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Energy Musings

Insights into the Energy Industry

Allen Brooks, Managing Director

Energy Musings *contains articles and analyses dealing with important issues and developments within the energy industry, including historical perspective, with potentially significant implications for executives planning their companies' future. While published every two weeks, events and travel may alter that schedule. I welcome your comments and observations.* Allen Brooks

August 23, 2022

Virginia Offshore Wind Project Approved But With A Twist

Dominion's offshore wind project was approved by Virginia regulators. To protect customers from excessive costs from power shortfalls, regulators want a "performance standard" for the project.

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Current Economic Questions Force Look At Demographics

U.S. labor force participation and falling productivity worry economists. They should be considering recent projections showing a "smaller, older, and more urbanized" population in 2100.

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Virginia Offshore Wind Project Approved But With A Twist

On August 5, the State Corporation Commission (SCC) of the Commonwealth of Virginia approved the application by Virginia Electric and Power Company (VEP), a subsidiary of Dominion Energy, to construct and operate the Coastal Virginia Offshore Wind (CVOW) project, but with a surprising twist. You will be surprised at what the SCC wants.

Exhibit 1. Offshore Test Turbines Will Have 176 More Of Them For Company

Source: Dominion Energy

CVOW will consist of 176 turbines, each rated at 14.7 megawatts (MW) of generating capacity, creating a wind farm with a nameplate capacity of 2,587 MW. The wind turbines will be positioned on a federal lease held by VEP that lies 24 nautical miles off the coast of Virginia Beach, Virginia. The wind farm is scheduled to be fully operational by the end of 2026. That is when the SCC's approval twist begins to operate. The twist is a "Performance Standard" that the wind farm must achieve, and failure to meet it puts all the cost burden to comply on Dominion and not its customers. This would be the first state energy plan that addresses the unlevel playing field enjoyed by renewable energy projects. More on this twist later.

According to VEP's filings, the total capital cost of the CVOW project is estimated to be approximately $9.8 billion, including approximately $1.15 billion for new and upgraded onshore Virginia facilities. Total project costs over the life of the project, including financing costs, minus investment tax credits, are estimated to be approximately $21.5 billion.

Over the project's 35-year lifetime (including the five years for construction and the 30-year projected useful life), the company projects that a residential electricity customer using 1,000 kilowatt-hours (kWh) will see an average monthly bill increase of $4.72 and a peak monthly bill increase of $14.22 in 2027. Dominion currently seeks to recover from customers in Rider OSW $78.7 million in costs associated with the project in its first year of construction.

In the SCC decision, the commissioners wrote:

- Approval and certification of electric interconnection and transmission facilities, comprising transmission facilities required to interconnect CVOW reliably with the existing transmission system ("Virginia Facilities");

- Approval and certification of electric interconnection and transmission facilities, comprising transmission facilities required to interconnect CVOW reliably with the existing transmission system ("Virginia Facilities");

- Approval of a rate adjustment clause, Rider OSW, for the recovery of costs incurred to construct, own, and operate the offshore wind generation facilities and related interconnection and transmission facilities that compose the CVOW Project; and

- Approval of a Foreign Currency Risk Mitigation Plan ("Currency Plan").

In our May 3 issue of *Energy Musings*, we wrote about this project and the issues and information that emerged from the first set of public hearings in the project's approval process. The issues revolved around this project being large and representing a new undertaking for Dominion, although it had previously installed two test offshore wind turbines to gather data to help in the planning for the CVOW project. Every intervenor in the approval process cited the magnitude of the project, the long construction period, the risk of cost overruns, and their potential impact on customer bills as issues. Many intervenors requested the SCC impose project monitoring schemes to protect against runaway cost overruns that would be borne by customers.

As the commissioners pointed out, neither its staff nor any intervenor opposed the approval of CVOW. Rather, they were concerned about possible significant risks that could impact affordability for customers from the numerous distinctive risks associated with the project. They cited risks such as project cost; size; technology; complexity; and ownership. The SCC went on to list the following examples of the distinctive risks they identified for CVOW.

- The Project will likely be the largest capital investment, and single largest project, in the history of the Company.

- The Project will also likely be the costliest project being undertaken by any regulated utility in the United States, with the exception of Southern Company's ongoing Vogtle nuclear project and will likely be the most expensive on a dollars per kilowatt of firm capacity basis.

- No other utility or independent developer has attempted to construct and operate an offshore wind project of this size in the United States.

- The Project requires 176 wind turbine generators, which are over twice the size (14.7 MW) as those in the current pilot project (6 MW), and which require construction and maintenance of three offshore substations for their operation.

- The designs for various components of these turbines, including the monopile and transition structures, have yet to be finalized.

- The Company has contracted to charter the Charybdis, a U.S. Jones Act-compliant vessel designed to carry the major wind turbine generator components. The Charybdis is the only Jones Act vessel available in the U.S., and the record reflects that the Charybdis is scheduled to be used in two other projects prior to being available for CVOW.

The commissioners went on to cite other considerations that arose from the record of the hearings and that could also lead to cost increases, and potential delays, including:

- As a first-mover project, there is no developed supply chain, including equipment suppliers, specialized installation vessels, and infrastructure to handle the transportation and installation of the equipment, which could lead to construction delays and cost overruns.

- Siemens Gamesa, the turbine supplier for the Project, has been "hit hard" by supply chain disruptions; this is further compounded by the fact that there are two installations ahead of the Project that will be receiving the same turbine designed by Siemens Gamesa.

- This type of project is not immune from general construction delays, e.g., Ørsted A/S, the largest wind developer in the world, has experienced recent delays on projects in both Europe and the United States.

- The "fixed price" contracts for the Project provide for change orders, which can increase costs from those specified in the contracts.

- Higher than expected commodity prices, to the extent those prices have not been locked in, may lead to cost overruns.

- The final costs of necessary PJM Interconnection, L.L.C. ("PJM") network upgrades are unknown because ongoing study work in the PJM generation queue was placed on hold to resolve the current backlog associated with issuing Facility Study Reports and Interconnection Service Agreements.

- The transmission interconnection facilities (i.e., Virginia Facilities) are a significant component of this Project and the Company has experienced delays and cost overruns on recent transmission projects.

- Dominion's cost projections do not specifically identify any costs it may seek to recover under Code § 56-585.1 A 5 e, which allows the Company to recover costs "necessary to

mitigate impacts to marine life caused by construction of offshore wind generating facilities."

- The Company's rate of return on equity for the Project is not fixed and could increase in future years.

- For a project of this size and risk, the Company has only included a contingency estimate of approximately 3%, or $300 million.

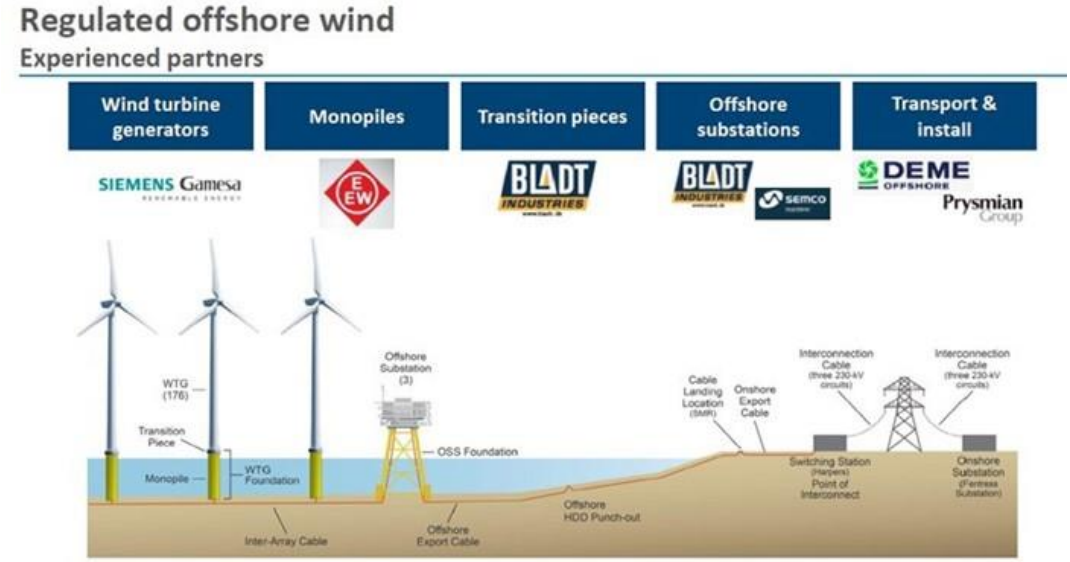
- There is inherent risk associated with weather being more severe than expected during the construction and operational phase of the Project which may lead to construction delays and cost overruns.

- There is substantial evidence in the record addressing the significant operational risks attendant to this Project. The lifetime revenue requirement and levelized cost of energy estimates presented by the Company are based on a projection that CVOW, once in operation, will achieve a net 42% capacity factor. The lifetime revenue requirement for Rider OSW and the levelized cost of energy ("LCOE") will increase if the actual achieved capacity factor is lower than projected.

One risk that was identified by Walmart in its intervenor presentation was that the piling for offshore turbine foundations is limited to only six months a year. Couple that restriction with possible bad weather, equipment operational issues, and availability of crews to operate the equipment and there could be meaningful project delays that would inflate costs.

Another area the commissioners explored was the unique ownership structure of CVOW. Dominion has chosen to construct, own, and operate the CVOW project. This contrasts with every other project in states pursuing large-scale offshore wind projects. They have used power purchase agreements (PPA) or offshore renewable energy certificate contracts. These financial structures limit the risks to customers by shifting construction, operational, and market risks from customers to the project's owner. The risk shifting issue was also raised during the SCC public hearings by intervenors concerned about the possible financial impact from cost overruns that Dominion would pass through to customers.

Exhibit 2. Dominion Is Touting The Expertise Of Its Offshore Partners



Source: Dominion Energy

Dominion has also opted not to use an engineering, procurement, and construction contractor (EPCC) for the CVOW project. The commissioners pointed out that this was a departure from how Dominion has managed prior generation construction projects. Using an EPCC would enable Dominion to shift materials, labor, and schedule risk away from the company and its customers, as well as minimize the risk of construction delays and cost overruns. By electing to manage the CVOW project in-house and using multiple interrelated contractors, Dominion is assuming additional risks while hoping to reduce the cost of the project by eliminating the fee paid to an EPCC. Dominion is touting the "experience" of its "partners" in constructing the offshore wind farm. This is shown in the exhibit above taken from Dominion's second-quarter earnings presentation. Could avoiding the hiring of an EPCC prove to be the proverbial "penny wise and pound foolish" decision?

In approving Dominion's CVOW project, the SCC relied on provisions of the Virginia Clean Economy Act (VCEA) that was enacted in March 2020. That law sets forth Virginia's clean energy goals along with directions for meeting those goals by December 31, 2034. The VECA requires a public utility to either construct or purchase "one or more offshore wind generation facilities located off the Commonwealth's Atlantic shoreline or in federal waters and interconnected directly into the Commonwealth, with an aggregate capacity of up to 5,300 megawatts." Projects meeting the specification are judged automatically to be "in the public interest and the Commission shall so find." It did.

Once again, a state legislature dictated how much latitude an agency established to protect the public has in exercising its expertise in evaluating the risk and cost of power projects to the public. Even though the SCC was restricted in what it could do with CVOW, the commissioners understood the project's risks, of which they listed many potential ones, so they created a protection mechanism for customers. Their plan immediately received a critical reaction from Dominion's CEO.

The SCC has created a "performance standard" for CVOW that protects customers and shifts risks back onto Dominion. As the SCC outlined in its decision:

- In choosing to construct the Project and seek recovery of the costs requested herein, the Company based its cost-benefit analysis and LCOE proposal on an average net capacity factor of 42%, and Dominion continued to affirm its high level of confidence in relying upon a 42% capacity factor to undertake this Project. In short, the net capacity factor reflects the Project's actual generation over a given period compared to the maximum amount it could have generated over that period.

- Based on the record herein, the Commission orders the required performance standard as recommended by Consumer Counsel witness Norwood, and as also urged by Walmart, Clean Virginia, the Virginia Department of Energy, and Appalachian Voices. Specifically, beginning with commercial operation and extending for the life of the Project, customers shall be held harmless for any shortfall in energy production below an annual net capacity factor of 42%, as measured on a three-year rolling average.

- As noted by the parties requesting such, this performance standard does not prevent the Company from collecting its reasonably and prudently incurred costs. Rather, it protects consumers from the risk of additional costs for procuring replacement energy if the average 42% net capacity factor upon which the Company bases this Project is not met. Dominion, nonetheless, asserts that it would be inappropriate for the Company to be put at risk if it fails to meet the capacity factor upon which it has justified and supported this Project. We disagree. This particular risk for this particular Project should not fall on the Company's customers.

Dominion CEO Robert Blue, in the company's August 8 earnings call with investment analysts, called the performance standard "untenable." He said it will likely lead Dominion to appeal the SCC's ruling, or at least request a formal reconsideration. It is also possible that Dominion could sue the SCC over its approval decision citing it as creating a new condition, not within its purview.

A media article reporting on the SCC ruling noted how a Wall Street analyst had written that CVOW's approval had been expected after agreements had been reached earlier this year between Dominion and various intervenors in the project's application hearing. The performance standard provision was a "twist" that added uncertainty to the development of CVOW.

On the earnings call, Blue was asked if the performance standard could result in Dominion electing to "walk away from this project." Because the company had only received the order on August 5 and it provided few details about the mechanics of the performance standard, Blue declined to give a detailed response to the question. "As we look at it (the order), it is inconsistent with the utility risk profile expected by our investors. But it's a great project and it has a lot of stakeholder support," Blue said. "There are options for us to seek reconsideration and options for us to work with stakeholders so that we can get that clarity that we need for this to meet our expectations of what utility investors are looking for."

CVOW is a high-profile renewable energy project and one that could become a feather in Dominion's cap if completed and the wind farm performs as advertised. Dominion has been working on this project for more than nine years. It paid $1.6 million at an auction in 2013 to acquire a 113,000-acre lease from the Bureau of Ocean Energy Management (BOEM), a miniscule price. In 2019, BOEM gave final approval for the 2,600 MW offshore wind project.

In the CVOW application last fall, Dominion applied for a rate adjustment clause (Rider OSW) to recover from its customers the costs to construct, own, and operate the offshore wind generation facilities and the interconnection and transmission facilities comprising CVOW. The rider was approved in the August 5 decision, and it allows Dominion a $78 million increase in revenue for the first year of the project to cover expenses already incurred. The rider will rise as more money is spent on the project.

While the CVOW decision adds uncertainty to the project's future, most investors expect a solution acceptable to all parties to be found allowing the project to move forward. As outlined in the risks cited by the commissioners was the number of offshore wind projects that precede CVOW, which they worried could create potential delays and/or disruptions. This uncertainty about the CVOW's status could also trigger costs from clauses in contracts for the project for delays. With the Biden administration pounding the table for offshore wind projects to move forward as quickly as possible, there is a lineup of new projects awaiting construction, and any disruptions in the progress of earlier projects could be detrimental to the financial returns of later projects such as CVOW.

Another media article about the SCC decision highlighted neighboring North Carolina regulators' challenge in approving a 1,600 MW offshore wind project for Duke Energy. The North Carolina Utilities Commission has the final word in these early stages on whether offshore wind will be a worthwhile investment. Eventually, like the Virginia SCC, it will set the final parameters on how Duke recovers its costs and what will be required of it in constructing and operating the offshore wind project. Duke paid $155 million to secure its federal lease for 55,154 acres in the Atlantic Ocean off the coast of North Carolina. Based on the latest offshore wind "overnight" construction costs from the U.S. Energy Information Administration (EIA), the Duke project's cost is estimated at $9.7 billion.

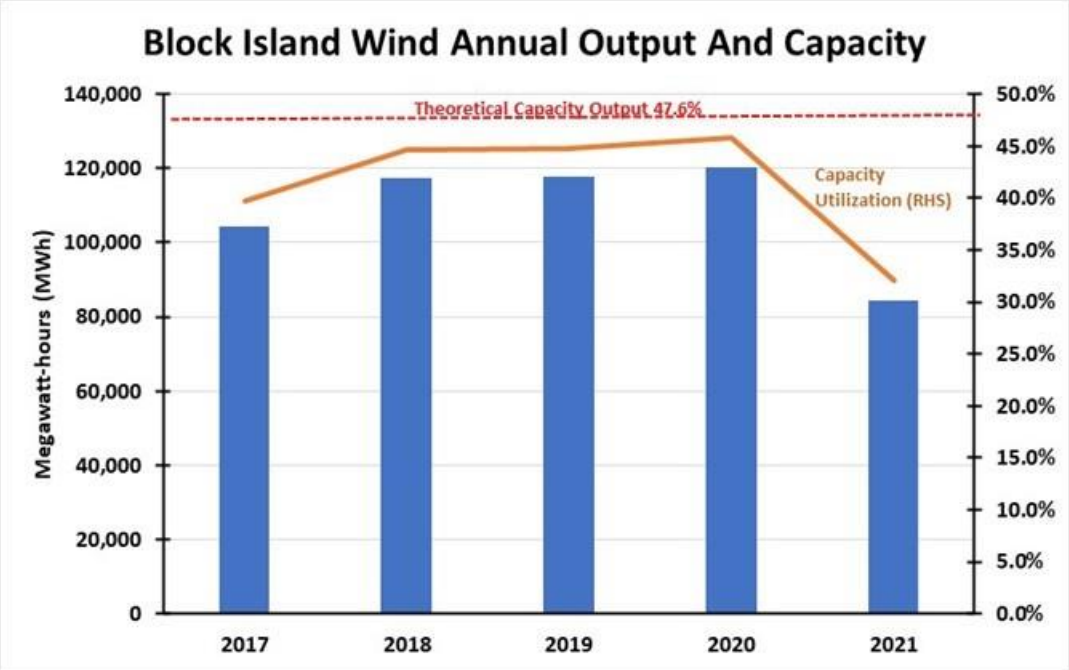
The genesis of SCC's performance standard is renewable energy. Wind and solar are intermittent power sources. Their supplies can be challenging for electricity grids to handle as the grid operator is mandated to maintain a stable power frequency, which requires stable sources of electricity supply. Because of the intermittent nature of renewable energy, grid operators and electric utility companies must maintain backup power supplies that can deliver electricity when renewable power is not available. The problem is that the electricity customers must pay the cost for this backup power. How to protect customers from surging power bills when expensive backup power must be purchased has become a serious problem for grids and ratepayers.

We have been involved in discussions with energy professionals about the idea of developers of renewable energy projects being held responsible for delivering a steady flow of power from their facility or backup power when they cannot meet their daily power delivery volume. The logic is that if a wind farm developer contracts to sell his power and says he can generate a certain percentage of his project's nameplate capacity, whenever he falls below that percentage, he would be responsible for delivering alternative power to offset the shortfall. The reality is that the developer would have to pay the utility that would procure that power supply. Such a strategy is at the heart of the SCC proposal – Dominion would bear the cost of that power shortfall because it is the developer of CVOW. Dominion CEO Blue's reaction that the SCC plan is "untenable" reflects how conditioned renewable energy developers are to the one-way street in power markets. Customers are growing mindful of the difference between the nameplate capacity of projects and the actual amount of power they will deliver.

When the 5-turbine, 30-MW Block Island Wind farm was approved by the Rhode Island Public Utility Commission, it was told the wind farm would deliver 125,000 megawatt-hours (MWh) of electricity a year. Based on 365 days, this translates into a 47.6% utilization rate. As the chart

below shows, so far in its operational history, the wind farm has yet to achieve the advertised target utilization rate in any year. Had a similar performance standard been mandated as proposed by Virginia's SCC, Ørsted, the current Block Island Wind farm owner, and D.E. Shaw, the original owner, would have been on the hook for the power supply shortfalls.

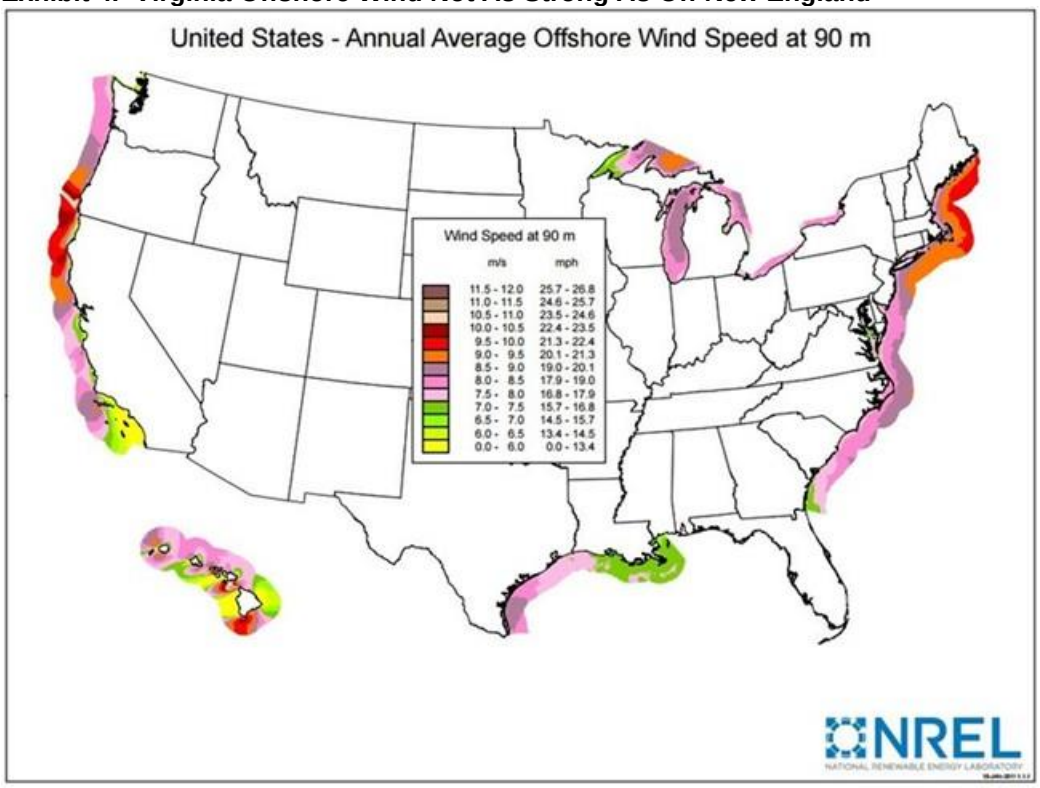
Exhibit 3. Block Island Wind Has Yet To Deliver The Power It Advertised



Source: EIA, PPHB

Notice how quickly Dominion's management reacted negatively to the idea of a power shortfall obligation. The performance standard is called risk management, meaning sound project planning and execution. We noticed from the application that Dominion has always been talking about a lower utilization rate (42.5%) than the Block Island Wind farm, which reflects the weaker winds off Virginia. Examining the map below of wind speeds at the height of the turbine hub/nacelle compiled by the National Renewable Energy Laboratory (NREL), we perceive a possible issue for CVOW. The lower utilization rate for CVOW compared to Block Island Wind is necessary because the winds off Virginia's coast are not as strong as those located along the Rhode Island and Massachusetts coastlines. However, the output from the new Block Island Wind is already underperforming, and as we know from the records of other older wind farms in Europe, wind farm utilization rates are often lower than initially assumed, plus the utilization rate declines as turbines age. A performance standard is protection for ratepayers from electricity shortfalls.

Exhibit 4. Virginia Offshore Wind Not As Strong As Off New England



Source: NREL

We will be monitoring developments with Dominion's CVOW. We applaud the Virginia SCC for its creative solution for protecting customers from wind output shortfalls. This is the first concrete step in correcting the unlevel playing field in power markets that are upending the power grids across the nation and increasing blackouts. Stay tuned.

Current Economic Questions Force Look At Demographics

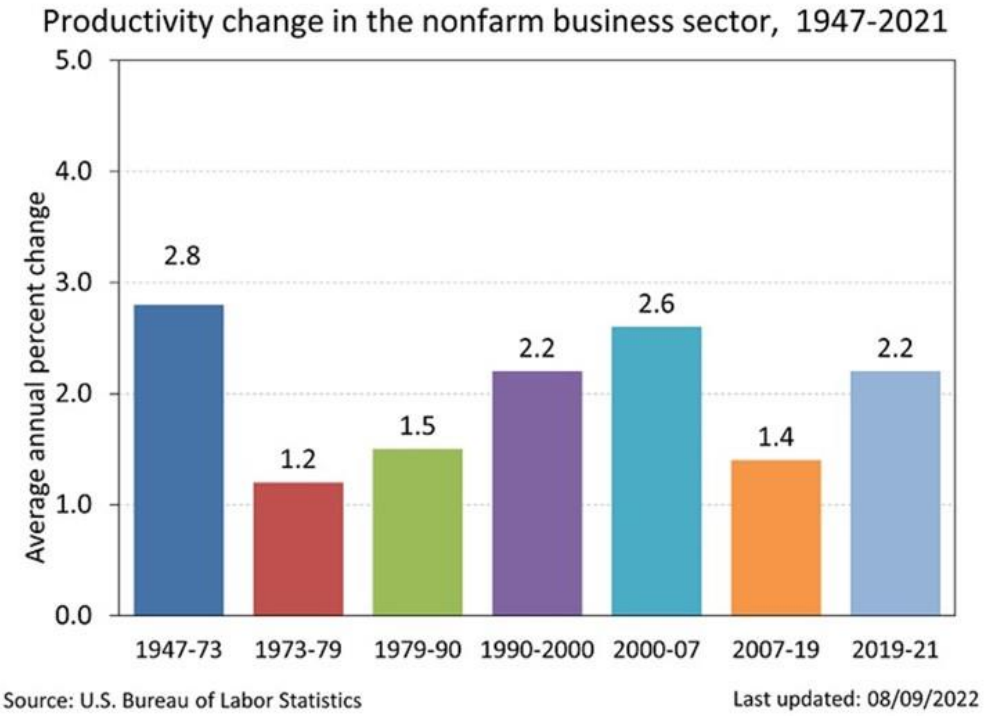
Is the U.S. in a recession or merely a minor dip in our growth path? The economic data is perplexing. Two consecutive quarters of real gross domestic production (GDP) declines meets the traditional definition of a recession, although we are told not the "technical" definition. The strong July jobs data – an increase of 528,000 employees on payrolls, twice the predicted number, and a decline of 0.1% in the unemployment rate bringing it to 3.5% – have some economists wondering how a recession could be underway amid such an extremely tight labor market. Workers are necessary for economic output, so the strength of the current labor market gives people confidence the U.S. will avoid a true recession, or it will not arrive until sometime next year. The historical record shows employment often peaks after recessions begin.

Some people answer the recession question with another: "Why does it matter?" It matters because the wrong answer may lead to government and monetary policy actions that could worsen the future economy – in particular, by helping kindle more inflation. To fight recessionary economies, the government and Federal Reserve move to stimulate the economy by boosting spending and loosening monetary conditions via interest rate cuts. While it appears the federal government is fine with continuing to spend money – the Inflation Reduction Act and the Chips

Act are examples – the Federal Reserve is actively tightening monetary policy through interest rate hikes and reductions in its bond holdings. If the Federal Reserve believes it needs to shift its strategy to fight a recession, rather than attempting to tamp down economic demand and choke off inflation via interest rate hikes, markets will be shocked.

Underlying this debate, however, is an often-ignored economic dynamic of labor productivity. The U.S. has experienced two consecutive quarters of GDP decline: -7.4% in 1Q2022 and -4.6% in 2Q2022. The 1Q2022 decline was the largest the economy has experienced since 3Q1947's 11% drop. As the historical chart of nonfarm labor productivity below demonstrates, usually the U.S. economy experiences productivity growth that underlies overall economic growth.

Exhibit 5. How U.S. Labor Productivity Has Varied Over Time



Source: Bureau of Labor Statistics

Economist and financial writer John Mauldin recently wrote a column titled "A Weird Recession" that reflects the conundrum we are considering. As Mauldin wrote:

- One final thought. We use GDP as a proxy for economic growth. What it really measures (with a lot of flaws) is output, or production. That's the "P" in GDP: Gross Domestic Product.

- At the most basic level, GDP is simply the number of workers a country has times the average worker's output. That's what we call productivity. A worker takes something—knowledge, building materials, whatever—and adds value by producing something new. Combine all that new value and you get GDP growth.

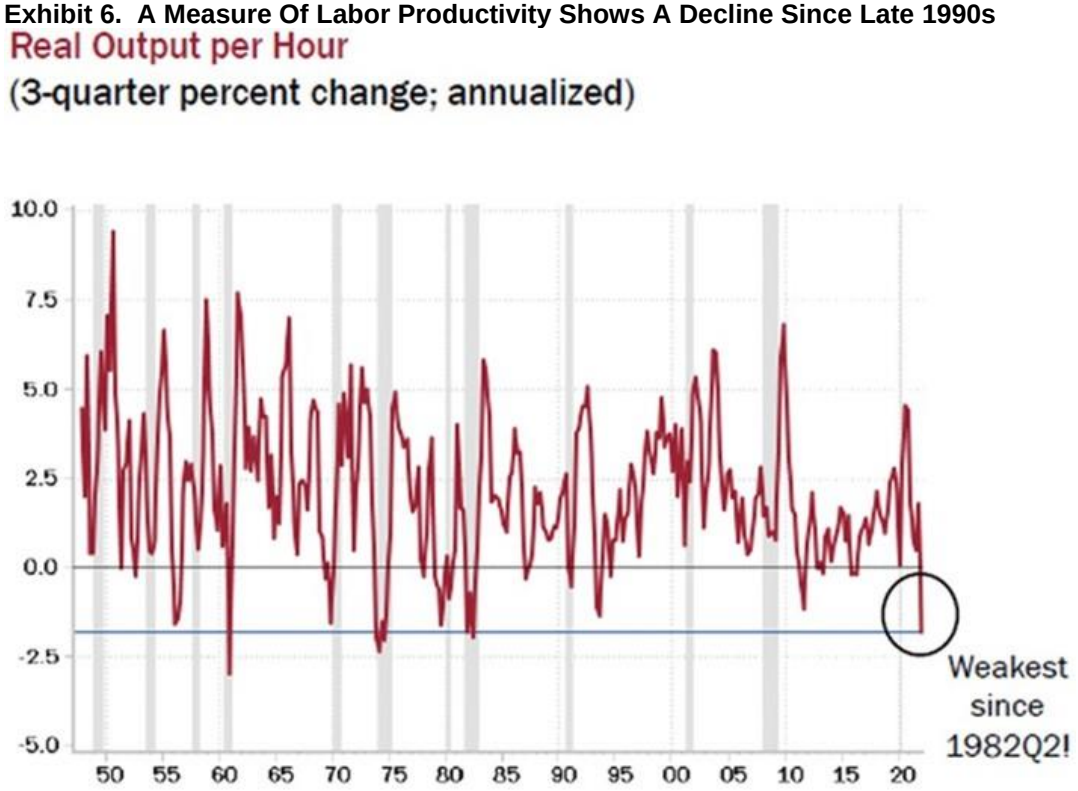
- If you want more GDP, math says you need some combination of more workers and/or more per-worker productivity. Postwar US economic growth happened for both reasons, but mainly productivity growth.

- With population growth slowing, GDP has been more dependent on productivity growth. This is becoming a problem.

Mauldin went on to point out that businesses are interested in having the most productive workers possible, which is why they offer skill training and labor-saving technology. These investments are not designed to lead to fewer workers but rather to boost their output and lead to greater output and profits. This can lead to an economy with more jobs and greater price stability. But the problem is the data is not showing these trends. It is showing disturbing trends. According to Bureau of Labor Statistics releases for the first and second quarters of this year, nonfarm business labor productivity decreased. Those outcomes came as output decreased in both quarters: -2.3% (1Q22) and -2.1% (2Q22). However, hours worked increased in both quarters: +5.4% (1Q22) and +2.6% (2Q22). With both quarters this year showing GDP declines, the reality is that more hours worked produced less output! This is the antithesis of how economies are supposed to work.

Using a different measure of productivity growth, – real output per hour – as tracked by economist David Rosenberg, we see that the latest figure is the worst since 1982. Rosenberg calculates the measure based on a 3-quarter moving percentage change, annualized.

Exhibit 6. A Measure Of Labor Productivity Shows A Decline Since Late 1990s

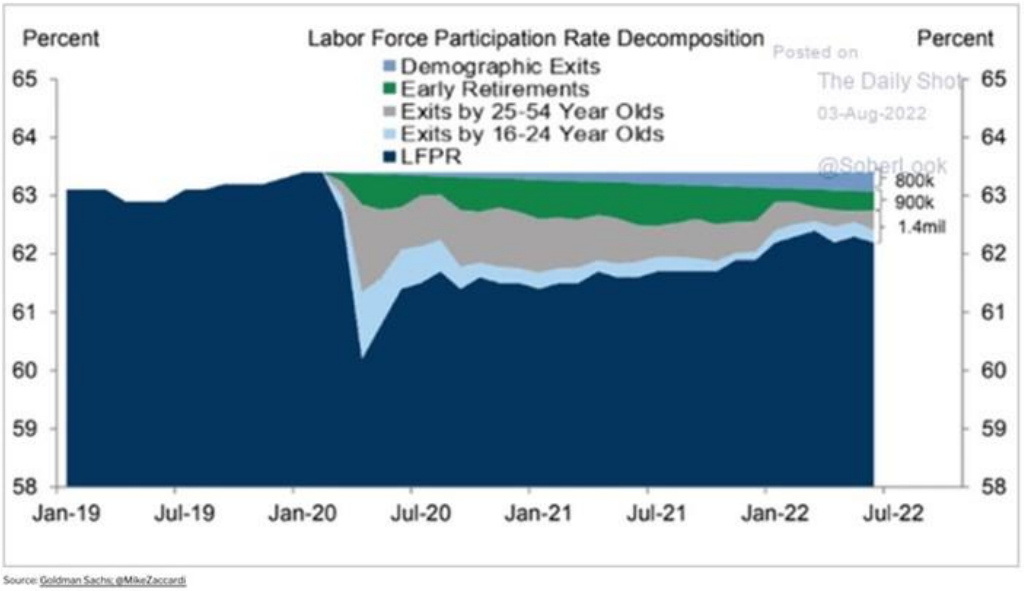


Source: Mauldin Economics

In Mauldin's view, "That's a noisy chart but if you take out the last two recession spikes, it looks like productivity has been broadly declining since the mid-1990s." He went on to tick off numerous actions by Federal Reserve leaders that may have contributed to this labor productivity problem, although one cannot "prove" such a relationship. Furthermore, Mauldin points out the challenges developing from "demographic factors that are shrinking the workforce." That observation is specific to the United States. That long-term trend is compounded by "pandemic-driven early retirements and 'Long COVID' disabilities. That means we need more productivity from the remaining workforce." Achieving this goal may prove more challenging than people realize.

The chart below shows the composition of the labor force participation rate from January 2019, the last year of pre-pandemic activity, through July 2022. The chart is designed to examine the decline in the labor force participation rate from 63.4% at its most recent peak that occurred in January 2020, to July 2022's 62.1%, a loss of 1.3%. If we had the same number of workers now as in January 2020, there would be 3.1 million additional workers helping to produce more GDP.

Exhibit 7. Accounting For The Missing Workers In America's Labor Force



Source: Adam Tooze

The chart shows that last month, 800,000 workers left the labor force because they retired under the current retirement age schedule. An additional 900,000 workers elected to take early retirement. Finally, 1.4 million workers from the two important age groups of 16-24- and 25-54-year-olds are also missing from the workforce.

While solving the mysteries of the decline in the labor force participation rate and declining worker productivity are important economic issues, the answers may be found in our demographic data and outlook. The U.S. is aging, although not as quickly as Europe or China, with significant geopolitical ramifications. The importance of the demographic trends is their role in shaping very long-term government policies and geopolitical strategies. We would point to the Russia-Ukraine war and the China-Taiwan tensions as events being driven by demographic trends in Russia and China. But an important pressure point is climate change, at least according to climate activists.

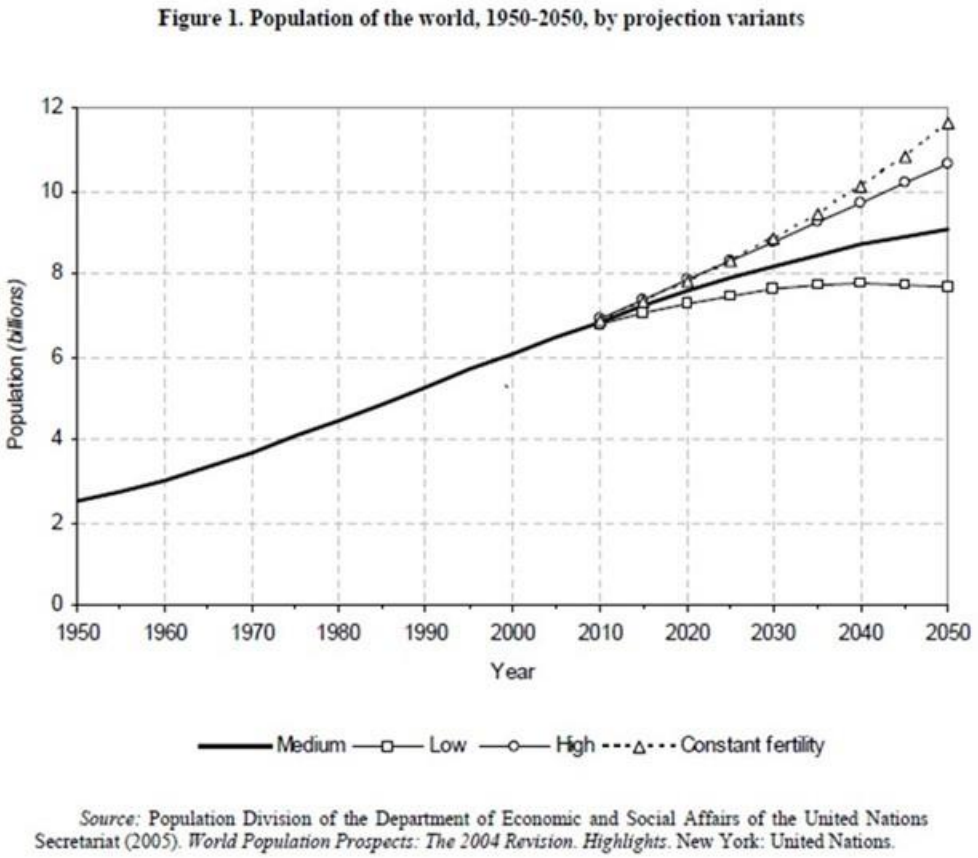
Climate models are based on assumptions about carbon dioxide (CO2) emissions that rest on estimates of future populations, economic activity projections, and how economies are powered. The Intergovernmental Panel on Climate Change (IPCC) is an arm of the United Nations. Thus, IPCC climate models utilize the UN's Department of Economic and Social Affairs' Population Division's forecasts of the global population in modeling future energy use. At the time these models were initially developed, the UN forecast called for 11.4 billion people to be residents on the planet in 2100. What if those projections are wrong?

This question was considered in a recent video interview of Darrel Bricker conducted by Maynard Holt and his Veriten team members. Bricker is a Senior Fellow in Global Affairs and Public Policy at the University of Toronto, CEO of Public Affairs at Ipsos (one of the world's leading social and public opinion global research firms), and co-author of Empty Planet: The Shock of Global Population Decline. The interview prompted us to not only read his book but to re-read Population Bombed! Exploding the Link Between Overpopulation and Climate Change by Pierre Desrochers and Joanna Szurmak. Desrochers is an associate professor of geography at the University of Toronto Mississauga, while Szurmak is a doctoral student at York University's Department of Science and Technology.

Amazingly, in the following weeks, there were multiple articles about population projections and our use of energy and raw materials. The interview, books, and articles provided resources as we considered today's world and what it may look like in 30 to 80 years. Ultimately, we were interested in exploring the questions raised by Bricker in his interview. Primarily, we were focused on our future energy demand if the world's population falls below UN estimates. This question becomes critical if the global population falls as low as Bricker and other demographers forecast. Concerning energy consumption, the age composition of the future global population is important. As Bricker commented in summarizing his view on the world's future population, it will be "smaller, older, and highly urbanized." Each attribute has implications for energy consumption. Bricker commented that he and his co-author found only one academic paper attempting to address future energy consumption in such a future world.

Every two years the UN Population Division prepares updates of its population forecast. As expected, these forecasts do not shift materially in two years, but over time there has been a meaningful downward adjustment. We began our review of UN forecasts with the 2004 revision. At that point, the UN was only projecting the population out to 2050. As shown in the chart below from that report, the medium forecast called for the world population to increase from 6.5 billion in 2010 to 9.1 billion in 2050. In its low case, the population only increased to 7.7 billion while the high case shows the population reaching 10.6 billion. Interestingly, the constant fertility rate model projects a global population of 11.7 billion.

Exhibit 8. 2050 World Population As Projected By UN In 2004

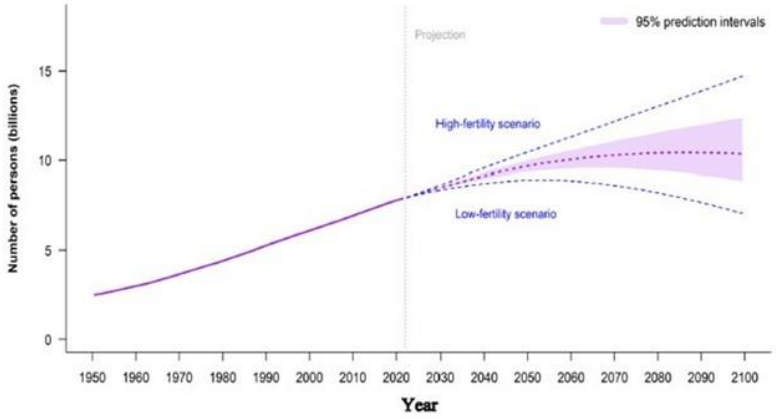


Source: United Nations

In the 2018 UN population report that focused on urbanization trends utilizing the 2017 updated UN population forecasts, the 2050 medium projection showed the population estimate rising from 9.1 billion in 2004 to 9.8 billion, a 700 million person increase in 13 years. According to the latest 2022 UN publication, the 2050 population forecast is now at 9.7 billion, but only 10.4 billion in 2100, merely 700 million more people over 50 years. This report comments that "with a probability of 95 per cent, the size of the global population will stand between 9.4 and 10.0 billion in 2050, and between 8.9 and 12.4 billion in 2100." These are the ranges for the medium scenario, but when lower fertility rates are considered, we find a smaller population projected. In fact, with a low fertility rate (the number of children a woman may be expected to give birth to during her child-bearing years), the population peaks around 2050 and begins to decline thereafter.

Exhibit 9. How Fertility Rates Can Significantly Alter Population Projections

Figure III.3
Global population size: estimates, 1950-2022, and medium scenario with 95 per cent prediction intervals and high- and low-fertility scenarios, 2022-2100



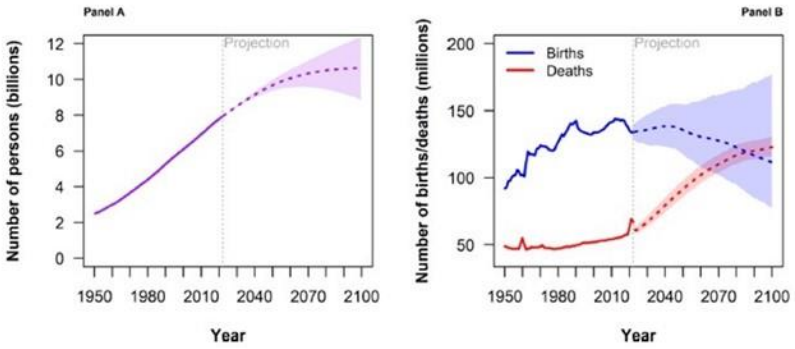
Source: United Nations

In contrast, in the high fertility rate scenario, the population never stops growing to 2100. In the medium case, the population growth slows from 2040 and remains level in the 2080-2090 period before declining slightly heading into 2100. To note the changes in the UN's forecasts, Bricker made the point that between the 2017 and the 2022 forecasts, the 2100 population projections declined from 11.2 billion to 10.4 billion, an 800 million reduction in five years.

To appreciate the issue of the fertility rate, the 2022 UN report had a two-graph chart showing its medium population projection, along with forecasts for birth and death rates. Note the 95% projection ranges for the three projections. The birth rate forecast range is extremely wide, while the range for the death rate is very narrow although the population estimate has a slightly wider range.

Exhibit 10. The Wide Range Of Birth Projections Can Alter Population Projections

Figure III.1
Global population size and total number of births and deaths, estimates (1950-2022) and medium scenario with 95 per cent prediction intervals, 2022-2100



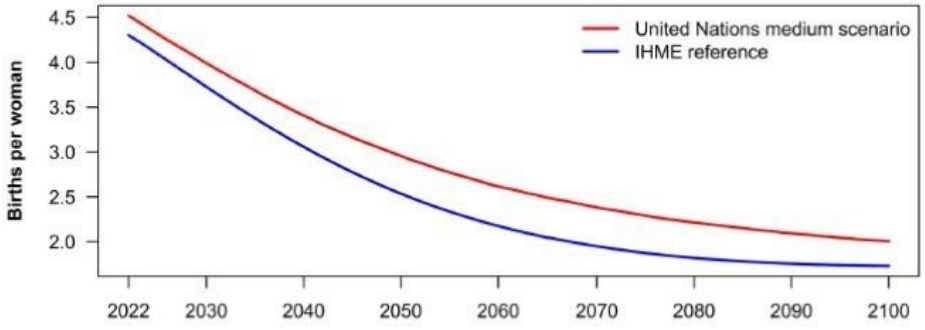
Source: United Nations

It is instructive to note the rise in the birth rate until 2040 but then a steady decline until the end of the century. One also needs to consider the possibility of the birth rate following the lower extreme of its 95% projection range. To gain an appreciation of how the fertility rate can vary between forecasters, the following chart shows the fertility estimates for the sub-Saharan Africa continent from 2022 to 2100 for the UN medium scenario and the reference scenario from the Institute of Health Metrics and Evaluation (IHME) model. Note that the IHME fertility rate falls faster in the earlier years out to 2060, but then declines at a slightly slower rate than the UN medium scenario. The key difference in the forecasts is that the 2100 fertility rate for the UN medium scenario is over 2.0 (replacement rate is 2.1) while for the IHME model it is about 1.0. The shape of the fertility rate curve in the IHME model is because of the earlier lower rate that reduces the population, leading it to become older sooner and thus producing fewer children, i.e., a worryingly older population. Will this happen? It is hard to know, but the work of Bricker and others to physically visit populations of women from around the world, especially poor women, and learn their attitudes toward the number of children they desire and how improvements in their social and economic standards of living encourage them to have fewer children, provide more evidence that lower fertility rates are becoming a relentless trend across the world.

Exhibit 11. Comparing Fertility Rates From UN And IHME Population Models

Figure III.5

Comparison of long-term fertility projections, sub-Saharan Africa, 2022-2100, United Nations medium scenario and IHME reference scenario

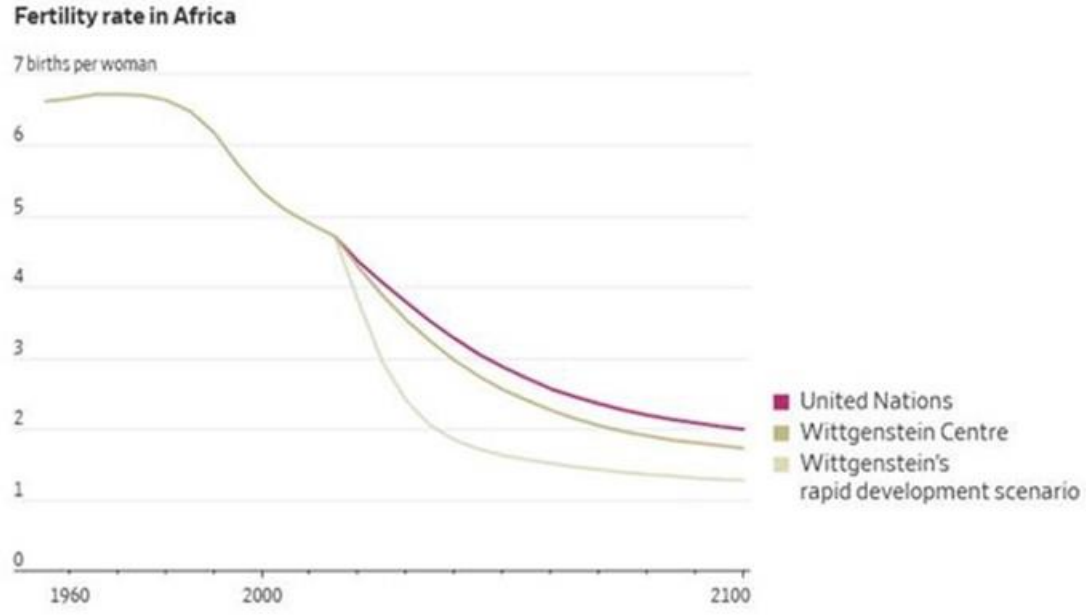


Data source: - IHME series: Institute for Health Metrics and Evaluation (IHME) (2020). *Global Fertility, Mortality, Migration, and Population Forecasts 2017-2100*. Seattle, United States of America: Institute for Health Metrics and Evaluation (IHME). https://doi.org/10.6069/MJND-3671.

Source: United Nations

A similar fertility pattern for Africa was noted in a *Wall Street Journal* article on population growth. The column's author compared the UN medium case population forecast with ones from the Wittgenstein Centre for Demography and Global Human Capital at the University of Vienna. Demographer Wolfgang Lutz of the Wittgenstein Centre explained that "There's two big questions. First, how rapidly fertility will decline in Africa… The other question is China, and countries with low fertility, if they will recover and how fast they will recover."

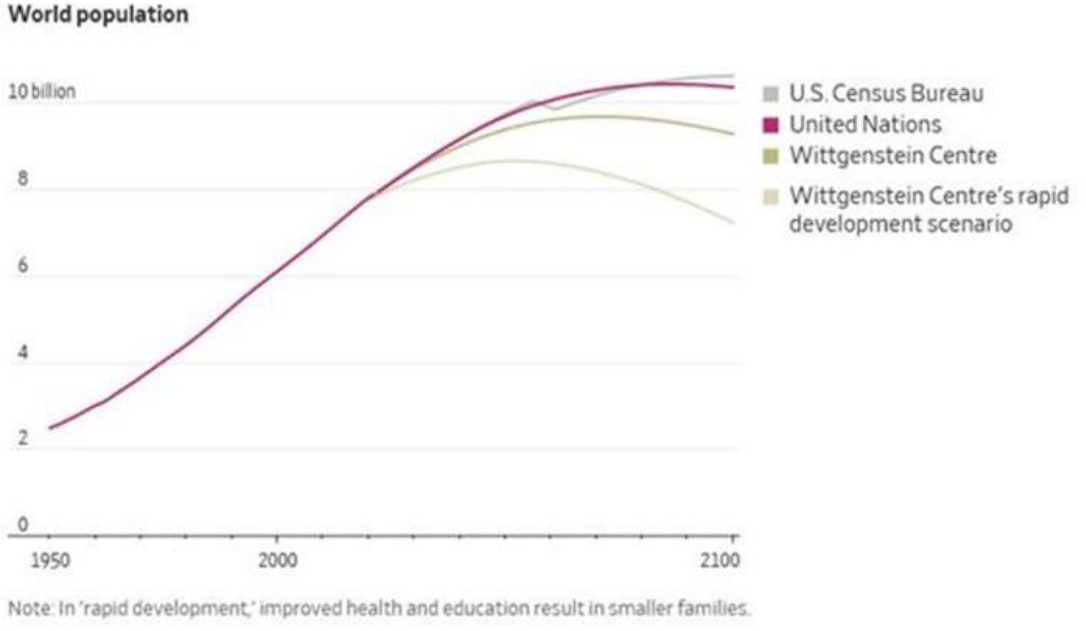
Exhibit 12. A Key Difference In Population Projections Is Africa Fertility Rates



Source: ***Wall Street Journal***

Using various fertility scenarios, along with death forecasts, is how population projection scenarios are prepared. Given the questions Lutz asked, his institute has developed several forecast models. *The Wall Street Journal* highlighted two Wittgenstein Centre models along with forecasts from the U.S. Census Bureau and the United Nations, shown below.

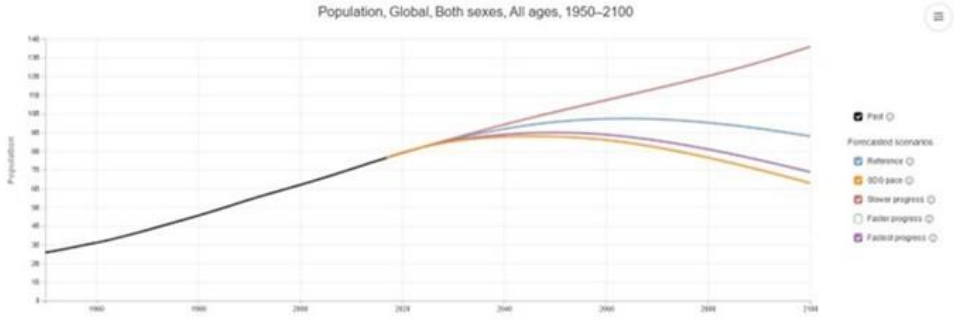
Exhibit 13. Comparing Multiple Long-Term Population Projections



Source: ***Wall Street Journal***

In the chart above, both Wittgenstein Centre models show noticeable population declines that put the world's population close to 9.0 billion and 7.0 billion by 2100, depending on fertility rate assumptions. In both cases, the Wittgenstein Centre's fertility assumptions are more conservative than either the UN or U.S. Census Bureau forecasts.

Exhibit 14. Different Population Projections From IHME Using Various Fertility Rates



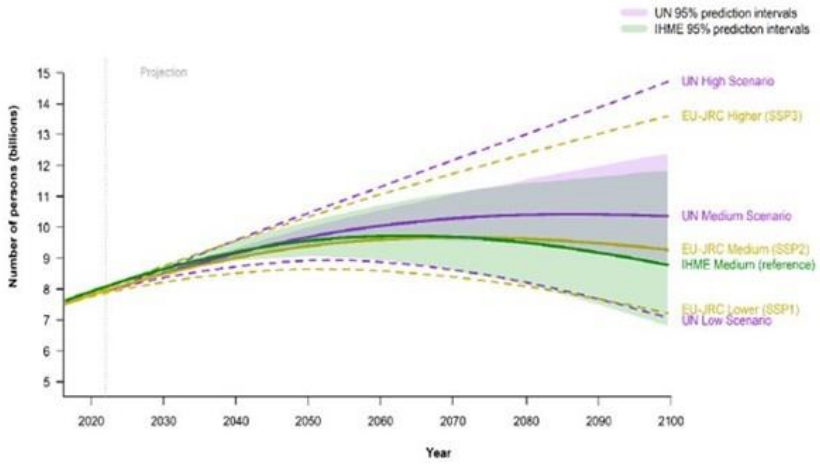
Source: IHME

The IHME has a series of forecasts based on different assumptions about fertility rates. Only in their Slower Progress model does the 2100 population projection show an increase. Across their forecasts for 2100, the range of population projections is from a low of 6.3 billion to a high of 13.6 billion. Excluding the two extreme forecasts, the range of the remaining middle three forecasts is between 6.9 and 8.8 billion. This means that there could be as many as 1.6 to 3.5 billion fewer people in 2100 than the UN currently projects.

Exhibit 15. More Population Projections Are Showing Lower Numbers Than UN

Figure III.4

Comparisons of long-term global population projections under various scenarios, United Nations, IHME and JRC, 2022-2100



Sources: - IHME series: Institute for Health Metrics and Evaluation (IHME) (2020). *Global Fertility, Mortality, Migration, and Population Forecasts 2017-2100*. Seattle, United States of America: Institute for Health Metrics and Evaluation (IHME). https://doi.org/10.6069/MJND-3671.

JRC series: Wittgenstein Centre for Demography and Global Human Capital (2018). Wittgenstein Centre Data Explorer Version 2.0. Available at: http://wittgensteincentre.org/dataexplorer.

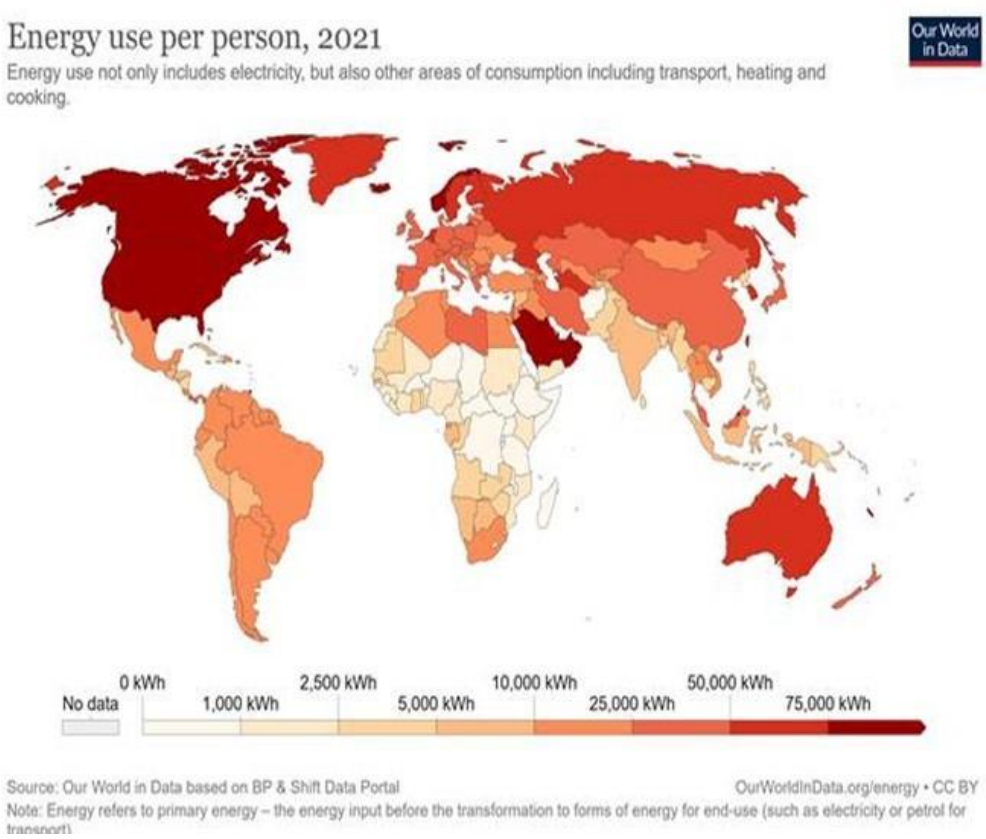
Source: United Nations

The chart above encompasses several forecasts – the UN, the IHME, and the EU-JRC, which come from the Wittgenstein Centre. Although the UN projects that the world's population will reach 8.0 billion by November 15, or maybe earlier, setting the date is highly uncertain. Instead of the population continuing to steadily march higher, we may be looking at a slowing growth rate and a peak being reached within the next 30 years, at which point the global population either stabilizes or begins declining.

Such an outlook would be contrary to the drumbeat of dire forecasts for the world based on Malthusian concepts that the planet is unable to support the number of people the UN has consistently and continues to project for 2100. A smaller population than the UN projects will have profound implications for society, the economy, the environment, and the energy markets. It means different paths for our future energy, water, and food consumption, as well as how much of other minerals and materials are used. These population forecasts have implications for where people live and how they manage their lives.

The chart below shows the nations of the world and their energy intensity. It is no surprise that, based on per capita measures, North America has the highest energy intensity along with Saudi Arabia and the Middle East. Note how low the per capita energy use is for countries in Africa, especially the central portion of the continent. What becomes critical for future energy markets is how the population projections for those countries consuming moderate amounts of energy change. There are also interesting scenarios for both the amount and types of energy used.

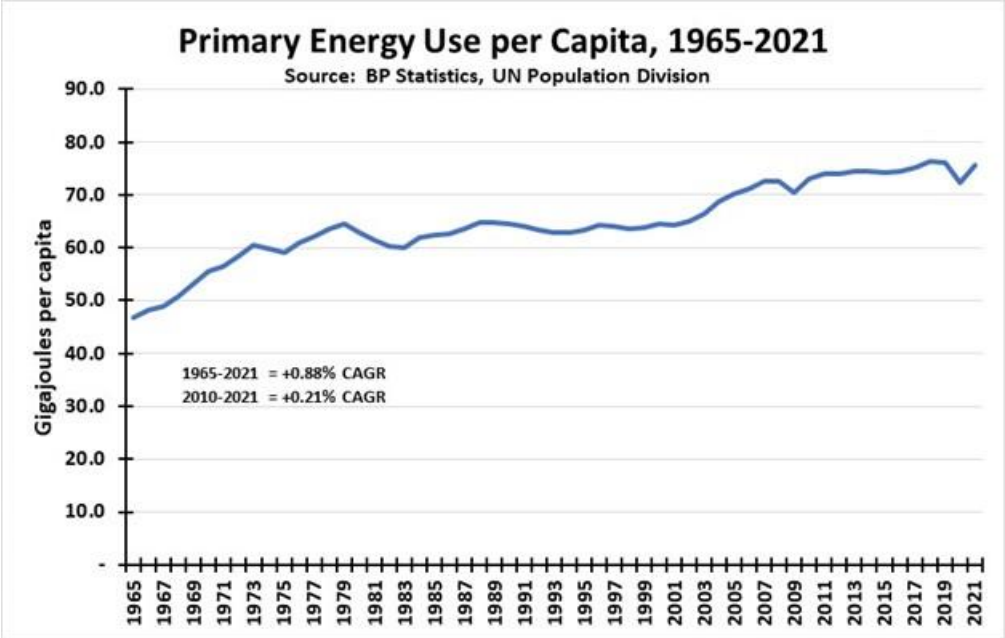
Exhibit 16. Where Per Capita Energy Use Is High And Low



Source: Our World in Data

Using BP's statistics for global primary energy consumption and the UN's population estimates, we were able to calculate the per capita energy use shown in the chart below. During 1965-2021, the compound annual growth rate in energy use was 0.88%. Interestingly, that rate was nearly half the annual rate of growth of the world's population for this period. That demonstrates how energy intensity in the global economy is declining. It means we are using our energy more efficiently to produce economic growth. To confirm this increased energy efficiency, we calculated the growth rate for energy use for 2010-2021, which was only 0.21%.

Exhibit 17. Energy Consumption Per Capita Has Slowed In Last Decade



Source: BP, United Nations, PPHB

If we think about the future of energy use, the questions become how many people will there be, how much energy will each consume, what forms of energy will they use, and will there be adequate supply at a reasonable cost? All these issues are interrelated. We have already addressed the question of how many people there may be in 2100. Potentially there will be billions of people missing from the UN projected population. Unless the remaining people dramatically increase their energy usage, substantially less energy will be consumed.

In examining the International Energy Agency's (IEA) World Energy Outlook 2021 report, we find that it is projecting global primary energy usage to grow at about an annual rate of 0.21%, like the rate of growth we had calculated for 2010-2021. The IEA's per capita energy consumption figure for 2050 (as far out as the IEA forecasts) compared almost exactly with our calculation. If we assume the per capita primary energy consumption rate continues at that rate to 2100, the world's total energy use, based on the UN's population forecast of 9.3 billion people, would be 882.1 exajoules (EJ). If we calculate energy use based on the IHME population projection, total energy consumption would be 777.9 EJ, or roughly 12% less. More dramatic is the 28% decline from the IEA/UN forecast if the world's population matches the Wittgenstein Centre estimate in its rapid development scenario. Their projected 2100 population would use 636.5 EJ.

Energy projections 80 years in the future are highly speculative, but 2100 is the timeframe climate activists have selected for predicting how dire our world will be if we do not stop burning fossil fuels now. Consuming 28% less energy, along with shifting the energy supply mix in favor of

cleaner fuels, would seem to go a long way to helping us reduce our climate risk. Remember, it takes decades of slower growth to reach these reduced 2100 population projections. Moreover, our analysis did not include scenarios that suggest the 2100 global population could be only 6.0 billion or even fewer people. Where the future population lives and how it lives will also have profound impacts on energy consumption.

We, like Bricker in his Veriten interview, marvel at how little work has been done on the energy implications of sharply lower population growth. Bricker paraphrased Thomas Huxley, the English biologist and anthropologist specializing in comparative anatomy, who became known as "Darwin's Bulldog" for aggressively advocating Charles Darwin's theory of evolution. Huxley stated: "The great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact." Bricker has modified that message in his statement that "The Ugliest Thing Is The Killing Of A Beautiful Hypothesis With An Ugly Fact." Sharply declining fertility rates across the globe is a fact seemingly being ignored by demographers and it can destroy conventional beliefs.

People are what drive economic, social, and climate scenarios. Ignoring declining fertility trends may kill many forecasts. Thus, economic policymakers should be asking questions about these smaller population scenarios as they ponder economic and social policies. Mistakes in policies now will compound in the future and create unnecessary and possibly irreversible harm.

Interesting Energy Topics And Our Thoughts

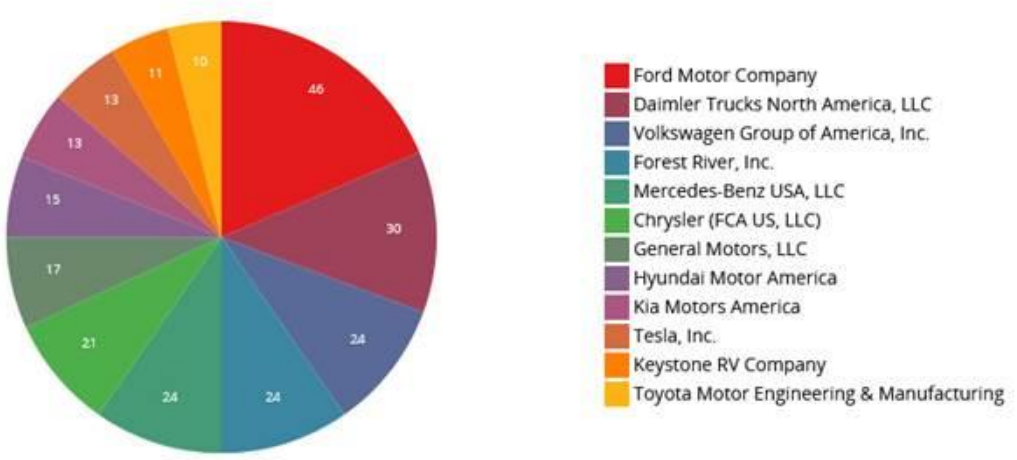
Interesting Data On Vehicle Quality

A recent article in *The Wall Street Journal* discussed the decline in vehicle quality at Ford Motor Co. that led to its management changing how it identifies defects. Vehicle quality is a significant issue, but at one point Ford's record was so good it touted the record in advertisements. After several recalls, Ford dropped that boast and revamped its quality department, separating it from operations and having its leader report directly to Ford's CEO Jim Farley. As the article mentioned and substantiated with data from the U.S. Department of Transportation (DOT) website, Ford had 46 recalls in the first seven months of 2022 involving 6.8 million vehicles, the most in the industry.

The Wall Street Journal had a chart showing the potential vehicles subject to recalls for five manufacturers (Ford, Tesla, General Motors, Chrysler, and Hyundai). That sparked our interest because Tesla was ranked second. We believe the companies selected for the table were chosen because they are the leading competitors to Ford's plans to build a huge electric vehicle (EV) business. Ford recently increased its EV investment plan by $20 billion. Ford now plans to spend $50 billion by 2026 on new EV manufacturing plants, battery supplies, and new model development.

The following chart shows the number of vehicles ordered recalled by the DOT so far in 2022. Ford is number one with 46, while Tesla only has 13 recalls, which has it tied with Kia Motors America.

Exhibit 18. DOT 2022 Vehicle Safety Recalls By Manufacturer



Source: DOT

The DOT data shows it has ordered recalls for 2,257,549 Tesla vehicles to correct safety defects. We assumed these recalls were tied to the Tesla vehicles made or sold in the U.S., which totals more than the company's total U.S. vehicle sales. According to Tesla data on U.S. vehicle sales, it has sold 1,419,244 EVs through the second quarter of 2022. Therefore, the recall total is more than 100% of U.S. Tesla vehicle sales.

Given the mismatch between recalled vehicles and Tesla's U.S. sales, we then examined Tesla's total vehicle sales. Again, based on sales data from 2013 through the second quarter of 2022, Tesla has sold 2,897,330 vehicles. That makes the DOT order applicable to 78% of all the Tesla vehicles sold. Is there a problem with the technology embedded in Tesla vehicles? Is Tesla's record a forewarning for the rapid expansion of the EV business? Or are there other issues?

Inflation Reduction Act Suddenly Renamed A Climate Bill

The shift in cheerleading for the recent passage of the Inflation Reduction Act (IRA) was very interesting. The media finally acknowledged what serious analyses of the IRA had concluded: it would do little or nothing to reduce inflation, and in the short term might make inflation worse. Because there was so much money packed in the bill and many issues addressed, there was plenty for the media to jump on. Suddenly, the IRA became a climate bill.

Interestingly, Mary Barra, General Motors Chief Executive Officer, was lobbying for passage of the IRA but the Business Roundtable organization that she currently heads was actively fighting against its passage. Even Barra did not get everything she wanted for her electric vehicle (EV) business, but she got much of what she needed to support GM's $35 billion in EV investments by 2025. She got out from under the EV cap that prevented GM EV buyers from receiving the $7,500 tax credit. There was also a $4,000 tax credit for used EVs sold under a price cap that was designed to help spur the used EV market and ultimately new EV uptake.

Barra also got a 10-year extension to the $7,500 tax credit, which can now be turned into a point-of-sale price reduction. Recently, both GM and Ford, another automaker making a huge bet on EVs, raised their model prices by $6,000 to $8,000. It was assumed this was done to offset raw material cost increases and to help boost the poor profit margins of EVs. By matching the

possible price reduction from the tax subsidy, this was a convenient maneuver to boost profitability. We thought the following comment from Resources for the Future, a clean energy research organization, in its review of the IRA and EVs interesting. They wrote: "Research has shown that in cases like these, most, if not all, of the incentive is passed through to the vehicle purchaser, meaning that the manufacturers and the dealer generally do not raise the base price of the vehicle in response to the available tax credit." Conveniently, GM and Ford EV prices were increased before the IRA's passage so the move would not draw attention.

A solid analysis of the EV provisions included in the draft of the IRA bill was prepared by the Anderson Economic Group which consults with the auto business. As far as we can determine, there were no changes to the legislation during the various legislative debates, and the bill was signed into law last week. The Anderson Economic Group's press release headline of their review stated: "At Least Four 'IRA' Provisions Will Negatively Affect Sales of Electric Vehicles." The following are the four provisions they cited.

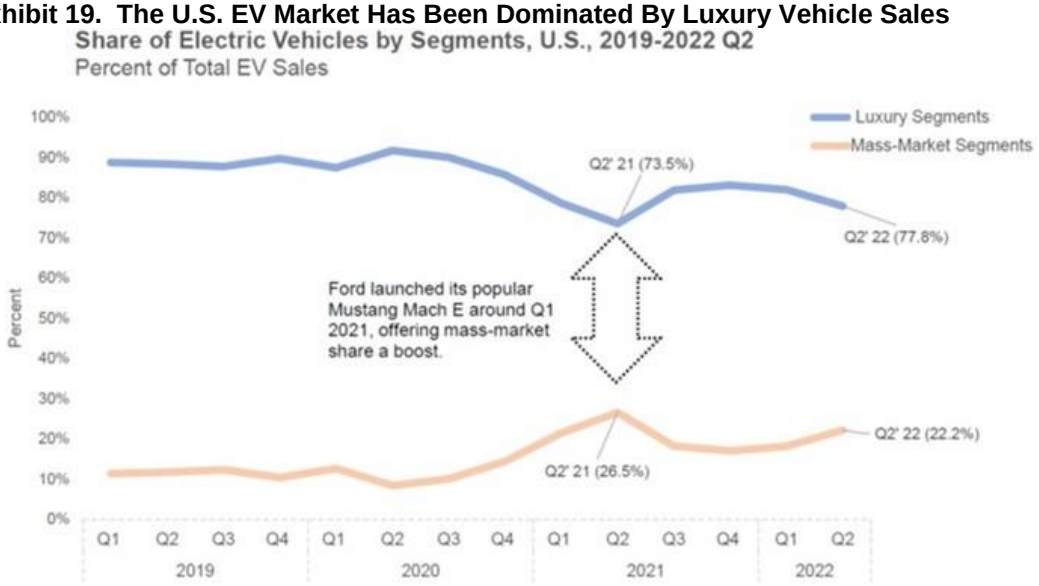
1. **North American Assembly Requirement for EV Credits**
   The IRA limits purchase tax credits to EVs assembled in North America.
2. **Price Caps for EVs**
   IRA imposes MSRP (manufacturer's suggested retail price) limitations on EVs eligible for a purchase tax credit. The bill would allow electric pickup trucks, SUVs, or vans to have an MSRP of up to $80,000, and a lower $55,000 for other vehicles. This is lower than the typical selling price of an EV.
3. **Battery Component Requirement**
   In a complicated section of a complicated bill, the IRA restricts EV purchase tax credits to those vehicles that meet a sliding scale of battery component sourcing in North America.
4. **Modified Adjusted Gross (MGAI) Income Thresholds**
   The bill limits new vehicle tax credits to those taxpayers who meet income thresholds of $150,000 for single and $300,000 for joint filers. These thresholds are defined by "modified adjusted gross income," or MAGI, which is an obscure concept for most taxpayers. Among other things, calculating MAGI typically involves adding back deductions for student loan interest, passive losses, IRA contributions, and other adjustments. These additional calculations often make the figure larger than one's adjusted gross income.

Other analyses pointed out that the various provisions of the legislation do not all come into effect at the same time. Some restrictions apply from the signing date to the end of this year. Others are effective starting January 1, 2023, while others, such as battery composition restrictions do not happen until 2024.

The most important initial tax credit restriction is the requirement that vehicles must be assembled in North America, which cuts out EVs sold by Hyundai, Porsche, Toyota, and Kia. That leaves only 21 EV models available for buyers for the rest of 2022.

Starting next year are limits on the income of buyers and price caps on EVs. Additionally, the sales caps on Tesla and GM are ended, making their EVs eligible for the tax credit. The income and price caps are designed to limit the credits going to high-income buyers, especially Tesla models. The Anderson Economic Group produced the chart below showing the share of the EV market represented by luxury vehicles versus mass-market sales.

Exhibit 19. The U.S. EV Market Has Been Dominated By Luxury Vehicle Sales



Note: The analysis is based on unit sales of battery electric vehicles (BEVs) each quarter. BEVs include vehicles such as all Tesla models, Ford Mustang Mach E, Hyundai Ioniq 5, etc.

Source: Automotive News Data Center (U.S. Light Vehicle Sales by Nameplate); IHS Markit (Segmenation)
Analysis: Anderson Economic Group

Source: Anderson Economic Group

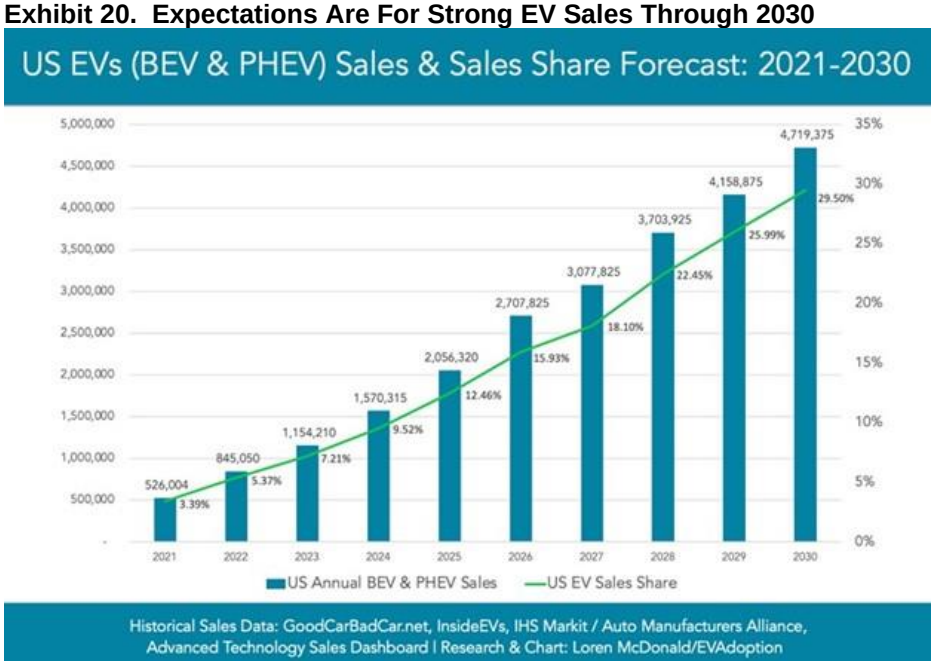
A key point for EVs in the language of the IRA is the industrial policy objective of building U.S. EV supply chains for the manufacture of both batteries and vehicles. This is the purpose of the restrictions on where vehicles can be assembled to qualify for the tax credits. The phase-in for battery requirements will further that policy. As pointed out above, the North American restriction will limit EV choices for buyers initially, but hopefully expand the number of choices later. The battery limitations are more complex and meeting them will be a challenge and could limit EV sales.

U.S. EV supply chains depend on imports of critical minerals, especially for batteries. The legislation disallows tax credits for EVs with a majority of their battery components imported, especially from "foreign entities of concern" such as China. However, most battery manufacturing happens overseas. China hosts 80% of the world's manufacturing facilities for lithium-ion batteries, while the U.S. has only 5.5%.

Specifically, the bill requires a percentage of the battery's minerals and manufactured parts to be produced domestically or by countries with fair-trade agreements, such as Chile and Australia. That percentage starts at 40% in 2023 and ramps up to 80% in 2026, only four years away. Will this requirement congest supply chains and drive costs up in the near term, at least until domestic battery-manufacturing plants are built and contracts with fair-trade countries have been finalized? Could these short-term cost increases boost EV prices beyond the price caps? These are open questions.

The following two charts help assess the issue. The first chart is the latest U.S. EV market forecast through 2030 by EVAdoption, LLC. It shows a healthy growth rate in sales, but we wonder what modifications to this forecast are necessary following enactment of the IRA. Projected EV sales go from under one million in 2022 to 4.7 million in eight years.

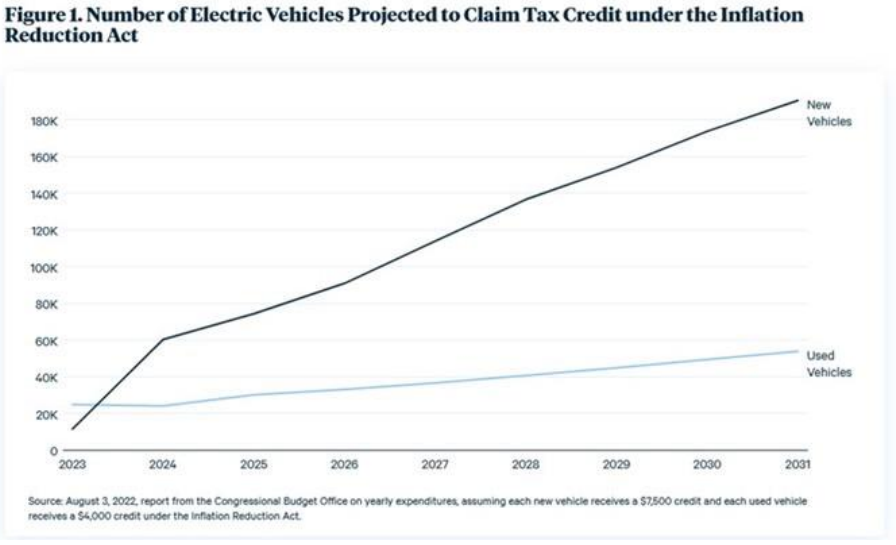
Exhibit 20. Expectations Are For Strong EV Sales Through 2030



Source: EVAdoption LLC

The more telling chart comes from the Congressional Budget Office review of the IRA provisions for the tax credit for new and used EVs. It sees only about 10,000 EVs sold in 2023 receiving the full $7,500 tax credit. That jumps to 60,000 EVs in 2024, before commencing a steadily rising number of EVs through 2030. The 2023 and 2024 tax credit eligible EVs represent only 1% and 4%, respectively, of EVAdoption's forecast for total U.S. EV sales in those years. How important is the $7,500 tax credit for EV sales, especially after auto manufacturers raise prices to offset the credit? Does this forecast suggest that the EV market may not grow as fast as many expect?

Exhibit 21. Number Of EVs To Get Full Tax Credit Is Small In Early Years



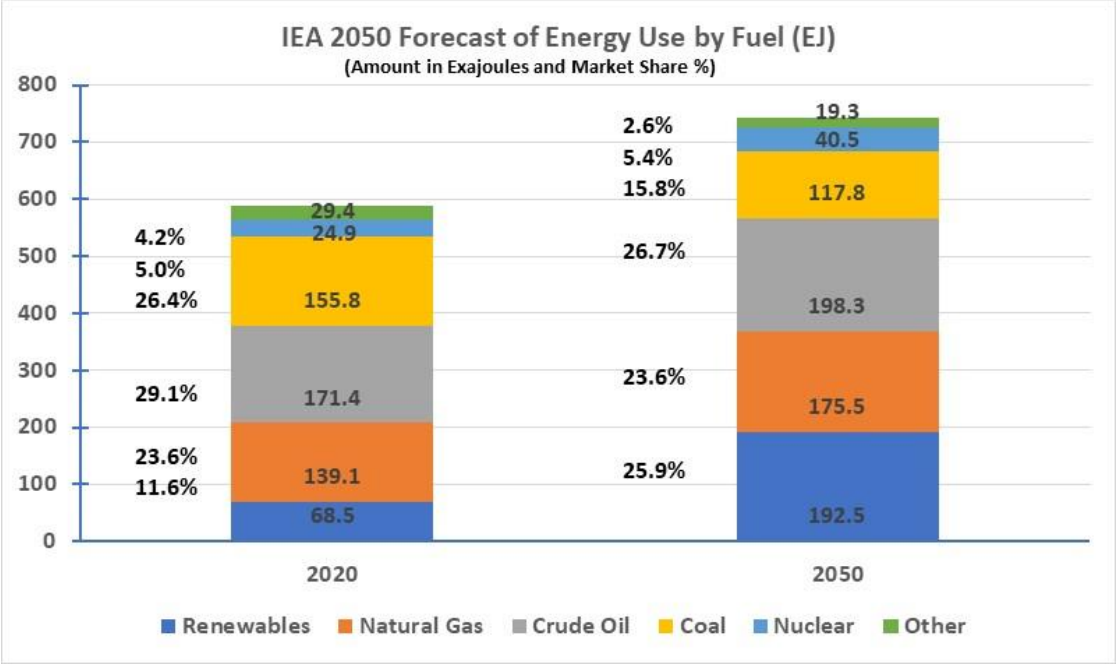
Source: Congressional Budget Office

As we always warn about economic and tax legislation, the details will determine the success of the industrial policy Congress is pushing. As for EVs, the IRA details may disrupt the market much more in the near term than policymakers envisioned.

Interesting Long-Term Energy Outlook From IEA

As we were researching our article on demographics and energy use, we relied on the International Energy Agency's (IEA) latest outlook based on 2021 data but published earlier this year. In the report was a table of world energy demand by fuel supply that showed the data for 2010, 2019, 2020, 2030, 2040, and 2050. The graph below focuses on the world's energy use, measured in exajoules, by fuel for 2020 and 2050. It is not surprising that world energy consumption will grow over the next 30 years. The IEA estimates that world energy consumption will grow at a 0.8% annual rate.

Exhibit 22. The IEA Sees Fossil Fuels Supplying Large Portion Of 2050 Energy



Source: IEA, PPHB

Interestingly, natural gas use grows at the same rate as overall energy growth. Crude oil consumption grows at the slightly lower rate of 0.5%. Renewables are the big winner showing a 3.5% annual growth rate, while coal is the big loser having its demand fall at a -1.0% rate. Climate activists' demands drive the rapid renewables growth rate as politicians respond by providing taxpayer money via subsidies to developers.

You see the result of the different fuel growth rates when examining the market share percentages alongside the columns of actual fuel consumption. Renewables see a market share gain from 11.6% to 25.9%, while natural gas remains stable at 23.6%. Crude oil lost a small market share (-2.4%) and coal was the big loser dropping from 26.4% to 15.8%. Overall, fossil fuel's share of total primary energy only declines from 79.1% to 66.1% over 2020-2050, 30 years.

Another interesting data point was the share of crude oil demand that came from non-energy use (petrochemicals) which is projected to increase from 28.5 to 38.2 EJ. In terms of the share of the crude oil demand, non-energy use grows from 16.6% to 19.2% of a smaller total consumption in 2050. This non-energy use was the point of ExxonMobil's CEO Darren Woods' comments in CNBC's documentary when he commented on the planning scenario his company ran to see what happened to its business if all cars in 2040 were electric. Woods shocked the CNBC reporter by stating that global oil demand would not be destroyed, nor would ExxonMobil's business, primarily because of the growth in demand for petrochemicals and other non-transportation demands. The above data and chart are a sobering view of the energy market's future, prepared by an organization that caters to the green energy demands of European governments and energy companies.

Contact PPHB:
1885 St. James Place, Suite 900
Houston, Texas 77056
Main Tel: (713) 621-8100
Main Fax: (713) 621-8166
www.pphb.com

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