

Ron Harrell, P.E.




Chairman Emeritus Ryder Scott Company

Mr. Harrell is a Petroleum Engineering graduate of Louisiana Tech University and continues as Chairman Emeritus of Ryder Scott Company. Ron remains active in the industry as a licensed engineer in three states and serves on several Management and Advisory Boards including corporations, not-for-profit organizations and three universities. He is a Senior Advisor to RSK (UK) LTD, Board Member of eCORP International plus holds energy advisory positions for The Carlyle Group and Morgan Stanley private equity energy divisions. He is a founding member and past Chairman of the UH Petroleum Engineering Advisory Board and an active member of the UH Subsea Engineering Program since its formation.

Mr. Harrell is also a founding member and Vice Chairman of the College of Engineering Advisory Board for Houston Baptist University. He served as an SPE Distinguished Lecturer in 2007-2008. He remains a member of SPE's Distinguished Lecturers Selection Committee and is a peer reviewer for SPE M&I technical papers. Further, he serves as SPEE's Observer on the SPE Oil & Gas Reserves Committee (OGRC).

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Panel Discussion

Topic: Energy Transition

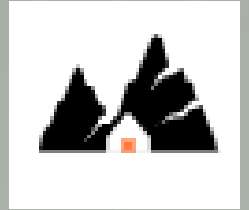
Moderated by Ron Harrell

OUR PANELISTS

Industry:



John Hessenbruch
Associate
David Hoffman & Associates



Money:



Logan Burt
Managing Director
Morgan Stanley – Investment Management

Morgan Stanley

Research:



Christine Ehlig-Economides
Professor & Hugh Roy and Lilly Cullen Distinguished University Chair
University of Houston – Petroleum Engineering Program



Moderator:



Ron Harrell
Chairman Emeritus
Ryder Scott Company





Numbers to Count On. Experts to Trust.

GLOBAL SUPPLY CHAIN CHALLENGES FOR THE ENERGY INDUSTRY

JOHN HESSENBRUCH

DAVID HOFFMAN & ASSOCIATES

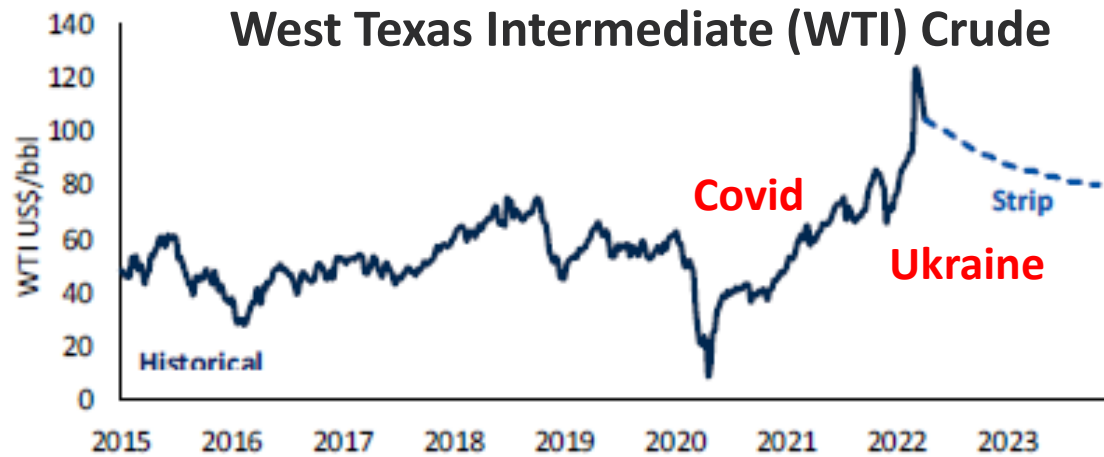
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MAY 2022

PARADIGM SHIFT IN ENERGY SUPPLY CHAIN MANAGEMENT

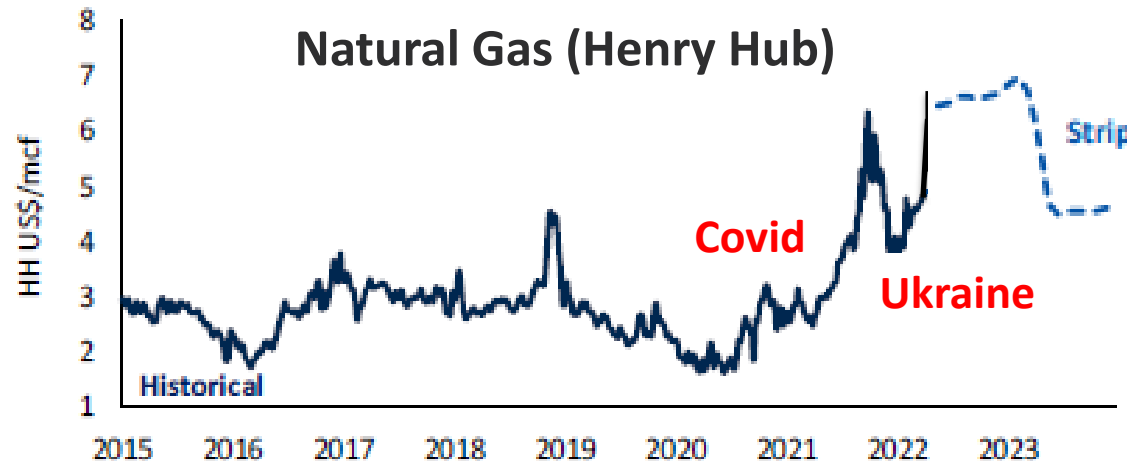
- **Covid Crisis and Ukraine/Russia Conflict have created extreme volatility and sector rotation in the global commodity markets, which have caused supply-side shocks to the economy**
- **Price escalation of energy & strategic metals has caused E&P companies to restructure their ordering process, which has created a paradigm shift in global supply chains**
 - Short Term Impact (3-6 months): Inflation as measured by the Consumer Price Index (CPI) will remain high (>8%)
 - Energy & natural resources costs will escalate until a rebalancing is achieved between supply & demand
 - Most energy firms are prudently allocating capital, increasing ESG disclosure and using cash flow to increase dividends & buybacks to enhance shareholder value
 - Investment community has increased its capital allocation to public E&P companies over last 6 months.
 - Long Term Impact: (6-18 months): Inflation will moderate (3-5%)
 - As more reliable and secure energy sources are developed at a greater cost, in order to stay competitive, companies may be forced to accept lower profit margin
 - Revised price deck may allow E&P firms to update their previous resources & reserve classifications
 - New climate related disclosure standards are being proposed by SEC and may begin as early as 2023
- **Global Conundrum: Lack of fossil fuel investment has created an Energy Void that has not been replaced by renewable resources**
- **DOE has released (Feb 2022) a series of clean energy supply chain reports that outline how to access federal funding for renewable development**

DOMESTIC OIL AND GAS FUTURES: 2015-2026



2022-2026

2022-2026		
	WTI	RBC
Year	US\$/bbl	Deck
2022	95.40	98.30
2023	82.41	96.29
2024	75.93	78.50
2025	71.84	55.00
2026	69.17	55.83

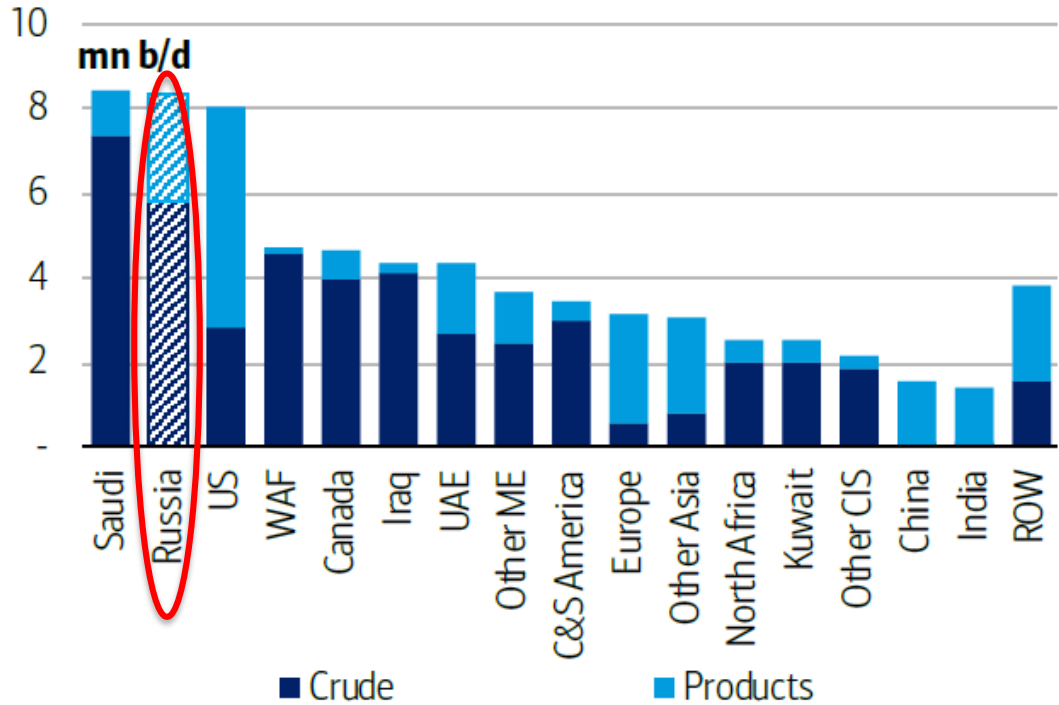


2022-2026

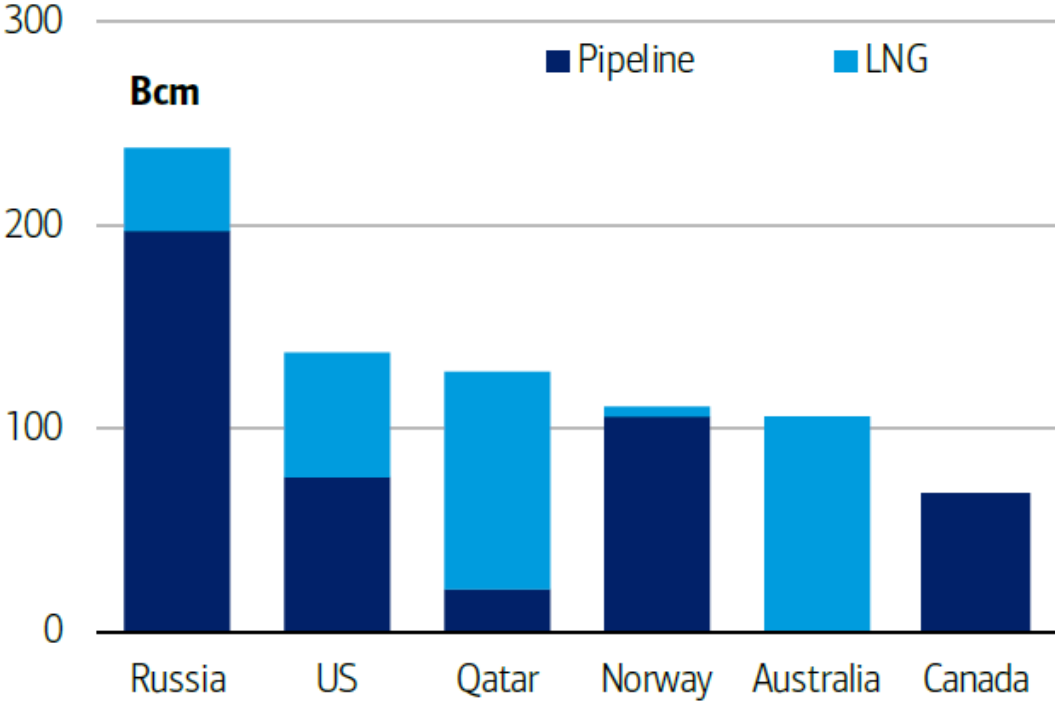
2022-2026		
	HH	RBC
Year	US\$/mcf	Deck
2022	5.05	3.85
2023	3.94	3.45
2024	3.50	3.25
2025	3.47	3.00
2026	3.50	3.05

GLOBAL OIL AND GAS EXPORTS BY COUNTRY

Crude Oil & Product Exports by Country/Region (2019)



Total Gas Exports by Country/Region (2020)



Source: BP Statistical Review

Source: BP Statistical Review

Bank of America, March 2022
IHS, March 2022

IMPORTS (BY NATION) FROM RUSSIA FOR NATURAL GAS, THERMAL COAL AND PETROLEUM (2020)

% of gas imports from Russia

Country	% of gas imports from Russia	% of coal imports from Russia
Germany	55%	77%
Turkey	34%	40%
Italy	31%	50%
Netherlands	29%	54%
France	17%	50%
United Kingdom	16%	68%
Spain	10%	57%
Belgium	4%	19%
Ukraine	0%	68%
Other EU	44%	

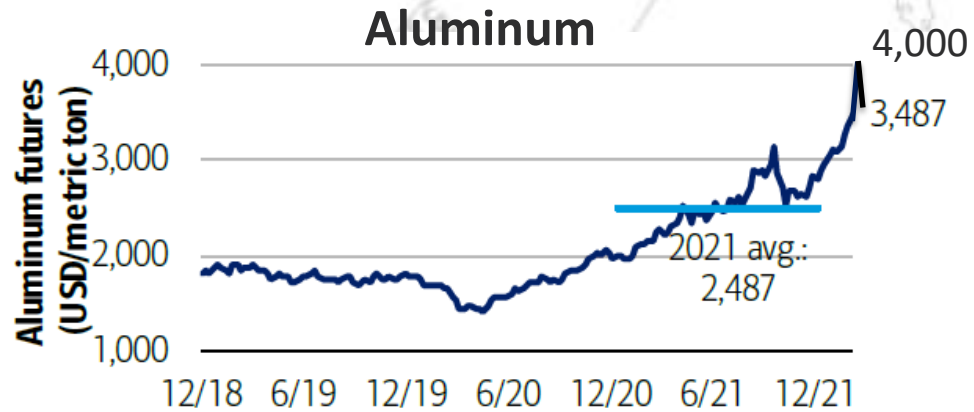
% of Petrol Imports from Russia

Country	% of Petrol Imports from Russia
Slovakia	79%
Lithuania	69%
Finland	68%
Poland	68%
Hungary	45%
Estonia	32%
Germany	30%
Czech Republic	29%
Greece	26%
Belgium	23%
Netherlands	19%
Turkey	19%
Latvia	18%

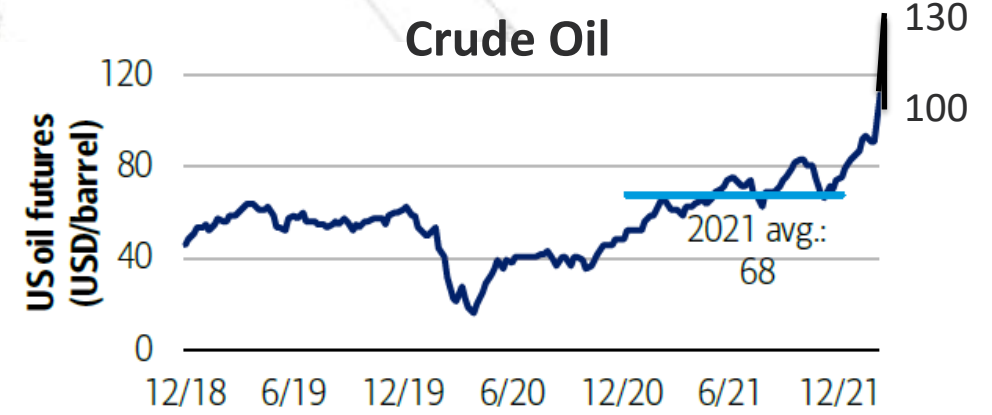
Source: IHS, BP

Bank of America, March 2022

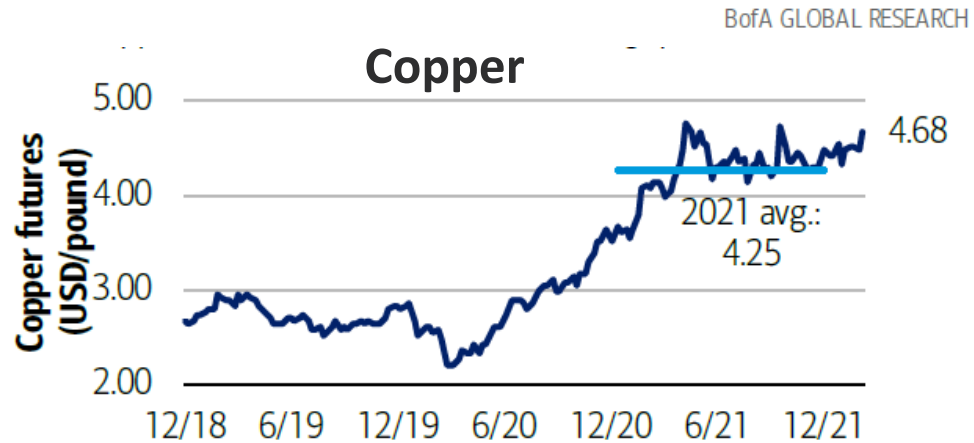
STRATEGIC COMMODITY FUTURES: 2018-2022



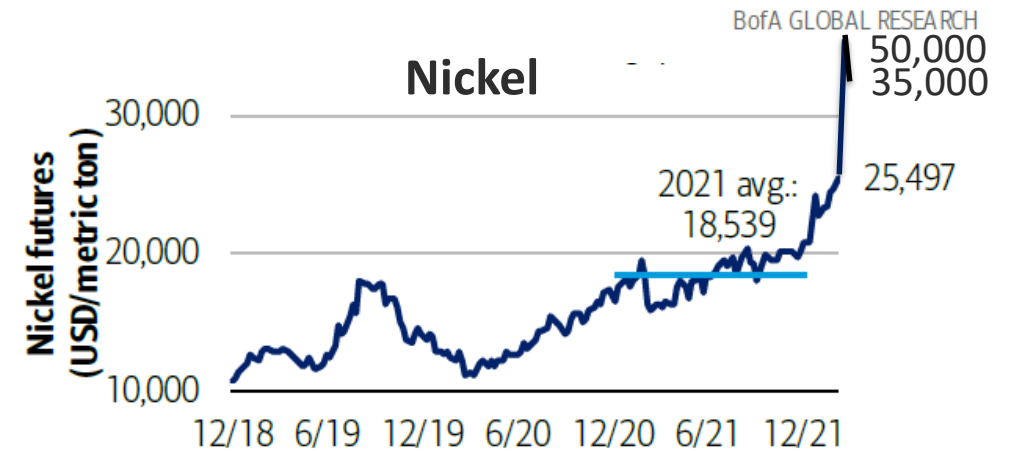
Source: Bloomberg, London Metal Exchange



Source: Bloomberg, Chicago Mercantile Exchange



Source: Bloomberg, Chicago Mercantile Exchange

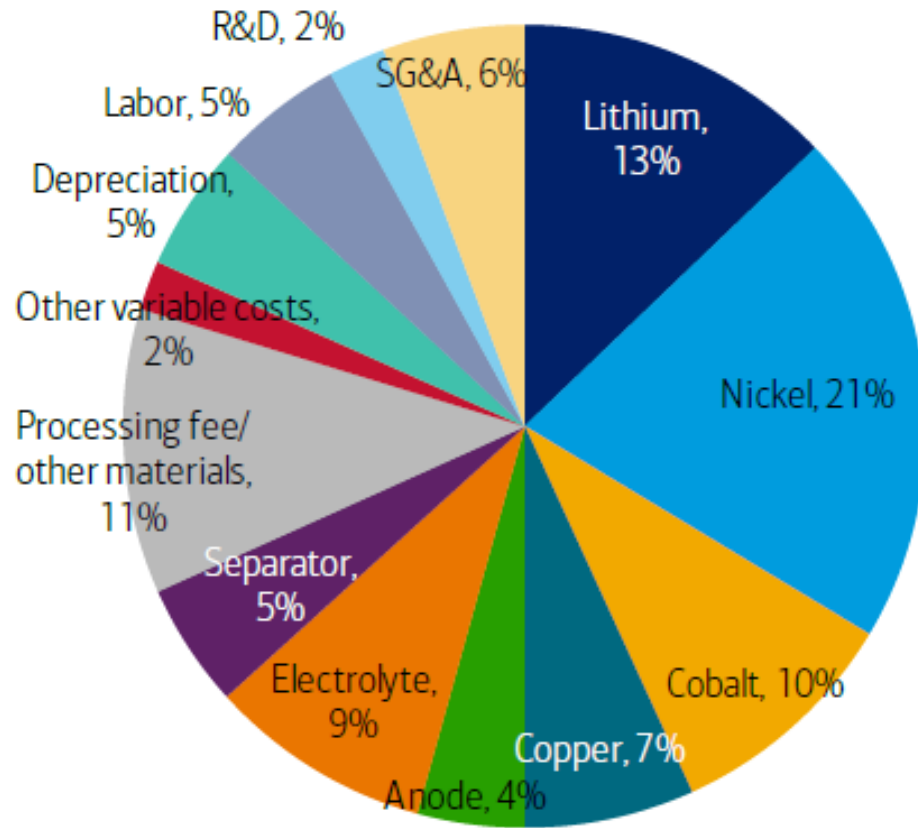


Source: Bloomberg, London Metal Exchange

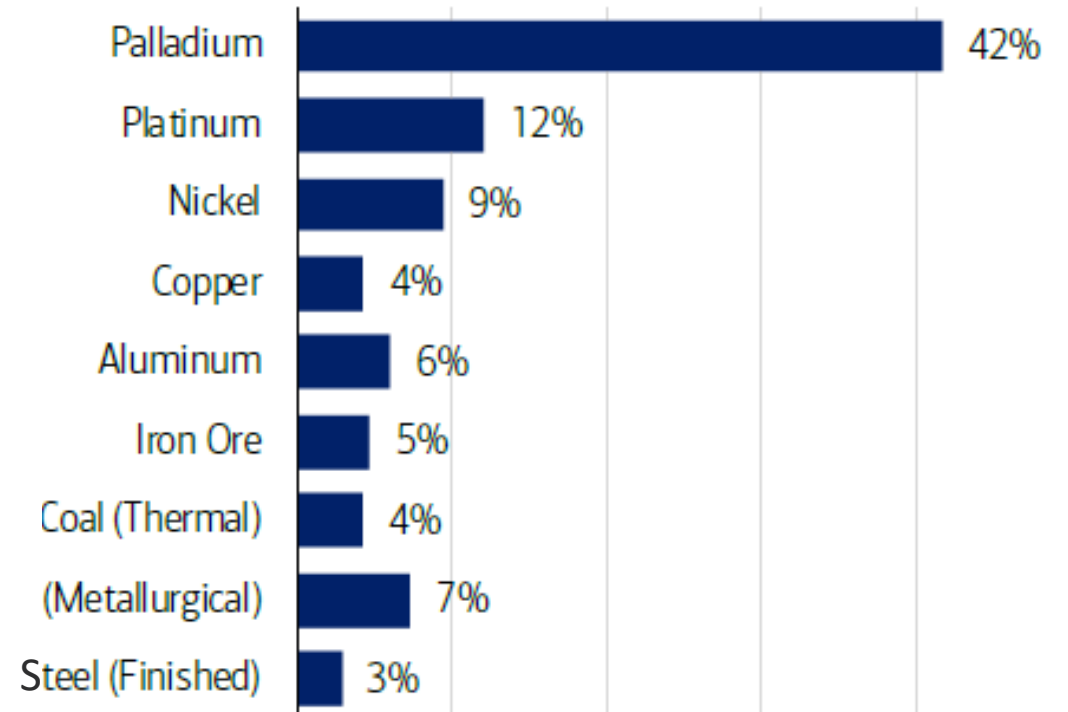
Bank of America, March 2022

PROJECTED 2022 COMMODITY/PROCESSING COSTS FOR BATTERY TECHNOLOGY

Battery Costs



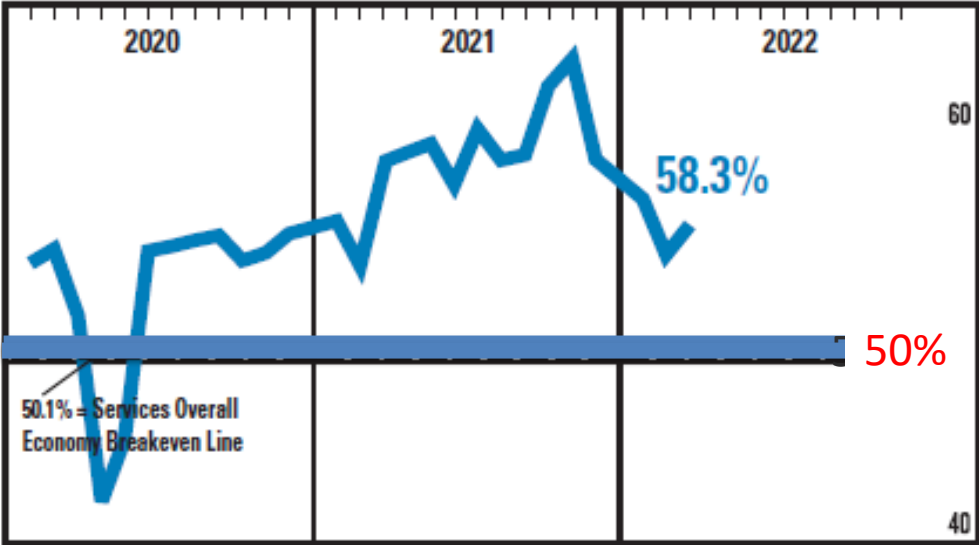
Russia's Share of Global Commodity Supply



DOMESTIC ECONOMY STILL EXPANDING AS SHOWN BY PURCHASING MANAGERS INDEX (PMI) FOR SERVICES & MANUFACTURING

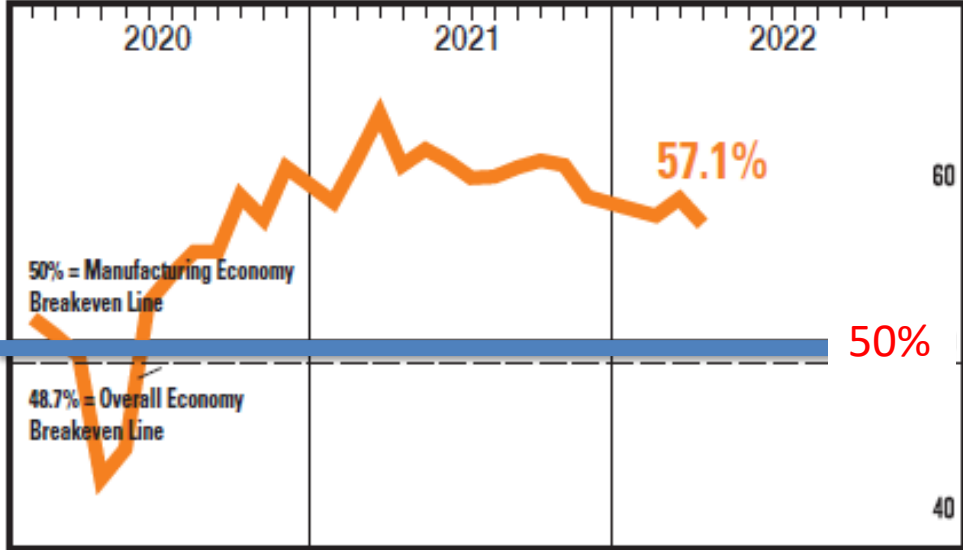
PMI Index: Services

Economic Growth: >50%



PMI Index: Manufacturing

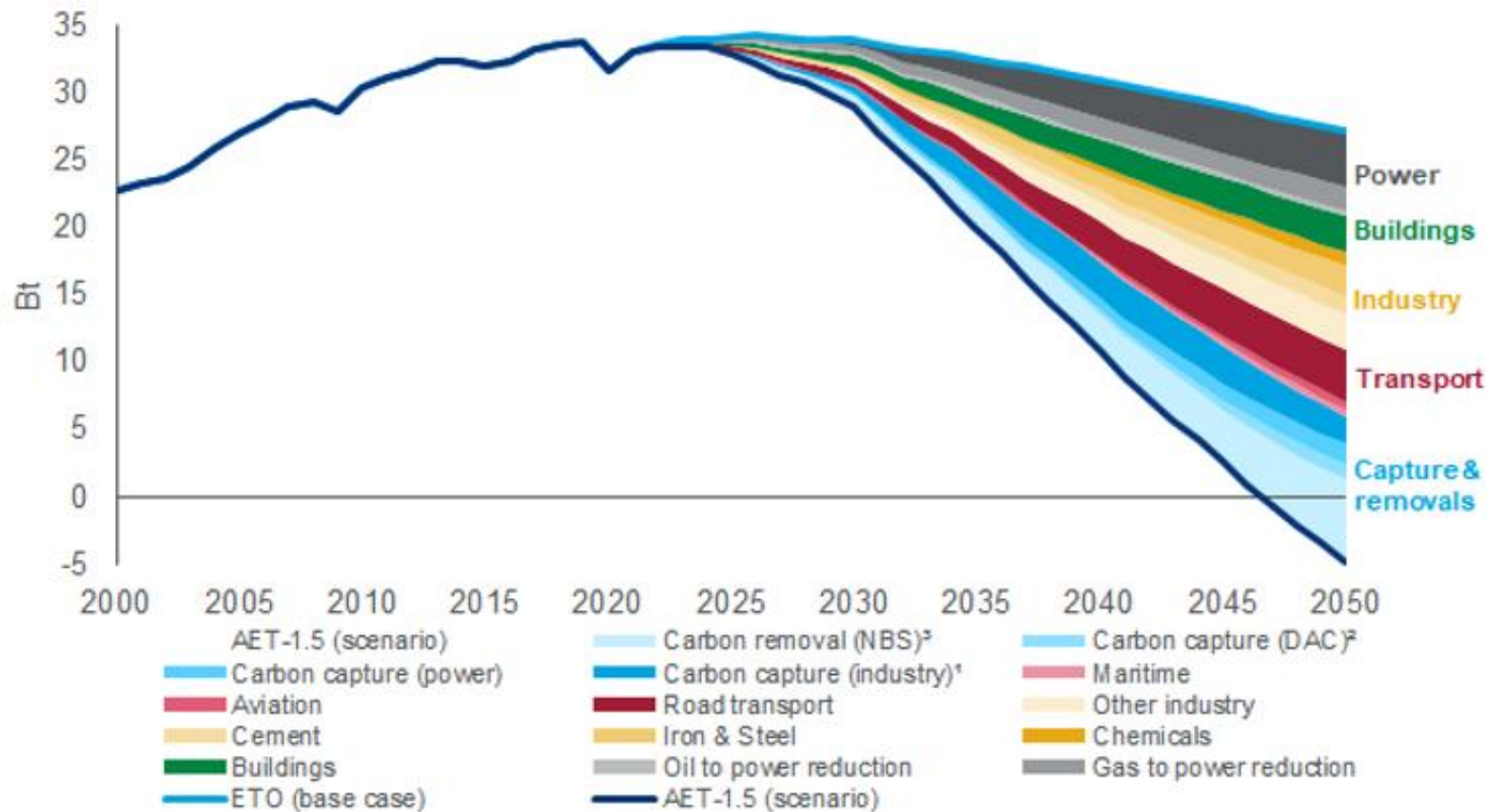
Economic Growth: >50%



Services Contributes ~90% to Domestic Growth

Manufacturing Contributes ~10% to Domestic Growth

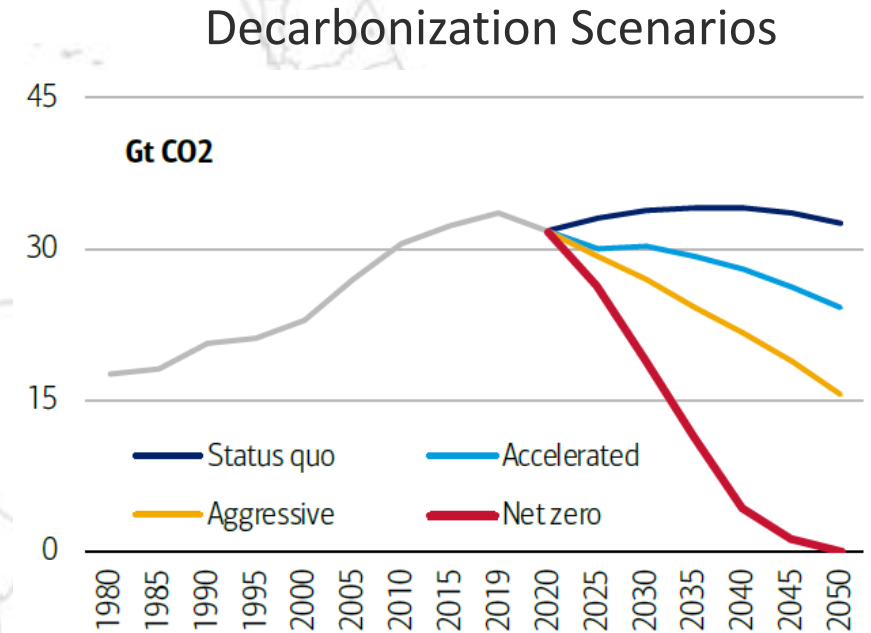
RUSSIA/UKRAINE CONFLICT SHOULD ACCELERATE TRANSITION TO A NET ZERO CARBON ECONOMY BY 2050



- Recent spike in fossil fuels has created an impetus to achieve low carbon energy alternatives
- Projected costs to achieve net zero: **\$60 trillion**
- Carbon prices may rise to a global average of **\$175/t** by 2050
- Additional federal incentives are required to reach projected goals
- Multiple clean energy **reports** issued by **DOE** in Feb 2022 (<https://www.energy.gov/policy/securing-americas-clean-energy-supply-chain>)


POTENTIAL UPSTREAM SUPPLY CHAIN CHALLENGES WILL PREVAIL IN 2022

- Continued global energy supply crunch means another year of volatile commodity prices
- Domestic LNG exports to Europe and Asia may replace a percentage of the volumes previously supplied by Russia via pipeline
- Henry Hub natural gas prices may remain above \$4/MCF for most of 2022
- E&P firms must balance investments with commitments to reduce emissions and diversify into renewables & low carbon energy
- Investment in renewable technologies is not yet sufficient to replace fossil fuel energy sources
- It is expected that Inflation should moderate by end of 2022 (3-5%) as supply & demand for fossil fuels, strategic metals and renewable sources of energy becomes more balanced



Source: IEA, Equinor, Shell, BofA Global Research estimates

SELECTED QUESTIONS REGARDING GLOBAL SUPPLY CHAIN CHALLENGES FOR THE ENERGY INDUSTRY



**LIST OF QUESTIONS &
ANSWERS**

QUESTIONS REGARDING GLOBAL SUPPLY CHAIN CHALLENGES FOR THE ENERGY INDUSTRY

1. What has been the biggest take-away from the global supply chain disruption?

Answer: Capital providers, the manufacturing industry, and consumers have begun to realize that fossil fuels and alternate energy sources can complement each other during the energy transition toward our 2050 goal.

2. How has the US economy managed to expand in light of the recent supply chain disruptions?

Answer: Unlike Europe which imports most of its energy, US has sufficient oil and gas reserves to support economic expansion

3. How have supply chain disruptions influenced capital investment in the energy sector?

Answer: According to Enercom (Mar 2022), Investment community has significantly increased its capital allocation to E&P companies over last 6 months.

- Top 10 investment firms own \$96 billion of a core group of 30 E&P firms

- Vanguard: \$25 bil

- Blackrock: \$23 bil

- State Street: 13 bil

- Fidelity \$8 bil

“We will continue to invest in and support fossil fuel companies... We have not and will not boycott energy companies.” – BlackRock, 1/3/22

Justification: E&Ps are prudently allocating capital and increasing ESG disclosure. They are also focused on using cash flow to increase dividends & buybacks to enhance shareholder value

4. What impact will rising energy prices have on reserves documentation in 2022?

Answer: Depending upon the reservoir parameters of the field, revised price deck may allow break-even levels for Contingent Resources to be realized, which will enhance commercial viability of these resources.

Answer: Contingent Resources classified as “Developed Pending” may have to be reclassified

Answer: Probable 2P cases may be reclassified as “economic project” if positive undiscounted cash flow is realized from evaluation date



Recent Energy Industry Trends

18th Annual Ryder Scott Conference

Logan Burt

Managing Director, Morgan Stanley Energy Partners

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Alternative investments are speculative and include a high degree of risk. Investors could lose all or a substantial amount of their investment. Alternative investments are suitable only for long-term investors willing to forego liquidity and put capital at risk for an indefinite period of time. Alternative investments are typically highly illiquid – there is no secondary market for private funds, and there may be restrictions on redemptions or assigning or otherwise transferring investments into private funds. Alternative investment funds often engage in leverage and other speculative practices that may increase volatility and risk of loss. Alternative investments typically have higher fees and expenses than other investment vehicles, and such fees and expenses will lower returns achieved by investors.

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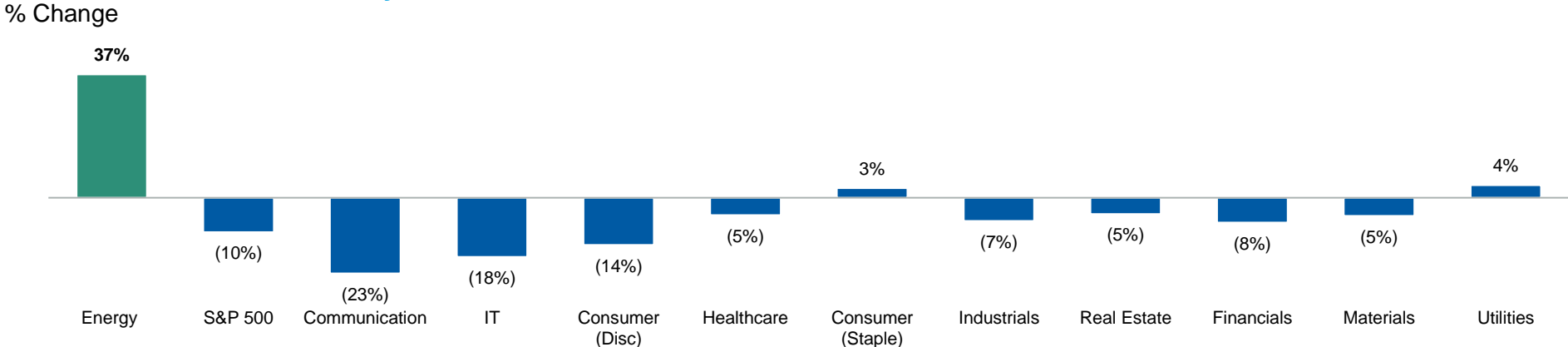
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No investment should be made without proper consideration of the risks and advice from your tax, accounting, legal or other advisors as you deem appropriate.

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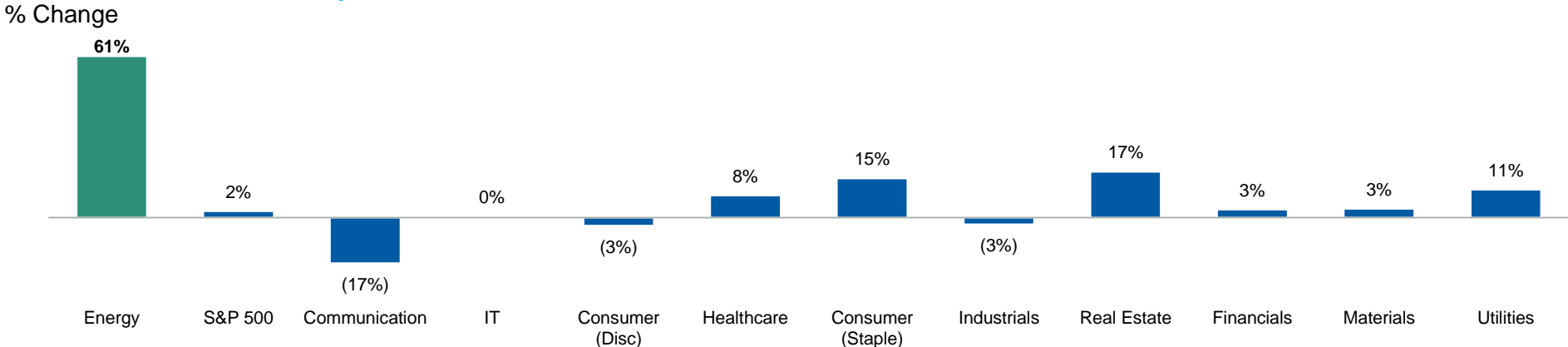
Energy Returns Have Significantly Outperformed

YTD 2022 S&P 500 Industry Index Performance



Source: Fidelity. Price data as of 4/22/2022

1-Year S&P 500 Industry Index Performance



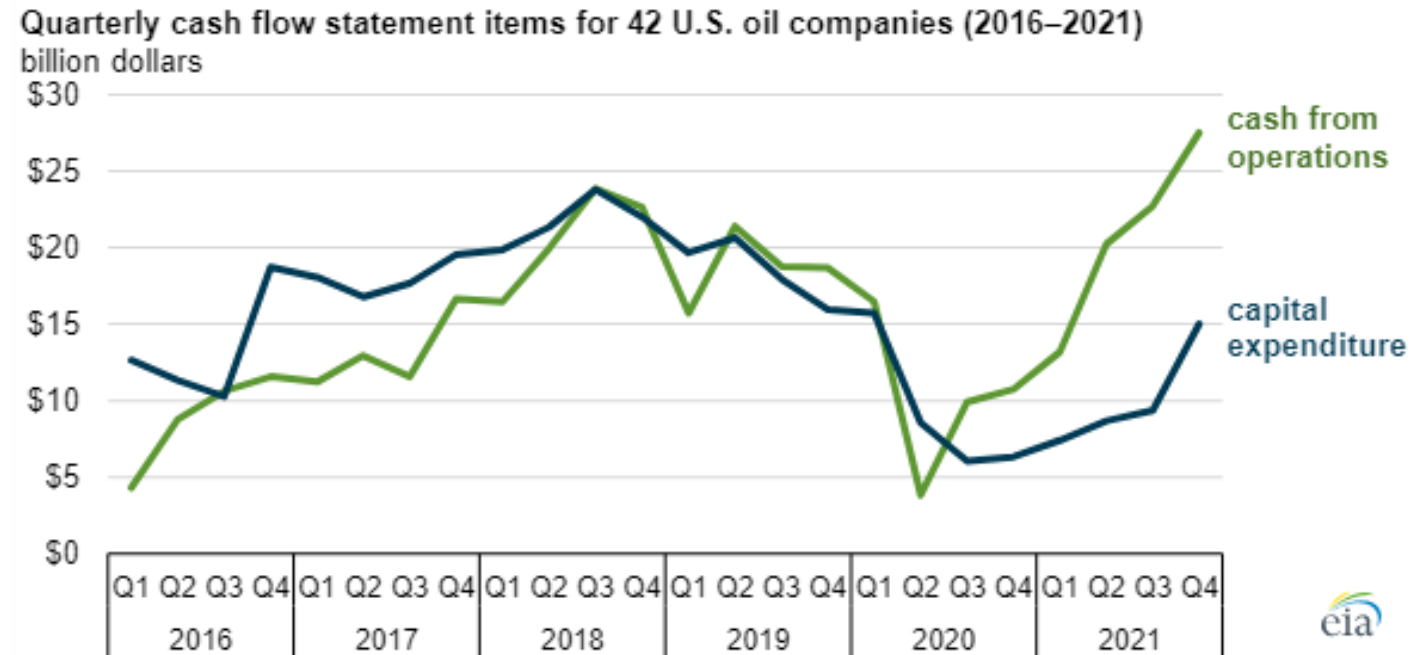
Source: Fidelity. Price data as of 4/22/2022

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Higher E&P Focus on Capital Allocation and Cash Flow Generation

E&Ps will need a deep and granular understanding of portfolio economics to respond quickly to market changes

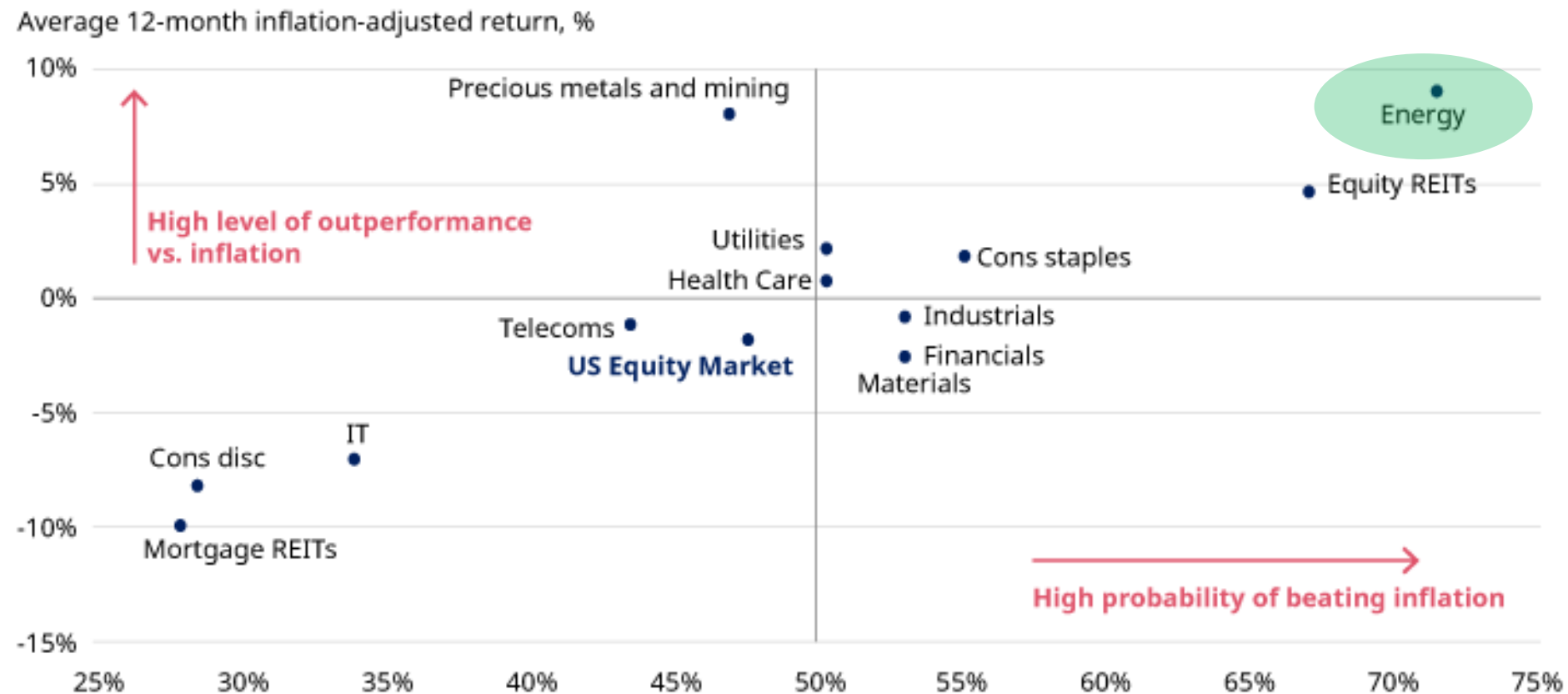
- Oil and gas companies need to ensure their portfolio decisions are based on market signals (i.e., demand and competitive economic positioning)
- This analytic view enabled companies to make better decisions about which projects to start, stop, maintain, or invest in
- 2022 should deliver record cash flow for the world's public E&Ps - now companies will need to prudently determine how to allocate that capital
- U.S. production comprised predominantly of an inventory of smaller, short-cycle shale wells should fare well



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Energy Equities Outperform During Periods of High and Rising Inflation

- Energy equities have historically outperformed in high and rising inflation environments
- Since 1973, US energy sector returns have exceeded the rate of inflation 71% of the time
 - Delivered ~9% average annual real rate of return during inflationary periods



Note:

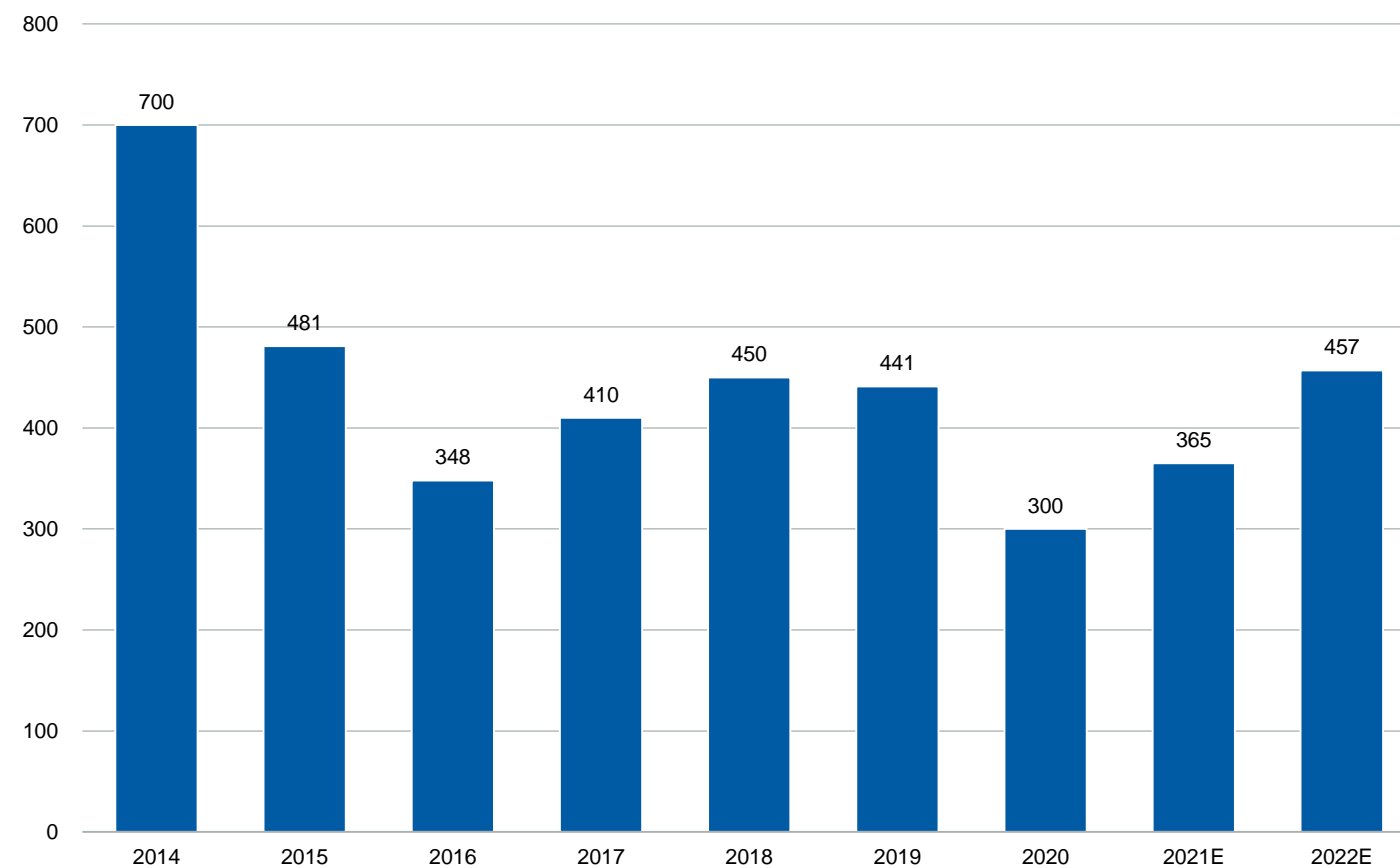
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Global Upstream Capital Spending Is Increasing

- Capital expenditures rebounding in 2021-2022 after a 7-year low of ~\$300 billion in 2020
- Capital discipline by energy companies both large and small and supply chains have constrained growth

Global Oil and Gas Upstream Capital 2014-2022 Estimated

USD billion



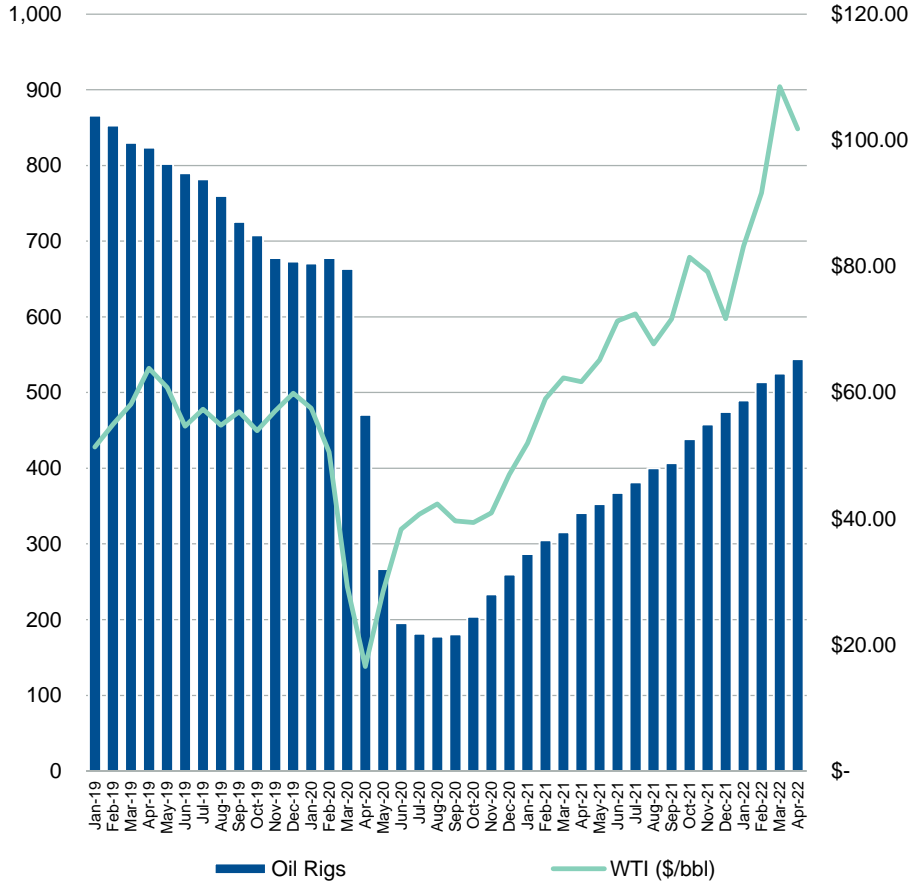
Source: EIA.

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Total Rig Count is ~175% Above the Trough, but Still ~-(25%) Below 2019 Levels

US Oil Rig Count vs. Oil Price

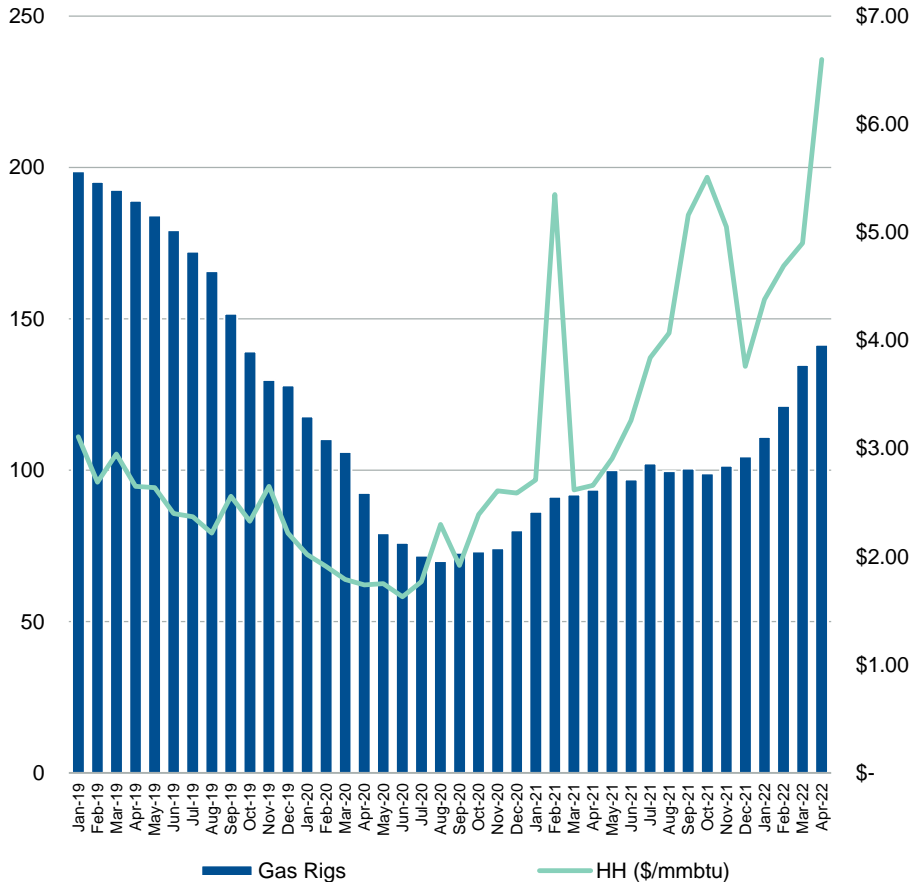
2019 – YTD 2022



Source: Baker Hughes Rig Count Data as of 4/22/2022

US Gas Rig Count vs. Gas Price

2019 – YTD 2022



Source: Baker Hughes Rig Count Data as of 4/22/2022

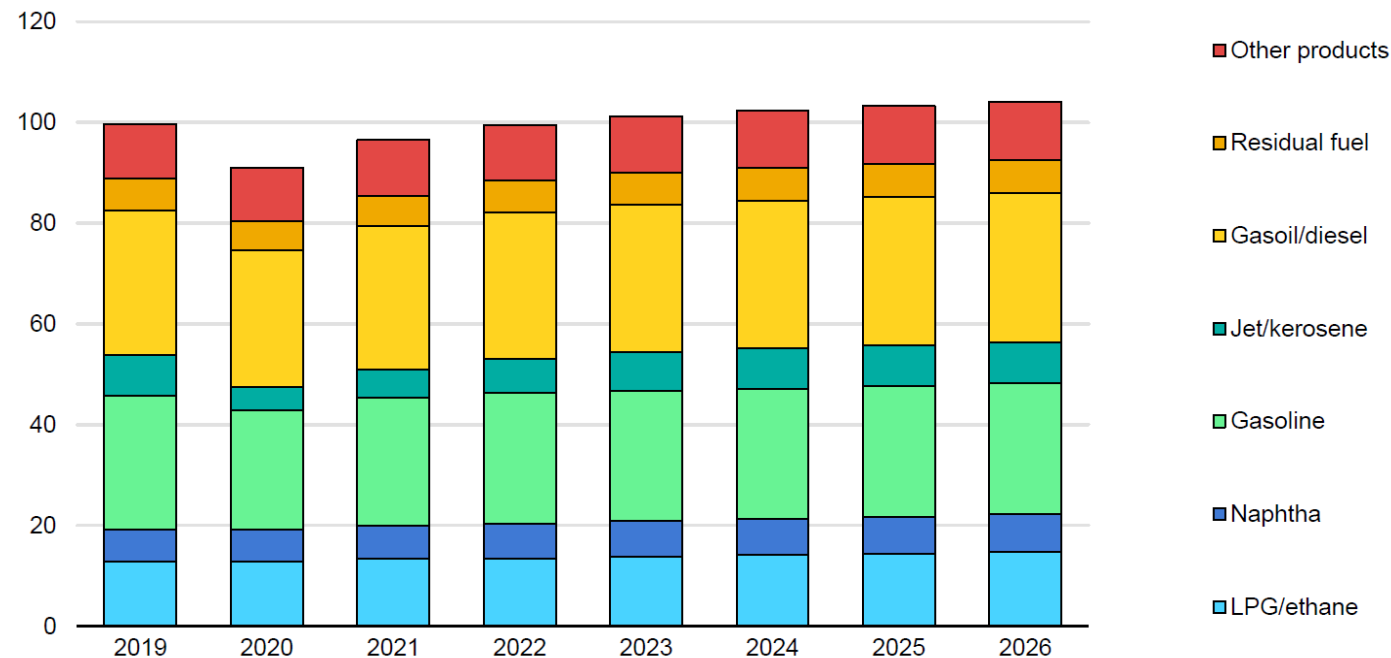
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Global Demand Rebounds in 2021/2022 and Forecasted to Grow Further

9-year low of 91 mb/d in 2020 to 104 mb/d in 2026

- Worldwide pandemic and tumultuous economic downturn triggered an unprecedented collapse in global oil demand of 8.7 mb/d in 2020
- Growth rebounded sharply in 2021/2022, and is projected to rise by 13.1 mb/d to 2026

Global Oil Demand by Product
Mb/d



Source: IEA 2021

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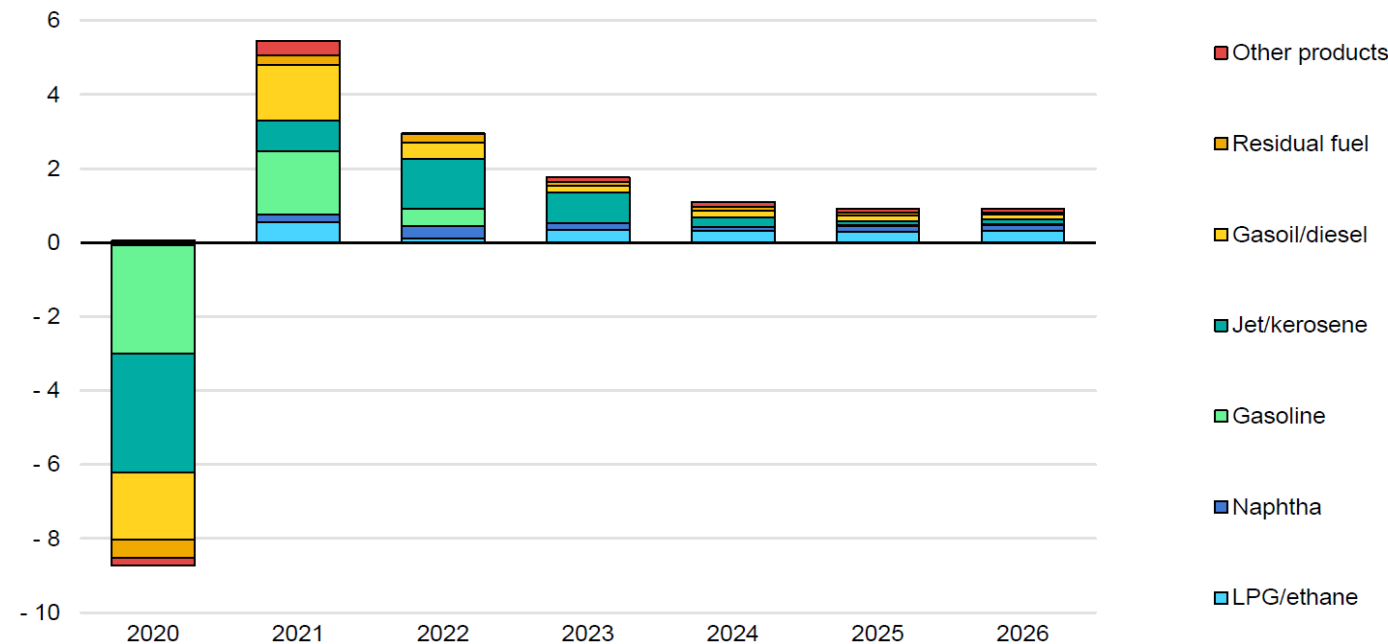
Following the Sharp Recovery, Demand Growth Expected to Slow

Despite the recovery over 2021-2022, short-term oil demand forecasts expected to slow

- The lingering impacts of the pandemic, coupled with a growing urgency to accommodate a lower-carbon economy, means that oil demand will likely moderate

Annual Global Oil Demand Growth

Mb/d



Source: IEA 2021

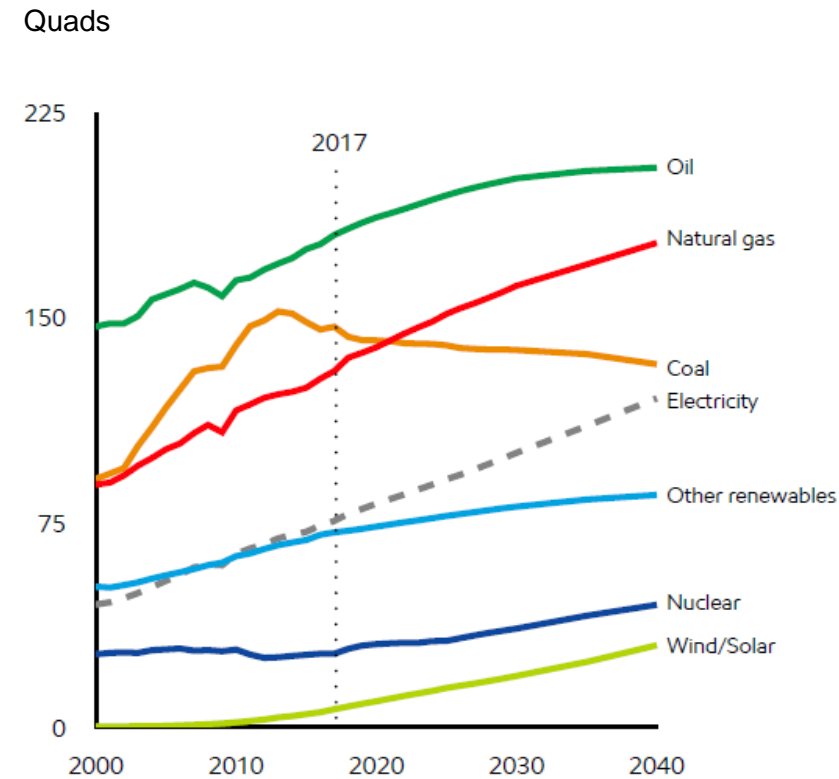
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Despite Slower Demand, Oil and Gas Will Continue to be Essential

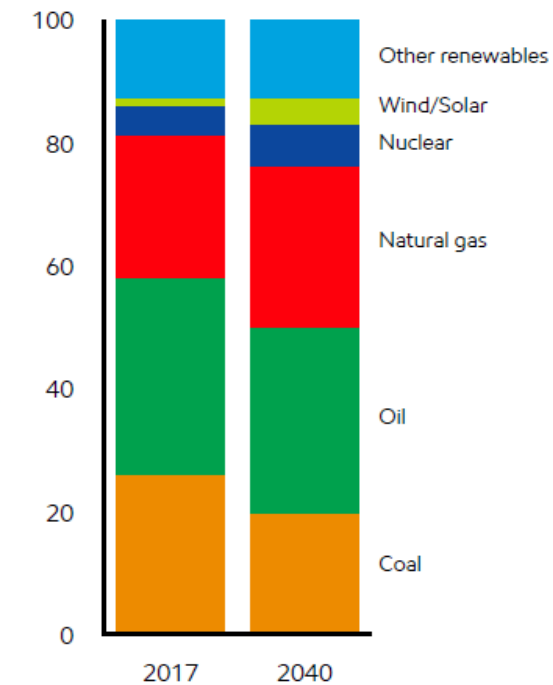
EIA estimates oil and gas still expected to represent between 46 to 53% of the energy mix through 2040

- Oil continues to play a leading role in the world's energy mix, with growing demand driven by commercial transportation and the chemicals industry
- Natural gas grows the most of any energy type, reaching a quarter of all demand
- Renewables and nuclear see strong growth, contributing more than 40 percent of incremental energy supply

Global Energy Mix Shifts to Lower-Carbon Fuels



Percent of Primary Energy (%)



Source: ExxonMobil

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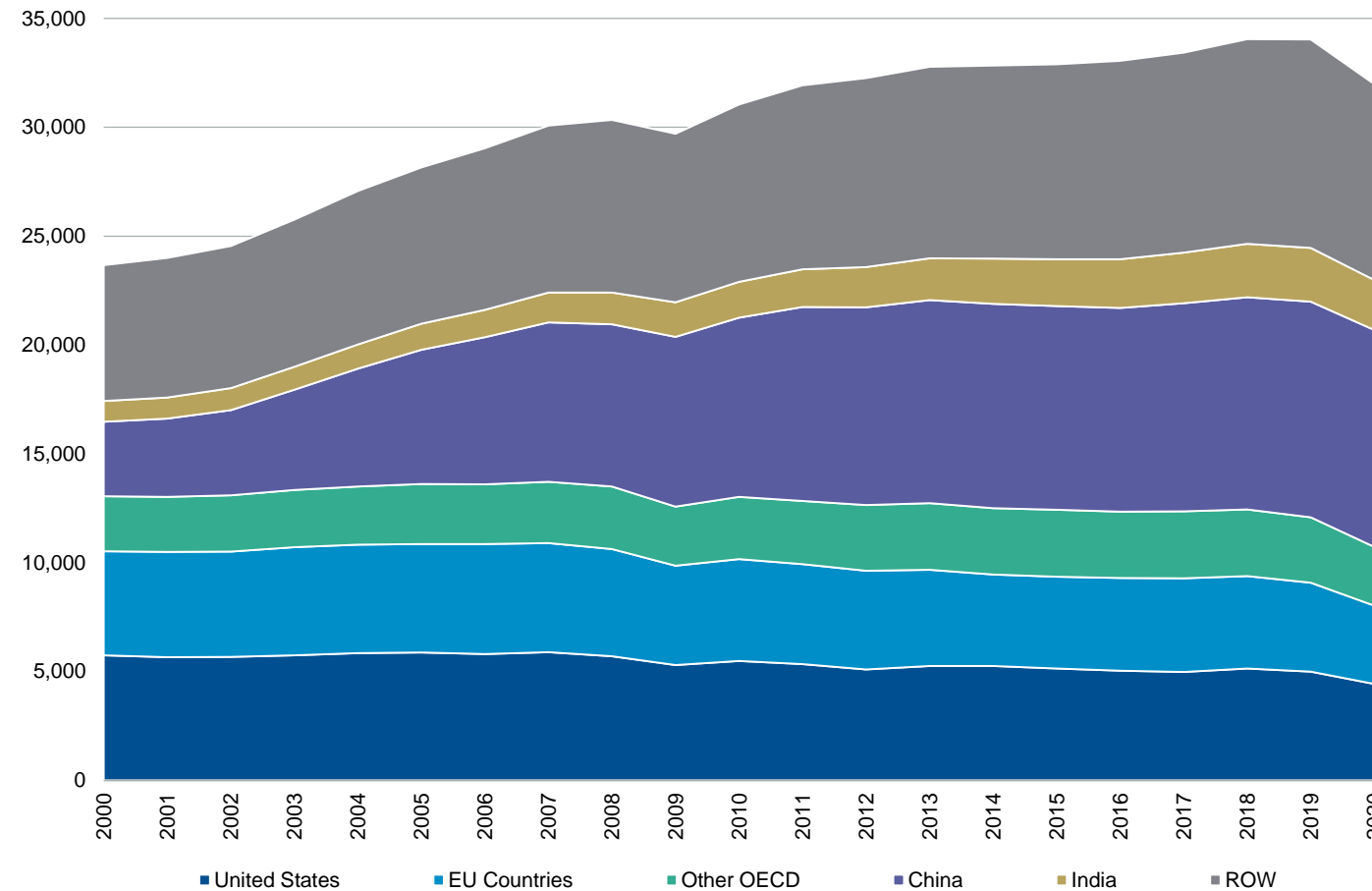
U.S. and European CO2 Emissions Have Been Declining While Global Emissions Have Been Rising

Percentage Change Since 2000

	Annual Change	Total Change
United States	-1.3%	-22.8%
EU Countries	-1.4%	-25.0%
Other OECD	0.4%	7.2%
China	5.5%	191.8%
India	4.5%	139.4%
ROW	1.8%	44.2%
Total	1.5%	35.2%

Global CO2 Emissions 2000-2020

MM Metric Tons



Source: BP Statistical Review of World Energy, June 2021.

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The Ongoing Energy Transition

The Big Themes



Secure and Reliable Energy Supplies to Meet Growing Demand



Decarbonization is a Global Imperative



Don't Let the Perfect Be the Enemy of the Good



Fix Intermittency or Sequester Carbon?

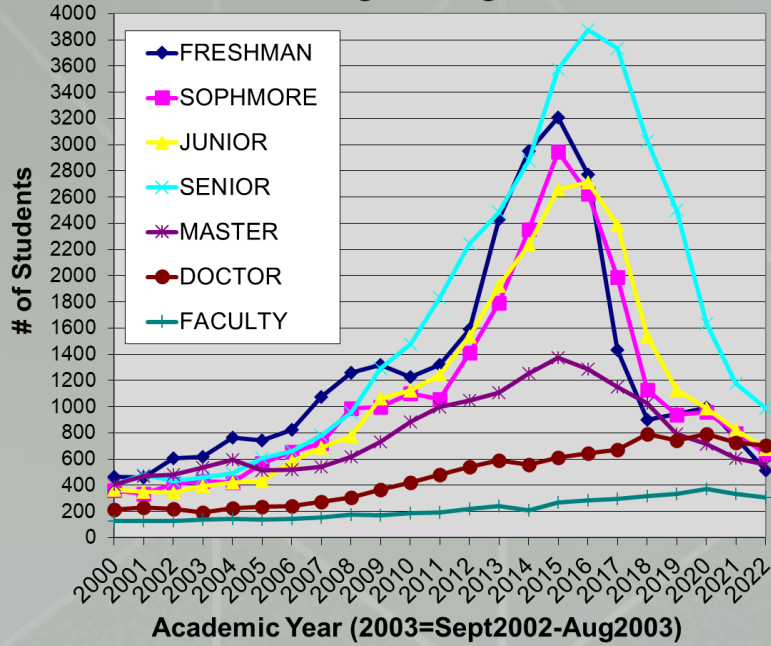
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WORKFORCE DEVELOPMENT FOR AN ENERGY TRANSITION

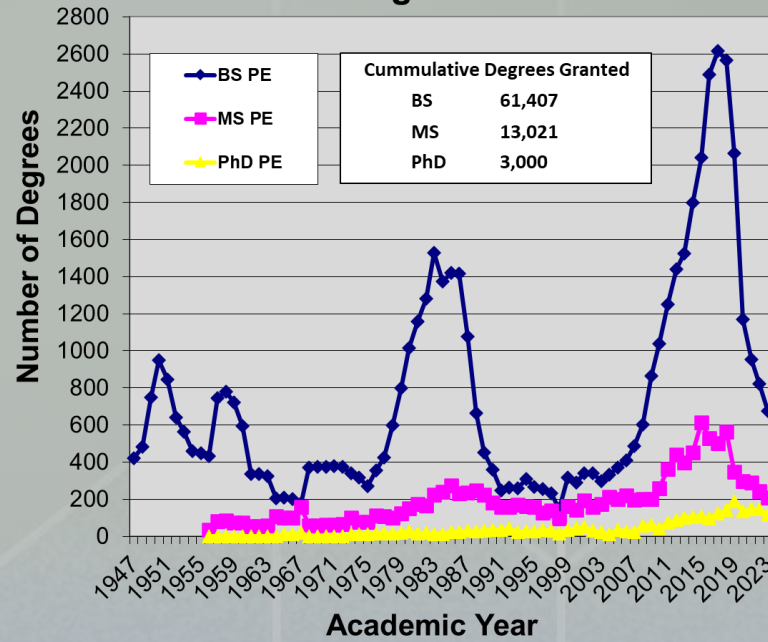
Christine Ehlig-Economides

DEMOGRAPHICS

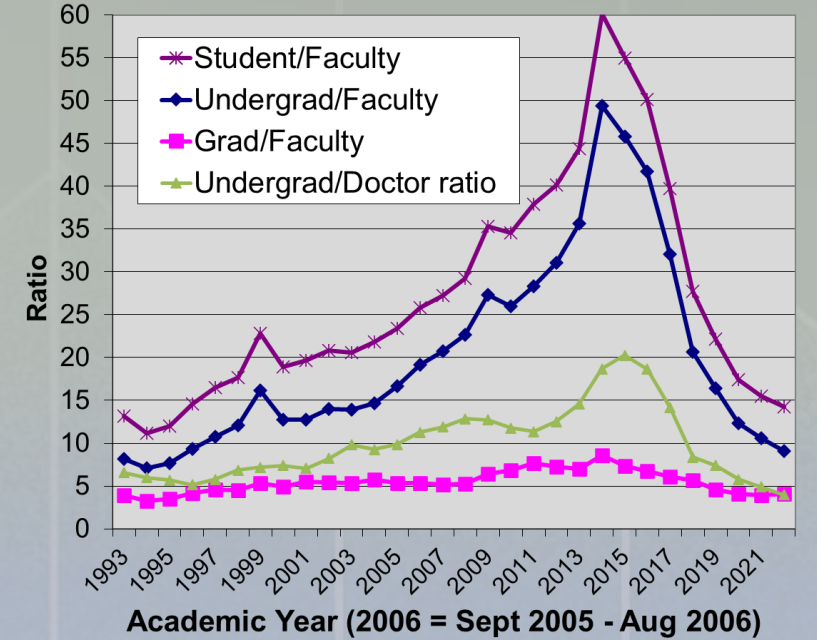
Petroleum Engineering Enrollment



Petroleum Degrees Granted



Petroleum Engineering, Student:Faculty Ratio



Courtesy Heinze 2022

STUDENT PLACEMENT

Response from CSM Miskimins

- Longer time to place students in 2020-2021, but placement fraction unchanged
- Placement fraction increased this year
- Several students with multiple offers

CURRICULUM MATTERS

- Post graduate level CCUS Certificates at UH and CSM
- Senior elective, post graduate level CCUS course at UH
- CSM midstream minor currently not populated
- EVOLVE CCUS introduction in fall 2022
- UH advisory board encouraging new courses
 - CCUS
 - Geothermal
 - Data analytics

CCUS STRATEGIC SKILLS

Disciplinary Strengths

- Drilling and completion
- Reservoir characterization
- Reservoir management
- Reservoir monitoring

Current Weaknesses

- Gas reservoir management
- Unfamiliar units
- Chemistry
- Unfamiliar financing



SPE/PEDHA Workshop: Petroleum Engineering Education: Energy Transition Impact

8 - 9 Aug 2022 | Colorado School of Mines | Golden, Colorado, USA

KEY THEMES

Energy Transition, Its Impacts, and How Petroleum Engineering Departments are Addressing the Transition

Attracting Students and Retaining Engineers

Preparing Petroleum Engineers for the Transition

Future of Petroleum Engineering Departments

WHO SHOULD ATTEND AND WHY

WHO SHOULD ATTEND

Petroleum engineering faculty, especially department/committee chairs that influence undergraduate/graduate curriculum

Representatives from oil and gas companies who recruit and/or train new petroleum engineering graduates

Representatives from federal agencies involved in the energy transition

Petroleum engineers who want to contribute to the energy transition as it impacts petroleum engineering education

WHY ATTEND



Chance to discuss the challenges faced during the energy transition with colleagues, federal agencies, and curriculum decision-makers.



Opportunity to develop solutions to the dilemmas caused by changing work environments and the impacts from the energy transition.

<https://www.spe.org/events/en/2022/workshop/22agol/petroleum-engineering-education-energy-transition-impact.html>