NATIONAL STRATEGY //CLIMATE

STORMCROW

A Modest Proposal Regarding Climate Change

November 12, 2022

Jon Hykawy, PhD
President
jon@stormcrow.ca

- **Sure, Electric Vehicles** – We have already started down this road, might as well keep driving. By mandating near-term adoption of hybrid, plug-in hybrid and battery electric vehicles around the world, we can cut perhaps 7% of global CO_2 emissions in a reasonable amount of time. Yes, only 7%. But there are other actions to take.

- **Kill Coal** – If other nations supported China's ready access to uranium to compensate for a lack of domestic Chinese uranium deposits, up to 20% of global CO_2 emissions could be eliminated through replacement of Chinese coal-fired power plants with modern mixed-oxide nuclear reactors, solar photovoltaic systems and wind power.

- **Basically, Build Better Buildings** – Mandating that structures be built to the passive standard means that we can remove perhaps 4% of global emissions over time, perhaps more as residential energy needs move from natural gas or heating oil to low-power electricity.

- **Steely Resolve** – The most 'R&D heavy' suggestion, that governments mandate a transition from making steel using blast furnaces and coking coal to using natural gas or to an electrochemical approach resembling the production of aluminum metal. Yes, it will require R&D and planning, but it could be worth 11% of global CO_2 emissions, so is worth striving for.

- **And No, This Isn't Satire** – All apologies to Jonathan Swift for riffing on the name, but we believe this analysis is worth putting into the public discourse. We believe that, with government action, we can eliminate more than 40% of global carbon emissions with minimal negative impact to the economy. That would be a good start.

Please see the end of report for important disclosures

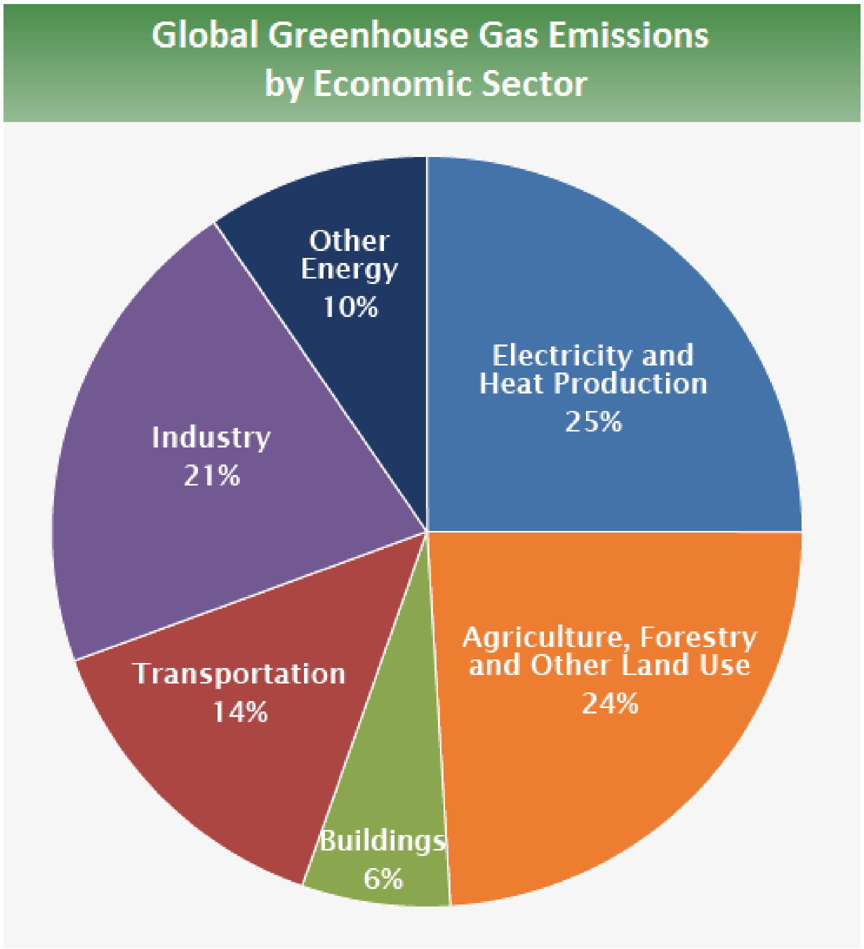
Introduction

COP26 has made it plain. The world needs to act to forestall the worst effects from the greatest existential threat human society has ever faced, namely climate change. Everything we have done in the west to combat this problem has been market-driven and, with one exception (that being natural gas replacing coal for electricity generation in the US and elsewhere), has been inadequate or ineffectual. Governments talk about taking action but do nothing, probably because they lack knowledge over what to do that would not have negative economic consequences. We are going to offer a few suggestions and project what resulting critical material demand might be in the face of their adoption.

In 2021, estimated total global man-made greenhouse gas emissions related to use and production of energy totaled 36.3 Gt_{CO2eq}, 36 billion tonnes in carbon dioxide equivalent terms. The estimate for 2022 is 36.6 Gt_{CO2eq}, a new all-time record and definitely not a decreasing amount. The entire output by the United States in 2021 was 4.9 Gt_{CO2eq}, only 13% of the global total. We have likely all seen the figures published after deliberation at COP26 that the world needs to reduce CO_2 emissions by roughly 40% by 2030 (from an anticipated 46 Gt_{CO2eq} to only 22 Gt_{CO2eq}, or 40% lower than today). Further, we need to continue reducing CO_2 emissions through to the middle of the century, essentially dropping man-made emissions to zero by 2050. So, clearly, even if the US dropped its carbon emissions to zero, overnight, which is patently absurd, taking 13% of emissions out of the global total doesn't get us to a 40% global reduction. That's simple arithmetic.

And the American solution seems, mainly, to be incenting drivers to switch to battery-electric vehicles (BEVs), as some scientists associated with COP26 are urging, along with building large amounts of renewable energy capacity. Reluctantly, we need to point out the obvious; that this simply won't be enough, and it won't even work.

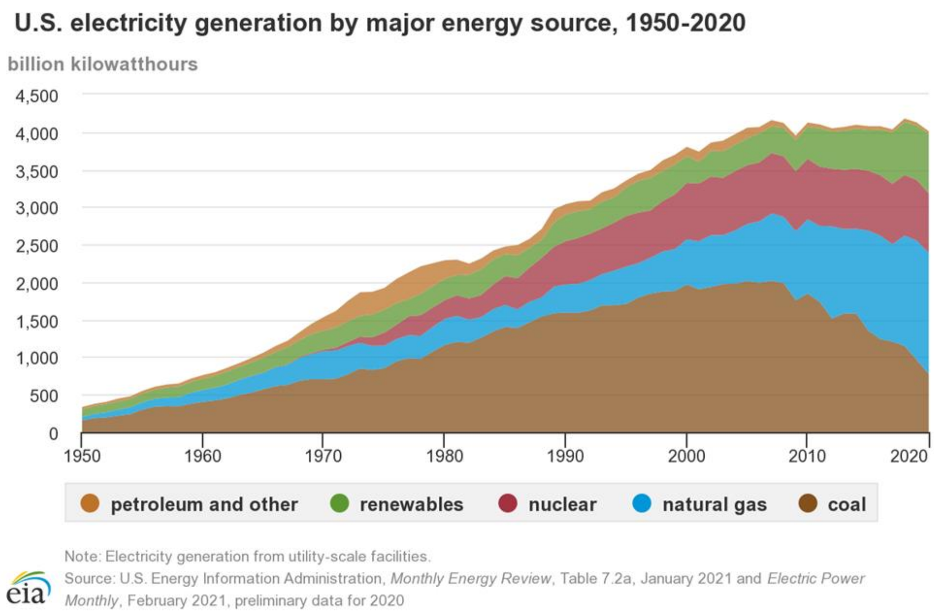
Exhibit 1 – Global CO_2 Emissions by Sector



Source: US EPA (IPCC 2014)

We can break down sectors such as electricity generation within a nation even further, to their source:

<u>Exhibit 2</u> – US Electricity Generation by Source and by Year



Source: US Energy Information Administration

From the above two figures, we see that even if global emissions from the transportation sector were reduced to zero, we are far from our goals. In fact, zero is impossible to achieve without severely damaging the global economy, given that lithium batteries have nothing approaching the energy density of fossil fuels such as diesel or jet fuel. In other words, while we might be able to require or incent everyone to drive a BEV, and even ignoring the fact that in many nations the production of electricity to recharge a BEV burns fossil fuels, we will still get nowhere close to zeroing out emissions from the Transportation sector because jet aircraft will continue to need jet fuel and locomotives and transport trucks will still burn diesel. Nothing short of a technological miracle will allow aviation to become fully electric and allow freight trains to run on batteries; for their size and weight, batteries simply don't store enough energy.

Still, one of the major recommendations coming out of COP26 is to do as much as we can, as quickly as we can, with respect to reducing carbon emissions. And transportation, as a sector, is a good place to start.

First Proposal – Transportation

Major western governments should announce, as soon as possible, that all new light- and medium-duty vehicles sold (most especially including pickup trucks and SUVs) must meet emissions standards that mandate these new vehicles be hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) or BEVs. This will dramatically reduce emissions from the transportation sector and, since HEVs and PHEVs can already be sold at essentially the same price point as internal combustion vehicles (ICVs) there should be little negative economic impact to this transition.

For those seeking to make 'perfection' the enemy of 'improvement', emphasizing only BEVs cannot work in the short- or medium-term, not without massive disruption in other sectors. For example, the USA used 520 billion liters of gasoline and 181 billion liters of diesel fuel in 2019, presumably burning most of this as transportation fuel. Those volumes of fuel represent a lot of energy. If we were to try to replace that energy with electricity, we would need to generate at least an additional 25% more electricity than the US generated in all of 2019 and we would need to ensure the grid could deliver it to all the new chargers required during the hours available for charging, a task that will not even be remotely close to completion by 2050 much less well underway by 2030. By mandating adoption of HEVs, PHEVs and BEVs, and stressing rapid adoption of HEVs and PHEVs, we believe emissions from the transportation sector could be reduced by 50-65% or more over time, with the present grid sufficient to charge PHEVs overnight and fossil fuels providing additional energy to HEVs and PHEVs when required.

Nor, in the short- or even medium-term, will we have sufficient amounts of the required critical materials to make a full transition to BEVs. The op-ed writer Bret Stephens wrote, compellingly, in the New York Times on 28 October 2022 of his changed opinions regarding the importance of climate change, which we laud. But he also wrote that, by his analysis, the best way to address climate change is through the action of the markets. He is a journalist, while I have been involved with the financial markets for 20 years and I believe he is entirely wrong. The preferred investment for a market professional is a zero-risk trade with massive profitability. Building more lithium or cobalt or nickel mines to satisfy an uncertain market with uncertain timing where demand is susceptible to unknown technological and legislative shifts is asking far too much of the market and its investors. This is the reason why we have seen prices of critical battery materials whipsawing over the years, as supply and demand do not move in tandem. And it is the reason that the market will not provide just what is required, at a nice, steady price, just when it is needed.

A PHEV is a BEV with a small battery and a back-up engine. By far, the least expensive way to drive a PHEV is to use electricity. However, if the PHEV's battery is depleted and the time is unavailable for recharging, then the owner can default to using fossil fuels. Given that the daily commute for most of the drivers in the western world is relatively short, it is far better for them to purchase a smaller battery that they can discharge regularly than to pay much more money for a large battery that is never fully used. The Tesla model of equipping everything with a large battery is the equivalent of GM deciding to shoehorn a 300-liter gas tank into every Silverado pickup truck; yes, that would provide added range, but range that the owner is unlikely to ever use. In its favor, though, at least a larger gas tank doesn't cost tens of thousands of dollars or weigh 500 kg, empty.

Exhibit 3 – The Most Popular BEV in China (Wuling Hongguang Mini, 9/13/26 kWh battery)

Source: Wuling

Perhaps the most welcome impact of such a change would be that many of the batteries in vehicles would be small. With a backup means of propelling the vehicle, it is no longer necessary to cram the most energy into the limited volume of a battery. Thus, the typical cathode active material used in these batteries could be something like lithium iron phosphate instead of, for example, the lithium nickel manganese cobalt oxide used by General Motors. This eliminates the need for expensive and rare metals such as cobalt in these small batteries.

If all new passenger vehicles in the world were sold as HEVs, PHEVs or BEVs, lithium demand from this use alone would be roughly one million tonnes lithium carbonate equivalent, based on roughly 80 million new vehicles, average battery size of 20 kWh and current LFP and NMC cathode material energy density. While this demand would greatly increase global lithium demand, worldwide lithium reserves are more than 117 million tonnes LCE, according to the USGS. Time and capital can increase lithium supply to these levels, but we need to buy the time for this buildout by shifting demand to smaller-battery HEVs and PHEVs instead of lamenting a lack of available critical materials that would allow us to build nothing but big-battery BEVs.

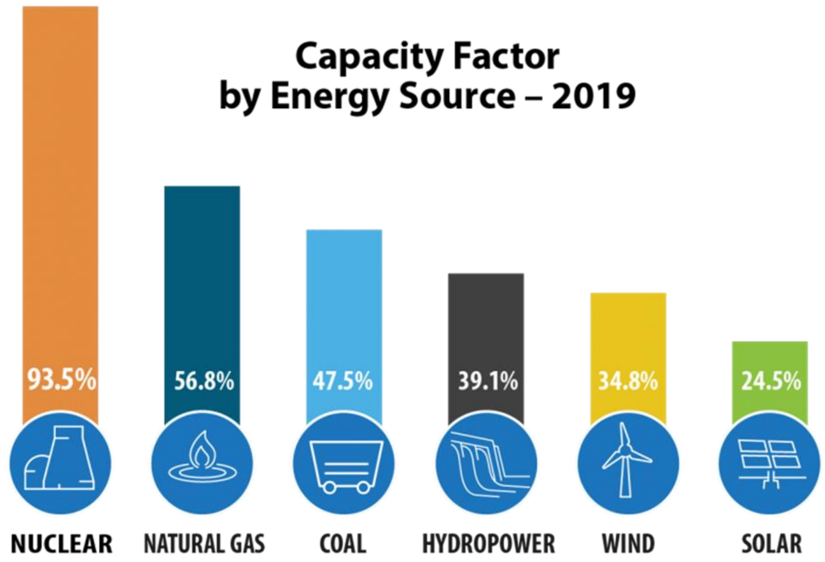
Second Proposal – Clean Energy

As soon as possible, all nations must mandate the replacement of coal power with non-carbon generation, including renewables (where possible) and nuclear, hydro or geothermal (when necessary and where practical). This has a potentially massive impact on global CO_2 emissions.

The potential impact on carbon emissions from a simple shift has already been demonstrated by the United States. While politicians and writers in the US like to crow about the reduction in CO_2 emissions that has occurred over the last 20 years due to the shift away from coal and to natural gas for production of electricity in the US, this shift did not occur because of its effect on carbon emissions but because using natural gas was significantly less expensive than continuing to use coal. If natural gas had a greater level of greenhouse gas emissions than coal, the US would have undergone this shift, anyway (and let's not completely discount that potential, depending on how much natural gas is inadvertently leaked into the atmosphere, adding its potent methane burden).

The United States government is touting the capacity to add significant amounts of renewable generating capacity to their grid. In 2021, renewables accounted for 826 billion kWh out of a US total of 4,115 billion kWh, total, or 20% (see Exhibit 2, above). Calculations that, to us, seem fairly realistic, estimate that the peak penetration of renewables into a grid such as the one in the United States will be about 25%. This is because many renewables are simply not dependable enough to replace coal or natural gas or, especially, nuclear. Capacity factor is a slightly more complex measure than simply saying it is 'reliability', but it serves to illustrate the problem:

Exhibit 4 – Capacity Factor of US Generating Assets, by type



Source: US EIA

While solar and wind are not reliable enough to entirely replace fossil fuels, there is capacity within the existing grid, in most regions, to expand use of solar and wind. This should be encouraged, but we must be aware that we need to add reliable generating capacity, as well.

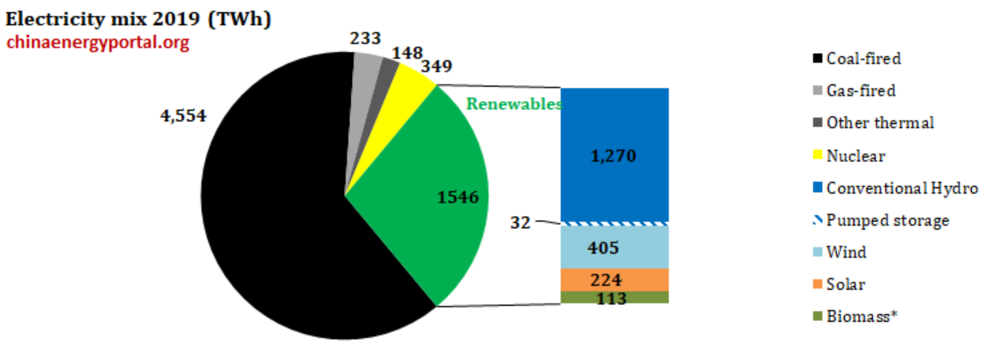
Nuclear is an effective replacement for coal, but the world also has serious limitations regarding uranium reserves. The World Nuclear Association reports that uranium reserves total 6.15 million tonnes, but current annual need is roughly 67,000 tonnes. If we were to dramatically increase uranium demand, global reserves will only last a few decades. And we would need to show greater concern for increasing the mining of uranium sooner, as in now, rather than later. No utility or government will build massive numbers of new reactors without being certain of the availability of fuel.

What we suggest is replacing coal with reactor designs that consume mixed uranium and thorium fuel while continuing to develop reactors that do not use uranium, at all. Combining thorium with uranium can dramatically reduce lifetime use of uranium but requires a reactor design that is capable of using such a fuel. Fortunately, there are licensed and proven designs that can use mixed uranium and thorium fuel, fuel that would actually improve reactor safety.

The impact of replacing coal with nuclear would be particularly large in China. However, Chinese authorities would likely view a profound dependence on uranium as decreasing their energy security, since China is not blessed with world-class domestic uranium reserves. Governments would likely have to find ways to guarantee necessary supply to China in order to allow such a generating shift to take place, but this is one of the best targets for CO_2 reduction available globally and something that all governments should work to enable. It should be especially attractive to western governments that (a) don't want new nuclear plants in their nations, and (b) don't actually want to take any meaningful carbon reduction actions at home and would much prefer another nation to do so. Certainly, asking China if they would participate in a program that would build a 5- or 10-year stockpile of nuclear fuel in China could be worthwhile, not least of which is for the economic boost that new uranium mining can give many areas of the world.

And the reason this is worth attempting is because of the potential impact on carbon emissions and air pollution, in general. China generated roughly 62% of its electricity in 2019 from coal:

Exhibit 5 – Chinese Electricity Production, by Source (2019)



Source: Chinese National Energy Administration via chinaenergyportal.org

In rough terms, the generation of 4,554 billion kWh of electrical energy from coal required burning 2.8 billion tonnes (equivalent, since different types of coal yield different amounts of energy). But using the standard coal for calculation by the Chinese NEA, we see that fixed carbon content is about 70%. Converting the carbon to (much) heavier carbon dioxide, and we find that Chinese use of thermal coal for energy generation in 2019 released 7.2 Gt of CO_2, out of a Chinese total of about 10 Gt and a global total of 36.7 Gt. The Chinese coal burning total is about 20% of global emissions. If we can knock down 20% of global carbon emissions and do so by attacking only one source of production, that would make a real difference. If we can do that by opening new mines, adding economic activity and jobs supporting this shift, then all the better.

Third Proposal – Identify and Target the Greatest Enemies in Industry

There are several specific industries that government must target. One is not a major polluter but would serve to demonstrate technology that could then allow a technology shift in the other.

Aluminum is made by electrolyzing aluminum oxide. A very hot bath of salts can dissolve a small amount of aluminum oxide, allowing an electric current to pull aluminum to one electrode, which is then collected as molten metal, while pulling oxygen to the other electrode. These electrodes are, presently, made of graphite. When oxygen reaches the graphite electrode, it combines with carbon atoms and creates carbon dioxide. In essence, the production of aluminum currently necessitates a CO_2 co-product.

It is possible to replace the graphite electrode collecting oxygen with a conductive ceramic electrode. The result will be improved reliability, lower operating costs and reduced electricity consumption. In fact, it is possible that the produced oxygen gas could now be collected and sold, modestly improving economics, as well.

Unfortunately, the aluminum industry is simply not large enough and does not produce enough CO_2 to make a huge difference to global emissions on its own. The reaction for making Al metal and CO_2 is:

$$2\,Al_2O_3 + 4\,e^- \rightarrow 4\,Al + 6\,O$$

$$6\,O + 3\,C \rightarrow 3\,CO_2$$

For every 4 aluminum atoms made, 3 CO_2 molecules are created. Primary aluminum production in 2019, worldwide, amounted to 63.7 million tonnes (according to the International Aluminium Institute). That means that production of 63.7 Mt of aluminum also directly produced 77.9 Mt of CO_2 (not including energy required in the form of electricity or heat). As we said, out of global CO_2 emissions of 33,300 Mt, this is a drop in the bucket (only 0.2%). But if getting rid of it costs little and actually means that making aluminum costs less money and uses less energy, why shouldn't it be done?

However, this potential points us toward something much more important. Making steel combines hot iron oxide with powdered metallurgical coal (in the form of coke) in a blast furnace to create molten iron and carbon dioxide. It is entirely possible, assuming we have ceramic electrodes and enough electricity, that we could contemplate making molten iron directly from iron oxide using electrolysis. According to Rio Tinto, each tonne of steel made uses 770 kg of metallurgical coal (plus more coal to make coke from metallurgical coal plus other energy needs).

Converting the making of iron and steel to an electrolytic model would dramatically reduce global carbon emissions. In 2021, the World Steel Association estimates global steel production at 1,951,000,000 tonnes. The world needs a lot of steel. 73% of that steel was produced in a variation of blast furnaces as primary steel, so 1,424,230,000 tonnes. If every kg of metallurgical coal contains about 65% fixed carbon, then adjusting for the fact that CO_2 is much heavier than C, alone, we find that the global steel industry emits some 3.9 Gt of CO_2 per year, roughly 11% of global emissions. Now, this doesn't count the coal used to convert metallurgical coal to coke through roasting and it doesn't include any external energy generation at a steel mill.

But if we are concerned about waiting years for the R&D into this technology to bear fruit, and we should be, then we can do something about it much sooner than later. For those areas of the world with sufficient availability of cheap natural gas, it is entirely possible to directly use natural gas to make molten iron for steel. The refitting of steel plants to demonstrate this technology is being done today. For example, the ArcelorMittal Dofasco steel plant in Hamilton, Canada, is undergoing a CAD$1.8 billion refit to use natural gas, directly. Instead of the chemical reaction:

$$2\,Fe_2O_3 + 3\,C \rightarrow 4\,Fe + 3\,CO_2$$

so that each eight atoms of iron are accompanied by six molecules of carbon dioxide, we now use the chemical reaction:

$$4\,Fe_2O_3 + 3\,CH_4 \rightarrow 8\,Fe + 6\,H_2O + 3\,CO_2$$

and our eight atoms of iron are now made with just three molecules of carbon dioxide and some steam. Basically, we halve the emission of carbon dioxide by the steel industry through use of economical natural gas, in much the same way that replacing coal with natural gas reduced US carbon emissions from electricity generation.

None of this will likely happen quickly without government intervention, however. Even if the use of ceramic electrodes and electrolysis to make steel or the use of natural gas turned out to be less expensive than using metallurgical coal, it is unlikely that the steel industry will rush to adopt the technology. To do so will require considerable capital expenditure and if every company in the industry spends the money, they will simply end up with a competitive environment and margins that look, more or less, exactly like the market today. Spending money without a good chance of boosting profits is not a winning business strategy.

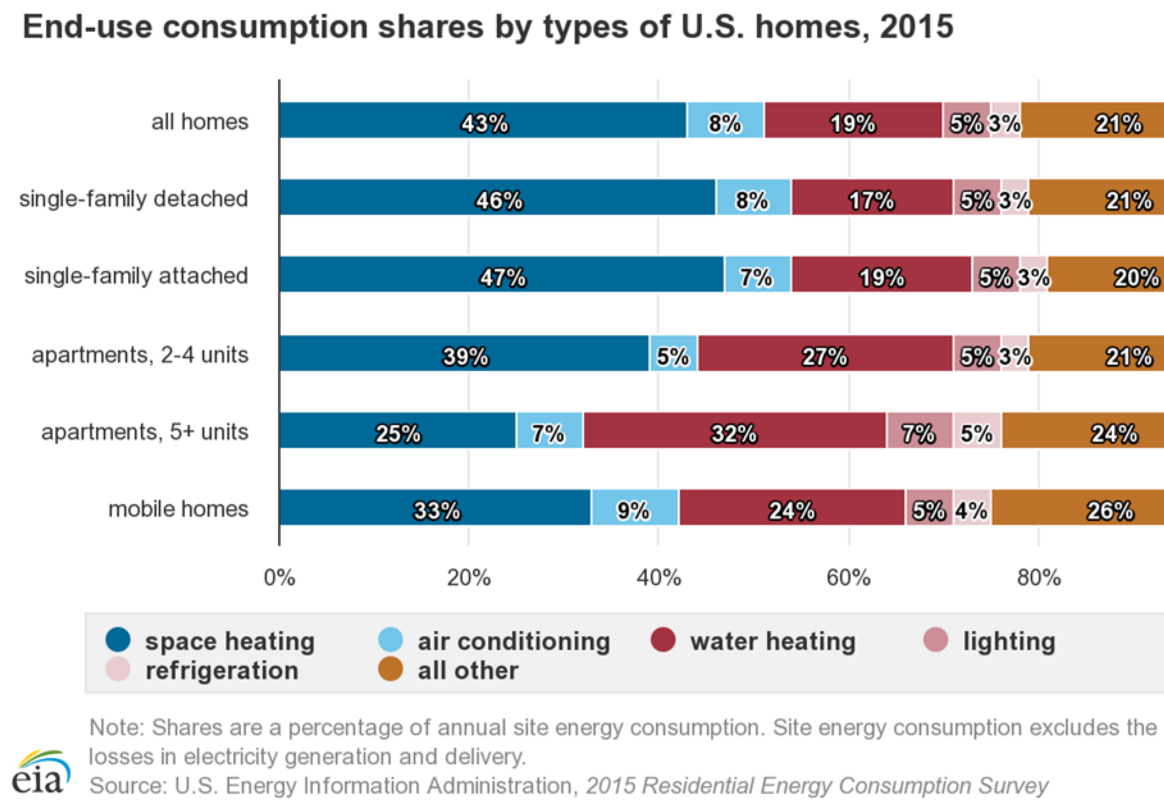
Even the use of natural gas, which at present prices is very likely less expensive per tonne of steel than continuing to use metallurgical coal, is being incented by government. The ArcelorMittal project in Hamilton that we mentioned above, with its cost of CAD$1.8 billion, is being supported to the tune of CAD$900 million by the Ontario provincial and Canadian federal governments.

But if governments do mandate these changes and perhaps provide low-interest loans to take some of the sting out of making the required changes to steel mills, it might be possible to clean up the global industry and cut a significant amount of CO_2 emissions.

Fourth Proposal – Stand-Alone Houses

Residential and commercial buildings are built to the standard of a local building code. As quickly as possible, relevant governments should move to require new construction to meet passive building standards. Passive buildings are designed to dramatically reduce the need for active heating and cooling, by as much as 90%. And along with the passive building standard, in all regions that would benefit from it, a requirement to install appropriately-sized solar hot water systems should also be put in place.

<u>Exhibit 6</u> – End-Use Energy Consumption in US Residences, by Type



Source: US EIA (2015)

The US government has done studies on homes and on energy use within various types of homes. In the US, an average of 70% of the energy used by a home is used for heating, cooling and making hot water. Even in Canada, where a disproportionate amount of electricity is generated by green sources, home heat and hot water are largely generated from fossil fuels like natural gas. Eliminating much of the need for this energy in new buildings would provide, over time, a significant reduction in CO_2 emissions, perhaps as great as 60%. And given the long life of new buildings, it is better to begin requiring this type of construction as soon as possible.

In nations like Canada, where electricity in much of the country is disproportionately generated from non-polluting sources such as hydro or nuclear, local governments should consider forbidding the use of natural gas in new and renovated homes that will be built to the passive standard. These types of homes use a minimal amount of energy for heating and cooling, anyway, so the existing grid is likely to be able to supply the required electricity demand.

Conclusions – A Result That Gets Us Close

Many people feel that our society is powerless against climate change, that there is no way to make meaningful reductions in CO_2 emissions without doing serious economic damage to our society. This is simply wrong. However, if you are hoping for market action to result in lower carbon emissions, you are also being foolish, for reasons discussed, above. Fortunately, or unfortunately, we need governmental action. Carbon taxes could work in the long term, but it is critical that we reduce emissions as rapidly as possible and the timeframe over which carbon taxes might do their job is uncertain, at best. Government can, and should, attack specific targets where CO_2 emissions can be reduced without excessive disruption of the economy and leave carbon taxes to act in a more diffuse and gradual way on other sectors, over time.

I find the approach taken by the government of the State of California, for example, objectionable. Their recent passage of a law that makes the sale of fossil-fuel powered cars after 2035 illegal is exactly what government should not do. Government should not try and pick winning technology before the marketplace has spoken or, indeed, without evaluating the technological options available. Instead, it should set the desired outcome and allow scientists, engineers and, most importantly, the voters and consumers, the opportunity to find the correct solution to the problem. Instead of simply mandating that no ICVs can be sold after 2035 (presumably someone living in California could cross the border into Nevada and buy whatever vehicle they wanted, or is registration also proscribed?), a more realistic and effective approach would be to mandate a maximum level of carbon emissions for any vehicle to be registered in California. If the easiest and least expensive way to accomplish this is by buying a BEV, wonderful, and if it is a PHEV, even better.

Contrast the California approach with what is happening in China. There, the central government wanted to generate demand for BEVs with large, energy dense batteries and provided subsidies geared toward doing so. Instead, the market in China has surged toward *kei* cars such as the Wuling Hongguang Mini EV. This is because a BEV with a small battery can be manufactured less expensively than any ICV, since there are simply a lot fewer moving parts, and Chinese consumers with short daily commutes find purchasing a $5,000 small BEV that is cheap to operate preferable to buying a $20,000 ICV or $40,000 large-battery BEV. To their credit, all levels of Chinese government are, at least, not impeding the growth in those sales, and China as a whole will benefit from what will likely become a thriving export market in future.

By emphasizing HEV and PHEV adoption over more expensive big-battery BEVs, we can likely make an appreciable dent in emissions from the global transportation sector over a relatively short period of time. I would estimate we can cut 7% of global emissions over a period of 10 years if every nation mandated much stricter emission limits for individual auto sales.

We also know that providing sufficient uranium fuel to China to engage in a mixed-oxide fuel reactor program to replace their coal-fired generating stations could cut 20% of global carbon emissions, on its own. If such a program could be expanded to India, it would have additional significant benefits. The effect of the western world doing nothing but tending to its own knitting regarding CO_2 emission reductions will be catastrophic in the long run, because there is simply not enough that we are willing to do, or even able to do, on our own. We should not ignore 20% cuts to emissions simply because they will primarily occur in China. Climate change is a global crisis, so reductions benefit us all wherever they happen. Instead, we should facilitate global action on replacing coal with renewables and nuclear, especially when it will open massively larger markets for uranium and related technology.

Attacking the global aluminum and steel industries and converting them from CO_2 producers on the grandest scale to clean electrochemical processors will require significant planning and some technology development. But this could yield, on its own, another 11% reduction of global emissions from the steel industry alone, not counting the knock-on effect of lower electrical energy consumption per tonne of aluminum or steel produced using ceramic electrodes compared to production using conventional graphite electrodes. In the interim, we can reduce carbon emissions from primary steel production, substantially, by replacing metallurgical coal with natural gas.

Finally, if we can eliminate 60% of the energy used in buildings for heating, cooling and making hot water, then we can subtract another 4% of global carbon emissions.

All told, we have a path that is fairly actionable to reduce global CO_2 emissions by 42%, with the timing determined by the aggressiveness of various governments to make these things happen. We have not even considered other industries or sectors to do this, but the likelihood is that this can be done. It does not require wishing new technology into being, everything discussed above is actually available today. It also keeps the future need for critical materials such as lithium, cobalt and uranium to manageable levels. Human society can overcome this crisis.

Yes, we will need greater supply of certain critical materials. Our First Proposal requires much more lithium, likely lithium hydroxide, in order to be implemented. The Second Proposal depends on available low-enriched uranium and thorium for nuclear reactors, along with rare earth elements and chemicals such as tellurium, for use in wind turbines and thin-film solar cells, respectively. The Third Proposal will require materials such as yttrium, zirconium and some rare earth elements to make the appropriate ceramic electrodes. And the Fourth Proposal, with greater use of insulation in construction, will require larger amounts of chemicals such as borates.

In short, we can meaningfully reduce CO_2 emissions without crushing our economies, but we need the political courage to try. Sadly, it seems that we have much less political courage in our world, today, than we have carbon emissions, but all it might take is one visionary political leader.

Any volunteers? Because we really need one.

Important Disclosures

Stormcrow Capital Ltd. ("Stormcrow") is a financial and technical/scientific consulting firm that provides its clients with some or all of the following services: (i) an assessment of the client's industry, business plans and operations, market positioning, economic situation and prospects; (ii) certain technical and scientific commentary, analysis and advice that is within the expertise of Stormcrow's staff; (iii) advice regarding optimization strategies for the client's business and capital structure; and (iv) opinions regarding the future expected value of the client's equity securities so as to allow the client to then make capital market, capital budgeting and capital structure plans. Stormcrow does publish research reports for general and regular circulation. Stormcrow is also registered in Canada with the Ontario Securities Commission in the category of Exempt Market Dealer. With the consent of Stormcrow's client, the client and/or its industry sector may be the subject of an investment or financial research report, newsletter, bulletin or other publication by Stormcrow where such publication is made publicly available at www.stormcrow.ca or elsewhere or is otherwise distributed by Stormcrow. Any such publication is limited to generic, non-tailored advice or opinions and should not be construed as investment advice that is suitable for the reader or recipient. Stormcrow does not offer personalized or tailored investment advice to anyone and its research reports should not be relied upon in making any investment decisions. Rather, investors should speak with their personal financial advisor(s).

Stormcrow intends to provide regular market updates on the affairs of the Company (at Stormcrow's discretion) and make these updates publicly available at www.stormcrow.ca. Readers who wish to receive notice when such updates become available, should browse to www.stormcrow.ca/research and click the "Subscribe to Research Distributions" link.

All information used in the publication of this report has been compiled from publicly available sources that Stormcrow believes to be reliable. Stormcrow does not guarantee the accuracy or completeness of the information found in this report and Stormcrow may not have undertaken any independent investigation to confirm or verify such information. Opinions contained in this report represent the true opinion of Stormcrow and the author(s) at the time of publication.

Any securities described in this research report may not be eligible for sale in all jurisdictions or to certain categories of investors. This report and the content herein should not be construed by anyone as a solicitation to effect, or attempt to effect, any transaction in a security. This document was prepared and was made available for information purposes only and should not be construed as an offer or solicitation for investment in any securities mentioned herein. The securities referred to herein should be considered speculative in nature and should be considered to involve a high amount of financial risk where investors may lose all of their investment.

Forward-looking information or statements in this report contain information that is based on assumptions, forecasts of future results, estimates of amounts not yet determinable, and therefore involve known and unknown risks, uncertainties and other factors which may cause the actual results, performance or achievements of their subject matter to be materially different from current expectations. No representation is being made that any investment or security will or is likely to achieve the return or performance estimated herein. There can be sharp differences between expected performance results and the actual results.

Dissemination of Research

This research report is private and will not be made available to the public.

Investment Rating Criteria

We do not provide an investment rating, beyond indicating whether the target price exceeds current trading ranges by a reasonable range, indicated as "Positive", or whether the target price is either below or roughly equivalent to the current trading range, indicated as "Negative". Each investor has an individual target return in mind, we leave it to the individual investor to determine how our target and the current price fit in their portfolio.