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Article

Global Solutions & Outreach Programs: Humanity's best chance to resolve global warming, Part 1: Global warming challenges

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Abstract: In June 2024, the world's largest standalone public opinion poll covering 77 countries, Peoples' Climate Vote 2024, reported that "89% of people [want] to see more climate action from their governments". That is all well and good. However, how are policymakers being informed on the viability of climate solutions? Policymakers are typically not engineers or scientists. They must rely on others for advice. Many who provide that advice are influenced by four types of bias: Corporate vested interests, career vested interests, public passions, and political agendas. In combination with business-as-usual, these biases are destroying humanity's chances of resolving global warming. They are detrimentally affecting current global projects to resolve global warming. To mitigate these biases, the Global Solutions and Outreach Programs (GSOP) proposal will be undertaken by multiple teams of engineers, economists, social experts, and policy experts within each country, using a Wicked-Problem Approach. This work will be done outside of, yet informing, governments, the marketplace, and public opinion. Country action plans will be rolled up to regional and global levels. The GSOP work will be iterated until the global action plan provides a resolution of global warming at the scale of Earth. Part 1 describes the challenges we face and a problem-solving approach to resolving it. Part 2 will describe our GSOP proposal using that approach.

Keywords: global warming; climate change; climate solutions; human bias; wicked problems; business-as-usual; collaboration; mineral limits

1. Introduction

Global warming and its climate change effects are the most complicated problems humanity has ever faced. In fact, it is a super-wicked problem. Humanity has not grasped this fundamental fact and is naively assuming that it can be solved with business-as-usual approaches.

There is now no global action plan to solve our existential problem. There is only false hope based on overconfidence in business-as-usual. This is a recipe for failure.

Within Part 1 of this article, we shed light on the frailties of humanity's current efforts and explain what must be done. Our proposal, Global Solutions and Outreach Programs, must be funded to complete three years of international collaboration among people from all countries of the world. The sooner this funding comes forward, the sooner humanity will have real hope and a genuine expectation to resolve our greatest existential threat.

We review the literature on wicked problems and methods to address them, emphasizing why global warming is a super-wicked problem. The document assesses well-intended global projects currently underway to resolve global warming, highlighting their progress and shortcomings. It discusses complex intersecting issues framed by planetary limits that challenge the resolution of the problem, such as mineral limits, capital limits, food security, and time constraints. Additionally, it identifies understandable human biases that undermine current efforts and stresses the need for much better international collaboration. The Wicked-Problem Approach is presented as an approach to mitigate these human biases and effectively address global warming.

Within Part 2 of this article, we will present our plans for the Global Solutions & Outreach Programs to overcome these obstacles and provide practical, successful solutions to global warming—successful on both Earth's terms and on human terms. Our proposal is an important step for humanity.

2. Literature review

In 1973, Rittel and Webber [1] coined the term "wicked" problems. They described characteristics of wicked problems, including (a) their solutions are not true or false, but only good or bad; (b) there is no way to test the solution to a wicked problem; (c) there is no stopping rule, so you don't know when you've solved the wicked problem; (d) they cannot be studied through trial and error; (e) there is no end to the number of solutions to a wicked problem.

In 2002, Hutchinson et al. [2] described their Wicked-Problem Approach as successfully applied to two real world problems. Hutchinson et al. [2] led a major U.S. Army project from 1990 to 1993 in conjunction with a Chemical Weapons Convention that concluded in 1993, and a project in the late 1990s to address the threat of biological terrorism in major U.S. cities. Hutchinson et al. [2] conclude that the power of the Wicked-Problem Approach derives from its close relationship to the scientific method in objectively testing results, and in focusing teams of people directly on the problem of interest.

Much has been written about the challenges associated with solving wicked problems, including a 2009 paper that concluded that an interdisciplinary approach is needed, but without much advice beyond that observation [3].

In 2012, Levin et al. [4] identified climate change as a super-wicked problem. They described four additional characteristics of super-wicked problems: (f) Time is running out to solve the problem; (g) those who cause the problem also seek to provide its solution; (h) the central authority needed to address the problem is weak or non-existent; and (i) policy responses irrationally discount the future.

Aside from a method to address wicked problems in industrial applications discussed in a 2016 paper [5], other real-world examples are few.

In 2019, Hutchinson and Smith [6] published a *People's Assessment of Global Warming, Plus Adaptation for Advancement and Survival* book that reviewed and assessed the science on global warming, concluding that humanity is dealing with a wicked problem. They argue that the situation is not hopeless but must be addressed expeditiously and responsibly with appropriate action. They present a detailed plan

for three international People's Projects utilizing the Wicked-Problem Approach to address global warming challenges effectively.

In 2020, Bentley and Toth [7] described wicked problems as messy because humans both cause a wicked problem and must work together to solve the problem. They quote Stanford University Emeritus Education Professor Larry Cuban, "… wicked problems arise when people compete for limited resources, hold conflicting values, and wrestle with diverse expectations… they are messy, ill-defined, open to many competing interpretations, more complex than we can understand". They also quote Alan Watkins, PhD Immunology: "The types of problems on which there is no real progress… are inherently wicked because they deal with societal problems; that is, problems created and exacerbated by people".

Bentley and Toth [7] include a chapter on climate change, discussing the wicked nature of the problem, but do not provide recommendations on resolving the problem. They say, seemingly in despair, "The current hurdles for constructive action with global warming are impossibly high. The prospect of the world coming together to solve it is negligible".

3. Humanity's super-wicked problem

Global warming and climate change comprise a super-wicked problem. Consider two of Levin's characteristics of super-wicked problems:

1) *Policy responses irrationally discount the future*. From *Pricing the Priceless* [8]: "Either we come to terms with the actual chain of value of natural resources and other intangible essentials and account for them literally and figuratively in our economic system, or they will slip away because we undervalue them… The stakes are vast and high. Estimates of the value of nature in conventional global economic ledgers have been as high as $125 trillion per year—more than global gross domestic product… Estimates vary, but research by the Nature Conservancy and 17 various institutions, published by the US National Academy of Sciences, found that 'natural climate solutions can provide 37% of cost-effective CO2 mitigation needed through 2030.' … The free ride on our planet's assets has run out of justification… Money flows are upside down, and must be reversed to properly value what we can never recreate."
   In our view, humanity has not yet adequately collaborated to stop degradation of our natural resources.
2) *The central authority needed to address the problem is weak or non-existent*. A phase down was put forward in 2015 in Paris at COP21. In November 2023, the Energy Transitions Commission [9] said that "by 2050, coal use can and must fall around 80%–85% from 2022 levels, gas by 55%–70%, and oil by 75%–95%. And this reduction can and must start now, with coal use needing to decrease around 15%–30% by 2030, gas by 15%–20% and oil by 5%–15%."
   How will a fossil fuel phase down be achieved without global agreement on action plans to achieve phase down?

In summary, humanity must face and overcome global warming. Global warming can only be resolved at the scale of Earth and in consideration of Modern Civilization, making it a strategic super-wicked problem. This is the most complex

and threatening strategic problem that humanity has ever faced. Strategic problems can only be defeated by mounting strategic attacks. We must proceed boldly with determination and hope: Global warming may present Modern Civilization with not only unprecedented challenges, but also unprecedented opportunities to advance technically, economically and socially, and to turn adversity into advantage!

How are we doing in meeting the challenges of the super-wicked problem of global warming?

4. Assessment of current progress and impediments

In this section, we review four global projects that are attempting to figure out how to resolve global warming and climate change. These include: 1) Annual COP Meetings; 2) Project Drawdown; 3) Deep Decarbonization Pathways Project; and 4) the International Energy Agency's Roadmap Net-Zero by 2050. A subsequent section, Surveys on human bias and collaboration, discusses the results of GSOP surveys on factors that are impeding these projects.

Thousands of well-intentioned people around our planet are working on climate solutions, to mitigate global warming or to best adapt to its climate change effects. Unfounded accusations abound that these people are doing their work for financial benefit. We do not share that view. We think they are doing their best to address the greatest existential challenge to Modern Civilization. Sadly, progress thus far is disappointing.

Without effective global collaboration, we will not resolve global warming. These four global projects involve considerable collaboration. Why then are we not making progress on our objective?

4.1. Annual COP meetings [10]

The UNFCCC, United Nations Framework Convention on Climate Change [11], was established in 1992 by 154 states at the United Nations Conference on Environment and Development in Rio de Janeiro. The UNFCCC's current work focuses on implementing the Paris Agreement [12], which resulted from COP21. By 2022, the UNFCCC had 198 parties.

As discussed elsewhere in this paper, there are major challenges associated with implementing the Paris Agreement. Annual Conference of Party (COP) Meetings are occasions where all parties (governments) come together and take stock of progress. Some of those challenges were discussed two months after COP28. The National Academies of Sciences, Engineering, and Medicine (NASEM) held a webinar to discuss the conference [13]. Comments from the panel:

- "COPs cannot do everything. They are a good forum to coordinate efforts."
- "I don't know how to solve the issues raised, such as the involvement of important segments of populations such as indigenous peoples. Frankly, we don't know how to do everything. People leave for home and continue conversations."
- "Monies available to third world countries are now in the form of loans. Monies should be available via grants. Money needed for adaptation will not return a profit, so grants are needed."

These comments support our view that global collaboration must be improved. This NASEM discussion focused on COP meetings but the same could be said about other attempts at global collaboration. We argue that collaboration is not nearly as effective as it should be. The COP meetings are an opportunity for people to connect and "coordinate efforts". However, we consider much of this to be ad-hoc, i.e., not driven by true plans of action. As noted in the middle bullet, important segments of populations such as indigenous peoples are not adequately engaged in COP meetings, and likely not in other global efforts such as we review in this article. Our Outreach Program will engage indigenous peoples, and our Global Solutions Program will be open to indigenous people having expertise in technical fields, economics, society, or policy. On the last comment, a considerable amount of money will be needed for adaptation that will not return a profit. Business-as-usual is driven by return on investment (ROI). Humanity needs viable plans of action to resolve global warming. The country, regional, and global plans of action that will be generated from the GSOP analyses will not be based solely on business-as-usual ROI. They will be based on pulling humanity back from the brink of our existential threat.

4.2. Deep decarbonization pathways project, DDP [14]

DDP was undertaken in 2014 as preparatory to COP 21, which was held in 2015 in Paris. COP21 concluded with the Paris Climate Agreement. The Deep Decarbonization Pathways Project is well-funded and continues its work. The focus of the DDP is sustainable energy systems. Other sectors of the economy, such as agriculture and land use, are not directly considered. DDP assumes no major changes in the lifestyles of people in developed countries.

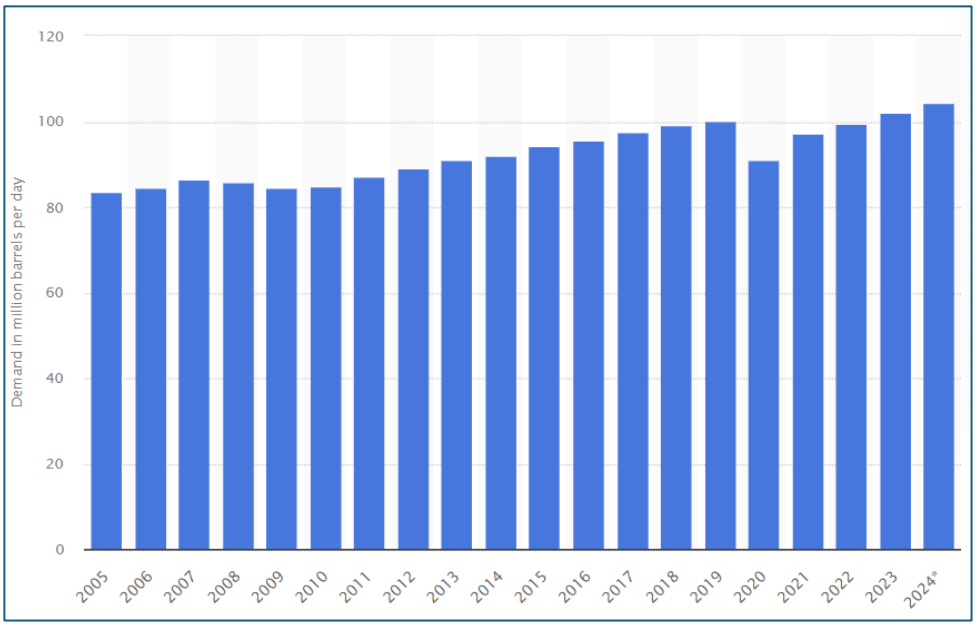

Figure 1. Demand for crude oil worldwide from 2005 to 2023, with a forecast for 2024 (in million barrels per day) [15].

The DDP analyses assume that petroleum consumption will drop 76%–91% by 2050 across all scenarios. This corresponds to the 2015 Paris Agreement, which called for a drastic reduction in the consumption of fossil fuels to achieve net zero emissions by 2050, which were 80%–85% for coal, 55%–70% for natural gas, and 75%–95% for crude oil. Intermediate 2030 emission reduction targets were set as a 50% cut in CO2 emissions and a 75% cut in methane emissions. Are we making progress? Quite the contrary. **Figure 1** shows the worldwide demand for crude oil, which rose from 92 to 102 million barrels per day from 2014 to 2023.

DDP is not to blame for an increase in crude oil demand. We humans love energy and the thousands of products that come from crude oil refining and petrochemical manufacturing. As a result, humanity is failing to achieve any progress on the Paris Agreement fossil fuel phase down. Does anyone have a plan to accomplish this phase down? We are aware of one initiative that is calling for a practical, albeit challenging, way to phase down fossil fuels. Krumdieck [16], PhD Mechanical Engineer, cofounded Transition Engineering in 2014. She and her colleagues have proposed an international collaboration with oil majors to work out an oil production retreat with targets to achieve the Paris Agreement fossil fuel phase down [16].

What is the prediction of oil demand going forward? On page 8 of the IEA report, Oil 2024: Analysis and forecast to 2030 [17], we are told that there will be a steady decrease in oil demand growth to the point where oil demand will plateau at 105 million barrels per day by 2030; see **Figure 2**.

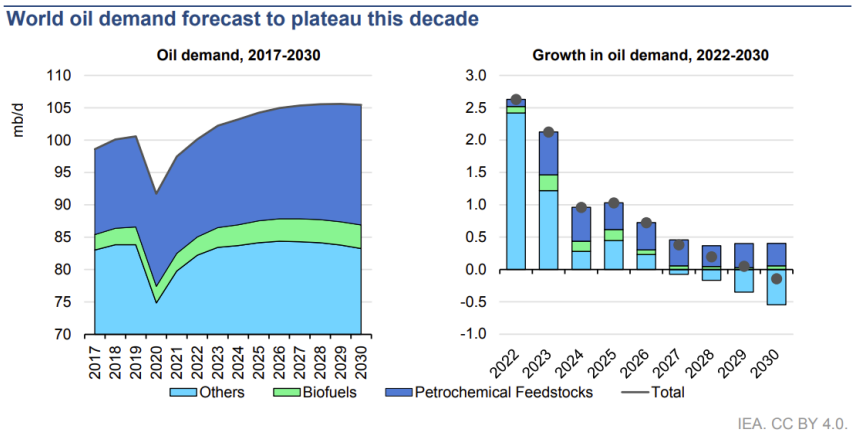

Figure 2. IEA world oil demand forecast through 2030.

Even with IEA's continued negative growth demand inferred in **Figure 2** beyond 2030, is that good enough? Or should humanity bite the bullet and do our best to meet the fossil fuel phase down of the Paris Agreement?

DDP has done an admirable job with its limited budget and within the constraints of today's business-as-usual paradigm. However, its scenarios and their guidance are limited by those constraints. Although well-intentioned people are trying to figure out how to resolve global warming, this will not be easily accomplished. Both the Annual COP Meetings, and the Deep Decarbonization Pathways Project, appear to be struggling to accomplish their objectives.

4.3. Project drawdown

In 2017, the book *Drawdown* was published [18]. It highlighted and described dozens of climate solutions. The work of the 200+ contributors to the book has continued within Project Drawdown [19]. We consider Project Drawdown an excellent reference for genuine global warming solution options, providing a broad overview of climate solutions across nine sectors, offering a holistic perspective on tackling climate change. The project relies on peer-reviewed research and rigorous methodology to evaluate the potential impact of different climate solutions. It presents complex climate science in an understandable way, making it accessible to a wider audience. Project Drawdown not only identifies effective solutions but also provides steps that individuals and organizations can take to implement them. By focusing on potential solutions and the possibility of achieving "drawdown", Project Drawdown promotes a hopeful narrative around climate change.

Project Drawdown also has a Roadmap overview, which provides a forum for overlapping issues associated with societal/industrial sectors and geographies.

Although Project Drawdown does provide an excellent reference for climate solutions, and has a Roadmap overview, comprehensive integration of options into practical systems of successful country, region and global action plans has not been achieved within Project Drawdown or within any other study.

4.4. International energy agency net zero by 2050 report

In October 2021, the International Energy Agency published its Net Zero by 2050 report [20]. Their Roadmap says that the world economy will be 40% larger by 2030 than it was in late 2021, but even so the world economy will use 7% less energy by 2030. They predicted that a global push to increase energy efficiency will be the major factor in achieving this reduction in energy usage. They call for annual global increases in generating capacity, through 2030, of 630 gigawatts of solar photovoltaic and 390 gigawatts of wind.

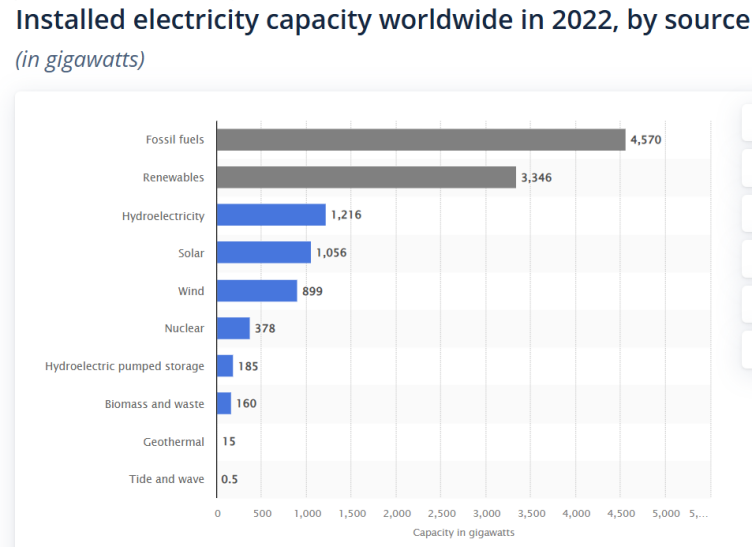

Figure 3. Installed electricity capacity worldwide in 2022. Clean sources are blue. The renewables bar is the sum of hydroelectricity, solar, wind, biomass and waste, geothermal, and tide and wave [21].

Figure 3 provides EIA data reported by Statista. Specifically, in 2022, the total global installed generating capacity of solar and wind was 1955 gigawatts, 1056 for solar and 899 for wind, so adding 1020 gigawatts per year is definitely an ambitious goal.

How did humanity do in 2023? Global renewable growth broke all records, adding 510 gigawatts, only 50% of the 1020 annual goal [22].

Why is the progress from these four projects so disappointing? What is keeping these four global approaches from a more expeditious resolution of global warming? It's really quite simple. The detrimental effects of four human biases are being ignored. None of those biases are being addressed. Also, although it may appear that global comprehensive analyses are being done on all possible climate solutions, this is not what is happening. No global integration of options into practical systems of successful country, region and global climate solutions has been conducted, is being conducted, or is planned to be conducted. Analyses are too focused within the silos of subsystems, such as electricity generation, transportation, manufacturing, and food systems. Intersecting issues between these complex subsystems are ignored or are very inadequately addressed. True global collaboration to conduct analyses on complex intersecting issues is not now occurring.

5. Complex intersecting issues framed by planetary limits

There are many complex intersecting issues that contribute to the super-wickedness of global warming. Some of them are planetary limits. To resolve global warming, we must acknowledge planetary limits and focus on them:

- Minerals needed by climate solutions;
- Capital needed;
- The threat of food insecurity;
- Time.

5.1. Mineral limits

Many climate solutions need minerals for which proven reserves may be lacking to meet global needs.

Renewable energy technologies need minerals such as copper, aluminum, lithium, nickel, cobalt, manganese, rare earth elements, indium, and tellurium. The demand for these minerals is growing rapidly as the world transitions to clean energy. The production and processing of these minerals can have negative environmental, social, and economic consequences, including greenhouse gas emissions, biodiversity loss, and severe human rights abuses [23].

Nuclear fission requires uranium which presently is judged to have proven reserves of about 90 years, based on three times current spot prices [24]. As a clean energy climate solution, nuclear fission is considered by many to be crucial to augment renewable energies which are incapable of providing firm steady baseload energy due to their inherent intermittencies. Also, 90 years of reserves is short-sighted. Humanity must solve our planetary dilemma going forward at least 100-200 years.

Proponents of renewables argue that power storage solutions, e.g., batteries, will resolve the intermittency problem, but here again minerals are required.

Michaux [25], PhD, Geometallurgy Analyst, warns of naivete regarding mineral limits in a 2022 podcast entitled the Great Simplification.

GSOP leadership advises that humanity should be very careful in understanding the planetary limits of mineral resources. Our planet is finite, so we cannot assume unlimited resources. Potential advances in mineral extraction and the success of circular economy strategies will undoubtedly help humanity stretch its available minerals, but to what extent? In Part 2 of this article, Global Warming Solutions, three People's Projects will identify limited resources required for various global solution options. Then, the Outreach Program will interface with the impacted sectors to identify ways to cope with these challenges.

5.2. Capital limit

In 2023, Georgetown University Professor Gael Giraud spoke at the UT Energy Symposium hosted by the University of Texas at Austin Energy Institute. He warned of a financial tipping point beyond which there will not be enough capital to resolve global warming. [26] A fundamental in his thesis is that global GDP will decline as climate change degrades economic capabilities around the world. He concludes that a financial tipping point will occur when the global temperature anomaly reaches 2.3 to 3.5 degrees Celsius above late 19th century pre-industrial levels. NOAA puts the anomaly now at 1.36 ℃. It is a sobering thought that we might someday be incapable of resolving global warming due to insufficient capital.

How much capital is needed to fix the problem? In January 2022, the international management consulting firm McKinsey & Company advised that a transition to Net-Zero emissions by 2050 will require 275 trillion USD in capital spending. They say that this will need to be front-loaded, i.e., more spending in the near term, ranging from 6.8% to 8.8% of global GDP per year between 2026 and 2030 before falling thereafter [27].

In early 2021, Rehm was invited to join the Basic Chemicals Technical Working Group for the Climate Bonds Initiative or CBI [28]. This initiative began in 2007, with the vision that climate solutions having the greatest potential to reduce emissions should be incentivized in the bond market. CBI is a European initiative, based in the Netherlands. Since its founding, cumulative Green Bond issuance to date was 3.535 trillion USD as of 30 January 2025.

Are we spending our money wisely? We must do better than our current business-as-usual paradigm framed around a bias-encumbered marketplace.

5.3. Food limit

There are at least four degenerative processes occurring globally that impact our food security, each a consequence of global warming. If managed properly, two can become climate solutions.

- Desertification. In 2019, the United Nations reported that 24 billion tons of fertile land are lost every year [29]. Desertification is directly tied to climate change.

- Soil health. When mechanical tillage became widely available in the early 1900s, soil loss through erosion accelerated. The United States is currently losing 4.7 metric tons of topsoil from every hectare of cropland per year. Although topsoil is replenished every year from organic materials such as fallen leaves, erosion in agricultural regions of the United States is estimated to be five times the rate of replenishment [30]. A third of rich topsoil in the U.S. Midwest may have already been lost through topsoil erosion [31]. The nutrient level in topsoil has degenerated due to reliance on industrial fertilizers. This serious situation is happening in other industrial agricultural areas of the world. Regenerative agriculture [32] and permaculture [33] focus on restoring nutrient health of soils. Improving soil health has an added major benefit, which is the drawdown of carbon dioxide from the atmosphere via carbon sequestration in the soil.
- Ocean health. Oceans are warming. Coral reefs are bleaching. Surface waters are now 30 percent more acidic than they were at the start of the industrial era. The average ocean pH has dropped from about 8.2 to 8.1 due to increased atmospheric CO2. In combination with overfishing, one study predicted that by 2050 we could lose the oceans as a source of food [34]. The oceans could be a major means of carbon sequestration if managed correctly [35].
- Biodiversity loss. According to the United Nations, up to one million species are threatened with extinction within this century [36]. Human encroachment is one cause. Another is climate change, with species migrating due to increasing temperatures.

5.4. Time limit

Humanity is running out of time to resolve global warming. We are staring in the face of several tipping points [37].

Much worry and effort are going into addressing these four planetary limits, but in a disjointed fashion while time is slipping away. Humanity must do better. These limits are examples of intersecting issues of very complex subsystems, which is why GSOP recommends the integration of options into practical systems of successful country, region and global climate solutions.

6. Surveys on human bias and collaboration

Human biases detrimentally affect climate solution decisions. Although many people are involved in making decisions on climate solutions, those with the greatest impact are those with authority over very large amounts of capital or those with authority to write and approve government policies. The former is needed to fund climate solutions. The latter is needed to enable business success through favorable tax laws and government stimulus spending. Those who authorize large capital and enable solutions via government policies have areas of expertise such as finance, political science and/or law. They are not experts in technology, which is fundamental to many climate solutions. They therefore must rely on advice from others on the viability of climate solutions. They are now receiving advice that is

likely biased. Not only that, but those giving the advice are influenced by the desire for a good return on investment, and likely by political pressures.

As a means of communicating our proposal, a bias survey has been on our website since May 2023. The survey was not comprehensive with respect to the general population. It only represents the opinions of those who visited our website who very likely are concerned about global warming and climate change; i.e., climate skeptics probably don't visit our website. Even among our website visitors, certainly not everyone took the survey. Therefore, we present the results of this survey, and also the collaboration survey, with these caveats. To us, these survey results are very meaningful and must be addressed, or we fear humanity will not resolve global warming expeditiously and responsibly.

We each have our biases, our opinions based on life experiences. There is nothing inherently bad about biases, unless they cloud our judgment. Humanity is now trying to resolve global warming within a business-as-usual paradigm of the marketplace framed by four understandable human biases:

- Corporate vested interests. Corporations are typically focused on short-term profit which is understandable. The marketplace demands it. Corporations, and those managing large capital investment funds, rightfully expect a return on their investments.
- Career vested interests. We must have experts involved in research, development, marketing, and the commercial success of climate solutions. Their work does not ensure optimal coordinated action plans to resolve global warming.
- Public passions (advocacy). Anyone dedicating a considerable amount of time promoting a climate solution, typically on a voluntary basis, will advocate for that solution.
- Political agendas. At best, elected officials listen to their constituents in formulating policy. (At worst, they are influenced by deep pockets.) If constituents are not well informed, policymakers will not set optimal policies to resolve global warming.

Individually, these biases don't appear as threats. However, in combination they are massively detrimental. On our website, a bias survey asks for opinion on the detrimental effects of these biases. There are four choices for each bias:

1) I am not at all concerned.
2) I am concerned but I do not think this is something to worry about.
3) I am very concerned, but I am hopeful that systems now in place will minimize its detrimental effects.
4) I am very concerned, and I doubt that systems now in place will minimize its detrimental effects.

157 have taken the survey at our website (**Table 1**).

Table 1. Bias survey results from GSOP website (157 took survey).

Type of human bias	Bias 1	Bias 2	Bias 3	Bias 4
Corporate vested interests	6%	3%	16%	75%
Career vested interests	3%	8%	37%	51%
Public passions (advocacy)	10%	14%	29%	48%
Political agendas	1%	1%	15%	83%

Most respondents are very concerned about the detrimental effects of bias on climate solution decisions (choices 3 and 4). The bias of least concern is "public passions (advocacy)", although even that bias has about 70% respondents "very concerned". The bias of most concern is "political agendas".

Concern about the detrimental effect of public passions increases with age. For every human bias, conservatives are not as concerned as liberals or moderates. These are the only conclusions we draw from these data.

In addition to mitigating the effects of bias on climate solutions, collaboration on climate solutions must be dramatically improved.

Before we developed our Global Solutions and Outreach Programs (GSOP) proposal in early 2021, Rehm hosted a Climate Collaboration Workshop in October 2020. In connection with that workshop, he took the first steps that led to our website www.climate-collaboration.com. A key focus of our proposal is collaboration. Without effective global collaboration, humanity will not resolve global warming. A collaboration survey has been on our website since November 2024. Results of that survey are provided in **Table 2**.

Table 2. Collaboration survey results from the GSOP website (135 took the survey).

Effectiveness of current global collaboration to resolve global warming	% response
Collaboration is abysmal. I feel hopeless.	16
Collaboration is poor. I am concerned.	70
Collaboration is on a good track. I am confident that collaboration will continue to improve.	15
Collaboration efforts are wonderful. There is no reason to change anything.	0

Table 3. Website demographics from the bias survey.

Age	#	Political View	#	Gender	#
20 years or younger	2	Liberal	53	Female	38
20-40 years	22	Moderate	65	Male	113
40-60 years	34	Conservative	11		
Over 60 years	76				
Region	**#**	**Education**	**#**		
Africa	5	High school diploma	3		
Asia	2	Some college	10		
Europe	24	College diploma	41		
North America	117	Masters or beyond	100		
Oceania	5				
South America	1				

hose taking our bias survey had the option of providing demographics. This provides insight into the people who are visiting our website; see **Table 3**.

7. Methodology: The wicked-problem approach

Although the concept of a wicked problem was first introduced in 1973 by Rittel and Webber, no practical method of solving a wicked problem was reported until 2002 by Hutchinson.

In the early 1990s, Hutchinson led 270 professionals from the Department of Energy, eight national laboratories, and 12 other federal agencies in a U.S. Army project to develop effective verification measures in support of U.S. negotiators working on a Chemical Weapons Convention in Geneva. That successful three-year project involved seven multidisciplinary teams. Our NATO counterparts endorsed the U.S. results to their delegations, resulting in 20 of the 24 U.S. Army program recommendations being included in the final language of the Convention. This was the first treaty ever to ban worldwide an entire category of weapons.

Later in the 1990s, Hutchinson led a program to test and improve city responses to biological terrorism. He realized that the approach from the Chemical treaty project could be applied to the biological terrorism problem. That program was also successful, resulting in a Modular Emergency Medical System that was shared with U.S. cities, including city response training.

Upon realizing the discovery of a problem-solving approach to solve highly complex problems, in 2002, Hutchinson et al. [2] was the lead author on a peer-reviewed paper that shared the Wicked-Problem Approach that arose from those Army projects.

Following his retirement to Penobscot, Maine, Hutchinson persuaded about 20 members of the town to use the Wicked-Problem Approach in resolving municipality issues. This was another successful application of the approach.

Considering all of these experiences, we asked ourselves “What makes our approach work?” and came up with these answers:

- Total delegation of responsibility to the teams for bottom-up effort was needed.
- No bosses, we used “problem facilitators” to lead & enable others and avoid top-down direction.
- Maintaining an atmosphere of truth, compromise, good will, and learning was critical in motivating and allowing everyone to contribute.
- Learning was key as it is needed to understand the problem, but it also breaks down barriers and catalyzes creativity.

We also learned that our results are very similar to Dr. Peter Senge’s work at MIT on corporate excellence. He published his results in a book titled Learning Organizations [38].

We also gained two more important insights into our approach: The Wicked-Problem Approach enables and taps the full human potential to solve wicked problems, the same as for Senge’s learning organizations in corporate settings. And this inherent human potential is likely our greatest and most underutilized natural resource for overcoming wicked problems. We say underutilized because our normal ways to deal with wicked problems are first to ignore them, or to kick them down the

road for others to deal with, or to address the symptoms rather than the problem itself. Thus, we rarely solve wicked problems.

The prior section, Assessment of Current Progress and Impediments, details how current approaches are unlikely to ever solve the problem of global warming. The Wicked-Problem Approach creates an objective, truth-based atmosphere and an integrated effort to overcome such barriers.

The Wicked-Problem Approach begins by brainstorming a Problem Diagram. Participants use the Problem Diagram to orient and guide the entire problem-solving effort. **Figure 4** provides a schematic.

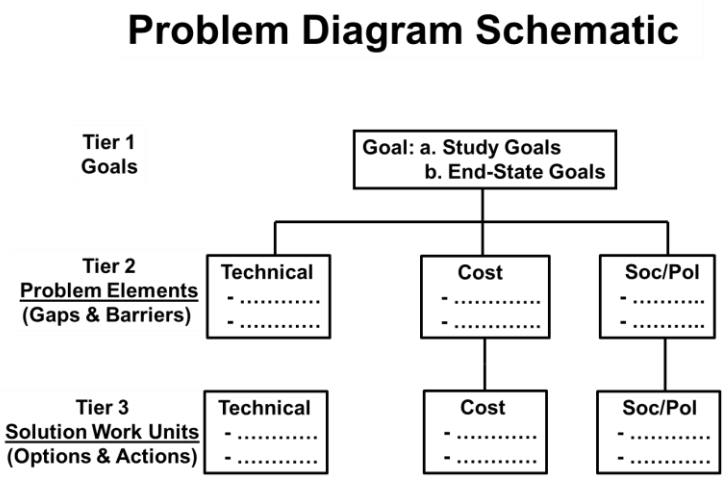

Figure 4. Problem diagram used to define the wicked-problem approach problem-solving effort.

The Problem Diagram has three tiers beginning with project goals:

- Tier 1 "Study Goals" state what the problem-solving effort is to accomplish. The "End-State Goals" are the broader benefits gained by accomplishing the study goals.
- Tier 2 "Problem Elements" are gaps, barriers & questions that must be addressed to meet the study goals. We divide these into technical, economic and social/political elements.
- Tier 3 "Solution Work Units" are the efforts required to overcome the Problem Elements. These work units must be executable tasks for engineers, economists, social/political experts and other specialists. They are analogous to a statement-of-work.

The Problem Diagram is updated throughout the effort to keep it current with ongoing learning and results.

A key aspect of the Wicked-Problem Approach is that the teams work on the technical, economic and social/political parts of the problem simultaneously and then integrate them into effective and practical systems that meet the Study Goals. The Problem Diagram leaves open how to accomplish the solution work units. Our approach is to employ people with the requisite skills to accomplish the work units. They will need to use their creativity, learning, and thinking to execute the Solution Work Units. These problem solvers are free to choose their methods and tools.

Practical considerations drive this approach: First, usually no one knows exactly how to perform the work units beforehand. A specified method could be very wrong. Second, the Wicked-Problem Approach is a bottom-up process that gives people maximum freedom to figure out how to accomplish work. This empowering approach motivates people. The overall goal of the Wicked-Problem Approach is to tap the full human potential to solve wicked problems.

Who drafts the Problem Diagram? Ideally, the entire problem-solving team will brainstorm and draft the diagram. Often, one or two program initiators will draft the Problem Diagram to use in proposals and presentations to secure funding. Once the project is initiated, then the entire team goes over it, making changes and additions to reach an initial Problem Diagram that they all agree on. Thus, the Problem Diagram is a living document that needs to be updated as the effort proceeds. Keeping the diagram current as new findings and knowledge are obtained helps to keep the entire effort on track.

Sometimes an initial investigation is needed to better understand the problem before creating the Problem Diagram. In the case of global warming, preparing the *People's Assessment of Global Warming Plus Adaptations for Advancement and Survival* filled that need [6].

Overall, the Wicked-Problem Approach involves breaking a complex problem into many components documented in the Problem Diagram and then establishing multidisciplinary teams to work on each component simultaneously. Integration teams assist those teams to integrate results and develop practical, effective action plans. In the case of global warming, these teams will include engineers, economists, social/political specialists, and other subject-matter experts. The Wicked-Problem Approach has many characteristics that it shares with other truth-based bottom-up rather than top-down management and problem-solving approaches, such as Transition Engineering [16], the Learning Organization [38], and Adaptive Governance [39].

In Part 2, Global Warming Solutions, we will explain how the Wicked-Problem Approach forms the basis for the Global Solutions and Outreach Programs to determine how to successfully overcome global warming.

8. Conclusions: Global warming challenges

Earth has warmed too much already, and it will continue to warm. To be completely honest, g*lobal warming cannot be solved*. *However, we must make our best effort to resolve global warming*, minimizing its consequences to the human race. To best resolve global warming, two complex challenges must be acknowledged and then rigorously addressed. We must resolve global warming on Earth's physical terms and on human terms.

Earth's physical terms. The Earth is one integrated system that will only respond to the sum total of actions by all countries and peoples. Our convenience, prosperity, and survival are irrelevant. By burning fossil fuels and releasing CO_2, we the people have destabilized the entire Earth's energy balance. More energy is coming in than going out and causing global warming, which, in turn, drives climate change, rising sea levels, extreme weather, and ocean acidification. We must stabilize

the Earth's energy balance to stop further warming and then adjust it to return to prior conditions. In short, we must solve global warming on Earth's terms. If we do not solve it on Earth's terms, we do not solve it.

Human terms. Modern Civilization was built and continues to depend on fossil fuel energy to survive (heating, cooling, food production, transportation, manufacturing, construction). While solving global warming on Earth's terms, we must also solve it on human terms of economic feasibility, social and political acceptability, and within the limits of natural and human resources. We must also cope with the ongoing impacts of climate change. If we do not solve it on human terms, we do not solve it.

Many challenges and impediments are hampering progress on resolving global warming, such as the lack of significant progress on current global projects, complex intersecting issues framed by planetary limits, human biases that detrimentally affect climate solution decisions, and fragmented global collaboration.

These challenges present humanity with complex, broad, interrelated strategic problems called "wicked problems" having technical, economic and social/political components snarled together like a "Gordian knot". We must understand the nature of wicked problems in order to overcome them, and must mount a strategic attack on humanity's most wicked problem, global warming. In Part 2, we will describe that strategic attack, the Global Solutions and Outreach Programs.

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