Chemicals

# Hydrogen: Revisiting Conversion Economics & US Breakevens

September 8, 2020

## Key Takeaway

**Converting to hydrogen is not a simple arbitrage: it depends on site design (e.g. the availability of waste heat); conversion technology (PEM vs. conventional electrolyzers); and whether there is a potential co-product value from CO2. As a rough rule of thumb, the US average electricity price of $0.13/kwH would translate into a hydrogen breakeven of $2.47/kg (~$3.90/kg for the PEM cells) and as high as ~$4.55/kg for a cogen design.**

**Some more rules of thumb on costs:** We estimate a world-scale project (~10MW) would cost ~$1m/MW, with ~30% lower capital intensity by 2025. Electrolyzers typically convert 1 MWh into ~17.5 kg of H2, compared with ~24.2 kg using high-temperature PEM cells. When converting hydrogen into energy, fuel cells typically produce 19 kwH/kg of H2 (~34% conversion efficiency), with PEM cells ~30 and cogen designs ~35. A process that includes a liquefaction step would introduce ~15% incremental energy costs and conversion losses.

**What hue H2?** The hydrogen industry distinguishes between 4 types: "turquoise", made from methane pyrolysis with solid carbon co-products (an attractive feedstock opportunity for carbon black); "green", made through electrolysis of water; "grey", produced by converting natural gas into CO2 and H2 (10 t CO2/t of H2); and "blue": grey hydrogen with the CO2 captured for chemical applications or stored underground (which could cost as much as $60/t of CO2 captured depending on project design).

**Potential bottlenecks & related investment cycles:** Hydrogen bus and truck fleets will require a significant built out of refueling infrastructure. Blending 10%-20% hydrogen into natural gas pipelines for heating applications will likely require a significant investment of capital and staff to retrofit industrial boilers, particularly ones that use the color of the flame to optimize operations. Trains may end up being more straightforward: Linde's train project should be able to support 14 trains in 2022 with a single station producing 1,600 kg/day of H2 (a 18-month trial of two trains was completed in 1H20). As for refineries, we estimate a world-scale unit could consume 150,000-180,000 tpy of H2, though conversion would alter mass balances across the system.

**Hydrogen not just an EMEA story:** >$3bn of US hydrogen projects target >3,300MW of electricity generation, with the hydrogen effectively acting as a battery for storing electricity from wind and solar power. ~1,600MW is targeted in Virginia, ~1,000 MW in both Ohio and Pennsylvania, ~840MW in Utah, ~600MW in New York and smaller plants in California and Florida. Many of these projects have very slow ramp schedules: the Utah project, for example, will only reach full production in 2045-2050.

Laurence Alexander, CFA *
Equity Analyst
(212) 284-2553
lalexander@jefferies.com

Christopher Sighinolfi, CFA *
Equity Analyst
(212) 707-6420
csighino@jefferies.com

^Prior trading day closing price unless otherwise noted.

"Green hydrogen" provokes objections from investors: vague tipping points; sticker shock; the Hindenburg; energy density; greenwashing; political risk; stranded assets and deja vu. Funding often dispels or delays the objections: for example, Germany has a €9bn hydrogen investment target and the UK £12bn. We sketch below frameworks for the first three objections.

First published July 30

**Potential Tipping Points:** Hydrogen is expected to become competitive for heating applications <$5/kg, for commercial vehicles <$3/kg, for passenger vehicles <$2.50/kg, and for low-carbon steel, glass and cement <$2/kg. For chemicals, the arbitrage will depend on the price of oil or natural gas: as a rule of thumb, 1 kg of H2 and 5-6 kg of CO2 can produce 4-5 kg of methanol or olefins. A carbon price, obviously, would shift this framework.

**Dealing With Sticker Shock:** Green hydrogen costs 6x-10x conventional hydrogen is an oft-cited shibboleth. Hydrogen made from natural gas can cost anywhere from $1/kg (US, Middle East) to ~$2/kg (Europe). Adding carbon capture and utilization can add $0.50-$1.00/kg to the cost, and each $10/t carbon tax could add $0.10/kg to the hydrogen cost. In 2019, the EIA pegged the cost of renewable or green hydrogen at $4-$7/kg, falling by ~30% by 2030, with particularly sunny and windy parts of the world moving <$2/kg longer-term (i.e., 15-20 years). Some industry participants peg the potential drop in production cost at 50%-60%, assuming economies of scale (e.g., the electrolysers could drop from ~$750/kW to <$350/kW). Learning rates (deflation in capex driven by cumulative industry experience) for electrolysers have been ~10%, compared to ~20% for wind and >30% for solar and batteries. Another element in the cost bridge is the cost of shipping the hydrogen in a distributed network. Compressing H2 costs ~$0.80/kg and liquefying it ~$1.60/kg -- these costs likely come down by 20%-30% over the course of a decade. Trucking the gas 250-315 miles costs ~$0.40/kg for liquid H2 and ~$1/kg for gaseous: cutting the distribution radius 50-60 miles can save ~$0.10/kg (non-linear). Fueling stations currently cost ~$5/kg: this is expected to come down to <$1/kg through aggressive deflation in equipment costs.

**What About The Hindenburg?** The Hindenburg rivals Three Mile Island and Chernobyl in notoriety, and is cited as shorthand for policy risk for the industry ("it only takes one accident"). Mitigating this, in our view, is that natural gas has comparable risks (e.g. estimates that an LNG tanker explosion could have >50% mortality rates for people within 1.4km and significant building damage and injuries out to 2-3km). Whether hydrogen or natural gas ends up being branded as the more dangerous fuel by consumers, in our view, is mostly a matter of the timing of accidents for each industry. Consumers tend to adapt: the >5,000 fires each year at gas stations (~$20m in total damage annually) have faded far into the background.

**Europe's Hydrogen Strategy Has Far-Reaching Implications:** Europe's hydrogen strategy could drive a reconsideration by ESG investors of the three industrial gas companies – Buy-rated LIN, AI FR, and APD. The hydrogen transition, if successful, would both decarbonize the companies' own production footprint and position them as key providers of technology, enablers through their distribution expertise, and translators who could help energy-intensive industries (steel, cement, glass) reduce their GHG emissions.

First published July 9

**EU Hydrogen Initiative:** As expected, on July 8, the European Commission announced a hydrogen strategy intended to shift hydrogen from <1% of energy consumption to 24% by 2050 while creating a >€800bn market. Hydrogen is envisaged to act as an alternative to batteries as a way to smooth out and backstop intermittent power supplies from wind and solar, as an alternative fuel for mobility, and as a supplement for home heating and other applications.

**Key Applications:** The EU strategy targets: 1) displacing natural gas directly and through blending (existing networks can absorb ~20% H2 blends), 2) contributing to decarbonizing aviation fuels as a feedstock for synthetic fuels or as an aviation fuel outright, 3) displacing hydrocarbons for rail and marine fuel applications, 4) decarbonising steel by powering blast furnaces, 5) complementing EVs as a renewable power alternative for larger vehicles such as trucks, buses, vans, forklifts, and taxi fleets, and 6) a renewable feedstock for olefins along with recycled carbon streams.

**An S-Curve:** The EU's interim targets are 4%-6% by 2030, or a €480-€665bn market. The targets imply displacing 7% of Europe's natural gas consumption by 2030 and >30% by 2050, a build-out of >3,700 fuel stations by 2030 (>€8bn of capex), >€3bn of industry R&D to help bring down production costs and improve efficiency, and a cumulative >€26bn in investment in hydrogen production, >€8bn in hydrogen storage and >€2bn in other network-related infrastructure. We estimate the 2030-2050 investment wave could exceed €200bn.

**Lessons Learned from Renewables:** We expect the EU to support hydrogen initiatives more aggressively and more consistently following the lessons learned in renewables over the past 15 years, particularly the ground lost to Asian competitors in solar and battery materials. We believe the EU hydrogen initiative also balances the Chinese Belt-and-Road methanol initiative.

## Company Valuation/Risks

**Air Liquide SA**

Our €168 PT is based on 28.2x 2022E EPS, and is supported by sector regressions and peer multiples. Key risks: industrial demand, customer capex cycles, project execution, and discipline on new contracts.

**Air Products**

Our $280 price target represents 24.7x 2022E EPS and 15.2x EBITDA**,** in line with peers. Key risks: slowing demand; deterioration in capital discipline.

**Linde PLC**

A 32x 2022E EPS multiple supports our $300 price target, and is based on our growth duration model and peer multiples. Key risk: competitor behavior disrupting supply/demand balances.

## Analyst Certification:

I, Laurence Alexander, CFA, certify that all of the views expressed in this research report accurately reflect my personal views about the subject security(ies) and subject company(ies). I also certify that no part of my compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed in this research report.

I, Christopher Sighinolfi, CFA, certify that all of the views expressed in this research report accurately reflect my personal views about the subject security(ies) and subject company(ies). I also certify that no part of my compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed in this research report.

As is the case with all Jefferies employees, the analyst(s) responsible for the coverage of the financial instruments discussed in this report receives compensation based in part on the overall performance of the firm, including investment banking income. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Aside from certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgement.

## Investment Recommendation Record

**(Article 3(1)e and Article 7 of MAR)**

| | |
|---|---|
| Recommendation Published | September 7, 2020 , 17:55 ET. |
| Recommendation Distributed | September 8, 2020 , 00:01 ET. |

## Company Specific Disclosures

Jefferies Group LLC makes a market in the securities or ADRs of Air Products.

### Explanation of Jefferies Ratings

Buy - Describes securities that we expect to provide a total return (price appreciation plus yield) of 15% or more within a 12-month period.

Hold - Describes securities that we expect to provide a total return (price appreciation plus yield) of plus 15% or minus 10% within a 12-month period.

Underperform - Describes securities that we expect to provide a total return (price appreciation plus yield) of minus 10% or less within a 12-month period.

The expected total return (price appreciation plus yield) for Buy rated securities with an average security price consistently below $10 is 20% or more within a 12-month period as these companies are typically more volatile than the overall stock market. For Hold rated securities with an average security price consistently below $10, the expected total return (price appreciation plus yield) is plus or minus 20% within a 12-month period. For Underperform rated securities with an average security price consistently below $10, the expected total return (price appreciation plus yield) is minus 20% or less within a 12-month period.

NR - The investment rating and price target have been temporarily suspended. Such suspensions are in compliance with applicable regulations and/or Jefferies policies.

CS - Coverage Suspended. Jefferies has suspended coverage of this company.

NC - Not covered. Jefferies does not cover this company.

Restricted - Describes issuers where, in conjunction with Jefferies engagement in certain transactions, company policy or applicable securities regulations prohibit certain types of communications, including investment recommendations.

Monitor - Describes securities whose company fundamentals and financials are being monitored, and for which no financial projections or opinions on the investment merits of the company are provided.

### Valuation Methodology

Jefferies' methodology for assigning ratings may include the following: market capitalization, maturity, growth/value, volatility and expected total return over the next 12 months. The price targets are based on several methodologies, which may include, but are not restricted to, analyses of market risk, growth rate, revenue stream, discounted cash flow (DCF), EBITDA, EPS, cash flow (CF), free cash flow (FCF), EV/EBITDA, P/E, PE/growth, P/CF, P/FCF, premium (discount)/average group EV/EBITDA, premium (discount)/average group P/E, sum of the parts, net asset value, dividend returns, and return on equity (ROE) over the next 12 months.

### Jefferies Franchise Picks

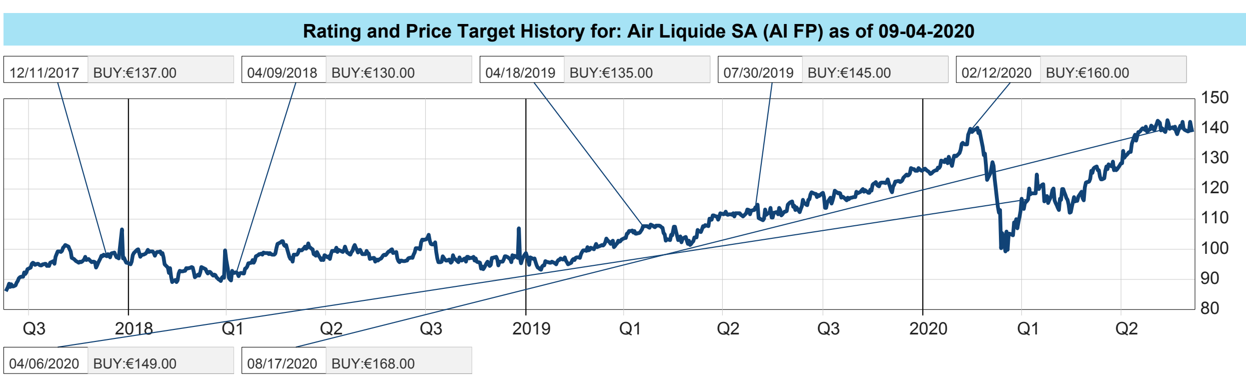
Jefferies Franchise Picks include stock selections from among the best stock ideas from our equity analysts over a 12 month period. Stock selection is based on fundamental analysis and may take into account other factors such as analyst conviction, differentiated analysis, a favorable risk/reward ratio and investment themes that Jefferies analysts are recommending. Jefferies Franchise Picks will include only Buy rated stocks and the number can vary depending on analyst recommendations for inclusion. Stocks will be added as new opportunities arise and removed when the reason for inclusion changes, the stock has met its desired return, if it is no longer rated Buy and/or if it triggers a stop loss. Stocks having 120 day volatility in the bottom quartile of S&P stocks will continue to have a 15% stop loss, and the remainder will have a 20% stop. Franchise Picks are not intended to represent a recommended portfolio of stocks and is not sector based, but we may note where we believe a Pick falls within an investment style such as growth or value.

### Risks which may impede the achievement of our Price Target

This report was prepared for general circulation and does not provide investment recommendations specific to individual investors. As such, the financial instruments discussed in this report may not be suitable for all investors and investors must make their own investment decisions based upon their specific investment objectives and financial situation utilizing their own financial advisors as they deem necessary. Past performance of the financial instruments recommended in this report should not be taken as an indication or guarantee of future results. The price, value of, and income from, any of the financial instruments mentioned in this report can rise as well as fall and may be affected by changes in economic, financial and political factors. If a financial instrument is denominated in a currency other than the investor's home currency, a change in exchange rates may adversely affect the price of, value of, or income derived from the financial instrument described in this report. In addition, investors in securities such as ADRs, whose values are affected by the currency of the underlying security, effectively assume currency risk.

## Other Companies Mentioned in This Report

- Air Liquide SA (AI FP: €141.15, BUY)
- Air Products (APD: $298.43, BUY)
- Linde PLC (LIN: $247.70, BUY)



**Rating and Price Target History for: Air Products (APD) as of 09-04-2020**


**Rating and Price Target History for: Linde PLC (LIN) as of 09-04-2020**


**Rating and Price Target History for: The Linde Group (LIN GR) as of 09-04-2020**


**Notes:** Each box in the Rating and Price Target History chart above represents actions over the past three years in which an analyst initiated on a company, made a change to a rating or price target of a company or discontinued coverage of a company.

Legend:

I: Initiating Coverage

D: Dropped Coverage

B: Buy

H: Hold

UP: Underperform

## Distribution of Ratings

| Distribution of Ratings | | | | | | |
|---|---|---|---|---|---|---|
| | | | IB Serv./Past12 Mos. | | JIL Mkt Serv./Past12 Mos. | |
| | Count | Percent | Count | Percent | Count | Percent |
| **BUY** | 1435 | 56.03% | 126 | 8.78% | 11 | 0.77% |
| **HOLD** | 975 | 38.07% | 25 | 2.56% | 4 | 0.41% |
| **UNDERPERFORM** | 151 | 5.90% | 0 | 0.00% | 0 | 0.00% |

**Other Important Disclosures**

Jefferies does business and seeks to do business with companies covered in its research reports, and expects to receive or intends to seek compensation for investment banking services among other activities from such companies. As a result, investors should be aware that Jefferies may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision.

Jefferies Equity Research refers to research reports produced by analysts employed by one of the following Jefferies Group LLC ("Jefferies") group companies:

**United States:** Jefferies LLC which is an SEC registered broker-dealer and a member of FINRA (and distributed by Jefferies Research Services, LLC, an SEC registered Investment Adviser, to clients paying separately for such research).

**United Kingdom:** Jefferies International Limited, which is authorized and regulated by the Financial Conduct Authority; registered in England and Wales No. 1978621; registered office: 100 Bishopsgate, London EC2N 4JL; telephone +44 (0)20 7029 8000; facsimile +44 (0)20 7029 8010.

**Hong Kong:** Jefferies Hong Kong Limited, which is licensed by the Securities and Futures Commission of Hong Kong with CE number ATS546; located at Suite 2201, 22nd Floor, Cheung Kong Center, 2 Queen's Road Central, Hong Kong.

**Singapore:** Jefferies Singapore Limited, which is licensed by the Monetary Authority of Singapore; located at 80 Raffles Place #15-20, UOB Plaza 2, Singapore 048624, telephone: +65 6551 3950.

**Japan:** Jefferies (Japan) Limited, Tokyo Branch, which is a securities company registered by the Financial Services Agency of Japan and is a member of the Japan Securities Dealers Association; located at Tokyo Midtown Hibiya 30F Hibiya Mitsui Tower, 1-1-2 Yurakucho, Chiyoda-ku, Tokyo 100-0006; telephone +813 5251 6100; facsimile +813 5251 6101.

**India:** Jefferies India Private Limited (CIN - U74140MH2007PTC200509), licensed by the Securities and Exchange Board of India for: Stock Broker (NSE & BSE) INZ000243033, Research Analyst INH000000701 and Merchant Banker INM000011443, located at 42/43, 2 North Avenue, Maker Maxity, Bandra-Kurla Complex, Bandra (East), Mumbai 400 051, India; Tel +91 22 4356 6000.

**Australia:** Jefferies (Australia) Securities Pty Limited (ACN 610 977 074), which holds an Australian financial services license (AFSL 487263) and is located at Level 22, 60 Martin Place, Sydney NSW 2000; telephone +61 2 9364 2800.

This report was prepared by personnel who are associated with Jefferies (Jefferies International Limited, Jefferies Hong Kong Limited, Jefferies Singapore Limited, Jefferies (Japan) Limited, Tokyo Branch, Jefferies India Private Limited), Jefferies (Australia) Pty Ltd; or by personnel who are associated with both Jefferies LLC and Jefferies Research Services LLC ("JRS"). Jefferies LLC is a US registered broker-dealer and is affiliated with JRS, which is a US registered investment adviser. JRS does not create tailored or personalized research and all research provided by JRS is impersonal. If you are paying separately for this research, it is being provided to you by JRS. Otherwise, it is being provided by Jefferies LLC. Jefferies LLC, JRS, and their affiliates are collectively referred to below as "Jefferies". Jefferies may seek to do business with companies covered in this research report. As a result, investors should be aware that Jefferies may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only one of many factors in making their investment decisions. Specific conflict of interest and other disclosures that are required by FINRA and other rules are set forth in this disclosure section.

* * *

If you are receiving this report from a non-US Jefferies entity, please note the following: Unless prohibited by the provisions of Regulation S of the U.S. Securities Act of 1933, as amended, this material is distributed in the United States by Jefferies LLC, which accepts responsibility for its contents in accordance with the provisions of Rule 15a-6 under the US Securities Exchange Act of 1934, as amended. Transactions by or on behalf of any US person may only be effected through Jefferies LLC. In the United Kingdom and European Economic Area this report is issued and/or approved for distribution by Jefferies International Limited ("JIL") and is intended for use only by persons who have, or have been assessed as having, suitable professional experience and expertise, or by persons to whom it can be otherwise lawfully distributed.

JIL allows its analysts to undertake private consultancy work. JIL's conflicts management policy sets out the arrangements JIL employs to manage any potential conflicts of interest that may arise as a result of such consultancy work. Jefferies LLC, JIL and their affiliates, may make a market or provide liquidity in the financial instruments referred to in this report; and where they do make a market, such activity is disclosed specifically in this report under "company specific disclosures".

For Canadian investors, this material is intended for use only by professional or institutional investors. None of the investments or investment services mentioned or described herein is available to other persons or to anyone in Canada who is not a "Designated

Institution" as defined by the Securities Act (Ontario). In Singapore, Jefferies Singapore Limited ("JSL") is regulated by the Monetary Authority of Singapore. For investors in the Republic of Singapore, this material is provided by JSL pursuant to Regulation 32C of the Financial Advisers Regulations. The material contained in this document is intended solely for accredited, expert or institutional investors, as defined under the Securities and Futures Act (Cap. 289 of Singapore). If there are any matters arising from, or in connection with this material, please contact JSL, located at 80 Raffles Place #15-20, UOB Plaza 2, Singapore 048624, telephone: +65 6551 3950. In Japan, this material is issued and distributed by Jefferies (Japan) Limited to institutional investors only. In Hong Kong, this report is issued and approved by Jefferies Hong Kong Limited and is intended for use only by professional investors as defined in the Hong Kong Securities and Futures Ordinance and its subsidiary legislation. In the Republic of China (Taiwan), this report should not be distributed. The research in relation to this report is conducted outside the People's Republic of China ("PRC"). This report does not constitute an offer to sell or the solicitation of an offer to buy any securities in the PRC. PRC investors shall have the relevant qualifications to invest in such securities and shall be responsible for obtaining all relevant approvals, licenses, verifications and/or registrations from the relevant governmental authorities themselves. In India, this report is made available by Jefferies India Private Limited. In Australia, this report is issued and/or approved for distribution by, or on behalf of, Jefferies (Australia) Securities Pty Ltd. It is directed solely at wholesale clients within the meaning of the Corporations Act 2001 of Australia (the "Corporations Act"), in connection with their consideration of any investment or investment service that is the subject of this report. This report may contain general financial product advice. Where this report refers to a particular financial product, you should obtain a copy of the relevant product disclosure statement or offer document before making any decision in relation to the product. Recipients of this document in any other jurisdictions should inform themselves about and observe any applicable legal requirements in relation to the receipt of this document.

This report is not an offer or solicitation of an offer to buy or sell any security or derivative instrument, or to make any investment. Any opinion or estimate constitutes the preparer's best judgment as of the date of preparation, and is subject to change without notice. Jefferies assumes no obligation to maintain or update this report based on subsequent information and events. Jefferies, and their respective officers, directors, and employees, may have long or short positions in, or may buy or sell any of the securities, derivative instruments or other investments mentioned or described herein, either as agent or as principal for their own account. This material is provided solely for informational purposes and is not tailored to any recipient, and is not based on, and does not take into account, the particular investment objectives, portfolio holdings, strategy, financial situation, or needs of any recipient. As such, any advice or recommendation in this report may not be suitable for a particular recipient. Jefferies assumes recipients of this report are capable of evaluating the information contained herein and of exercising independent judgment. A recipient of this report should not make any investment decision without first considering whether any advice or recommendation in this report is suitable for the recipient based on the recipient's particular circumstances and, if appropriate or otherwise needed, seeking professional advice, including tax advice. Jefferies does not perform any suitability or other analysis to check whether an investment decision made by the recipient based on this report is consistent with a recipient's investment objectives, portfolio holdings, strategy, financial situation, or needs.

By providing this report, neither JRS nor any other Jefferies entity accepts any authority, discretion, or control over the management of the recipient's assets. Any action taken by the recipient of this report, based on the information in the report, is at the recipient's sole judgment and risk. The recipient must perform his or her own independent review of any prospective investment. If the recipient uses the services of Jefferies LLC (or other affiliated broker-dealers), in connection with a purchase or sale of a security that is a subject of these materials, such broker-dealer may act as principal for its own accounts or as agent for another person. Only JRS is registered with the SEC as an investment adviser; and therefore neither Jefferies LLC nor any other Jefferies affiliate has any fiduciary duty in connection with distribution of these reports.

The price and value of the investments referred to herein and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

This report may contain forward looking statements that may be affected by inaccurate assumptions or by known or unknown risks, uncertainties, and other important factors. As a result, the actual results, events, performance or achievements of the financial product may be materially different from those expressed or implied in such statements.

This report has been prepared independently of any issuer of securities mentioned herein and not as agent of any issuer of securities. No Equity Research personnel have authority whatsoever to make any representations or warranty on behalf of the issuer(s). Any comments or statements made herein are those of the Jefferies entity producing this report and may differ from the views of other Jefferies entities.