

10 Things You Need To Know to Solve the Climate Change Problem

By Glenn Weinreb, Director, *The Manhattan 2 Project*

When discussing climate change with government officials, they sometimes ask me, "How do I fix this?" I tell them we need to think more like Henry Ford. In 1900, cars were made by hand, one at a time, and Henry automated, to drive down costs. Today, we handle climate change like we handled cars in 1900, one at a time. And, as a result, worldwide carbon dioxide (CO₂) emissions are increasing. To fix this, we need to reduce the cost of green energy to a level below that of coal, oil, and natural gas. Customers worldwide would then switch over to save money.



More specifically, we need to focus on 10 key concepts:

1. Green energy is energy that does not emit CO₂.

"Green" energy does not emit CO₂ and is primarily generated by solar panels, wind farms, hydroelectric dams, and nuclear power plants. After being generated, it typically takes the form of electricity, heat in a pipe, hydrogen gas (H₂), or liquid ammonia (NH₃).

2. Current decarbonization efforts are small relative to problem size.

Each year the world consumes 583 EJ of heat energy. This corresponds to 56,000 TWh of electricity when heat is converted to electricity with a 35% efficient turbine. To decarbonize, the world needs to generate this without emitting CO₂. To get a sense of how large this is, one can note how many Hoover Dams, London Arrays, solar farms, and nuclear reactors corresponds to this amount of energy:

- 22,600 London Arrays, a wind farm off the coast of England with 175 windmills
- 13,500 Hoover Dams, a large hydroelectric dam in Nevada

- 43,700 Topaz Solar Farms
- 21-times more than the world's current installed base of 400 GWe of nuclear power

One can think of these numbers as our "problem size".

The world is failing to decarbonize since our green initiatives are small, relative to problem size.



London Array Wind Farm



Hoover Dam



Topaz Solar Farm

3. Solar, wind and hydro are resource constrained.

Solar, wind, and hydro are "resource constrained". This means that although they might initially be built in favorable locations, costs inevitably go up as these locations are exhausted and building expands to less conducive areas. Hydro needs sloped land with running water. Wind needs windy land away from people, or windy shallow water close to shore. And solar farms need cheap cleared sunny land close to population.

In some regions, we can build up solar and wind power until electricity is discarded at midday due to supply exceeding demand. However, after reaching this saturation, communities are reluctant to add more solar or wind power.

Low cost methods of storing electricity and transmitting far distances would be helpful, yet this does not exist.

4. Nuclear is not resource constrained, yet has issues.

Nuclear fission is not resource constrained, which means one can build as much as one needs, without having costs increase. However, nuclear has several big issues. These include high costs, meltdown risk, nuclear waste, and proliferation risk. Each of these can be mitigated, yet only to an extent, as summarized below.

- **High Cost:** Electricity from nuclear currently costs more than electricity from coal or natural gas. To improve, one can reduce cost with factory mass production, and automated site construction.

- **Meltdown Risk:** Most existing nuclear power plants are at risk of meltdown. To avoid this for new reactors, one can use newer fuels that do not melt down, even with no coolant, due to additives that attenuate energy output when fuel becomes too hot.
- **Nuclear Waste:** Most nuclear reactors produce waste that lasts 100,000 years. To improve, one can work with newer designs that produce less waste, or waste that lasts 300 years.
- **Proliferation Risk:** There is a concern that more nuclear power plants will increase proliferation risk (i.e. risk of bomb). To reduce this risk, one can work with nuclear fuels that are not easily refined into weapons grade material. However, even with proliferation-resistant fuels, some risk remains. After the climate change problem has passed, one might observe that we traded climate change risk for proliferation risk.

Alternatively, one can consider nuclear fusion, which has no waste and no meltdown risk (e.g. [ITER](#)). However, this is still in development, and it is not clear when technical hurdles will be resolved, if ever.

5. The easy way to decarbonize is cheaper green energy.

If green energy was cheaper than carbon-based fuels, then consumers worldwide would switch to save money, and banks and bond markets would lend money to companies that build the power plants that make the green energy. If green energy was cheaper, market forces would solve the climate change problem for us.

6. Climate change is an automation problem.

To solve the climate change problem, we need to handle a large problem size (e.g. 13K Hoover dams), and we need to reduce the cost of green energy to a level below that of carbon-based fuels. Both of these require automation, both inside factories, and in the field. Therefore, in a sense, climate change is an automation problem.

7. Decarbonizing most of electricity is easy.

The US, for example, could decarbonize ~85% of electricity (~36% of energy) without causing more than a \$0.02/kWh electricity price increase. It could do this by building more PV solar farms, more land-based wind farms, and more transmission lines. The remaining 64% of energy involves oil, coal and natural gas that is primarily used to power vehicles and make things (e.g. chemicals, metals, plastics, and cement). While the bulk of electricity is easy to decarbonize, it is not clear how to decarbonize this remaining 64% of energy, at low cost.

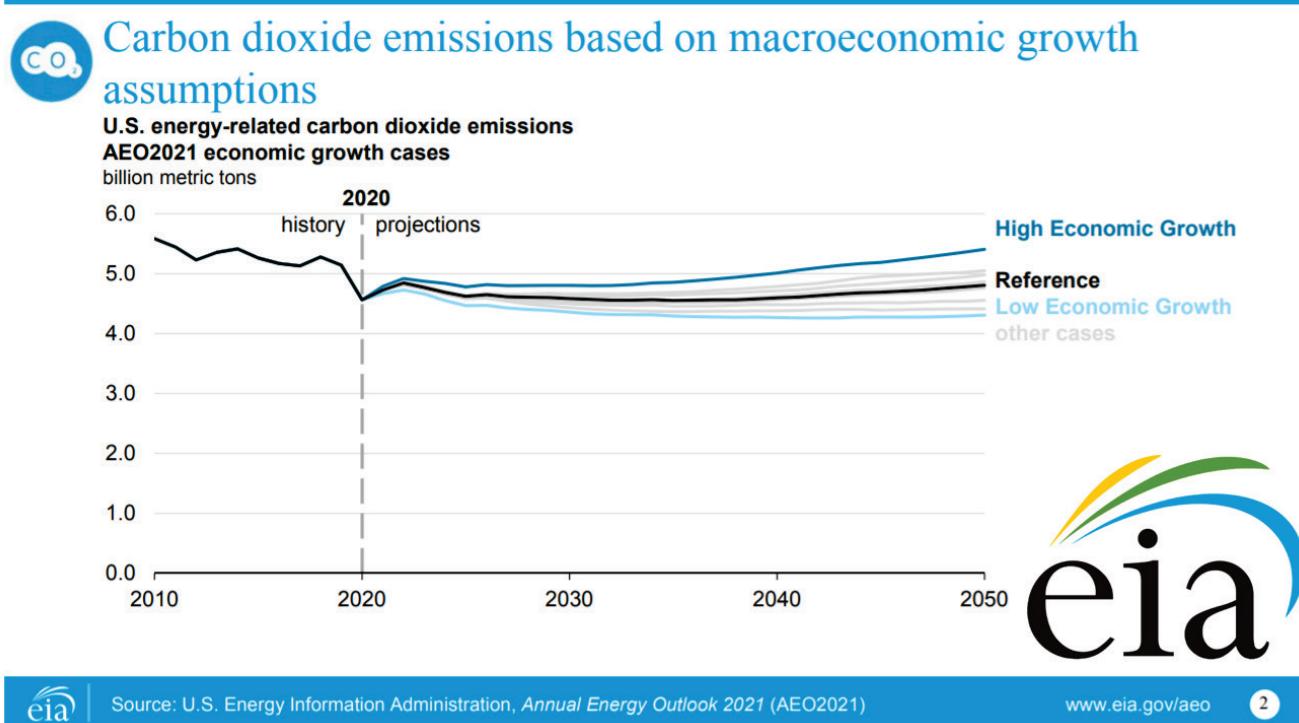
8. Nuclear power is inevitable yet not everywhere.

Significant use of nuclear power is inevitable since it is the lowest cost way to manufacture many materials, via direct heat from a nuclear reactor. However, nuclear power does not

need to be deployed in all nations. Instead, countries receptive to nuclear, such as China, can use it to take market share away from nuclear-averse nations who manufacture at higher costs. For example, green liquid ammonia could potentially replace oil since it can be converted to electricity via a fuel cell, or be combusted. And countries comfortable with nuclear could use their reactors to make large quantities for export, at competitive prices. Many nuclear-averse nations will favor importing green materials, over building nuclear reactors at home. For a discussion on how nations who are receptive to nuclear power might use it to decarbonize the world, and gain wealth, see [Nuclear Power is Inevitable, Yet Not Everywhere.](#)

9. The US and others are failing to decarbonize.

US government's Energy Information Administration (EIA) [Annual Report](#) projects United States CO₂ emissions, from all energy sources, to remain approximately constant over the next 30 years, as shown below. In other words, according to the US gov't, the US is not reducing CO₂ emissions toward zero. This is based on current gov't policy, and the fact that consumers buy the lowest cost solution. Other countries are similar.



10. If one wants to decarbonize, consider Decarbonize Law and Decarbonize Plan.

Decarbonization primarily involves constructing PV solar farms and land-based wind farms; and the quantities built each year are determined by [gov't intervention](#).

To decarbonize to zero, a nation could enact a Decarbonization Law. For example, it could: (a) mandate the amount of decarbonization that occurs each year over several decades, (b) mandate that gov't intervention be sized to support annual decarbonization targets, (c) limit consumer cost increases caused by intervention to ensure projects are acceptable, and (d) require that lowest cost projects be tackled first.

For a discussion on how this might work, see [A Plan to Get to Zero CO₂ Emissions](#).

A detailed Decarbonization Plan is primarily a list of solar farm and wind farm construction projects. To generate this list, lawmakers could specify how candidates are scored and selected, as discussed in [Develop Your Own Decarbonization Plan](#).

In summary, if one wants to decarbonize to zero, consider Decarbonization Law and Decarbonization Plan.

Further Reading -- Aspencore Climate Change Solutions Series

Summary

How to Solve the Climate Change Problem

<https://www.EETimes.com/how-to-solve-the-climate-change-problem/>

A Framework to Tackle Climate Change

<https://www.PowerElectronicsNews.com/a-framework-to-tackle-climate-change/>

10 Things You Need To Know to Solve the Climate Change Problem

<http://www.ma2life.org/g/10-things-you-need-to-know-to-solve-the-climate-change-problem.pdf>

Why COP Conferences are not More Productive

<https://www.PowerElectronicsNews.com/why-cops-conferences-are-not-more-productive/>

Decarbonization Plan

A Plan to Get to Zero CO₂ Emissions

[https://www.PowerElectronicsNews.com/a-plan-to-get-tozero-co2-emissions/](https://www.PowerElectronicsNews.com/a-plan-to-get-to-zero-co2-emissions/)

Develop Your Own Decarbonization Plan

<https://www.PowerElectronicsNews.com/develop-your-own-decarbonization-plan/>

Gov't Needs to Think Big

<https://www.PowerElectronicsNews.com/govt-needs-to-think-big/>

How to Accelerate Green Electricity

<https://www.PowerElectronicsNews.com/how-to-accelerate-green-electricity/>

Transportation

How to Decarbonize Transportation

<https://www.PowerElectronicsNews.com/how-to-decarbonize-transportation/>

Solar

How to Solve the Climate Change Problem with Solar Farms

<https://www.PowerElectronicsNews.com/how-to-solve-the-climate-change-problem-with-solar-farms/>

Turning Deserts into Factories

<https://www.PowerElectronicsNews.com/turning-deserts-into-factories/>

Mechanizing PV Solar on Land

<https://www.PowerElectronicsNews.com/mechanizing-pv-solar-on-land/>

Why Spend \$1B on Solar Installation R&D?

<https://www.PowerElectronicsNews.com/why-spend-1b-on-solar-installation-rd/>

Transmission

How to Reduce the Cost of Electrical Power Transmission

<https://www.PowerElectronicsNews.com/how-to-reduce-the-cost-of-electrical-power-transmission/>

Nuclear

Nuclear Power is Inevitable, Yet Not Everywhere

<https://www.PowerElectronicsNews.com/nuclear-power-is-inevitable-yet-not-everywhere/>

How to Reduce the Cost of Nuclear Power

http://www.ma2life.org/g/how-to-reduce-the-cost-of-nuclear_power.pdf

Buildings

Standards Are Needed to Thermally Cover Windows

<https://www.PowerElectronicsNews.com/standards-are-needed-to-thermally-cover-windows/>

Using processors and software to make buildings smarter

<https://www.EDN.com/using-processors-and-software-to-make-buildings-smarter/>