Carbon Neutrality, Resources, Prosperity and other Musings

Adam C. Simon
An historical perspective on resources

“Men know how to mine silver and refine gold, to dig iron from the earth and melt copper from stone“ (Job 28:1-2)

Gold, 6000 BCE
Copper, 4200 BCE
Silver, 4000 BCE
Tin, 1750 BCE
Lead, 3500 BCE
Iron, 1500 BCE
Mercury, 750 BCE

These seven “Metals of Antiquity” were critical for the development of human civilization.
Where are we as a society?
Since 1900, global population, economic activity and prosperity have increased significantly.
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Maternal Mortality, 1751-2013

Percentage of mothers dying in childbirth

- Ethiopia
- Malaysia
- United States
- Sweden
Child Mortality, 1751-2013

Percentage of children dying before the age of 5

- South Korea
- Canada
- Sweden
- Chile
- Ethiopia
World Population Living in Extreme Poverty

Percentage of world population living in extreme poverty

Year:
- 1820
- 1840
- 1860
- 1880
- 1900
- 1920
- 1940
- 1960
- 1980
- 2000
- 2020
Resources consumption and discretionary ("free") time

Access to electricity
Resources consumption and discretionary ("free") time

Access to electricity

Hours of housework per week

Percentage of households

1890 1915 1940 1965 1990 2015
Resources consumption and discretionary ("free") time

Housework

Access to electricity
Inventions and discretionary time, 1890-2015

- Housework
- Running water
- Electricity
- Refrigerator
- Vacuum cleaner
- Washing machine
- Stove
- Dishwasher
- Microwave
With manual labor and manual tools, it took 25 men a full day (dawn to dusk) to harvest and thresh a ton of grain, compared to one person on a GPS-guided, air conditioned, lumbar-seat-heated combine (the big green tractor) that does this in 6 minutes.
Figure 1. S-curve fits to historical electricity access data by year and average income level in international Geary–Khamis dollars (GKS).
Literacy Rate in the Middle East and Northern Africa, by Age Group – by Max Roser

Litarcy Rate of the Population 65 and older

Data source: UNESCO.
The interactive data visualisation is available at OurWorldInData.org. There you find the raw data and more visualisations on this topic.

Licensed under CC-BY-SA by the author Max Roser.
Since 1900, global population, economic activity and prosperity have increased significantly.
Since 1900, global population and economic activity have increased significantly, along with fossil fuel consumption.
The positive and negative consequences of prosperity?
Easter morning 1900: 5th Ave, New York City. Spot the automobile.

Source: US National Archives.
Easter morning, 1900.
New York City’s Fifth Avenue

Easter morning, 1913.
New York City’s Fifth Avenue

Source: George Grantham Bain Collection.
The Nineteenth Century, 1868

Frank Blackwell Mayer
(b. 1827, Baltimore, 1827; d. 1899 Annapolis)

The leather-aproned blacksmith was a potent American symbol of noble handcrafts during the increasingly mechanized 19th century. His tools lie idle, and his anvil is nearly covered by an open newspaper, that all important vehicle for mass dissemination of information.
Literacy Rate of the Population 65 and older

Our World in Data
Literacy Rate in the Middle East and Northern Africa, by Age Group – by Max Roser

Literacy Rate of the Population 65 and older

Literacy Rate of the Population between 15 and 24

Data source: UNESCO.
The interactive data visualisation is available at OurWorldinData.org. There you find the raw data and more visualisations on this topic.

Licensed under CC-BY-SA by the author Max Roser.
Chinese students enrolled in US universities.
USA

- 1891: First mining regulations; only ventilation
- 1910: Bureau of Mines established; coal focus; could not enter mines
- 1941: Congress directed inspectors to enter mines
- 1952: Federal Coal Mine Safety Act; required annual inspections of some mines
- 1966: amended to require annual inspections at all mines
- 1977: Mine Safety and Health Act (MSHA)
- 2006: Mine Improvement and New Emergency Response Act (MINER Act); underground mines inspected four times annually

**Number of fatalities and fatality rates (5-year aggregates) in the mining industry by sector, 1911-2015**

- **Coal Fatalities**
- **Noncoal Fatalities**
- **Coal Rate**
- **Noncoal Rate**

**NOTE:** Excludes office employees. Noncoal includes metal, nonmetal, stone, and sand & gravel operations. Sand & gravel miners included starting in 1958. Hours for 1911-1923 computed on assumption that weighted average length of workday was 9.36 hours. Full-time equivalent employees (2,000 hours = 1 FTE employee). Data source: USBM and MSHA
How can we stay below a 2°C rise in global temperatures?

Reduce carbon emissions to 0 by 2050.
RACE TO NET ZERO
CARBON NEUTRAL GOALS BY COUNTRY

Which countries have made a carbon neutral pledge?
This map breaks down pledges by target year and level of commitment.

THE U.S. COMMITTED TO A 2050 TARGET, with a 50%-52% reduction in emissions by 2030, after rejoining the Paris Agreement in 2021.

SWEDEN'S 2045 TARGET is the earliest commitment entailed in law.

CHINA'S 2060 TARGET is one of the most impactful, covering an estimated 25% of global emissions.

AUSTRALIA AND SINGAPORE have carbon neutral ambitions for the second half of the 21st century, but no concrete date.

THE MAJORITY of carbon neutrality goals are only under discussion with no firm plan of action.

MEXICO AND OTHER MEMBERS of the Carbon Neutrality Coalition promise to target net zero emissions by 2050, but commitment is up to members.

URUGUAY'S 2030 TARGET (under discussion) is the earliest carbon neutral pledge.

BRAZIL'S 2050 TARGET was one of many new pledges made during the U.S. Climate Summit in April 2021.

BHUTAN AND SURINAME are the only two countries that are carbon negative, removing more carbon than they emit.

Presented by:
motivepower
NPUC
Visual Capitalist

SOURCES: Energy and Climate Intelligence Unit, Carbon Neutrality Coalition, Climate Action Tracker
Calls for 100% of U.S. primary energy to be replaced with renewable energy resources including wind turbines, solar panels and grid-scale battery storage,
Progress toward targets.

The maps displayed are for reference only.
FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies

AFRIL 22, 2021
STATEMENTS AND RELEASES

Building on Past U.S. Leadership, including Efforts by States, Cities, Tribes, and Territories, the New Target Aims at Percent Reduction in U.S. Greenhouse Pollutio from 2005 Levels in 2030.
Americans see too little federal action on climate change, back range of policies to reduce its effects

% of U.S. adults who say ...

<table>
<thead>
<tr>
<th>A great deal</th>
<th>Some</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global climate change is affecting their local community</td>
<td>24%</td>
<td>39%</td>
</tr>
<tr>
<td>Federal government is doing too little to reduce effects of climate change</td>
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Favor each of the following proposals to reduce the effects of climate change

- Planting about a trillion trees to absorb carbon emissions
- Providing a tax credit to businesses for developing carbon capture/storage
- Tougher restrictions on power plant carbon emissions
- Taxing corporations based on their carbon emissions
- Tougher fuel efficiency standards for cars
- U.S. should prioritize developing alternative energy sources

Note: Respondents who gave other responses or did not give an answer are not shown. Source: Survey conducted April 29-May 5, 2020.

“Two-Thirds of Americans Think Government Should Do More on Climate”

PEW RESEARCH CENTER
Share of electricity generation from wind energy sources worldwide from 2010 to 2021

- 2010: 1.66%
- 2011: 2.03%
- 2012: 2.39%
- 2013: 2.82%
- 2014: 3.08%
- 2015: 3.52%
- 2016: 3.97%
- 2017: 4.57%
- 2018: 4.91%
- 2019: 5.4%
- 2020: 6.08%
- 2021: 6.59%
Certain renewable energy generation technologies have an LCOE that is competitive with the marginal cost of existing conventional generation.

**Levelized Cost of Energy Comparison—Renewable Energy versus Marginal Cost of Selected Existing Conventional Generation**

- **Levelized Cost of New-Build Wind and Solar**
  - Onshore Wind: $26
  - Onshore Wind (Subsidized): $9
  - Solar PV: $37
  - Solar PV—Thin Film Utility Scale: $37
  - Solar PV—Thin Film Utility Scale (Subsidized): $31
  - Gas—Combined Cycle, Unsubsidized: $29
  - Gas—Combined Cycle, Subsidized: $19
  - Nuclear: $33
  - Coal: $31

**Marginal Cost of Selected Existing Conventional Generation**
- Onshore Wind: $47
- Solar PV: $40

**Source:** Lazard estimates.

Note:
- Unless otherwise noted, the assumptions used in this sensitivity correspond to those used in the global, unsubsidized analysis as presented on the page titled "Levelized Cost of Energy Comparison—Unsubsidized Analysis".
- Represents the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs. Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper and lower quartile estimates derived from Lazard’s research.
- The subsidized analysis includes sensitivities related to the TCJA and U.S. federal tax subsidies. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to U.S. Federal Tax Subsidies" for additional details.
What resources are required to achieve carbon neutrality?
How much land is needed for 100% renewable energy?

Includes all vehicle miles driven, heating, air conditioning, hot water, #electrifyeverything

Utility scale solar
Utility scale wind
Ann Arbor

Ann Arbor bans solar panels in residential front yards

Updated: Jan. 30, 2019, 9:53 a.m. | Published: Mar. 02, 2018, 5:20 p.m.
Ann Arbor bans solar panels in residential front yards

Updated: Jan. 30, 2019, 9:53 a.m. | Published: Mar. 02, 2018, 5:20 p.m.
Copper required in EVs (lbs)

- Conventional Cars: 18 to 49 lbs
- Hybrid Electric Vehicles: ~85 lbs
- Plug-in Hybrid Electric Vehicles: 132 lbs
- Battery Electric Vehicles: 183 lbs
- Hybrid Electric Bus: 196 lbs
- Battery Electric Bus: 814 lbs

Source: Copper.org
Metals come from mines.
Global Copper Forecast

- Supply
- Primary Demand

Supply Shortage?
So You Want Wind Turbines But Don’t Want Copper Mines?

Renewable energy advocates generally believe the United States should use renewable energy sources like wind and solar to generate electricity and stop using fossil fuels like coal and natural gas for our energy needs.

Many of these same people also oppose the proposed copper and nickel mines in Northern Minnesota.

There’s only one problem:

Windmills use an enormous amount of copper. For example, a single wind turbine can contain 335 tons of steel, **4.7 tons of copper**, 3 tons of aluminum and 700-plus pounds of rare earth minerals.
Metals in a net-zero scenario
Current production rates of some important metals, including copper, are likely to be inadequate to satisfy future demand. (supply/demand ratio, energy and non-energy demand coverage)
Discovery drought continues

Data as of May 10, 2022.
* Annual average London Metal Exchange Copper Grade A cash price.
Source: S&P Global Market Intelligence
For those deposits that are developed into mines, it takes on average 16 years from discovery to production.

Brownfield projects tend to be quicker to develop.

Greenfield: 18 Years
Brownfield: 12 Years
We must rapidly increase the permitting process for metals resources.
End-of-life recycling rates, global.
New direct air capture industry body aims to build public support

By Cecilia Keating   June 3, 2022
Energy resources, identities, economics