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The Challenging Quest for Decarbonisation by M. Schloss

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The Challenging Quest for Decarbonisation

Miguel Schloss[*]

Summary & Introduction

"I have not failed. I've just found 10,000 ways that won't work."
(Thomas A. Edison)

Isn't it noteworthy that an agreement reached in the 1990's to combat climate change has triggered to this day so much conflict (with strong deniers of the existence of the problem and militant supporters of the need to address the issue)? Are the temperature increases over the last decade an indication that global warming is finally catching up with us? Or are the paltry changes in our energy matrixes and policies an indication of failure of the decarbonization effort, or the inherent limitations of human endeavors to address emerging global issues? Perhaps both obviously contradictory postures may signal that the discussion has become overly ideologized, and thus impervious to proper diagnoses that provide technically sound answers for effective response to the issue.

The current discussion is loaded with partial and often poorly thought-out responses. Economic problems would be solved with more efficiency and growth; environmental concerns with more incentives and market signals – or others may argue for more controls, if not downright banning of coal, gas and any form of hydrocarbons, and their substitution by renewables to decidedly reduce emissions.[1] *Everyone in love with their own answers and solutions. The time is ripe to put questions to the forefront, subjecting answers and solutions to scrutiny and review of evidence. As long as we maintain our infatuation with questions and not answers, there is hope. After all, responses are transitory; the questions, permanent.*

Similarly, the empirical evidence of greenhouse emissions is equally unclear, leading to unsettled discussions whether investments and policy actions will lead to internationally agreed goals. This article summarizes the main statistical trends, to disentangle the different outcomes and range of projections, and identify possible causes and courses of action to achieve more effective results.

The Record

"Dig the Well Before You Are Thirsty."
未雨绸缪 (Chinese Proverb)

All things considered; indications are that we are reaching the warning points of crossing 400 ppm carbon in the air. This suggests that we are already exceeding the yearly average temperature threshold of + 1.5 c, and upper ranges of 2.4 c above pre-industrial levels.

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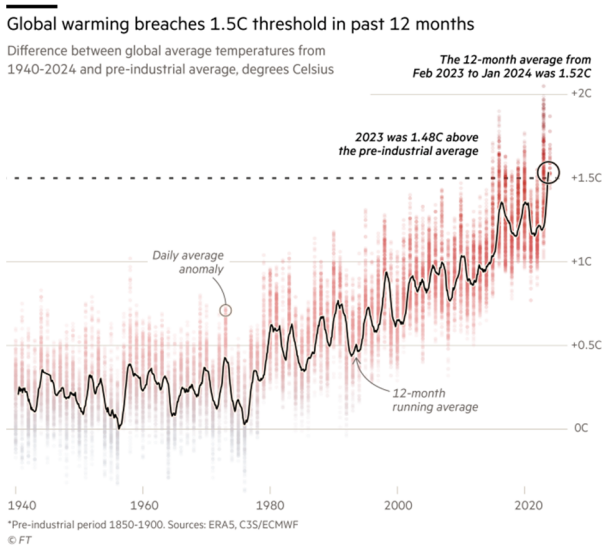
[1] Miguel Schloss; Global Journal of Science Frontier Research (Environment & Earth Science) (USA) May 2023: "Aligning Interests or Precipitating Energy Transition" https://www.sur-invest.com/ Downloads Publications/Global Journal MS 10 June 2021.pdf. Miguel Schloss; Oil, Gas & Energy Law Intelligence (OGEL), Feb. 2023 "Changing the Conversation on Energy Transition - Aligning Interests or Mandating Actions to Combat Climate Energy Transition in Unsettled Times.

Moreover, of all countries, just four explain over half of the CO2 dischargers, and emitters concentrate on large economies — i.e., China, the US, the EU27, India, Russia and Japan, which discharge over 65% of global fossil emissions.

While this does not provide a full answer to all problems that must be addressed, these numbers alone, already put some perspective on where to concentrate attention to achieve global impact. This should avoid the temptation to deal with the myriad of issues that may deflect from achieving tangible and much needed overall progress.

Temperatures; Global Warming



FT, Climate Graphic of the Week: Critical 1.5C threshold breached over 12 month period for first time https://www.ft.com/content/8927424e-2828-4414-86b7-f3a991214288

CO2 Emissions by Country

#	Country	Share of world
1	China	29.18%
2	United States	14.02%
3	India	7.09%
4	Russia	4.65%

Source: Emission Database for Global Atmospheric Research (EDGAR); CO2 Emissions from Fuel Combustion - IEA; https://www.worldometers.info/co2-emissions/co2-emissions-by-country/

An interesting contrast in outcomes can be seen between major emerging and developed economies. In India and China, heavy reliance on coal and higher electricity demand following the post pandemic economic recovery pushed emissions significantly higher, offsetting reductions in other economies. Emissions rose more than 7% last year in India, where a weaker monsoon season drove hydropower output lower. In China, emissions from energy combustion rose by 5.2% to 12.6 billion tons—by far the largest on a global scale despite the country's leading position in the deployment of clean-energy technology.

On the other hand, in advanced economies, emissions fell 4.5% to a 50-year low last year, supported by a stronger deployment of renewables and energy-efficiency measures, but also weaker industrial production and milder weather in some regions resulting in lower energy demand.

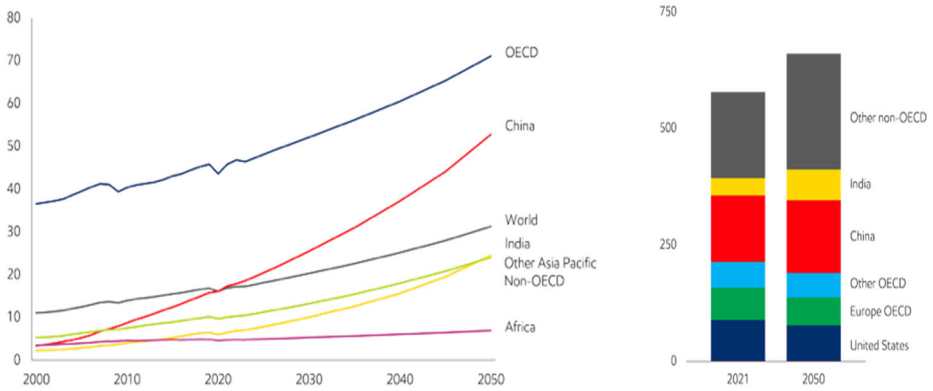
According to the International Energy Agency (IEA), electricity generation from renewable sources and nuclear power in those economies reached 50% of total generation. Renewables alone accounted for 34% of electricity output, while the share of coal fell to a historic low of 17%.

In the European Union, emissions from energy combustion fell by almost 9% in 2023 driven by a surge in renewables generation and drop in both coal and gas generation, despite economic growth of around 0.7%. In the U.S., emissions fell 4.1% on higher electricity generation from renewables and gas rather than coal, in spite of economic growth of 2.5%.

Still, the deployment of clean-energy sources remains heavily concentrated in advanced economies, and to a lesser extent China. Increasing attention will thus be required to enhance investment and deployment in emerging economies. It is there where economic growth, industrialization (in part stemming from a migration of industries from OECD to emerging economies) and growing economic "catch up" is bound to take place.

As a result, the bulk of energy growth will be in non-OECD countries (particularly China and India), which by mid-century may well lead energy demand worldwide.

In thousands of purchasing power parity (PPP) per person 2017$ *Primary energy demand - Quadrillion Btu*



Source -- https://www.exxonmobil.co.mz/energy-and-environment/looking-forward/outlook-for-energy/global-energy-fundamentals

This will put an entirely different perspective on the energy and environment perspective. As a billion more people move towards greater prosperity, we may well see emissions decline as a variety of low-carbon solutions advance. However, achieving net-zero emissions, as aspired in the international agreements, seems rather unlikely, requiring adoption of constructive policies that can facilitate new technologies, including market-driven policies, more in line with institutional capabilities of emerging economies.[2]

As the bulk of growth is bound to concentrate in emerging economies, it will become increasingly critical for success and sustainability of the decarbonization effort to focus on the need to provide the reliable, affordable energy that drives economic prosperity and better living standards, while reducing greenhouse gas emissions.

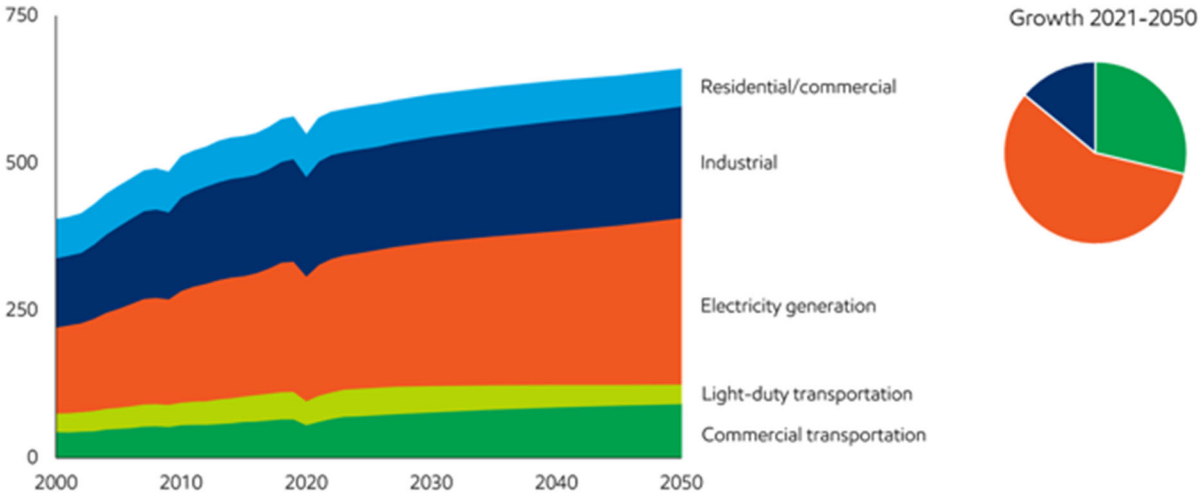
This will inevitably still include oil and natural gas, which will still be required to drive critically needed economic growth in the developing world, particularly as some industrial

[2] Geoffrey Heal; Endangered Economics; Columbia University Press, 2017 https://www.thriftbooks.com/w/endangered-economies-how-the-neglect-of-nature-threatens-our-prosperity_geoffrey-heal/11610560/#edition=11182883&idiq=34742655. Miguel Schloss; Editorial Académica Española: "Cambiando la conversación energética", 2023.

activity may bound to migrate to emerging as part of narrowly understood environmental concerns, which may be bound to remain unchanged from a global perspective, and emissions for such activities may just migrate to emerging economies.

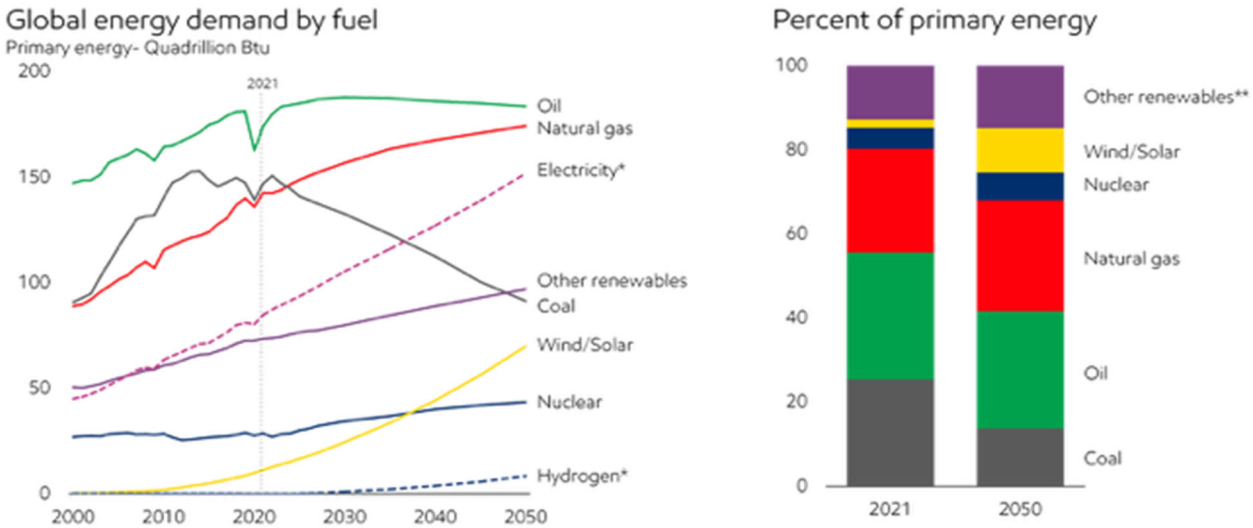
As a result, demand for energy-intensive activities (mainly industry, mining and electricity generation) is bound to continue to grow globally, and is likely going to remain by far the largest share of energy consumption globally by mid-century:

Global Primary energy demand - Quadrillion Btu



Source -- https://www.exxonmobil.be/en-be/energy-and-environment/looking-forward/outlook-for-energy/energy-demand

Short of major technological breakthrough. Renewables are going to continue growing, though from a still small base (and coal decline), leaving hydrocarbons still as the major (though with a larger share of lower emitting gas) as the predominant share of energy supply.



Source – https://www.exxonmobil.be/en-be/energy-and-environment/looking-forward/outlook-for-energy/energy-demand

Every day, billions of people around the world benefit from the ability to heat and cool their homes, cook their food, access medical equipment and modern medicine, and travel for work and pleasure. Affordable and reliable energy is at the core of every key measure of human development - elevating living standards, life expectancy, education, and income per person. Yet for billions of more people, modern living conditions are still far out of reach.

In developing countries, such as India, gross domestic product (GDP) per person is only about $2,000 per year1, and many people earn far less and lack access to basic necessities, including clean drinking water, heat, and cooking fuel. This challenge will only grow as the world's population increases from about 8 billion people today to nearly 10 billion in 2050 – a rate of about 1 million people every six days. And just as human progress has been fueled by higher energy use, further expansion of economic prosperity will depend on increased access to abundant, affordable energy.

In other words, energy use and economic development are inseparable. Where there is energy poverty, there is poverty. And where energy availability rises, living standards rise as well. Economic development and the integration of emerging economies have to go hand-in-hand to generate greater world prosperity, including meeting increasing energy needs to fuel much needed economic expansion.

Between now and 2050, developing countries will see GDP per capita more than double, driving higher demand for energy. Meeting that demand with lower-emission energy options is vital to making progress toward society's environmental goals. At the same time, failing to meet demand would prevent developing nations from achieving their economic goals and their citizens from living longer, more fulfilling lives, and constrain economic expansion, including in developed economies.

The critical question is how that growing energy demand will be met. Renewable energy continues to hold great promise, and we see wind and solar providing 11% of the world's energy supply in 2050, five times today's contribution. Other lower- emission options, such as biofuels, carbon capture and storage, hydrogen, and nuclear, will also play important roles. And even with this unprecedented rise in lower-emission options, oil and natural gas are still projected to meet some 52-54% of the world's energy needs in 2050.

As lower-emission options grow, the world's energy-related CO2 emissions may well decline 25% by 2050. That's a major change as these emissions rose by 10% over the past decade. While the progress is substantial, larger reductions are needed to keep global warming from exceeding 2° Celsius, according to the United Nations Intergovernmental Panel on Climate Change (IPCC).

The world will thus need to dramatically scale up lower-emission solutions – beyond the current trajectory – that preserve the advantages of today's energy system while significantly and efficiently reducing emissions. Doing this will require policy support from governments, significant advances in technology to reduce costs, and ultimately, market-driven solutions to incentivize emission reductions in a manner that is more in line with institutional capabilities with public sectors around the word, and efficiency and skills to be provided by private sectors.

Powering Human Progress, While Reducing Emissions

"It's not the size of the dog in the fight, it's the size of the fight in the dog"
(Mark Twain).

Energy use and improved living standards thus go hand in hand. One can't have one without the other, and powering human progress to increase standards of living will have to embed reducing emissions, but in an efficient manner. When China's per capita GDP was around $2,000, its energy use was low – about 36 million British thermal units (MMBtu) per person per year, deep in the realm of energy poverty. By 2021, when per capita GDP passed $11,000, China's energy use had risen to 101 MMBtu per person, well above the global average.

In contrast with China, Africa's energy use per person has remained at a low 27 MMBtu for the past two decades, and its per capita GDP has only risen by about $500 during that time. Areas that remain mired in energy poverty struggle to raise the living standards of their people.

As we look ahead to 2050, how much more energy must the world produce to meet the needs of 2 billion additional people and a global economy that has doubled in size? About 15% more, with nearly all of it going toward meeting the higher living standard of a developing world with a larger population. Contrast that with the developed world, where there will be little population growth, and greater efficiency is projected to cause energy use to decline across all sectors of the economy.

But all energy types are needed to raise living standards and reduce emissions:

- Energy from solar and wind is projected to more than quintuple, from 2% of the world's supply to 11%. Coal will increasingly be displaced by lower-emission sources of electricity production – not just renewables but also natural gas, which has about half the carbon intensity of coal. Overall, electricity use may grow 80% by 2050.
- Oil and natural gas are projected to still make up more than half of the world's energy supply. The utility of oil and natural gas in meeting the world's needs remains unmatched. They are energy dense, portable, available, and affordable — and serve as essential raw materials for many products we use today. Given that oil and natural gas are projected to remain a critical component of a global energy system through 2050, sustained investments are essential to offset depletion as production naturally declines by 5-7% per year.
- Oil use is expected to decline significantly in personal transportation but will remain essential for the industrial processes and heavy-duty transport like shipping, long-haul trucking, and aviation that underpin economic growth. Even if every new passenger car sold in the world in 2035 were an electric vehicle, oil demand in 2050 would still be 85 million barrels per day, the same as it was around 2010.
- Natural gas use is projected to increase by more than 20% by 2050 given its utility as a reliable and lower-emissions source of fuel for electricity generation, hydrogen production, and heating for both industrial processes and buildings.

Adding All Up: Where's The Problem?

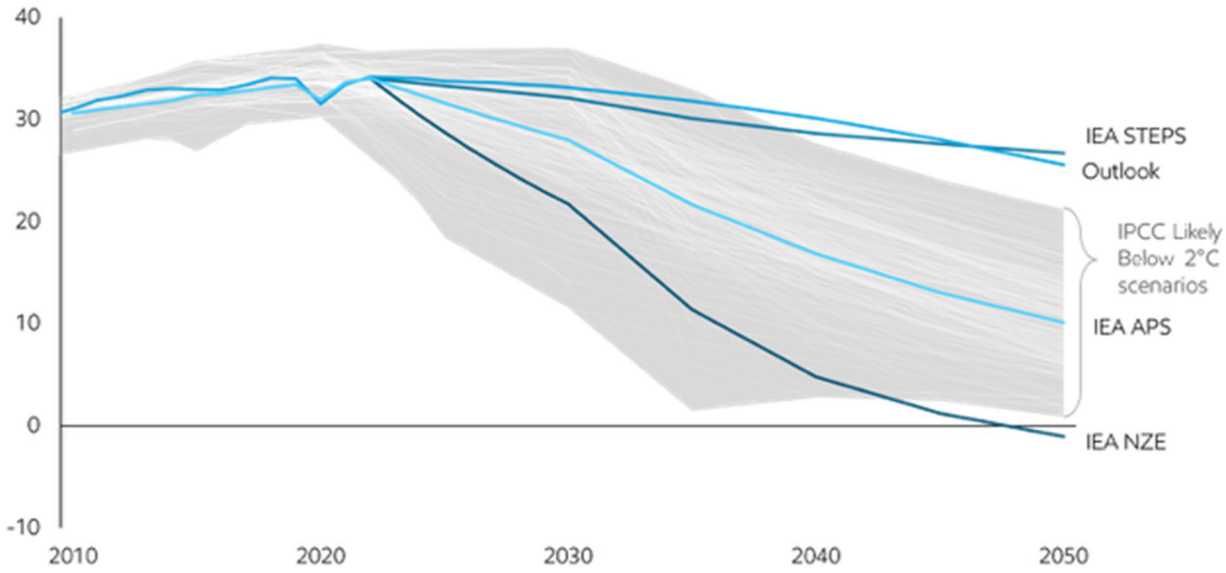
"El papel aguanta mucho"
(Spanish expression to denote that on paper everything is possible).

We are flooded with an overdose of reports, so extensive and elegantly crafted that it is difficult to distill what they are conveying, distinguishing the fundamental from the trivial, and what to conclude. In the process, we seem to have lost a clear and unapologetic sense of: (i) whether and where we are (or aren't) making progress; (ii) why, and ultimately (iii) what needs to be done.

After all, the above projections ae based on assumptions of the degree of introduction of renewables on the supply side, and consumer adoption on the market demand side. The declining costs of solar and wind technologies has certainly helped the adoption of such technologies, but their heavy location and weather dependence still limits their load factor capabilities, and with it the continuing need of traditional technologies to serve the needs of industry and urban centers that need high reliabilities to respond to major market requirements.[3]

It should thus not be surprising that the range of projections of global energy-related emissions remains high, even assuming compliance with international pledges and agreements, as can be observed in the following graph of generally accepted projections from different sources:

CO2 billion metric tons



Source: IEA World Energy Outlook 2023, IPCC Sixth Assessment Report

[3] Miguel Schloss: Global Journal of Science Frontier Research (Environment & Earth Science) (USA) Dec. 2023: "Energy Transition in Unsettled Times". Miguel Schloss "The Elephant in the Room; Preaching or Working on Climate Change"; the Global Journal of Science Frontier Research (Sept 2023)) https://globaljournals.org/GJSFR_ Volume23/2-The-Elephant-in-the-Room.pdf.; "Decarbonizing Energy - with Speed, Wisdom and Balance". "Mapping Carbon Neutrality in Uncharted Territory - Governance & Policy Implications for the Mining Sector" Generis Publishing, 2023.

Broadly speaking, views of the future path of the world's energy system and emission levels can be grouped into three categories.

- Society's Current Trajectory
  - Generally Presented Global Outlooks tend to be grounded on views of energy demand and supply through 2050 on observable trends in population, economic development, policy, technology and consumer preferences.
  - The International Energy Agency's Stated Energy Policies Scenario (STEPS) that reflects a sector-by-sector assessment of current policy in place or announced by governments around the world.
- Paris-Aligned Scenarios
  - The U.N. Intergovernmental Panel on Climate Change's (IPCC) database contains 311 scenarios defined as pathways with a 67% likelihood of limiting peak warming to below 2°C throughout the 21st century. These are labelled IPCC Likely below 2°C scenarios.
  - The International Energy Agency's Announced Pledges Scenario (APS)1 assumes that all aspirational targets announced by governments are met on time and in full, including their long-term net zero and energy access goals.
- Net zero by 2050
  - The International Energy Agency's Net-Zero Emissions by 2050 Scenario (NZE)1 is an aggressive pathway that assumes all necessary changes in policy, technology and human behavior occur for the global energy sector to reach net-zero CO_2 emissions by 2050.

It is important to note that according to the U.N. Environment Program Emissions Gap Report the current Nationally Determined Contributions (NDCs) to emissions reductions that countries have pledged to make by 2030 are not yet within a Likely Below 2°C pathway. It further states that G20 members as a group do not have policies in place to achieve their current NDCs.

All considered, the projections are based on fairly mechanical criteria, and that in the majority of countries, accountability for results, institutional competencies to regulate effectively the transition and incentives prevailing in the private sector remain generally weak, and thus conditions for compliance with estimated agreed goals may be still rather lose to provide much credence to such (even wide ranging) projections.

Crisp assessments are thus needed on where priorities should be placed, what is being done in these economies to seek tangible decarbonization results impacting globally, and at least pose probing questions on whether the current record shows if countries and sectors are on the right track, and if not, what corrective actions may be needed to assure genuine progress towards the international goals. Without clear responses to these questions, it is unlikely to identify steps to contribute to achieve proper global impact.

Such approach should facilitate where progress is made, and where not, which policies and actions are taken, and what this can tell us of successful or failing policies. This may help move the discussion towards much needed transparency, and the build-up of accountability for improvements. A valid discussion on increasing temperatures and greenhouse gas emissions can be engaged to assess whether sufficient progress, is being made, and a more disciplined approach to focus on results, the build-up of proper analytic underpinnings of what polices and actions work, and which ones not, to define a more discerning contribution to the subject.

Its Half-Time - Poising to Achieve Genuine Decarbonisation

"A man will fight harder for his interests than for his rights"
(Napoleon).

Improved outcomes over the current record are far from trivial. All indications are that we may be seeing "tipping points" (or points of no return) in action, such as sustained melting of the Greenland, Arctic and Antarctic ice masses, Pacific islands going under water, the dieback of the Amazon and other forests with no other plausible explanations than human caused climate change. Scientific consensus is sparce, but one them is that planetary tipping points represent one of the gravest threats. In the absence of clear frameworks, four areas merit specific attention:

- Through **regulatory and/or institutional compulsion**: quite aside of the institutionally-intensive requirements of such processes to manage these types of changes, they tend to demand increasing costs and time, and are difficult or burdensome to manage, particularly in emerging economies, and thus hard to see how they could contribute to tangible outcomes in the foreseeable term solution of the issue, as they probably may be a rather taxying and burdensome avenue.
- Through **enabling pricing and/or taxation policies** reflecting energy scarcity and/or "pricing" carbon emissions, as successfully done in Chile and a growing number of countries,[4] and the face-out of chlorofluorocarbons (CFCs pursuant to the Montreal Protocol to stem ozone depletion) in essence "internalizing" external costs to reflect societal harm and align incentives to minimize the latter, as in the EU, with its emissions trading system and national carbon taxes. For such policies to work, it is indispensable to have a working private sector and enabling conditions that further the development of enterprises capable to respond to such policy environment.[5]
- Through **proactive management of transformative policy**, such as tax credits, focused policies like the Inflation Reduction Act aimed at supporting renewable energy incentive opportunities to help US businesses manage and reduce their energy costs and improve security by enhancing renewable infrastructure providing public sector support for decarbonized sources of energy supply, or the European Union measures to cut off Russian gas. Within five years they have been instrumental in reducing Russian gas as a percentage of total gas piped in to Europe, and new facilities for changing energy matrix. Such policy, inevitably depends on significant public sector resources (which in times of fiscal constraints, is bound limit sustainability) and management inputs for appropriate resource allocations. Overall, the EU is now introducing its ambitious supply-side measures through industrial plans to enhance competitiveness of Europe's net-zero industry to accelerate the transition to climate neutrality by scaling up its manufacturing capacity for the net-zero technologies and products.

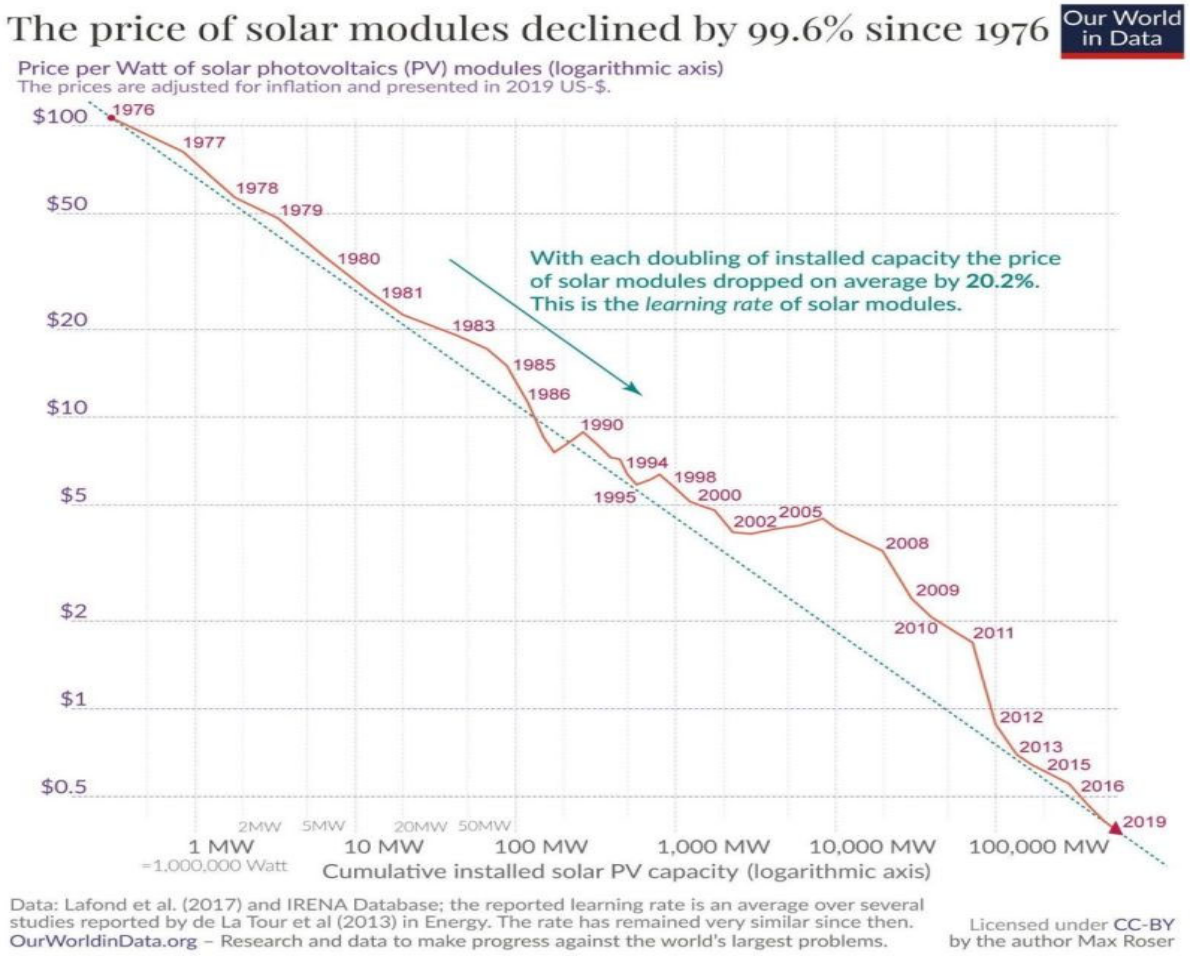
[4] Ministerio de Energía, Chile (2023); Planificación energética de largo plazo (2023) https://energia.gob.cl/pelp
[5] The Economist; Oct 1, 2023: "How carbon prices are taking on the world" https://www.economist. com/finance-and-economics.

The Lure (And Risks) Of Simplicity

"Everything should be made as simple as possible, but not simpler."
(A. Einstein).

Much of public debate is grounded on assumptions that the energy and associated environmental issue depends on simple political decisions promoting the right investments, with little concerns and/or awareness of their viability. The seeming "free" availability of sun shine and/or wind leads many to demand rapid investments in such renewable facilities.

Up to a point, there is validity in such logic as, over time businesses, through their innovations in manufacturing, optimized supply chains, and improvements in the deployment of PV modules, have led to major improvements in this space. The dramatic reduction of price of solar panels shown in the graph below, need to be replicated and upscaled to make a deeper dent in the energy matrix around the world.



In the early stages of development, such facilities were subsidized by producer of PV facilities (in the main China), and many countries, like Chile, deliberately expanded their solar generating facilities in effect subsidized by China. This is no longer necessary, although their inherent - and thus location-dependence inevitably require complementary investments in major storage and transmission facilities to overcome varying luminosity (e.g., evenings) or climate constraints prevalent in many areas. Similarly, as China is still a largely carbon-dependent economy, with limited transparency on their production facilities, it is unclear for

the moment the carbon footprint that PV facilities really leave when seen through the entire value chain (particularly at the PV production phase).

Be that as it may, the viability of any option ultimately depends on the *affordability* for final consumers (whose acceptance of decarbonization, but "not from my pocket"), the *reliability* of supply required from energy-intensive industries (like mining), that require 24-7 power supply with proper reserve capabilities (or adequate load factors), as any cut of supply can have costly implications; and civil society and other public goods organizations require proper *coverage*, preferably universal service to achieve share social and economic development.

Reconciling these objectives require major investments, mobilization of financial and technical resources (with public policy, legal, engineering, project management and a wide range of other skills) to achieve net zero goals. Public and private sector entities across the globe will need approximately $3.8 trillion in additional annual investment flows [equivalent to 3.8 percent of global GDP through 2030.[6] But only a fraction of this capital is currently being deployed. Even when viewed with a wider lens that considers funding such as transition finance, expected needs still outweigh flows by 66%.[7]

The problem is particularly serious in low-income and climate-vulnerable developing countries, which have long called for meaningful climate finance to allow them to carry out emissions reduction plans and build resilience against the accelerating impacts of climate change. Yet previous pledges of finance and support from developed nations have been largely insufficient, delayed, complex to access and/or are yet to be delivered.

While COP meetings are meant precisely to address these issues, including the adoption of realistic and ambitious investment and associated global climate finance goals, such efforts have proven to be politically contentious issues -- from the size of the goals to the quality of the funding, and how to address the failure major countries to fully deliver on past commitments. With the benefit of hindsight, COP proceedings have tended to rely too heavily on government pledges, which in the face of major conflicting claims on public resources have put unrealistic demands on public financial and human resources.

Inevitably, to achieve the more ambitious net zero emissions by 2050, private sector businesses are thus increasingly called upon to provide the thinking, technical skills and solutions, to address societal questions. To do so, this will, require increasing attention to market-driven solutions, including various forms of pricing and taxing of externalities, visibilizing the invisible, so to speak, to enable a more demand-driven and spontaneous mobilization of human and financial resources from the private sector.

In sum, with the significant cost reductions, and increased adoption of renewables, the case the case for them has already largely (though not yet fully, or for some convincingly) been made. The promise of lowered aggregate CO2 emissions and consequent mastering of climate change is, far from materializing. A thorough and systematic review of what has been achieved so far

[6] The Bretton Woods Committee; The Role of Multilateral Banks in Closing the Climate and Energy Transition Finance Gap https://www.brettonwoods. org/sites/default/files/documents/CFPT Template_ Final_Digital_1.pdf

[7] Bretton Woods Committee (Oct. 2023) https://www.brettonwoods.org/article/decarbonizing - energy-with-speed- wisdom-and-balance; "Essay on Combating Believers and Deniers on Energy Transition"; Oil, Gas & Energy Law Intelligence (Sep. 2023), https://www.ogel.org/article.asp?key=4101.

might be instrumental in revisiting existing approaches to achieve more impactful results and the goals that have been defined in repeated COP meetings.

Conclusion – Here Comes the Sun

"Let's build a city, with a tower that reaches heavens"
הבה נבנה לעצמנו עיר, עם מגדל שמגיע עד השמים (Genesis 11)

By now, it should be painfully evident that environmental investments are a "hard sell", and that, even with the reductions of the global energy systems in the world's CO_2 emissions, larger cutbacks are still needed to meet the agreed objectives of limiting peak warming to below 2°C throughout the 21st century.

This situation should not be surprising, since (in contrast with a great number of economic activities), benefits of environmental investments produce "global goods" – i.e., reduced CO2 emissions to the stratosphere to constrain global warming, for the benefit of the world at large, rather than the stakeholders undertaking the investments. Under the circumstances, much of the initiatives are promoted and steered by governments and international agencies, through (oftentimes top-down) institutional compulsion, regulatory and legal actions, rather than societal (or demands-driven) approaches as such.

The continuing rise in carbon emissions and the increasing frequency of extreme weather events in recent years highlight more clearly than ever the importance of and conditions for a decisive shift towards a net-zero future. The paucity of progress, however, highlights the complexity of an endeavor of massive proportions There is of course a case for pursuing existing approaches more decisively -- pushing *harder,* rather than *smarter* to achieve the agreed goals. But chances are that such efforts may be reaching their point of diminishing returns, and alternative ways may need to be explored to achieve closer connections between intended goals with enhanced environmental results. To this end, special attention may be warranted in four areas:

> ***First;*** by taking a **broader view of investment planning, and bringing in a wider range of (mainly private sector) players,** to mobilize much needed management and technical skills, and financial resources, to help devise more effective and efficient approaches to the issue. This will require the generation of enabling conditions, such as proper pricing and taxation arrangements that can better reflect the environmental externalities that are generated and attract enterprises that can assess risks, develop technical and organizational solutions to address emerging issues. This can also help overcome constraints of global institutions, which are clearly overstretched to meet the multitude of issues in an effective manner.
>
> The Covid pandemic, the growing environmental agenda and institutionally-intensive COP tracking arrangements, and others have revealed the weaknesses of globalization, exposed the fragility of existing institutions, fueling rather than defusing today's apocalyptic alarmism about climate change, energy and demographic constraints. In part this is the result of conflicting purposes of different policy instruments pursued by various governments, such as subsidies for hydrocarbons to mitigate costs of living, increasing import duties for solar generating equipment to foster local industries, etc.,

They can undermine much needed signals for enhanced environment for renewables, at the expense of local industries' or, worse, vested interests' protection.[8]

Second; the events of the past year have served as a reminder to us all that this transition also needs to take account of the **security, affordability and sustainability of energy**. Any successful and enduring energy transition needs to address all three elements in tandem, and well-tuned to evolving conditions.

If anything, the experience from the major energy supply shocks since the1970s suggests that events that heightened energy security concerns can have significant and persistent impacts on energy markets. Most importantly, the desire of countries to bolster their energy security by reducing their dependency on imported energy – dominated by fossil fuels – and instead have access to more domestically produced energy – much of which is likely to come from renewables and other non- fossil energy sources – suggests that the war is likely to accelerate the pace of the energy transition.

The scale of the economic and social disruptions over past years associated with the loss of just a fraction of the world's fossil fuels has also highlighted the need for the transition away from hydrocarbons to be orderly, such that the demand for hydrocarbons falls in line with available supplies, avoiding future periods of energy shortages and higher prices. Similarly, public reactions to increased energy or transportation charges require a clear-headed focus on efficiency, as much as on increased supply to meet market demand.

Third; The events have also highlighted the complexity and **interconnectedness of the global energy system,** and with it the dependence on emerging economies, which at present already more than double the GDP of OECD countries. They are in addition, by far the fastest growing parts of population, economic activity and fossil fuel consumption.

As was the case of high-income economies, early stages of development they are bound to rely on on small internal combustion engines with limited prospects for energy renewable solutions in the foreseeable future. The pace of the energy transition, thus hangs heavily on such economies, including their constrained institutional capabilities, which must be overcome to accelerate the transition to achieve the net-zero goal in the foreseeable future.

Fourth**;** the world may be different over the next few decades, but the need to provide energy is bound to drive economic prosperity and better living standards, while reducing emissions, will remain as critical as it is today. This will, however, require **widening the aperture of technical solutions and organizational arrangements** to facilitate pooling resources and experimentation to enhance value beyond what individual firms can do on their own. This is particularly important in oil and natural gas (which per most projections) will continue driving economic growth in the developing world, where power generating facilities are difficult and expensive to replace. To do so, an enabling environment has to be enhanced to facilitate technological improvements (and breakthroughs) to mobilize the large technical,

[8] The Economist; Oct 1, 2023: "How carbon prices are taking on the world" https://www.economist. com/finance-and-economics.

financial, resource base and organizational capabilities that such enterprises have to focus on reducing (and eventually carbon capturing) emissions for a range of products to meet environmental goals, **in a manner that is secure, affordable and sustainable.** For the time being, there are technologies than can address the issue, but whose costs need to be significantly reduced to be of use in the energy field.

The same logic can be applied to other areas, such as has been recently undertaken in Chile to intermediate mining (geological) risks for energy plants to enable and leading to major increases in new power facilities based on geothermal sources, and an associated decrease in emissions (based on the retirement of coal generated facilities), and a diversification of energy sources (see Annex on change in energy matrix in Chile).

In sum, looking at fundamentals, there will be billions of more people, more prosperity, and more energy. Emissions will decline as a variety of low-carbon solution advance, but achieving net-zero emissions will require adoption of constructive policies, the emergence of new technologies, and the establishment of enabling market-driven mechanisms that facilitate the integration of relevant players that can address such issues. All this will take place in a context determined by the number of people there are and the level of economic growth they enjoy. O both counts, the numbers are staggering.

Undergirding centuries of changes, human beings have shown to be adaptable, though with great pains. The accommodated themselves to new conditions, confronted and resisted change, migrated when they could not adapt themselves. Always seeking ways of survival, adapting themselves to their changing environment, and when this was not possible, migrating and seeking new horizons. When the changes were too big or challenging, this has led to conflicts or disasters, The Bible's recording of the ambitious construction, and subsequent fall of the Babel Tower may well be one such event. As human beings keep developing, beyond a certain point they need to rethink the underlying ways of living, materials they use and other ways of developing. It may well be that climate change could be the manifestation of another such instance – i.e., the need to adjust our ways of living, construction and even the surrounding environment we create to adapt and live in a world with greater climatic challenges.

In the world of structural engineering, Galileo had already defined the "principle of similitude" whereby that size and strength do not increase or decrease at the same ratio, and that beyond certain scales, structures and practices need to be recast.[9] It is not inconceivable that this principle could apply just as well to human development, and that climate change is another manifestation of human beings having developed with technologies beyond the capabilities of nature to keep responding to population growth and associated availability of materials that cannot be sustained without adjustments in the modes of living and practices for further development.

Accordingly, a more agnostic and eclectic approach may be necessary on the policy instruments and technology, as well as complementary approaches such as adaptation and mitigation arrangements, carbon capture, energy storage and other vehicles to facilitate the transition in more productive and efficient manner, and within the scale of what is absorbable. Such

[9] The Bretton Woods Committee; The Role of Multilateral Banks in Closing the Climate and Energy Transition Finance Gap https://www.brettonwoods. org/sites/default/files/documents/CFPT Template_ Final_Digital_1.pdf

approach should at the same time provide a viable option to address development under emerging conditions.

By the same token, such approach should facilitate the design of complementary investments to overcome inherent limitations of renewables (such as their lack of reserve capacity and heavy location- and weather-dependence), and improve their low load-factors for energy-intensive activities, high density urban areas, etc.

More broadly, while recognizing one-size-fits-all does not fit all, international arrangements should focus less on forcing a particular approach to decarbonization, which hardly can respond to different country circumstances and capabilities. Instead, attention can be productively focused on more basic foundational reforms, strengthening governance, cutting red tape, improving access to capital, combating corruption. These factors generate enabling conditions for development, including energy transition. With artificial intelligence already upon us, coordination on global rules is as important as having the technology and the skills to tap into it.

All said, it is incumbent on governments to align their own policies (be they industrial, protection or social development) in such a manner that they are consistent with environmental concerns. If they do, they could avoid acting at cross purposes, and forcing countries to compensate with tax and other policies the distortions they create by generating costs that have no connection with the externalities that ideally should be charged either through prices or taxes to encourage the use of renewables without excessive institutional burden. In the end, focused and economically-driven approaches for policy formulation, are bound to be more effective to capture the varying institutional and contextual conditions that need to be integrated for enhanced outcomes.

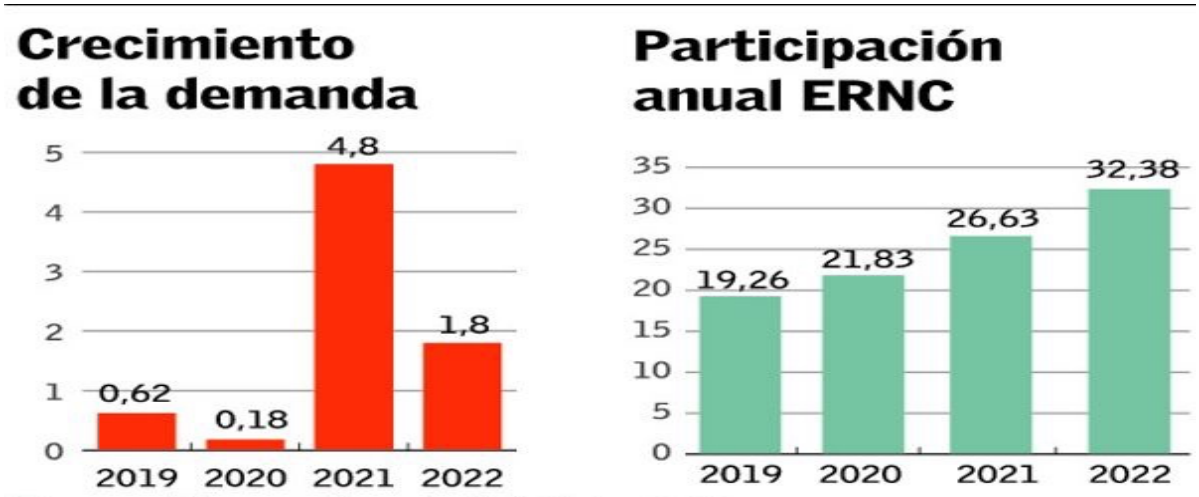
ENDNOTES

Gernot Wagner & Conor Walsh: "Don't Slam the Door on Inexpensive Chinese Electric Vehicles (NYTimes, May, 2024 https://www.nytimes.com/2024/05/15/opinion/biden-china-trade-electric-vehicles-solar-panels-tariffs.html); Costas Arkolakis & Conor Walsh "Clean Growth" (macro)econ implications: https://www.conor-walsh.com/s/CleanGrowth.pdf

Alessandro Casaburo, Giuseppe Petrone, Francesco Franco, Sergio De Rosa; A Review of Similitude Methods for Structural Engineering" Appl. Mech. Rev. May 2019; https://doi.org/10.1115/1.4043787

Annex

Change in Energy Matrix Resulting from Policy Change



Generación por fuente total (en TWh)

	2022	2021	Var. %
Eólica	8,8	7,2	**22,4**
Geotérmica	0,5	0,3	**43,8**
Hidráulica	20,1	16,3	**23,2**
Solar	14,1	10,5	**33,4**
Térmica	38,9	46,5	**-16,3**

Generación renovable no convencional (en TWh)

	2022	2021	Var. %
Biomasa	1,51	1,63	**-7,4**
Eólica	8,75	7,15	**22,4**
Pasada (minihidro)	2,23	2,05	**8,8**
Solar	14,03	10,53	**33,2**

Generación térmica (en TWh)

	2022	2021	Var. %
Biomasa	1,65	1,86	**-11,3**
Carbón	19,03	27,47	**-30,7**
Diésel	1,48	1,81	**-18,2**
Gas Natural	15,84	14,48	**9,4**

*Cifras al 28 de diciembre de 2022

Fuente Coordinador Eléctrico Nacional EL MERCURI