Broken Promises:

Why Renewables Offer no Resilient Recovery.

Robert Lyman

5/5/20

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BROKEN PROMISES:

WHY RENEWABLES OFFER NO RESILIENT RECOVERY – PART1

EXECUTIVE SUMMARY

Those who believe that human greenhouse gas emissions are causing catastrophic global warming see the eventual recovery from the current pandemic-related economic recession as an opportunity. They are lobbying governments to pour large amounts of taxpayers' dollars into renewable energy, so that this industry allegedly can offer a resilient recovery for the Canadian economy and replace the jobs lost in the hydrocarbons industries. In the first of a multi-part series, I here describe what actually is happening in global oil and gas and renewables markets.

The British Petroleum Statistical Review of World Energy 2019 is an authoritative source of data on global energy supply, demand and emissions trends. According to that report, with one brief pause in 2008-2009, global demand for all energy sources rose steadily from 1993 to 2018. In 2018, fossils fuels (oil, natural gas and coal) still constituted 84% of global energy demand, while renewable energy (mainly solar and wind energy plus biofuels) provided 4%. While renewable energy use is growing rapidly from a small base, in 2018 the market for oil and gas worldwide was 14 times larger than the market for renewables. Further, the growth in oil and gas usage from 2017 to 2018 was ten times larger than the growth in renewables use. The growth in oil and gas use that year was higher than the total use of renewables in 2018.

The factors that drive oil and gas markets and renewables markets are quite different. People who produce, refine and market oil and gas have made money because billions of consumers freely decide that the benefits of the energy services these fuels provide are worth it. Renewable energy sources in most cases cost more than their alternatives, whether used for electricity generation or as transport fuels. Consequently, their use is driven mainly by government mandates, regulations and subsidies. Here, I identify 24 generic ways in which governments provide advantages to wind, solar and biomass industries that are not available to competing conventional energy suppliers.

Globally, according to the REN21 Renewables Global Status Report published by the United Nations Environment Program, from 2006 to 2017 nearly U.S. $2.5 trillion was funneled into government mandated renewable energy investments. Yet, despite that monumental expense, global emissions increased by almost 20%.

As the global economy emerges from the current pandemic, logic would suggest that oil and gas, which now constitute 60% of global energy use, will grow far faster than renewables which hold only a 4% share. Further, in emerging from a period of depressed income, companies and people would probably prefer energy sources that are less expensive and more reliable; that consideration strongly favours oil and gas. However, government mandates, so common in many countries, may require people to continue using less economic renewable energy where free choices would dictate otherwise.

BROKEN PROMISES

WHY RENEWABLES OFFER NO RESILIENT RECOVERY.

PART 1 IN A SERIES

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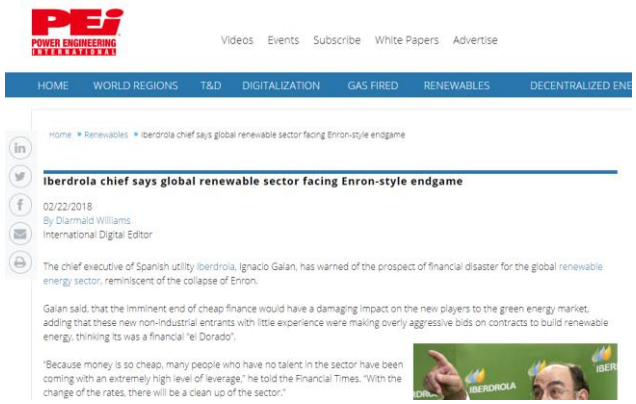
As Canadians struggle to cope with both the adverse health and economic effects of the coronavirus, some are turning their thoughts to how economic activity should be renewed once the worst of the pandemic is past. Those who believe that human greenhouse gas (GHG) emissions are causing catastrophic global warming and that Canadians must hasten their transition away from fossil fuels see this as an opportunity. Organizations like Clean Energy Canada, sponsored by Simon Fraser University and several renewable energy companies, recently launched a letter-signing campaign to urge federal and provincial governments to provide even more support to their industry to promote a “resilient recovery”. They and others are arguing publicly that, as the economy begins to recover, this will be the time to pour large amounts of taxpayers’ dollars into renewable energy, so that this industry can recreate the jobs lost in the hydrocarbons industries.

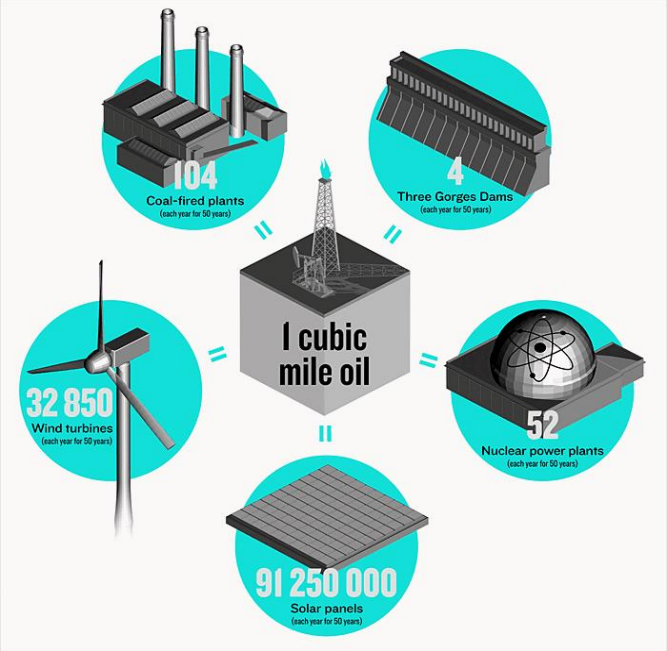


My initial reaction to this was to list all the reasons why the idea is wrong. A simple list, however, would not be convincing. So, I plan to post a few articles on the subject. These will set out, in terms that the average person easily understands, the reasons why renewable energy is not a promising source of either economic growth or job creation. This first article will answer the questions, "*What is happening in energy markets? How are supply and demand for hydrocarbons and renewable energy actually changing?*"

SOME BASICS ABOUT ENERGY

Energy sources differ in many respects, but most importantly in terms of how they may be used to provide the energy services upon which our economy and standard of living depend – notably, heat for buildings, industrial processes and cooking; lighting; air conditioning; and the thousands of uses of electricity. They also differ in terms of their level of energy density (i.e. amount of energy present in a given mass) and how much space is required for their production. Further, they differ in terms of how safe and expensive they are to store and to transport from where they are produced to where they are used. Finally, they differ in terms of the geographic areas where they can be produced and where their consumers live, and the various geopolitical factors that are associated with these areas.

CRUDE OIL has advantages over other fuels in that it has a high level of energy density and it is relatively easy, cheap and safe to transport and store. Crude oil is refined into many different products that serve needs in the transportation, manufacturing, commercial and residential sectors, and it is a key feedstock for the production of petrochemicals and fertilizers. **Ninety per cent of the energy needs of world transportation are served by oil products.** More than 125 countries produce 100,000 barrels of oil per year or more, but the bulk of production is concentrated in the Middle East, North America, Russia and China. The largest oil importers are all in Asia (China, India, Japan and South Korea).



The world presently uses 3 Cubic Miles of Oil-Equivalent energy every year; One Cubic Mile of that energy **is Oil**.

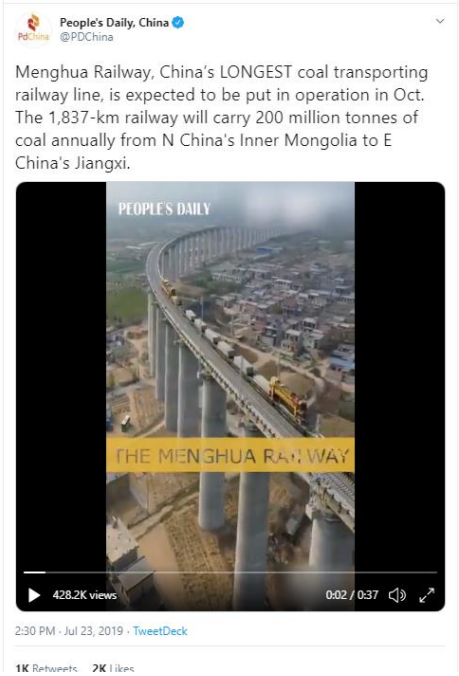
"To obtain in one year the amount of energy contained in one cubic mile of oil, each year for 50 years we would need to have produced the numbers of dams, nuclear power plants, coal plants, windmills, or solar panels shown here."

Assumptions: The Three Gorges Dam is rated at its full design capacity of 18 gigawatts. A nuclear power plant is postulated to be the equivalent of a 1.1-GW unit at the Diablo Canyon plant in California. A coal plant is one rated at 500 megawatts. A wind turbine is one with a 100-meter blade span and rated at 1.65 MW. A solar panel is a 2.1-kilowatt system made for home roofs. In comparing categories, bear in mind that the average amount of time that power is produced varies among them, so that total energy obtained is not a simple function of power rating. https://spectrum.ieee.org/energy/fossil-fuels/joules-btus-quads-lets-call-the-whole-thing-off

NATURAL GAS like oil but to a lesser extent, is a dense form of energy that can be easily and cheaply transported by pipeline. It is comparatively expensive to store. Its advantage is that it is a clean-burning fuel, with very few pollutants that affect local air quality. Gas is used mainly for electricity production, residential heating and industrial processes. The growth of natural gas trade internationally has been due to the increased use of technologies by which gas is liquified and transported in ships then re-gasified at a port before being moved to final markets by pipeline. About 31 countries produce significant amounts of natural gas, but the largest producers are the United States, Russia, Iran, Qatar and Canada. Seventy-one countries import significant amounts of natural gas, but the largest importer by far is the European Union.

Natural gas is cooled into a liquid form "Liquified Natural Gas" for easier transport of large volumes.
Source: https://safeshippingbc.ca/?page_id=105

COAL's energy content is of medium density. It can be produced at relatively low cost, but it contains many impurities that can affect local air quality unless it is burned in plants that have advanced "scrubbing" technologies. Most coal is used for power generation, but about 10 per cent is used for steel making. Like natural gas, coal-fired generation is reliable and dispatchable (i.e. it can be varied up and down to meet changes in electricity demand) though natural gas is more 'nimble' and the favored choice to back-up renewables; coal-fired plants take a long time to power up or down. About 20 countries produce coal but about two-thirds of production are in China, India and the United States. Fifteen countries account for 84% of all coal imports, but the top five are all in Asia. While coal remains an important source of world energy, most of the rest of this article will focus on the comparison between oil and gas and renewables.



Watch video clip:

https://twitter.com/PDChina/status/1153764219176857603

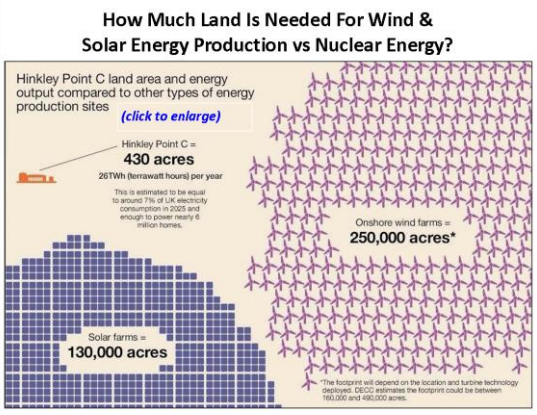
Wind energy (or wind power) refers to the process of creating electricity using the wind, or air flows that occur naturally in the earth's atmosphere. Modern wind turbines are used to capture kinetic energy from the wind and generate electricity. Utility-scale wind turbines range in size from 100 kilowatts to several megawatts, where the electricity is delivered to the power grid and distributed to the end user by electric utilities or power system operators. Distributed or "small" wind are single small wind turbines below 100 kilowatts that are used to directly power a home, farm or small business and are not connected to the grid. Energy produced by industrial wind turbines has very low density. Wind resources are widely distributed in the world but often distant from the markets that the electricity is intended to serve. The costs of transmission are higher than those of hydrocarbon and nuclear electricity generation sources.

["Transmission" refers to the high voltage power lines running between remote regions where wind and solar farms capture kinetic energy to take that energy to power distribution hubs. The 500kV transmission line from Calgary to Pincher Creek wind farms is ~213km and cost taxpayers $2.2 billion for only 4% of Alberta's power, intermittently, and cumulatively only ~30% of the time. By contrast, Calgary's Shepherd Energy Centre natural gas plant cost $1.4 billion and provides ~800 MW of dispatchable power 24/7.]

Wind farms in Southern Alberta, including early trellis design. Alberta set up the first windfarm in Canada in 1993. Photo credit: Clive Schaupmeyer

Active solar energy methods use technology to convert solar energy into a secondary form (e.g., a fluid or electricity) that has its own use. Simple solar thermal collectors are typically pipes filled with a heat-transfer fluid, such as water, placed on a roof. Sunlight heats up the liquid within the pipes. A pump then moves this liquid into a storage tank. People can use this heated liquid directly or as part of a process that requires heat. Photovoltaic (PV) cells are thinly sliced wafers of semiconductor, a material used to control and direct electrons. Two of these wafers are stuck together inside the PV cell. The movement of electrons across the gap between the two wafers creates a small electric current. The direct current (DC) from PV cells can power any number of things, from lights in a home to machines in a factory. However, changing DC to the alternating current (AC) used in most homes and businesses requires an electrical device known as an inverter.

Solar and wind farms require huge amounts of land. Both wind and solar energy are intermittent sources, meaning that their production of electricity varies by the presence of windy conditions (often influenced by the seasons) or the amount of daylight. This is a significant disadvantage, in that electricity demand changes in ways that do not correspond to the production from intermittent energy sources, and the costs of electricity storage are very high).



This illustration compares the footprint of the Hinkley Point C nuclear plant in the UK with equivalent wind/solar capacity.

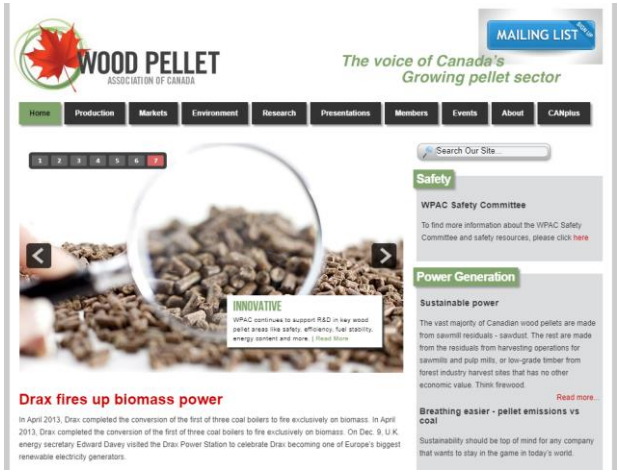
Battery storage?

"The cost to provide enough storage for one cold winter day in Alberta would be C$69 billion. Unfortunately, this wouldn't be nearly enough. We would need weeks, if not months, of storage to maintain a reliable grid. The costs would be in the C$100's of billions if not trillions of dollars.

https://www.linkedin.com/pulse/winds-winter-discontent-curtis-sheptycki/

"Biofuels" and "biomass" are terms that describe a range of energy products based on plants and animals. Primary biofuels include the use of wood, wood chips and pellets, and animal dung as energy for heat, light and cooking, as is done in many developing countries. This type of energy use is not even counted in many statistical summaries of modern energy use. Secondary, or manufactured, biofuels include ethanol and biodiesel, which derive from several agricultural products, mainly corn, sugar cane, palm oil, soybeans and canola. Where locally sourced, primary fuels are often the lowest cost energy available, although the combustion of wood and animal dung in rural dwellings is often cited as causing major respiratory problems. Ethanol and biodiesel are more expensive than fossil fuels and must be subsidized to be competitive.

Stockpiled cattle manure used for heating and cooking.
Hailar District, Inner Mongolia Autonomous Region, China



Hydroelectricity, one of the most important renewable energy sources in Canada, is largely absent from the public policy discussion about the role that renewable energy can and should play in meeting future world energy needs. The reason for this is partly because many of the hydroelectric power sites in the world that are well suited and located to meet energy needs have already been developed. Probably more important, however, is that much of the dialogue about future energy needs and uses is dominated by radical environmentalists who, for largely ideological reasons, refuse to contemplate the role that electricity sources like hydroelectricity and nuclear energy can play in the world's future.

Spillway of the Robert Bourassa dam P199 / CC BY-SA
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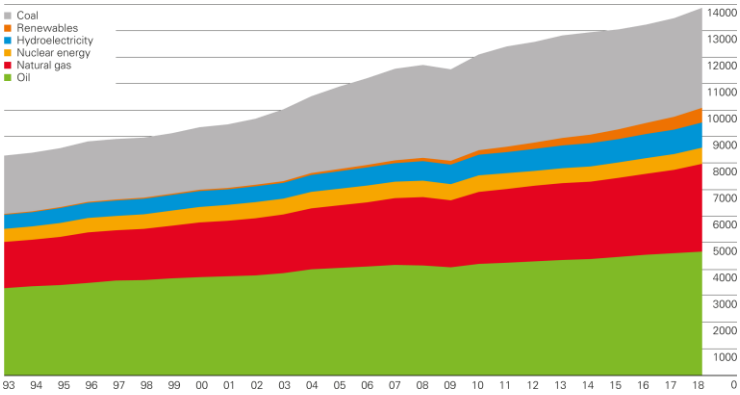
RECENT GLOBAL ENERGY SUPPLY AND DEMAND TRENDS

The British Petroleum Statistical Review of World Energy is the most authoritative source of data on global energy supply and demand trends. The information in this section in from the 2019 version of that review.

The adjacent graph shows the recent trends in demand by energy source, measured in terms of million tonnes of oil equivalent, over the period 1993 to 2018.



This single graph contains critical information that people must have to understand what is actually happening in energy markets. It directly contradicts many of the claims often made by environmentalists. The graph illustrates that:

- Except for a brief period during and following the 2008-2009 global recession, global energy demand has steadily risen.
- Oil (green), coal (grey) and natural gas (red) supply by far the majority of global energy use; in 2018, they supplied 84% of the total, with most of the remainder provided by nuclear energy and hydroelectricity.
- **Renewables, meaning wind power, solar energy and biomass used for power generation, provide only 4% of global energy needs.**

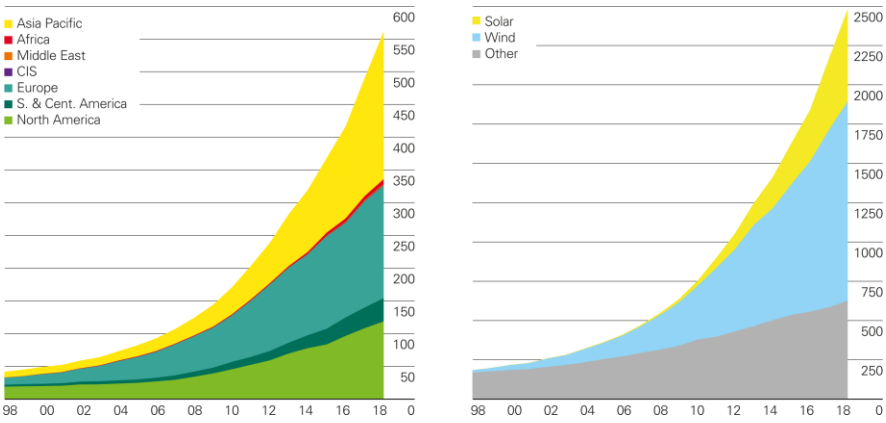
What is not apparent from the graph but becomes clear when one examines the underlying data is that:

- Almost all of the growth in primary energy use since 1993 has occurred in the non-OECD ("developing") countries.
- By 2018, the non-OECD constituted 59% of global energy demand.
- Both oil production and consumption have risen by more than one million barrels per day per year since 2012.
- Oil demand is at its highest level in history.
- **In absolute terms, oil demand is growing twice as fast as renewables.**
- Global oil reserves have risen throughout the period, from 1141 billion barrels in 1998 to 1730 billion barrels in 2018; peak oil is nowhere in sight.
- **In absolute terms, natural gas is experiencing the fastest rate of growth of all energy sources, almost three times as fast as renewables.**
- Natural gas demand is at its highest level in history.

In 2018, oil and gas provided almost 8 billion tonnes of oil-equivalent energy to the world, while all renewable energy provided 561 million tonnes. In other words, **the market for oil and gas world-wide in 2018 was 14 times larger than the market for renewables**. Further, the growth in oil and gas demand from 2017 to 2018 was 669 million tonnes while the growth in renewables demand was only 71 million tonnes. **The growth in oil and gas usage was ten times larger than the growth in renewables use; in fact, the growth in oil and gas use from 2017 to 2018 was higher than the total use of renewables in 2018.**

RENEWABLE ENERGY TRENDS

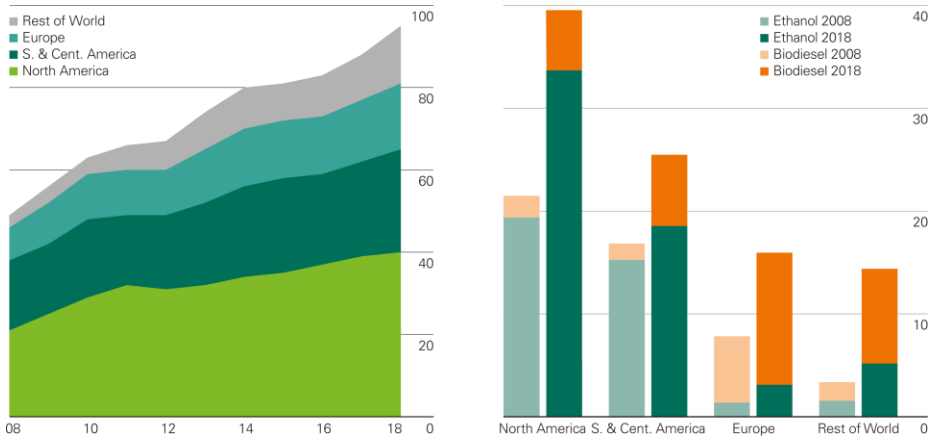
To be sure, renewable energy production and use is growing. This is shown in the following graphs, also from the British Petroleum Statistical Review of World Energy. The graph on the right shows electricity generation by wind, solar and other (mostly biomass) sources in terms of terawatt hours. The one on the left shows renewables consumption by region in terms of million tonnes of oil equivalent.



The graphs tell an interesting story:

- From very low levels of use in 2000, renewable energy power generation grew to 2,840 terawatt hours in 2018.
- 1,270 terawatt hours of production, or 45%, was by industrial wind turbines, 585 terawatt hours, or 21%, was from solar, and 626 terawatt hours, or 22%, was from "other" sources.

The next graphs show the biofuels production trends in terms of million tonnes of oil equivalent.



According to some sources, like ExxonMobil, biofuels account for 60 to 70% on renewable energy consumption worldwide. The British Petroleum Statistical Review of World Energy reports on a category called "other renewables" (to distinguish them from wind and solar) used for power generation. In 2018, these fueled 626 terawatt hours of global electricity production, or 25% of the total renewables contribution. In 2017, biofuels represented about 3% of the energy used in global transportation. The growth of ethanol and biodiesel as transportation fuels has been driven by governmental mandates, primarily in North America and Europe. Biofuels production globally has grown from about 55 million tonnes of oil equivalent in 2008 to about 95 million tonnes of oil equivalent in 2018. Somewhat surprisingly, eighty-five per cent of biofuels production is in the Americas and Europe, and only 15% in the rest of the world. Ethanol accounts for about 60% of total biofuels production.

THE ROLES OF PRIVATE INVESTORS VS GOVERNMENTS IN ENERGY MARKETS

These demand trends also should be viewed in the context of the great difference between the oil and gas markets and the renewable energy markets. Oil and gas are commodities that have been profitable for over a century based on supply and demand in free competitive markets. In other words, people who produce, refine and market these products have made money because there were millions of consumers who freely decided that the benefits of the energy services provided were worth it. They did not need governments to direct or compel them to buy.

In contrast, wind and solar energy are good mainly for electricity generation, which in most of the world is owned, managed and operated by government-owned monopolies and under heavy regulation with respect to prices, rates of return and purchase practices. With some exceptions, electrical utilities are far less subject to the market discipline of having to produce usable energy in accordance with consumers' tastes. They are monopolies. Even where wind and solar energy sources cost far more than the competing energy sources and they are less secure and reliable, utilities buy them because government policy directs them to do so.

Ethanol and biodiesel cost far more to produce than the conventional oil-based fuels promoters seek to replace. Since the 1970's, however, governments in North America and Europe have imposed mandates that require the use of ethanol and biodiesel, primarily because of the indirect multi-billion-dollar subsidy this provides to growers of corn and other crops (even when the ethanol has to be imported!). Powerful political lobbies have defended these mandates and blocked governments from eliminating them.

Several governments across the world have sought to accelerate the purchase and penetration in the electrical energy systems of renewable energy technologies that were not yet mature and far from competitive with existing generation sources. **Governments have given wind, solar and biofuels suppliers several advantages over conventional electricity supply. I identified 24 generic ways in which governments provided advantages to wind, solar and biomass industries:**

- Direct government investment in plants that manufacture renewables equipment, ethanol and biodiesel;
- Renewable portfolio standards that require a certain percentage of electricity generation to be based on renewables;
- Ethanol and biofuel mandates setting minimum standards for fuel content or minimum quantities of biofuels that refiners must purchase every year;
- Exempting biofuels from excise taxes applicable to gasoline and diesel fuel"
- Mandated phase out of competing coal and nuclear power generation;
- Funding of research and development conducted either in government research facilities or private research laboratories;
- Funding for technology demonstration projects;
- Funding for R&D on bulk energy storage technologies;
- Grants, contributions, and low-interest loans made either to suppliers or purchasers;
- Tax incentives such as credits, deductions and exemptions that are provided to renewables producers or purchasers;
- Tax incentives that allow renewables producers to pass through the benefits to other investors in the form of flow-through shares;
- Tax incentives for "Green Bonds";
- Qualification of renewable energy projects as "offsets" from which companies governed by emissions trading systems (i.e. "cap and trade") can buy emissions permits;
- Preferential, above-market utility rates, as used in "feed-in-tariff" regimes, guaranteed at fixed rates for the life of the contract;
- Priority access ("first-to-the-grid") rights that require the electricity system operators to use the production from wind and solar generation when it was available, and to back out, or "curtail", alternative sources of supply;
- Requiring the construction of other transmission and distribution systems expansions and upgrades (e.g. "smart meters" and other "smart" systems) to accommodate the additional renewable generation capacity;

- Requiring other suppliers and ratepayers to pay for the cost of additional balancing and flexibility (e.g. backup generation) to deal with situations when demand was high but the sun was not shining or the wind blowing;
- Similarly, requiring ratepayers to pay the costs of dumping surplus power supplies on export markets when the renewables plants produced electricity, but the demand was low;
- Preferential government procurement practices;
- Restrictions on the authority of local governments to impose property and other taxes on wind and solar projects;
- Granting renewable energy generators exemptions from environmental assessment and land-use planning requirements that apply to all other energy projects;
- Granting power plants exemptions from GHG emissions standards for emissions caused by burning wood (i.e. treating biomass as carbon dioxide-neutral), even though the forests cut down to produce the wood chips will take decades of tree growth to reabsorb the released CO2;
- Exemptions from species-at-risk legislation in several areas to avoid prohibitions due to adverse effects on rare birds and bats; and
- Often overlooking health-related complaints about the effects of industrial wind turbines or failing to enforce setback requirements separating the turbines from residences.

Image licensed from Shutterstock.

Few countries even keep track of the value of the subsidies, mandates and other market advantages given to renewable energy. The United States Energy Information Administration (EIA) periodically publishes reports on the U.S. government's "financial interventions and subsidies" to all energy sectors. The most recent report, published in 2018 and based on data from 2016, showed that subsidies to renewables (including wind, solar and biofuels) declined from about U.S. $15.3 billion in 2013 to U.S. $6.7 billion in 2016.[1] Only end-use (i.e. energy efficiency) subsidies came close in value at U.S. 6.2 billion out of total energy subsidies of U.S. $15 billion in 2016. **For the three years for which the EIA report provides data (2010, 2013 and 2016), U.S. federal subsidies to renewables totalled U.S. $37.9 billion.** State-level subsidies, as in places like California and New York, added more.

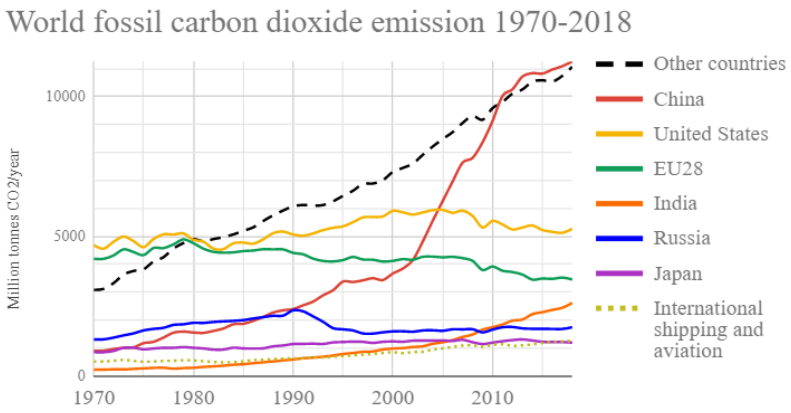
Globally, according to the REN 21 Renewables Global Status Report published by the United Nations Environment Program, from 2006 to 2017 nearly U.S. $2.5 trillion was funnelled into government-mandated renewable energy investments. How much is $2.5 trillion? There are

[1] *Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Years 2016*. Energy Information Administration, Washington, April, 2018

about 160,000 hospitals in the world. With $2.5 trillion to spend, you could increase that number of hospitals by 20 times. The REN 21 Renewables Global Status Report can be seen here:

https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf

The public justification for such extensive and multi-faceted government support for renewable energy was that it would reduce GHG emissions. **Yet, despite that monumental expense, from 2006 to 2017, global emissions increased by almost 20%.**



In short, the growth in use of renewable energy to date has not been due to any inherent technical or market-driven advantages. It has not been because consumers freely choose renewables. It has been driven entirely by government policies, policies that have imposed major costs on energy consumers, whether residential, commercial, industrial or transportation-related. At best, the subsidy-driven growth in renewable energy production and use has only slightly slowed the growth in global GHG emissions.

HOW WILL THE PANDEMIC CHANGE MARKET TRENDS?

At this point, it is almost impossible to predict with confidence how the effects of economic shutdowns imposed by governments in the wake of the coronavirus pandemic will affect supply and demand for oil and gas on the one hand and renewable energy sources on the other. Broadly, the sharp reduction in overall economic activity will reduce demand for all energy sources. As oil and gas account for about 60% of global energy use, it stands to reason that they will be affected more than wind, solar and biomass energy sources.

Government support and regulatory requirements will probably protect renewables from the market-driven reductions to some extent. Ontario provides an example of how this will work. Parker Gallant, an expert on Ontario's system of energy regulation, described what happened during a three-day period in April 2020. Citing reports from the Independent Electricity System Operator (IESO), he noted that during the Easter three-day weekend, average daily Ontario electricity demand was 293,400 megawatt hours (MWh), or an average hourly rate of 12,225 MWh. That demand peaked at 14,174 MW and could easily have been supplied by nuclear generation that averaged 10,000 MW and hydro ramped up to over 4,800 MW. Instead, the "must take" contracts

granted to wind and solar generators meant that IESO was obliged to accept their generation or pay to curtail what they might generate.

"*Over those three days, lESO accepted approximately 125,000 MWh of wind generation to the grid and curtailed 84,400 MWh. The cost of the grid-accepted and curtailed wind power works out to a cost of $213.44/MWh or about $26.9 million for unneeded power.*

Saying the electricity wind generated was unneeded is not a misnomer, as over those three days we exported 250,000 MWh which was double grid accepted wind… IESO sold exports at an average price of $2.71/MWh so if we assume all of the wind generated electricity was exported it would have generated $339 thousand while costing $26.9 million. Even paying the idling costs (about $10K per month per MW) on the 9,500 MW capacity of gas plants (to back up wind and solar generation) only cost us about $9 million for the three days. The other exported power of 125,000 MWh over those three days cost us the GA (Global Adjustment). Based on IESO's first estimate for April the forecast of the GA at $137.07/MWh would mean the additional 125,000 MWh exported cost ratepayers/taxpayers another $17.1 million.

Adding the costs of wind generation of $26.9 million to the costs of the other exported generation of $17.1 million and deducting the revenue from the sale of the exports of $600K would see Ontario ratepayers/taxpayers paying $<u>43.4 million over the three days for NOTHING</u>! Something is inherently wrong with the management of our electricity system despite all of those well-paid public servants operating it. Thank god it was a cloudy weekend or solar *costs would have added to the burden."*[2]

In jurisdictions like Ontario's, where the continued existence of feed-in-tariffs and "first-to-the-grid" rights for wind and solar generation continue, electricity prices for residential, commercial and industrial consumers, already suffering the ill effects of the shut-downs and recession, will inevitably go higher. While people see the effects of lower energy demand in sharply reduced prices for gasoline, few people ask why, in the face of reduced electricity demand, rates go higher and higher, and the general media remains silent.

For countries and companies dealing with a forthcoming recession, considering which power generation sources to build in future, the choice may well depend more on the consideration of cost rather than claims of impending climate catastrophe. Especially if oil and gas markets remain depressed, natural gas should enjoy a significant cost advantage over wind and solar for a long time.

Part 2 in this series will address the comparative costs of the different energy sources.

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[2] *Easter Weekend and Wind Generators Gorged on Ontario's Chocolates,* Parker Gallant Energy Perspectives blog article, April 14, 2020.

About the Author

Robert Lyman is a former public servant of 27 years and a diplomat for 10 years. Lyman's bio can be read here.

About Friends of Science Society

Friends of Science Society is an independent group of earth, atmospheric and solar scientists, engineers, and citizens who are celebrating its 17th year of offering climate science insights. After a thorough review of a broad spectrum of literature on climate change, Friends of Science Society has concluded that the sun is the main driver of climate change, not carbon dioxide (CO_2).

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