Kopernik
Global Investors, LLC

Lord Make Me Green…But Not Yet

The title above is a play on the quote by Christian theologian Saint Augustine of Hippo, “Lord make me chaste, but not yet,” where he expresses a prayer and sentiment that he would like to be pure and good, but not until he has partaken of earthly pleasures (which conflict with that purity) first. Whether St Augustine was really talking about himself or pointing out how most other people treat the conflict between sin and salvation, we will leave to religious scholars. However, we think it has a modern parallel in terms of the energy transition movement and “net-zero” pledges we are seeing today. This is timely now because the world’s leaders are now attending COP26 in Glasgow where they are sure to be making lots of new pledges to address climate change.

There is no doubt that the need to address the causes and effects of climate change has captured a significant amount of mindshare around the globe. Think tanks, companies, universities, government officials, economists, Swedish teenagers and even investment analysts are all trying to forecast and opine on where, when, if, and how this issue will be resolved and what the effects will be on their work and their communities. As investment analysts, we are particularly interested in how this will play out in the markets and whether there are any profitable opportunities to be had and/or risks to be avoided.

The intention of this paper is not to theorize on whether climate change will or will not be persistent, catastrophic or otherwise. Hopefully, we will not trigger too many political emotions although we know there are passionate arguments surrounding this issue. As investors and stewards of other people’s capital, we are in the business of earning returns. We are interested in what is likely to happen as well as thinking probabilistically on what could potentially happen and whether those scenarios present investment opportunities. We are less interested (but not uninterested) in what should happen.

For those of you who don’t intend to follow us through this whole white paper, we will give out the spoiler now. Basically, we feel that fossil fuels will be with us for a long time and that not only are most of the world’s reserves not at risk of being stranded, but that the industry in fact needs to find more oil and gas in the future which will require incentive price economics to come into play. While an energy transition definitely seems underway, it will be very slow, as most past energy transitions have proven to be.

As value investors, we are frequently confronted by clients and others in the business who are shocked at the “riskiness” of some of our holdings. Mines in the Congo and Kyrgyzstan? Farms in Ukraine? Anything in Russia? Nuclear energy? Fossil fuels? Are we insane? Maybe a little, but we prefer to think we are simply evaluating the obvious risks in our holdings more accurately than the market, which tends to be very emotional. It’s not that we don’t think these investments have risks. They are just not nearly as bad as the market has discounted, so we view the risk/reward in them as heavily skewed in our favor.

Investing in fossil fuels is one of those areas where we have disagreed with many in the market for some time. Our Global All-Cap portfolio weighting in fossil fuels is about 12% while the MSCI ACWI Index weight (and most “active” investors as well) has been closer to 3%. This is up a bit from a few years ago but we have had considerable exposure to fossil fuels. We realize it takes less courage to tout fossil fuels at a time like now when oil and gas prices have been skyrocketing but rest assured, we have felt this way for quite a while.

It seems like virtually everyone from cities to countries to corporations is setting targets to reach “net-zero” emissions. Over 3,000 companies and countries representing 89% of global emissions have “committed” to reaching net-zero. We put the word “committed” in quotes because that commitment can mean very different things to different people. Also, those commitments, like St Augustine’s chastity, are far out in the future. Even the United Arab Emirates recently declared a net-zero pledge for the year 2050, but not before they increase oil and gas production by 20% first. Let me be green…but not yet.

It is easy to make a pledge for somebody else to fulfill 30 years from now. That is why virtually everyone is doing it. These are low barrier to entry virtues. If everyone can do it, it can’t be that hard. Unfortunately, the problem is much more difficult to solve, and we might say, it is near impossible.

We can see how someone looking at the headlines might assume that oil and gas are going away soon. Virtually any newspaper, magazine or news service has stories daily about climate change and the necessary energy transition. Anyone with a Bloomberg terminal is treated to an endless stream of articles proselytizing for the new energy economy. Most treat the subject as a fait accompli, that because it needs to happen, that it will happen. The problem with this is that it leads to starting with a conclusion and then building models and forecasts on how that must happen, ignoring how unlikely or difficult it might be.

For example, below are a couple of headlines touting the end of oil from the Economist magazine, 17 years apart. We suspect it will be a while before they dust this one off again.

For more fun and games with forecasts look at the list below. All of these predictions were supposed to happen in or by the year 2020. Maybe 2020 didn't turn out to be such a bad year after all, compared to what was supposed to take place[1]:

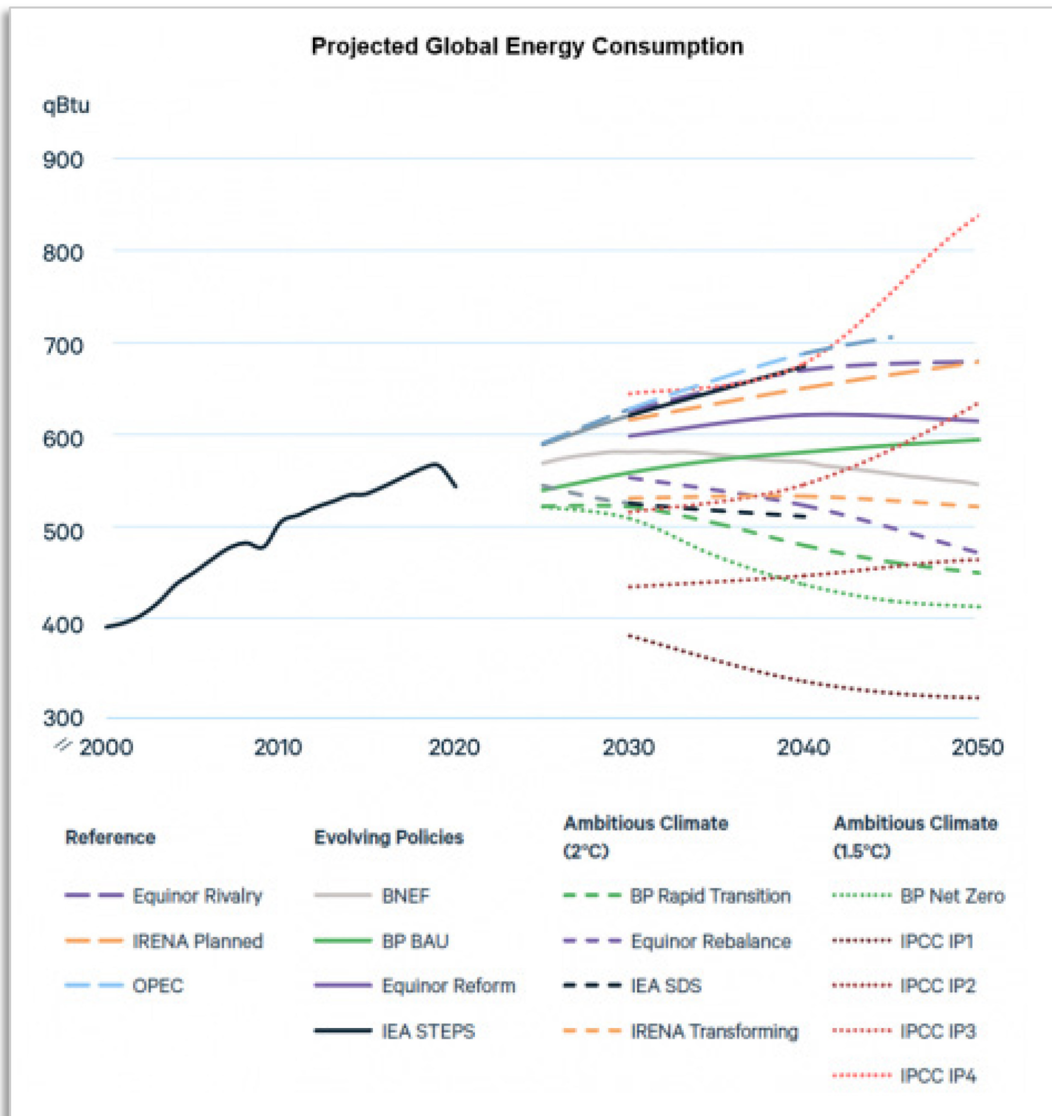
- Maldives completely under water.
- NY West Side Highway under water.
- Children in the UK have never seen snow.
- Britain plunged in "Siberian" climate.
- Northern Hemisphere in 10th year of drought.
- North Pole ice cap gone.
- Mass migration from Scandinavia to the Middle East and Africa as Northern Europe becomes uninhabitable.
- Severe storms break levees making The Hague unlivable.
- Failure of delta levees on Sacramento River disrupts aqueduct so water can no longer be transported to Southern California.
- Gulf Stream is disrupted by Greenland ice melt, completely changing the climate of Eastern U.S. and Northern Europe.
- Mega-droughts in Southern China and Northern Europe.
- Europe's climate is more like Siberia's.
- Bangladesh uninhabitable causing emigration crisis with India and China.
- Widespread famine in China.
- Global crop yields fall by 10-25%.
- Mass migration from Holland and Germany to Spain and Italy.
- Fifty million climate refugees.
- Snows of Kilimanjaro vanish.

[1] Sources vary from news organizations, professional experts, analysts and academia.

The point of this is not to mock poor predictions (although some of these are amusing in hindsight). It's that the media tends to breathlessly report doomsday forecasts about many subjects, and frequently these find their way into the financial markets. We predict that there will be many of these headlines coming out in a couple of weeks after the COP26 meetings in Glasgow, along with many more net-zero commitments. If our prediction is wrong, feel free to mock us in turn. We have found that most predictions of the end of the world haven't come true.

But making predictions is hard (especially about the future, as Yogi Berra once said). Extrapolating trends and assumptions out over long periods of time can lead to very divergent outcomes. As a result, there are myriad models out there forecasting how and when the energy transition will happen, with some predicting scenarios that could be either very good or disastrous for fossil fuels.

The charts below (from RBN Energy, an energy research and consulting company) show the wide divergence of possible outcomes based on relatively small differences in assumptions, extrapolated over very long time frames. If they show anything, these examples of "spreadsheets gone wild," demonstrate that the science is far from settled.



Source: RFF

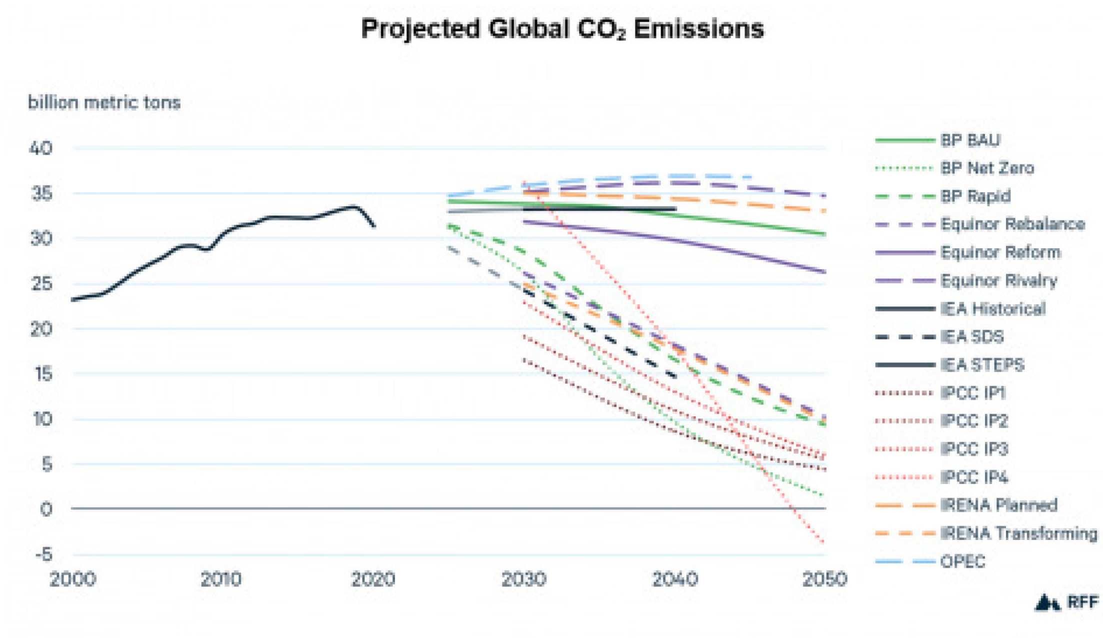
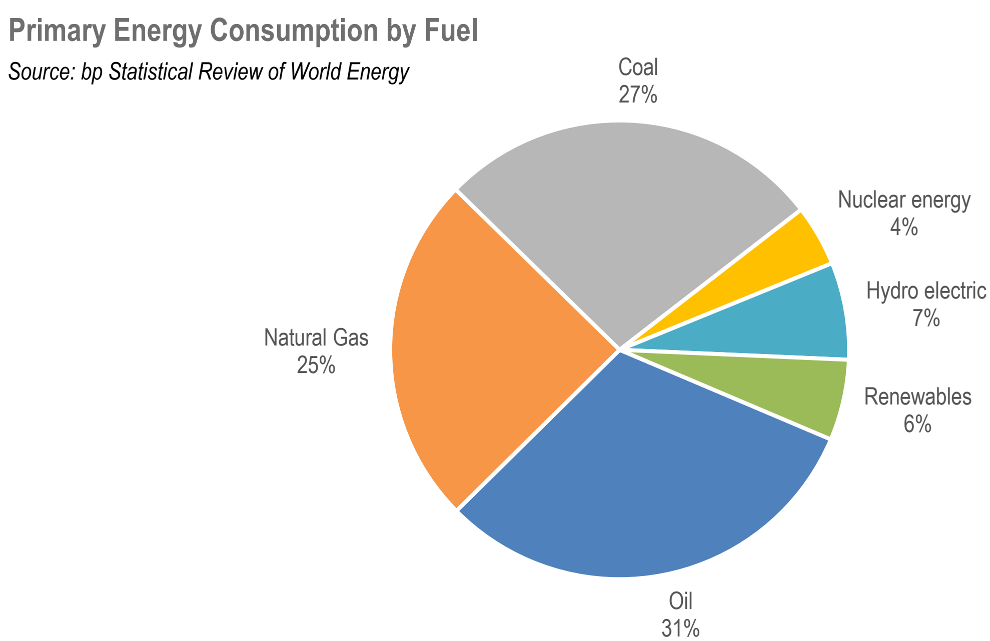


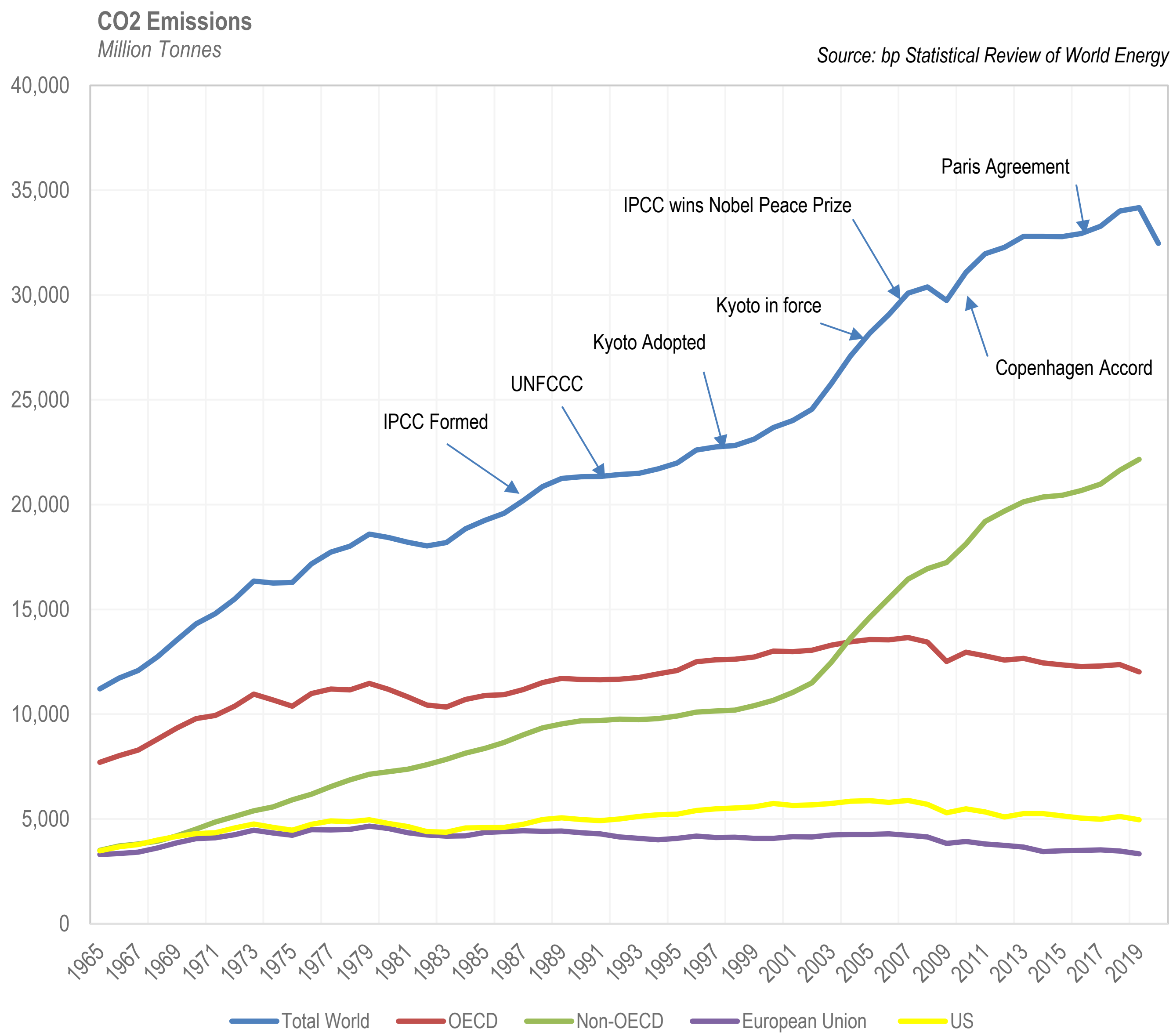
Figure 4. Projected Global CO_2 Emissions from 16 Other Forecasts. Source: RFF

To start to appreciate the enormity of the challenge, consider the chart below. The green sliver is renewables which made up 6% of global energy consumption in 2020. That is still a very small percentage, especially as the world has spent over $3.6 trillion over the last ten years growing this from 2% to 6%. This is about the same amount of spending as the entire oil and gas industry (56% of energy) spent over the last seven years.



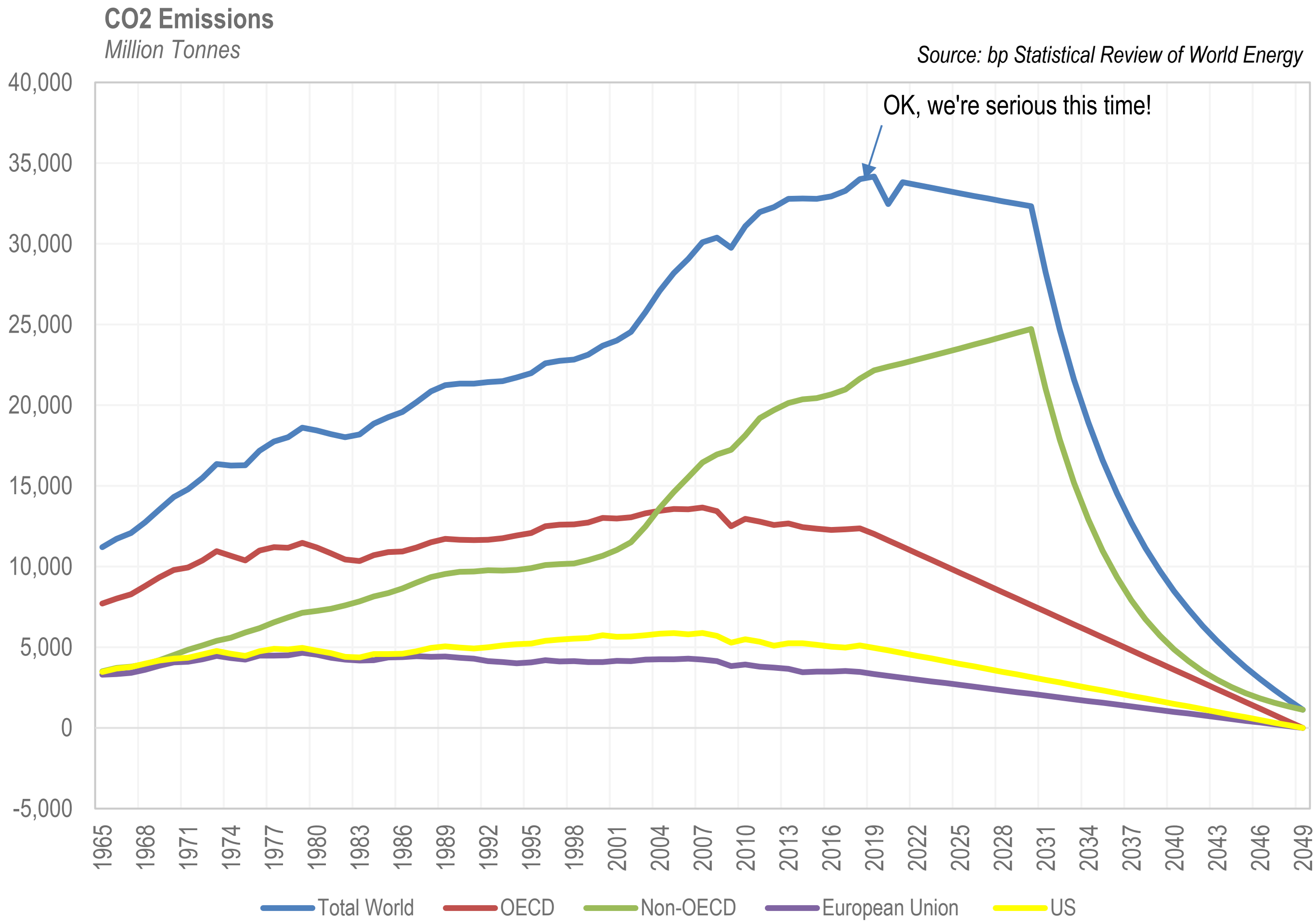
Next, consider the chart below which shows historical global CO2[2] emissions in the blue line. As far back as 1965, the only things that have put any dent in CO2 emissions have been the global financial crisis, from which CO2 rebounded within a year, and the Covid pandemic, from which CO2 looks to recover within a few more months. This, despite the world getting together every year for 26 years (the 26 in COP26) to discuss the crisis and make pledges to "do something," This reminds us of the joke about the guy who says, "I set a goal to lose 10 pounds this year. Now I only have 15 pounds to go."

Also notice in the chart below, even if the OECD countries went to zero emissions today, we would still be where we were in terms of total emissions as when we first started talking about this. This is because the developing world (green line) has grown dramatically and looks to do so for at least the next ten years.



Yet we are supposed to believe that this chart will look like the one below going forward? The required reversal and steep slope (especially in that green line) makes us a bit skeptical.

[2] Carbon dioxide



We focus on CO_2 here because it is the biggest contributor to greenhouse gases and is most affected by using fossil fuels. To see the levers of how we can reduce the use of fossil fuels we start with the following formula:

Population x GDP per Capita x Energy Intensity of GDP = Energy Demand

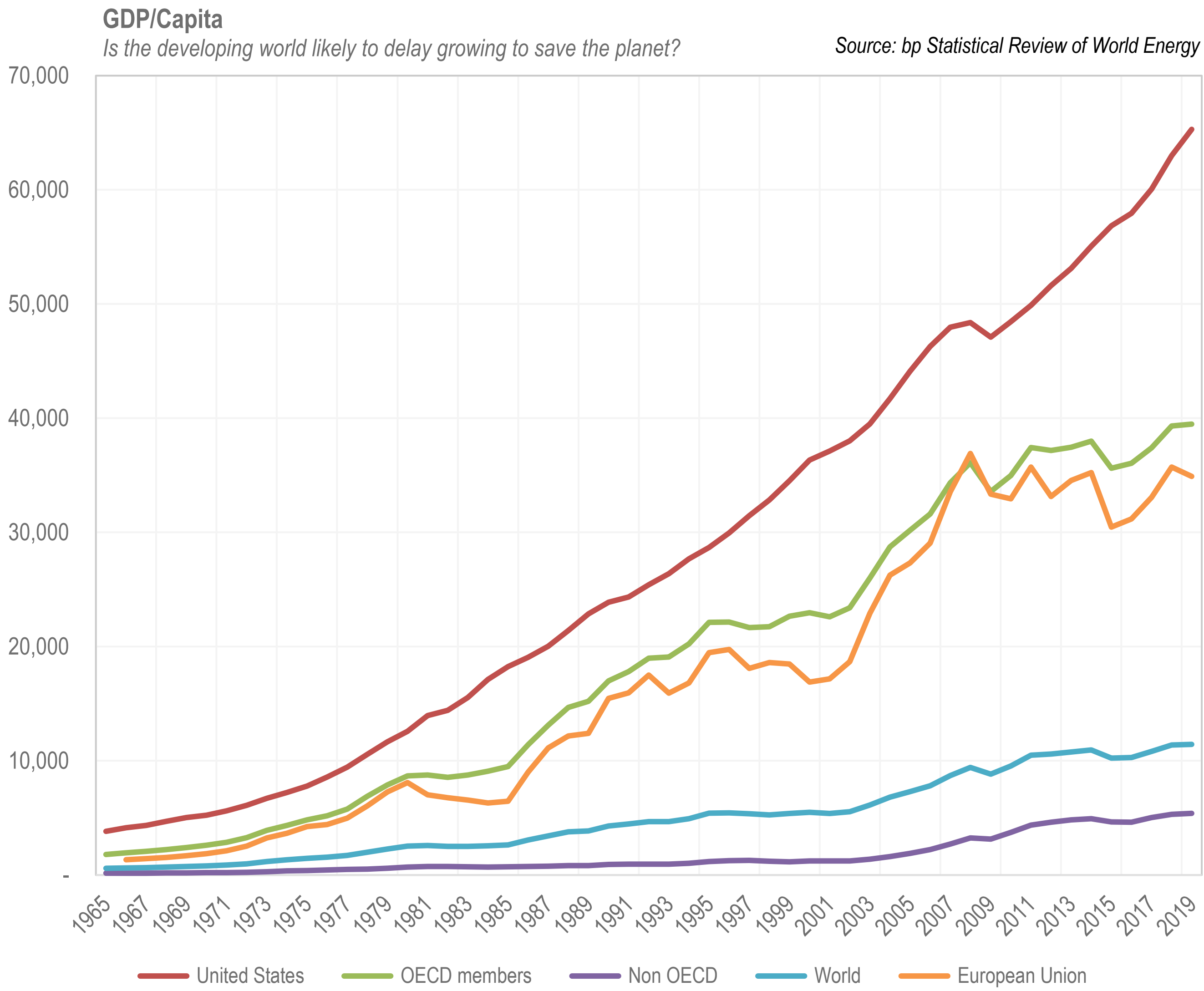
And expand it to:

Population x GDP per Capita x Energy Intensity of GDP x Fossil Fuel share = Fossil Fuel Demand

While there are some on the lunatic fringe of the environmental movement that advocate for extreme population control as a solution to the climate crisis, this is probably not a viable policy option. Besides, as Thanos discovered, the Avengers would never allow it. So, we should probably assume that the global population continues to grow going forward. This is headwind number one.

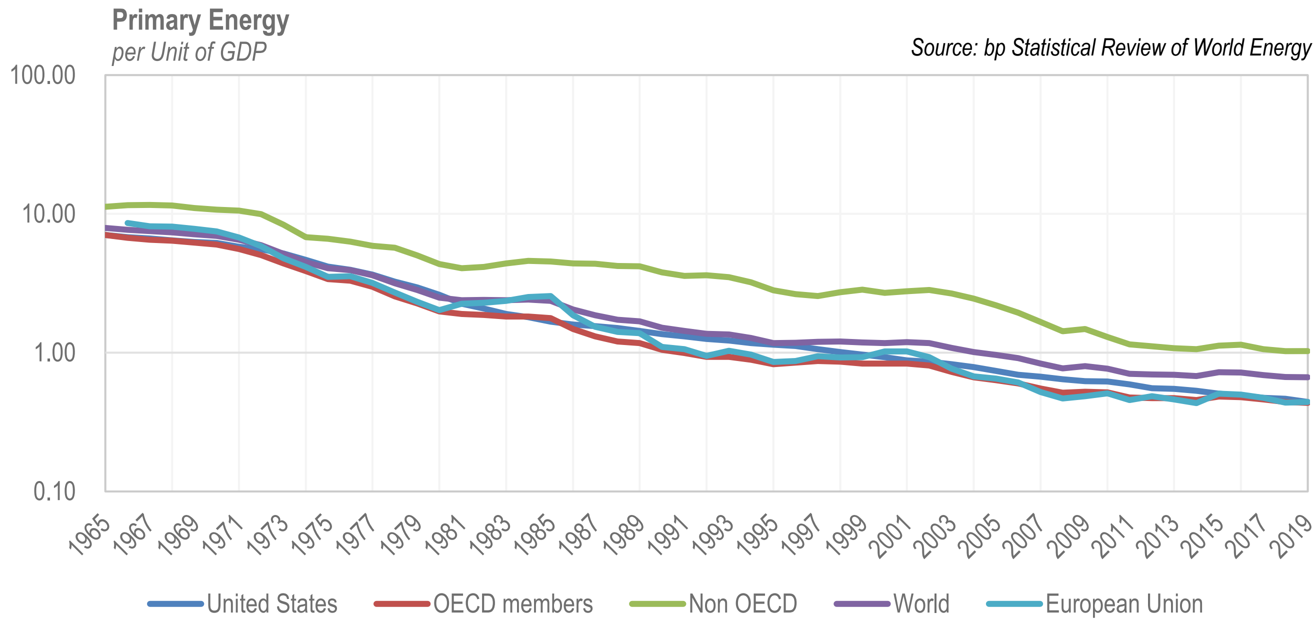
GDP[3] per Capita is a strong driver of energy demand growth and another factor that would go a long way to reducing emissions if it were to go negative. However, this too is probably not a good policy option as no country wants to stagnate and the developing world still wants and needs to grow materially. In addition, the developed world, particularly the U.S., is unlikely to sacrifice its standard of living to give its carbon budget to poorer countries. This is headwind number two.

[3] Gross domestic product

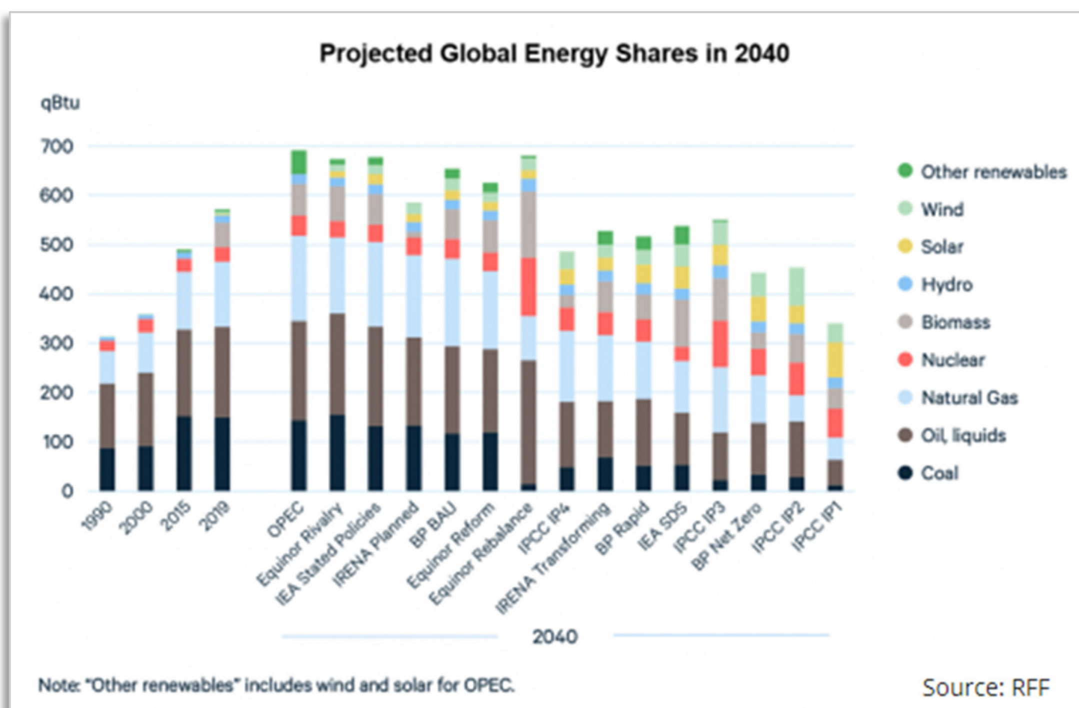


Despite our dismissal of the first two factors above, they have proved to be some of the most effective ways so far to reduce CO2 emissions. Despite the narrative of Europe's environmental bona fides, a good deal of the EU's CO2 declines over the last ten years have been a result of virtually no population growth and very low economic growth, particularly in the southern countries and Ukraine (the decline in Ukraine CO2 of 86 million tons from 2009-2019 was greater than that of Germany and about 20% of the total decline in Europe emissions). All of the flattenings or declines in the CO2 graph have coincided with fairly severe recessions.

The energy intensity of GDP does indeed show a declining trend over time, although not enough to overcome the previous two factors mentioned, hence the inexorable rise in total energy demand. As countries mature, however, energy efficiency gains seem to get harder to come by. For example, Europe has had energy efficiency improvements (Primary Energy per Unit of GDP) of over 4% per year over the long term but these have slowed to only 1% over the last 10 years. Globally energy efficiency has been about 1.8% over the last ten years. There is room for this to get better through efficiency mandates and the developing world coming around to our economic model of making Tik-Tok videos rather than making things. However, even this will only serve to slow the growth of energy use, not make it level off, much less decline.



So, if the first three factors above still add up to positive growth in total energy consumption, it is left to share of energy from fossil fuels to go down materially (maybe to zero) to solve the climate crisis. The chart below (again from RBN Energy) shows various estimates of market shares from different energy sources in 20 years. Note that the most aggressive estimates below for fossil fuel declines also assume that total energy consumption not only doesn't grow, but actually declines over the next 20 years. We need the total pie to shrink, not only the share of energy from oil, gas and coal. Even the higher estimates assume total energy consumption growth of under 1%/year, versus 2.5% over the long term and 2% over the last ten years. We feel pretty comfortable dismissing the models on the right side of this graph.



There are many models out there showing how we are going to get to net-zero, but we will use here the one published by the International Energy Agency (IEA) earlier this year as an example of how the world is expected to make this happen. We use the IEA report (which can be found at https://www.iea.org/reports/net-zero-by-2050) because it is a relatively unbiased organization, and it is the "road map" that many are turning to and using as evidence that "it can be done." The report runs 224 pages and has 36 authors, countless other contributors and 83 peer reviewers from academia, government and industry.

Let's go through some of the main assumptions in this report and see if we can handicap the likelihood of them happening.

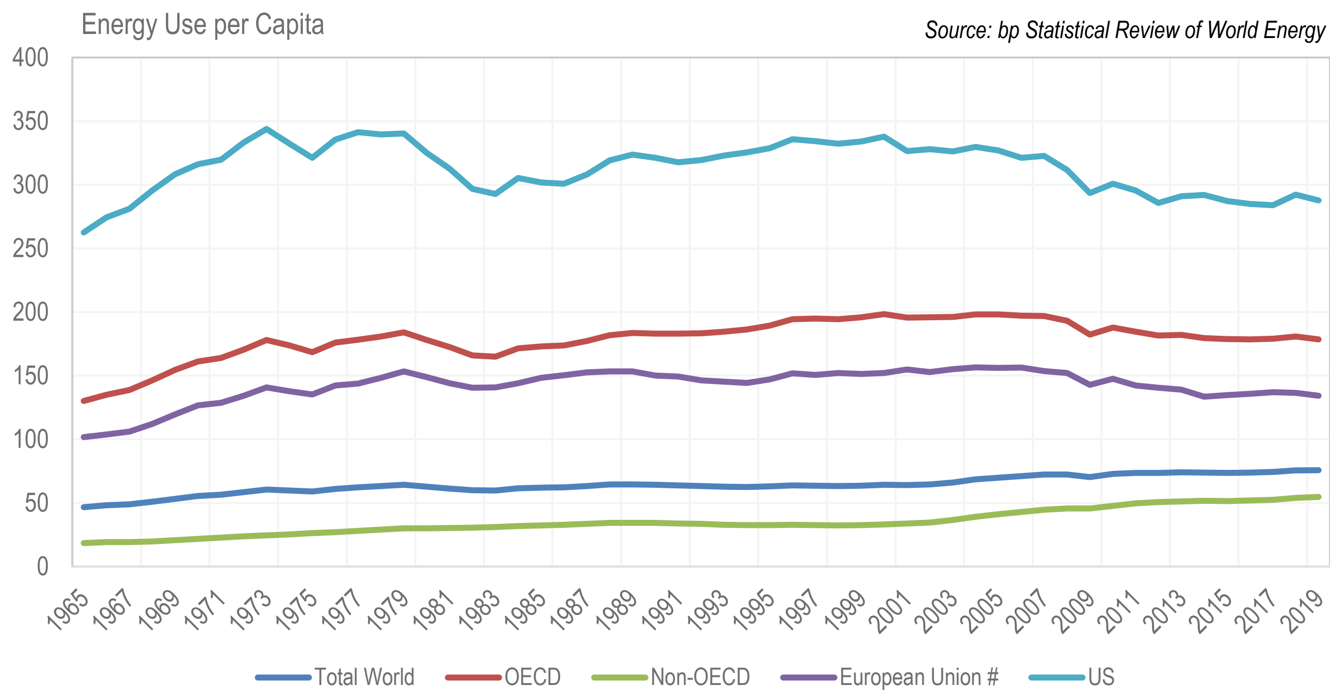
The first major one is that a global economy that is 40% bigger in 10 years will be using 7% less total energy. By 2050, the global economy will be over twice as big and population 2 billion higher, yet energy demand will be 8% lower than today. This will require an acceleration of efficiency gains from 1% to 4%/year, despite those gains actually going in the opposite direction over the last 10 years. It also assumes 785 million people who currently have no access to electricity and 2.6 billion people without access to clean cooking are provided these. Somehow adding this many people to the energy economy is going to result in lower total energy use?

It is more likely total energy consumption will be much higher 30 years from now. Automobile penetration in China is where the U.S. was a hundred years ago and India's auto penetration per capita is virtually nil (although you wouldn't know it from the traffic). These countries will probably never get to U.S. and Europe levels of auto use, but the direction is most likely up for them.

Consider the picture below. The black stuff on the wall behind the stove is indoor air pollution. According to the World Health Organization, four million people a year die prematurely from breathing this as billions of people around the world cook like this. Ironically, this would probably qualify as "clean energy" as they are using wood, which is theoretically a renewable resource. Someday this woman will want to upgrade to a hotplate, stove, refrigerator and maybe even splurge on a Keurig machine. She probably already has a smartphone and social media accounts. Are we to tell this woman, "How dare you!" for wanting to enjoy the luxuries of the early 20th century? We feel safe in assuming total energy demand will continue to grow, as it has throughout history. Energy is the sine qua non of civilized society and the arc of civilization continues to be upward.

The IEA roadmap lays out several "pillars" of the transition to net-zero. These include Energy Efficiency, Behavior Changes, Electrification, Hydrogen, Bioenergy, Wind and Solar, and Carbon Capture. Most of these include very ambitious plans.

Behavioral changes, which account for about 8% of CO2 reductions, include such things as lowering the thermostat, limiting driving speeds (don't tell Sammy Hagar), taking the bus rather than the car, and traveling by high-speed rail instead of air. These are all doable but require quite a change in people's habits as well as major changes in infrastructure. Unfortunately, things here are not moving in the right direction.



Energy use per capita in the U.S. and Europe has been flat for ten years. As evident in the chart above the U.S. has the most room to improve efficiency. However, this does not seem to be happening. The share of SUVs[4] in the car mix continues to climb, average home size is growing, families continue to move to the suburbs, and people are increasingly travelling to far-off places on vacation (at least they were before COVID). All of these trends could well reverse but these kinds of societal shifts usually occur very slowly and the IEA map requires they start now and go fast. In addition, if industrial production offshored to China over the last 20 years starts coming back, energy use per capita would climb.

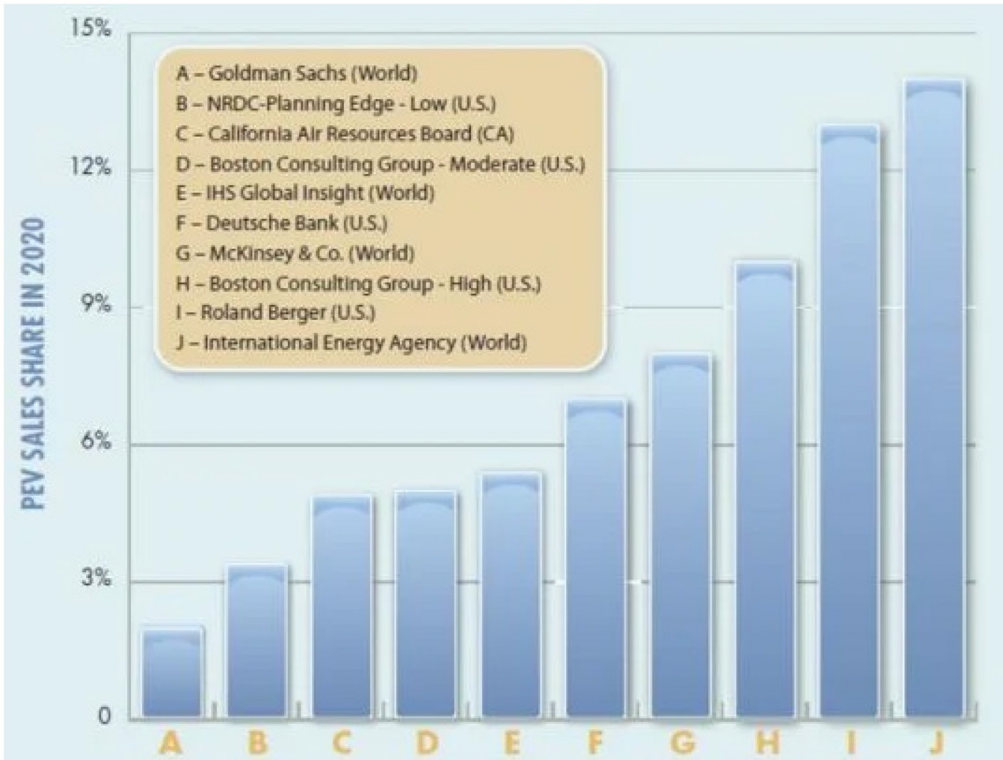
Energy Efficiency is the next pillar and includes primarily retrofitting the world's housing stock to be "carbon neutral" and transitioning to all-electric vehicles. In the IEA's scenarios these need to be front loaded, meaning they need to happen aggressively and soon. The urgency on these is due to them being based on technologies that actually exist as opposed to other solutions that still need to be invented. We feel that these things will be very slow to happen.

For example, the needed changes to home energy systems include replacing gas furnaces, water heaters, stoves and ovens with all electric appliances. Existing electric appliances would have to be replaced with the highest efficiency models available today. Yet gas furnaces last 20 years, stoves 15 years and water heaters 10 years meaning only 5-10% of the existing stock would be replaced per year. And that's if total bans on gas appliances were enacted globally. Getting appliances replaced early would require massive subsidies. Even then we doubt the furnace and appliance industry is ready for an immediate shift of over half their unit sales from gas to the most efficient electric models.

The next part of the efficiency drive will come from the shift to electric vehicles ("EV"). The IEA roadmap calls for over 60% of 2030 automobile sales globally to be EV or plug-in hybrids. The share in advanced economies would be over 75%. In fact, sales of EVs do seem to be growing quickly. This is the trend that has launched a dozen SPAC's and driven Tesla's market cap up to a trillion dollars. But are they really taking over this rapidly?

Below are forecasts from some of the most sophisticated banks and consulting companies from 2010 on what they expected EV shares would be in 2020. Actual EV sales turned out to be 4.6% of global sales and 2% in the U.S. Most of these were way off the mark.

[4] Sport Utility Vehicle



Source: California Plug-In Electric Vehicle Collaborative 2010

A lot has been made of the rapid recent growth of EV sales in Europe, particularly Norway, and China. Norway has indeed shown amazing growth in EVs which make up about 80% of recent sales. But these have come with very large subsidies. Some studies have shown that the value of subsidies in Norway amount to $50,000-$60,000 per car. With this level of subsidies, we wonder who is still buying an internal combustion car? Norway can afford this as it is a rich country (How did it get that rich? Must be the salmon farms). There are very few countries in the world that can afford this level of government largess.

An interesting side fact, despite the enormous growth in EV sales in Norway, they had one of the lowest declines in oil consumption in the world last year (down 2.5% versus Europe down 13.8%, and the world down 9.3%). They may be buying EVs, but they seem to be driving their gasoline cars.

The growth in China has also been impressive. However, most of the Chinese EVs are little more than golf carts, very light and low range. These are hardly the types of cars that will sell in the West. And these also need to be heavily subsidized or incentivized in other ways.

One of the problems with the narrative of EVs taking over rapidly is that people don't really seem to want them. That's why they must be subsidized so heavily. They are expensive and the charging infrastructure simply isn't in place yet. A recent study by the UK House of Commons found that 68% of EV sales in the UK were to fleets, not to private individuals. EVs make more sense for fleet use as they can have common charging infrastructure and tend to take shorter trips, obviating the range concerns. But a Tesla doesn't get you to work, or the grocery store any faster so from a utilitarian standpoint, people just don't need them.

The other big issue with growing EVs this fast is the need for raw materials. For example, an EV uses 140 pounds more copper than an Internal Combustion Engine ("ICE") car. Getting to the IEA's 350 million EV target for 2030 would require two years of total current global copper production. And this is before factoring in a large copper demand increase from wind energy. Cobalt, lithium and nickel show even greater demand increases and supply deficits. Satisfying anywhere near this demand will require huge increases in commodities costs, which in turn will greatly increase the cost of the EV.

Even if the very aggressive (although unlikely) sales of EVs come to fruition, it doesn't spell the near-term death of oil. Consider the table below. Assuming total U.S. auto sales and total cars on the road stay flat (scrappage equals new sales) and market share of EV sales goes to the IEA's 75%, the amount of gasoline displaced is only about 25%. As gasoline is about 25% of oil demand, this means a hit of only 6% to U.S. oil consumption. Not nearly the disaster we are led to believe. This assumes there is no growth. If oil demand grows at the rate of the last ten years (0.8%/yr.) we would still end up back where we started, despite this unrealistic market share capture of EVs.

	2021	2022	2023	2024	2025
Total Sales	17,000,000	17,000,000	17,000,000	17,000,000	17,000,000
EV % of Total	2%	10%	20%	30%	40%
EV Sales	340,000	1,700,000	3,400,000	5,100,000	6,800,000
Cars on Road	290,000,000	290,000,000	290,000,000	290,000,000	290,000,000
EVs on Road	1,300,000	3,000,000	6,400,000	11,500,000	18,300,000
EV Share on Road	0.45%	1.03%	2.21%	3.97%	6.31%

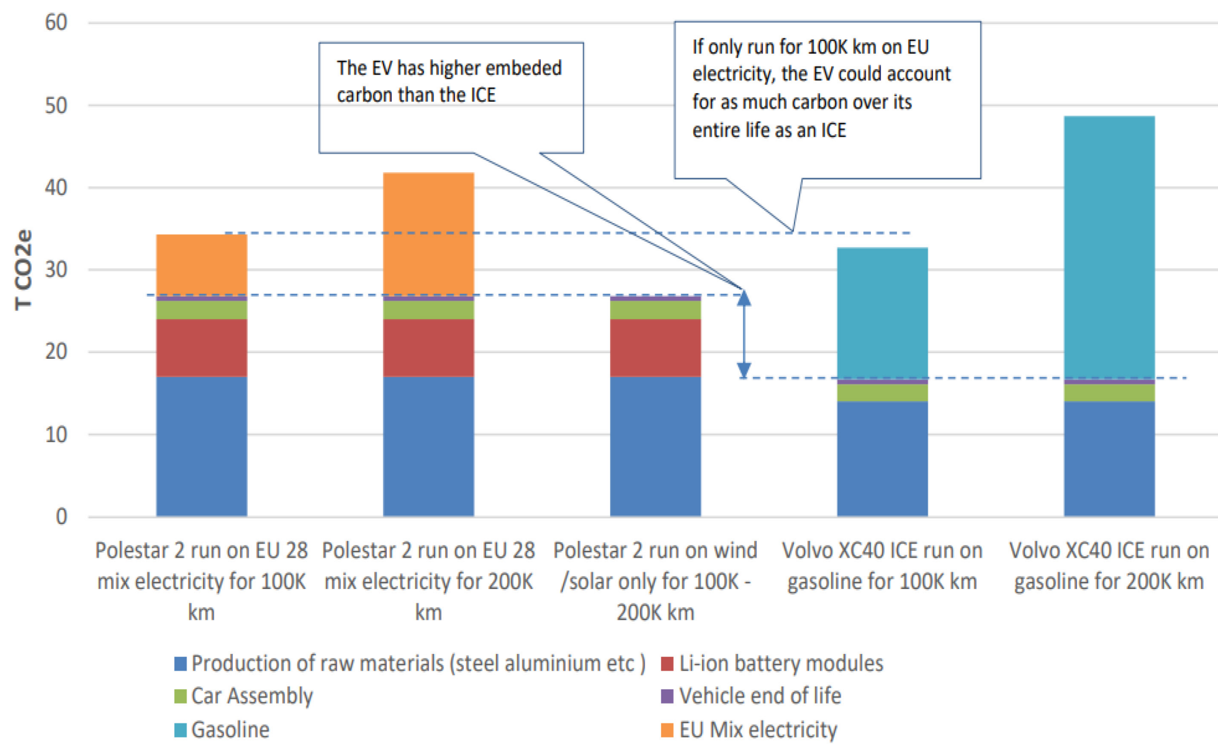
	2026	2027	2028	2029	2030
Total Sales	17,000,000	17,000,000	17,000,000	17,000,000	17,000,000
EV % of Total	50%	60%	70%	70%	75%
EV Sales	8,500,000	10,200,000	11,900,000	11,900,000	12,750,000
Cars on Road	290,000,000	290,000,000	290,000,000	290,000,000	290,000,000
EVs on Road	26,800,000	37,000,000	48,900,000	60,800,000	73,550,000
EV Share on Road	9.24%	12.76%	16.86%	20.97%	25.36%

Source: Kopernik

Going electric in heavy truck transportation and aviation seem very far away and will require some significant technological advances/discoveries. This could happen with heavy trucks over the very long term, particularly if hydrogen becomes a viable solution, but we see no solution in long-range air transport on the horizon. The only way to decarbonize aviation is to shift it to high-speed rail which, if the California High-Speed Rail project is any indication, is neither a cheap nor quick solution.

Our last point on EVs is that for them to really reduce CO2 emissions, the electricity that powers them needs to become zero carbon. The chart below from Jefferies Research shows that unless the electrical grid is decarbonized and/or the vehicle is driven for over 100,000 miles, the CO2 emissions savings are actually quite low.

Exhibit 1: "Cradle-to-grave" carbon emissions comparison of Polestar 2 (EV) vs. Volvo XC40 (ICE) based on lifetime use scenarios of 100K km and 200K km (tonnes of CO_2 equivalent)



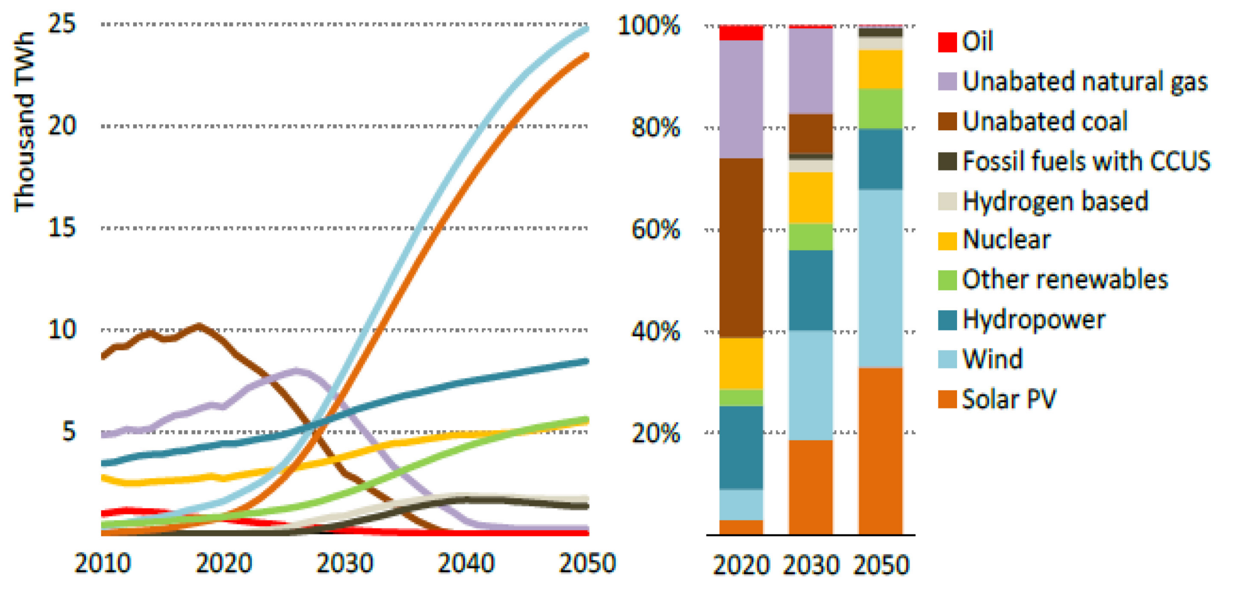
Source: Polestar. Note: Data is based on 2020 models of cars using EU methodology of life cycle assessment; assumes 158-179g CO_2/km for gasoline-use and 75g CO_2/km for EV-use (based on EU28 electricity mix).

This brings us to electrification of most energy use through solar and wind energy as the next major factor on the drive to net-zero. This build out might be the most ambitious assumption in the IEA's road map. They anticipate electricity consumption up 40% by 2030 and 166% by 2050. Keep in mind, this is in a scenario where total energy demand declines, which is highly unlikely. Because the incremental generation will be coming from intermittent sources, this requires a near doubling of capacity by 2030 and a quadrupling of capacity by 2050. If total energy consumption follows historical growth with GDP, these numbers will have to double again unless quite a bit of coal and gas generation is kept around.

This build out requires an immediate quintupling of annual wind and solar builds over current production. Last year, solar and wind builds consumed about 1,000 tonnes of copper out of total copper demand of 23,000 tonnes. Quintupling renewable production would require an immediate 17% increase to total copper supply. It is very unlikely that the copper mining industry could meet this demand, at least until the end of the decade and at much higher copper prices.

The chart below is from the IEA report showing their anticipated shares of electricity from various sources. Their scenario calls for most coal generation to be phased out by 2030. This despite China, the biggest coal generator in the world by far, signaling that they are still building coal plants and intend to grow coal consumption at least through 2025. The chances of them shutting these down within the next five years (or even 20 years) are slim.

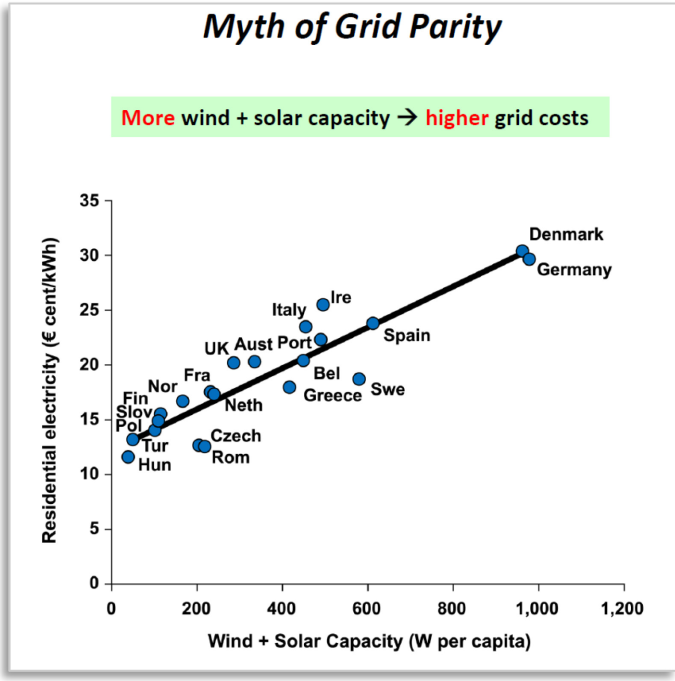
Figure 3.10 ▷ Global electricity generation by source in the NZE



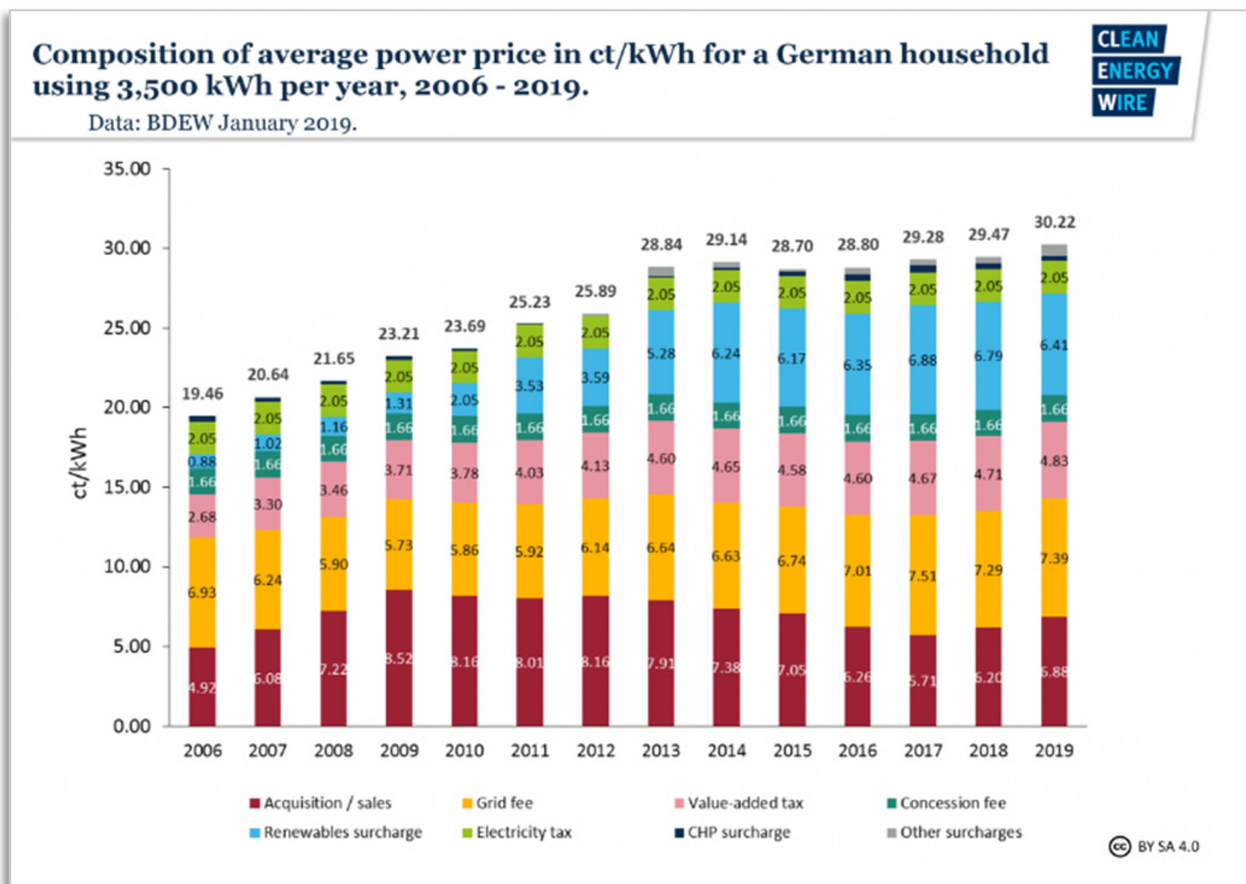
Solar and wind power race ahead, raising the share of renewables in total generation from 29% in 2020 to nearly 90% in 2050, complemented by nuclear, hydrogen and CCUS

Even environmentally minded Europe's plans to shut down fossil fuel generation could get delayed after the recent volatility in the energy markets, which shows the need for flexible and diverse energy sources. In fact, recently even the Germans are increasing coal use and the UK is probably ruing the speed with which they shut down their coal plants.

Another factor of renewable energy that we feel is misunderstood is the very high cost of solar and wind energy. There is a common perception that renewables are as cheap or cheaper unsubsidized than coal or natural gas. We don't think this is possible. If that were the case, it would be awfully coincidental that the countries with the highest renewables generation also have the highest electricity costs.



(Mark Mills presentation, CLSA Conference 2021)



For years we have been regaled by shale oil and gas companies with tales of 60-100% after-tax IRR's[5] on their wells. Yet somehow by the time they got to net income they made very little, or no, money. This is because they were clearly ignoring a lot of costs and cherry picking only their best wells to show to investors. We think the solar and wind players are doing the same. They are showing best-case conditions with generous assumptions to show how cheap they are, even if real life results are very different.

For a real-life example, we can look at the results for ERG s.p.a., an Italian producer of renewable energy. As the table below shows, the company makes very good money on wind and solar energy with EBITDA[6] margins in the low 70% range. But if we take out the subsidies they get above the market price of their electricity, the margin drops to barely breakeven. Breakeven on an EBITDA basis for a company that is supposed to have most of its costs up front is not good. It means it could never earn back its invested capital, much less get a return on it.

ERG spa

	2018	2019	2020
Wind Revenue	389.00 €	420.70 €	402.20 €
Solar Revenue	38.00 €	71.50 €	72.60 €
Total Revenue	427.00 €	492.20 €	474.80 €
Wind EBITDA	274.00 €	300.80 €	282.50 €
Solar EBITDA	32.00 €	62.80 €	65.60 €
Total EBITDA	306.00 €	363.60 €	348.10 €
Wind Margin	70.4%	71.5%	70.2%
Solar Margin	84.2%	87.8%	90.4%
Total Margin	71.7%	73.9%	73.3%

	2018	2019	2020
Wind Subsidies	264.00 €	291.87 €	293.13 €
Solar Subsidies	30.00 €	60.34 €	62.07 €
Total Subsidies	294.00 €	352.21 €	355.20 €
Wind EBITDA w/o Subsidies	10.00 €	8.93 €	-10.63 €
Solar EBITDA w/o Subsidies	2.00 €	2.46 €	3.54 €
Total EBITDA w/o Subsidies	12.00 €	11.39 €	-7.09 €
Wind Margin w/o Subsidies	2.6%	2.1%	-2.6%
Solar Margin w/o Subsidies	5.3%	3.4%	4.9%
Total Margin w/o Subsidies	2.8%	2.3%	-1.5%

Source: Kopernik, ERG spa Annual Report

This is not meant to be an indictment of ERG. They are a well-run company that gets decent returns. But let's not pretend that this business exists without significant government subsidization. We feel the high cost of wind and solar will be another factor slowing down their deployment.

The intermittency of solar and wind present another difficulty in growing them rapidly. Solar utilization averages about 20% of capacity and wind 25-30%. This means to become the predominant electricity source, they need a huge amount of battery backup for when the sun doesn't shine or the wind doesn't blow. So far, long-term battery storage is not even close to being economically viable. We lump hydrogen in with this as it is really just like a battery in that it is an "energy-in, energy-out" technology. Over the long term, batteries and hydrogen could make sense but the cost is prohibitive now and big leaps in technology need to be made here.

Even if we could build this much solar and wind capacity, where would we put them? The map below shows photovoltaic power potential with the best spots for solar being in orange and red. We could put lots of solar panels in the Sahara Desert, but nobody lives there and wheeling it up to Germany would be impractical and costly. Here in the U.S., there is plenty of solar resource potential in Arizona, New Mexico and Nevada. But again, there is not much electricity demand there. The same is true in China where the best sun is in the west of the country, but everyone lives in the east.

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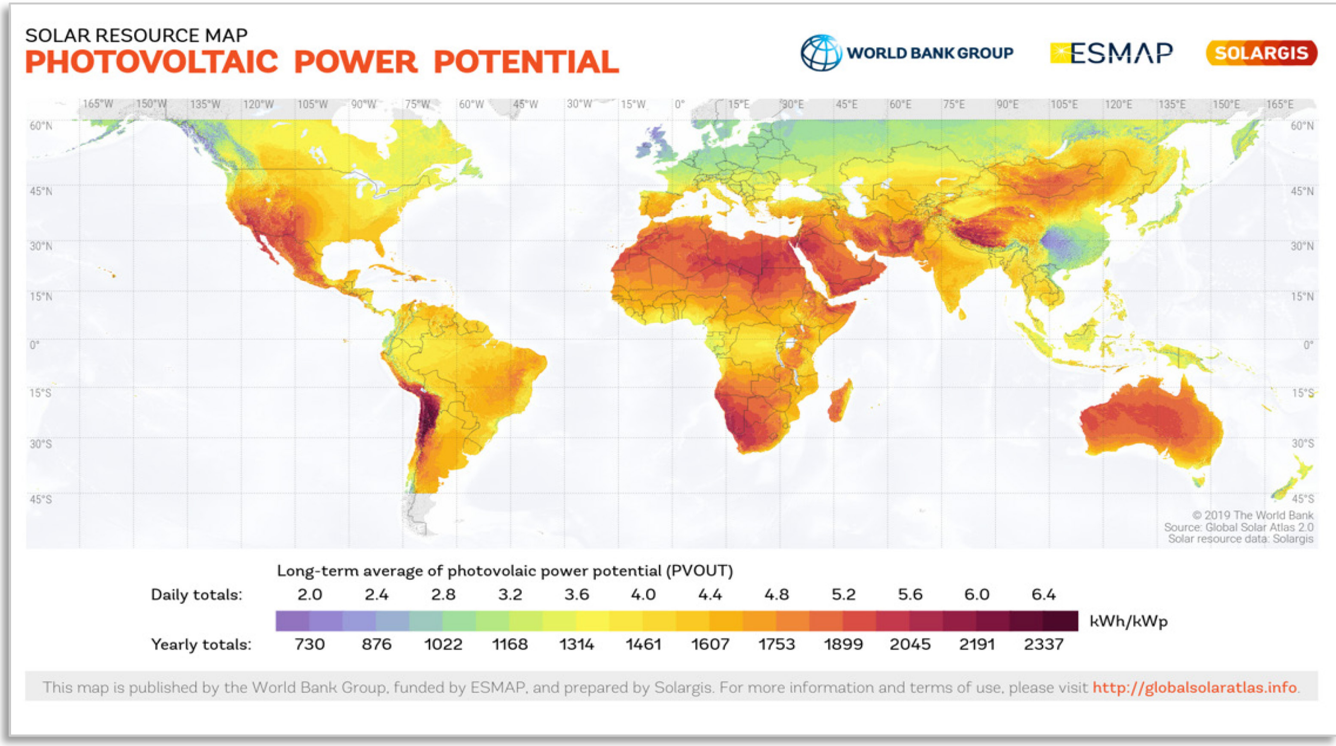
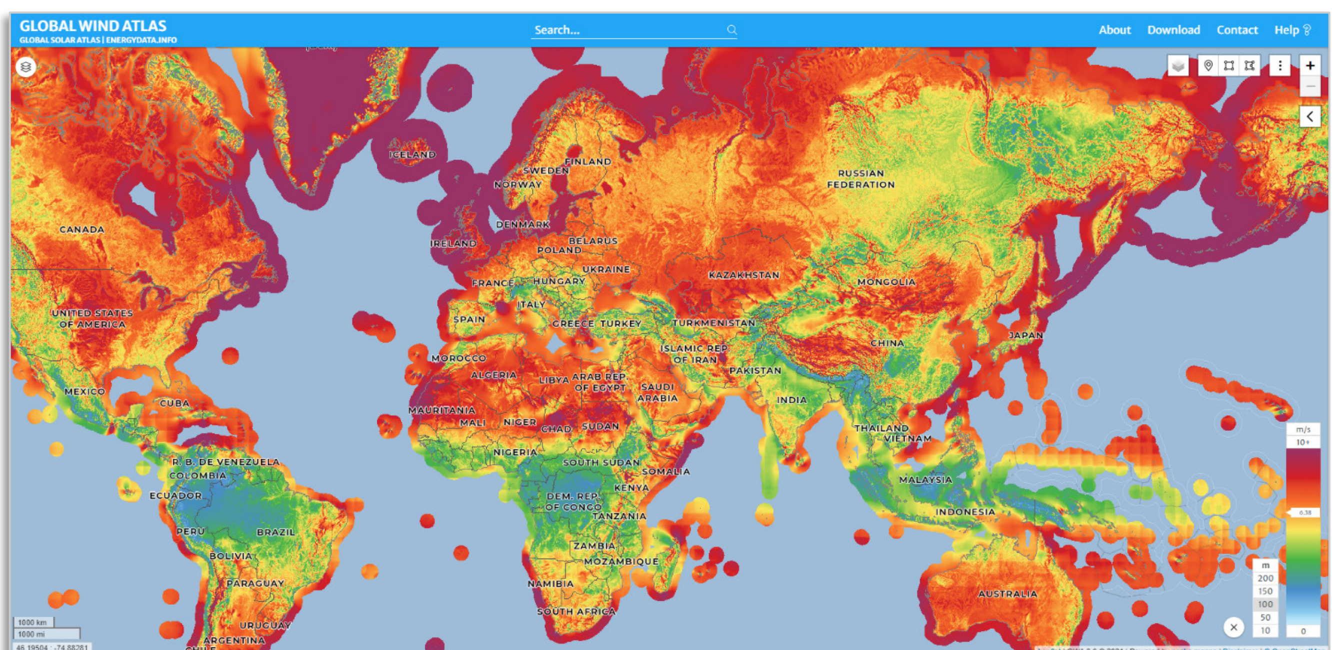
5 Internal rate of return

6 Earnings Before Interest, Taxes, Depreciation, and Amortization



The wind resource map shows similar potential, mostly in places where nobody lives although offshore looks promising (albeit expensive). The problem with offshore, besides the cost, is that people don't seem to want wind turbines near them. For example, Maine recently outlawed offshore wind in state waters, North Carolina coastal communities are fighting hard against it, and the Navy has put half of the coast of California off-limits to offshore wind. Even green Massachusetts has been trying to get a big offshore wind project started for ten years and has only recently been approved once it was moved out of sight of the Kennedy and Koch estates on Cape Cod.



One of the last major factors in the IEA report contributing to "net-zero" is carbon capture and sequestration (CCS). We won't dwell too much on this except to say that this too seems very far away and needs to become much cheaper. There are a few industrial processes such as cement, chemicals, refining and power generation that could lend themselves to CCS if the costs come down and they are subsidized. The problem comes with transporting and sequestering the CO2.

There are plenty of places we can store the gas underground; the problem is they are not always the same places as where the CO2 is generated. A cement plant on the U.S. gulf coast can pump it underground nearby. One in Germany not so much. Building the pipelines necessary to transport CO2 requires greenfield development as existing natural gas pipes won't work, and we have seen over the last ten years or so that building any kind of pipeline runs into a lot of permitting and social problems. Building a nationwide pipeline system to transport CO2 or hydrogen would be a mammoth undertaking and certainly not one done quickly or cheaply.

The only place CO2 sequestration has proved economical is in enhanced oil recovery (EOR) operations where the gas is pumped underground to improve the ultimate recovery of oil from the well. Of course, if we are getting rid of oil and gas this outlet goes away.

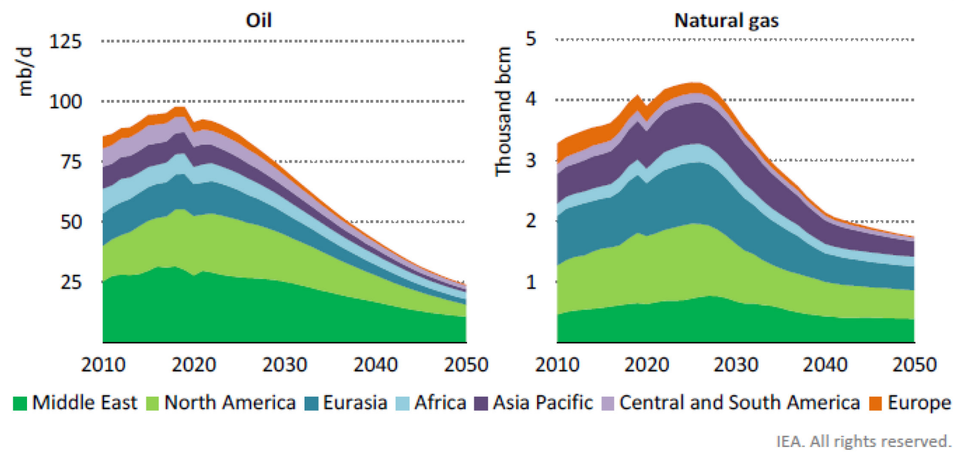
We have referred frequently in this paper to the costs of the various solutions to climate change, but we believe it bears further discussion. We have seen estimates of the costs of getting to net-zero at between $50 trillion and $150 trillion. The low end of these estimates (if we can call $50 trillion "low") assumes a lot of cost reductions and efficiencies and assumes no stranded costs. However, if we shut down a coal or gas plant that still has 20 years of useful life left, that is a cost that has to be paid by someone. Whether it is ratepayers, investors, or governments, someone has to assume this financial outlay.

To put $100 trillion in perspective, it is more than global GDP this year. It is about $13,000 for every person on the planet. Since the emerging world is unlikely to contribute much to this, $100 trillion amounts to $77,000 per person in the OECD countries. People might say this spending will contribute to GDP but since we are just replacing existing productive capacity, it falls victim to the broken window fallacy.

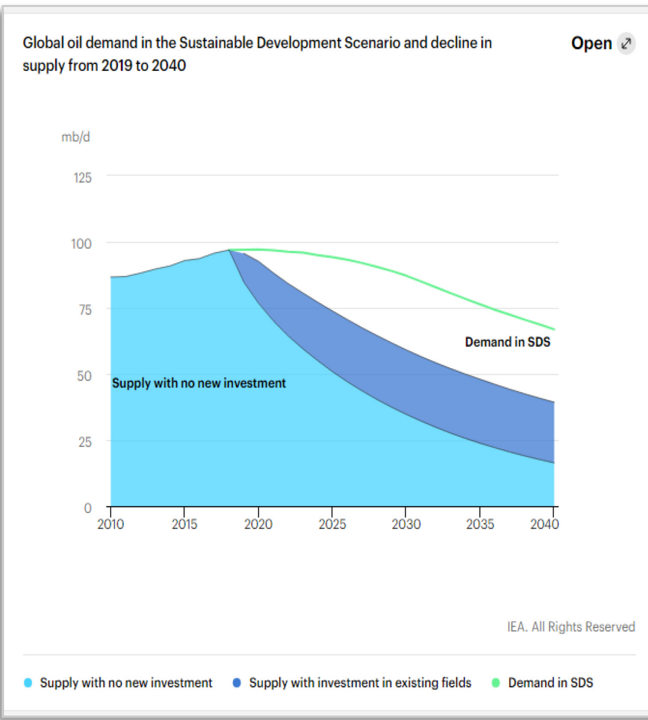
Of course, the world's central banks have made it so a trillion dollars is not such a big deal anymore. They easily could, and probably will, print plenty of Dollars, Euros and Yen to fund the energy transition but even for them this is an outlandish number, four times the combined assets of the big three central banks. Printing this much money will likely cause inflation to spike, raising all of the costs mentioned above.

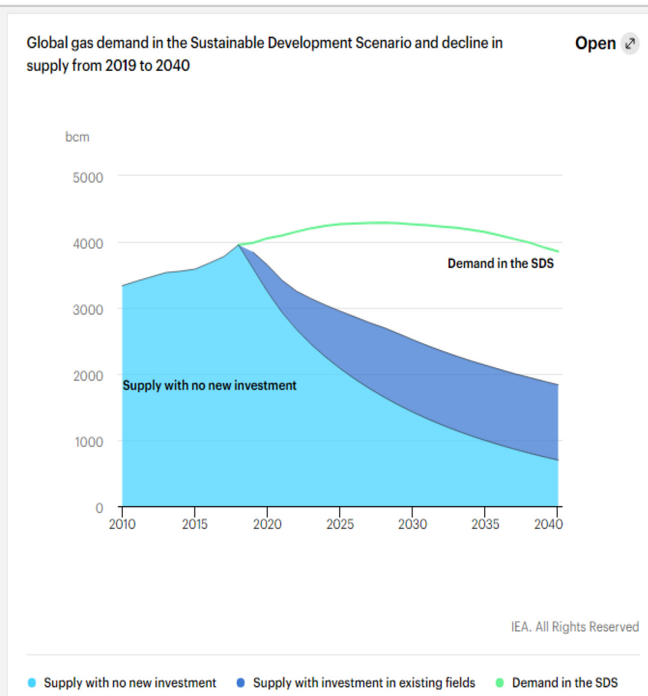
We have ranged pretty far here but the point of this paper is to handicap how much financial risk there is in fossil fuel (particularly oil and gas) reserves. If we assume the IEA net-zero scenario comes to pass (which we clearly think is near impossible), it still does not mean reserves are worthless. The report estimates that even in this scenario oil demand will still be about 25 million barrels per day and gas 1.8 trillion cubic meters per day. These are decline rates of about 5% and 3%, respectively. Coal on the other hand goes away completely.

Figure 3.3 ▷ Oil and natural gas production in the NZE



However, oil and gas are depletion businesses. The average natural decline rates for them are about 8% per year, faster than the declines depicted above. This means that even in the worst-case scenario (and we can't overemphasize how unlikely this is) the world will need all of the proved reserves out there, plus find more to meet demand. If the transition happens more slowly or only partially, we will require a great deal more.

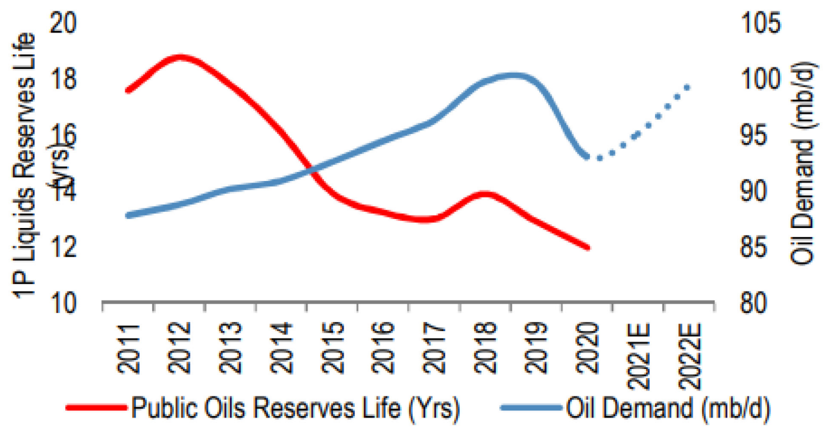




Unfortunately, as the oil and gas industry has been underspending their sustainable levels, reserves have been depleted over the last ten years. Declines in reserve lives have allowed the industry to maintain production but at some point, production has to follow reserves. Someone in the industry is going to have to find and develop more oil and gas or we are going to have more energy squeezes like we are seeing right now.

Figure 4: Proven reserves life for the 43 largest global oils* is down 36% from a 2012 peak to ~12yrs; 2020 the worst year in two decades

R/P (years), Oil Demand (mmbo/d)



Source: J.P. Morgan estimates, Bloomberg Finance L.P. *Note: Data comprises the 43 largest listed producers (by liquids production) globally, excluding Aramco (given limited historic data).

However, things do not seem to be going in this direction. While proved reserves among the biggest oil companies (excluding the Russians or Saudis) have declined by 25% over the last ten years, capital spending plans this year are about flat and will struggle to get back to the (already insufficient) levels of the previous 5 years. To maintain production long-term, CAPEX would have to quadruple from current levels. This is not going to happen from any of the European majors who are under ESG pressure to self-liquidate, nor U.S. producers who seem to have found discipline and are returning cash to shareholders. We suspect the latter will change once balance sheets are repaired, but it will take some time.

We believe this underpins the value in company proved reserves as well as a constructive long-term outlook on oil prices.

Our intent with this paper was not to throw cold water on the attempts to address global climate change. We agree that many of the energy transition pillars will come to fruition. EV's, wind and solar power will continue to grow. Some behavioral changes will happen, leading to greater energy efficiency. Certainly, a great deal of money is going to get spent on greening the system, just not at the speed or to the extent that the "Net-Zero" crowd is anticipating.

A lot can, and will, happen over the next 30 years. Thirty years ago, few people had heard of the Internet. Merck, Exxon and GE were the most valuable companies in the U.S. Microsoft and Apple had $15 billion and $6 billion respective market caps and Google, Facebook and Amazon hadn't even been dreamed of yet. It would be the height of hubris to think we know what the next 30 years has in store. We might still go green…but not yet.

Thanks again for your support.

Steve Rosenthal
Analyst
Kopernik Global Investors, LLC
November 2021

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