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The Global Energy Agenda

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The Global Energy Center promotes energy security by working alongside government, industry, civil society, and public stakeholders to devise pragmatic solutions to the geopolitical, sustainability, and economic challenges of the changing global energy landscape.

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The Global Energy Agenda

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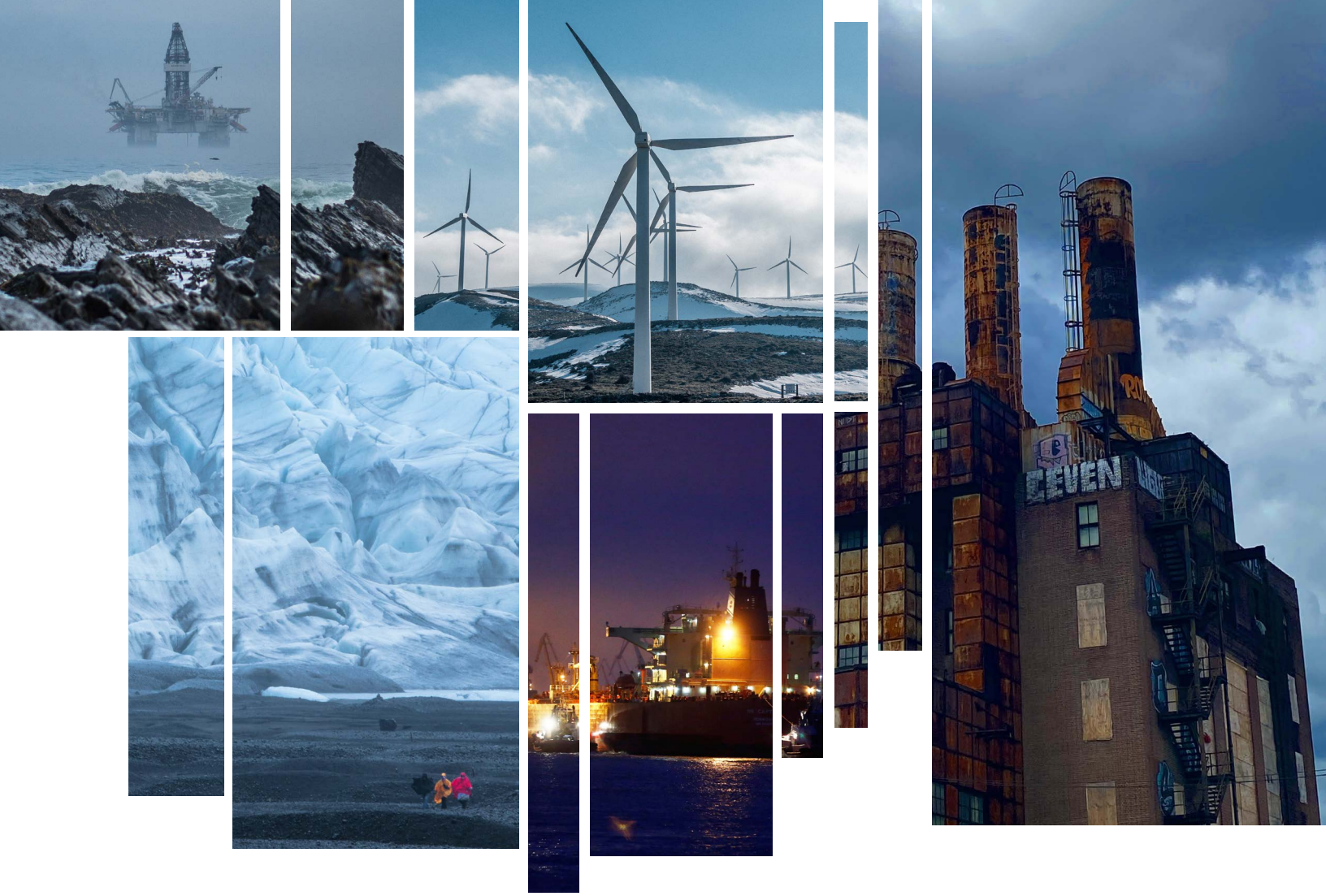


FOREWORD

As we begin 2021, the COVID-19 crisis that began a year ago still hangs over the world with its public health and economic consequences. That said, with the spread of vaccines and treatments, we see the light at the end of the tunnel. For the energy world, we are even more hopeful.

For many governments, clean energy investments have been a significant part of their economic stimulus plans in the past year. We are also hearing from an increasing number of government officials, not least of which from the incoming Biden administration, that 2021 could be the year that global leaders get more serious about addressing climate change.

It is in this context that the Atlantic Council releases the inaugural edition of *The Global Energy Agenda,* a publication intended to set the stage of the energy debate for the year ahead. Its publication coincides with the fifth annual Atlantic Council Global Energy Forum. Normally convened in Abu

Dhabi, one of the world's great energy capitals, this year's forum is entirely virtual. As such, we intend to build upon the Forum's established reputation for convening the best minds and leading players influencing the energy world – at a time when this conversation is most needed.

The Global Energy Agenda's launch edition includes a revealing survey of energy leaders from governments, industry, think tanks, and academia and a rich series of essays from a remarkable group of authors that provide context and understanding of the energy implications of the political, economic, and social upheavals of the year that has passed.

The survey's primary take-away is that energy leaders, by and large, believe that COVID-19 has accelerated the energy transition. This is remarkable given that one might have suspected the economic slowdown would impede progress on clean energy. However, many of our essay authors caution that nothing is inevitable and that it is up to policy makers and other leaders to seize the opportunity to rebuild economies in a cleaner way.

The essays in the publication that follows capture the Zeitgeist of this moment, balanced between the hope that grows from innovation and the human spirit, and the dangers that remain in our sometimes vulnerable and often politically divided societies. The events of January 6 in Washington, DC, were an unsettling reminder of the challenges facing even the most advanced societies.

It is a moment of hope as countries worldwide make serious climate commitments and together combat COVID-19, but it is also a moment of political uncertainty in many parts of the world, colored by a leadership transition in the United States and increased US-Chinese tensions. At the same time, the Abraham Accords underscore how long-time rivals can become partners through far-sighted diplomacy.

This publication has several underlying themes, but central to them is a conviction that the energy transition will be difficult, but that the political and industry will to take it on is considerable and growing.

In Chapter One, you can read about the role of oil and gas as the industry moves to reduce its emissions footprint; in Chapter Two, you'll learn how the geopolitical map of energy producers and consumers has been shifting as the emphasis on decarbonizing the global energy system grows and countries compete to be leaders addressing climate change. Chapter Three builds on these ideas to examine the role of public policy in meeting the climate challenge on a global scale. One key question emerges in Chapter Four: will technology and the human imagination be up to tackling climate challenges in a timely manner. The final chapter argues that it will require a global movement, one that brings clean and reliable energy to all the world's citizens, to produce justice in the energy transition.

The Atlantic Council's mission is that of "shaping the global future together" with partners and allies. What the essays that follow underscore is how crucial that collaborative ambition is to a successful energy transition toward cleaner and more sustainable energy sources.

If we have learned anything from COVID-19, it is that an issue in one part of the world can influence all parts of the world. We have also learned that it is better to be pro-active in anticipating challenges and then finding their answers, whether it has to do with pathogens or global warming.

We hope we can contribute our part to a better world through the work of our Atlantic Council Global Energy Forum, alongside our partners and participants, and through this publication and the debate we hope it spawns. We are stronger together.

Frederick Kempe

President and Chief Executive Officer
Atlantic Council

INTRODUCTION

The year 2020 was unlike any other in our lifetimes. The dramatic impacts that COVID-19 had on the global energy system—including oil prices in the United States going negative for the first time—were a side note, however, compared to the larger stories of suffering and death, economic upheaval, and the singular scientific achievement of developing multiple highly effective vaccines in under a year. Nonetheless, it is quite possible that the energy system will emerge from the COVID-19 crisis indelibly altered, changes that could be seen by future generations as some of the most consequential impacts of the pandemic.

Spurred by the need to rebuild their economies in the face of COVID-19, many global leaders saw an opportunity to address climate change through "green stimulus" plans and net-zero pledges. With the pandemic raging and unemployment at near-record highs, one could have easily imagined that climate change would have yet again been put on the backburner, a long-term problem that could be addressed only after the crisis at hand was resolved. But in a year of record wildfires, hurricanes, and extreme heat, many leaders saw an opportunity to address both the economic and climate crises together.

While all is not lost if leaders ultimately fail to implement comprehensive climate plans this year, it is hard to imagine a stronger global alignment of political will to act on climate change—and, crucially, to spend on climate action—than we have right now. 2021 will be the year we see if leaders start to make good on their promises and if the global community can meaningfully address climate change or not.

A renewed commitment to the fight against climate change of course will not be the only energy story in 2021. Oil and gas still play a crucial role in the global economy and the industry is at an inflection point, unclear about the future of demand and what level of investment is necessary to meet that demand. Geopolitical and energy security concerns drive the energy decision making of most countries, and—as the pandemic continues to reshape the geopolitical order—2021 could be even more volatile than the past few years. Finally, energy leaders are waking up to the deep injustices of the energy system, which includes the sometimes conflicting needs of providing energy to the millions of people worldwide who suffer from energy poverty while also minimizing the environmental impact of the energy system on the most vulnerable populations.

The 2021 Global Energy Agenda Survey

To better understand the key issues facing the energy system in 2021, the Atlantic Council Global Energy Center surveyed a global group of energy leaders, asking them a dozen questions in five issue areas:

- Oil and gas;
- Energy geopolitics and energy security;
- The energy transition, decarbonization, and climate change;
- New energy technologies and innovation; and
- Energy and environmental justice.

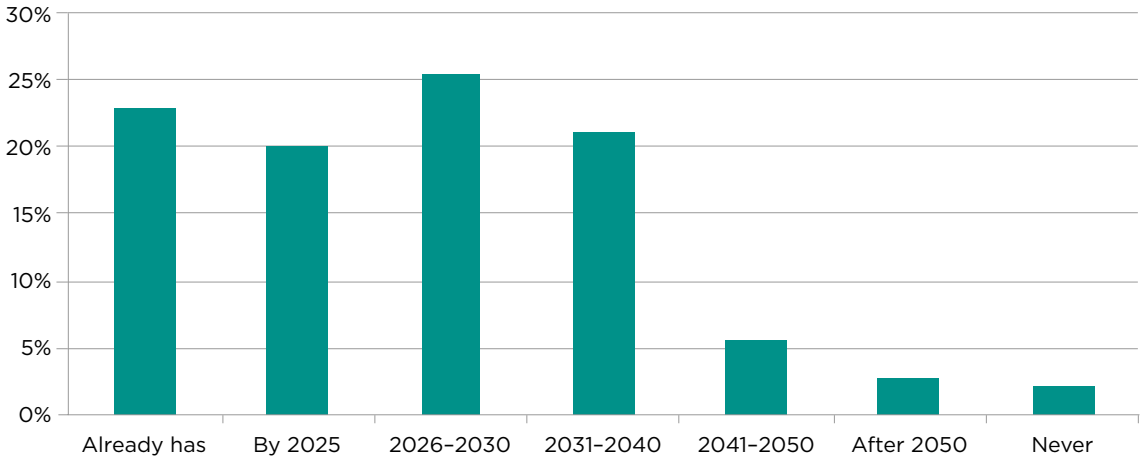
We conducted the survey between October 28 and November 23, 2020, a period that both spanned the US presidential election and the announcement of hopeful results from several major phase III trials of vaccines against COVID-19. See the Appendix for more demographic information about survey respondents.

The survey results will be explored in more detail in their respective chapters below. But a few key takeaways help provide overall context for this volume.

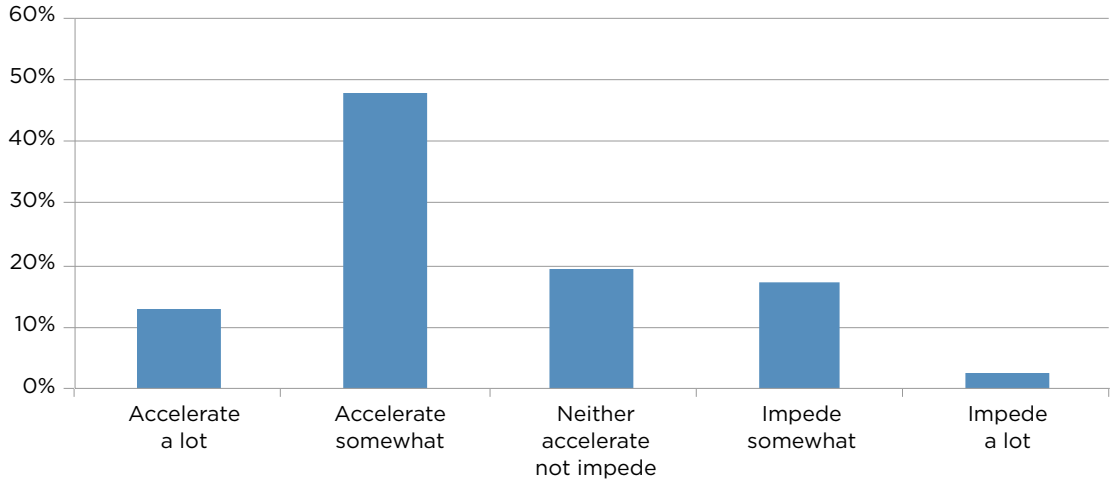
COVID-19 has accelerated the energy transition and peak oil demand is coming soon: 61 percent of those surveyed said that the pandemic will accelerate the energy transition while just 20 percent believe it will

For energy leaders, then, the agenda for 2021 should be to realize the opportunities created by COVID-19 to build a more sustainable energy system.

When will oil demand (global annual average) peak?



Will COVID-19 accelerate or impede the energy transition?

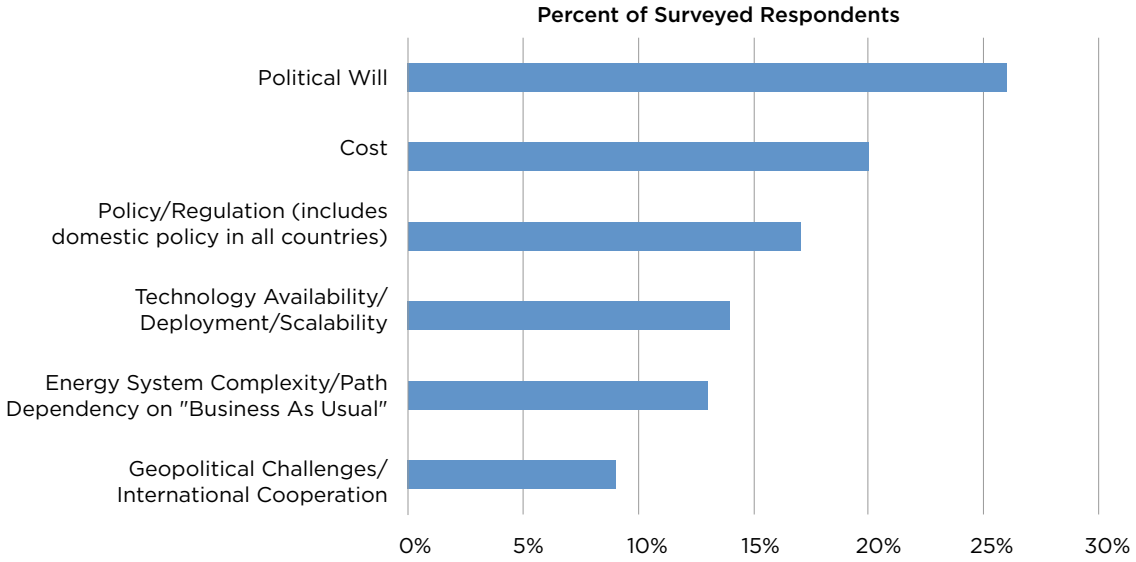


impede it. Similarly, nearly nine in 10 survey respondents believe that oil demand has already peaked or will do so within 20 years.

Three clusters of energy experts: The data reveal three poles of opinion among energy experts, and these clusters are best identified by their projections about the timing of peak oil demand. Forty-three percent of respondents believe that peak oil demand has already occurred or that it will occur within the next five years; 46 percent forecast that it will occur late this decade or sometime in the next one; finally, 11 percent think it will occur in 2040 at the earliest or that it may not ever take place.

These groupings reveal more than divergent thoughts on one issue. At various times, respondents' thinking on peak oil demand correlates strongly with what they think in other areas, indicating three internally consistent views of the world.

What is the primary obstacle to reaching net-zero by 2050?



We have labelled those who think peak oil demand has occurred or will do so in the next five years as "the transition bulls;" those seeing it delayed until after 2040 as "the transition bears;" and those in between as "the moderates," to reflect their thinking on the speed of decarbonization in the industry. Most of our comments will be about the first two groups, as the moderates tend to hew closely to the average results.

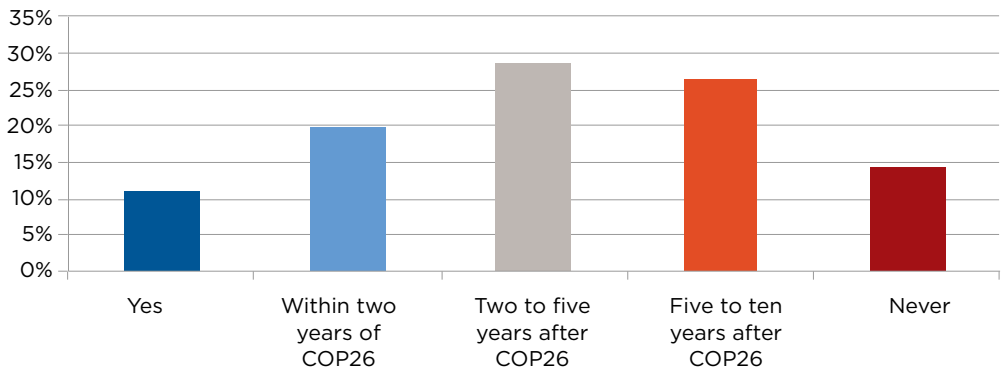
Pandemic impacts receding: When we first launched the survey, early respondents believed that COVID-19 would continue to be a substantial driver of change in the energy system; however, the pandemic's profile receded with the arrival of vaccines. Before the announcement of successful vaccine trials in early November 2020, respondents identified COVID-19 as the leading risk, by far, in energy geopolitics in the coming year. However, after the vaccine announcements, the number citing COVID-19 as a risk—as well as saying that its impact on the energy transition would be substantial—declined noticeably. Although in the latter period pandemic-related risk remained the most frequently cited problem, those choosing it dropped from 41 percent to 35 percent.

Political will is the biggest impediment to climate action: Our respondents claim that emissions reduction is both feasible and worthwhile, but many in the industry are unsure that political leaders can deliver. Roughly three-quarters of those surveyed believe that the goal of net-zero emissions by 2050 is possible to achieve without damage to the economy, but only 36 percent are very or somewhat certain that it will take place. The main reason that they see for this disconnect is policy and political will.

Similarly, 94 percent say that a consensus at COP26 this year on carbon trading rules is important to prevent a rise in average temperature of over 2 degrees Celsius, but only 11 percent believe that this consensus will occur at the Glasgow meeting. Forty percent think it will be at least another five years before the countries in question can reach a consensus. More worrying still, 19 percent of government respondents say it will never happen.

Parochial vision: At times, the survey results suggested answers were most determined by the field in which the respondent works. This trend was the clearest when we asked respondents how to best ensure

Will the international community come to a consensus on carbon markets (as per Article 6 of the Paris Agreement) at COP26?



that low-income and marginalized communities would benefit equally from the global energy transition. With a striking commonality, respondents claimed that the best way to help those in need is to support the field in which the respondent works.

While not entirely surprising, it does suggest that energy leaders who seek to understand the perspectives of all sides of the industry are best positioned to make objective decisions. In a time of dramatic change, that could be an invaluable asset.

The 2021 *Global Energy Agenda* Essays

To complement the survey and provide a deeper, qualitative exploration of the key energy questions for 2021, the Atlantic Council Global Energy Center also commissioned a series of essays from global experts, corporate leaders, and government ministers.[1] Essay contributors hail from five continents and include the head of the Organization of Petroleum Exporting Countries (OPEC), the head of the International Renewable Energy Agency (IRENA), the High Level Climate Champion for COP25, and the former director of the Chinese government's Energy Research Institute.

These essays are not intended to provide a uniform outlook for the year ahead in energy. Instead, through their diversity, they aim to set the terms of debate and outline what possible outcomes might look like, depending on the decisions that governments and industry collectively make.

Taken together, we hope *The Global Energy Agenda* survey responses, analysis, and essays will lay out the contours of the current energy system, assess the events and trends that will shape the energy system in 2021, inform fact-based debate and analysis about the best path forward, and set the shared energy agenda for the year.

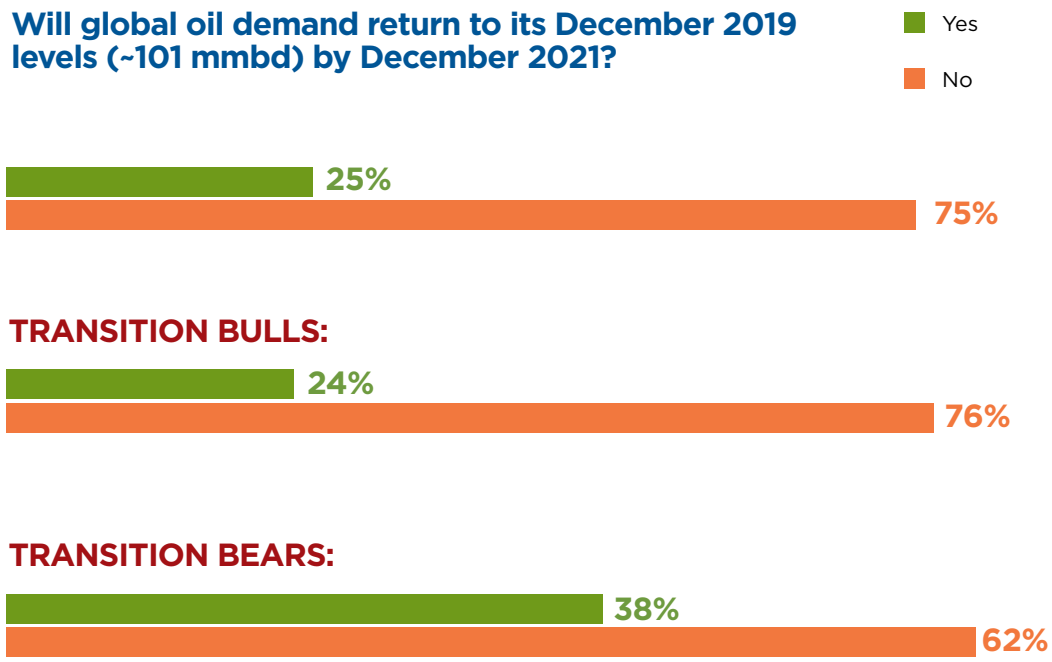
1 Leading partners of the Atlantic Council Global Energy Center bring unique insights and experience to these critically important topics, and their views are an important component of this volume. The Atlantic Council Global Energy Center invited select partners to contribute essays to *The Global Energy Agenda* to complement the views provided by other recognized energy leaders and to bring diverse and dynamic perspectives to the project. To ensure transparency, and to meet the Atlantic Council's intellectual independence policies, partner contributions are designated as such within the overall body of work. All partner contributions are subject to the Atlantic Council's editorial discretion, guidelines, and review.

UNSPLASH/CLYDE THOMAS (@CLYDEO)

An oil rig arrives at Cape Town harbor.

CHAPTER I: OIL AND GAS

The oil and gas industry was battered in 2020, with COVID-19 lockdowns constraining transportation and dramatically reducing nearly all forms of liquid fuel demand. Global oil demand dropped from about 101 million barrels per day (mbd) in December 2019 to 85 mbd at its low in the second quarter of 2020, and oil prices in the United States even temporarily went negative as storage capacity filled up. As a result of the demand crash, oil majors across the United States and Europe collectively wrote down more than $145 billion in assets—about 10 percent of their total value. An oil price war between Saudi Arabia and Russia in March and April further shook market confidence, and tension among OPEC members later in the year revealed further weaknesses in the current OPEC/OPEC+ -centric oil governance system.



Short-term Predictions

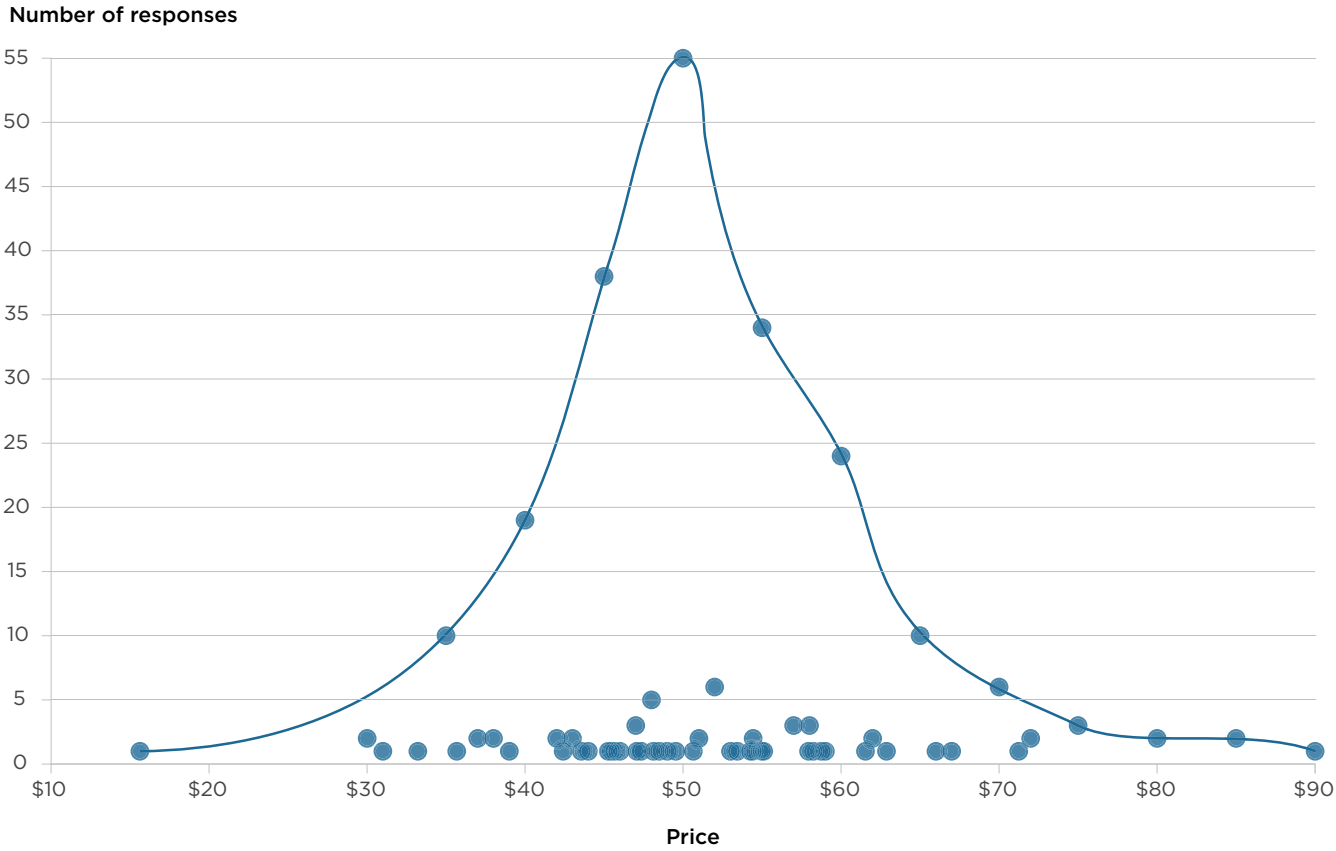
With the oil market showing early signs of recovery during the survey period—demand had returned to about 95 mbd—we asked survey participants two related questions about the oil market in 2021: will oil demand return to its December 2019 levels by December 2021, and what will the Brent crude oil price be on December 31, 2021?

The large majority of survey respondents do not expect the pace of the revival in demand to continue. Seventy-five percent believe that, by December 2021, worldwide consumption will remain below the 101 mbd figure of December 2019. On the other hand, there is a nearly universal expectation of some rise in the Brent benchmark price for oil, with 84 percent projecting a higher figure than the $42.93 (the figure on October 16, 2020, when the survey period began), which will require either some further growth in consumption or cutback in production.

While most respondents in all of the major sectors covered in the survey believed that demand would not return to 2019 levels by the end of next year, the size of the minority expecting such growth differs by sector. Those involved in upstream and midstream oil, for example, are noticeably more likely than average to forecast such a revival (33 percent). Indeed, these expectations are more widespread across energy industry respondents, including those collectively involved in electrical transmission, distribution, and nuclear power (33 percent) liquid natural gas (31 percent), and even renewables (29 percent). Such views are far less common among interested parties observing the industry, notably academics and researchers (20 percent), and those working in government (17 percent).

Forecasts of oil demand in the coming year in part reflect expectations about levels of economic activity. This is also the first instance in this survey in which differing viewpoints on peak oil demand scenarios indicate likely viewpoints on other questions. Of the group that projected a near-term peak demand scenario (the transition bulls), 24 percent believed that oil demand would return to 2019 levels in 2021; 23 percent of the moderates expected a return to 2019 levels; and 38 percent of respondents forecasting that a peak demand scenario would take decades, if it were ever to occur, (the transition bears) anticipated a return to 2019 oil demand in the year ahead.

On December 31, 2021, what will be the Brent crude oil price (in $)?



Seventy-five percent believe that, by December 2021, worldwide consumption will remain below the 101 mbd figure of December 2019.

Respondents' average estimate for the likely price of Brent crude at the end of this year is $55.78.

Respondents' average estimate for the likely price of Brent crude at the end of this year is $55.78, which is roughly the same as of the date of publication, though significantly higher than the average of slightly over $40 during the survey period. (In comparison, on December 31, 2019, Brent was $67.77 per barrel. In late April 2020, COVID-related economic disruption drove it below $20, but it had recovered to just above $40 by June.)

This average price reflects a substantial level of agreement among those surveyed, with 58 percent giving a figure somewhere between $45 and $55 inclusive, and 80 percent a figure between $40 and $60 inclusive. The average result was also highly similar across differences in age, geography, and sector. The most extreme difference—between the transition bulls and bears—is also relatively muted. The former predict a price of $49.63 by December 2021 and the latter predict $53.33. Even those who foresee a return to demand levels of December 2019 or better still set an average price of just $57.03, over $10 per barrel lower than the price at that time. This is consistent if they believe that rising demand will drive producers to raise output faster than the market recovery can absorb.

Partner Perspective: OPEC+: Back from the brink

by Helima Croft

When we assembled in Abu Dhabi in January 2020 for the Global Energy Forum (GEF), geopolitics seemed set to exert upside pressure on oil prices. Coming just days after the Iranians fired missiles at Iraqi bases housing US troops in response to the US killing of IRGC Quds Force leader Qasem Soleimani, GEF participants discussed the risk of additional attacks on critical gulf energy infrastructure. For a brief period it looked as if OPEC might be called on to put more barrels on the market in the event there was a repeat of the type of attack we saw on September 14, when Saudi Arabia's Abqaiq facility was struck by drones and cruise missiles and half of the country's oil output was temporarily taken offline. And yet all of these early assumptions about the oil market in 2020 were scrambled as a result of the viral outbreak in Wuhan, China.

The entire Declaration of Cooperation arrangement was put to the test as the OPEC+ producers struggled to form a collective response to the emerging global health crisis. Saudi Arabia pushed for early action at the end of January, fearing a demand contraction similar to what was witnessed in the 2008-2009 financial crisis. Russia, on the other hand, was reluctant to sideline more barrels, having just agreed to a deeper reduction at the December meeting. Russian officials publicly called for more time to assess the actual demand impact of the virus. However, behind closed doors some powerful energy executives were reportedly growing weary of providing an economic lifeline to US shale producers and thereby enabling American energy dominance and Washington's coercive sanctions regime. Everything came to a halt that first week in March in Vienna and when Russia balked at the OPEC proposal to cut an additional 1.5 mb/d of supply, the stage was set for a ruinous price war between the sovereign producers. Global storage quickly reached tank tops as producers opened the taps amidst the worst demand collapse in history as governments around the world mandated shelter in place restrictions. Faced with the potential collapse of the US shale industry, President Trump did a 180-degree turn on OPEC, going from being a fierce critic of the producer group to playing the de facto marriage counselor role to forge a reconciliation and help get the largest collective production cut across the finish line in April.

That 9.7 mb/d OPEC+ reduction provided crucial support to the market, and alongside the sharp recovery in Chinese demand, laid the foundation for the current return to $50/bbl prices, an achievement which seemed almost unimaginable in late April when WTI briefly plunged to -$37.63/bbl. And yet the question is whether OPEC+ cohesion will hold in 2021 with vaccine optimism abounding, and along with it the hope of a swift return to pre-crisis mobility patterns? Unity seems easier to achieve in a lower price environment, when all the producers are essentially in a foxhole together. We have already seen the reemergence of some fissures at the most recent OPEC meetings. Russia has pushed for increased output, pointing to the strength of Asian demand and vaccine progress. It has also expressed concern about losing market share, with Russian Deputy Prime Minister Alexander Novak insisting in December that other producers would put more barrels on the market if OPEC+ did not fill the void. Novak's remarks were widely seen as aimed at shale producers and we believe that Russia may seek a more constrained oil price environment to keep US production on the sidelines. Several other producers have recently showed signs of lockdown fatigue as they struggle under the financial weight of their quota obligations or are reluctant to idle their expanded output capacity indefinitely. Saudi Arabia, on the other hand, has emphatically argued that the producer group must remain ever vigilant in the face of the slow vaccine rollout and cascading government lockdown restrictions. At the January meeting, the Kingdom announced a surprise 1 mb/d unilateral production cut, which we view as an important shot in the arm for the market given the fragility of the near-term demand outlook. Saudi Arabia appears firmly back in the OPEC driver's seat, but we will continue to monitor Moscow's moves as its priorities may diverge from a number of the key sovereign producers in the year ahead.

***Helima Croft** is the Managing Director and Global Head of Commodity Strategy at RBC Capital Markets. RBC Capital Markets is a sponsor of the Atlantic Council Global Energy Forum.*

REUTERS/LEONHARD FOEGER

Nearly nine in ten survey respondents believe that oil demand will peak within twenty years.

An Austrian army member stands next to the logo of the Organization of the Petroleum Exporting Countries (OPEC) in front of OPEC's headquarters in Vienna, Austria April 9, 2020.

Long-term Assessments

With long-term demand for hydrocarbons an open question, especially given increasingly ambitious national and private sector climate commitments, we asked respondents two questions about the future of oil and gas.

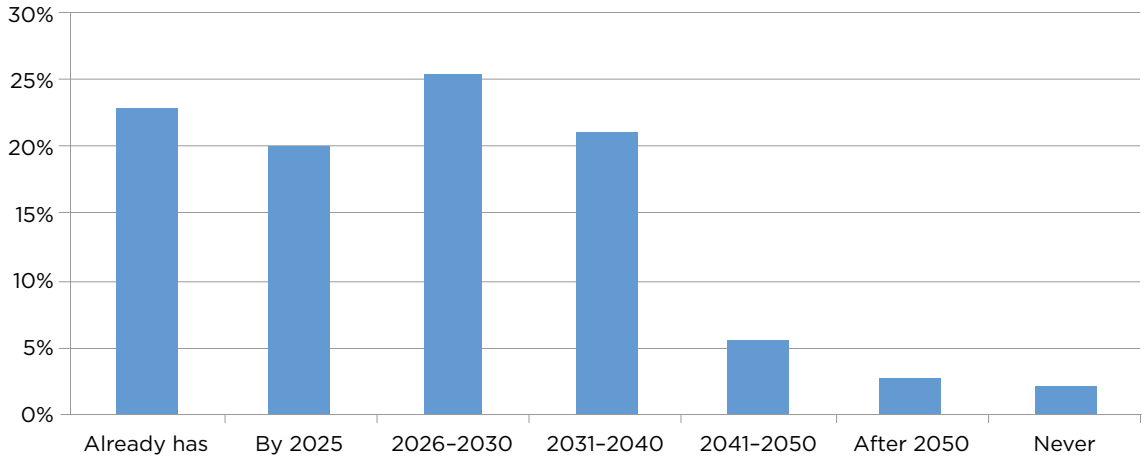
As discussed earlier, a respondent's answer to the question "When will oil demand (global annual average) peak?" was singularly predictive of their overall view of the energy system. A closer look, however, suggests that demographic attributes do not predetermine the views of our surveyed experts on peak oil demand.

In terms of geography:

- The transition bulls are slightly more likely than the bears to come from the United States (46 percent to 41 percent) with 54 percent of moderates from that country.
- Twenty-two percent of bulls, 21 percent of bears and 17 percent of moderates are from Europe.
- The equivalent figures for the Middle East and North Africa (MENA) are 22 percent, 29 percent and 17 percent. Despite some variation, these figures are not very far away from the shares reported above of overall respondents coming from these same regions.

Certain employment sector differences also exist between the two groups, but again, they are less pronounced than might be expected. Perhaps predictably, a much greater share of bears than bulls associate themselves with oil and gas (53 percent to 22

When will oil demand (global annual average) peak?



Bulls vs. Bears: When will oil demand (global annual average) peak?

The transition bulls are slightly more likely than the bears to come from the United States (46 percent to 41 percent) with 55 percent of moderates from that country. Saudi respondents were much more likely to be bears. UAE respondents were balanced between the categories.

	France	Saudi Arabia	UK	USA	UAE
Bulls	6%	3%	6%	46%	17%
Moderates	4%	2%	8%	55%	11%
Bears	3%	12%	3%	41%	18%

percent). That said, important similarities in this area are surprising: roughly the same percentage of each of these ideologically very different groups, for example, are associated with renewables (27 percent of bulls and 21 percent of bears).

All of this aside, a key figure emerges from the data: nearly nine in ten survey respondents believe that oil demand will peak within twenty years. A more precise year during which that milestone will occur, however, is a matter of some disagreement. As the chart below shows, between 20 percent and 25 percent believe each of: that the tipping point has already passed, that it will do so within five years, that it will occur in the second half of this decade, or that it will happen in the 2030s. The overall average of these individual expectations is that peak oil demand will take place in 10.5 years, or soon after the start of the next decade.

Among respondents, certain characteristics are consistent with different expectations about peak oil's arrival. Not surprisingly, those involved with renewables expect the future to come a little sooner than do most. Those in this field—after taking out those who are not also involved in oil and gas—forecast, on average, that the date will arrive in 7.2 years. Those in government expect developments to move a bit slower, giving an average figure of 9.0 years. Those in the oil and gas industry, on the other hand, think that they have more time. Respondents from this sector who are not also involved in renewables expect the high point in demand to occur 14.5 years from now. Even they, though, see the writing on the wall, with 82 percent predicting peak oil demand within the next two decades.

While one's field of work affects views in this area, so too does one's generation. Respondents aged below

thirty-five years expect peak oil demand to happen, on average, in just six years and nearly half (46 percent) believe that bridge has already been crossed. Respondents who are between thirty-five and fifty-four years old foresee peak demand to occur in 8.4 years on average, and those fifty-five or over in 12.9 years, more than twice the time forecast by the youngest respondents.

While we do not have survey data from before COVID to back up this claim, we suspect the number of people who believe oil demand has already peaked is far higher now than before the pandemic, and that the average predicted timeline for a peak in oil demand was far sooner in 2020 than it would have been in 2019. Numerous articles were published in 2020 like one from *Bloomberg* called "Peak Oil is Suddenly Upon Us,"which surely reflected and impacted the Zeitgeist.[2]

But as International Energy Agency (IEA) Executive Director Fatih Birol argues in his essay below, "Overall, there is no indication that the pandemic has come close to triggering a major structural shift in the oil intensity of the global economy. If the world economy recovers without significant changes in government policies to accelerate the adoption of low-carbon alternatives, oil demand will recover with it." The role of government policy, Birol argues, will be crucial in order to seize the opportunity presented by COVID and accelerate the energy transition.

REUTERS/TOBY MELVILLE

An almost empty Trafalgar Square is seen during a lockdown in response to the COVID-19 pandemic in London, on January 7, 2021.

2 Tom Randall and Hayley Warren, "Peak Oil is Suddenly Upon Us," Bloomberg, December 1, 2020, https://www.bloomberg.com/graphics/2020-peak-oil-era-is-suddenly-upon-us/.

Despite the pandemic, oil's dominance isn't over: What happens next hinges on governments

by Fatih Birol

For more than half a century, oil has been the global economy's primary energy source. It has shaped geopolitics, investment flows and energy security strategies. After the oil shocks of the 1970s, oil was largely phased out from electricity generation and the heating of buildings, but it remains dominant in the transportation sector. Today, it is the fuel that enables mobility among the growing ranks of the middle class in emerging economies, and it moves goods along global supply chains. In the second half of the past decade, the share of oil in the global energy mix actually increased as lower oil prices contributed to a growing preference among consumers for larger vehicles like SUVs.

Given oil's unique role in the transportation sector, it is not surprising that the travel restrictions implemented in response to the COVID-19 pandemic have hit global oil demand hard. It is expected to decline by 8 percent in 2020, a shock unprecedented since World War II. The pandemic also unleashed social changes: people are now working from home and using online cooperation tools to a much greater extent. In addition, concerns and political commitments to address climate change intensified this year. The European Union, China, Japan, New Zealand, the Republic of Korea, and other economies—together representing a substantial proportion of global oil demand—made new, more ambitious climate pledges targeting net-zero emissions by the middle of this century, or soon thereafter in the case of China. Unsurprisingly, this has spurred further debate on the future of oil, which was one of the key focus areas of the International Energy Agency's (IEA) recently published *World Energy Outlook 2020*.

This new IEA analysis took a granular, data-driven look at some of the changes brought about by the coronavirus and their impact on energy demand. It turns out that these changes affect demand in both directions. Video conferences can clearly replace some business travel, and more extensive working from home leads to less commuting. However, there are also clear indications that people are reluctant to use public transportation during the pandemic. For example, if a person who used to take the train to work every day switches to a routine of going to the office only one day a week—but by car—it would result in a net increase in oil demand. Moreover, depending on the logistics involved, the shift from buying goods from local stores to ordering them online for delivery can also increase oil demand. While the overall aviation industry struggled during the pandemic, e-business supported robust air cargo activity. The epidemic also led to a surge of demand for petrochemical products like packaging, masks, and sanitizers. Overall, there is no indication that the pandemic has come close to triggering a major structural shift in the oil intensity of the global economy. If the world economy recovers without significant changes in government policies to accelerate the adoption of low-carbon alternatives, oil demand will recover with it.

There is still a considerable degree of uncertainty over how the pandemic and the subsequent economic recovery will play out. In the *World Energy Outlook*, the Stated Policies Scenario—which reflects current announced policy intentions and targets of governments—is based on the assumption that the global economy will recover in 2021 and then return to the pre-pandemic growth path in the following years. This is consistent with the International Monetary Fund's latest economic outlook. That macroeconomic environment would lead to global oil demand reaching its 2019 level again in 2023. However, even if the projected recovery were to take place, the era of dynamic oil demand growth is likely over. Energy efficiency policies and the increasing electrification of transportation are weighing on oil demand growth, adding to the impact of the ongoing phase-out of oil from the heating of buildings and the electricity sector. Still, a global economic recovery would offset that trend by driving growth in areas like shipping, aviation, trucking, and petrochemicals.

The comprehensive policy measures that would put global oil demand into sustained decline while still supporting robust economic growth are incorporated into the *World Energy Outlook*'s Sustainable Development Scenario, which provides a roadmap for achieving international energy and climate goals. A structural decline in global oil demand would result from clear policy action by governments rather than spontaneous economic and social changes, even in

the wake of a pandemic as serious as today's global health crisis. In the Sustainable Development Scenario, global oil demand never recovers to its 2019 level. Instead, by the end of the coming decade, it falls to 87 million barrels a day, a level comparable to that of May 2020 when large parts of the world economy were under a lockdown. No single policy or technology is able to achieve this outcome; a comprehensive set of measures would need to be applied globally.

The biggest single reduction would come from using electricity to power an increasing number of cars and other light vehicles. Electric cars have developed rapidly and are now ready for large-scale deployment. Impressive innovation and entrepreneurship have enabled electric cars to reach this stage, but they still need a helping hand from policy makers. A combination of vehicle emission standards, financial incentives, and investments in recharging infrastructure are essential. Plug-in hybrid vehicles can be a reasonable bridge technology, especially in regions where road journeys often span long distances and consumers prefer large vehicles.

Even with an accelerated rise of electric cars, millions of internal combustion engine vehicles will remain on the road for decades, so continuous improvements to their energy efficiency are vital. Robust efficiency standards and the gradual introduction of low-carbon fuels such as advanced biofuels and hydrogen for heavy vehicles will have to accompany the growth of electric cars.

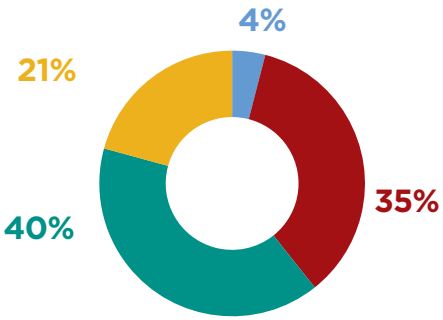
Trains also need to play a greater role in the transportation sector. IEA analysis shows that additional investment into railway infrastructure has the potential to displace 10 million barrels a day of oil demand from road and air transport. Railways are especially important for meeting transportation needs in densely populated countries such as India. Another valuable area of investment is the development of infrastructure favoring pedestrians and cyclists in urban areas.

Oil demand declines significantly in the Sustainable Development Scenario, but it does not evaporate overnight. Given the geological depletion of existing upstream production, this will mean further investment is still needed to supply this declining demand, around $400 billion annually over the next decade. Coincidentally, this is close to the investment level observed in 2020 after a series of deep cuts to capital spending by oil producers. The adjustment to the coronavirus shock was painful, but the projects that survived are not going to be stranded assets.

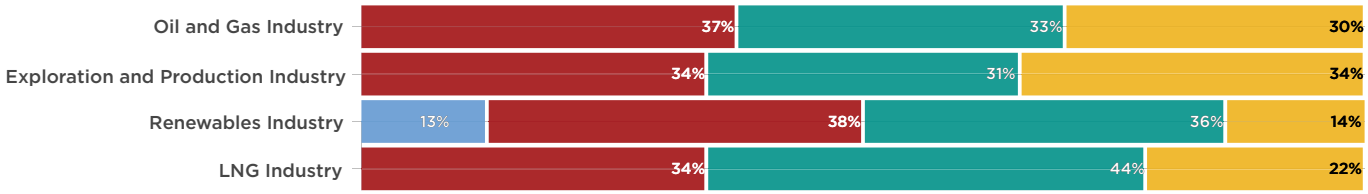
The coronavirus crisis has not put either global oil demand or global CO_2 emissions into structural decline, but it might represent a crossroads for the industry. Since early on in the crisis, the IEA has consistently called for clean energy to be placed at the heart of economic recovery efforts. If governments rise to the challenge, the future of the energy sector could be transformed. Oil will not disappear rapidly; it will remain a significant part of the global economy and geopolitics for years to come. But with more ambitious policies, technological innovation, and clean energy investment, the future of oil will be increasingly defined by global clean energy transitions. No oil producer can ignore this. Every part of the industry needs to consider how to respond. Doing nothing is simply not an option.

***Fatih Birol** is the Executive Director of the International Energy Agency.*

Which of these statements best describes the future of natural gas?



- Gas will have a minimal role in the future global energy mix, given competitiveness of renewables.
- Gas will be a necessary bridge fuel to displace coal demand while we wait for scaled renewables. Natural gas consumption will be slowly phased out over 30-50 years.
- Gas will enable and integrate with key low-carbon technologies, such as hydrogen, but with a decrease in overall consumption in the medium- to long-term compared to 2019-2020 levels.
- Gas will be a destination fuel, maintaining a large share of the energy mix.



The Future of Natural Gas

The second question we posed was on the future role of natural gas, and respondents—as a whole—see a longer-term future for natural gas than for oil. But natural gas, which just a few years ago was readily hailed as a crucial "bridge fuel" for enabling the power sector to transition away from more CO_2-intensive coal, is increasingly under attack. Climate change concerns now suggest that building gas infrastructure could "lock in" those future gas emissions at a time when the world needs to move increasingly to a net-zero power system.

We asked "Which of these statements best describes the future of natural gas?

Only 4 percent of all respondents project that gas will have a minimal role in the years ahead. Opinions diverge, though, over its precise role in that future. Thirty-five percent expect it to be a necessary bridge fuel from coal, but still see it largely being phased out over the next three to five decades. A majority think gas has more staying power: forty percent say it will integrate within the future energy mix—albeit making up a lower percentage than currently—while 21 percent call it a destination fuel, which will maintain a large market share.

These figures show only minor variations across age and geography; however, a sharp difference exists between those surveyed in renewables and the ones in oil and gas (in both cases after taking out respondents who overlap the two sectors). Among respondents in renewables, 24 percent believe gas will have a minimal role and only 11 percent that it will be a destination fuel. However, no one in oil and gas foresees gas being a minimal part of the energy mix and 36 percent think is will maintain its share within that mix into the future. Meanwhile, although the bulls and moderates have views similar to the average figures, 59 percent of bears believe that natural gas will be a destination fuel.

Mohammad Sanusi Barkindo, the Secretary General of the Organization of Petroleum Exporting Countries (OPEC), argues that both oil and gas will continue to play a role in the energy system, even as global leaders work to eliminate greenhouse gas emissions. Providing a specific example of this argument, Dharmendra Pradhan, Cabinet Minister for Petroleum and Natural Gas and Steel in the Government of India, discusses India's new energy map, which includes turning what is soon to be the world's largest country by population into a "gas-based economy."

The continued role of oil and gas in the global economy, and their role in the energy transition

by H.E. Mohammad Sanusi Barkindo

The world will continue to need more energy in the decades ahead. This is true in the near-term—as we recover from the COVID-19 pandemic—and looking longer term to 2045, as the global economy more than doubles in size and the world's population is projected to grow by over 1.7 billion people, and given the need to rid the world of the scourge of energy poverty, bringing light, heat, power, and low-emission fuels for cooking to billions that still go without.

There are many facets to the future energy transition, but the basic challenge is simple: how can we ensure that there is enough energy supply to meet expected future demand growth, and how can this growth be achieved in a sustainable way, balancing the needs of people in relation to their social welfare, the economy, and the environment?

What is clear in OPEC's recently published *World Oil Outlook* (WOO) 2020, as well as other recently published outlooks, is that oil and gas have a vital role to play. Although there are some who believe the oil and gas industries should not be part of the energy future, that they should be consigned to the past, and that the future is one that can be dominated by renewables and electric vehicles, it is important to state clearly that the science does not tell us this, and the statistics related to the blight of energy poverty do not tell us this either. The science and statistics tell us that we need to reduce emissions and use energy more efficiently.

Renewables are coming of age, with wind and solar expanding quickly, but—even by 2045 in our WOO—they are only estimated to make up just over 20 percent of the global energy mix. Oil and gas combined are forecast to still supply over 50 percent of the world's energy needs by 2045, with oil at around 27 percent and gas at 25 percent.

We appreciate that some will view this as an OPEC forecast, dispute the numbers, and state that the Organization is against renewables.

In response, it is clear that many OPEC Member Countries have great solar and wind resources, and huge investments are being made in this field. OPEC welcomes the development of renewables. However, we do not see any realistic outlook projecting in their business-as-usual base cases that renewables will come anywhere close to overtaking oil and gas in the decades ahead.

In terms of electric vehicles, there is no doubt that they will continue to see expansion in the transportation sector. In our WOO, the share of electric vehicles in the total road transportation fleet is projected to expand to around 16 percent by 2045. We support their development in a sustainable manner.

However, for many of the world's population, electric vehicles do not offer a viable alternative to the internal combustion engine, primarily due to cost. Moreover, there is also debate about how environmentally friendly they are considering their build process, especially the required batteries, and the sourcing of the vehicles' electricity.

Looking at the scale of the challenge of the energy transition, we need to utilize all available energies, and it is crucial that we appreciate just what each energy source can provide in the decades ahead.

The challenge of tackling emissions has many paths, and we need to explore them all. Complex problems require comprehensive solutions. The oil and gas industries are part of the solution; they possess critical resources and expertise that can help unlock our carbon-free future.

We need to look for cleaner and more efficient technological solutions everywhere, across all available energies. We will need a very broad portfolio of emissions removal technologies to tackle climate change. We are believers that solutions can be found in technologies, such as carbon capture, utilization, and storage (CCUS) and others

The future requires massive investments, with the WOO 2020 highlighting that the global oil sector alone requires a cumulative investment of $12.6 trillion through to 2045.

It is vital that the required investments are made, in all energies, to ensure stable and continuous supplies, and to help reduce and, ultimately, eliminate emissions.

REUTERS/NICK OXFORD

Oil rigs in a storage facility wait to be transported to an oil field in Midland, Texas, in August 2018.

Without the necessary investments, there is the potential for further volatility and a future energy shortfall, which is not in the interests of either producers or consumers.

Moreover, if billions of people in the developing world suffering from a lack of energy access feel they are excluded from access to energies that have helped fuel the developed world, then this could sow further divisions and expand the divide between the haves and have nots, the global North and the South.

At OPEC, we welcome coordinated action within the industry and through various research and development platforms, such as the Oil & Gas Climate Initiative (OGCI), a CEO-led group that aims to accelerate the industry's response to climate change and engagement with all stakeholders in the energy community.

The Organization reaffirms its faith—time and time again—in the need for dialogue, cooperation, and respect. We need to talk to each other and not at each other. The challenges our planet faces require solutions from every corner of the energy sector and an appreciation of the nuances in the debate. The contributions of an entire industry cannot be overlooked.

We are all dedicated and passionate about evolving a sustainable energy future for all, and in this we need to leverage all available resources. This includes the huge capacity for technical know-how and innovation in the oil and gas industry that can help unlock the carbon-free future that we all seek. Working together, we can build a future worthy of future generations.

***H.E. Mohammad Sanusi Barkindo** is the Secretary General of the Organization of the Petroleum Exporting Countries.*

Ministerial Perspective: The continued role of oil and gas in a new energy map of India

by H.E. Minister Dharmendra Pradhan

Before the COVID-19 pandemic impacted the oil and gas industry in significant ways, the global energy system had been transforming at an unprecedented pace. Two global agreements in 2015 on sustainable development and climate change initiated a new energy paradigm, bringing renewables to the forefront of the energy discourse. The Paris Agreement signaled the gravity of climate change, thereby triggering a globally determined resolution to address the issue.

Last year, the pandemic brought about a global economic meltdown, oil demand destruction, and supply chain shocks. Now, a new energy system is emerging, the full contours of which will unfold over decades at various paces across the world. Today, every country—whether primarily an energy exporter or importer—is calibrating its approach towards revival of the energy sector by carefully assessing the impact of the COVID-19-induced disruptions.

India is among the fast-growing large economies of the world with a strong determination to end poverty, including energy poverty. India is in the midst of a major transformative shift in our energy sector, both in scale and complexity and also the interdependence across different systems. We have now emerged as the key center for energy demand in the coming decades, as our share in global energy consumption is set to double in the next three decades. Our per capita consumption of energy is only about 40 percent of the global average.

Under the decisive and visionary leadership of Prime Minister Narendra Modi, India is making concerted efforts to ensure energy justice for all its citizens while also pursuing the green path to progress. Considering this, we are finding ways to achieve the twin objectives of enhancing the availability and affordability of clean and green options for fossil fuels and reducing the carbon footprint through a healthy mix of all commercially viable energy sources.

A new energy map of India

India's energy transition road map has been outlined by Prime Minister Modi with seven key drivers: accelerating efforts to move towards a gas-based economy; cleaner use of fossil fuels, particularly petroleum and coal; greater reliance on domestic sources to drive biofuels; achieving renewables target of 450 GW by 2030; increasing contribution of electricity to de-carbonize mobility; moving into emerging fuels including hydrogen; and digital innovation across all energy systems.

Fostering an environment for transforming India into a gas-based economy

We are rapidly deploying natural gas in our energy mix, by increasing the share of natural gas from the current 6 percent to 15 percent by 2030. An estimated $60 billion investment is lined up in developing gas infrastructure covering pipelines, city gas distribution, and LNG re-gasification terminals. We are working towards a "one–nation-one–gas-grid" structure through the addition of approximately 17,000 kms of gas pipelines in the eastern and north-eastern parts of the country. Further, with the near-term implementation of city gas distribution networks in all authorized areas, more than 70% of India's population will have access to clean and affordable natural gas.

We are also adopting clean mobility solutions with greater use of LNG & hydrogen CNG as a transportation fuel. We have recently launched the Indian Gas Exchange (IGX) to enable the nation to move towards free market pricing of natural gas.

India's energy transition milestones

India remains committed to environmental and climate causes with the massive thrust on renewable energy and the energy efficiency measures. In the past six years, India has increased its renewable power portfolio from 32 GW to almost 100 GW. We are well on track to achieve our goal of 175 GW of renewable energy capacity by 2022 and have scaled our target to 450 GW of renewable energy capacity by 2030.

We are tapping into our huge biomass potential through the National Biofuels Policy 2018. The renewed efforts on the ethanol blending program through a series of progressive reforms has resulted in

a significant jump in a blending percentage from less than 1% to around 8.5% in the past six years. We aim to achieve 10% blending by 2022 and 20% by 2030.

Ensuring access to clean cooking fuel has been at the core of our development strategy for ease-of-living and empowerment. In the past six years, the LPG landscape has changed dramatically through LPG's 55% penetration in 2014 to now more than 98%. LPG access through the Pradhan Mantri Ujjwala Yojana (PMUY) scheme has become an instrument of ending energy poverty, creating social upliftment, and catalyzing social change.

We have been able to reduce greenhouse gas emissions by 43 million tonnes annually by LED bulb distribution and the LED Street Lighting National Programme. Further, we have successfully transitioned to Bharat – VI emission norms (equivalent of Euro VI) fuel since April 2020 for curbing emissions in the road transport sector.

We are boosting the rural economy by waste-to-wealth generation under the Sustainable Alternative Towards Affordable Transportation (SATAT) initiatives. We are setting up 5000 compressed biogas (CBG) plants by 2024 with a production target of 15 MMT with an investment of about 20 billion dollars.

India: An attractive investment destination

Driven by Prime Minister Modi's vision of *Minimum Government, Maximum Governance*, we have used the Covid-19-triggered challenges as opportunities to bring the most significant reforms in contemporary times.

India has emerged as an attractive investment destination for the energy sector as several policy reforms have enhanced the ease of doing business. A testament to the same is the projected investment of around $143 billion in the Indian oil & gas sector, of which $56 billion is in E&P, $66 billion dollars in gas and $20 billion in refining. We are keen to partner with global companies and investors to further strengthen the energy infrastructure in the country as we chart our unique path towards decarbonization, the energy transition, and firmly charting a green path to progress.

H.E. Dharmendra Pradhan ***is Cabinet Minister for Petroleum and Natural Gas and Steel in the Government of India.***

REUTERS/INTS KALNINS

NS Captain tanker with the first Belarus-bound shipment of oil from the US arrives at the port of Klaipeda, Lithuania, in June 2020.

CHAPTER II: ENERGY GEOPOLITICS

If 2020 had not been so dominated by COVID-19, it might be remembered for the war with Iran that wasn't. On January 3, the United States assassinated Qasem Soleimani, the commander of Iran's Islamic Revolutionary Guard Corps' (IRGC) Quds Force. Iran responded four days later, launching a series of missile attacks against US bases in Iraq that injured US soldiers but caused no deaths. On January 8, Iran mistakenly shot down a Ukraine International Airlines flight bound from Tehran to Kiev, killing all 176 passengers on board. This tragic and embarrassing move, which led to mass protests in Iran, ultimately quashed Iran's immediate ambitions for retribution against the United States.

The narrow aversion of open war between Iran and the United States was a fortunate outcome—albeit at tragic cost—in an otherwise terrible year. From

an energy perspective, however, the most remarkable part was the oil market's reaction, or lack thereof. In stark contrast to the price swings later in 2020, the oil market's reaction to the tension was relatively muted: prices initially jumped by 3 percent but then remained stable.

Four months earlier, in September 2019, Iranian drones had destroyed oil processing facilities at Abqaiq and Khurais, Saudi Arabia, temporarily shutting down about 5 percent of global oil production. Again, from an energy perspective, what was most remarkable about these attacks was the lack of response by the market. Though oil prices initially jumped 20 percent, that surge faded, and prices quickly stabilized in the week following the attacks. The attacks came in the midst of a well-supplied market: spare production capacity left by OPEC+'s production cuts and countries' strategic petroleum reserves easily covered for lost production as Saudi Arabia rebuilt its facilities.

The key change to oil markets had been the rise of US shale production. In 2019, the United States became the largest oil producer in the world, and also became a net exporter of energy for the first time since the mid-20th Century. The United States' rise in the market added a new major supplier to the global oil market, dampening the impact of disruptions abroad on oil prices, and reduced the country's dependence on imports. For better or worse, this new status as an energy superpower gave the United States the geopolitical freedom and flexibility to act in ways it might previously have resisted, with little risk to its energy security.

While energy security remains a critical geopolitical issue, the questions and risks—and the key players—are far different from the days of the oil embargo. Instead, countries now worry about new supply chains, critical minerals, and cybersecurity. The gravitational centers of the energy market have begun to shift from the Middle East to the United States, China, and Russia, with major implications for how energy and diplomacy intersect. Dan Yergin lays out this new world of energy geopolitics and its fault lines in his essay, "The Shale Revolution: What It Means for US Foreign Policy," adapted from his recent book *The New Map*.

The shale revolution: What is means for US foreign policy

by Daniel Yergin

What seemed to be unachievable has been achieved. "Energy independence" had been the repetitive mantra for eight US presidents, going back to the early 1970s. For most of those decades, it was also a chimera, and sometimes even a joke for late night comedians.

Yet, for the most part, the United States was largely energy self-sufficient even in those years. Oil was the big exception, and it loomed large; in 2008, net imports accounted for 60 percent of US consumption. But the shale revolution has transformed the position of the United States, more than doubling production and making the country virtually energy independent. Indeed, recently the United States has even been a slight exporter in net terms of oil, and a growing exporter of natural gas.

This first issue of the Atlantic Council's *Global Energy Agenda* thus provides a very timely forum to consider what energy security now means. And we have a specific case study at hand.

In September 2019, drones slammed into Saudi Arabia's Abqaiq facility, the most important hardware in the world oil industry, through which as much as seven million barrels per day can pass. Pre-shale, such an attack would likely have ignited panic in the world oil market and spiked prices. But this attack on a critical node in the global system did no such thing. Partly it was the speed and capability with which Saudi Aramco repaired the facility. But even before that, it was also because the growth of US shale had changed the balance of supply in the world market, and the psychology of the market. As the world's largest oil producer, the scale of US production served as a giant security cushion against the shocks that would otherwise have radiated across the world.

Yet sometimes it seems to be a characteristic of human nature that when one actually has something, it is taken for granted. And that could be the case in terms of the shale revolution in the United States. Had the "ban fracking" slogans of the 2020 Democratic primary been realized, they would have turned back the clock. If enacted, a "ban fracking" policy would actually have been an "import more oil" policy. For there are about 280 million cars in the United States, and almost all of them run on oil. Those cars are not going to stay in the garage. If the oil is not produced in the United States, it will be imported, starting the country back up the track of rising net imports. In the years ahead, along with the growth of renewables, more electric cars will be coming into the fleet, but that will take time; on average, cars remain on the road in the United States for twelve to fifteen years. Moreover, oil (and natural gas) molecules have many uses other than transportation.

While the US transition to greater energy independence is well-documented, *The New Map* also explores the broader impacts of the shale revolution that are not as well-recognized. Shale has been a major driver of business investment in the United States and a big market for Midwest manufacturing industries. The shale revolution has stimulated over $200 billion of investment in new petrochemical facilities in the United States and has become a significant source of revenues for the federal government and a number of states. The reduction of imports and the growth of exports has been a big contributor to the US balance of payments. Using 2007 as a baseline, the US trade deficit was more than $300 billion lower in 2019 than it would have been without the shale revolution.[3]

The shale revolution has also had an under-recognized impact in foreign policy. Overall, that once supposedly unachievable "energy independence" has provided the United States with a flexibility in foreign policy that it did not have in previous decades. Nowhere is that more obvious than with regard to Iran. Whether one is a supporter of the Obama administration's approach to Iran, or Trump's, or what will be that of the Biden administration, the change in the oil position of the United States has been critical. When the Obama administration began its drive to force Iran to the nuclear negotiating table, Tehran scoffed that sanctions on the export of its oil were "doomed to fail."[4] It assumed that sanctions were destined to fail because the world market would require Iranian oil. But the growth of shale proved a critical offset, more than making up for the sanctioned Iranian barrels.

The foreign policy aspects are evident in other areas, as well. Exports to India have brought a new, concrete

3 Daniel Yergin, *The New Map: Energy, Climate and the Clash of Nations* (New York: Penguin, 2020), 26-30.
4 Yergin, *The New Map*, 61.

dimension to relations between India and the United States, bolstering that overall bilateral relationship. US exports of oil and gas to China are one of the positives in a relationship increasingly strained in terms of trade and certainly overall.

Of course, the shale industry is not what it was one year ago. It has been battered by the economic impact of COVID-19, which has included the shutdowns; the constriction of travel; the drop in demand; and the collapse in prices, which have only partly rebounded. As of January 2021, US oil production is eleven million barrels, two million barrels lower than it was in February 2020, although still more than double the level of 2008.

The industry has responded in two ways: first, it has become even more concentrated on returning money to investors, in order to win them back. Secondly, it has focused on reducing costs, both in terms of operations and through consolidation.

When growth resumes again, it will be at a much more modest rate than in past years. Shale will no longer be the disruptive technology it previously was in the global market, when its explosive growth was adding one or two million barrels a day year after year. Instead, it will be one of the foundations of the global market, recognized as such, and continuing to deliver its economic and political benefits and, along with that, energy security.

***Dr. Daniel Yergin** is the author of the new book, The New Map: Energy, Climate, and the Clash of Nations, which was selected as one of the best books of 2020 by both USA Today and NPR. Vice chairman of IHS Markit, Dr. Yergin is also author of both The Quest and The Prize, the latter of which received the Pulitzer Prize. He was the first recipient of the James Schlesinger Medal for Energy Security from the US Department of Energy.*

UNSPLASH/DELFINO BARBOZA (@DELFINOB4)

Oil pump in the Permian Basin, West Texas, US.

The Role of China

The flip side of America's energy production growth is China's energy demand growth. Between 1990 and 2018, China's primary energy demand grew from 7.65 to 23.9 terawatt-hours. And in 1993, China went from being a net oil exporter to a net importer, despite being the world's fifth largest oil producer. China has been the world's leading oil importer since 2013, will soon become the leading importer of liquefied natural gas, and is the world's third-largest coal importer. In a year where global natural gas demand fell by 4 percent, China was one of the only bright spots for the industry, with its demand rising by 4 to6 percent. Energy security is still clearly a massive issue for the world's second largest economy. Tensions in the Gulf or tensions with the United States can and do have a material impact on China's energy supply.

To mitigate some of these energy security risks, China has embarked on a massive program of renewable energy and electric vehicle development and deployment.[5] It is dominant in solar photovoltaic cell manufacture, the world's largest producer of electric vehicles, and is looking to turn its attention to hydrogen fuel cell technology.

This effort has had huge benefits for accelerating the energy transition—it is one of the primary reasons the cost of renewables has dropped dramatically over the last decade—but this has created its own set of energy security risks, primarily for other countries increasingly dependent on Chinese technology. From trade wars with the United States to global dependence on Chinese critical mineral supply chains, clean energy security—and hence the energy transition—now depends on China.[6]

Han Wenke, former head of China's National Development and Reform Commissions Energy Research Institute, explores the energy security risk that China continues to face from hydrocarbon imports, but also lays out a positive vision for a new energy security paradigm that would provide for common energy security and advance the energy transition.

5 Robert Johnston, *Asian energy transition: Moving the oil market one step closer to peak demand*, Atlantic Council, January 8, 2018, https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/asian-energy-transition-moving-the-oil-market-one-step-closer-to-peak-demand/.

6 Meghan L. O'Sullivan, "After Oil: U.S.- China Split Will Hurt Clean Energy," Bloomberg Opinion, September 14, 2020, https://www.bloomberg.com/opinion/articles/2020-09-14/u-s-china-spat-threatens-energy-shift-from-oil-to-solar-wind.

China's new energy strategy: Maintaining global security

by Han Wenke

The political and economic map of the world is becoming increasingly diversified, while also becoming increasingly unstable. Population, natural resources, and the environment are crucial factors affecting the economic and social development—and decision making—of various countries. But energy security is still the most significant driver for all countries to ensure their economic and resource security.

In recent years, disputes among the great powers—and the divergence of their foreign policies—have reordered international geopolitics, sometimes triggering regional conflicts, which have become another source of global instability. Disputes between countries over territories—especially those rich in energy resources—have also occurred. All of these have threatened the stable supply of global energy.

Although some regional conflicts have subsided temporarily, the root causes of conflicts and instability persist. In the past two years, tension in the Arab Gulf, and pronounced changes in the situation in Venezuela, have brought pressure on oil producers and suppliers in the regions in question, as well as in other countries, especially those dependent on energy imports from volatile countries.

This geopolitical instability creates uncertainty in the global energy supply chain, and it also raises energy costs. Not only does instability work against the promotion of the green and low-carbon energy transition—as well as the ability of countries to cope effectively with climate change—but it also causes extremely unfavorable conditions for the recovery of the global economy, which has been hit hard by the COVID-19 pandemic.

Since the beginning of the 21st century, China—as the largest developing country—has committed to its own economic and social development, and the country has made remarkable achievements. However, China is also deeply aware that, in today's world, all countries face national security challenges from military, political, and diplomatic conflicts; economic security risks; ecological and environmental damage; public health problems; and security threats from non-state actors. Facing these 21st century challenges, China has put forward an overall national security strategy that emphasizes development and security. In China, an increasingly open country with a large population, the underpinnings of economic security are a stable income, food supplies, and energy access.

As the largest energy producer and consumer in the world, China views energy security as a top priority for ensuring its national security. After more than forty years of reform and opening up to the global community, China has formed an energy supply system with the comprehensive development of coal, electricity, oil, natural gas, nuclear power, and renewable energy. After rapid development in the first decade of this century, China has realized that, in order to reduce its increasingly serious air pollution and support the growth of ecological civilization, China must prioritize energy conservation and improvements in energy efficiency, while also promoting upgrades to energy infrastructure. With the adjustment of China's energy consumption policy and continuous achievements, the momentum of China's energy consumption, despite rapid growth, has been effectively controlled.

From 2013 to 2019, China's economy grew by 7 percent annually, while primary energy consumption grew by only 2.7 percent annually. Over the same period, China's energy consumption and energy efficiency in industry, transportation, construction, and other sectors greatly improved. In particular, China's end-use electrification levels have rapidly improved. The ratio of energy consumption for power generation to the energy intensity of end-use consumption is now basically equivalent to that of developed countries.

At the same time, China has promoted supply-side structural reform in the energy sector, reducing nearly 1 billion tons of excess capacity of coal, while eliminating, suspending, or delaying the construction of coal-fired power generation capacity of more than 200 million kilowatts. China has also promoted the large-scale development of non-fossil energy, and is constantly expanding energy infrastructure, allowing China to diversify its energy supply system. China's scale of non-fossil fuel energy development has taken the lead in the world. In 2019, the installed capacity of hydropower, wind power, and solar power in China has reached 840 million kilowatts, accounting for 42 percent of total installed capacity and 32.7 percent of total power generation.

UNSPLASH/ZHANG KAIYV (@ZHANGKAIYV)

A view of Beijing, China.

In terms of oil and gas supply, China's domestic oil and gas is limited. In 2019, China's total oil and gas production was equivalent to 347 million tons of oil. China imported 506 million tons of crude oil and more than 130 billion cubic meters of natural gas. China depends on imports for 72.6 percent of its oil and 42.1 percent of its gas, and it has realized that oil and gas imports are a weakness in its energy security. In response, China has improved maritime security around shipping lanes and also developed an emergency reserve. At the same time, a fundamental solution is to continuously increase the development of alternatives to oil and gas, especially through vigorously promoting electric vehicles in the field of transportation.

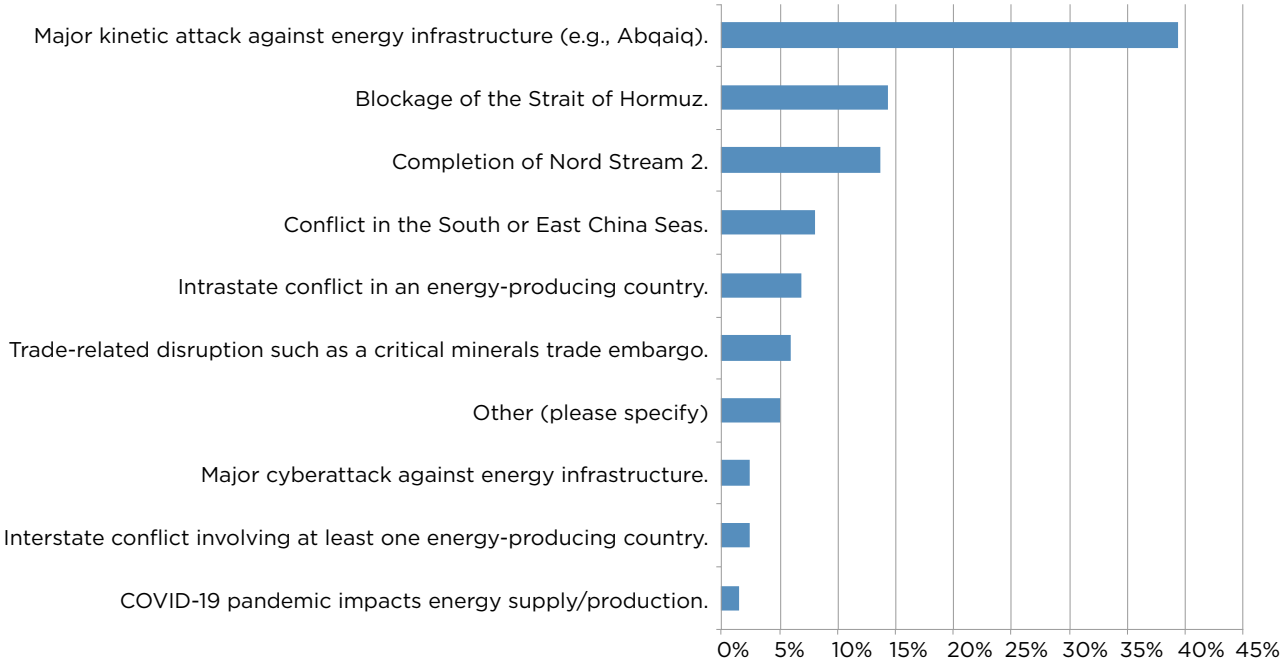
However, China's current energy system, which is highly dependent on fossil fuels, does not align with the goals of green and sustainable development. These problems will persist as long as China's energy system is based on high-carbon, traditional energy, with a centralized energy supply. This energy supply system is defective in promoting more competitive economic sectors, meeting more employment demands, increasing consumer rights and interests, and improving higher quality energy products and services. It is also not conducive to China's further integration with the world energy system.

Internationally, China advocates for the realization of common energy security. China's aim is to cooperate with other countries in the field, as well as with multi-level and whole industrial energy supply chains, so as to better promote the development of all countries. China's energy cooperation under the Belt and Road Initiative is designed for this purpose. By 2019, China's power grids were interconnected with Russia, Mongolia, Vietnam, Laos, Myanmar, and other neighboring countries. The level of clean energy cooperation between China, Southeast Asian countries, and other countries has been greatly improved. China has also actively participated in global energy and climate governance to address global energy and climate challenges in a more positive manner.

Therefore, China's president Xi Jinping has proposed to promote a revolution in energy production and consumption and build China's modern energy system. This modern energy system should ensure China's green development and low-carbon development, make China achieve peak carbon emissions before 2030, and ensure that China is carbon-neutral by 2060. Of course, It should also ensure that China can achieve its economic and social development goals by the middle of this century. This is China's new national energy security strategy.

***Han Wenke** is a Senior Adviser and Research Fellow at the Energy Research Institute of the National Development and Reform Commission in the People's Republic of China.*

What is the biggest risk in energy geopolitics in 2021?



Evaluating Geopolitical Risk

Between the changing energy system and the changing global order, energy geopolitics and security means something different today than it did during the oil crises of the 1970s. But what are the biggest risks? To find out, we asked our survey respondents just that: "What is the biggest risk in energy geopolitics in 2021?"

Respondents believe that the biggest risk in energy geopolitics in 2021 will be the possibility of energy production or supply problems arising from the COVID-19 pandemic.

Those surveyed believe, by some margin, that the biggest risk in energy geopolitics in 2021 will be the possibility of energy production or supply problems arising from the COVID-19 pandemic (39 percent). The leading concerns of the remaining respondents are split fairly evenly between a wide range of other risks (see chart). Among these, inter-state conflict involving an energy-producing state (14 percent) and a major cyberattack on energy infrastructure (14 percent) are slightly more common choices than the others.

Even during the course of our survey, though, risk perceptions were changing. Answers of those who responded on or before November 8 and on or after 1November 13—the period in which positive interim results from several COVID-19 vaccines and the results of the US presidential election were announced—were markedly different. Although in the latter period, pandemic-related risk remained the most frequently cited problem, those choosing it dropped from 41 percent to 35 percent. Meanwhile, two issues discussed in the context of Sino-US relations—the possibility of trade-related disruption, such as a critical mineral embargo, and potential conflict in the South or East China Seas—dropped from being the leading concerns collectively of 12 percent of respondents in the initial period to just 5 percent in the latter. Growing concerns about cyberattacks, a perennial challenge, instead seemed to be moving to the front of minds, as the choice of just 13 percent in the first of these periods but 23 percent in the second. This was well before the SolarWinds attack was announced in December, so we have to presume cyber would trend even higher now than it did two months ago.

As Leo Simonovich and Andrew Gumbiner argue in their essay below, with decarbonization goals encouraging greater electrification and digitization of the energy system, cybersecurity is no longer only an energy security risk, but could also impede the energy transition. And those in the renewables sector recognize this. While COVID-19 was still the most frequent answer for those in the renewables sector, the second place concern of cyberattacks on infrastructure, at 24 percent, was a much more common reply than among other respondents. For example, for those in the oil and gas industry, cybersecurity was a leading concern for only 7 percent of respondents.

Partner Perspective: An innovation architecture to secure the energy transition: How to sustainably scale industrial cybersecurity for the digital age

by Leo Simonovich and Andrew Gumbiner

The SolarWinds cyberattack is the latest glaring example of the urgent need for a new industrial cybersecurity architecture to protect the energy industry. While the attack has renewed calls for ambitious action to secure the energy transition from cyberattacks, what remains unclear is *how* to reimagine security in the digital age.

Increasingly, mega-attacks like SolarWinds use critical infrastructure assets—often developed, owned, and operated by the private sector—as collateral in broader geopolitical conflict between nations. The threat of foreign malicious actors cutting off power to an entire city, or infiltrating critical infrastructure systems that control pipelines, water, and emergency communications systems, not only paralyzes entire economies and sows discord among unsuspecting civilians, but also shifts the focus and responsibility to secure critical infrastructure from the government to the private sector.

With 2.5 billion new industrial devices expected to be connected to energy infrastructure in the next two years—from gas turbines and microgrids, to electric vehicle charging stations—digitalization is rapidly transforming the energy industry from a century-old commodity-based business run on analogue equipment, into a technology-driven industry that makes risk-based decisions with internet-like speed.[7] The digitized energy future looks clean, competitive, and efficient in large part because digital connections enable operational technology (OT) to control and connect energy assets optimized into a multi-directional network with information technology (IT). However, the catch is that cybersecurity is its Achilles Heel.

To secure the energy transition, the industry needs to apply the same attention historically focused on ensuring the reliable and affordable delivery of energy to a new task: protecting a complex network of OT assets vulnerable to cyberattacks. Securing the energy transition will require a new market-based architecture to help companies deploy necessary defenses, with the goal of making cybersecurity a part of the sustainable, revenue-generating value proposition. At its foundation, this new architecture must start with public and private sector collaboration to help energy companies strategically innovate, scale, and sustain the cutting-edge cybersecurity technologies needed to protect the industry.

While some large energy companies have the balance sheets to undertake the adoption of novel technologies and innovative cybersecurity programs, most lack the funding and expertise to secure their operating environments affordably. Thankfully, newly available artificial intelligence (AI)-powered tools are within reach of all OT organizations, providing full visibility and context to identify, detect, and prevent an imminent cyberattack. Collaboration with federal and state governments can help companies drive down risk, overcome investment hurdles, and prove the efficacy of deployment-ready technologies. Shortening the technology adoption cycle with public-private partnerships and public-backed loans or grant programs will give the industry a necessary edge and scale to stay ahead of attackers.

In the past decade, companies in the early stages of the renewable energy transition relied on public-private partnership projects and public capital to scale market-ready technologies. That process can work for cybersecurity investments too. In 2020, the New York Power Authority (NYPA) and Siemens Energy started such a partnership aimed at creating an industrial cybersecurity program of the future, which includes deploying AI-based monitoring and detection solutions on New York's critical infrastructure. Proving new cyber solutions with early adopters in the energy sector builds the foundations for other agencies and regulatory bodies—as well as more budget constrained energy companies—to trust the efficacy of AI-based monitoring and detection solutions for the OT environment. As these technologies demonstrate value, large-scale federal loan guarantee or grant programs and state-run green banks can help provide low-cost capital to scale security solutions tailor-made for the digital energy ecosystem.

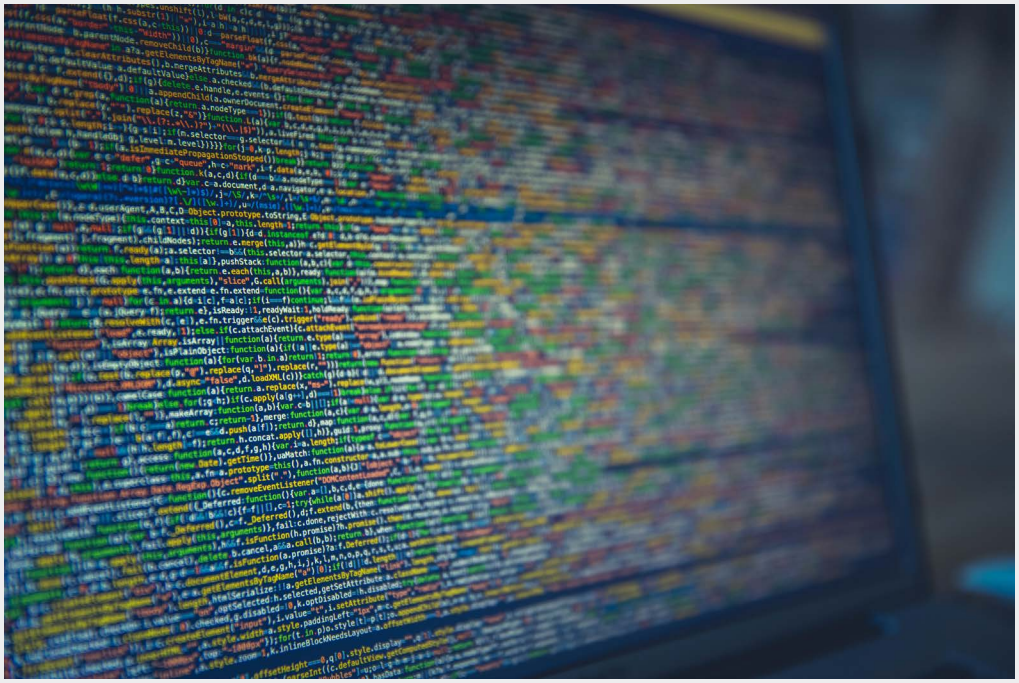
7 Cisco Annual Internet Report (2018-2023), Cisco, Updated March 9, 2020, https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.pdf.

While helping the energy industry deploy new technologies is a first step in securing the energy transition, expanding and sustaining cybersecurity programs will require updating how the industry monetizes security. Energy companies must protect not only the assets they own and operate, but also every new digital connection linked to their network. Reliability depends on protecting the full ecosystem, from power generation equipment producing and transmitting energy all the way down to end users—or prosumers—who sell power from rooftop solar panels back to utilities. This complex ecosystem requires transparency to reveal the true cost of security, and then implement a dynamic, market-based architecture to invest in programs that can adapt to current and future threat landscapes.

Today, the risk-adjusted cost of cybersecurity is treated inconsistently across the energy industry, leaving regulators and energy companies without a common understanding of the needed investments. Recently, a regional US utility projected to regulators that a rate case adjustment to enhance its cybersecurity defenses would cost more than $100 million.[8] Cost transparency will reveal weak points among nearly all industrial operators, especially in smaller and underfunded organizations. As its stakeholders better understand common security gaps, the energy industry can implement a sustainable pricing model to drive investments in the total cost of cybersecurity, including programmatic steering, human capital, and cutting-edge technologies.

The energy transition hinges on cybersecurity to defend affordable, efficient, and clean energy as it powers homes and businesses across the world; cybersecurity measures must no longer be an afterthought. They require an innovation-based architecture that can help energy companies invest in new technologies and sustain cybersecurity programs that are just as sophisticated as the digital energy ecosystem they aim to protect. The result will maintain and expand security to all connected energy assets and lead the energy transition over the long term.

Leo Simonovich is the Vice President and Global Head of Industrial Cyber and Digital Security at Siemens Energy; Andrew Gumbiner is the Founder of AJG Strategies, LLC. Siemens is a sponsor of the Atlantic Council Global Energy Forum.



UNSPLASH/MARKUS SPISKE (@MARKUSSPISKE)

A display of complex computer code.

8 Tucker Bailey, Adam Maruyama, and Daniel Wallance, "The energy-sector threat: How to address cybersecurity vulnerabilities," McKinsey & Company, November 3, 2020, HYPERLINK "https://www.mckinsey.com/business-functions/risk/our-insights/the-energy-sector-threat-how-to-address-cybersecurity-vulnerabilities" https://www.mckinsey.com/business-functions/risk/our-insights/the-energy-sector-threat-how-to-address-cybersecurity-vulnerabilities#.

UNSPLASH/LORENZO CASTAGNONE (@THEPARCEL)

Glaciers in Iceland.

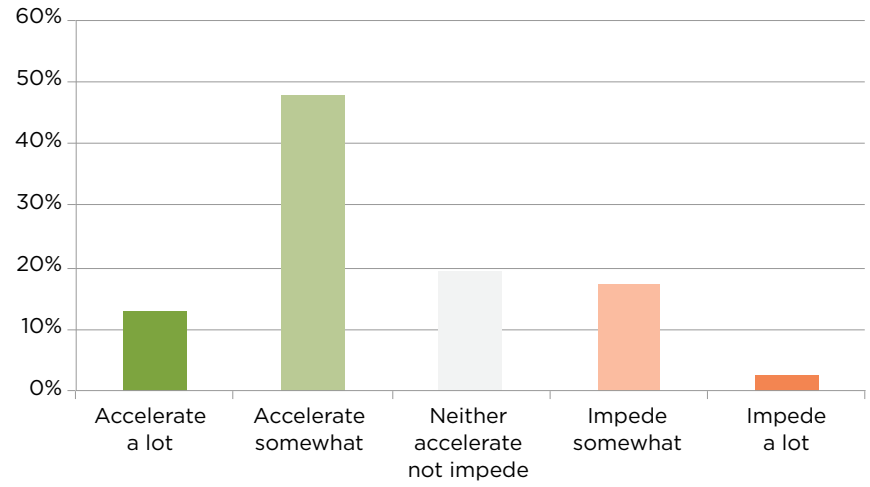
Sixty-one percent of those surveyed said that the pandemic will accelerate the energy transition while just 20 percent believe it will impede it

CHAPTER III: CLIMATE CHANGE, DECARBONIZATION, AND THE ENERGY TRANSITION

Even as respondents see COVID-19 as a short-term risk to energy production and supply, they also forecast that it will have an impact on the energy transition. We asked our respondents if COVID-19 will accelerate or impede the energy transition, and 61 percent of those surveyed said that the pandemic will accelerate the energy transition while just 20 percent believe it will impede it.

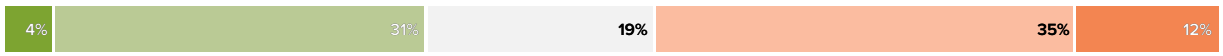
Sound arguments certainly exist to expect some acceleration, such as substantial investment in green energy projects by governments looking to promote post-pandemic economic recovery. Nevertheless, a

Will COVID-19 accelerate or impede the energy transition?



BULLS:

BEARS:



closer look at the responses suggests that, for many of those surveyed, the extent of COVID-19's longer-term impact remains unclear. Overall, only 15 percent expect it to have a large effect either driving or holding back the transition. As hopeful news of effective vaccines spreads—and, with it, the hope of bringing the pandemic to heel—the number expecting the virus to bring big changes has declined. Among those answering on or before November 8, 18 percent saw a large impact one way or another. After November 13, that dropped to just 8 percent.

Indeed, to some extent respondents may not simply be forecasting the likely changes that COVID-19 will bring in this field. Instead, we may be seeing a kind of Rorschach test: we expect the pandemic to be too big an event not to drive change, but which kind we expect it to bring reveals our thoughts on the future of oil as much as the mechanics of pandemic-induced change. Among our bears group, for example, 45 percent expect it to impede the transition, compared to 33 percent who say it will drive such change. The equivalent figures for the bulls are 13 percent and 74 percent.

But as Francesco La Camera, Director-General of the International Renewable Energy Agency points out, despite the difficult year for energy, in 2020 "renewables displayed remarkable resilience." Ninety percent of new electricity generation in 2020 was renewables, and the IEA notes that, "in sharp contrast to all other fuels, renewables used for generating electricity will grow by almost 7 percent in 2020."[9] The data suggest that the bulls might be right. But just as Fatih Birol argued earlier, La Camera also notes that the choices we make will decide whether or not this trajectory continues.

9 Damion Carrington, "Renewable energy defies Covid-19 to hit record growth in 2020," *The Guardian*, November 10, 2020, https://www.theguardian.com/environment/2020/nov/10/renewable-energy-covid-19-record-growth-2020; *Renewables 2020,* International Energy Agency, November 2020, https://www.iea.org/reports/renewables-2020.

Renewable energy for the energy transition: An opportunity we cannot miss

by Francesco La Camera

The world is at a crossroads, where governments, companies, and individuals need to make decisions about the future of the global energy system. Fundamental changes to the current energy system are necessary in order to align with climate priorities. A new deal based on the energy transition can provide a meaningful framework to secure economic growth and resilience, promote equity, and improve quality of life for all.

In the last decade, renewable technologies soared from niche to major global industries with a speed and intensity that has changed global energy. Renewable power generation capacity has grown by approximately 80 percent over the past decade. Today, renewables account for nearly 35 percent of global electricity generation capacity**.** The International Renewable Energy Agency (IRENA) estimates that by 2021 up to 1,200 gigawatts of existing coal-fired capacity will cost more to operate than new utility-scale solar photovoltaic will cost to install.

As 2020 took an unexpected and catastrophic turn due the global pandemic, multiple crises began to emerge. The energy system was no exception, but as IRENA forecast in April, renewables have been more robust than the rest of the energy system. As the economic downturn ravaged the oil markets and low electricity demand reduced fossil fuel-based generation, renewables displayed remarkable resilience. In the European Union and United Kingdom, for instance, coal-based power generation fell by over a quarter (25.5 percent) in the first three months of 2020, compared to 2019, as a result of falling demand due to COVID-19, with renewable energy reaching a 43 percent share of the electricity mix. By the end of September, as power demand returned, renewables were still 40 percent of the electricity mix, a 10 percent increase in comparison to January 2020. These developments, along with the possible speed and ease of deployment of renewables, have injected increased confidence and enthusiasm into the potential for a renewables-based energy transition.

To realize this potential, IRENA proposed a set of priority investments to simultaneously tackle short-term goals and make decisive strides towards long-term climate and development objectives, while creating millions of jobs. At a projected investment of $6 trillion over three years, the renewables-based energy transition will require a doubling of annual investment into renewables, energy efficiency, innovation, and smart grids compared to recent years.

Governments, businesses, and communities are already investing in an array of renewable solutions, which are abundant and available in nearly every country on the planet. But the transformation of the global energy system is a formidable challenge that will require a myriad of solutions to reverse the current balance of non-renewable and renewable supply. And we must do so rapidly. Renewables such as biomass, geothermal, and hydropower have formed the backbone of many grids for decades. Together with solar, wind and ocean energy they continue to evolve, with compelling technical and economic viability. The cost of almost all renewables is competitive with fossil fuels. Solar and wind are going to be the most cost-competitive way to produce energy in large parts of the world. In 2019, 72 percent of the new installed capacity was renewables, 90 percent of which was solar and wind. Green hydrogen (from water electrolysis using renewable power), storage technologies and Artificial Intelligence (AI) will play a vital role in balancing electricity supply and use at different time scales to ensure that a high share of variable renewables can be incorporated into the grid. Grids should be redesigned to ensure interconnectivity and flexibility, harnessing the opportunities of digitalization to maximize renewable energy generation.

Some renewable solutions hold an immense promise but remain untapped. Oceans are a source of abundant renewable energy potential, capable of driving a blue economy. Energy harnessed from oceans, through offshore renewables including offshore wind and ocean energy, can not only contribute to the decarbonization of the power sector but also provide a range of end uses including cooling, desalination, and aquaculture.

Offshore wind power generation has gained traction in the last decade, and IRENA projects this promising technology will grow almost ten-fold from 28 gigawatts (GW) in 2019 to around 230 GW of global cumulative installed capacity by 2030. Ocean energy

technologies are yet to reach commercial viability, but the sector is attracting growing attention. From the current capacity of 0.5 GW, IRENA has identified a global project pipeline of close to 4 GW of additional capacity.

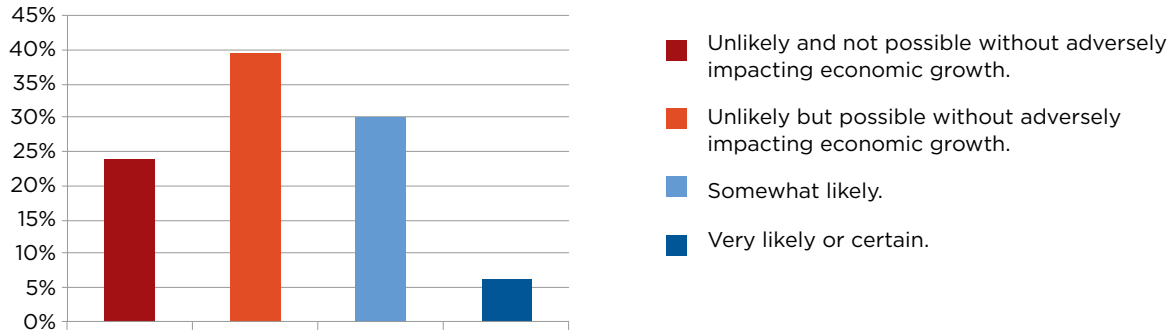
This immense potential to grow green power capacity opens the door for sector coupling through direct or indirect electrification of buildings, industry, and transport. Similarly, the scaling up of hydrogen produced with renewable electricity has given green hydrogen unprecedented political and financial attention. Chile, Denmark, the European Union, Germany, and Spain have all released hydrogen strategies, with more nations to follow suit. Today around 0.3 GW of electrolysers are in operation, but 60 GW of new projects are in the pipeline. IRENA analysis suggests up to 4 terawatts of electrolyser capacity will be needed by 2050, an increase of four orders of magnitude. Green hydrogen must therefore become a new energy commodity, for which a standard and certification system must be put in place to assure its origin. With the ultimate goal of the green hydrogen economy, "blue hydrogen," produced from natural gas with CO_2 capture and storage, can play a complementary role during a defined transition period.

There are very few economic sectors that are growing as rapidly and as dynamically as the renewables sector, which will have a tremendously positive impact on jobs and GDP growth. For every $1 million invested in renewables, twenty-five jobs can be created. This is an opportunity that cannot be missed. The change we need requires more than rapid development and deployment of technologies. Persistent global economic and environmental inequalities, together with emerging socioeconomic risks, underline the pressing need for inclusive and resilient economies and societies. An energy transition must be just and not leave anyone behind. We need policy frameworks that will not only guide investment toward the renewable energy transition but also create new value chains and promote industrial development.

The energy system of the future will be based on renewables complemented by electrification, green hydrogen, and modern bioenergy. New technologies supporting the energy transition should be encouraged. It is vital that the renewable energy transition play an important part in the global response to the COVID-19 pandemic, pulling us towards the medium-and long-term objectives of the sustainable development goals and the Paris Agreement.

***Francesco La Camera** is the Director General of the International Renewable Energy Agency.*

How likely is achieving global net-zero GHG emissions by 2050?



Net-Zero Pledges

Net-zero greenhouse gas (GHG) emissions pledges accelerated in 2020, with numerous companies and several key countries making these commitments. The most significant pledge came from China, which, in September, committed to net-zero by 2060. While most other net-zero pledges are by 2050, that the largest global CO_2 emitter (nearly double that of the United States, which is in second place) took on this challenge turned heads. Japan and South Korea soon followed with their own 2050 commitments.

On the private sector side, over 1,500 companies made net-zero pledges in 2020.[10] Perhaps most significantly, major oil and gas companies started making these pledges, beginning with Repsol in 2019 and followed in 2020 by BP, Shell, Eni, Total, Equinor, and ConocoPhillips. Each company takes a different approach to their emissions reduction and defines "net-zero" in different ways. The most important differences are how they approach scope 3 emissions, which account for 90 percent of oil companies' total emissions. These differences have led to legitimate questions about how impactful these pledges actually will be.

Nonetheless, the fact that only seven significant oil and gas companies have made net-zero pledges suggests that these are difficult to achieve and, as such, meaningful commitments.

Perhaps the more important question is how these pledges work in tandem to achieve global net-zero emissions. We asked survey respondents how likely it is that we will achieve net-zero GHG emissions by 2050, and what is the primary obstacle to reaching this goal.

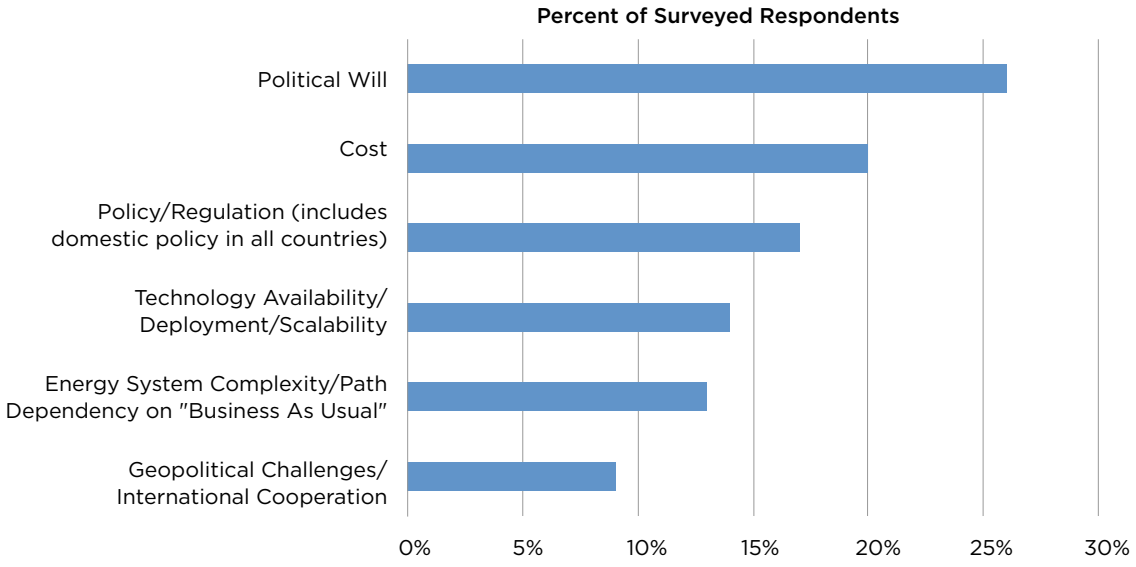
Most survey respondents consider net-zero emissions within thirty years to be a feasible goal: only 24 percent think it both unlikely and impossible without adverse effects on economic growth. Among the rest, though, slightly more are dubious that it will occur than are hopeful. Forty percent of those surveyed believe that, even though it would be possible without damaging the economy, net-zero is unlikely to be reached; 30 percent think it somewhat likely; and just 6 percent consider it very likely or certain.

Only 6 percent of those surveyed consider it very likely or certain that the world will reach net-zero by 2050.

Given these answers, it comes as no surprise that considerations of policy figure prominently for respondents when asked the primary obstacles to reaching this goal. Although cost was the most common word to appear in the freeform answers which those surveyed gave, "policy" and "political will" were the third and fifth most frequent words to appear and if combined as a single category would occur over 50

10 "Commitments to Net Zero Double in Less than a Year," United Nations Framework Convention on Climate Change, September 21, 2020, https://unfccc.int/news/commitments-to-net-zero-double-in-less-than-a-year.

What is the primary obstacle to reaching net-zero by 2050?



percent more often than cost. The second most frequently used word, “energy” also often appeared in the context of policy choices, such as “government commitments to policy changes required to meet targets plus making necessary investments in clean energy research and development.” So too, the sixth most common word, “lack” was often linked up with policy or political will.

Levels of optimism vary by geography. Perhaps surprisingly, 47 percent of respondents in MENA countries think reaching net-zero is likely, as opposed to 40 percent in Europe and just 32 percent in the United States. These geographic differences do not reflect disagreements over whether success is achievable. In all cases, only between 21 percent and 26 percent think the economic damage would be too great. Instead, the big divergence is between those who think it possible but not probable and those who think it likely. Here the United States and MENA are mirror images: in the former, 47 percent say that it is unlikely but could be done without hurting growth and 32 percent that it is somewhat or very likely. The equivalent figures for MENA are 32 percent and 47 percent.

The similarity between all these geographies in their freeform answers about barriers to reaching net-zero suggest that these variations in numbers reflect differences in confidence in policy makers to do what is needed.

Once again, a more fundamental set of differences exist between our bulls and bears. The former are more positive about the ability of the world to reach net-zero emissions by 2050, with 51 percent thinking it somewhat or very likely, and just 15 percent saying that it cannot be achieved without hindering growth. As with other respondents, questions of political will and policy figure most prominently in their answers about barriers to success.

Among the bears, on the other hand, 81 percent call net-zero unlikely. For this group, policy and political will play a much smaller role in explaining how the future will unroll in this area. Instead, practicalities dominate. For example, 48 percent of bears say it is simply not possible to reach net-zero without limiting economic growth. Similarly, their freeform responses speak about the technology not being ready or affordable to displace fossil fuels in the face of economic growth. We will get to questions about technology in Chapter 4. If bears see oil as a big part of the future, it seems largely to reflect a lack of confidence in anything else delivering on its promises, not a simple lack of political will.

While the United States at the federal level has exemplified the lack of political will that our survey respondents identified as the biggest impediment to achieving global climate goals—particularly over the past four years, but before then as well—some US states and cities have been global climate leaders. None has been as forward leaning as California, which would be

the world's fifth largest economy if it were an independent nation.

Mary Nichols, sometimes called the "Queen of Green," twice led California's principal environmental regulatory agency, the California Air Resources Board. Appointed by both Republicans and Democrats, she is considered one of the most important environmental regulators globally. Here she argues that efforts like California's to reach net-zero are both crucial, but also economically beneficial.

Mohammed Al Ramahi, Chief Executive Officer of the Abu Dhabi Future Energy Company, better known as Masdar, makes a similar argument to the one made by Mary Nichols, but coming from a very different energy and economic context. The United Arab Emirates (UAE) is a low-cost and low-carbon oil producer, and so—in a world that is moving away from hydrocarbons and reducing emissions—they are likely to be one of the last significant oil producers. Nonetheless, Al Ramahi sees a similar opportunity in green investment to meet the moment, both in the UAE and globally.

Survey respondents believe that the lack of political will is the greatest obstacle to achieving global climate goals.

US leadership is integral to global success in the fight against climate change

by Mary Nichols

While the world watched the US national elections unfold over the first week of November, another event of critical global consequence went almost completely unnoticed. The United States officially withdrew from the historic 2016 Paris Climate Agreement. Nearly every country in the world is a signatory to the agreement, which is critical to fate of our planet. With its withdrawal, the United States joined a handful of uncommitted countries like Iran, Iraq, and Yemen.

Climate change is fundamentally altering our lives. It is no longer a threat that lies somewhere out beyond the horizon. It is right here right now, rapidly pushing us toward a public health nightmare.

For the past four years, the most prosperous, technologically advanced society in the history of the world cowardly turned its back on the effort to address the biggest environmental challenge humanity has ever faced. Not only did the Trump administration refuse to participate in the effort, it actively sought to prevent individual states from taking action to protect the health and welfare of their citizens.

We have lost valuable time and have a great deal of damage to repair. But there is hope. We once again have a president that believes in science and understands what leadership means. The Biden-Harris administration will restore the United States to its rightful place as a global climate leader, including by working with and supporting state efforts to cut emissions by investing in clean, sustainable economic growth.

The words of Louis Brandeis still ring true today. States remain great laboratories of democracy, where ideas and innovations can be developed, tested, and put to work. It is no secret that states have been carrying the load on climate leadership in this country for the past four years. What many people do not know though, is that they have been doing it not merely to cut greenhouse gas emissions, but as part of a deliberate plan to grow the economy, create jobs, and advance critical equity and environmental justice goals.

The path we are taking in places like California gives us the chance to dramatically re-envision our future. It will protect and improve the health and welfare of our citizens, while creating unparalleled opportunities for clean, pollution-free economic and job growth.

Through implementation of a whole range of programs, California met its 2020 emissions target four years ahead of schedule while, at the same time, it grew to be the fifth largest economy in the world. Emissions went down faster and economic growth went up quicker than the national average.

In 2019, clean energy jobs in California outnumbered jobs in the fossil fuel industry six to one.[11] The same year, we invested over$1billion from California's climate programs to cut air pollution in the state's most impacted communities.[12] Over the next few decades, these programs will save literally tens of billions of dollars in health costs and provide thousands and thousands of good, long-term job and career opportunities.

Many other states are doing the same thing. More than a dozen states have 100 percent clean energy laws in place. Thirteen states and the District of Columbia, which make up thirty percent of the total US vehicle market, have followed California's lead in implementing zero-emission vehicle standards.[13] Midwest states like Nebraska and Iowa are taking innovative steps to support smart climate agriculture practices. New York has committed to direct at least one third of all state climate investments to benefit its most disadvantaged communities. Further, through organizations like America's Pledge and the US Climate Alliance, states have banded together to work on collective solutions that will cut greenhouse gas emissions and create long-term economic growth.

11 *Clean Energy Jobs California: America's Clean Energy Powerhouse in the Wake of COVID-19*, Environmental Entrepreneurs, June 2020, https://e2.org/wp-content/uploads/2020/06/E2-Clean-Jobs-California-2020.pdf.

12 "California Clean Investments Provided More than 1 Billion for Underserved Communities in 2019," California Air Resources Board, April 22, 2020, https://ww2.arb.ca.gov/news/california-climate-investments-provided-more-1-billion-underserved-communities-2019#:-:text=SACRAMENTO%20%E2%80%93%202019%20was%20a%20record,disadvantaged%20and%20low%2Dincome%20communities.

13 "States that have Adopted California's Vehicle Standards under Section 177 of the Federal Clean Air Act," California Air Resources Board, September 27, 2019, https://ww2.arb.ca.gov/resources/documents/states-have-adopted-californias-vehicle-standards-under-section-177-federal.

These critical state efforts can now benefit from and help reinforce a renewed commitment at the federal level in the United States to address climate change. It can and should be the role of our national government to give states the support and resources they need to develop smart, tailored solutions that cut emissions and drive clean economic growth.

Meeting the goals of the Paris Agreement globally will be challenging. Achieving carbon neutrality by mid-century will be even more so. It will not happen without strong and sustained American leadership. Because of the many activities that have been taking place in states across the country, we have a blueprint to tackle climate change, grow our economy, and ensure that all Americans share the benefits equitably. Now is exactly the right time to put it to action.

***Mary Nichols** is the former Chair of the California Air Resources Board.*

. UNSPLASH/MICHAL VASKO (@MICHALVASKO)

A view of San Francisco's Golden Gate Bridge, California

Only 6 percent of those surveyed consider it very likely or certain that the world will reach net-zero by 2050.

Partner Perspective: A green recovery is needed, but it is not yet a done deal

by Mohamed Jameel Al Ramahi

Much is being made of the potential for a green recovery to revive economies flattened by COVID-19, but the decisions we take as policymakers and as investors in 2021 will also be critical to arresting climate change and keeping global warming below 2 degrees Celsius.

And, while we can all agree there is little shortage of will to enable a green recovery, the challenge will be ensuring that there is a way for all nations to reap the benefits from a potential surge in investment in sustainable infrastructure.

In the United Arab Emirates (UAE), we have a compelling example of both the will and the way. Today, the UAE is setting the pace for the transition to cleaner energy sources, not just in the Middle East but also across the globe. Despite its abundant hydrocarbons, the UAE has set an ambitious target to reduce carbon emissions by 23.5 percent by 2030 on top of its previous commitment to generate 50 percent of its energy from clean sources by 2050.

Since it was established in 2006, the Abu Dhabi Future Energy Company—more commonly known as Masdar—has played a key role in this energy transition, and not just domestically. Today, we are one of the fastest-growing renewable energy companies in the world, with a portfolio covering solar, wind, waste-to-energy, electric mobility, energy storage, and sustainable urban development across more than thirty countries.

What we have learned in our journey is that, to make real progress, you must ensure that three key elements are in place: the policies that set the framework for change; the technology that effects change; and the opportunities to invest in change.

Looking to 2021, US President-elect Joe Biden's Build Back Better initiative and commitment to net-zero emissions by 2050 are likely the gold standards for policy in this regard. Build Back Better, in particular, recognizes the importance of making the clean energy transition central to economic recovery, and demonstrates that investment strategies targeting both the economy and the climate need not be mutually exclusive.

With technology, we can build on already huge advances to wind and solar that have made these once prohibitively expensive energy sources cost-competitive for emerging markets as well as developed economies, as well as invest more into the potential sources of the future, such as green hydrogen. We also need to address the associated technology required to ensure renewables contribute effectively to an energy mix. This entails battery and storage solutions to integrate renewables with grids, or allow them to work efficiently off-grid; mobility solutions such as charging stations that have the power to transform mass transit in cities; and the materials and techniques required for truly sustainable building and urban infrastructure construction.

And then there's opportunity. The International Renewable Energy Agency (IRENA), which is headquartered in Abu Dhabi (at Masdar City, I am proud to say), estimates that average annual investments of $2 trillion in renewables and sustainable technologies in a 2021-2023 post-COVID recovery phase could create 5.5 million additional jobs—while an extra nineteen million jobs could be created by 2030—if we scale up investment in the energy transition.

The good news here is that there is no shortage of private capital for renewable or sustainable projects. On the contrary, there is a global shift of capital towards renewable energy where clean energy technologies such as solar and wind are well understood and are cost competitive.

However, the challenges for emerging markets are twofold: first, emerging markets may struggle to capture their share of that capital as they are typically seen as higher risk for investment, especially if blue-chip economies such as the United States offer easier, less risky returns. Second, they need to have the political will to absorb potential short-term financial hits to ensure long-term, sustainable gains.

Before COVID-19 put the brakes on the world economy, Southeast Asia, for example, was emerging as a high-growth economic powerhouse, with increased industrial output driving up gross domestic profit across the region. Energy demand was growing at an average of 6 percent a year, one of the fastest rates in the world. Despite renewable energy production

UNSPLASH/JULIANA (@JULIANASNAPS)

Night in Masdar City, Abu Dhabi, UAE.

getting more and more cost-effective—at Masdar we are installing floating photovoltaic plants in reservoirs in Indonesia, the region's biggest energy user—many of these countries were still looking to coal in order to meet their growing energy needs.

With the pandemic set to trigger the worst recession of our lifetimes, I am concerned that cash-poor nations may stall their commitments to invest in renewables and instead double down on coal and fossil fuels to kickstart moribund economies.

Therefore, to make the green recovery truly global, we will need more initiatives such as Scaling Solar, the World Bank program that Masdar has partnered with to facilitate market entry in Uzbekistan. IRENA has also played a significant role by helping countries streamline contract packages to enable bankability and attract investors and has set up the Climate Investment Platform to connect developers with investors.

Today, we stand at a pivotal moment as we look to reboot economies, accelerate clean energy transitions, and keep global warming to a maximum of 1.8C, 1.5C, or even 1.2C. In the UAE, we are particularly excited about our future collaboration with energy innovators in the United States, Europe and, from this year on, Israel, a welcome development made possible by the historic Abraham Accords signed in August 2020. I personally look to a new era of international cooperation, with the UAE uniquely placed to invest in key technologies in developed nations and well-positioned to help apply those technologies in established and emerging markets the world over.

Mohamed Jameel Al Ramahi is the Chief Executive Officer of Masdar, the Abu Dhabi Future Energy Company. Masdar is a sponsor of the Atlantic Council Global Energy Forum.

Article 6 of the Paris Agreement and International Carbon Markets

State- and country-level environmental regulation, as well as investment in clean technologies, are crucial for achieving climate goals. But, given the global nature of the climate challenge, it is unclear they are enough.

One potential mechanism for encouraging global collaboration on climate action is Article 6 of the Paris Agreement, which would facilitate international carbon markets. If structured effectively, carbon markets would incentivize carbon trading, facilitating faster overall global emissions reductions.

But Article 6 has been the most complicated part of the Paris Agreement to implement, having been pushed off both at COP24 and COP25. We asked our survey participants if they think the international community can come to a consensus on carbon markets (as per Article 6 of the Paris Agreement) at COP26 and how important is it that they do so at COP26 if we are to limit global warming to well below 2° C.

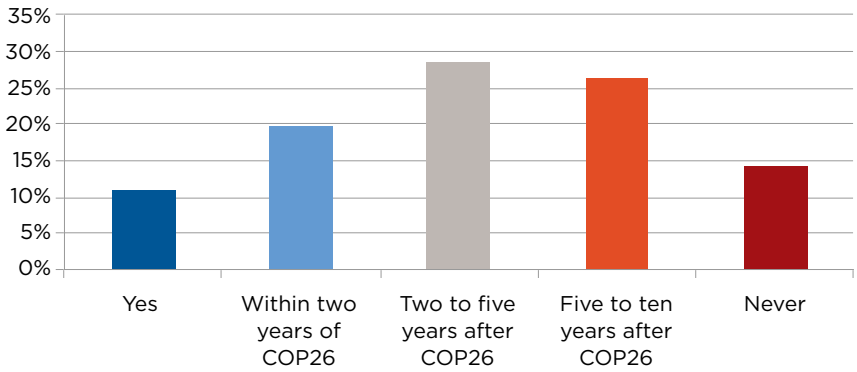
One area of substantial agreement is the need—if the limit of global warming is to stay well below 2° C—for negotiators at COP26 next year to fashion a consensus on international carbon markets under Article 6 of the Paris Agreement. Overall, 57 percent of respondents consider such progress to be very important if any warming is to be kept low, and only 6 percent consider it unimportant for that goal. Results in different geographies all tell a similar story, which holds across age groups as well.

Fifty-seven percent of survey respondents consider consensus on international carbon markets to be very important for curbing global warming.

Differences between the oil and gas sector and the renewables sectors are also just a matter of degree. Of respondents from the former, 60 percent call reaching a consensus very important, while 76 percent of those from renewables do. At the same time, the figures for those considering consensus unimportant are practically identical (4 percent and 5 percent respectively). Even 61 percent of the bears group put themselves in the very important camp.

Although little divergence exists over what is at stake in these talks, disagreement does occur over when, or if, they will ultimately be successful. Progress in this field has not been rapid. Already in 2009, the Clean Development Mechanism in the Copenhagen Accord was—it was hoped—supposed to evolve toward some kind of international carbon markets. It did not do so. The Paris Agreement will already be six years old by the time of the COP26 meeting, and efforts in 2018 and 2019 to devise rules for Article 6 have fallen short. The task, therefore, is very important and success is by no means certain.

Will the international community come to a consensus on carbon markets (as per Article 6 of the Paris Agreement) at COP26?



This history may explain the mixed views on the likelihood of an agreement. Only 11 percent think that this will occur in Glasgow in 2021, but 20 percent expect to see it within two years of the conference. Another 29 percent foresee success after further effort, taking between two and five years. Forty percent, though, believe that agreement will take at least five more years—meaning more than after a decade from the Paris Agreement—including 14 percent of the entire survey group who think it will not happen at all.

Some variation in views occurs by age, with 62 percent of all respondents under sixty-five years of age expecting consensus before 2026, while 55 percent of seniors believe it will take longer or not occur.

The biggest differences are again by sector. After taking out those respondents who overlap between the two sectors, the remaining respondents in the renewables group are the most hopeful. Forty-six percent believe that negotiations will achieve consensus either at COP26 or within two years thereafter, and only 27 percent believe that it will take more than five years or potentially never happen. Oil and gas respondents have a sharply differing view, with the equivalent figures being just 19 percent for rapid progress and 60 percent expecting slow or no agreement.

Government officials—who are perhaps best-informed regarding intergovernmental agreements—fall in between these two sectors but are more pessimistic than the overall survey average. Only 4 percent expect success at COP26, and just 19 percent expect it in the following two years. Nearly half (47 percent) believe it will take a further five years or more, with roughly one in five resigned to consensus never happening.

Fifty-seven percent of survey respondents consider consensus on international carbon markets to be very important for curbing global warming.

Partner Perspective: The Circular Carbon Economy Platform

by Adam Sieminski and Eric Williams

G20 Leaders, meeting under the Saudi Presidency in November 2020, endorsed the Circular Carbon Economy (CCE) Platform, with its 4Rs framework (Reduce, Reuse, Recycle and Remove). The CCE is a voluntary, holistic, integrated, inclusive, pragmatic, and complementary approach toward more comprehensive, resilient, sustainable, and climate-friendly energy systems that support and enable sustainable development. The CCE framework encourages countries to take advantage of all technologies, forms of energy, and mitigation opportunities, according to resource availability, economics, and national circumstances.

To better understand CCE, we can first consider a linear economy approach that is based on the assumption of a once-through system of limitless resources, and a limitless capacity to absorb waste. Resources, however, are finite and so is waste disposal capacity. This inadequate model has resulted in many environmental problems, which include climate change, poor air and water quality, solid and hazardous waste, and plastics contamination.

The idea of the CCE is an evolution and extension of the notion of the circular economy and its three Rs: reduce, reuse and recycle. The circular economy was developed as an alternative to the unsustainable linear economy. A circular economy seeks to use as few new raw materials and creates as little waste as possible, while producing the same goods and services. The circular economy does this through reducing raw resource use, reusing products, and recycling materials from products that cannot be reused.

For decades, models of the circular economy have focused on material flows and recycling, waste flows, and energy efficiency. More recently, the circular economy has developed new business models, such as "products as service." Making the economy more circular by minimizing material flows and product manufacturing also saves energy, which, in turn reduces emissions. The focus of the circular economy, though, is not on managing carbon.

The CCE, on the other hand, is focused directly on managing carbon. CCE applies the same 3Rs as the circular economy, while adding a fourth R for remove. We can reduce the amount of carbon that must be managed in the first place by using energy resources that do not create carbon—such as non-biomass renewables and nuclear power—alongside energy efficiency measures. Trees, plants, algae, etc. already recycle carbon by drawing it from the atmosphere. We can harness this process by using bioenergy derived from these biomass resources. Carbon capture technology can remove carbon before it is released into the atmosphere; direct air capture technology can even remove it from the air, making it available for storage. We can reuse the carbon by converting it to feedstocks for industry to make chemicals, concrete and other building aggregates, and even to make fuels.

See the following figure from "CCE Guide Overview: A guide to the circular carbon economy" written by KAPSARC, which shows a stylized view of the circular carbon economy. The circular economy of material and product flows is at the center. Energy efficiency and energy supply resources power the circular economy. Energy efficiency, renewables and nuclear reduce carbon that needs to be managed. By drawing carbon from the atmosphere through photosynthesis, natural sinks recycle carbon to produce biomass; that biomass can then be harnessed through bioenergy, which also powers the circular economy. Carbon can be removed by carbon capture at large point sources or through direct air capture, and that carbon can be stored geologically. Captured carbon can also be reused to create new materials and products that feed back into the circular economy.

This chart was reprinted from the Guide to the Circular Carbon Economy and reprinted with permission from KAPSARC (https://www.cceguide.org).

The circular principles of the 4Rs serve as a guiding framework in which technologies and approaches are loosely clustered. Reasonable people may disagree on which particular technology or approach should be included in any given R. Hydrogen, for example, depending on how it is produced can be in one or more Rs. Enhanced Oil Recovery (EOR) clearly reuses carbon, but it also removes it because much of it remains in the ground when injected for EOR. Rather than merely a way to categorize options, the 4Rs help with developing a strategy for managing carbon.

By looking at carbon flows as a system, the 4Rs approach reveals constraints or choke points in that system. For example, we can quantify the net result of all of the projected deployment of carbon management options—renewables, energy efficiency, nuclear, bioenergy, hydrogen, carbon utilization (e.g., CO_2 to chemical feedstock), carbon capture from point sources and direct air capture from the atmosphere to safe, permanent geologic storage—and then see where the critical points in the system are and focus efforts on those areas.

By shifting the focus directly toward the problem of carbon and GHG emissions, the CCE offers a pragmatic approach to address climate challenges, while contributing to sustainable economic development and diversification. The CCE welcomes all options that can help achieve climate goals.

Adam Sieminski is the President of the King Abdullah Petroleum Studies and Research Center (KAPSARC) and Eric Williams is a Senior Climate Advisor at KAPSARC.

UNSPLASH / JASON BLACKEYE (@JEISBLACK)

Wind turbines in Greece.

CHAPTER IV: NEW ENERGY TECHNOLOGIES AND INNOVATION

Current technology will almost definitely not be sufficient to meet net-zero emissions goals, both because costs of extant technologies need to continue to decrease to deploy them quickly and at scale, and because current technology cannot effectively address hard to decarbonize sectors such as the industrial and aviation sectors. Innovation is required to meet climate goals. And while, at least in the United States, political support for innovation is sometimes used as a way to avoid more difficult discussions about more aggressive climate policy and support for currently available clean energy technology, it is still necessary, though of course not sufficient.

To understand what clean energy technologies might be the most important, we asked survey respondents which technologies will see the greatest percentage increase in investment in 2021?

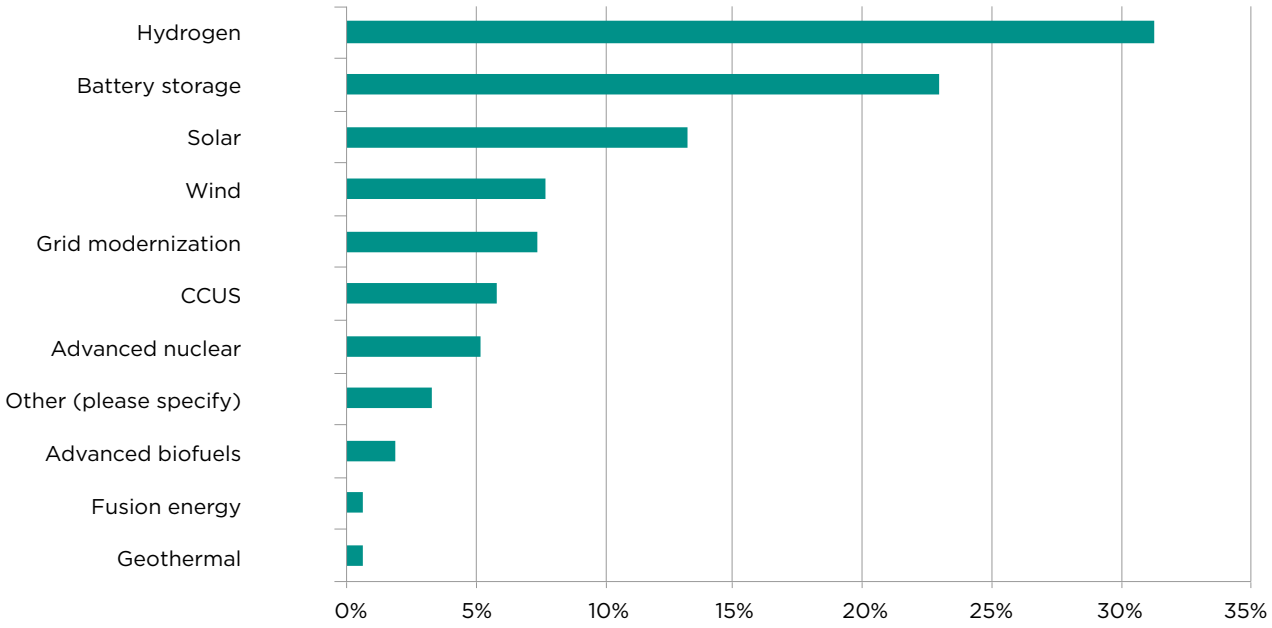
The three most commonly-cited choices were hydrogen (31 percent), battery storage (23 percent), and solar (13percent). After that, four other fields—wind, grid modernization, carbon capture, and advanced nuclear—each received between 5 percent and 8 percent, with others trailing further back.

Although the numbers vary, especially for the less frequent choices, only minor variations occurs in rank order of the top three: the Europeans put solar (18 percent) ahead of battery storage (15 percent), while the Americans switch storage (30 percent) and hydrogen (24 percent). Different sectors also show little divergence here. Even the bulls and the bears agree that hydrogen will be the top technology. The latter see more activity in solar than do the former and less in battery storage, perhaps in keeping with a faith in more proven technologies.

Our essay contributors did not know the results of the survey in advance, but three out of five in this section discussed hydrogen, lending further credence to the idea that 2021 might be the "year of hydrogen." First, we hear from Emily Reichert, CEO of Greentown Labs, a leading climatetech startup incubator, who situates energy technology innovation within the context of meeting climate goals.

Hydrogen is predicted to see the largest growth in investment in 2021.

Which of these will see the greatest percentage increase in investment in 2021?



Climate solutions for a clean energy future

by Emily Reichert

At Greentown Labs, we see four critical pillars of climate action: technology, finance, policy, and justice. Each will play an essential role in moving society toward a decarbonized future and we are optimistic that, if we act across each area, we will be able to solve the climate crisis.

Pillar one: Climatetech

Climate technology—also known as climatetech—is what Greentown's community of entrepreneurs is working on every day. But what is "climatetech"?

Some fear a return to the "cleantech bubble" of 2009, but more than a decade later, the world is in a very different place. The 2018 Intergovernmental Panel on Climate Change (IPCC) report stated the world had the next twelve (now ten) years to radically change course, from the top to the bottom of the global economy.[14] In the United States US, there is unprecedented dialogue on the urgency of addressing climate change.

Climatetech is at the heart of this determined push for actionable climate solutions. Some organizations grew out of the cleantech crash and joined a new generation of scrappier, capital-efficient technology addressing the world's biggest energy and environmental challenges. This new generation of cutting-edge technology is climatetech—technological solutions that mitigate the impacts of climate change and build resilient communities.

Mitigation technologies capture or reduce greenhouse gas emissions. Examples include innovations in sustainable infrastructure in the buildings sector; renewables, energy storage, and grid infrastructure in the electricity sector; healthier food, streamlined supply chains, and methane-reducing animal food in the agtech and water sector; circular economy in the manufacturing sector; electric vehicles in the transportation sector; and carbon capture processes that include carbon capture, utilization, and storage.[15]

Resilience technologies prepare people, communities, and infrastructure for the impacts of climate change, with a focus on equity. This category includes technologies that address environmental justice, such air pollution sensors; technologies for use in natural disasters; distributed energy resources to provide electricity resiliency; heat-resistant crops; drones for mapping droughts; and other technologies that help us understand or model climate data. The emphasis of resilience on equity acknowledges that solving climate change is about helping people as well as the planet, not only those who were part of creating today's resource-inefficient and extractive paradigm, but most certainly, those who were not and disproportionately feel its impact.

Climatetech solutions represent massive opportunities and benefits for society, and the next two pillars will play a critical role in their successful development and deployment.

Pillar Two: Climate Finance

The narrative around climate finance has transformed in recent years. What was once only discussed within the context of corporate social responsibility (CSR) or environmental, social, and corporate governance (ESG) has expanded to many more facets of the finance and banking industries. Notably, when BlackRock Chief Executive Officer Larry Fink used his 2020 annual letter to highlight the climate crisis, the finance world—and

14 *Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments*, United Nations Intergovernmental Panel on Climate Change, October 8, 2018, https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/.

15 "Member Companies: Meet the entrepreneurs building our sustainable future (buildings)," Greentown Labs, accessed December 28, 2020, https://greentownlabs.com/members/?cat=buildings&location=boston&status=current; Member Companies: Meet the entrepreneurs building our sustainable future (electricity)," Greentown Labs, accessed December 28, 2020, https://greentownlabs.com/members/?cat=electricity&location=boston&status=current; Member Companies: Meet the entrepreneurs building our sustainable future (agtech + water)," Greentown Labs, accessed December 28, 2020, https://greentownlabs.com/members/?cat=agtech-water&location=boston&status=current; Member Companies: Meet the entrepreneurs building our sustainable future (manufacturing)," Greentown Labs, accessed December 28, 2020, https://greentownlabs.com/members/?cat=manufacturing&location=boston&status=current; Member Companies: Meet the entrepreneurs building our sustainable future (transportation)," Greentown Labs, accessed December 28, 2020, https://greentownlabs.com/members/?cat=transportation&location=boston&status=current.

UNSPLASH/BENJAMIN SUTER (@BENJAMINJSUTER)

Willis Tower, in Chicago, which achieved a Leadership in Energy and Environmental Design (LEED) Gold rating in 2018.

the business world more broadly—paid attention.[16] He underscored the relationship between climate risk as an investment risk and urged all shareholders, companies, and governments to confront climate change.

The investment and venture capital landscape for climatetech has evolved over the past decade too, and it is now understood that climatetech solutions require significant research and development, long product development timelines, and may be capital intensive. More and more investors—including early-stage funds such as Clean Energy Ventures and Powerhouse Ventures—have acknowledged these commercialization obstacles and built funds dedicated to supporting climatetech.[17] Other investors include DBL Partners, which arguably spurred the impact-investing movement in the early 2000s, and Breakthrough Energy Ventures, the Bill Gates-backed venture capital fund

16 Larry Fink, "A Fundamental Reshaping of Finance, Blackrock, accessed December 28, 2020, https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter.

17 "150+ Combined Years of Climate Tech Investing," Clean Energy Ventures, accessed December 28, 2020, https://cleanenergyventures.com/; "Powerhouse Ventures," Powerhouse Ventures, accessed December 28, 2020, https://www.powerhouse.fund/ventures.

that supports innovations that will lead the world to net-zero emissions.[18]

Recently, many major corporations have announced ambitious climate goals and launched their own climate funds. For example, Jeff Bezos' Earth Fund, Microsoft's $1 billion climate innovation fund, or Unilever's $1 billion climate and nature fund. We've also seen a new cohort of nonprofit and startup support organizations invest philanthropic capital into climatetech startups, including VertueLab, Clean Energy Trust, and Prime Coalition.[19]

Pillar Three: Climate Policy

Speaking of investment, Greentown is encouraged to see the incoming Biden-Harris administration's bold climate action plan, which includes investing $400 billion in clean energy research and innovation over the next ten years. This investment will accelerate the energy transition and ensure that climate solutions can be developed and scaled. The United States can and should be the world's innovation laboratory for climatetech. The United States has world-leading universities, research organizations, corporations, scientists, and entrepreneurs developing the next-generation climate solutions, and climate policy can be an industry driver that encourages more deployment and utilization of these solutions.

Pillar Four: Climate Justice

For the first time, ensuring the coming energy transition will be just is central to the incoming administration's climate policy. This focus will support and prioritize environmental justice communities that have been disproportionately affected by climate change and traditional energy sources. Additionally, a just transition means workers in today's energy industries, as well as those who have been traditionally underrepresented in the energy industry, can be trained and reap the economic benefits. In a place like Houston, Texas, the site of Greentown's first out-of-state expansion, this is critical to bringing everyone along toward a clean energy future, one in which we need all hands on deck.

At Greentown, we believe the name "climatetech" helps us to center on the problem we are all trying to solve, in all its dimensions. It is the technology needed to minimize the impacts of the changing climate on people—with an understanding that this involves not only mitigation, but resilience—across all communities. And unlike the descriptor "cleantech," it does not make a value judgement about clean or dirty: it casts the challenge in a way that brings us all together to create our best future. It is time to move on from cleantech, to what must be our focus for the next decade, and beyond: climatetech.

Emily Reichert, PhD, is the Chief Executive Officer of Greentown Labs, the largest climatetech startup incubator in North America, on a mission to support entrepreneurs tackling the biggest climate and environmental challenges.

18 "We Are Venture Capitalists and Impact Investors," DBL Partners, accessed December 28, 2020, http://www.dblpartners.vc/; "Our Challenge: Overview," Breakthrough Energy Ventures, accessed December 28, 2020, https://www.breakthroughenergy.org/.

19 Justine Calma, "Jeff Bezos announces first beneficiaries of his $10 billion climate fund," *The Verge*, November 16, 2020, https://www.theverge.com/2020/11/16/21569902/jeff-bezos-first-recipients-10-billion-climate-change-fund; "Climate Innovation Fund," Microsoft, accessed December 28, 2020, https://www.microsoft.com/en-us/corporate-responsibility/sustainability/climate-innovation-fund; Anmar Frangoul, "Unilever lays out plans for $1 billion investment in climate and nature fund," *CNBC*, June 15, 2020, https://www.cnbc.com/2020/06/15/unilever-plans-for-1-billion-investment-in-climate-and-nature-fund.html; "Climate Impact Fund," VerteuLab, accessed December 28, 2020, https://vertuelab.org/impact-fund; "Programs," Clean Energy Trust, accessed December 28, 2020, https://www.cleanenergytrust.org/programs/.

Addressing Hard-to-Abate Sectors

Between technological advances and government ambitions, hydrogen is having a moment. As noted above, our survey respondents believe hydrogen technologies will see the greatest percentage increase in investment in 2021. Why? Probably because, as renewables come down the cost curve, innovators and policymakers are looking to sectors that are harder to decarbonize than the power sector, including heavy transportation and industrial applications.

Masakazu Toyoda, the Chairman of the Institute of Energy Economics, Japan, situates the role of hydrogen in a country that is heavily dependent on energy imports, has limited renewable resources, but nonetheless has pledged to reach net-zero emissions by 2050. Japan has been a leader in hydrogen technology development for years, and now that effort might bear fruit.

Gonzalo Munoz, the Chilean High Level Climate Champion, also discusses the hydrogen opportunity from the perspective of a country dependent on energy imports. But unlike Japan, Chile has excellent renewable energy resources. Munoz sees hydrogen as the opportunity to help Chile's energy security, decarbonize its energy system, and be a lucrative export opportunity (perhaps even to Japan.)

REUTERS/YUKA OBAYASHI

A fuel cell bus at the newly opened Toyosu Hydrogen Station, operated by Tokyo Gas, in January 2020.

Hydrogen: The third zero-carbon energy source

by Masakazu Toyoda

We are five years since the historic Paris Agreement was signed and just a few years since the European Union (EU) and major European countries officially stated their objectives of carbon neutrality. This autumn we witnessed further developments with a series of announcements by major economies such as China, Japan, and the Republic of Korea. Those countries pledged to make their energy systems net carbon neutral by around 2050-2060. President-elect Biden might consider making a similar statement, and he has already vowed to rejoin the Paris Agreement

Although it is still not entirely clear how any of these countries will achieve their targets, the possibility of using hydrogen is gradually attracting attention as one of the solutions. Since the release of Japan's "Hydrogen Strategy" in 2017, more than ten countries have announced comparable strategies. Hydrogen could be the "third" zero-carbon energy source, next to renewables and nuclear energy. It is easy to understand why and how renewable and nuclear energies are making substantial contributions in addressing climate change, but they are also recognized as insufficient to meet current and future world needs. Hydrogen might decarbonize some of the sectors that renewables and nuclear cannot, but it will require a concerted international effort to deliver this technology at an acceptable cost, especially to a public that may greet hydrogen with skepticism.

Is there not enough potential for renewable energy?

The endowment of hydro, solar or wind energy resources differs depending on the country and region. The Association of Southeast Asian Nations (ASEAN) and Japan, unfortunately, are not particularly rich in these forms of energy. Although the cost of solar power is substantially declining, in these regions, it is not yet competitive with coal, primarily because of too many rainy and cloudy days. Furthermore, in mountainous countries like Japan, utility-scale solar projects face the extra hurdle of finding suitable locations. The cost of wind power in many parts of ASEAN and Japan is also high, primarily because of unreliable wind. Wind farms in these regions often are faced with insufficient wind or, alternatively, turbines must be stopped during monsoons and typhoons to prevent strong winds from damaging them.

If there is not enough renewable energy, what about nuclear energy?

Some ASEAN countries have already expressed interest in introducing nuclear energy. Regrettably, it is not an easy sell without clear improvements in Japan's public acceptance, which would be necessary to reopen a majority of the fifty-four reactors that were in operation before the Fukushima-Daiichi nuclear accident, ten years ago. Japan's current nuclear energy mix target of 20-22 percent requires that about thirty reactors must be in operation. So far only nine reactors have successfully been approved for operation. Japan's Nuclear Regulatory Authority appears to be proceeding cautiously given that public confidence in nuclear energy has not yet fully recovered. Without the re-opening of an additional twenty reactors, it will be extremely difficult to achieve the current energy mix target and impossible to consider increasing it.

What's left? Can hydrogen be expected to be the third zero-carbon energy?

Zero-carbon hydrogen can be produced in many different ways and can replace fossil fuels in a multitude of applications. Blue hydrogen can be produced from fossil fuels with carbon capture and storage, and green hydrogen can be produced through electrolysis, either from renewable or nuclear energy. It is possible to produce large quantities of hydrogen without increasing the release of CO_2 in the atmosphere, and hydrogen can be used not only for power generation, but also for transportation, heating, and industrial applications.

How much zero-carbon hydrogen can be produced, transported, and consumed?

Currently, the world is dependent on fossil fuels for 80 percent of its primary energy demand. If using hydrogen could remove half of the fossil fuels from the power generation and transportation sectors, that would account for almost 20 percent of primary energy.

Because the existing supply chain for ammonia—which is an efficient hydrogen carrier —can be expanded, the cheapest way to transport hydrogen could be in the form of ammonia, provided it is handled by professionally trained personnel only, due to its toxicity. In the fall of 2020, Aramco, the Institute of Energy Economics, Japan (IEEJ), and some Japanese companies conducted experiments to demonstrate the possibility and potential of burning ammonia directly, as well as co-burning it with coal or gas in thermal plants. The experiments demonstrated that ammonia could gradually reduce CO_2 emissions from fossil fuel-fired plants and could eventually turn existing and newly constructed coal-and gas-fired plants into zero-carbon thermal plants. A video covering the experiments has been made and is publicly available via Aramco and IEEJ. In addition to the use of hydrogen in the form of ammonia in thermal plants, hydrogen can also be used efficiently for transportation and industrial use. This is why we could call hydrogen the "third" zero-carbon form of energy.

What are the challenges and solutions to the promotion of hydrogen use?

The biggest challenge for the use of zero-carbon hydrogen is to achieve substantial cost reductions. IEEJ believes that cost reductions in the range of one fifth to one third would be sufficient to make hydrogen (and hydrogen in the form of ammonia) commercially viable. With the right research, development, and investment, costs should start decreasing in the next few years, with the likelihood of commercial viability becoming commonplace around 2030.

Due to the unavailability of large and suitable sites for CCS and renewable energy in Japan, the country would import both blue and green hydrogen, regardless of the production method.

How can hydrogen production costs be reduced?

The first solution to cost reduction is to continue the international cooperation that is already ongoing. For example, in addition to the above-mentioned cooperation between Aramco and IEEJ, some Japanese companies have already begun working with counterparts in Australia, Brunei, and Abu Dhabi. The second approach is continued government support to overcome "the valley of death," support that could take the form of government procurement, subsidies, or the introduction of a feed-in-tariff or feed-in- premium.

Concluding remarks

There are limits to increasing the use of renewable and nuclear energies (currently the two zero-carbon energy forms). With international collaboration and government incentives to accelerate research and development, hydrogen could easily become the "third" zero-carbon energy source.

If these steps are taken globally, it will be possible to further reduce emissions and get closer to the scenario of limiting global warming above pre-industrial temperatures to 2°C—or even 1.5°C.

Masakazu Toyoda ***is the Chairman and Chief Executive Officer of the Institute of Energy Economics, Japan.***

How Chile can lead the green hydrogen economy and the energy transition

by Gonzalo Muñoz

The year 2020 will be remembered as the year of the COVID-19 pandemic. It is difficult to identify areas in which 2020 will prove to have been a positive turning point in history; instead, it will be remembered as a watershed year directly associated with death, loss of health, loss of wellbeing, the suspension of many activities, and the temporary or permanent closure of many organizations. However, while we are still in the midst of the pandemic, we can already foresee that this year—in spite of, and in many cases because of, COVID-19—will also be remembered as the year when the energy transition to carbon neutrality accelerated at an unprecedented pace.

The fact that the global economy has slowed—and with it the use of coal for electricity production, as well as the use of oil for transport—has accelerated the processes of divestment away from these resources and supported the rapid advancement of clean energy technologies throughout the world. Thus, according to the International Energy Agency (IEA), it is estimated that electricity production from renewable sources will grow this year by around 7 percent, in the same period in which global energy demand is estimated to fall by 5 percent. But we know that a single shock, like what the world has experienced this year, will not solve the climate crisis. Structural and permanent changes are needed. Similarly, it is not enough to electrify everything that can be electrified with energy from renewable sources. We also need to speed up the energy transition in the hard-to-abate sectors (e.g., steel, aluminum, refineries, glass, maritime transport, and aviation). And since some of these sectors will take years to decarbonize, it is essential that the policy frameworks, financial alignment, and public-private partnerships are all in place this year to accelerate this process. 2020 is the year in which investment in renewable energy projects accelerated, including those that will make it possible to replace oil and its derivatives in hard-to-abate sectors. And the technology that is positioning itself as the ideal replacement for petroleum is green hydrogen.

For those who have followed this topic for a while, this year we have witnessed a real green hydrogen revolution, following the relevant growth of renewable energies worldwide, as well as the movement away from fossil fuels.

Chile is a country that has historically been resource poor in fossil fuels and therefore has had to import almost all of them; at the same time, it is one of the countries with the greatest wealth of renewable energy sources (solar, wind, tidal, and geothermal). Thanks to the great reduction in the cost of solar and wind energies, as well as a special focus on facilitating the rapid scale of electrolyzers, Chile aspires to lead the green hydrogen economy in order to help it become competitive with fossil fuels. If Chile succeeds, the entire Chilean economy will be decarbonized earlier than 2050 and, in addition, Chile will be able to position itself as a country that exports low-cost green hydrogen to the world, creating a sector in its economy that equals or exceeds the role that copper has historically played. If it succeeds, green hydrogen could serve as the platform that allows Chile to achieve necessary sustainable development.

As an example of the green hydrogen revolution that we have been promoting from Chile, Chilean Minister of Energy Juan Carlos Jobet launched the Green Hydrogen Strategy in early November, and now Chilean industry leaders wish to take active part in the Green Hydrogen Catapult initiative, which aims to facilitate the global implementation of 25 gigawatts of electrolyzers no later than 2025, in order to pull the cost of hydrogen production below $2kilogram.

Chile is a country with abundant sources of high-quality renewable energy. The solar radiation in the north and the powerful winds of the south give the country an opportunity to produce many times what will be needed to entirely decarbonize the national economy. And the green hydrogen economy also offers the possibility for Chile to integrate a multi-stakeholder value chain with high-quality green jobs—with its capability to increase the complexity of Chile's main exports—which have traditionally been associated with raw materials. Therefore, if Chile capitalizes on this opportunity, the country can become a leader in the production and export of green hydrogen, at the same time as it moves towards real sustainable development. I truly believe the Race to Zero will be fueled with clean energy, including competitive Chilean green hydrogen.

Gonzalo Muñoz is a High Level Climate Champion at the United Nations Framework Convention on Climate Change.

UNSPLASH/ANTONIO GARCIA (@ANGARAV)

Solar panels in the Region de Antofagasta, Chile.

Innovation in the UAE

Musabbeh Al Kaabi—the CEO of UAE Investments at Mubadala Investment Company, the United Arab Emirates' primary vehicle for diversifying its economy—writes about hydrogen from almost the exact opposite perspective as Masakazu Toyoda and Gonzalo Munoz. The UAE is resource rich, its economy is driven by energy exports, it also has fantastic renewable resources, and it too aims to make a significant contribution to mitigating climate change. Hydrogen produced either from natural gas with carbon capture or from clean power can help the country lower its emissions while also creating an export to potentially replace hydrocarbons as the world shifts to cleaner energy sources. To close this chapter, we turn to H.E. Suhail Al Mazrouei, the Minister of Energy and Infrastructure in the UAE. He takes a broad perspective of how the UAE is innovating across its energy sector to decarbonize at home while continuing to provide energy to the world.

Partner Perspective: 2021: Looking ahead to the energy transition

by Musabbeh Al Kaabi

As we are all well aware, global energy demand has been increasing steadily since the 1960s, driven by developing economies and rising living standards. While the COVID-19 pandemic curtailed this demand in 2020, the International Energy Agency (IEA) World Energy Outlook estimates that demand could return, relatively quickly, to pre-pandemic levels if the virus is brought under control in 2021. Nevertheless, even with a return to pre-pandemic energy demand levels in 2021, more modest energy demand growth is projected out to 2030 and 2040 than we have seen in the past.

This demand picture will evolve in parallel with the transition towards a lower carbon world. Some 90% of new electricity generation capacity in 2020 came from renewable sources, according to the IEA, putting wind and solar on track to become the largest source of power in 2025, and displacing coal, which has dominated for the past 50 years or more. But this shift is also favoring lower carbon-emitting fossil fuels, such as the Middle East's oil production, which has the lowest lifecycle emissions footprint globally compared to that of other regions.

In order to meet future global demand, hydrocarbon resources will remain an important part of the energy mix, coupled with continued robust growth in renewables. Energy transition strategies will require a fit-for-future approach that considers integrated and sustainable solutions that also deliver reliable, secure, and affordable energy supplies to the world's population.

We also need to recognize the valuable role that hydrocarbons play as feedstock for a wide range of complex materials essential to new and more efficient products—for example, electric vehicles—through the development of strong, lightweight materials. As we have seen through the pandemic, hydrocarbons also have a vital role to play in manufacturing PPE and other equipment in the health sector and packaging to ensure high levels of hygiene in the food supply chain.

It is clear then, that continued investment across the entire energy landscape—from traditional hydrocarbons, renewable energy, nuclear energy, and energy efficiency solutions, to infrastructure and energy networks—is needed to make the energy transition a reality, alongside advances in energy storage, circular economy strategies, and mobility.

The UAE has long been an energy leader and also a prime driver of the energy transition and sector diversification. As the world's seventh-largest oil producer and fourth-largest exporter, the country established LNG exports in the late 1970s and built the first cross-border gas pipeline in the region fifteen years ago. It is also a pioneer of clean energy. Almost 20 years ago, many questioned the commercial position of renewable energy. Nevertheless, in a visionary move by the Emirate's leadership, the Abu Dhabi Future Energy Company—Masdar—was established, and today the company, a subsidiary of Mubadala, is a leader in the development of renewables and sustainable real estate projects, not just in the UAE but also around the world. In a further bold step, earlier this year, the country also became the first Arab nation to harness nuclear power generation.

We believe that all forms of energy—including renewables and fossil fuels, produced efficiently and responsibly—will be required to meet future energy demand; our portfolio reflects this holistic view with its range of energy related investments from Masdar, hydrocarbon-focused businesses, utilities and energy infrastructure assets, and emerging and alternative technologies. We share the view about the potential role of hydrogen.

Significant advances will be required to deliver such projections, but the members of the Hydrogen Council —of which Mubadala is a part—are actively working with governments and other stakeholders to explore ways to accelerate technology solutions, advance commercial projects, and attract the required investment. Once again, we believe the UAE is strongly placed to play a prominent role in this next transitional phase; building on the strong foundations of the nation's gas production and infrastructure, its development of solar and nuclear power solutions, its favorable geographic position between the markets of East and West, and its extensive experience and partnerships, and a track record as a reliable energy supplier worldwide. UAE has the potential to quickly become a substantial hub and global supplier for both blue and green hydrogen.

In conclusion, there is no one-size-fits-all solution to tackling the energy transition. This shift presents an opportunity for innovative and collaborative ways of developing and investing in the energy landscape of the future. However, a responsible strategy for the energy transition can only be pursued if all stakeholders—from investors to utilities to decision makers to citizens—work together. We believe the 2021 Global Energy Forum, the World Future Energy Summit, and the other events during Abu Dhabi Sustainability Week play an important role in aligning stakeholders around the energy transition agenda and its delivery. At Mubadala, we are excited to be a part of this journey.

***Musabbeh Al Kaabi** is the Chief Executive Officer of UAE Investments at the Mubadala Investment Company.*

Barakah Nuclear Power Plant began operations in 2020.

Ministerial Perspective: Future outlook: Oil and gas, innovation and the energy transition in the UAE

by H.E. Suhail Al Mazrouei

> **"THE ONE WHO DOES NOT THINK OF ENERGY IS NOT THINKING ABOUT THE FUTURE."**
>
> **His Highness Sheikh Mohamed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai**

As the world raises its ambitions to accelerate the energy transition towards a low-carbon fueled future and seeks to reduce emissions to keep global warming below 2°C, it is vital that this transition also ensure continued and growing socio-economic well-being for all citizens of this world.

With globally increasing energy demand predicted to outpace the deployment of alternative energy sources over the next three decades, a critical triple challenge presents itself: first, how to meet that energy demand; secondly, how to ensure reliable, affordable, and accessible energy; and, thirdly, how to continue on the path to a lower-carbon future. The response to this challenge and the sheer abundance of demand will include energy from hydrocarbon sources, particularly those with a lower carbon intensity in relative terms. This means that, within the transition period, the focus will be on both cleaner and greener energy sources. As the energy system evolves to a lower-carbon future, all stakeholders must work towards the same goal and ask themselves what is required to change our current energy systems' status quo to address these truly multi-dimensional challenges effectively and responsibly.

Aiming for both an effective and fair response makes it essential to examine what is meant by "the energy transition" and design our approaches to support it. At its core, the energy transition calls for collective action towards social and environmental sustainability, underpinned by the Paris Agreement. While the energy transition includes elements of renewables, electrification, and distributed energy generation, balancing the elements of energy security and affordability to meet growing energy demand will necessitate different definitions of the energy transition in different parts of the world. These variations in energy strategies—coupled with the triple challenge—place oil and gas firmly in the energy mix of the future, particularly since, across all global future energy outlooks, we see a growth in demand for oil and gas. As a result, the broader transition will be made up of multiple transitions, a series of fundamental shifts towards cleaner and renewable energy, low-carbon and decarbonization strategies, higher levels of interconnection, and the rapid adoption of innovation and technology. The uniting and ultimate objective remains the increasing reduction of greenhouse gas (GHG) emissions through the transition period.

A shift towards clean and renewable energy

The energy sector is capable of building structures that support high-energy growth and low-carbon pathways for the future. With its deep insight into the energy system and its global outreach, the energy sector can accelerate these changes by supporting policies, innovations, and diversification of the energy mix, and it needs to actively lead these changes. The industry is now geared towards low-carbon intensity oil production and an increasing role for natural gas, which is the cleanest burning hydrocarbon and an important transition fuel that can sustain the demands of balancing power systems that have high renewable penetration. There are many available strategies for diversification within the oil and gas industry, such as electrification of operations, a transition of assets to include wind and solar farms, or hydrogen production. All of these present opportunities and positive outcomes for all stakeholders within the multidimensional energy challenges discussed.

A shift towards low carbon and decarbonization

As we look towards implementing solutions for a sustainable energy sector and a low-carbon future, it is crucial to examine and utilize existing resources throughout the industry. We see the growing adoption of a circular carbon economy, where each component of the production line is thoughtfully managed to ensure carbon is either reduced, reused, recycled or removed from the system. The Abu Dhabi National Oil Company (ADNOC) is targeting a 25 percent carbon intensity reduction by 2030, while already having a leading low position in GHG intensity in the global oil and gas industry.

A shift towards higher levels of interconnection

In the coming decades, the oil and gas sector will represent the most viable energy source to support growing demand, minimizing future supply shortages, and ensuring a reliable, affordable and accessible supply. Through grid interconnections, we are able to maximize the benefits of energy supply across countries and continents and support global demand. The oil and gas sector plays a crucial role in identifying projects or partnerships that require critical energy supply, especially in developing regions with high population growth and an increasing middle class, which will experience greater long-term oil and gas demand. In this context, natural gas will offer an important alternative. These partnerships will allow the industry to transition and diversify sustainably, increase energy efficiency and stability, support growing energy demands, and prevent the risk of stranded assets.

A shift towards rapid adoption of innovation and technology

Technology will no doubt play a vital role in supporting decarbonization, including carbon capture, utilization, and storage (CCUS); 4th Industrial Revolution technologies to optimize production and operations; as well as innovation in resource recovery and productivity. Innovation is the most important tool in building on our existing skillsets and resources throughout the industry to quickly mobilize new lower-carbon forms of energy. The sector needs to promote research and development and focus on increasing efficiencies in oil and gas operations as well as low-carbon emission technologies.

One key area of development is hydrogen production. The United Arab Emirates (UAE) has been producing and consuming hydrogen as part of its refinery operations. The production of hydrogen from fossil fuel sources in our region is currently the most cost-competitive at $1.50 per kg. Furthermore, the UAE is home to ADNOC's Al Reyadah CCUS plant, which is the world's first fully commercial project capturing CO_2 from the iron and steel Industry and the Middle-East's first commercial-scale CO_2 capture plant. Building on this experience and expertise, the addition of CCUS technology to hydrogen production can neutralize the emissions, which gives us the potential to produce blue hydrogen.

Diversification is key: The UAE Energy Strategy 2050

We all know what is at stake and the importance of addressing these challenges. In solving the issues, we know there is no one-size-fits-all solution; the diversification of the energy mix and our approach to it is key. The UAE is working to diversify the energy mix by combining renewable, nuclear, and cleaner energy sources to meet domestic and international requirements. The UAE Energy Strategy 2050 aims to increase the contribution of clean energy in the national capacity mix from 25 to 50 percent by 2050 and reduce the carbon footprint of power generation by 70 percent. The strategy sets a firm commitment to accelerate efforts to deliver access to stable, affordable, and sustainable energy supply for all and to safeguard social and environmental sustainability by improving energy efficiency by 40 percent.

This vision does not exclude the UAE's oil and gas sector, which is set to grow and continue to support increasing global energy demand. Nonetheless, it sets ambitious targets and highlights the country's priority to support the sustainable energy transition. Over the past decade, the industry has been rapidly preparing for a lower-carbon economy. It must continue to evolve in ways that contribute to the decarbonization of the energy system quickly. As the UAE prepares for "the next fifty years" as part of its 2071 Agenda, the oil and gas sector is committed to a low-carbon future. To achieve our shared goals of a sustainable energy transition and support growing energy demand, oil and gas—and, in particular, natural gas—will remain an essential part of the energy mix.

H.E. Suhail Al Mazrouei ***is the Minister of Energy and Industry in the United Arab Emirates. The United Arab Emirates ministry is a sponsor of the 2021 Global Energy Forum.***

UNSPLASH/CHRIS SANTILLI (@NOMADICRX)

A factory building in Philadelphia, Pennsylvania.

CHAPTER V: ENERGY AND ENVIRONMENTAL JUSTICE

Rising awareness of historical and ongoing injustice against marginalized communities was another issue that dominated 2020, and addressing energy and environmental injustice is now higher on the priority list of global energy leaders. The three issues to contend with in delivering justice in the energy system are not mutually exclusive, but nonetheless are sometimes in conflict with each other. We must work to simultaneously address environmental harms caused by the energy system, which predominantly impact marginalized communities; a lack of energy access, particularly in the developing world; and risks that the energy transition does not leave fossil fuel workers, and fossil fuel-producing countries, behind.

Respondents believe that training and upskilling of workers for the green economy and developing more robust grids in vulnerable areas are the top priorities for ensuring that low-income and marginalized communities benefit from the energy transition.

The differences within sectors seem to suggest one underlying commonality: respondents believe that best way to help those in need is to support the field in which the respondent works

Survey data suggest a disconnect between energy leaders and those they profess to want to help

The data on these issues is clear and should be a call to action. In the United States, low-income Black people have the highest risk of death from power plants' fine particulate emissions, followed by middle-income Black people, low-income White non-Latinos, and upper-income Black people.[20] Globally, more than 90 percent of the annual seven million air pollution-related premature deaths occur in low- and middle-income countries, mainly in Asia and Africa, followed by low- and middle-income countries of the Eastern Mediterranean region, Eastern Europe, and the Americas.[21] At the same time, in 2019, 840 million people globally did not have access to electricity, and—at current electrification rates—650 million people will still be without electricity by 2030, 90 percent of whom are in sub-Saharan Africa. And as the world transitions away from fossil fuels, there is a significant risk to employment. For example, total US mining employment was nearly cut in half between 2012 and 2019, from 95,000 to just 50,000, with most of those job losses in West Virginia and Kentucky.[22]

Given the multifaceted nature of ensuring energy and environmental justice, we asked our respondents to pick up to three options to the question: which investments would best ensure low-income and marginalized communities would benefit from the energy transition? The most popular responses fell into two tiers. At the top were training and upskilling of workers for the green economy (41 percent) and developing more robust grids in vulnerable areas (39 percent). The second group was made up of energy efficiency programs (28 percent), a focus on delivery of the cheapest energy (26 percent), and community solar with low-cost panels (25 percent).

Respondents believe that training and upskilling of workers for the green economy and developing more robust grids in vulnerable areas are the top priorities for ensuring that low-income and marginalized communities benefit from the energy transition.

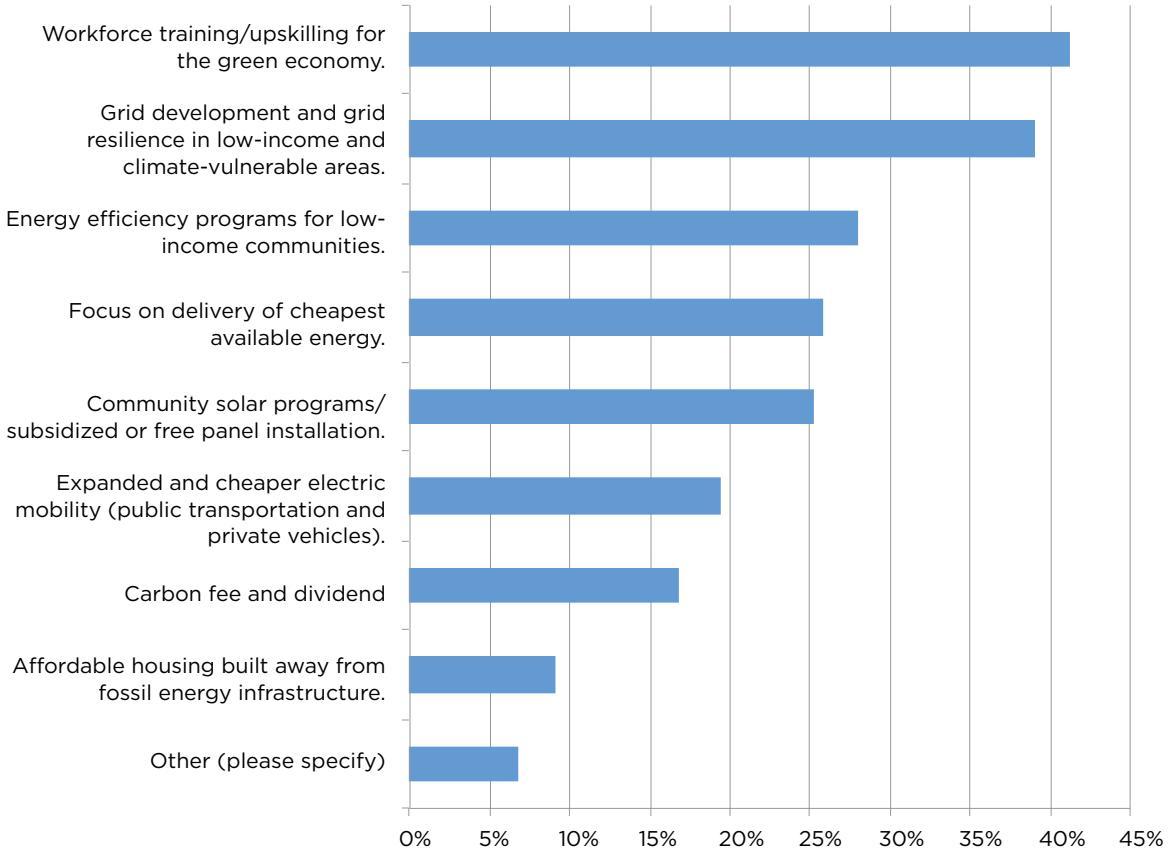
The differences within sectors seem to suggest one underlying commonality: respondents believe that best way to help those in need is to support the field in which the respondent works

20 Maninder P. S. Thind, Christopher W. Tessum, Inês L. Azevedo, and Julian D. Marshall, "Fine Particulate Air Pollution from Electricity Generation in the US: Health Impacts by Race, Income, and Geography," *Environ Sci. Technol.* 53, 23 (Nov 2019): 14010- 14019, Accessed January 16, 2021, https://pubs.acs.org/doi/10.1021/acs.est.9b02527.

21 "9 out of 10 people worldwide breathe polluted air, but more countries are taking action," World Health Organization, May 2, 2018, https://www.who.int/news/item/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action.

22 Taylor Kuykendall and Gaurang Dholakia, "US coal mining employment hits new low at the end of 2019, may go lower in 2020," S&P Global Market Intelligence, February 19, 2020, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-coal-mining-employment-hits-new-low-at-the-end-of-2019-may-go-lower-in-2020-57173047.

Which investments would best ensure low-income and marginalized communities can benefit equally from the global energy transition? (Pick up to three)

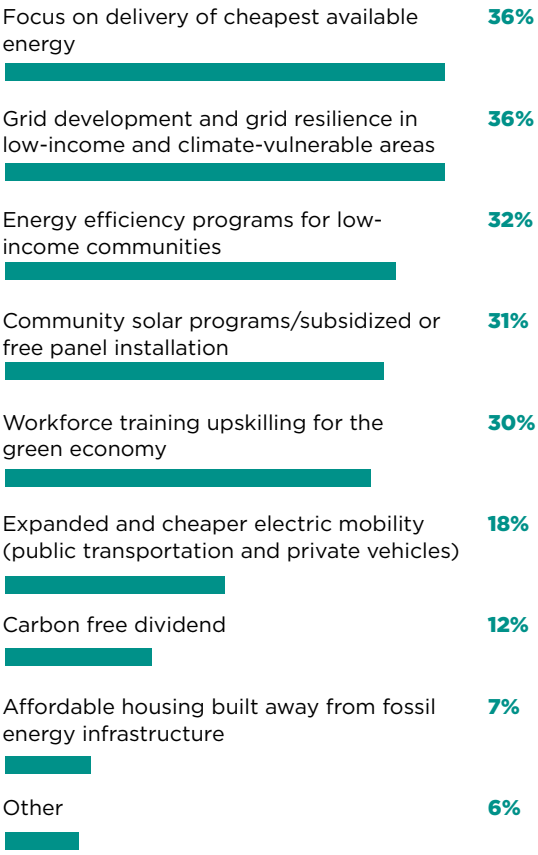


These numbers, however, mask a wide range of variation between certain groups. The most striking at the geographic level is that MENA respondents put community solar first, with 43 percent citing it. This may reflect the large levels of sunlight year-round in their latitudes (only 18 percent of the more helically challenged British, Canadians, and Scandinavians thought it worth putting in their top three).

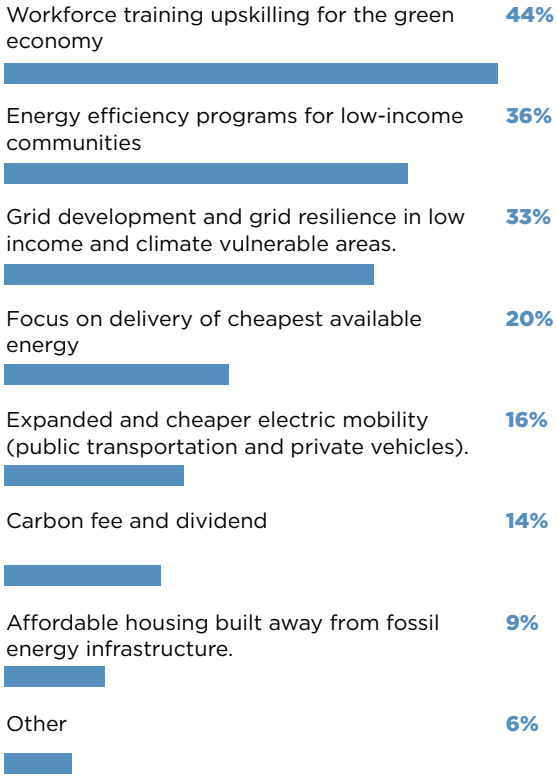
The differences within sectors seem to suggest one underlying commonality: respondents believe that best way to help those in need is to support the field in which the respondent works. A clear example comes again from comparing renewables with oil and gas after removing the respondents who overlap both. The single most popular choice among those associated with renewables, by some margin, is training workers for the green economy (51 percent), which would also provide a steady supply of talent for their industry. On the other hand, oil and gas respondents pointed most often to focusing on provision of the cheapest fuel available (41 percent) which would frequently be their product. As the above chart shows, both sectors saw the other's preferred option in a less favorable light.

Those involved in electricity—including any indicating an association with nuclear, transmission, and distribution—exhibit a similar tendency. These respondents, despite including a large number of respondents also involved in renewables, put grid development and resilience as their first choice (45 percent). Even academic and think tank researchers appear to find solutions related to the sectors that they study. Although the numbers are too small to draw firm conclusions, those researching the electrical sector most often saw grid development as an important investment; those looking at oil and gas put cheap energy tied at the top;

Oil and Gas Sector Respondents



Renewables Sector Respondents



and, among those studying renewables, workforce training came second, after community solar.

Survey data suggest a disconnect between energy leaders and those they profess to want to help

While these biases need not be self-interest so much as a perspective shaped by daily activities, they nonetheless are concerning. First, and most important, they suggest a disconnect between energy leaders from those actually in need. While not surprising, it argues for a far more intentional effort by those in positions of influence—the editors of this volume not excluded—to understand the actual needs of those they profess to help. Second, at a broader level, this result suggests that energy leaders who seek to understand the perspectives of all sides of the industry are best positioned to make objective decisions. In a time of dramatic change, that could be an invaluable asset.

Our essay contributors tackle these issues head on, providing an action plan for beginning to right the injustices of the energy system. Sunita Narain, the director general of the Centre for Science and Environment in India, discusses the concurrent issues of energy access, polluting cooking fuel (the main source of household air pollution), outdoor air pollution, and climate change. With a particular focus on India, she argues that clean and renewable energy in the developing world is crucial for meeting these concurrent challenges; in fact, it might be the only way to do so.

In a similar vein, Damilola Ogunbiyi, CEO and Special Representative of the UN Secretary-General for Sustainable Energy for All (SEforALL), argues for a just transition that leaves no one behind, with a particular focus on how energy inequity disproportionately impacts African countries. She calls for leaders to take an environmental justice approach to the energy transition. And, to our point above about energy leaders' disconnect with those in need, she argues that diverse leaders need to be heard and need to shape the energy transition.

The "other" energy agenda

by Sunita Narain

Energy is a determinant of our economic wellbeing. We know that. But today, it is crucial that we discuss the future trajectory of energy, particularly clean energy, for the global challenges that confront us. We need to reset the global agenda for energy.

First, there is the challenge of electricity supply. In India, the government has an aggressive plan to reach every household with electricity. But the fact is that, even as the grid reaches everywhere, the electricity does not. This may be because people are too poor to pay for electricity, or because the distribution company is too poor to supply the electricity, or because the market has no way of providing services in the cashless energy sector. Whatever the reason, millions in the country are still in darkness. Energy poverty is still crippling vast numbers of Indians, who cannot use this crucial enabler of progress in areas that range from education to employment.

Second, there is the challenge of clean cooking energy. This is the world's wicked, wicked problem. Women, across the developing world—including China and India—are exposed to toxic emissions because of the biomass they burn to fuel their cooking stoves. Even in 2030, the International Energy Agency estimates that 43 percent of the developing world (33 percent of the world's population) will continue to cook with biomass.

The Indian government's much needed national Ujjwala program—which provides cheaper liquified petroleum gas for cooking energy to households below the poverty line—transfers subsidies from the rich to the poor. But it is also a fact that, in spite of this, households are still using biomass fuel—often from firewood, leaves, or cow dung—for cooking food. This is because it is free. And the health impacts on women are not accounted for because their labor is also free. There is a definite correlation between income and types of cooking fuel. So, all too often, households do not get the refill of their fuel cylinder as frequently as they require. The data on this is patchy, but what is clear from any visit to rural India is that smoke still fills the air.

The third challenge is air pollution. Many urban areas are reeling under choking air, which is literally making their residents ill. There are the fumes from our ever-growing fleet of petrol- and diesel-powered vehicles. Industry is competing to reduce costs and they say electricity is either too expensive or too unreliable. So, industry often uses the dirtiest of fuels, from bottom of the barrel pet coke to anything cheap and dirty.

Worse, air pollution knows no boundaries. So, emissions from the biomass cooking fuel of the poor ends up in the same airshed as the diesel SUV of the rich. The health impact of the foul air is now so big that even governments cannot deny the problem. Clean combustion has a big role to play in clearing the air of toxins.

Fourth, without any doubt, is the climate conundrum; the world and India remain addicted to fossil fuels. We need an energy transformation, not just a transition. This means that renewable energy must supply 70-85 percent of all electricity by 2050. Currently renewables supply some 20 percent of global electricity, the bulk coming from hydropower plants. So, the challenge is enormous. This also means that coal use must be close to zero percent by 2050. At the same time, the developing world needs to provide affordable energy to large numbers of its people. How can it replace coal while still providing this energy security?

So, I would argue, given these challenges, it is time that we begin an altogether different discourse about clean energy and renewable power. We need to reinvent the clean energy imperative. We need to redefine its objective so that it can meet societal needs. It must meet the poor's energy, clean air, and climate change needs.

So, how will it happen? The fact is that energy security for vast numbers of the poor requires an energy delivery system that is different from what exists today. It will require delivering energy, which costs less but is advanced and cleaner, into households that cannot even afford to buy basic fuel or electricity. It will require making energy more affordable by cutting the length of supply lines, leakages, losses, and everything else that increases energy costs. There is no clear idea what will work. But what is clear is that we have to push the envelope so that renewable energy transforms society and environment.

We need to deliberately ask what it would take to put clean energy into the hands of the poor. For this, we will need to do everything to make the transition to clean power, not just a few light bulbs, but the entire energy system and its supply chain. Similarly, we need to ask how clean and renewable energy can work to clean up local air in our cities. It is not just about battery electric vehicles, but clean power to charge the batteries. It is not about shifting the source of pollution, but really cleaning it up. Every house needs to generate clean power; every vehicle—ideally to included buses and two wheelers—and every industry needs to be powered by clean energy. This is where we need to go.

The same is the case with the wicked problem of cooking energy of the poor woman. We need clean energy to be the basis of the electricity that powers the cookstove—from solar, to wind, to biogas—and all other ways in which energy can be brought to the hearth. We can do this if energy is available, convenient, affordable, and clean. The basis for this transition has to be the health of the most vulnerable, in this case the woman behind the cookstove.

This is the dialogue we must have so that we can seek new policies and methods. Clean and renewable energy has to be the moral and economic imperative for a sustainable and more inclusive world. Anything less is selling us short. Anything else is unacceptable.

***Sunita Narain** is the Director General of the Centre for Science and Environment.*

A Himachali woman cooking food on a woodfire stove in her kitchen, in Shimla, Himachal Pradesh, India. Shutterstock/dushi82

A global energy transition must be a just energy transition

by Damilola Ogunbiyi

2015 was a monumental year for energy. Not only did the world secure a historic agreement on climate change through the Paris Agreement, global governments also agreed on a new blueprint to achieve a more sustainable, fair future through the adoption of the Sustainable Development Goals (SDGs).

A clean and inclusive energy transition is at the heart of both these agreements. Yet far too often, when we talk about the energy transition, we talk about megawatts, storage, and fuels only through a climate lens. While all critical elements, we often forget that this energy transition for billions of people and communities around the world is much simpler: being able to access energy at all.

That is why Sustainable Development Goal 7—access to affordable, reliable, sustainable, and modern energy for all by 2030—is so important to ensure that, not only do we achieve an energy transition that supports climate action, but we deliver a just and equitable energy transition that leaves no one behind and provides access to a basic right that many of us take for granted.

This is an urgent challenge. Since 2015, energy access progress has been painfully slow. The latest data shows that not only are we off track to meet universal energy access by 2030, we risk missing it by decades. 789 million people globally are living without electricity, and 2.8 billion—over a third of the world's population—are living without access to clean cooking solutions and fuels. Thanks to the unprecedented challenges of the COVID-19 pandemic, we've had a painful reminder that energy access saves lives.

Sadly, these figures do not fully reflect the reality on the ground for many vulnerable populations. Research shows that millions more do not have reliable—or anything beyond very basic—electricity access. For too long, simply owning a solar lamp has been deemed as energy access. Yet true access allows people to be productive, providing them with economic opportunity.

For clean cooking—the often-overlooked element of energy access—the picture is even more worrying. New data from the World Bank and partners shows that four billion people around the world still lack access to clean, efficient, convenient, safe, reliable, and affordable cooking energy, a challenge that is now a public health crisis in its own right.[23] While around 1.25 billion are considered in transition with access to improved cooking services, 2.75 billion face significantly higher access barriers.

The reality is that we cannot reduce these access gaps without taking an environmental justice approach. This means we must genuinely and repeatedly engage all people—across race, gender, geography, and income—to develop equitable solutions that will truly meet everyone's needs.

Equity is key. Today, inequalities in energy have never been starker, disproportionately impacting African countries, where over 70 percent of the population without access lives. For example, entire nations—including Nigeria, Myanmar, and Ethiopia—use less electricity than Americans use *just* playing video games in one year. People in Senegal, Ethiopia, Tanzania, and other African countries also use less annual electricity than the average fridge in America does.[24]

As the world continues to deal with the pandemic, growing climate change impacts, and societal injustices, it is critical we accelerate a just energy transition that can address these inequalities.

Even before the pandemic hit, progress to meet universal energy access was too slow. Now COVID-19 risks derailing progress further. The good news is that we can still meet SDG7 by 2030, but this window of opportunity is closing. COVID-19 has presented us with a unique opportunity to accelerate action and allow countries to 'Recover Better' from the pandemic to change the SDG7 trajectory and enable allow countries to reap the rewards of sustainable energy for all.[25]

23 Energy Sector Management Assistance Program (ESMAP), The State of Access to Modern Energy Cooking Services, World Bank, 2020, http://documents1.worldbank.org/curated/en/937141600195758792/pdf/The-State-of-Access-to-Modern-Energy-Cooking-Services.pdf. License: Creative Commons Attribution CC BY 3.0 IGO.

24 Rose Mutiso, "Rose Mutiso on TED: The Energy Africa Needs to Develop—And Fight Climate Change," Energy for Growth Hub, October 13, 2020, https://www.energyforgrowth.org/rose-mutiso-on-ted-the-energy-africa-needs-to-develop-and-fight-climate-change/.

25 "Recover Better with Sustainable Energy," Sustainable Energy For All, accessed January 11, 2020, https://www.seforall.org/RecoverBetter. .

These rewards come in the form of resilient economic growth, new jobs, and a cleaner environment. For example, investments in clean energy produce three times the number of jobs as the same size investment in fossil fuels, and for every US dollar invested in the transition towards renewable energy, an additional 93 US cents of additional GDP growth is expected to occur.

As we begin this 'Decade of Action' on SDG7, as called for by the United Nations, we have the data, knowledge, and technology we need to deliver this targeted progress. Political commitment, greater finance, and policy must catch up.

Finance, like in many areas of development, remains a challenge. Recent SEforALL data has highlighted a chronic underinvestment in electricity and clean cooking finance for African and Asian countries that need it the most.[26] The little finance that is committed is not being disbursed quickly enough—stalling energy access projects that will improve people's lives and grow economies—a challenge the development finance sector and partners must quickly overcome.

Technology also has an important role to play in the transition. Our research show that 111 million households could be served by mini-grids in Sub-Saharan Africa, Asia, and small island nations by 2030.[27] Despite this opportunity and it being the least-cost option for electricity access in many areas, the mini-grid market remains nascent. Now, more than ever, we need a thriving off-grid sector that can power life-saving infrastructure and provide electricity to the more remote populations that the traditional grid will not reach. These efforts must ensure diversity and engage indigenous companies to truly deliver energy solutions that meet the needs of people on the ground and drive localized economic growth.

Solutions must also be gender inclusive. Far too often, women and girls are disproportionately impacted from a lack of energy access. Women bear the brunt of cooking with dirty fuels—putting themselves at risk of indoor air pollution which kills an estimated four million each year—and miss out on economic opportunity, with wages for women with access to energy 59 percent higher than the wages of those without.

It is clear the challenges ahead of us can only be achieved if we work together. Energy is the golden thread to economic development, and we cannot achieve the vision of the SDGs or Paris Agreement without an inclusive energy transition.

The next few years are key. To support these efforts, the UN General Assembly will host its first High-level Dialogue on Energy in over forty years in September. The Dialogue—co-led by SEforAL—will increase SDG7 action and ambition just ahead of a pivotal COP26 later this year. As High-Level Champion for the Dialogue, I am committed to ensuring that diverse leaders are heard and shape a just and equitable energy transition for all.

We need countries to arrive at the Dialogue with the same ambition they did in 2015, and ready to recommit to a global energy compact that puts the focus on an integrated, resilient energy transition that rapidly accelerates the pace of progress on access, prioritizes energy efficiency, and supports faster growth of renewables to leave no one behind.

In today's world, everyone has the right to a dignified life where they can achieve their full potential. We must seize this moment to deliver sustainable energy for all and change this injustice faced by so many.

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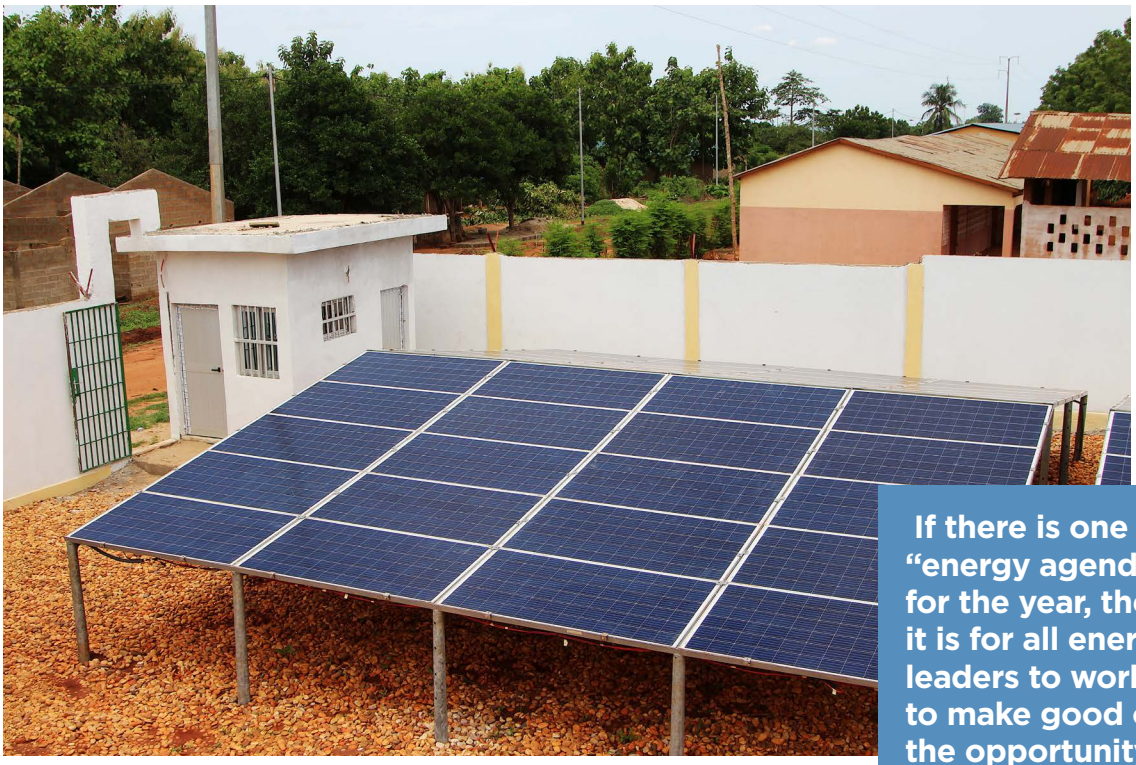
26 "Chronic underinvestment in clean energy putting millions at risk as they continue to be left behind in energy transition," Sustainable Energy For All, November 19, 2020, https://www.seforall.org/news/chronic-underinvestment-in-clean-energy-putting-millions-at-risk.

27 "Solar mini-grids set to play critical role in achieving universal electricity access with right policy support," Sustainable Energy For All, July 1, 2020, https://www.seforall.org/press-releases/solar-mini-grids-set-to-play-critical-role-in-achieving-universal-electricity-access.



REUTERS/NOEL KOKOU TADEGNON

A view of solar panels, which provide electricity to Sikpe Afidegnon Village, in Togo. Photograph taken in May 2019.

If there is one "energy agenda" for the year, then, it is for all energy leaders to work to make good on the opportunity of the post-COVID energy system.

CONCLUSION

As *The Global Energy Agenda* survey suggests and our essay authors articulate, 2021 could be an inflection point in the fight against climate change.

But we should not underestimate the enormity of the challenge to simultaneously enact policies to reach net-zero greenhouse gas emissions by 2050, build a more just energy system, and recover from the economic damage wrought by COVID-19. That 89 percent of survey respondents think oil demand will peak by 2040—a true accomplishment, given that global oil demand grew by about 88 percent between 1971 and 2019—and yet only 36 percent think we are likely or somewhat likely to reach net-zero emissions by 2050, illustrates the scope of the challenge.

From a technical perspective, this is obvious: oil is only one source of emissions, and reductions must be realized across many sectors. The survey data suggest that, while energy leaders are optimistic about stopping the growth of—and perhaps reversing emissions from—the production and consumption of oil, they are less optimistic about reducing other emissions, especially in hard-to-abate sectors, and in regions of the world that still depend on fossil fuels.

Thus, we must think bigger and look to new technologies that cut emissions in hard-to-abate-sectors. The energy system of the future is one with a multitude of technologies, all pushing towards cleaner energy and meeting growing global energy demand at the same time. Nothing is off the table as long as it can be made sustainable.

To reach these goals, survey respondents put a premium on international cooperation. Whether or not they believed that consensus among nations on how to address climate change was achievable, most thought that it was necessary.

COVID-19 has created the political and financial will to transform the energy system and combat climate change. This is why, in 2021, it is up to all of us to realize the opportunities that have emerged from the tragedies of 2020.

APPENDIX

The survey sample was global, with respondents based in thirty-nine countries. Nearly half (49 percent) live in the United States; around a fifth are from the Middle East and North Africa (22 percent) and Europe (21 percent); the remainder are from Asia, Sub-Saharan Africa, and Latin America. All age groups are represented with a roughly normal distribution between eighteen and eighty years old. The average age is forty-nine years and nine months.

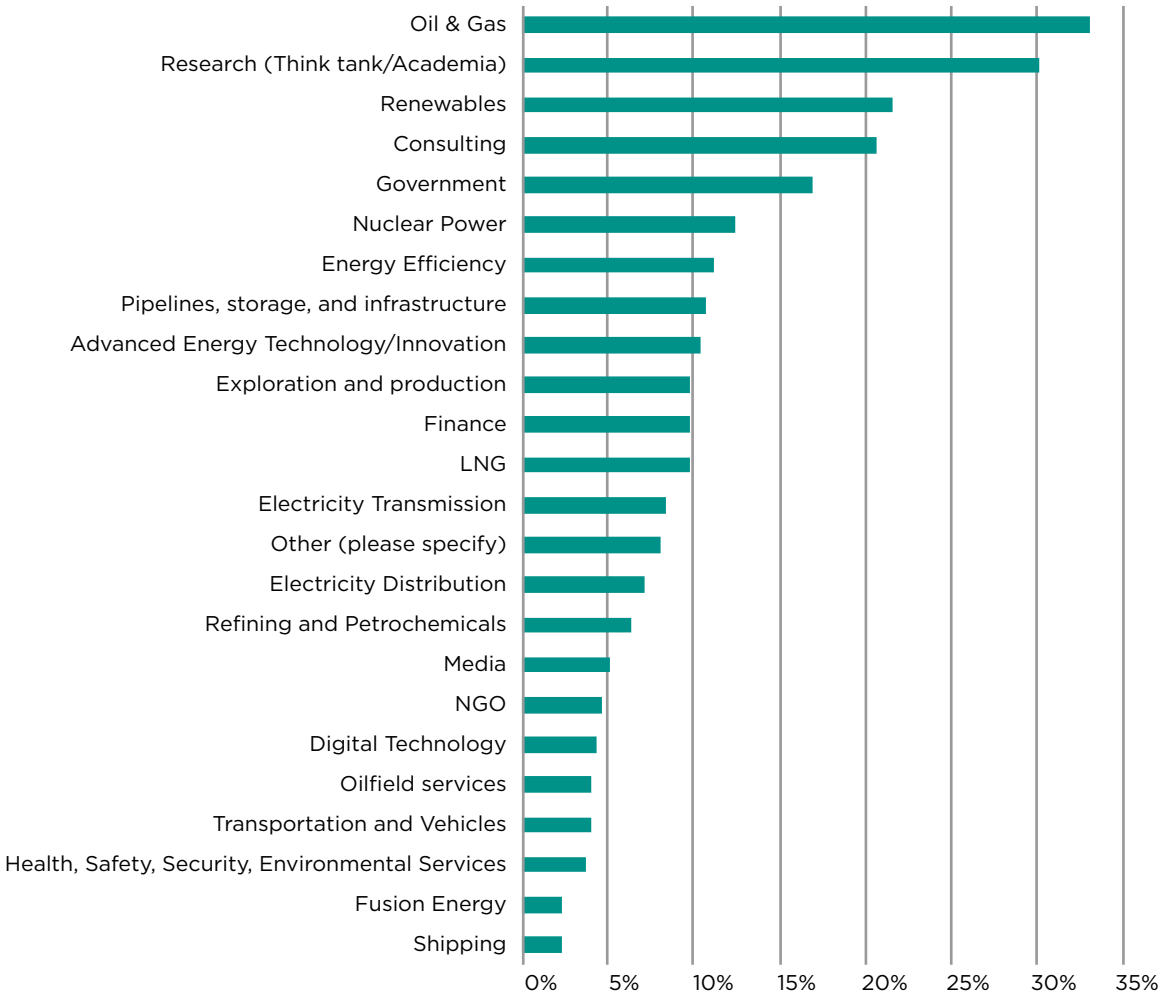
Participants also represented a variety of sectors within the energy ecosystem, including 33 percent associated with oil and gas, 22 percent with renewables, and 18 percent with predominantly electricity-related fields (nuclear power, transmission, or distribution). The survey also extends beyond the private sector: 17 percent report that they work for a government and 35 percent work for a research think tank, an academic institution, or a nongovernmental organization.

Sectoral identification, however, was not mutually exclusive, demonstrating how intertwined the energy world is: respondents placed themselves, on average, in 2.5 categories. For example, of the 33 percent associated with oil and gas, a third also described themselves as involved in renewables.

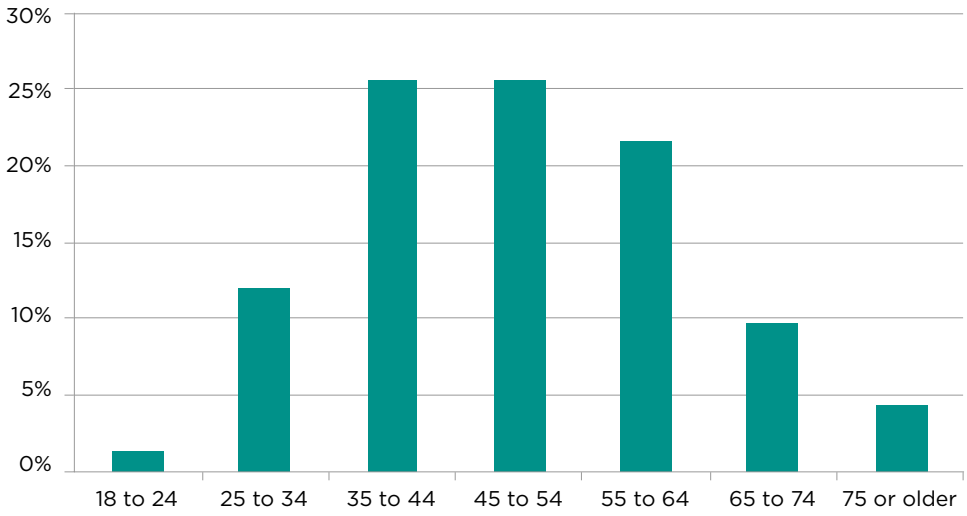
In what country do you live?

48.7%	United States of America
16.1%	United Arab Emirates
6.0%	United Kingdom of Great Britain and Northern Ireland
4.3%	France
3.4%	Saudi Arabia
2.0%	Romania
1.7%	Italy
1.7%	Turkey
1.4%	Canada
1.2%	Germany
1.2%	Japan
0.9%	Greece
0.9%	India
0.9%	Netherlands
0.6%	Austria
0.6%	Belgium
0.6%	China
0.6%	Croatia
0.6%	Kuwait
0.6%	Morocco
0.6%	Norway
0.6%	Republic of Korea
0.6%	Singapore
0.3%	Bahrain
0.3%	Cyprus
0.3%	Iceland
0.3%	Indonesia
0.3%	Iraq
0.3%	Jordan
0.3%	Lebanon
0.3%	Monaco
0.3%	Mozambique
0.3%	Oman
0.3%	Poland
0.3%	Spain
0.3%	Switzerland
0.3%	Timor-Leste
0.3%	Venezuela (Bolivarian Republic of)

What sector do you work in? Check all that apply.



What is your age?



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