The Third Energy Transition: Small-scale innovations essential to reaching a net-zero carbon future

By Alexander Chmelev, Partner, GEC

Governments, environmental groups, and corporations around the world have become increasingly active about efforts to mitigate climate change by slowing global warming driven by Green House Gas ("GHG") emissions. The most profound example of this is the Paris Agreement reached in 2016, which aims to limit the global average temperature increase to "well below" 2 degrees Celsius above pre-industrial levels.[i] Initiatives by certain governments and corporations strive to achieve net-zero emissions as soon as 2050, reducing GHG emissions caused by human activities and removing GHG by natural (e.g. oceans and forests) and possibly artificial carbon sinks in the future.

The global energy industry is a critical component in these efforts, as the production, transportation, conversion, and use of energy is the largest source of global GHG emissions. The transformation of the energy industry in response to these objectives is commonly referred to as the "energy transition". While the greatest focus is on large-scale, multi-national energy producers in this energy transition, significant positive impact will come from small-scale innovations developed by the less-visible companies supporting the large producers. **We believe that making real progress toward a net-zero carbon future requires diffuse invention across energy-services companies, where entrepreneurs will develop winning technologies and processes that will continue to change the energy industry.**

We are in the third Energy Transition

The current energy transition is the world's third, following the first energy transition in the 1800s when the shift from wood to coal drove the industrial revolution, and the second at the start of the 20th century when oil and gas became the predominant energy source, transforming transportation and large scale electricity generation. Each energy transition has brought benefits to broad segments of the global population. The current energy transition is the same, expected to increase the share of energy produced by renewable technologies while enabling global access to modern energy and eradicating or significantly reducing poverty.

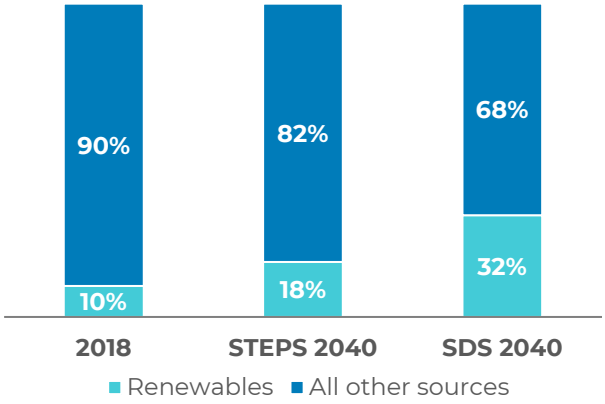
Low-carbon sources will scale up — but more energy is needed

To understand the percentage of global energy requirements which can be met by renewable energy, we can look to scenarios developed by the International Energy Agency (IEA). The IEA has published two simulations using their comprehensive model: 1) The Stated Policies Scenario (STEPS) forecasts the energy transition based on policy initiatives that have already been announced and nationally determined contributions under the Paris Agreement; and 2) The Sustainable Development Scenario (SDS), the IEA's most ambitious scenario for the energy transition, uses the United Nation's energy-related Sustainable Development Goals in addition to the Paris Agreement to model the low-carbon future.[ii]

Renewable energy sources are used almost exclusively to generate electricity. Thus, a continued increase in renewable energy consumption is dependent on the extent of electrification of the global economy, which is not a straightforward task. Due to the challenges of electrification, the share of global final energy consumption in the form of electricity only grows from 20% (2018) to between 24% (STEPS) or 31% (SDS) by 2040. As a

result, while total global energy demand is likely to continue to grow, the share of energy consumption delivered by renewables reaches only between 18% (STEPS) and 32% (SDS) by 2040. The balance is provided primarily by natural gas and oil, out of necessity and due to the challenges of widespread electrification.[iii]

Renewables Share of Total Final Consumption (IEA)



Improved living standards globally mean growing demand for energy

Along with global population growth, approximately 1.6 billion people will be added to the middle class by 2030.[iv] In 2018, approximately 860mm people in the world were without electricity.[v] As access to modern energy improves the lives of millions of people, the demand for energy will grow. Furthermore, as people move out of poverty, they will seek conveniences such as indoor heating/cooling, electrical appliances, vehicle transportation, as well as products and services that require energy to provide. For an illustration of the disparity between developed and developing economies, in 2017–2018, *per-capita* energy consumption in the United States (representing 4% of global population) was 10 times the per-capita consumption of Africa and India, which together represent 35% of global population.[vi]

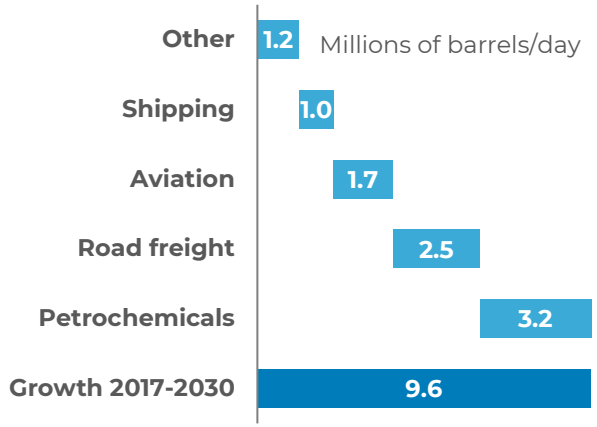
Propagation of renewable energy sources has had tremendous success, particularly in developed markets. The share of electricity generated from wind and solar continues to set records. Between 2010 and 2018 the price of solar photovoltaic (PV) modules dropped by 90% and the price-per-unit of wind-power turbines fell by approximately half with further dramatic declines expected in the coming decade.[vii] These renewable energy sources are expected to play an important role in delivering modern energy to those who need it.

The low-carbon future still requires traditional energy sources

With the anticipated gains in renewable energy, why will these sources comprise only 18 to 32% of future energy needs, and why are oil and gas still essential to our everyday lives? The explanation lies in the structural and scientific limitations imposed by global economic activity, physics, and chemistry.

The transportation sector is the biggest consumer of energy globally.[viii] Increasing penetration of electric vehicles should help reduce GHG emissions and curb fossil fuel demand growth. However, shipping, aviation, and heavy freight transportation do not lend themselves to electrification, given their need for the superior energy density of fossil fuels. Today's best lithium ion batteries, which are used in electric motors, have energy density 50 times less than that of jet fuel.[ix] Advancements in battery technologies should drive gradual increases in densities, but batteries are structurally unable to achieve the energy density of hydrocarbon fuel, since its mass can be completely burned to release energy.

Oil Demand Growth by 2030 (IEA)

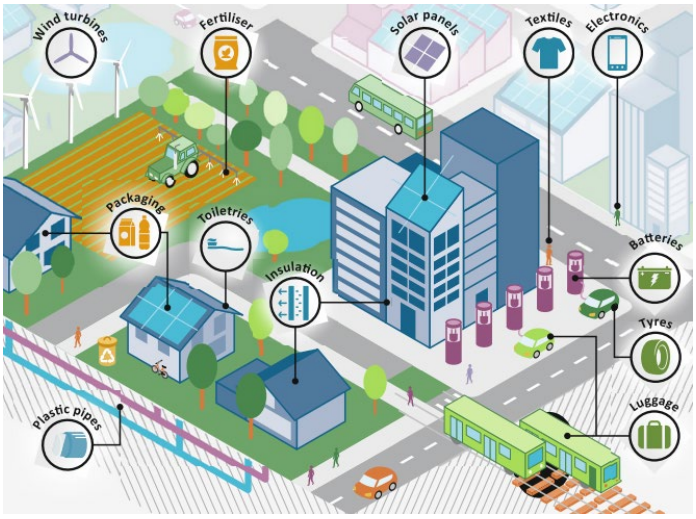


Looking more broadly, decarbonization of the global industrial sector is far more complex than transitioning the transportation sector to electricity-based power. As an example, vehicles

powered by electricity are still manufactured from materials that are made from petrochemicals or that rely on heat- and energy-intensive manufacturing processes (e.g. aluminum, plastic, rubber, steel, etc.) that typically require hydrocarbons.

Within the petrochemical sector, approximately half of the energy consumption comes from fuels that provide raw materials to create molecules used to physically construct product.[x] Petrochemicals are converted into many daily products, without which it would be difficult to imagine the modern world. These include packaging, clothing, medical equipment, fertilizers, detergents, tires. Petrochemicals are also critical to components for the alternative energy sector, including wind turbine blades, solar panels, batteries, and electric vehicle parts.

Petrochemicals in Everyday Life (IEA)



The chemical sector currently represents approximately 14% of oil and 8% of natural gas consumption globally and is the largest industrial consumer of energy.[xi] As growing populations, industrialization, and improvements to quality of life drive demand for these products, petrochemicals are expected to account for over one-third of the oil demand growth to 2030, ahead of road freight, aviation, and shipping.[xii]

Oil and gas will be part of the solution

For all the reasons discussed above, the IEA scenarios project that oil and gas will provide between 55% (STEPS) and 48% (SDS) of global energy in 2040.[xiii] Taking into account the projected global growth in demand for energy and the unknowns regarding which scenario will prevail, we have considered the midpoint estimates between the STEPS and SDS scenarios, which indicate that the natural gas and oil supply in 2040 will need to match 2018 levels.[xiv]

Because the challenge of combatting climate change cannot be solved solely by increased deployment of renewable energy sources, the hydrocarbon energy complex must be part of the solution. Currently, 15% of energy-related GHG emissions come from processes required to get oil and gas out of the ground and to consumers.[xv] Thus, the oil and gas industry can make a tremendous contribution towards climate change efforts by reducing the GHG emission intensity of its operations. The oil and gas supply chain is complex, including hundreds of steps and participants, using many energy intensive services and equipment. Primary emissions, which are the emission of Carbon Dioxide (CO2) and Methane during the active steps of the process, result from powering the supply chain and leaks of gases during extraction, storage, transportation, and refining, as well as generation of energy purchased by the industry (electricity, etc.). These account for 20% of emissions attributable to the oil and gas industry on a full-cycle basis.[xvi] Hydrocarbon processes also generate fugitive emissions when GHGs and vapors simply escape into the atmosphere from pressurized equipment and industrial activities. Methane, commonly referred to as natural gas in its purest form, is a greenhouse gas that is 30 times more potent than CO2.[xvii]

Oil and gas companies can directly tackle and largely eliminate their primary emissions by optimizing their operations, deploying relevant existing technologies, and improving sustainability of their supply chains. Examples of such improvements include elimination of fugitive emissions of GHG gases and methane flaring, reduction of energy intensity and electrification of oil and gas operations, productivity and efficiency optimization of exploration and refining processes, and integration of carbon-capture infrastructure.

Numerous small-scale innovations are needed for big results

The most visible decarbonization initiatives have been announced by national and supermajor oil and gas companies, with the objective of reducing their primary emissions. Some have ambitious goals of tackling full-cycle emissions, which also include those produced by end-consumers. "Full-cycle" plans include carbon sinks, offsets, and credits, as well as diversification into alternative energy.

However, due to the complexity of the energy supply chain, large oil and gas producers are dependent on thousands of under-the-radar services and products companies that must be a part of achieving these energy transition goals. These smaller energy-services companies are largely invisible outside of the energy industry, yet their innovations are a key factor in the success of the industry's efforts to decarbonize. As more oil and gas companies embrace their role in the energy transition, they will seek new solutions and technology providers, change procurement methodologies, improve operations and equipment, and adjust supply chains to incorporate the most-effective innovations.

Energy-services companies include a wide range of technical specialties, including artificial lift, chemical and refining services, drilling, product transportation and storage, reservoir testing and analysis, software and services, well completions, and well stimulation. These companies, often led by entrepreneurs, can quickly introduce and commercialize new technologies, equipment, and processes, as they are unburdened by the more rigid organizational structures of the large multi-national producers. Furthermore, the fragmentation in this sub-sector yields dispersed innovation as energy-services providers compete to deliver greater benefits and win more customers.

In the process of competing, some truly innovative products and services are being developed that can help the industry become more energy efficient, reduce emissions, improve productivity, and minimize operational footprint. Opportunities to support the industry's move to a low-carbon future that are being addressed by energy-services companies include:

- Electrification of oil and gas drilling, completion, and production operations, replacing diesel engines.
- Production recovery enhancement and optimization.

Case Study: Small company with big impact

Stage Completions

Bringing an oil and gas well online consists of three distinct phases: drilling, completion, and production. The completion phase is the most intensive in terms of capital, equipment, and time. If producers can reduce time required in the completion phase, they can both save money and reduce their environmental impact. Stage Completions is an energy-services company that has developed a truly innovative completions technology system, addressing exactly this challenge. Stage's system requires as little as half of the pumping horsepower needed to stimulate the reservoir and less surface machinery and equipment to deploy it. The streamlined completions process, reduced heavy equipment footprint on site, and associated fuel savings result in the reduction of ~290 metric tons of CO_2 per each oil and gas well completion. Water consumption also decreases by ~5,000 barrels per well. If this technology were implemented on all new wells completed in the U.S. alone each year, the release of ~3 million metric tons of CO_2 would be eliminated, equivalent to the annual emissions of 632,000 light duty vehicles.[xviii]

This disruptive technological innovation was developed and commercialized by a company of only 15 people, based in Calgary, Canada. Already deployed on 150 wells , Stage's technology can support the global energy transition and reduce GHG emissions by reaching oil and gas producers around the world.

- Automation and remote control of operations.
- Technologies that capture and repurpose methane that would otherwise be flared or vented.

We believe that these smaller-scale energy-services innovations are an essential component of helping the energy industry move toward the IEA low-carbon scenarios while producing the oil and gas that the world's population will demand, as indicated by the UN's Sustainable Development Goals. Technologies that eliminate operational steps and increase production from assets under development will allow the industry to satisfy ongoing demand for hydrocarbons with a lower GHG emissions footprint and will ultimately allow oil and gas activities to become carbon neutral.

Conclusion

As corporations and governments increasingly focus on this third energy transition and move toward a net-zero carbon future, the traditional energy industry plays an important role in enabling social improvements globally while embracing decarbonization. This will require innovation at all levels to drive efficiencies, lower emissions of assets and of the supply chain, lower the energy intensity of operations, and reduce the carbon footprint of products. Many of these innovations will come from smaller, under-the-radar energy-services companies that offer deep technical expertise combined with a need to deliver superior solutions to their large producer customers. **We believe that the disruptive innovations coming from some of these companies have the potential to deliver significant positive impact and help the oil and gas industry leverage its vast resources and capabilities to support the global energy transition and moving toward net-zero emissions.**

Contact GEC to learn more:

www.geclp.com or +1.713.993.7222

[i] United Nations Climate Change, The Paris Agreement, November 2015
[ii] IEA, World Energy Model: Scenario Analysis of Future Energy Trends, November 2019
[iii] IEA, World Energy Outlook 2019, November 2019
[iv] Brookings Institute, The Unprecedented Expansion of the Global Middle Class, February 2017
[v] IEA, SDG7: Data and Projections, November 2019
[vi] IEA, Total Primary Energy Supply (TPES) per capita - World Energy Balances and Statistics
[vii] IRENA, Renewable Power Generation Costs in 2018, May 2019
[viii] IEA, World Energy Outlook 2019, November 2019
[ix] Wired, The Age of Electric Aviation is Just 30 years Away
[x] IEA, The Future of Petrochemicals, October 2018
[xi] IEA, The Future of Petrochemicals, October 2018
[xii] IEA, The Future of Petrochemicals, October 2018
[xiii] IEA, World Energy Outlook 2019, November 2019
[xiv] GEC calculations based on IEA, World Energy Outlook 2019, November 2019
[xv] IEA, The Oil and Gas Industry in Energy Transitions, January 2020
[xvi] IEA, The Oil and Gas Industry in Energy Transitions, January 2020
[xvii] EPA, Understanding Global Warming Potentials
[xviii] Calculations by Stage Completions and GEC, assuming completion of 10,000 new wells in the U.S. annually (vs. nearly 14,000 average p.a. 2017–2019, per the Energy Information Administration). Stage's technology reduces emissions by requiring 20% less diesel fuel per well than the conventional hydraulic fracturing methodology (plug & perf), which consumes ~110,000 gallons per well. Stage's technology also eliminates the need to mill out frag plugs, which can further reduce CO2 emissions by 67.3 metric tons per well, per a study commissioned by Nine Energy Service. CO2 emissions mitigation from reduced need for surface equipment is not factored into this analysis. According to the Environmental Protection Agency, a typical passenger vehicle emits 4.6 metric tons of CO2 annually.