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Global helium market update: Market shifting to oversupply by mid-2020s

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Global helium market update

Market shifting to oversupply by mid-2020s

Oil and gas/industrials

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Despite the pandemic weighing heavily on demand, the helium market remains under-supplied in 2021, as it has been since 2018. From 2022, significant additional supply should enter the market from Qatar and Russia which could see the start of a significant loosening of the market. By 2026, these two countries alone could add 3.8bcf/year to global supply, causing >20% oversupply out to 2030, based on 2% pa demand projections. We would expect significant pricing pressure by the mid-2020s unless demand surprises on the upside. For security of supply, it is concerning that by the late 2020s, 75% of global helium supply will come from Qatar, Russia and Algeria (up from 50% in 2020). Some customers may be willing to pay a premium to secure supply of helium from outside of these three countries.

COVID-19 accelerates helium market balancing

We estimate that global helium demand was down 10% in 2020 due to the impact of the ongoing pandemic. In 2021, we believe demand will rebound to recoup half of the reduction seen in 2020. As a result of this and based on our bottom-up helium supply model, we estimate the global helium market remains tightly balanced during 2021 (4% undersupply), as it has done since 2018. If it were not for the pandemic, and instead demand had stayed flat at 2019 levels (6.2bcf), we estimate there would have been 13% undersupply in 2020 (rather than 3% undersupply) and 9% in 2021.

Significant oversupply likely from mid-2020s

During 2022, significant supply should come online from the start-up of mega-gas/liquefied natural gas (LNG) projects in Qatar (Ras Laffan) and Russia (Amur), which could see the start of a significant loosening of the market, even as demand accelerates above 2019 levels. By 2026, these two countries alone should add 3.8bcf/year to global supply (resulting in global supply of 9.2bcf), and the market could experience nearly 30% oversupply (in 2026), based on our base case 2% pa demand scenario. The significant oversupply persists into 2030, where it would still be above 20%. Demand would need to grow above 4% pa for the oversupply to be more manageable. Otherwise, we expect significant pricing pressure by the mid-2020s. However, due to concerns over security of supply, with 75% of global helium coming from Qatar, Russia and Algeria from 2027, some customers may be willing to pay a premium to secure helium from outside of these three countries.

Climate targets will have a profound impact

From 2030, due to global net zero carbon targets (by 2050) and in order to limit global warming to 1.5 degrees, the market dynamics will shift profoundly. Very little or no new natural gas production will be required and as currently >95% of helium is produced as a by-product of gas or LNG production, substantial new helium production forms will be required outside of traditional methods; otherwise, a wind-down of traditional gas fields (by 2050) will destroy the supply. We see significant opportunity for pure-play helium producers during this period.

Companies in this report

Air Liquide
Air Products
Arizona Energy Partners
Blue Star Helium
Desert Mountain Energy
ExxonMobil
Gazprom
Helium One
Irkutsk Oil
Kinder Morgan
Linde
Matheson Tri-Gas
NASCO Energie & Rohstoff AG
Noble Helium
North American Helium
Praxair
Qatar Petroleum
Qatargas
Renergen*
Royal Helium
Sonatrach Petroleum Corporation
Taiyo Nippon Sanso Corporation
Tumbleweed Midstream
Uniper
*Edison client

Report summary

Helium is a vital element in the manufacture of MRIs and semiconductors, as well as being critical for space exploration, rocketry and high-level science. We assess the supply/demand picture for helium, examining key supply sources in the US, Qatar and Russia and globally. We also include some information on pricing and helium reserves, although data is limited.

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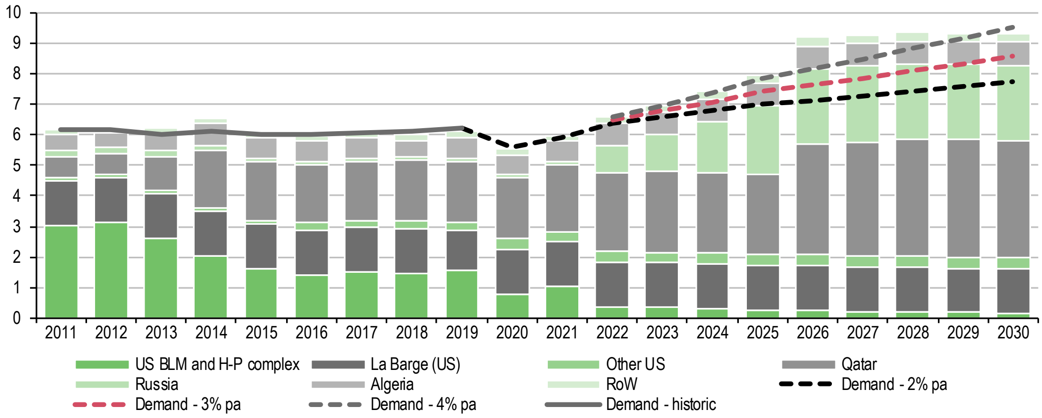
Key findings

COVID-19 accelerates helium market balancing; expect price support into 2022

We estimate that global helium demand was down 10% in 2020 due to the impact of the ongoing pandemic. Party balloons, which account for up to 10% of global helium demand (15% in the United States), will have been massively affected due to national lockdowns. Most other segments are linked to the global economy, so will also be significantly affected, although there are pockets of robust growth in areas such as semi-conductors and aerospace. In 2021, we believe demand will rebound to recoup half of the reduction seen in 2020. As a result of this and based on our bottom-up helium supply model, we estimate the global helium market will remain tightly balanced during 2021 (4% undersupply), as it has been since 2018 (see Exhibit 2). If it were not for the pandemic, and instead demand had stayed flat at 2019 levels (6.2bcf), we estimate there would have been 13% undersupply in 2020 (an increase from 10% undersupply in 2019), rather than 3% undersupply, and 9% in 2021 (rather than 4% undersupply). This excludes withdrawals from private helium reserves at the Bureau of Land Management (BLM) storage facility, which are typically used to better balance the market. We note that data on global helium supply/demand and prices are not widely disclosed, which creates uncertainty around exact estimates.

Based on limited data from public auctions for strategic reserves in the United States and other anecdotal evidence, prices have been increasing from 2017 as the market moved into undersupply. BLM auction prices increased by 11% in 2018 (to $119/mcf)[1] and then by 135% in 2019 (to $280/mcf) as Air Products won all 12 lots (equating to 210mmcf) in the final auction. Only three of the over 10 chemical companies competing at the auction were willing to bid above $130/mcf, indicating that, due to increasing scarcity, the prices may be distorted above a going market rate. Anecdotally, we have seen that for some consumers prices continued to increase into 2020. We believe this is the last leg up for this cycle, and that balanced supply-demand suggests current prices will be supported into 2022. During 2022, significant supply should come online from the start-up of mega-gas/liquefied natural gas (LNG) projects in Qatar and Russia, which could see the start of a significant loosening of the market, even as demand accelerates above 2019 levels.

Exhibit 1: Estimated global supply/demand forecast (bcf)



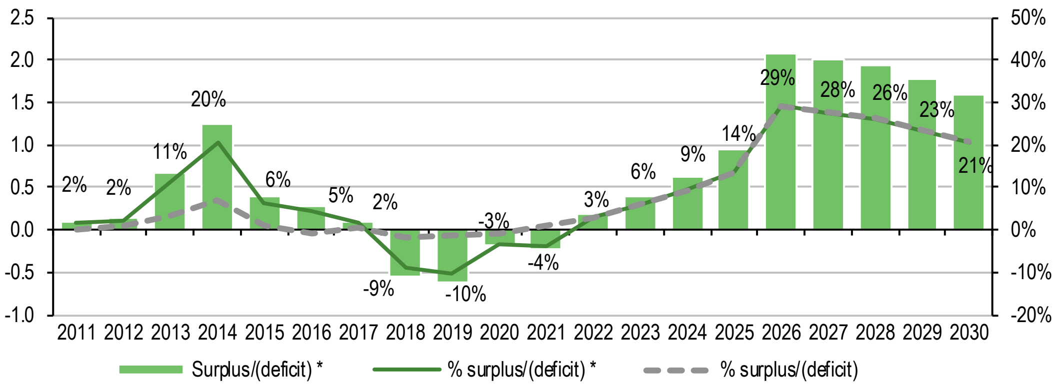
Source: Edison Investment Research based on various sources

[1] Penultimate BLM auction for volumes delivered in FY18 (1 October 2017 to 30 September 2018).

A flood of large projects means significant oversupply likely from mid-2020s

We estimate new phases to mega-projects in Russia and Qatar should start ramping up from 2022. Gazprom updated the market in December that Amur is progressing well, and the final phase should start production by end-2024 (sooner than its previous guidance of 2025). Qatar Petroleum has announced that it will add a fourth helium plant to the Ras Laffan (RL) facility (RL 4), which adds another 1.2bcf/year by 2028 (above our previous projections, published in February 2019). By 2026, these two countries alone should add 3.8bcf/year to global supply (of which 3.5bcf/year is from the two mega projects), and the market could experience nearly 30% oversupply, based on our base case 2% pa demand scenario (see demand section for definition). RL 4 (1.2bcf/year by 2028) along with incremental new production in Russia and Algeria (0.8bcf/year in aggregate) are the main reasons that the market swings from being tightly supplied (as per our previously published view) to being significantly oversupplied. We discuss, in more detail, the key differences between our new and previous projections in the Global supply section. The significant oversupply persists into 2030 (still above 20% oversupply). We would expect significant pricing pressure by the mid-2020s unless demand surprises on the upside. Due to very limited historical pricing data, we do not offer price projections; however, we note that BLM conservation (private sector) prices were at least 30–70% lower during the last period of oversupply in 2013–14 (which was not as severe as the projected oversupply from 2026).

Exhibit 2: Global helium surplus/(deficit) (LHS, bcf) versus % surplus/(deficit) (RHS)



Source: Edison Investment Research based on various sources. Note * Excluding changes in private storage (from supply).

Demand would need to grow in line with our 4% pa demand scenario (see demand section for definition), which is not inconceivable given strong Asian market growth potential particularly in semi-conductors, for the oversupply to be more manageable. Under this scenario, the market would see looseness over 2026–28, peaking at 13%, before tightening again in 2029–30. Our projections do not factor in the possibility of rebuilding private storage levels at the BLM reservoir, which could decrease oversupply by up to 3 percentage points (assuming all volumes from the Hugoton-Panhandle (H-P) complex are stored).

For security of supply, it is concerning that from 2027, 75% of global helium supply will come from Qatar, Russia and Algeria (up from 50% in 2020). While helium production is at two separate locations in Algeria, it is at one location in each of Qatar and Russia. During 2017, multiple Arab states closed their borders to Qatar, disrupting helium production and transportation for several weeks, affecting 30% of global supply, until alternative supply routes were established. This Saudi-led embargo was lifted in early 2021. More recently, the temporary blocking of the Suez Canal (in March) due to a huge container ship running aground highlights issues. Russia is the biggest unknown; its Amur facility, which should come online over four stages from 2022, will see its share rise from 2% today to more than 25% from 2025. Disruption to Qatari or Russian supply sources could see a period of market tightness even under our 2% pa demand growth profile; thus, we believe that some industrial gas companies might be prepared to pay a premium to secure supply of helium from outside of these three countries. As a recent example, in March, South African helium producer Renergen signed a 10-year take or pay (conditional) contract for substantial volumes from its phase 2 helium production, which is scheduled to commence in 2024.

Climate targets will have a profound impact on the helium market post-2030

Under all our supply-demand scenarios, oversupply peaks in the mid-2020s. From 2030, due to global net zero carbon targets (by 2050) and in order to limit global warming to 1.5 degrees, the market dynamics will shift profoundly. Very little or no new natural gas production will be required (with existing production left to decline) and as currently >95% of helium is produced as a by-product of gas or LNG production, substantial new helium production forms will be required outside of traditional methods; otherwise, a wind-down of traditional gas fields (by 2050) will destroy the supply. There is a need for helium-focused producers, where the primary economic driver is not methane extraction, to emerge in the coming years to replace existing supply. There are favourable helium resources in the United States, Canada, South Africa and Tanzania, with helium-rich gas deposits of up to 10% helium. Helium-focused companies operating in these geographies include:

- **United States:** Blue Star Helium, Desert Mountain Energy, Tumbleweed Midstream
- **Canada:** North American Helium, Royal Helium
- **South Africa:** Renergen
- **Tanzania:** Helium One, Noble Helium

Some of these companies expect commercial production to start ramping up in the 2020s, with massive growth potential into the 2030s.

Global supply

Global supply of helium is difficult to estimate and reporting of production data is non-existent, primarily because it is immaterial to the large O&G (eg Exxon) or chemical (eg Linde, Air Products) companies that own the helium extraction plants. The USGS compiles some data, providing some useful information for US production; however, we believe its international data (by country) in some cases understates production. We have built a bottom-up supply model by patching together existing and planned production capacity data from numerous sources, and adjusting for factors such as gas field depletion, factory capacity under-utilisation or the impact of COVID-19 on LNG production.

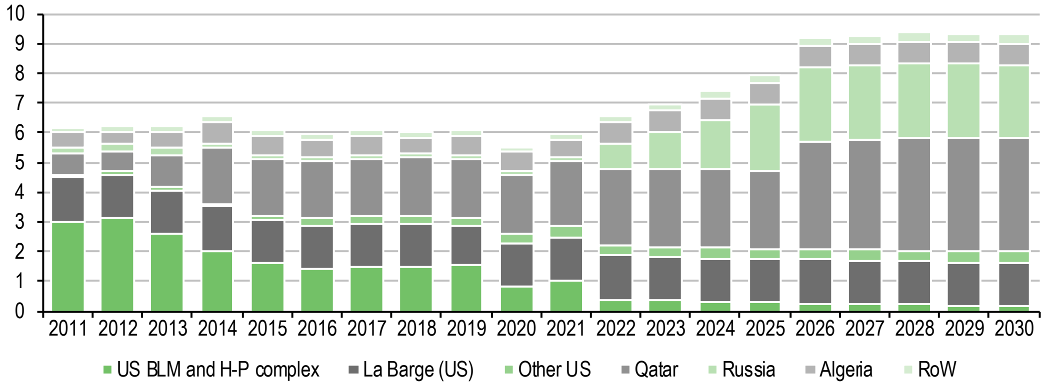
Nearly all (>95%) global helium supply depends on liquefaction plants in seven locations across the United States, Qatar and Algeria. The United States is the major producer, with almost 50% of global production in 2020 (c 2.8bcf); however, its share has decreased from 75% in 2011 and should further decrease to not much above 20% over the next decade. This is due to depletion in some of its key locations (BLM and H-P complex) and the emergence of new production capacity in Russia and Qatar and other locations (such as Canada and South Africa).

Historically, the bulk of US production was related to the BLM, which manages the world's largest helium reserve, and the connected H-P complex, which together accounted for two-thirds of US production in 2011. Since then, production from these sources has diminished considerably, due to natural depletion in H-P and a decision by the US government to sell-down the strategic BLM reserve.[2] They accounted for under one-third of US production in 2020 and should almost entirely disappear by 2030. In recent years, this has caused tightness in the global helium market, but

2 As mandated by the US Helium Stewardship Act of 2013.

supply-demand dynamics are now shifting. Significant new supply is expected in Russia (from later this year) and Qatar, adding combined new annual production of 3.7bcf by 2027. Meanwhile, unprecedented demand destruction caused by the ongoing global pandemic has provided some relief to the market.

Exhibit 3: Estimated global supply forecast (bcf)



Source: Edison Investment Research based on various sources

Our supply model is sensitive to delays or changes to Russia's mega-project in Amur or Qatar's RL Helium 3 and 4, and to disruption of existing supply. For example, maintenance at La Barge (US) in summer 2019 removed 20% of global supply for five weeks when the market was arguably at its tightest. Also, during 2017, multiple Arab states closed their borders to Qatar, disrupting helium production and transportation for several weeks, affecting 30% of global supply, until alternative supply routes were established. This Saudi-led embargo was lifted in early 2021. More recently, the temporary blocking of the Suez Canal (in March) due to a huge container ship running aground highlights issues. For security of supply, it is concerning that from 2027, 75% of global helium supply will come from Qatar, Russia and Algeria (up from 50% in 2020).

Our new supply projections are 2.0bcf/year higher (by 2027) than our previously published projections (in February 2019). The key changes are due to:

- A fourth helium plant will be added to the RL natural gas project. We assume it starts up by 2026 and ramps up to full capacity of 1.2bcf/year by 2028. This is the most significant incremental change.
- New information from Qatar Petroleum suggests RL Helium 1 and RL Helium 2 are operating 0.2bcf/year (in aggregate) above their nameplate capacities, whereas we were previously estimating they were operating 0.4bcf/year below capacity based on information provided by USGS.
- Based on a recent update from Gazprom, which indicated that Amur is ahead of schedule, we estimate Amur 3 will start-up during 2025 and be at full capacity in 2026. This compares to our previous estimate of start up during 2027 (at half capacity). Our estimates for Amur 3 are now 0.36bcf higher.
- A new helium production facility at Yaraktinsky is included in our latest projections. We estimate it starts up in 2022 and is operating at 0.27bcf/year by 2023.
- Additional feedstock due to an expansion of LNG facilities at Arzew unlocking underutilised helium production capacity. We assume the feedstock becomes available during 2021, ramping to 0.2bcf/year by 2022.
- Our new estimates are 0.3bcf lower for Canada. More than half of this difference is due to more recent information suggesting production at Battle Creek is lower than we were previously estimating (50mmcf/year vs 200mmcf/year previously). The remaining difference is due to revising down other production estimates and removal of the Medicine Hat project from our forecasts due to a lack of visibility.

Most (>95) of the new helium supply continues to be as a by-product of gas or LNG production. If globally we are to achieve net zero carbon by 2050 and limit global warming to 1.5 degrees, then little new natural gas production capacity is required, such that as we approach 2030 we should see a significantly decreasing number of new projects sanctions and existing projects left to decline. This causes complications for helium supply post-2030. There is a need for helium-focused producers, where the primary economic driver is not methane extraction, to emerge in the coming years to replace existing supply. There are favourable helium resources in the United States, Canada, South Africa and Tanzania, with helium-rich gas deposits of up to 10% helium. Helium-focused companies operating in these geographies include:.

- **United States:** Blue Star Helium, Desert Mountain Energy, Tumbleweed Midstream
- **Canada:** North American Helium, Royal Helium
- **South Africa:** Renergen
- **Tanzania:** Helium One, Noble Helium

Some of these companies expect commercial production to start ramping up in the 2020s, with massive growth potential into the 2030s.

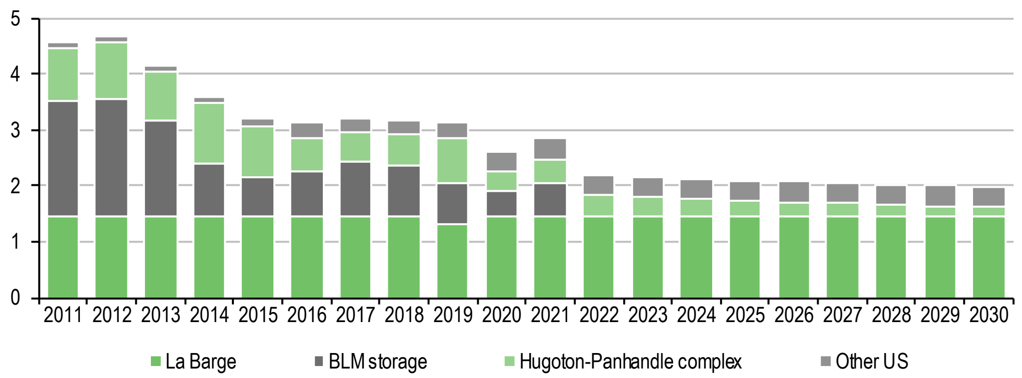
Key supply sources

Our research of major production facilities in the United States indicates little new (guaranteed) supply will start in the coming years to replace declines elsewhere in BLM and the H-P complex. Qatar, Russia and Algeria are likely to see large helium production increases, although risks of continued delays are significant. We review the major projects below.

United States

The United States has been the key source for helium for decades. However, the depletion of the strategic reserve and the H-P complex together with the new supply from Qatar has lessened its role.

Exhibit 4: Estimated US supply forecast (bcf)

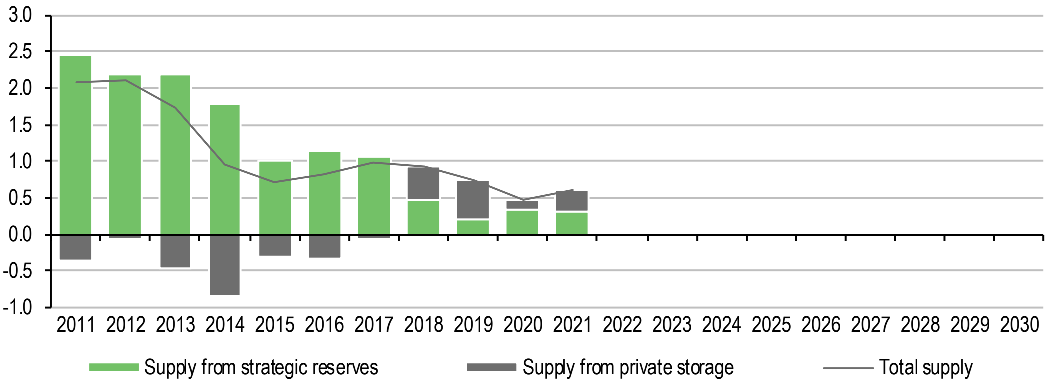


Source: Edison Investment Research based on various sources

BLM

We estimate annual helium supply from strategic reserves and private storage (see chart below) from changes in year-end reserves balances reported by BLM. Where appropriate, we adjust our annual supply estimate from private storage, so that our total annual BLM supply agrees with the figure reported by USGS; adjustments are only minor.

Exhibit 5: Estimated BLM helium supply (bcf)



Source: Edison Investment Research based on various sources

BLM is the only large-scale helium storage facility in the world. Its storage comprises the strategic US government reserves and private storage.

- **Strategic reserves:** pre-1996, US Congress mandated that the federal government keep a reserve of helium. The strategic reserves were maintained above 30bcf in the 1990s, however, in 1996, US Congress moved to privatise the federal helium program by passing the Helium Privatization Act, requiring government to sell off its helium reserves using a rigid price formula to repay the debt accrued from a large helium buy-up in the 1960s. From 2002, there was significant reduction in the strategic reserves, from 29bcf at the start of 2003 to around 2.5bcf by end-2020. Until the end-2017, the annual rate of sell-off of strategic reserves was 1–2.5bcf, equating to roughly 20–40% of global demand (at a market size of 6bcf). Over the last three years as the reserves are almost depleted, under 0.5bcf has been sold, mostly through annual auctions. This has caused significant tightness in the global market in the absence of any significant new supply coming online.
- **Private storage:** privately owned helium produced from the connected H-P complex can be stored in the BLM reservoir system. There were reserves of 1.6bcf at the start of 2003 and close to 2.5bcf by end-2020, with a range of 0.7bcf to 3.4bcf, based on end of year data points. Private helium stored at BLM has helped to balance the market: typically, there have been drawdowns during periods of undersupply (2018–19) and there have been stock builds during periods of oversupply (2013–16).

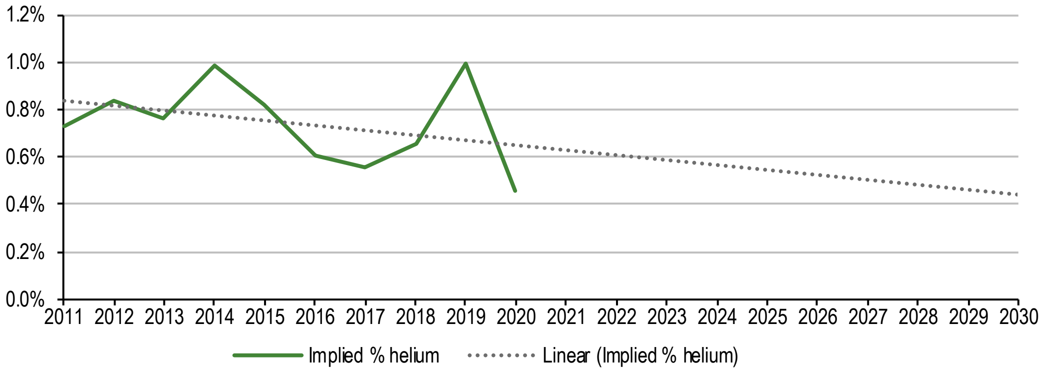
According to the Helium Stewardship Act 2013, the BLM must privatise its remaining helium assets by 30 September 2021. We assume a strategic reserve and private storage drawdown of 300mmcf each in 2021, which helps balance the market as demand growth returns, due to the worst of the coronavirus pandemic being behind us. From 2022, we assume no further drawdowns from BLM as the market becomes increasingly looser. We do not go as far as modelling an increase in private inventories; however, we note that even if we assume all volumes from the H-P complex are put into storage, there would not be a significant reduction to the expected supply surplus: it would peak in 2025 at 30% compared to 34% (without a private storage build). See the pricing section below for more detail on these sensitivities.

Hugoton-Panhandle complex

The H-P complex comprises Hugoton, one of the largest gas fields in the United States, Pandhandle West and some small fields (including Panoma, Keyes and Greenwood), spread across Kansas, Oklahoma and Texas. The complex is connected via pipelines to a series of helium extraction plants and the BLM storage reservoir. The fields have a high helium concentration (0.3–1.9%) and have been a substantial contributor to helium supply in the United States for many years; however, according to natural gas production data for the main Hugoton field (source Kansas Geological Survey), it is declining by an average of 6% pa (based on 10 years production data).

We estimate historic helium production from the H-P complex, by adopting the USGS figures for helium extracted from natural gas (for the US) and subtracting estimated helium production from La Barge (which we assume is stable) and other US fields (which are relatively small and stable). We use these estimates and Hugoton field natural gas production data to calculate implied annual percentage of helium concentrations (see chart below).

Exhibit 6: Implied % helium concentrations at the H-P complex

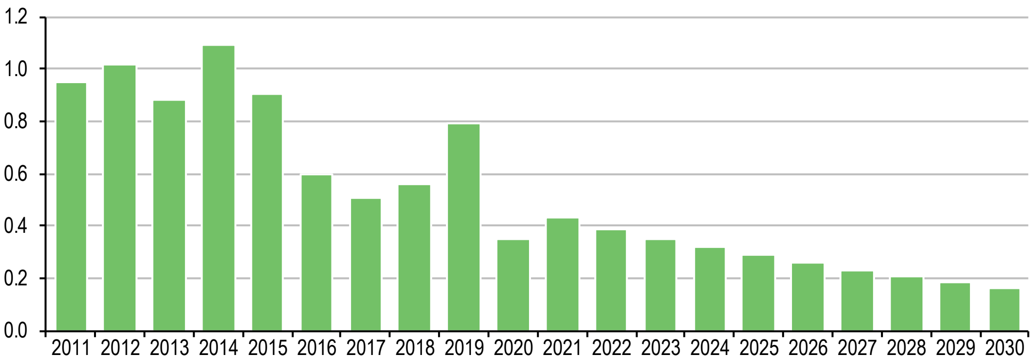


Source: Edison Investment Research based on various sources

The trend line suggests concentrations are declining from above 0.8% in 2011 to 0.6% in 2021 and extrapolates to 0.4% by 2030. This suggests recoverable helium concentrations may be falling as field pressures decline. Variability in the historic implied percentage of helium around the trend line could be due to a combination of our assumptions on production for La Barge and other US fields; only having data for the Hugoton field (although it accounts for a vast majority of production in the H-P complex); and inaccuracies in the USGS data. The anomaly in 2019 may be due to us overestimating the impact of the closure of the Shute Creek helium plant during summer 2019.

In our forecasts we assume helium concentrations shown in the trend line (ie decline to 0.4% by 2030) and apply this to field production data for Hugoton with a 6% annual decline rate applied.

Exhibit 7: Estimated H-P complex helium production (bcf)



Source: Edison Investment Research based on various sources

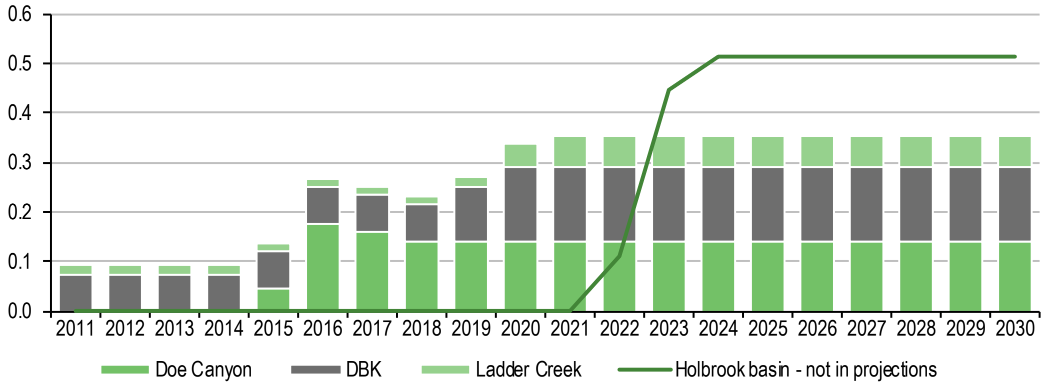
La Barge field

La Barge is a large natural gas field in Wyoming with high concentrations of CO_2 and a relatively high concentration of helium (0.6%). The field economics rely on the efficacy of the CO_2 in enhancing oil production in surrounding oil fields as La Barge is only 21% methane and is 65% CO_2 (and 5% hydrogen sulphide and 0.6% helium). It feeds the Shute Creek facility, which separates out the gases, reinjecting the hydrogen sulphide (and some CO_2) into the reservoir, liquefying the helium and piping the rest of the CO_2 to surrounding fields in Wyoming and Colorado. The facility, owned by ExxonMobil, has a helium production capacity of 4mmcf/d, or 1.46bcf/year, making it a substantial contributor to global demand (>20%).

According to Exxon, all the gas was contracted for sale since the start of operations in 1986, but long-term sales averaged only half capacity for much of this time, as the CO_2 enhanced recovery market did not develop as fast as anticipated, partially as a result of the distance to the fields. Higher oil prices from the 2000s onwards made project economics more attractive. We have estimated the facility continues to produce at its capacity over the forecast period, as we do not believe there will be any declines in the availability of gas for processing.

Other US facilities

Exhibit 8: Estimated other US helium production (bcf)



Source: Edison Investment Research based on various sources

New helium sources (outside of natural gas production) are being developed in the Southwestern US, especially in the Four Corners area (where the States of Utah, Colorado, New Mexico and Arizona meet), where concentrations of helium in natural gas range up to 10% (0.3% is generally considered to be of commercial interest). There are a number of companies, including pure-play helium start-ups, seeking to exploit this potential.

Dineh-bi-Keyah (DBK) expansion. NASCO Energie & Rohstoff AG, a German-listed player, has completed the expansion of its DBK facility in Arizona. We assume production of 150mmcf/year from 2020.

Doe Canyon. Air Products started a 230mmcf/year capacity helium separation plant from CO_2 feed gas at Kinder Morgan's Doe Canyon plant in 2015, but we estimate production had declined to 140mmcf/year within a couple of years, due to lack of demand for the CO_2 feed gas. We expect the plant will continue to produce at this rate during the forecast period, although a sharp increase in oil prices could motivate greater CO_2 output (used in enhanced oil recovery) and therefore increased helium extraction.

Ladder Creek. Tumbleweed Midstream has secured long-term feedstock agreements (announced in June 2020) that have quadrupled production at its Ladder Creek helium plant. We assume it increases production from 16mmcf/year in 2019 to 65mmcf/year from 2021 onwards.

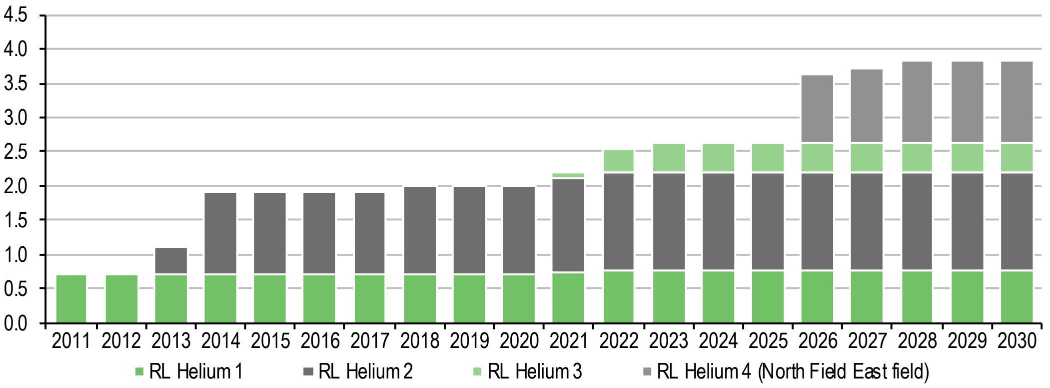
Desert Mountain Energy, an exploration start-up (listed on the TSX Venture Exchange (Canada), OTCQX (US), and Frankfurt Stock Exchange) in the Holbrook basin, Arizona, is planning to commercialise the area and ultimately set up a helium production facility with capacity of 275mmcf/year. It has drilled 2 wells (with helium concentrations of 4% and 7%). It plans to start production with 5 wells costing $26m and is targeting end of 2021; in order to ramp up to 275mmcf/year would require 50-55 wells. Due to a lack of clarity on timing, we do not include this in our supply projections.

Arizona Energy Partners, an affiliate of PetroSun, is planning to commercialise the Conch Dome area of the Holbrook basin and ultimately set up a helium production facility with capacity of 240mmcf/year. Due to a lack of clarity on timing, we do not include this in our supply projections.

Worldwide projects

Qatar

Exhibit 9: Estimated Qatar helium production (bcf)



Source: Edison Investment Research based on various sources

The start of the RL Helium 1 and 2 projects had a major impact on helium supply and contributed to a surplus in 2014–16 (after the shortage of 2012), following the start-up of RL Helium II in 2013. Although there is limited public information, in what appears to be a one-off, Qatar Petroleum published its annual helium production data in its Annual Review 2018 (AR 2018), stating production was 1.9bcf in 2017 and 2.0bcf in 2018, which is notably above the 1.5bcf for 2017 and 2018 that USGS adopts for Qatar in its annual Mineral Summaries. We note that AR 2018 stated that combined capacity from RL Helium 1 and 2 is now 2.2bcf/year (combined), which implies production can be optimised up to 200mmcf/year above the nameplate capacities of the two plants (of 2.0bcf/year, combined). We have gradually increased our projections for RL Helium 1 and RL Helium 2 to fully reflect this increased potential by 2022 (when we will hopefully be past the ongoing coronavirus pandemic).

RL Helium 3 was originally set to start production in 2018 with a capacity of 400mmcf/year; however, we have not seen any recent updates on progress. Moreover, there was no mention in Qatar Petroleum's AR 2018, which gave an update on the helium plant at the North Field East project, and there is nothing whatsoever on helium in AR 2019. We assume that the plant's start-up has been further delayed due to pandemic and estimate that production commences in H221, ramping up to full capacity during 2023.

On 8 February 2021, Qatar Petroleum announced it has sanctioned the North Field East (NFE) project, which is a 30% expansion to its massive North Field and the world's largest LNG project.[3] Four new LNG liquefaction trains will be installed at the Ras Laffan Qatargas LNG plant. It is expected to start production in Q425. In its AR 2018, Qatar Petroleum stated there would be a new fourth helium plant at RL as part of the NFE project, with a planned production of 20 tons per day of pure helium (equating to 1,450mmcf/year); however, there is no update on the helium plant in the recent announcement. An article from an engineering staffing provider[4] dated February 2020, which gives an overview of the NFE project, suggests production will be 16 tons per day, equating to 1,200mmcf/year, which we have adopted in our projections as we assume it reflects updated plans.

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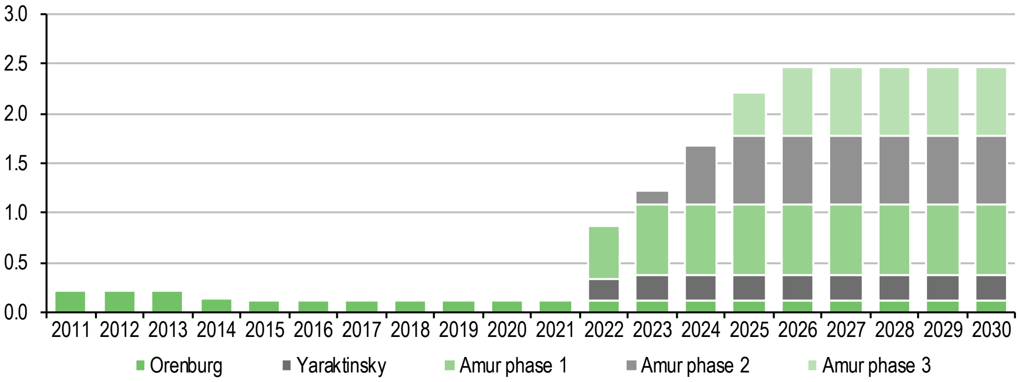
[3] www.offshore-technology.com/news/qatar-petroleum-makes-fid-on-28-7bn-north-field-east-project/

[4] www.nesfircroft.com/blog/2020/02/10-biggest-middle-east-oil-and-gas-projects-to-watch-in-2020

Evidence we have seen suggests that Qatar's LNG exports have not been significantly affected by the pandemic, as reduced demand from Europe has been offset by increased demand from Asia. We have therefore not adjusted our 2020 and 2021 helium production estimates for Qatar.

Russia

Exhibit 10: Estimated Russia helium production (bcf)



Source: Edison Investment Research based on various sources

The massive Amur gas development has the potential to turn Russia from a small helium producer (it produces about 110mmcf/year from its Orenburg helium plant) to the second largest globally (behind Qatar) by 2025. Amur should produce 42bcm of natural gas per year, 90% of which will be exported to China over 30 years. The phased development could produce as much as 60mmcm/year (2.1bcf/year) of helium.

Gazprom released an update in December 2020, stating it expects to commission two of six production trains in 2021 (Amur phase one), and the remaining trains (phases two and three) will be in operation before the end of 2024 (a year ahead of its previous guidance). It expects the helium plant to reach its design capacity by 2025. Russia has been badly hit by COVID-19, so we would not be surprised if there are delays to each of the phases.

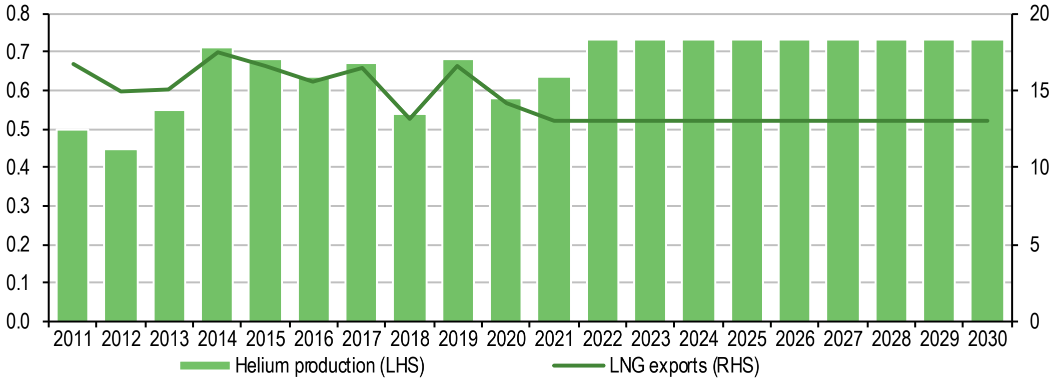
- **Amur phase one:** we assume three to six months delay for phase one, with production starting in early 2022 and reaching full capacity (700mmcf/year) the following year.
- **Amur phase two:** we assume phase two starts production during H223, reaching full capacity (700mmcf/year) during 2025.
- **Amur phase three:** we assume phase three starts production during H125, reaching full capacity (700mmcf/year) the following year.

We therefore expect full capacity at Amur in 2026, a year later than Gazprom is expecting. Although we are being realistic in our assumptions, Amur is a highly complex project and it is not inconceivable that it might experience delays beyond those we have factored in, particularly in the later phases.

We also include Irkutsk Oil's Yaraktinsky project in our projections. Its planned capacity is 266mmcf/year. Originally, in an announcement in October 2018, Irkutsk had expected to start production in early 2021; however, a more recent announcement by Uniper (July 2020), which has secured a long-term purchase agreement, suggested production would start by the end of 2021. We have assumed it starts up in 2022, reaching full capacity the following year.

Algeria

Exhibit 11: Estimated Algeria helium production (LHS, bcf) vs LNG volumes (RHS, bcf)



Source: Edison Investment Research based on various sources

Algeria supplies helium when gas from its massive Hassi R'Mel field is exported via LNG. While the helium concentration is low (0.17%), the field accounts for c 60% of Algerian gas exports so economic extraction is possible (no other fields have commercial helium extraction). It has helium extraction capacity at two plants in Arzew and Skikda. They each have production capacity of 600mmcf/year; however, we do not believe they are running at full capacity. We believe Algeria prioritises its pipeline gas exports to Europe, with LNG a less critical component. LNG volumes can therefore suffer if demand in Europe increases. A further limitation to helium production is that only a portion of the LNG facilities provide feedstock to the plants at Arzew and Skikda. Arzew is fed from GL2Z and Skikda is fed from the GL1K facility. There are plans to unlock underutilised capacity at Arzew by delivering feedstock from additional LNG facilities.

In November 2018, Air Products announced that its HELIOS joint venture with Sonatrach Petroleum Corporation will recover helium from two existing LNG facilities (GL1Z and GL3Z), and that helium will be delivered to HELIOS's existing liquid helium plant in Arzew. We estimate the additional feedstock could unlock at least 200mmcf/year of underutilised capacity at Arzew. It was originally planned for completion by the end of 2019, but we assume the pandemic has caused further delays and estimate start up during 2021, ramping to 200mmcf/year during 2022.

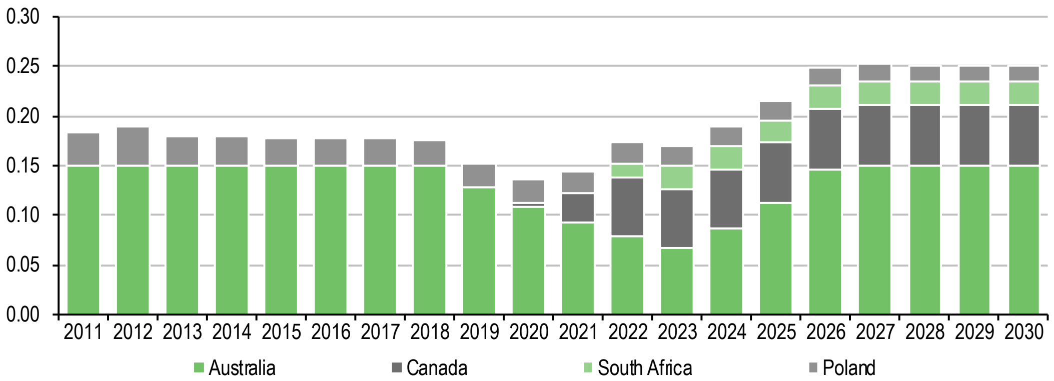
We model the helium output at Arzew and Skikda as a function of LNG exports, with historic LNG export data from Statista for 2011–19. We adopt helium production of 500mmcf/year (combined from both facilities) in 2011 then scale helium production according to movements in LNG exports over 2011–30, taking into account increases in helium factory capacity or feedstock availability. The 500mmcf/year, in 2011, represented 60% utilisation, because the Skikda facility had its capacity reduced by a fire (we assume to 250mmcf/year). It was restored to its original capacity of 600mmcf/year by 2014.

We estimate LNG exports declined by 15% in 2020, due to the effect of COVID-19 on demand. We understand a number of cargoes from Algeria have been affected due to cheaper supplies being available from the US and port-related issues. We project this trend will continue and reduce LNG exports by a further 7.5% in 2021. We then keep exports flat over the rest of the period to reflect underinvestment preventing production from returning to pre-COVID-19 levels. There could be downside to our LNG projections: they imply a 20% reduction by 2025 (relative to a 2019 base). This is notably higher than Enerdata's projections, which suggest Algeria's natural gas exports could decrease by more than 40% by 2025 due to stagnant production, rising domestic demand and insufficient investment. However, the Algerian government aims to attract international investors to mitigate this potential production decline.

RoW

In our projections we include some smaller helium production plants in Australia, Canada, South Africa and Poland.

Exhibit 12: Estimated RoW helium production (bcf)



Source: Edison Investment Research based on various sources

Australia. There is one helium production plant in Darwin operated by BOC, a member of the Linde Group, since 2010. We assume it has been operating at capacity of 150mmcf/year over 2011–2018; however, we have factored in field declines over 2019–23, before investment should allow production to ramp back up to 150mmcf/year by 2027. Australia has very large natural gas reserves and there are several LNG export facilities either under construction or proposed and, as a result, significant opportunities of increased helium production. Due to uncertainty over economics and the willingness to proceed with these projects, we do not include any of this potential in our forecasts.

South Africa. Renergen (via its 90% subsidiary, Tetra4) operates a natural gas field in the Virginia field in Free State in South Africa, which has high helium concentrations (2–4%) and 9.2mkg of 2P reserves (corresponding to c 2bcf). As South Africa is extremely short of energy, there are strong incentives to develop any gas (and associated helium). We assume production commences in early 2024 and ramps up to 20–25mmcf/year.

Poland is one of the minor players in global helium, but the only European producer. According to the Polish Geological Institute, there are 16 helium fields in the country (situated in the Zielona Góra-Rawicz-Odolanów area), which were producing 0.69mmcm (24mmcf) in 2019, with 75% of this coming from just three fields. The reserve life of the complex is over 30 years. We assume a 4% annual decline based on the historical average (10-year) annual decline suggested by Polish Geological Institute data.

Canada. There are a number of projects in Canada of differing maturities. Exploration companies include North American Helium, which is ramping up production, and Royal Helium, which spudded their first two exploration wells in January. Exploration for helium in Canada could be very promising given proven deposits of helium in deeply buried traps, often with little associated CO_2 or other gases (other than nitrogen) making extraction and liquefaction cheaper. We have included projects at Cypress and Battle Creek (both owned by North American Helium) in our projections, which commenced production from 2020 and we assume ramp up to a combined capacity of 60mmcf/year by 2022. We do not include projects in Mankota and Medicine Hat, which could have a combined capacity of 80mmcf/year, due to a lack of visibility over commercial production and timing.

Other possible sources

Saudi Arabia. Saudi Aramco is planning to build a helium plant at a gas facility in Fadhili. There is very little public information at present, so we have excluded it from our projections.

China. According to a news article in July 2020,[5] China has opened a new low-cost helium plant at a natural gas processing plant in Ningxia, which although only has a capacity of 5mmcf/year, could potentially be scaled by opening hundreds of similar facilities. This could conceivably provide China with >1 bcf/year over the next decade or so, which could go some way to satisfying its fast-growing demand for helium.

Tanzania. Helium One, which floated on the London Stock Exchange in December 2020 (ticker: HE1 LN), is exploring for helium in Tanzania after traces of it were detected in geothermal springs. According to Helium One's website, it has identified 21 prospects and 4 leads in the Rukwa Rift Basin and is targeting a 2U/P50 un-risked prospective resource of 138bcf (100% equity) (based on a 2019 report from SRK Consulting). The prospects are spread over 4,512km^2 with surface helium concentrations of up to 10.6%. . Noble Helium, an early stage private Australian company, also has substantial prospective resources in Tanzania (its website suggests 98bcf); it has not yet confirmed any drilling plans.

Many of the other potential projects are yet to undertake exploration wells and hence we remain cautious about their prospects.

Global demand

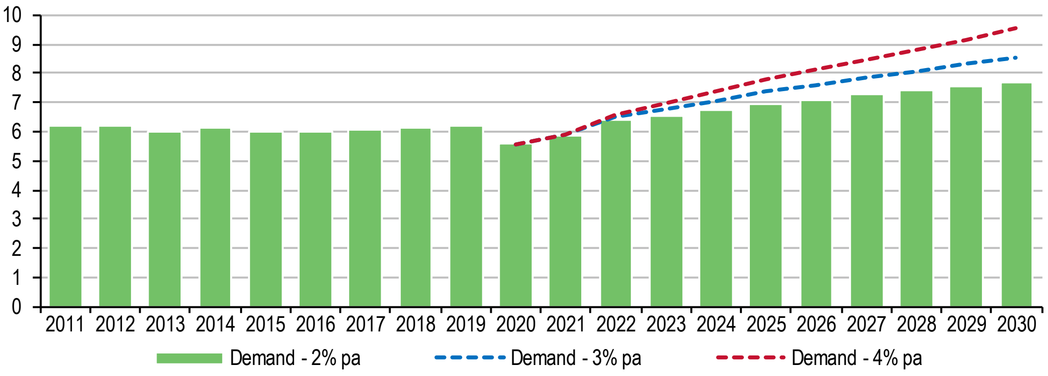
As with helium supply, there is very limited and patchy data on global helium demand. We assume global demand was 6.2bcf in 2019. For 2011–16, we adopt data from JR Campbell & Associates. We use linear interpolation between 2016 and 2019. The global pandemic initially had a massive impact on helium demand. In March/April 2020, we read anecdotally that demand was down c 2010–25% but has since been recovering in line with the global economic recovery. We estimate global helium demand was down 10% in 2020. Party balloons, which account for up to 10% of global helium demand (15% in the United States), will have been massively affected due to lockdowns. Most other segments are linked to the global economy, so will also be significantly affected, although robust growth has been reported in areas such as semiconductors and aerospace. Demand will have reduced less in scientific research and related areas, where helium must be periodically added to superconducting magnets to avoid permanent damage (scientific research accounts for roughly 15% of the US market). In addition, we understand there is potential for helium to be used in the transportation of Pfizer's vaccine, which needs to be kept at minus 70 degrees. We assume that half of the declines experienced in 2020 are recouped in 2021, which implies a 6% y-o-y growth rate, before growth above 2019 level being resumed from 2022.

We consider three demand scenarios, which adopt the same 2020 and 2021 growth assumptions, but differ from 2022 onwards. They are defined as follows:

- **2% pa demand scenario:** long-term growth from 2025–30 of 2% pa, with accelerated growth over 2022–25 (of 3% pa; with 2022 itself 3% above 2019) to catch up demand lost due to the pandemic, such that demand from this growth profile converges in 2025 with a 2% pa growth profile from a 2019 base.
- **3% pa demand scenario:** long-term growth from 2025–30 of 3% pa, with accelerated growth over 2022–25 (of 4.5% pa; with 2022 itself 4.5% above 2019) to catch up demand lost due to the pandemic, such that demand from this growth profile converges in 2025 with a 3% pa growth profile from a 2019 base.
- **4% pa demand scenario:** long-term growth from 2025–30 of 3% pa, with accelerated growth over 2022–25 (of 6% pa; with 2022 itself 6% above 2019) to catch up demand lost due to the pandemic, such that demand from this growth profile converges in 2025 with a 4% pa growth profile from a 2019 base.

[5] https://chinaeconomicreview.com/china-opens-first-large-scale-helium-plant-as-it-tries-to-reduce-reliance-on-us-imports/

Exhibit 13: Global helium demand (bcf)



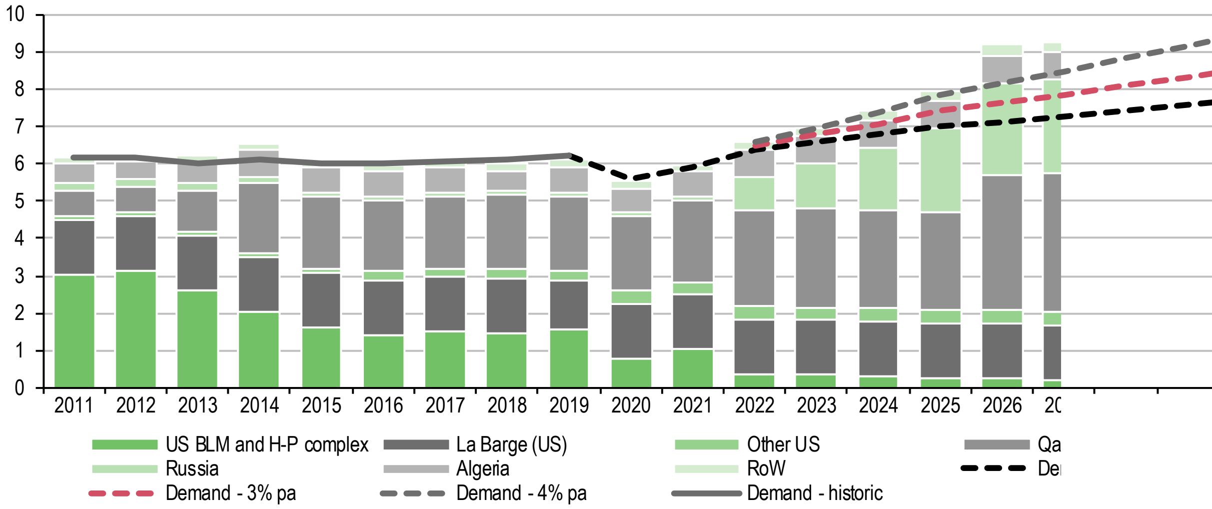
Source: Edison Investment Research based on various sources

The 2% pa demand scenario is our base case assumption. Growth in global demand has been shifting toward Asia (China, India, South Korea, Taiwan), and the Middle East, particularly in areas such as magnetic resonance imaging (MRI) scanners, electronics and fibre optics. In electronics, semi-conductors are a particularly interesting growth area; demand for semiconductor chips is increasing and an increasing quantity of helium is required per chip (it improves processing speed). An article in Gasworld in 2016 suggests that electronics accounted for 15% of global demand for helium up from 1% a decade earlier. Data storage is another growth area, which has possibly been boosted by the pandemic; helium allows for less turbulence when hard drive disks spin, reducing power consumption and allowing for a higher number of discs to be incorporated in the same space. Space travel is another interesting growth area; helium is used in space rockets. An increasing number of countries are developing space programs (including the United States, Russia, India, China and the EU), and companies such as Space X and Virgin Galactic are putting numerous rockets and satellites into space. Some of these end-segments are industries that could grow substantially above global GDP, so we believe our 2% pa base case demand scenario is realistic and achievable. Even our 4% pa demand scenario is attainable, if one were to make aggressive assumptions relating to some of the growth segments mentioned above.

Overall, demand for helium is mostly inelastic. However, there is some more elastic demand that would have been removed during the recent period of undersupply and price increases (particularly in 2018 and 2019). There is a possibility that some of this demand might come back if pricing becomes more accessible as helium markets move into oversupply. This represents upside risk to our 2% pa demand scenario.

Supply-demand balance, sensitivities and pricing

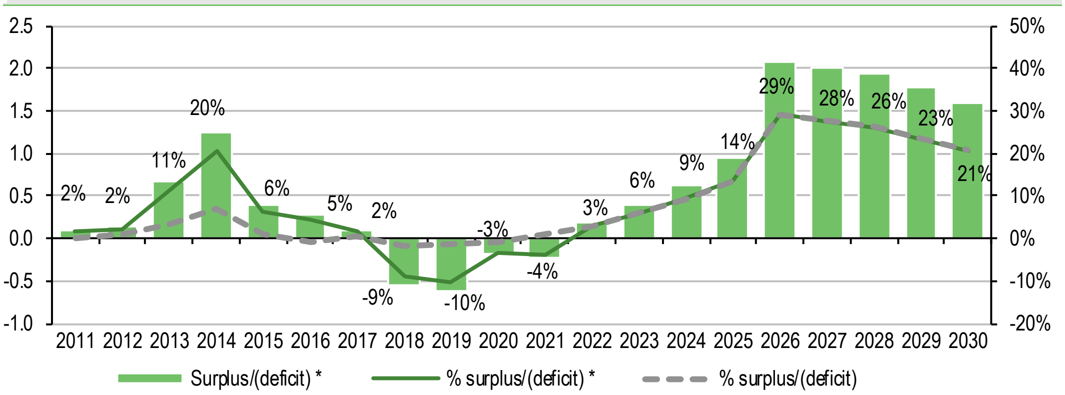
Exhibit 14: Estimated global supply/demand forecast (bcf)



Source: Edison Investment Research based on various sources.

The supply-demand balance was very tight over 2018–19 but has been given some relief since 2020 due to the ongoing coronavirus pandemic, although is still tightly balanced. By excluding annual changes in private storage (from the BLM reservoir), which is typically withdrawn (in periods of undersupply) or built (in periods of oversupply) to balance the market, we get a clearer picture of the extent to which supply-demand is out of balance. The chart below shows the market was loose during 2013–16 (caused by the commissioning of the 1,200mmcf/year capacity RL Helium 2 in 2013) and then tight in 2018–2019 caused by a reduction in volumes made available from the federal strategic reserve). It is tightly balanced in 2020–23 (slight oversupply, when including estimated private volumes released to the market in 2021), due to the impact of COVID-19 on demand in 2020–21. In 2022, we estimate demand will be above 2019 levels (by 4.5%) and so supply-demand balance is naturally restored, assisted by new projects starting up in Russia and Qatar. This does not last long; more capacity is added as the projects in Russia and Qatar ramp up into the mid-2020s. By 2026, these projects alone should add 3.5bcf to global supply, and the market could experience nearly 30% oversupply. The oversupply persists into 2030 (still above 20%).

Exhibit 15: Estimated global helium surplus/(deficit) (LHS, bcf) versus % surplus/(deficit) (RHS)



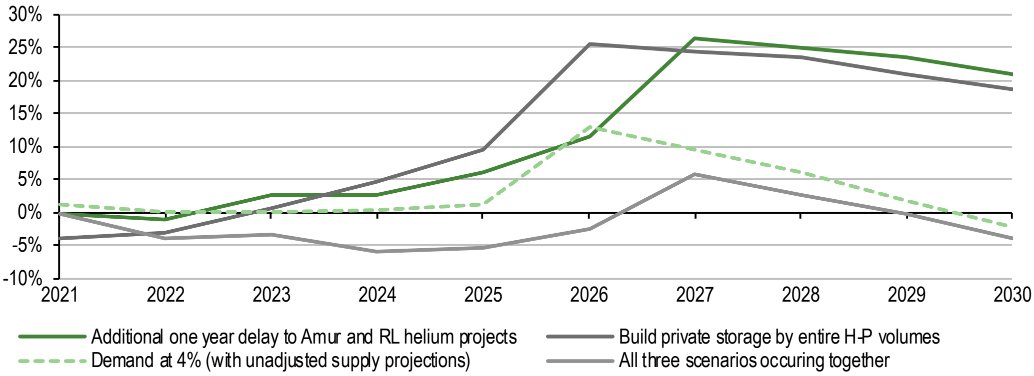
Source: Edison Investment Research based on various sources. Note: *Excluding changes in private storage (supply-side).

Sensitivities

As shown in the chart below, even assuming maximum private storage build (at BLM reservoirs), equating to the entire production from the H-P complex, there would not be a significant impact on the level of oversupply from the mid-2020s; the maximum surplus (in 2026) reduces to 25% (from 29%). Likewise, if the mega-projects in Russia and Qatar are postponed an additional year (our supply projections already factor in a one-year delay), then the maximum surplus is slightly lower (26% vs 29%) and pushed back a year to 2027.

The oversupply situation starts to become more manageable when we adopt the 4% pa scenario, with a peak of 13% surplus in 2026 swinging back to undersupply by 2030. When we combine the other two scenarios with the 4% pa demand scenario (ie those circumstances all occurring together), we see a much trickier supply situation, with undersupply persisting until some short relief in 2027–28, before returning in 2029. We note that our supply projections exclude possible projects in Saudi, United States (Four Corners Area), Canada and China, which could add another 1–1.5bcf/year by 2030.

Exhibit 16: Sensitivities in global helium % surplus/(deficit)



Source: Edison Investment Research based on various sources

Pricing

Due to the nature of the market, there is very limited data on pricing; anecdotal evidence suggests prices rose steeply over 2018–19 and some evidence suggests they were still rising in 2020; if so, this is likely their last leg up for the current cycle. The market is tightly balanced over 2020–22, so we do not expect to see significant pricing pressure until later in 2022 as the mega-projects in Russia and Qatar ramp up production. We would expect significant pricing pressure by the mid-2020s unless demand significantly surprises on the upside; demand would need to be at least as high as our 4% pa demand scenario. Due to the very limited historic pricing data, we do not offer price projections; however, we note that during the last period of oversupply (2013–16), which peaked in 2013–14, BLM conservation (private sector) prices were $80–90/mcf for crude helium, 30% below the FY18 auction price ($119/mcf) and 70% below the final BLM auction price in FY19 ($280/mcf). The financial year (FY) corresponds with the US government's fiscal year ended 30 September.

Recent price history

Some sense of recent price history can be garnered from BLM's final auctions of crude helium volumes. Nearly 1.5bcf were sold over five consecutive annual auctions. Volumes sold were for delivery in FY15–19.[6] Air products won 70% of the total volumes sold, including 100% of volumes sold for FY19 at the final auction. We watched the final auction and the average price across the 12 lots was $280/mcf, an increase of 135% over FY18 ($119/mcf), demonstrating the scarcity premium

[6] US FY20XX = year to 30 September 20XX

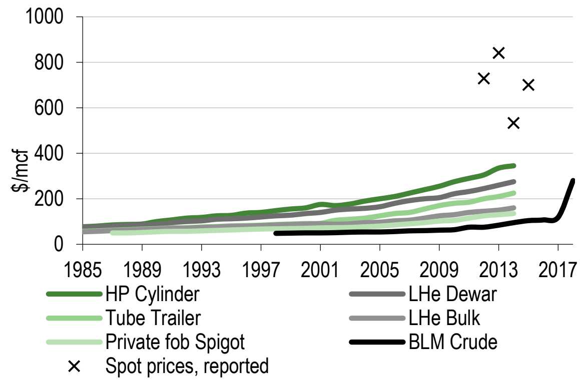
that some companies were willing to pay; although there were more than 10 chemical companies present, only Praxair (now Linde) and Matheson Tri-Gas (subsidiary of Taiyo Nippon Sanso Corporation) were bidding with Air Products when bid prices rose above $130/mcf.

Exhibit 17: BLM crude helium auction results by volume (mmcf)

Auction date	30-Jul-14	26-Aug-15	20-Jul-16	19-Jul-17	31-Aug-18	
Fiscal year to 30 Sep:	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**
Air Liquide	0	30	0	0	0	30
Air Products	73	125	225	385	210	1,018
IACX	0	15	0	0	0	15
Matheson	0	15	175	20	0	210
Praxair	20	90	0	25	0	135
Uniper	0	0	0	30	0	30
Weil	0	0	0	15	0	15
Total	**93**	**275**	**400**	**475**	**210**	**1,453**
% Air Products	78%	45%	56%	81%	100%	70%
Average price ($/mcf)	161	104	107	119	280	
% y-o-y		**-36%**	**3%**	**11%**	**135%**	

Source: Edison Investment Research based on BLM data

Exhibit 18: Prices for different customers, from wholesale (BLM and private spigot at the bottom) to retail



Source: USGS, 'Determination of fair market pricing of crude helium', assorted sources for spot prices

Global reserves

There is no clear picture of global helium reserves or resources and relatively little written publicly. Many papers and books reference papers that are decades old and there are no global authorities or industry bodies that publicly release data on helium. In 2013, this uncertainty led US Congress to request the US Geological Survey (USGS) to perform a national and global helium gas assessment. Given the scarcity and niche nature of helium, the USGS expects this to take many years. As of end-2020 BLM has analysed 22,700 gas samples from 27 countries. It expects results of the assessment to be published in 2021. The BLM also expects to update its view on helium resources in the United States by mid-2021. The most recent data available from USGS is from pre-2007; it comprises US data for proven and probable reserves of 9.6bcm (337bcf) dating back to 2006 and non-US data for helium resources, which we assume relate to proven and probable reserves of 31.3bcm (1,102bcf). A split by key geography is shown in Exhibit 19. Assuming roughly 6.2bcf/year global demand (estimated 2019 demand), this would translate to 25 years of proven reserves for the US, or over 200 of proven reserves globally. While this may superficially seem generous, these resources have to be developed and this is not a given. Furthermore, most of these reserves contain helium at low concentrations (<1%), for which extraction is uneconomic unless as a by-product of natural gas production. As natural gas production becomes obsolete as we transition towards net zero carbon emissions by 2050, many of the reserves in Exhibit 19 will likely be rendered uneconomic.

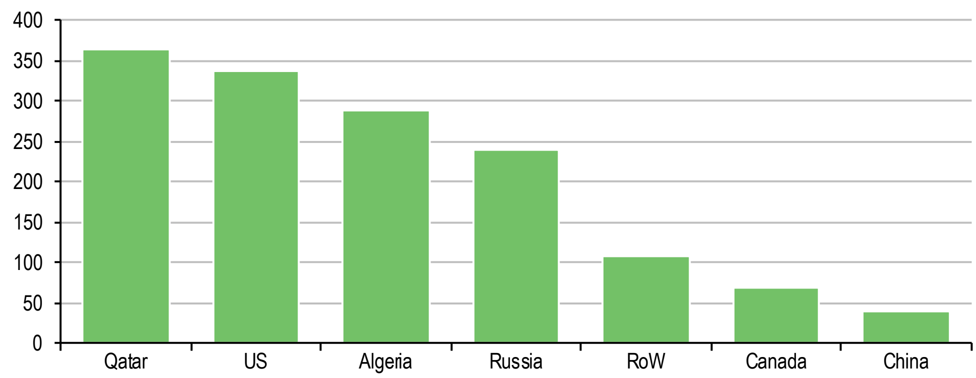
Most of the time, helium production is hugely dependent on the development of the gases that it exists alongside (non-hydrocarbons fields being the main exception). Transparent reporting of reserves and resources is not helped by the tiny concentrations found in many natural gas fields. It exists in such small quantities in many natural gas reservoirs that it is often overlooked given the small volumes/revenues it may represent versus natural gas. Helium has largely been a profitable by-product but not valuable enough to justify standalone developments (or in the United States of a statute to allow federal land lease).

In most fields, large quantities of natural gas (or CO_2) have to be extracted for commercial volumes of helium to be separated, and as a result, the commerciality of a helium project largely rests away from the helium itself. As natural gas prices have declined in recent years (particularly in the United States), projects have become less attractive and fewer projects have been sanctioned:

- the current surfeit of LNG supplies (and low prices) has led to postponement of large LNG projects (such as Browse) from which helium could have been recovered;
- the recent low oil prices mean the use of CO_2 (from which helium can be extracted) in enhanced oil recovery (EOR) has become less economic, reducing the demand for CO_2 and a number of projects have been put on hold; and
- shales cannot trap helium, which means supplies have not benefited from the massive shale boom in the United States and the economics of shale gas production have the potential to price out conventional natural gas development (which may contain helium) in the United States in the medium term.

In the United States therefore, helium development may have to be driven by helium economics, necessitating higher helium prices to incentivise investment.

Exhibit 19: Summary of global helium resources (1P+2P) pre-2007*(bcf)



Source: USGS Mineral Commodity Summaries, January 2016. Note: *US data is from 2006 and non-US data is from 2003; converted using a 35.2cf/m ratio.

Reserve replacement of helium has been very poor and hampered by a number of factors:

- Helium is scarce and generally found within conventional natural gas reservoirs in small concentrations (<0.5%), making it a valuable by-product as long as the gas is profitable to extract. In the past, this has meant upstream companies had no strong incentive to negotiate high prices for helium, while in recent years depressed gas prices (particularly in the United States) have discouraged development of conventional natural gas fields.
- Prices of helium have arguably been kept artificially low by the large-scale, well-publicised sell-off of the US strategic reserve to a limited number of buyers that gave mid/downstream companies a reliable supply over the last 10 years.
- Helium has traditionally been traded on confidential long-term private contracts, keeping pricing opaque and reducing initiatives for helium exploration.
- Due to its properties, helium cannot be stored or produced from shale. Helium therefore has to be sourced from conventional natural gas reservoirs, which hinder its economics. Helium associated with CO_2, will also suffer from low oil prices.

What is helium?

Helium is a unique industrial gas that exhibits characteristics both of a bulk, commodity gas and of a high-value ‘specialty’ gas. Due to the high cost of extraction, helium use is restricted to relatively few, generally high-technology applications. Only a handful of sources in the world produce helium; it can be transported in large quantities, in tanks ranging from 5,000 to 11,000 gallons (0.8–1.8mcf).

Why is helium important?

Helium is a vital element that cannot be replaced in the manufacture of MRI scanners, as well as in space exploration, rocketry and some areas of scientific research. For other applications, other gases can replace helium, although not necessarily with the same performance or favourable economics.

How is helium made/extracted?

Helium is made either by the nuclear fusion process of the sun, or by the slow and steady radioactive decay of terrestrial rock, which accounts for the Earth's entire store of the gas. It cannot be manufactured artificially and it is uneconomic to extract it directly from air. Instead, a large majority of commercially available helium is extracted as a by-product of natural gas production from a small number of natural gas reservoirs with relatively high concentrations of helium. Over the last decade or so, LNG has increased the amount of economically recoverable helium.

Helium is mostly extracted by fractional distillation from natural gas; it has a lower boiling point than any other element, which means that low temperature and high pressure are used to liquefy nearly all the other gases (mostly nitrogen and methane). Any remaining gases are removed through exposing the crude helium to increasingly lower temperatures. In the final purification phase, activated charcoal is used; typically resulting in 99.995% pure Grade-A helium.

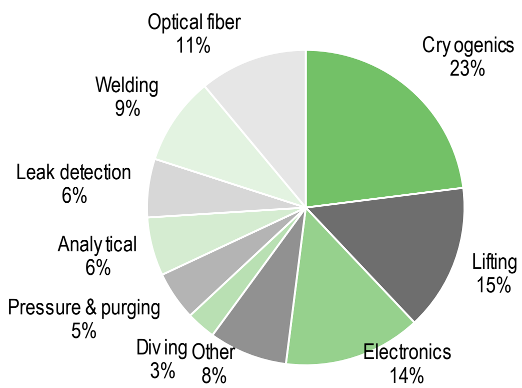
Gaseous helium is mostly liquefied (via a cryogenic process),which reduces the cost of long-distance transportation, as the largest liquid helium tanks can have more than five times the capacity of the largest gaseous helium containers.

Beyond extraction from natural gas, more recently certain companies have started exploration and production activities from non-hydrocarbon sources, with helium extraction as a primary target. These sources still represent a very small percentage of global supply; however, a key advantage of these sources is the production flexibility (as helium is the key target and not a by-product of natural gas extraction, production can be activated when pricing and demand conditions are most favourable). In addition, these projects may be able to attract funding also from 'sustainable' investors, whose mandates often require them to avoid hydrocarbons investments. Also, large helium buyers may find these sources as more environmentally friendly and more compliant with their own sustainability targets.

Uses of helium

A breakdown of uses for helium from USGS is shown in Exhibit 20 below.

Exhibit 20: Global share of helium applications



Source: USGS

Some of the most important applications, where helium is critical and cannot be replaced, are:

- MRI: only helium can act as the crucial refrigerant in superconducting magnets, which are used in MRI medical devices. The helium needs to be periodically topped up to avoid damage to the machine.
- Purging: this is a process used in the space industry. Helium is used to safely displace liquid oxygen or liquid hydrogen at very low temperatures without freezing. Hydrogen, despite having similar properties, cannot be used due to its reactivity oxygen.
- Laboratory: helium is used in laboratories to cool superconducting equipment for accelerators, particle detectors and research magnets. Only helium can act as the crucial refrigerant in superconducting magnets.

Some of the most important applications, where helium can be replaced by other gases, although not necessarily with the same performance or favourable economics, are:

- Lifting: hydrogen is sometimes (but not often) used as a substitute subject to safety concerns.
- Welding: uses in welding of titanium, aluminium, stainless steel and other high-value, high-reliability applications. It is sometimes possible to use neon as a substitute.
- Electronics and fibre optics: high thermal conductivity of helium gas has been incorporated in manufacturing processes. Sometimes, hydrogen may be substituted. Helium is also used within semiconductor chips to increase their processing speed. It is also used in data storage, where helium allows for less turbulence when hard drive disks spin, reducing power consumption and allowing for a higher number of discs to be incorporated in the same space.

Exhibit 21: Summary of the properties and applications of helium

Property	Application
Lowest boiling point; does not solidify at atmospheric pressure	Liquid cooling of low temperature superconductors Purging liquid hydrogen systems
Second lightest element (after hydrogen)	Lifting medium for balloons, airships
Smallest molecular size	Leak detection
Chemically inert	Carrier gas – analytical, semiconductor
Very high specific heat and thermal conductivities	Gaseous cooling – fibre optics
Radiologically inert (no radioactive isotopes)	Heat transfer medium in fusion reactors
Highest ionisation potential	Metal arc welding – aluminium Plasma arc welding – titanium
Extremely low solubility	Deep sea diving gases
Very high sonic velocity	Metal coating
Superfluid below 2.2k	Cooling of low temperature superconductors

Source: Air Products and Chemicals Inc, paper on ‘Challenges to the Worldwide Supply of helium in the next decade’

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