing industries in the ISM survey, including computer and electronic products as well as transportation equipment, reported moderate to strong growth. Prices for steel plate and hot-rolled coil appear to be nearing a plateau, according to manufacturers of fabricated metal products.
- **U.S. services industry activity** unexpectedly rose in November, hitting a fresh record high as businesses boosted hiring, but there was little sign that supply constraints were easing and prices remained high.
- **U.S. construction spending** in October gained 0.2% as a decline in homebuilding blunted a surge in outlays on public projects. Spending on state and local government construction projects jumped 0.9%, while federal government spending accelerated 14.6%.

Key Update: *A decade of underbuilding has resulted in a massive home construction shortfall and a limited inventory.*

- **Tariffs on Japanese steel and aluminum** may be eased in the latest step by the White House to reset trade relations with allies. The administration announced a plan to start negotiations with Tokyo on easing the tariffs, with a goal to set up an arrangement to allow some Japanese metals to enter the U.S. tariff-free. The decision follows the administration's agreement with the EU to relax tariffs on European steel and aluminum.

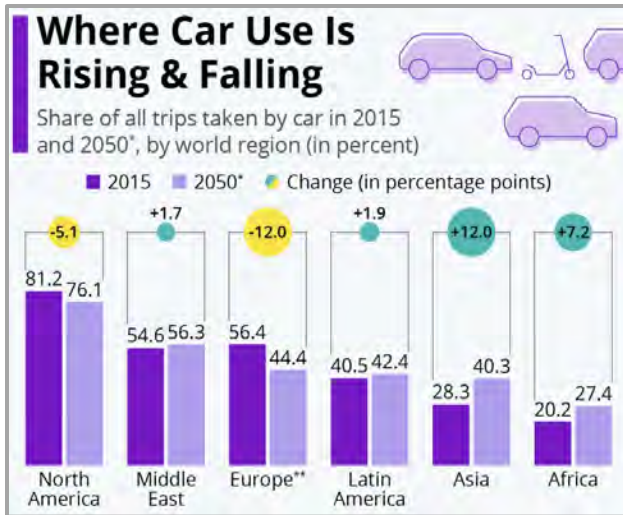


- **Steel mills** shipped 8.085 million tons of steel in September, a 3.8% drop from August but a 21.3% advance from a year ago. Shipments YTD through September were 70.739 million tons, a 17% increase vs. the same nine month period in 2020. (See [Appendix: Steel](#), page 13)
- **Stainless steel pricing** remains strong as buyers contend with a tight U.S. market. The base price announced in October has been fully accepted into the market and, combined with higher alloy surcharges, lifted all November prices more than 3%. Most domestic stainless mills are closing in on a strong finish to a good year, highlighted by demand recovery, increases in scrap and alloy surcharges and the exit of major producer ATI from the commodity stainless sheet market. Service centers have built some inventory, closing October with 386,300 tons, up 11.6% from a year ago and the highest level since June 2020. YTD shipments through October of 1.5 million tons were 13% greater than the same period in 2020. Buyers may see some relief from European imports free of the 25% Section 232 tariffs after January 1, 2022, although that will not be a long-term solution to the domestic market deficit.

Key Update: *Stainless demand has strong potential to improve in the new year as construction picks up and alleviation of the microchip shortage allows increased production of vehicles and appliances.*

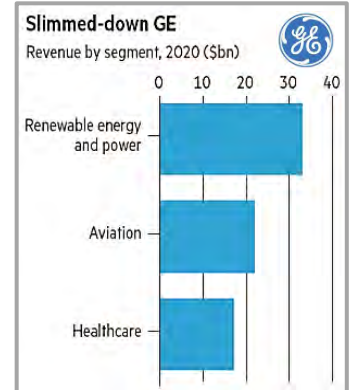
- **Steel imports into the U.S.** YTD through October increased 38.5% to 26.530 million tonnes (MT); finished steel imports rose 39.6% to 19.012MT vs. the same period last year. Finished steel import market share in the U.S. over the first 10 months of 2021 was estimated at 21%.
- **The LME aluminum cash price** averaged \$1.20/lb in November, down from October's average of \$1.34, but still a long way from the November 2020 average of \$0.88/lb. The drop in the LME price and the lack of spot demand for primary ingot resulted in traders reducing the MW premium to \$0.29/lb. Because of the decline in both the LME aluminum ingot price and the Midwest premium, the price of mill products will decline by \$0.20/lb in December.

- **Ford Motors** entered into a strategic agreement with U.S.-based semiconductor manufacturer GlobalFoundries to develop chips, a pact that could eventually lead to joint U.S. production. Ford’s move may eventually bring some chip development in-house. The auto maker said designing its own chips could improve some vehicle features—such as automated-driving capabilities or battery systems for electric vehicles—and potentially help Ford sidestep future shortages. Part of the agreement with GlobalFoundries is intended to enhance near-term chip supplies for Ford.
- **General Motors** is seeing a better flow of semiconductors, and most of its assembly plants in North America are now back to running regular production, including Mexico. The first week of November represented the first time since February that none of GM’s North American assembly plants were idled due to the chip shortage.



- **Samsung Electronics** plans to build a \$17 billion chip plant in Taylor, Texas, a mega investment by the South Korean tech giant. The Taylor factory is expected to serve as an advanced chip-making facility for Samsung’s contract-manufacturing operations, making semiconductors designed by other firms. Such high-end manufacturing is attracting the bulk of semiconductor industry investment. The types of chips with the longest backlogs tend to be lower-priced and haven’t been the focus for massive expansion. (See **Appendix: Automotive**, page 10)
- Key Update:** Samsung, the world’s largest semiconductor maker by revenue, plans to invest more than \$205 billion over the next three years, with chip-making a priority. Taiwan Semiconductor Manufacturing Co. has earmarked more than \$100 billion over the next three years to build new chip factories. Intel Corp. has also unveiled more than \$100 billion worth of semiconductor factory investments plans in the U.S. and Europe over the coming decade.

- **General Electric** plans to split into three public companies, the culmination of a years-long process of shrinking the company. GE has already sold off its locomotive and home appliances business, spun off its oil-and-gas operations and sold most of its once massive financial services arm. What remains are three businesses—aviation, healthcare and power.



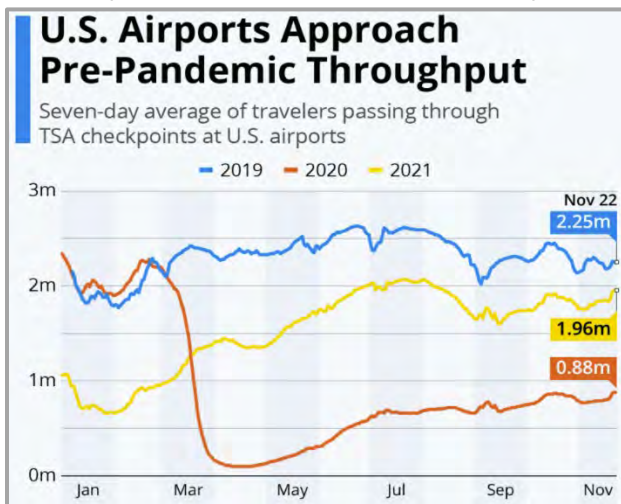
GE Healthcare, which makes MRIs and other hospital equipment, will be spun off in early 2023. GE plans to combine its power unit and renewable energy unit, which make turbines for power plants and wind farms, and spin off that operation in early 2024. That would leave behind a company focused on making and servicing jet engines.

Key Update: The global market for equipment for medical imaging—including ultrasounds, MRIs, X-rays and CT scans—was worth around \$22 billion in sales globally in 2020. GE’s healthcare unit is the world leader in the medical-imaging equipment market with a share of around 26%, closely followed by Siemens with 21% and Philips with 17%.

- **U.S. utilities** are facing the highest natural gas prices in years as they build stockpiles for winter. Pipelines to Mexico and Canada and tankers traveling to Europe and Asia have moved record amounts of U.S. gas this year as parts of the world fall short of supplies. Frackers are holding the line on new drilling as investors pressure them. Natural gas exports are pushing domestic prices higher—only the second time this has happened since companies began shipping shale gas from the Gulf Coast in 2016. U.S. Henry Hub gas prices reached \$5.59 per million BTUs, up from just over \$3 a year ago. (See **Appendix: Energy**, page 9)
- **A record amount of renewable electricity** was added to energy systems globally in 2021, but it remains about half of what is needed annually to be on track to reach net zero emissions by 2050, according to the International Energy Agency. New renewable power capacity is forecast to reach 290 gigawatts this year, surpassing last year’s record of 280GW, the IEA said in its annual review of renewable energy. This compares with current fossil fuel and nuclear power capacity of 4,800GW. However, higher commodity prices, which were driving up the cost of producing and transporting solar panels and wind turbines, threatened to undermine investments in the short term, the report said.

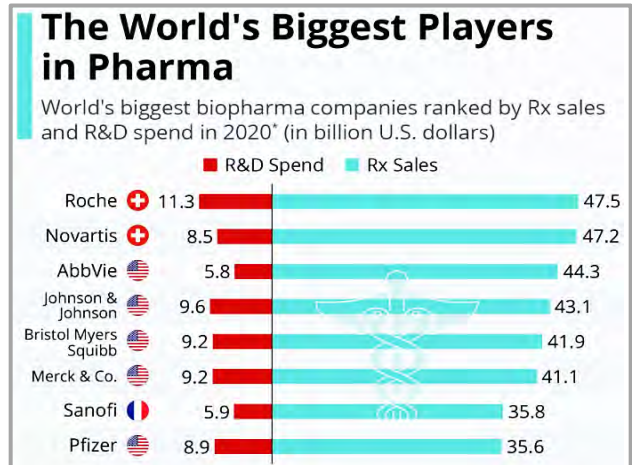


- **SpaceX** launched another crew of astronauts into orbit, the fourth time the company has blasted astronauts into space for NASA. SpaceX, Elon Musk’s enterprise, has emerged as the leader in human spaceflight in the U.S., providing NASA with an alternative to purchasing seats on Russian government rockets. Meanwhile, Boeing is working to develop a spacecraft that would fly astronauts to the space station as part of NASA’s “commercial crew” program, but Boeing’s effort has suffered through all sorts of problems and delays. The company said it would not back away from the program as a result of the additional costs.
 - **The Pentagon** selected Northrop Grumman, Lockheed Martin and Raytheon to research and develop a missile system that would be able to defend the U.S. against a hypersonic weapons attack. The three companies were awarded separate contracts totaling about \$60 million to develop a glide phase interceptor that would be guided by a constellation of satellites and sensors to intercept a hypersonic missile inside Earth’s atmosphere as it glides towards its target. The program will ultimately yield billions of dollars of revenue for defense contractors.
- Key Update:** *The U.S and its global rivals have intensified their drive to build hypersonic weapons - the next generation of arms that fly at high speeds. As a result, hypersonic arms require quicker defenses and new systems to defeat them.*
- **The International Space Station (ISS)** had to swerve away from a fragment of a U.S. launch vehicle, the head of Russia’s space agency said, the latest in a series of incidents in which space debris has forced astronauts to respond.



- **American Airlines** said the Omicron variant is a threat to trans-Atlantic travel, indicating it will have less flights to Europe in January. Those routes are the most lucrative long-haul market, accounting for up to 17% of pre-pandemic passenger revenues for the major U.S. carriers.

- **Becton, Dickinson & Company**, one of the world’s largest manufacturers of medical products, is optimistic the pandemic is coming under control but has warned that inflationary pressures will continue for up to two years and prices are unlikely to return to pre-COVID levels. Thomas Polen, BD chief executive, said prices for some raw materials, such as plastics and resins, had doubled and transportation costs tripled during the pandemic for the company, which supplies 45 billion medical devices across 190 nations every year. (See **Appendix: Medical**, page 13)
- **Johnson & Johnson** plans to spin off its consumer health division to focus on pharmaceuticals and medical devices. The move underscores how big, diversified corporations are under pressure to simplify their structures, particularly in healthcare, where the slow-and-steady business of selling products such as shampoos and moisturizers has increasingly diverged from the high-risk, high-reward work of developing and marketing blockbuster drugs. J&J’s pharmaceutical and medical equipment business, which makes cancer treatments, vaccines and surgical tools, is on track for nearly \$80 billion in sales this year, way ahead of the \$15 billion for consumer products.

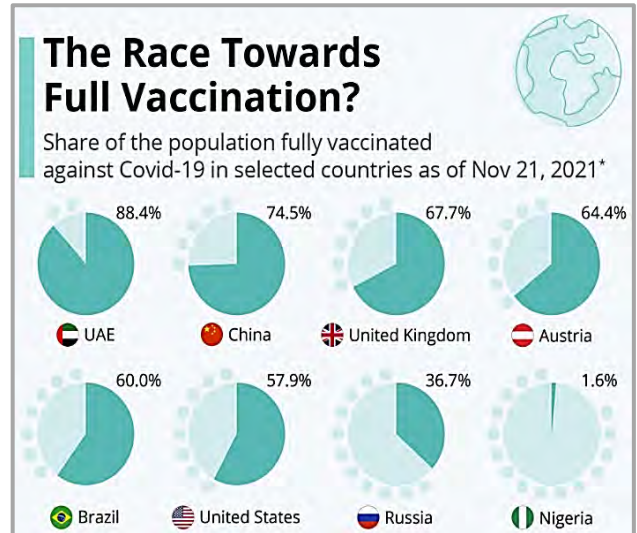


- **NuVasive** resumed U.S. shipments of its titanium-based Precice devices after updating its instructions for use of the products. Global shipments of the devices, which are used to lengthen or shorten limbs, stopped in April as NuVasive worked through the biocompatibility issues raised by European authorities. The stainless steel devices remain off the market but titanium models are available again.
- Key Update:** *The FDA voiced its support for the reintroduction of the titanium-based Precice devices, telling healthcare providers it is in the best interest of patients, as the benefits outweigh the known risks.*

EUROPE, AFRICA & THE MIDDLE EAST

- **Eurozone business activity** strengthened in November, but record inflationary pressures and surging COVID-19 cases weighed on the outlook. IHS Markit said stronger expansion of business activity in November defied economists' expectations of a slowdown, but it is unlikely to prevent the Eurozone from suffering slower 4thQtr growth.
- **Consumer prices in the euro area** rose by 4.9% YOY in November, the fastest increase since the single currency was launched in 1999. Inflation has risen because of high energy costs (up by 27% YOY in November) and supply-chain disruptions. In December, the European Central Bank is expected to announce the date it will end its pandemic asset-purchases.
- **A deal to remove Trump-era tariffs** on UK steel and aluminum is being delayed because of Washington's fears over London's threats to change post-Brexit trading rules in Northern Ireland. The EU and Washington have repeatedly warned London that unilaterally changing the EU-UK accord that sealed Britain's exit from the bloc in 2020 could threaten peace on the island of Ireland.
- **Availability of stainless steel** from domestic European producers remains tight. Steelmakers have been unable to supply sufficient tonnages to service centers and distributors since the rapid upturn in demand in late 2020. Initially, this was most notable in flat product categories, due to the strong rebound in the requirements of the automotive and white goods industries. Delivery lead times vary between mills, but are generally between January and April of next year for 300 series stainless steel coils and a far cry from the pre-pandemic four-week dispatch dates to which many buyers were accustomed.
- **ArcelorMittal** reported its highest quarterly profit since 2008 as the boom in steel prices helped the world's largest producer shrug off weaker demand from carmakers. The Luxembourg-based group reported profits of US\$6.1 billion in the 3rdQtr, 19.9% higher than in the 2ndQtr. Sales were also higher at \$20.2 billion. Steel shipments fell 9% to 14.6 million tonnes vs. the 2ndQtr due to weaker demand.
Key Update: Western steel producers have been enjoying their best year after a decade during which many closed plants and cut staff amid low demand. The global economic recovery from the pandemic has helped to drive demand for steel, while constraints on supply have also buoyed prices. The high price of steel has fed through the supply chain and added to mounting costs of manufacturers in industries including automotive and rail.

- **Tesla** was forced to turn down more than €1.1bn in EU subsidies for its planned battery plant near Berlin after delays to the flagship project breached a key condition of the funding. The EU requires any sites in receipt of the funds to be the "first industrial deployment" of the technology, meaning the batteries cannot already be made at another Tesla plant. Legal challenges to the construction of the factory delayed its opening by several months. That means Tesla is likely to begin producing the same batteries elsewhere sooner. (See **Appendix: Energy**, page 8)

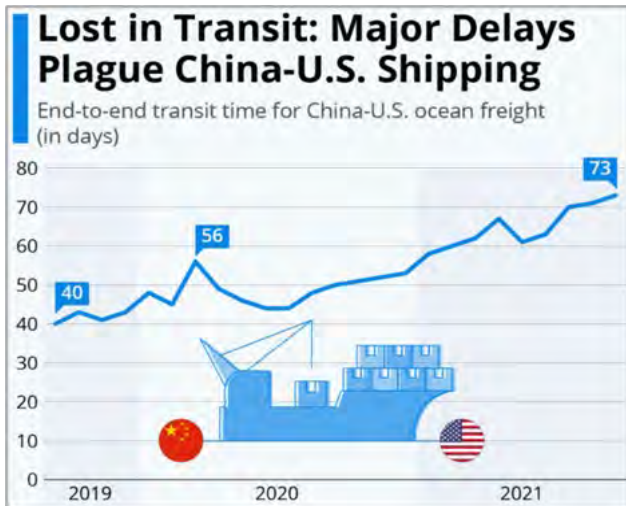


- **Airbus** landed a multi-billion-dollar order for 255 single-aisle jets in a deal that underlines Airbus' forecast that the industry is poised to rebound strongly from the pandemic. The deal packages A321neo aircraft for delivery to a number of low-cost airlines backed by Indigo Partners, including Europe's Wizz Air and Frontier in the U.S. Airbus also secured its first commitment for a new freighter version of its popular A350 aircraft, as Airbus seeks to challenge Boeing's dominance of the booming cargo market. U.S. lessor Air Lease placed an order for seven wide-body A350 freighter aircraft. (See **Appendix: Aerospace**, page 12)
Key Update: Airbus forecast demand for 39,000 new-build passenger and freighter aircraft, 15,250 of these as replacements for aging planes by 2040.
- **Infineon, Europe's largest chip-maker**, almost doubled its profits in the 3rd Qtr, benefiting from surging demand for semiconductors amid a global shortage. The Munich-based company, which relies on the automotive industry for more than 40% of its revenues, said profits for the period were €464 million, up from €245 million in the previous quarter. Infineon CEO Reinhard Ploss said, "Supply is bound to catch up with demand eventually, but we do not see this happening on a broader scale within 2022."

ASIA/PACIFIC, JAPAN, AUSTRALIA & INDIA

- **Factory activity in China** picked up in November, for the first time in three months. The official manufacturing purchasing managers' index rose to 50.1 (any score over 50 represents expansion). In recent months, Chinese manufacturing has been hit hard by surging raw material prices and power-supply crunches—these data suggest the constraints may be easing.

Key Update: *New data restrictions have made it harder to get details on what's happening inside China, including about port activity, supplies and political dissent cases.*



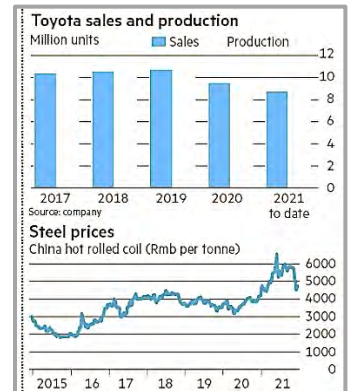
- **Japan's economy** shrank at an annualized rate of 3% in the 3rd Qtr. Global supply chain disruptions and a resurgence in COVID cases cut spending by consumers and businesses. Japanese carmakers reduced their output to address a chip shortage caused by a rise in coronavirus cases in Southeast Asia. Consumer spending fell 4.5% and exports fell 8.3%. It was Japan's first contraction in five quarters.
- **A coal shortage** that led to an energy crisis in China is rippling beyond its borders, threatening to disrupt supply chains and farming in countries that rely on its exports of a chemical used in fertilizer and diesel exhaust systems. India and South Korea are experiencing shortages of urea, which is produced using coal, since China placed new restrictions on exports. It is widely used in India as a fertilizer and in South Korea to produce urea solution, which is used to reduce diesel emissions in vehicles and factories.
- **World crude steel production** was 145.7 million tonnes (Mt) in October, a 10.6% decrease from a year ago. China produced 71.6 Mt, down 23.3% vs. October 2020. The U.S. produced 7.5 Mt, up 20.5% vs. the same month last year. Total crude steel output YTD through October was 1.607 billion tonnes, up 5.9% from the same period in 2020.

- **Japan's largest steelmaker, Nippon Steel**, lifted its net profit forecast for the second time this year to a record US\$4.5 billion, a significant turnaround from a net loss it reported in the last fiscal year. Nippon now expects revenue to rise 39% for the year ending in March. It was reported in August that price negotiations between Nippon Steel and its customer Toyota Motor resulted in a significant increase.

Key Update: *Nippon filed a lawsuit in October against Toyota and Baoshan Iron & Steel for infringing on its patents in nonoriented electrical steel sheets, which is used in electric vehicle motors. The steelmaker is seeking US\$176 million from each company.*

- **Nissan**, Japan's third-largest carmaker, announced plans to invest \$17.6 billion over the next five years to ramp up its electric-vehicle production. It hopes to launch 23 new models and generate half of its global sales from electric or hybrid vehicles by 2030. Last year, the share was only 10%. Nissan is working to remove expensive materials such as cobalt from its EV batteries to reduce the cost to \$75 per kilowatt-hour, 65% cheaper than the current generation of the Leaf, which was introduced in 2017.

- **The Omicron variant** poses further risks to the Toyota's already stretched supply lines. Shortages of chips and other essential parts have come at the same time as high steel prices and a shrinking workforce. Japan has closed its borders in hopes of keeping out travellers harboring the Omicron variant. Toyota's output of cars fell by more than 25% in October



compared with the previous year. Production fell for the third straight month and sales declined by a fifth.

- **China** approved the creation of one of the world's largest rare-earths companies to maintain its dominance in the global supply chain of the strategic metals as tensions deepen with the U.S. The new firm will be called China Rare Earth Group and will be based in resource-rich Jiangxi province in southern China. The new entity would be created by merging rare-earths assets from some state firms. The combined group is designed to further strengthen Beijing's pricing power and avoid infighting among Chinese firms, and to use that clout to undercut Western efforts to dominate critical technologies.

(See **Appendix: Commodities**, page 15)

ECONOMIC UPDATE: APPENDIX TO THE DECEMBER 2021 ISSUE

ENERGY: THE POWER AND ENERGY EFFICIENCY OF A URANIUM PELLETT

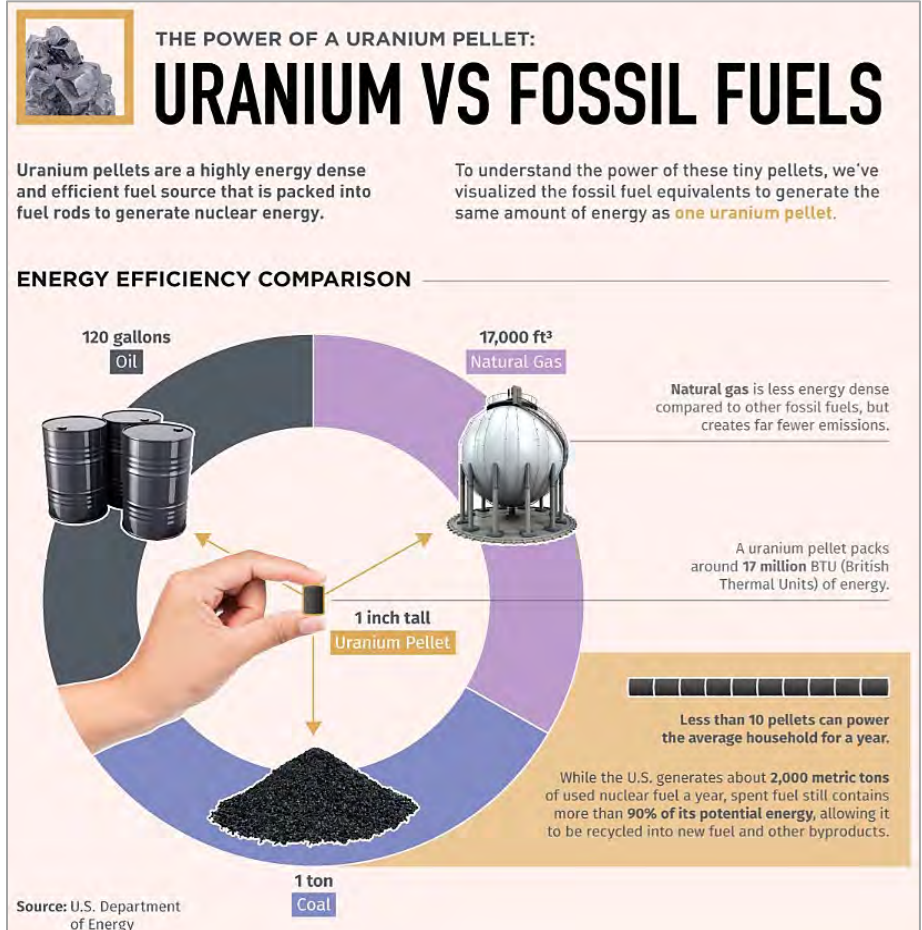
The Energy Efficiency of a Uranium Pellet:

Nuclear energy's incredible efficiency and powerful nature comes from uranium's high energy density. It is the most energy dense and efficient fuel source we have, with just ten uranium pellets able to power the average household for an entire year. Using research from the U.S. Department of Energy, this graphic puts in perspective the efficiency of a single uranium pellet in comparison to fossil fuels. **Uranium's energy efficiency comes from its highly dense atomic and material nature, which is split apart when nuclear fission occurs.** It is the second-heaviest metal in terms of relative atomic mass and is also one of the densest at around 19 g/cm³. For context, a gallon of milk weighs around 8 lbs, while a same-sized container of uranium would weigh around 150 lbs. In the process of nuclear fission, the U-235 isotope of uranium is hit by a moving neutron and splits in two. This splitting of the atom produces heat energy and releases more neutrons that hit other U-235 atoms, causing a chain reaction of nuclear fission. The energy generated by the fission of a single uranium pellet is equivalent to 1 ton of coal or 120 gallons of crude oil or 17,000 ft³ of natural gas. With about 17 million BTU worth of energy in a uranium pellet, many are now looking at nuclear energy as a key piece to the clean energy puzzle. Nuclear power isn't just an improvement over fossil fuels, it also beats out renewable energy sources in a few other key areas. Along with low lifecycle emissions, nuclear power also has a low land footprint and the highest reliability compared to other sustainable energy sources.

Nuclear Energy's Water Usage and Waste Disposal: Although nuclear energy is incredibly efficient and much cleaner than fossil fuels, it still isn't quite a perfect energy solution. Nuclear power plants rely on large amounts of water especially for their cooling operations, which is why many are located near bodies of water. When compared with other energy sources, many estimates find that nuclear power plants typically consume the most water when using cooling towers. Along with their water consumption, nuclear power plants also produce nuclear waste which must be safely removed and stored in a permanent disposal site. While countries such as France, Germany and Japan recycle the majority of their spent fuel, the U.S. currently treats it as waste. This results in the spent uranium fuel needing to be cooled for 2-5 years, with the most common cooling method requiring even more water consumption.

Uranium's Future as the World's Energy Fuel: While uranium offers an incredible amount of energy in a tiny package, nuclear power is still working to shake off the shadows of past incidents like Fukushima, Three Mile Island, and Chernobyl. Despite this, nuclear still is an incredibly safe energy source compared to fossil fuels, and safety improvements continue to be invested in and researched today. Nuclear energy is also receiving a fiscal boost in the U.S., with the recent infrastructure bill passed by the Senate providing funding for two commercial-scale demonstration projects. Just as important, the bill also mentions that when determining whether to certify a reactor, priority will be given to reactors that use uranium produced and enriched domestically. As the world continues working to reduce carbon emissions, people recognize that uranium's energy efficiency could be vital in weaning the world off of fossil fuel dependence.

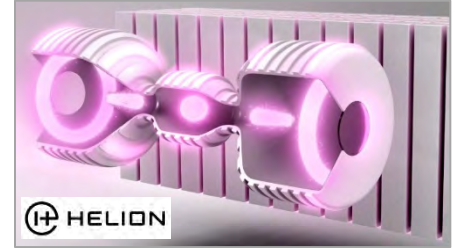
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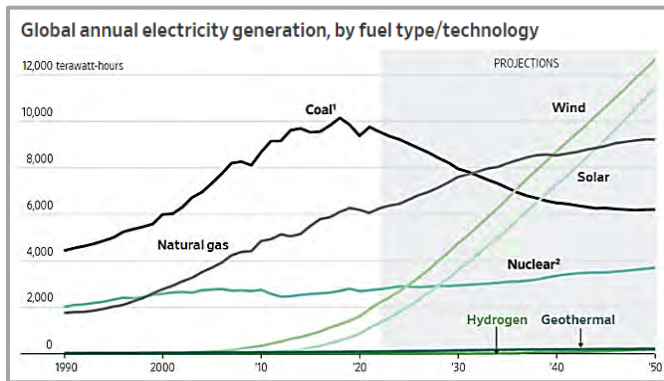


ENERGY: NUCLEAR FUSION START-UP HELION RECEIVES \$500 MILLION BOOST

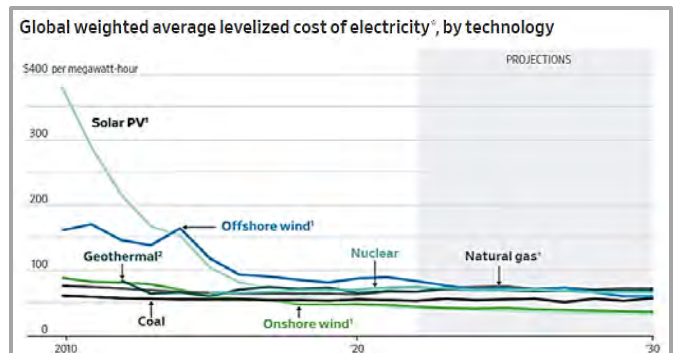
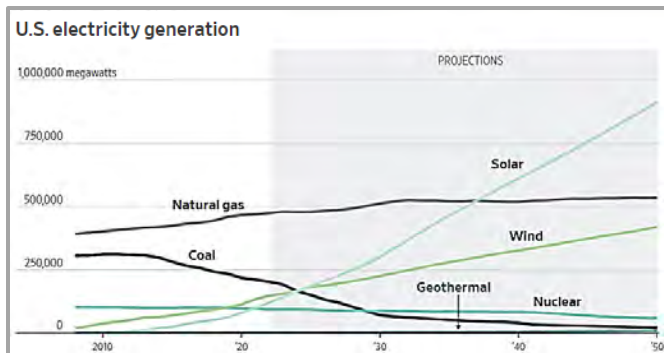
A nuclear fusion start-up backed by Silicon Valley investor Sam Altman and Peter Thiel’s Mithril Capital has secured \$500 million to demonstrate commercially viable power in the largest capital-raising effort yet by a private fusion company. **The investment in U.S.-based Helion is the latest sign of growing private sector confidence in the potential of nuclear fusion to provide clean, cheap power.** “Fusion has been missing from the global conversation about what we’re going to do about the climate crisis, but that is rapidly changing,” said Altman, who will join Helion as executive chair. The newly formed Fusion Industry Association said in November that at least 35 different companies were now pursuing nuclear fusion around the world. The prospect of fusing atoms to generate almost unlimited power from minimal fuel has tantalized scientists for decades. Soviet scientists pioneered development of the first fusion machine, known as the “tokamak”, in the 1950s, but no group has been able to achieve fusion while producing more electricity than the system consumes. Unlike the tokamak approach, which uses energy from the fusion reaction to drive steam turbines, Helion’s system enables it to generate electricity directly from the fusion reaction as the fuel expands. David Kirtley, Helion’s CEO, compared it to the regenerative braking system in a Tesla electric car, where the kinetic energy from the vehicle is used to recharge the battery system. “The key there is that we can bypass the capital cost and the complexity of all those steam turbine systems and focus on getting fusion as small and fast as possible.” The \$500 million investment, led by Altman, fully funds Helion to build by 2024 what would be the first fusion demonstration plant to generate net electricity. If successful, the investors, who also include Facebook co-founder Dustin Moskovitz and sustainability-focused Capricorn Investment Group, have committed to a further \$1.7 billion to fund future manufacturing. Helion wants to produce 50 megawatt fusion generators the size of shipping containers that can be transported to a site and plugged in. Sufficient to supply 40,000 homes, the company initially hopes to power data centers and other industrial sites. “With a small amount of fuel, you can generate a tremendous amount of energy,” Kirtley said. **Helion’s approach uses the hydrogen isotope deuterium, which can be extracted from seawater. It is combined with helium and heated to more than 100 million° C, causing the atomic nuclei to fuse, releasing vast amounts of energy.** One glass of the fuel is equivalent to the energy potential of 1 million gallons of oil and could generate 9 million kilowatt hours of electricity, enough to power a home for 865 years, according to Helion. “The key is that we can focus on getting fusion as small and fast as possible,” said David Kirtley, Helion CEO.



ENERGY: HOW FAR HAVE WE REALLY GOTTEN WITH ALTERNATIVE ENERGY?



The call to move to cleaner forms of power comes from all sides—utilities, politicians, advocates and energy companies. There are all sorts of ideas on where to go and how to get there. Where exactly do we stand on alternative energy now? There’s definitely big movement under way. **Electricity generation from coal, oil and natural gas represented 60% of all power generated world-wide this year, down from 67% in 2010 and is projected to drop to 42% to 48% by 2030, depending on how aggressively countries move toward renewables.** Each of the alternative fuels has its own potential, and its own obstacles. The graphs show a closer look at current status and outlook for carbon-free energy that could play a bigger role in the future.





TRANSPORTATION: HYDROGEN-POWERED VEHICLES – A REALISTIC PATH TO CLEAN ENERGY?

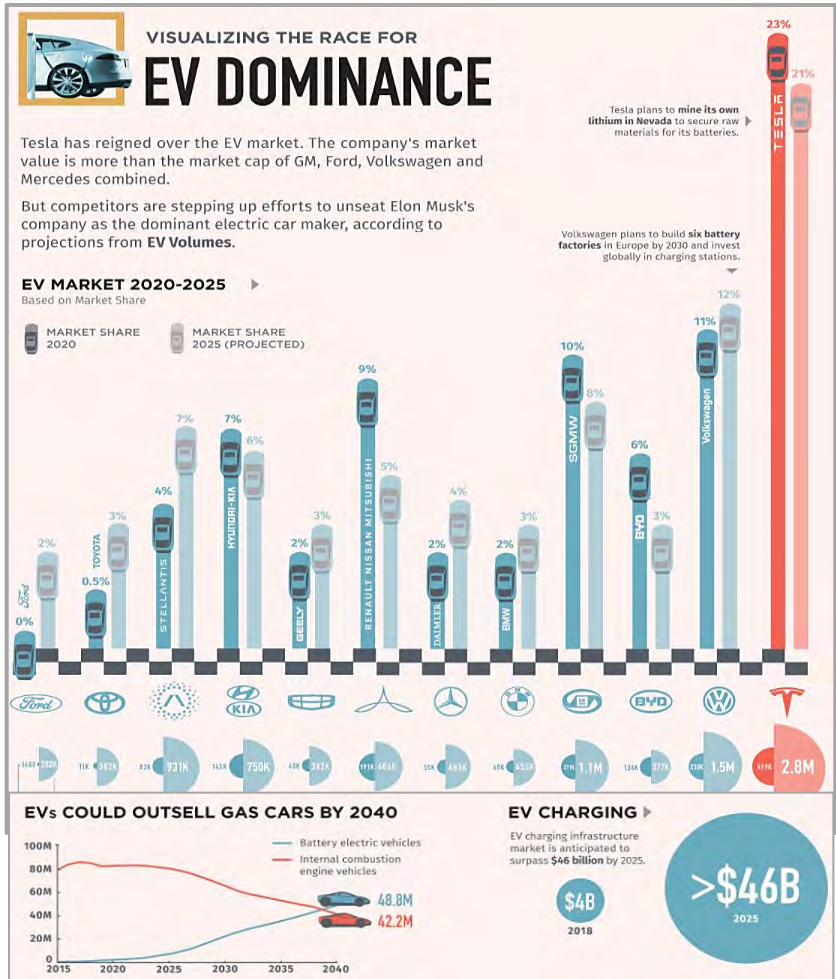
Manufacturers of large trucks and commercial vehicles are beginning to embrace hydrogen fuel cell technologies, as are makers of planes, trains and passenger vehicles. Transportation is the single biggest U.S. contributor to climate change, which is why hydrogen power is seen as a potentially important way to help reduce carbon emissions. **GM, Navistar and the trucking firm J.B. Hunt plan to build fueling stations and run hydrogen trucks on several U.S. freeways within three years. Toyota, Kenworth and the Port of Los Angeles have begun testing hydrogen trucks to haul goods from ships to warehouses.** Volvo Trucks and Daimler Trucks have announced partnerships as well. The companies hope to commercialize their research, offering zero-emissions trucks that save money and meet stricter pollution regulations. Toyota is two years from having a hydrogen truck ready for sale. A test



at the Port of Los Angeles started in April, when the first of five semis with Toyota hydrogen powertrains began hauling freight to warehouses in Ontario, about 60 miles away. The \$82.5 million public-private project eventually will have 10 semis. The long-haul trucking industry appears to be the best bet for early adoption of hydrogen. Fuel cells, which convert hydrogen gas into electricity, provide a longer range than battery-electric trucks, fare better in cold weather and can be refueled much faster than electric batteries can be recharged. Proponents say the short refueling time for hydrogen vehicles gives them an edge over electric vehicles for use in taxis or delivery trucks, which are in constant use. Currently, it costs more to make a hydrogen truck and produce the fuel than to put a diesel-powered truck on the road. Hydrogen costs about \$13/kilo in California, and 1 kilo can deliver slightly more energy than a gallon of diesel fuel, which is only about \$3.25/gal. Experts say that disparity will narrow as they scale up the technology for production. A diesel semi can cost around \$150,000. Nikola, a startup electric and hydrogen fuel cell truck maker, estimated about \$235,000 for each hydrogen semi it sells.

AUTOMOTIVE: ELECTRIC CAR COMPANIES – EATING TESLA’S DUST

Tesla has reigned supreme among electric car companies, ever since it first released the Roadster back in 2008. **The California-based company ended 2020 with 23% of the EV market and recently became the first automaker to hit \$1 trillion market capitalization.** However, competitors hope to accelerate their own EV efforts to unseat Tesla as the dominant manufacturer. This graphic compares Tesla and other top carmakers’ positions today and gives market share projections for 2025. The auto majors are playing catch-up. According to Wood Mackenzie, Volkswagen will become the largest manufacturer of EVs before 2030. To achieve this, VW is in talks with suppliers to secure direct access to the raw materials for batteries. It also plans to build six battery factories in Europe by 2030 and to invest globally in charging stations. Still, by 2025 VW is forecasted to have only 12% of the market versus Tesla’s 21%. GM wants to stop selling fuel-burning cars by 2035 and is making a big push into pure EVs, with more than 30 new models expected by 2025. Ford expects 40% of its vehicles sold to be electric by the year 2030, laying out plans to invest tens of billions of dollars in electric and autonomous vehicles in the coming years. Bloomberg forecasts annual passenger EV sales to reach 13 million in 2025, 28 million in 2030, and 48 million by 2040, outselling gasoline and diesel models.



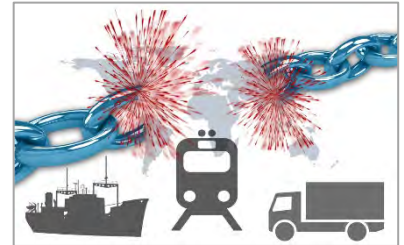


ECONOMY/SUPPLY CHAIN DISRUPTION: IS THE WORST OVER?

Supply chain glitches dominated the latest company earnings season, with mentions of the issues by chief executives jumping 412% from last year. The coming months will show if the snarl-ups portend a toxic scenario of stagflation for the world economy or are just a bump in the road to recovery. As companies, investors and policymakers fret over port logjams, freight costs and chip shortages, some indicators are starting to signal that global supply chain stress may be on the wane. Here are some indicators that may show the problems easing.

Ships and ports: Cargo shipping costs tracked by the Baltic Exchange Dry index are down a third in the past month after hitting their highest since 2008 in October.

Further out, data from shipbroker Alibra Shipping shows six-month contracts for Atlantic and Pacific routes cost \$54,000 and \$52,500 a day respectively for capesizes, the largest dry cargo vessels. For contracts in 12 months, Pacific routes slip to \$36,000 and then \$26,000 two years out. This could mean the market doesn't anticipate that the port congestion situation will be as big a problem next year. Port congestion has eased at most Chinese ports but the giant Los Angeles/Long Beach container port still has a backlog of 222,000 TEUs (twenty-foot equivalent unit). The time-of-turnaround metric for the key U.S. port is at 7.5 days compared with 3.5 days before the coronavirus pandemic and normally is not expected to be restored until May 2022.



Inventories: Purchasing managers say delivery times are deteriorating for manufacturers worldwide, with the global delivery time index down to 34.8 in October.

Any number below 50 shows deliveries are taking longer and October's reading was the worst on record. Jefferies analysts expect shortages to intensify at the end of 2021 before demand shifts towards services. They said that should ensure supply chain bottlenecks begin to clear by the 1stQtr of 2022 as seasonal demand drops sharply and inventories are rebuilt. The PMI orders-to-inventories ratio in the euro zone has been declining, and some manufacturers are already bracing for shortages to turn into gluts.

Chips: The outlook for semiconductors is murkier. Chip shortages will cut global light vehicle production by 5 million this year, IHS Market estimates, while some carmakers warn that constraints could last through much of 2022.

Toyota said the worst was over. Asset manager Capital Group says carmakers who cancelled orders when the pandemic hit were then caught as spiralling chip demand from the gaming and cloud computing sectors gobbled up available semiconductors. "Since it takes about four months to manufacture auto chips, the situation is likely to correct itself by the end of this year." While Malaysian chip suppliers predict it will take two to three years for the market to normalize more broadly, the industry is also boosting production with 3rdQtr sales rising to \$145 billion.

Wood, paper, metal: China's growth slowdown may play against further commodity price rises and weaker property markets are resulting in a plunge in the price of iron ore.

Beijing has also moved to tame energy prices after power shortages shuttered swathes of factories and mines. Those steps knocked coal futures off record highs and also hit metal prices. China's record paper pulp market rally early this year sent prices sky-rocketing globally, causing shortages of packaging materials. Since May, Shanghai-traded wood pulp futures are down 30%. U.S. futures for lumber, a key housebuilding component, are also 60% below springtime highs.

COVID-19: Vaccination rates against COVID-19 are creeping higher in key manufacturing nations, especially chip suppliers such as Malaysia and Taiwan, making production disruptions less likely.

UBS estimates vaccination rates in Vietnam, Taiwan and Malaysia should reach 80% by January 2022. Portfolio strategists are optimistic about supply chains, as long as COVID-19 is tamed.

ECONOMY/CLIMATE: HOW THE WORLD PUTS A PRICE ON CARBON



As the COP26 climate change conference concluded in Glasgow, **the World Economic Forum and PwC (a consulting firm) published calculations that suggest creating an international price for carbon emissions could reduce global greenhouse gases by 12%, while costing less than 1% of global GDP.**

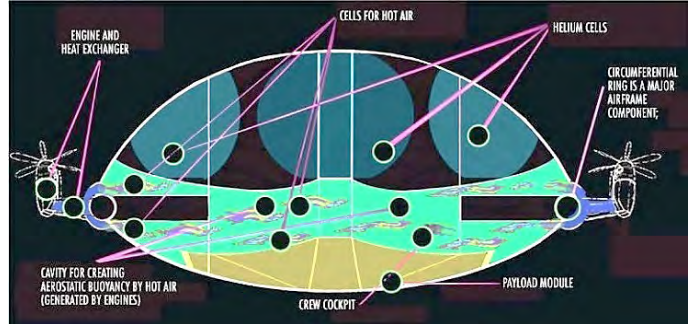
The report is based on a scheme proposed by the IMF earlier this year, under which companies with high greenhouse gas emissions in high-income countries would be subject to a carbon price of \$75 for every tonne of carbon dioxide emitted. This would fall to \$50 a tonne for polluters in middle-income countries, and \$25 a tonne for low-income countries. As this infographic using OECD data shows, carbon pricing varies hugely among the world's largest economies. Some of the most stringent carbon policies are carbon taxes European countries have implemented. Nevertheless, looking at the G20 countries specifically, the OECD warns that further action is urgently needed across the board: "Around half of all emissions in

G20 countries remain unpriced, and price levels are not high enough for a successful transition to net zero."



AEROSPACE: INNOVATIVE AIRSHIPS COULD CHANGE THE FACE OF TRANSPORT AIRCRAFT

While some aerospace engineers are working on attention-getting aircraft such as supersonic airliners and Mach 3+ jet fighters, others are focused on the more mundane but more useful goal of developing innovative heavy-lift cargo aircraft. One such team of designers at the Airship Initiative Design Bureau Aerosmena (AIBDA) in Russia is working on a lighter-than-air hybrid that could expand the scope of aviation and cargo transport. **Their approach combines helium and hot air for lift, along with turboprop jet engines turning helicopter-like rotors for propulsion, thrust-vectoring, control and some additional lift.** The Russian-team, plans on turning out a family of four such airships that can carry anywhere from 22 to 660 tons up to 3,700 miles. The planned A600 airship will be able to carry 660 tons of cargo or passengers a distance of 3,700 miles. Its 807-ft diameter gives it a bigger footprint than the Superdome, which has a 680-ft diameter. The AIBDA concept consists of two modules: the flight module (FM), which is a piloted airship, and mission-specific payload modules (PM). The FM contains the lift and propulsion subsystems and acts as the aircraft's "locomotive." Each FM can carry a PM clipped and clamped onto the rigid internal cross-truss structure on its underside. Attaching a PM to the FM takes about 15 min. for the smaller airships and 45 min. for large ones, based on preliminary designs. The designers envision a range of PMs tailored to the mission at hand. They could carry strictly cargo, passengers, or a mix of both. PMs could also be outfitted as firefighters, mobile hospitals or repair facilities, luxury "yachts," sightseeing vehicles and military drone carriers. For bulky and oversized cargo too large for other PMs, such as an entire building or drilling rig, a PM could be equipped with winches and cables to pick up and deliver the payload on a sling hanging below the airship. This eliminates the need for any landing field and will let the airships service remote, forested areas or crowded cities, as well as stationary and underway ships at sea.



AEROSPACE: WHAT'S ON AEROSPACE LEADERS' MINDS AS 2021 COMES TO A CLOSE?

Competition from China: China's jet industry may be behind, but "they don't mean to stay that way," Washington Lt. Gov. Denny Heck said at the Aerospace Futures Alliance summit in late October. China's ability to perform quick pivots under its command-and-control leadership could give its manufacturers an edge as it grows to take on Washington's considerable industry base, but the relationship doesn't have to be adversarial, Heck added. "I don't think we should look at China as the enemy, but I do think we should look at them as our fiercest competitor, and we have to take that very seriously." China likely won't have the same outside demand for commercial jets that it had in the past two decades, senior aerospace analyst Richard Aboulafia said in a recent virtual forecast. While its relationship with the West is changing as it prioritizes its fledgling domestic industry, Chinese jet makers are still heavily dependent on Western technologies from engines to avionics, which is likely to keep them at the table. **Supply**



chain challenges: Janene Collins, vice president of supply chain contracts and sourcing at Boeing, said the company's chief struggle is the consolidation of its supply base. Those with the balance sheet to do so used the pandemic-driven recession to buy up capacity they don't have, she said. Around 65% of the global aerospace giant's costs come from its supply chain, which is still catching up to demand from the recovering airline industry. In response, Boeing created an internal team to better understand its 5,400-factory supplier network, which produces billions of parts that need to be delivered "just in time" to meet the its production rates, she said. Those rates have increased to 19 planes per month by the end of the 3rdQtr, and its inquiries have indicated its supply chain can support the 31 planes it plans to produce per month by 2022. **Rising costs:** Rising labor costs are the most "organic" form of cost increases and a leading indicator of the inflationary pressures manufacturers are likely to see in the coming months, Aboulafia said. While long-term pricing contracts could mask the trend in the short term, costs for materials have risen over the past several years while commercial jet prices have stayed stubbornly flat, squeezing profit margins for Boeing and Airbus. **Sustainability investments:** Infrastructure is the watchword for sustainability efforts, aerospace leaders said. While manufacturers are game to develop technologies ranging from sustainable aviation fuels (SAF) to hydrogen and battery-powered electric propulsion, each one will require huge investments to enable mass production and delivery, said Jon Gordon, co-founder of Hawthorne, California-based Universal Hydrogen. "The infrastructure problem is tremendous, but it can't be the excuse anymore," he said. "We don't have time." While sustainable technologies could take an unusual form — like the hinged wing that helped Boeing increase fuel efficiency on its 777X — fuel reduction and SAF are only an interim measure, he said.

MEDICAL: PEDIATRIC HEALTH – SCREENS DON'T REALLY HURT KIDS, THEY MAY HAVE SOME BENEFITS

School-aged children who spend more time in front of screens are only slightly more likely to have attention disorders, disturbed sleep or lower grades and are no more likely to suffer from depression and anxiety, finds one of the largest studies to date to explore how screen time impacts youth. The research, published in the September issue of the journal *PLOS ONE*, also revealed a potential upside to the oft-maligned devices: Kids who spent more time with screens had more close friends. On average, boys spent about 45 minutes more daily with screens than girls, topping out at nearly five hours daily on weekends and four hours on weekdays. Boys and girls used screens differently, with boys spending twice as much time with video games, while girls spent more time engaging with social media. (The data, collected prior to the COVID-19 pandemic, did not include screen time associated with homework or online learning.) Like previous smaller studies, the research found that children who spent more time in front of screens tended to sleep worse, get poorer grades and show more 'externalizing' behaviors (things like ADHD, Conduct Disorder and Oppositional Defiant Disorder). **However, compared to other factors shaping their lives, the influence of screen time was minute. For instance, a child's socioeconomic status had 2.5 times greater impact on such behavioral outcomes. Of all the influences assessed, screen time accounted for only about 2% of the variation between kids in the outcomes measured.** "A number of papers in recent years have suggested that screen time might be harmful for children, but there have also been some reviews that suggest those negative effects have been overestimated," said senior author John Hewitt, director of the Institute for Behavioral Genetics. "Using this extensive data set, we found that there are relationships between screen time and negative outcomes, but they are not large and not dire." While the study did find associations between screen time and some mental health and behavioral problems, Paulich stressed that this does not mean it caused them. In fact, the reverse could be true. Because the new study looked only at youth aged nine and 10, the findings don't necessarily apply to older kids.



STEEL: DECARBONIZATION OF PRIMARY STEELMAKING ESSENTIAL TO MEET PARIS GOALS

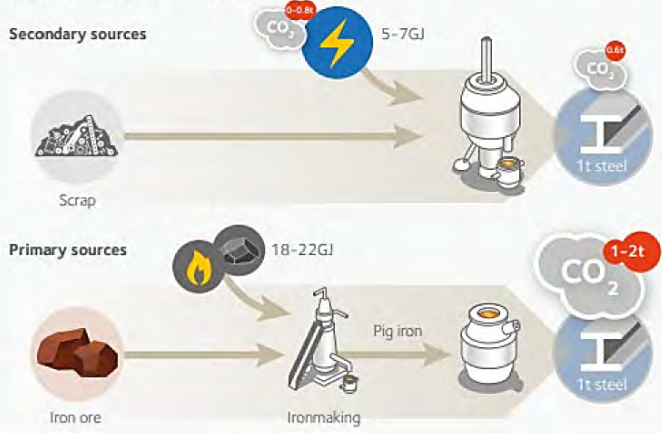
Decarbonisation of primary steelmaking will be needed to meet Paris goals

Availability of scrap is limited; recycling of existing steel will be insufficient to meet total demand for decades



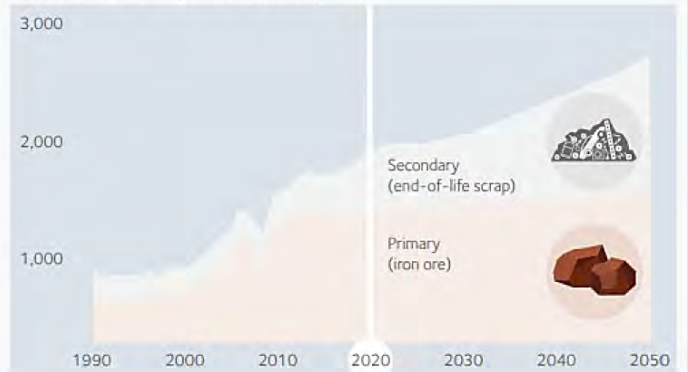
- Availability of secondary sources of iron (scrap) is limited; is dependent on steel products reaching end of life
- scrap currently provides ~30% global steel demand. Decarbonisation of primary steelmaking requires industrial transformation

Today, steel from primary sources (iron ore) has much higher CO₂e emissions than from secondary sources (scrap)



As with most materials, the world is going to need to rely mainly on primary sources (iron ore) beyond 2050

Global steel demand outlook, without taking into account additive manufacturing or behavioral circular economy trends



STEEL/INNOVATION: STEEL-BUILT HYPERLOOP TECHNOLOGY REVOLUTIONIZES HOME DELIVERY

The explosion in e-commerce has had a corresponding impact on city streets, with delivery vehicles and the emissions they produce rising steadily over time. Global shipping volumes are expected to reach 200 billion parcels by 2025, and this continuing rise in deliveries comes with an environmental cost at a time when there is renewed focus on curbing emissions. The World Economic Forum is predicting a 30% rise in urban last-mile delivery emissions in the planet's 100 largest cities by 2030. **Magway aims to eliminate those emissions and take that congestion off the streets with its revolutionary approach that could massively improve the sustainability of delivery systems in urban centers.** Co-Founder of Magway Phill Davies says, "Magway is a solution for addressing the explosive growth of online deliveries and the resulting volume of goods that have been transported on polluting vehicles. Initial installations are focused on connecting a West London distribution center with two large consolidation centers just outside the city, with the capacity to handle more than 600 million parcels a year. The carriages that carry deliveries will run through pipes that are just one meter in diameter. The system is capable of handling 90% of parcels that are ordered for delivery. There are no driver limitations, and the tunnel system offers a highly secure delivery method with no chance of road accidents. It can also operate efficiently any time in any weather, as well as offering accurate tracking of parcels along delivery routes. Magway runs inside plastic small diameter pipes similar to those utilized by large gas and electricity providers. Magway's carriages travel just milliseconds apart from each other at speeds of up to 30mph. Automated loading and unloading processes controlled by advanced computer programming maintain a steady flow of carriages through the system. The carriages are lightweight plastic with a steel carriage and wheel structure that does not contain a motor or battery. Instead, they are propelled by linear synchronous magnetic motors that are installed in the structure of the track. Mounted to each carriage is an array of ultra high-strength permanent magnets. This array is then propelled forward by a magnetic wave that repels the magnets in the carriage. The magnetic wave of electrical current is powered directly from the grid and the lack of moving parts in the drive train keeps the operating and maintenance costs very low. Davies says, **"We have a steel wheel on steel rail to give us maximum durability of the carriage as well as the track. With respect to rail, we tried aluminum but didn't get the durability. The steel rail is incredibly easy to work with – it bends easily, and it's highly durable."** Steel also forms a crucial part of the linear motor system embedded in Magway's track, with a 7kg steel core with three copper windings constituting the coil. This coil is combined with silicon laminations which boost steel's natural speed and efficiency at producing and maintaining magnetic fields. **Steel's unique electromagnetic qualities and its durability are at the center of the Magway system.** Magway intends an installation to have a lifetime of between 50 to 80 years and has a plan for recycling – another area where steel performs well as a material due to its infinite recyclability.



METALS/INNOVATION: A CLEARER SOLUTION WITH NICKEL OXIDE FOR FULLY TRANSPARENT SOLAR CELLS

It's a brilliant idea with a bright future — glass with invisible solar panels that generate electricity. In a recent study published in the *Journal of Power Sources*, Professor Joondong Kim and his colleagues at Incheon National University, Korea, detailed **their latest invention: fully**



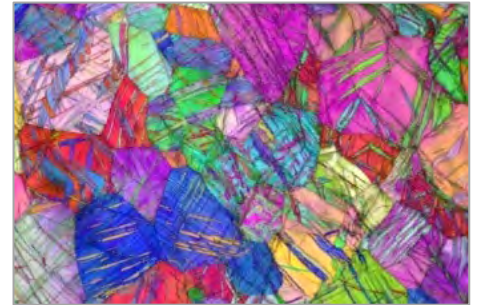
transparent solar cells that can be integrated into windows, buildings, or even mobile phone screens. Abundant and easily manufactured nickel oxide is playing a pivotal role. Until now, solar cells tended to be opaque, limiting their use. Professor Kim and his team developed an innovative technique, zeroing in on the heterojunction, which comprises thin films of materials responsible for absorbing light. To make the junction, the researchers chose nickel oxide, a semiconductor known to have high optical transparency. By combining titanium dioxide and nickel oxide semiconductors, they generated an efficient, transparent solar cell. The device was built with a glass substrate,

a fluorine-doped tin oxide (FTO) film – on top of which the two layers were deposited – and a coating of silver nanowire. "The FTO and silver nanowires serve as the bottom and the top electrodes for collecting photo-generated carriers, respectively," the Korean team explained, adding that the heterostructure-based TiO₂ can also separate the photogenerated charges by the internal electric field at junction interface, resulting in self-powered operation. The measurements taken by the scientists showed that the integrated PV device is able to produce electric power with a conversion efficiency of 2.1%, with more than 57% of visible light being transmitted through the cell's layers. By UV illumination, the transparent solar cell generated power to move a motor. This clearly suggests the transparent solar cell would serve as an invisible power generator. The low-cost cell may be suitable for various applications in many electronic devices.

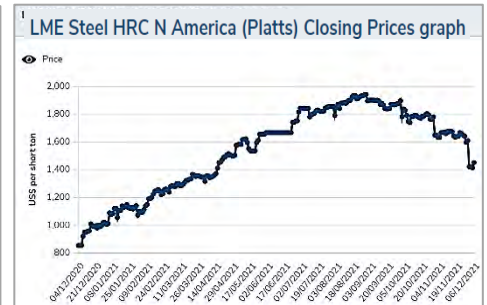


METALS/INNOVATION: NANOTWINNED TITANIUM FORGES PATH TO SUSTAINABLE MANUFACTURING

Titanium is strong, lightweight and has the highest strength to weight ratio of any structural metal, but processing it while maintaining a good balance of strength and ductility is challenging and expensive. Now, researchers at the Lawrence Berkeley National Laboratory have discovered a new and practical path forward. **The team found that they could use a technique called cryo-forging to manipulate pure titanium on the scale of a billionth of a meter (a nanometer) at ultra-low temperatures to produce extra-strong "nanotwinned" titanium without sacrificing any of its ductility.** The mechanical properties of metals depend in part on their grains—tiny individual crystalline areas of repeating atomic patterns that form the material's internal structure. Boundaries between grains, where the pattern changes, strengthen metals by stopping defects known as dislocations from moving across and weakening the material's structure. The strength of a material is normally correlated with the size of the interior grains—the smaller the better, but high strength and ductility are generally mutually exclusive properties. Enter nanotwins. **Nanotwins are a specific type of atomic arrangement where the tiny boundaries in the crystal structure line up symmetrically, like mirror images of each other.** A nanotwinned structure makes it easier for atoms to move around without the buildup of stress while maintaining increased strength. Scientists at Berkeley Lab's Molecular Foundry used an electron microscopy technique called electron backscatter diffraction (EBSD) to image the structure of pure titanium with a nanotwinned structure (**photo above**). Each color represents a unique orientation of the grains. The thin strips reveal the nanotwinned structure produced via a process called cryo-forging—manipulating the structure of the metal at ultra-low temperatures. The technique starts with a cube of very pure titanium placed into liquid nitrogen at minus 321°F, and compression is applied to each axis of the cube. Under these conditions, the structure of the material begins to form nanotwin boundaries. The cube is later heated to 750°F to remove any structural defects that formed in between the twin boundaries. The researchers put the newly formed material through a series of stress tests and used electron microscopes to uncover the source of its unique properties. They found that nanotwinned titanium had better formability because it has the ability to both form new nanotwin boundaries and undo previously formed boundaries, both of which help with deformation. They tested the material to extreme temperatures up to 1,112°F, as hot as flowing lava, and found it maintained its structure and properties. At super-cold temperatures, nanotwinned titanium is able to withstand more strain than normal titanium, which is the opposite of what generally happens for most metals—at low temperatures, most materials become more brittle. Nanotwinning doubled the metal's strength and increased its ductility by 30% at room temperature. At super-low temperatures, the improvement was even more dramatic—the nanotwinned titanium was able to double in length before fracturing. **Nanotwinned titanium also maintained its excellent properties at relatively high temperatures, showing that these properties would persist in the extreme cold of outer space and near the intense heat of a jet engine.** Fabricating nanotwinned titanium using cryo-forging is potentially cost-effective, scalable for commercial production, and produces an easily recycled product.



COMMODITIES: COMMODITY PRICES DROPPED IN NOVEMBER — 12 MONTH HISTORY



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Email | economicupdate@ulbrich.com

ULBRICH CORPORATE HEADQUARTERS

153 Washington Avenue, P.O. Box 294
North Haven, CT 06473

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Charles was a Senior Vice President of procurement in the metal container industry, with a career spanning nearly four decades. He specializes in steel and aluminum procurement and utilizes his expansive knowledge of the steel and aluminum industry in the production of this detailed monthly update for Ulbrich and the company's valued employees and partners.



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