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Testimony

Hearing on Solving the Climate Crisis: Key Accomplishments, Additional Opportunities, and the Need for Continued Action

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Before the:
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Select Committee on the Climate Crisis
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Congresswoman Kathy Castor, Chair, Congressman Garret Graves and Members of the House Select Committee on the Climate Crisis, thank you for inviting me to participate on this panel.

As the 117th session of Congress concludes business and with preparations for the 118th well underway, I offer these thoughts on the myriad, complex, challenging, interwoven energy, environment and economic considerations of our times.

- **People are adaptable, as are societies overall.**

Our adaptability shows up broadly in societies, in our economies, the technologies we embrace, mobility, knowledge and communication. We are most adaptable if we are able to detect and seize opportunities, and we can most easily accomplish those things if we are healthy, educated and prepared, with ample resources at our disposal. A basic rule of thumb is that we make decisions to maximize our benefits, subject to constraints. Whatever one thinks about economics, this rule of thumb works every time – it is merely an expression of observed behavior throughout human existence.

- **As a nation we face that same rule – we want to maximize benefits of our investments, subject to budget constraints.**

The wealth of nations that are composed of free and democratic societies comes mainly from the income that we, the taxpayers and voters, provide. It certainly is more comfortable for everyone if we the citizens are willing to fund government, than if we are not. That means free and open debate about choices in full view of all of the tradeoffs: all of the costs – not just some (or even none), and all of the presumed benefits – whether or not we want to acknowledge them. The full, total cost includes opportunity costs of doing something else, including foregone benefits that are in hand today.

- **Energy goods and services are more affordable when provided competitively, in free and open markets, than when they are not.**

A major challenge in addressing energy poverty worldwide is instilling competition. This means allowing producers and customers to discern, react to and, in their own ways, manage risks and uncertainties associated with shifting market conditions. If we distort markets to subsidize or otherwise promote energy sources, to shelter producers or customers, or engage in other actions, no matter how well intentioned they may seem, we inhibit competition and the free flow of price signals. We simply are creating new cost burdens while shifting costs from the transparency of markets to the opacity of government influence, reducing or negating benefits in the end. In no way do these approaches guarantee any form of resilience or security for national economies, for energy, the environment, food and water.

- **Government control and ownership of energy resources and systems induces often-severe energy poverty along with associated food and water poverty.**

The tendency to subsidize pricing, mostly to curry political favor, boosts demand while blocking competitive entry and provision, resulting in subpar products and services. Most of the developing world is this way, including Latin America, which is interesting to consider in light of our immigration debates. In the developed world we are adopting too many of these tendencies with mandates that effectively pick technology winners, creating domino effects in costs while degrading reliability and security. Why would anyone want that outcome? Why would we want it here in our country? Why would Europeans want this?

- **All of these dynamics are in play when it comes to what we should do, if anything, about energy supply relative to earth's climate.**

I note that, outside of the extraordinary circumstances in Europe, demand is rarely on the table. Political debates are singularly focused on replacing fuels and energy sources deemed to be out of favor with as little inconvenience as possible to voters and taxpayers. Alternatives to legacy energy sources are always presented in the most alluring terms yet the tradeoffs are acute. In Europe, the widespread upheaval and disruptive demand destruction that are taking place and cumulative economic damage should be a warning. Responsibility and accountability are expensive political penalties.

- **Removing fossil fuels (and nuclear, for those with that predisposition) from the picture bears enormous consequences for reliability and security of the energy-food-water nexus that so many worry about.**

The potential costs, which we would experience now, would surpass any hypothesized benefits that lie in the distant future. The expense column includes shifting risks and uncertainties - geopolitical, environmental, economic and other – from fuels and supply chains that we know, including our domestic resources, to raw materials supply chains that we do not. Every hypothesized benefit in avoided mortality risk associated with climate scenarios must be balanced by mortality risks associated with a chaotic scramble away from fossil fuels. As well, we must account for the huge cost of missed opportunities to keep fossil fuels in the mix with enabling technology. As the detrimental impacts of a forced march away from fossil fuels make their way through households and economies, the political costs would mount up quickly. For those who care, the risk is that energy transitions, however they might be envisioned, are delayed or even abandoned.

- **When it comes to wind and solar, far too many costs are hidden or ignored.**

To deploy wind and solar at large scale for our modern societies and economies requires industrial equipment with materials inputs that are out of balance with energy outputs. Any discerning reader of the IEA report[1], *The Role of Critical Minerals in Clean Energy Transitions*, can detect this well-established "hard truth". I was a peer reviewer for the IEA report, and included the key image in Supplemental Information for my testimony, below. I also recommend that readers scrutinize IEA's conclusions on cycle times for minerals supply development, upwards of 20 years for strategic metals like nickel and copper, fully compatible with what I see from my own research and experience.[2] "Cancel" renewable – that term has been misleading

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[1] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[2] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/reliable-supply-of-minerals#abstract. IEA notes, "Long project lead times exacerbate the risk of a mismatch in timing between demand and the industry's ability to bring on new projects".

public attitudes for decades. Modern wind and solar systems, whether grid-based or decentralized, encompass enormous commitments of natural resources for full execution.

They also entail life cycle management requirements that have never been part of discussions. These include commitments of hydrocarbons for wind turbine blades, solar PV Plexiglas and thermal energy backup to intermittent, non-dispatchable energy and disposal of waste associated with replacement of parts that cannot be recycled or repurposed.[3]

Voters, taxpayers, customers need to discern and respond to the full cost of electricity, including all of the expense to integrate wind and solar into power systems. Levelized cost of energy (LCOE) estimates do not capture all of the costs of using wind and solar. Components are nearly all made in cheaper locations outside of the U.S. but the full brunt of systems costs are here.

While optimistic in tone, the National Renewable Energy Laboratory (NREL) report[4] in August this year noted that, "In all modeled scenarios, new clean energy technologies are deployed at an unprecedented scale and rate to achieve 100% clean electricity by 2035." Projections of capacity needs, especially for transmission, rarely incorporate cycle time realities associated with permitting. These usually are "assumed away". The NREL team suggests that, "If there are challenges with siting and land use to be able to deploy this new generation capacity and associated transmission, nuclear capacity helps make up the difference and more than doubles today's installed capacity by 2035."

Forcing wind and solar into markets with subsidies provides initial appeal to investors – we are de-risking investors by transferring risk to taxpayers and their households. These subsidies undermine power markets in ways that hurt those same, and other, investors and reduce affordability to households.

- **Transforming mobility from the flexible, fungible liquid fuels based transportation system we have now to electrification is a hugely complex undertaking.**

A colleague in the automotive industry remarked that, "Retooling an industry that has been the backbone of our manufacturing infrastructure is truly an historic undertaking." Moreover, building sufficient domestic supply chain competence will take decades.[5] The product and its potential, the interaction of electric vehicles and grids and EV-consumer interface, are attractive, to say the least. Yet many of the innovations and potential benefits, for instance autonomous driving, already are available in current combustion engine vehicles.

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[3] https://www.bakerinstitute.org/research/call-action-recycling-and-waste-management-across-alternative-energy-supply-chains

[4] https://www.nrel.gov/analysis/100-percent-clean-electricity-by-2035-study.html. See https://www.nrel.gov/analysis/100-percent-clean-electricity-by-2035-study.html for news release. Also see https://repeatproject.org/docs/REPEAT_IRA_Transmission_2022-09-22.pdf for comparison.

[5] Comment during a private roundtable on "Materials Sourcing and Recycling with a Focus on Electric Vehicle Manufacturing, Use and the EV Life Cycle", May 24, 2022. Discussion centered on coordination problems associated with developing new supply chains, and the importance of recycling to the longevity of the industry. A conclusion was that gaps in policy exist ranging from tax/subsidy arrangements at various points in the recycling value chain to regulatory standards for handling and safety. These gaps are a consequence of the policy-driven pace at which the market is growing. Report forthcoming. Contact Dr. Michot Foss for details.

All of my concerns regarding supply chains, expressed in the Committee on Energy and Commerce Subcommittee on Energy hearing on May 5, 2021[6], have only become more pronounced. Since that hearing, challenges in raw materials supply chains have become more acute, China's formidable control and dominance more sensitive. While Chinese investment has enlarged the global pie, the complicated tensions may be more than other nations can manage. Countries where opportunities exist for raw material supply growth – Latin America, Africa, Southeast Asia and elsewhere – must be able to sustain commercial frameworks that ensure transparent governance and oversight. The responsibilities and accountabilities embedded in geopolitical risks and uncertainties alone, along with the sheer costs of rebuilding, reshoring, friend shoring supply chains make electrification of transport daunting.

Meanwhile, energy use to support battery manufacturing is becoming a hot topic among power grid managers responsible for operations in regions where these energy intensive operations are emerging. Local utility companies have shared that even a 15% market penetration of electric vehicle models customers prefer will mean significant expenditures that regulators must allow and approve and that will affect household electricity costs. How to coordinate across the amazing array of jurisdictions and needs is of increasing concern to the auto industry representatives with whom we interact.

- **We have many competing needs for raw materials.**

One of those competing needs is defense. Civilian use of, and expansion of, raw materials supply chains can enhance defense industries. If supply chains cannot grow to accommodate both, national security will deteriorate or priorities will need to shift. We are participating in a NATO review of supply chain resilience. Within the context of that effort, the ongoing war in Ukraine and with Russia a major supplier of metals to Europe, questions are being raised about defense priorities relative to the "call" on raw materials for environmental mandates.

- **The combination of accelerating alternatives without forethought or acknowledgement of full costs while coercing abandonment of legacy fuels and systems by restricting capital flows raises the possibility of an "energy transition valley of death"[7].**

The physical and thermochemical properties and attributes of energy sources and systems and financial realities of what we face are too important to disregard, and yet they are widely snubbed. We suggest that we are beyond initial scale up and already have reached the "valley floor". The valley floor is marked by system disruptions and more complete public understanding of (and potentially, backlash to) the economic costs of energy transitions. We expect this stage to persist, exacerbated by geopolitical conflicts. The ascent up the valley's far wall begins at an undefined point and will feature an uncertain confluence of new technologies reaching commerciality. Policy resets and economic and supply chain burdens will have already imprinted their tangible and psychological impacts firmly into energy consumers and producers alike.

- **We have options, and need to hold some dry powder.**

We can pace ourselves in order to do a better job of sequencing supply chains and manufacturing, of thinking through the full set of obligations for energy balancing and reliability, and for balancing energy, environment and security. We also need time to ask, in full disclosure, a

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[6] See transcript, The Clean Future Act: Decarbonization of the Transportation Sector, May 5, 2021, Subcommittee on Energy of the Committee on Energy and Commerce, U.S. House of Representatives, https://www.govinfo.gov/content/pkg/CHRG-117hhrg47848/pdf/CHRG-117hhrg47848.pdf.

[7] https://www.bakerinstitute.org/research/global-energy-transitions-looming-valley-death.

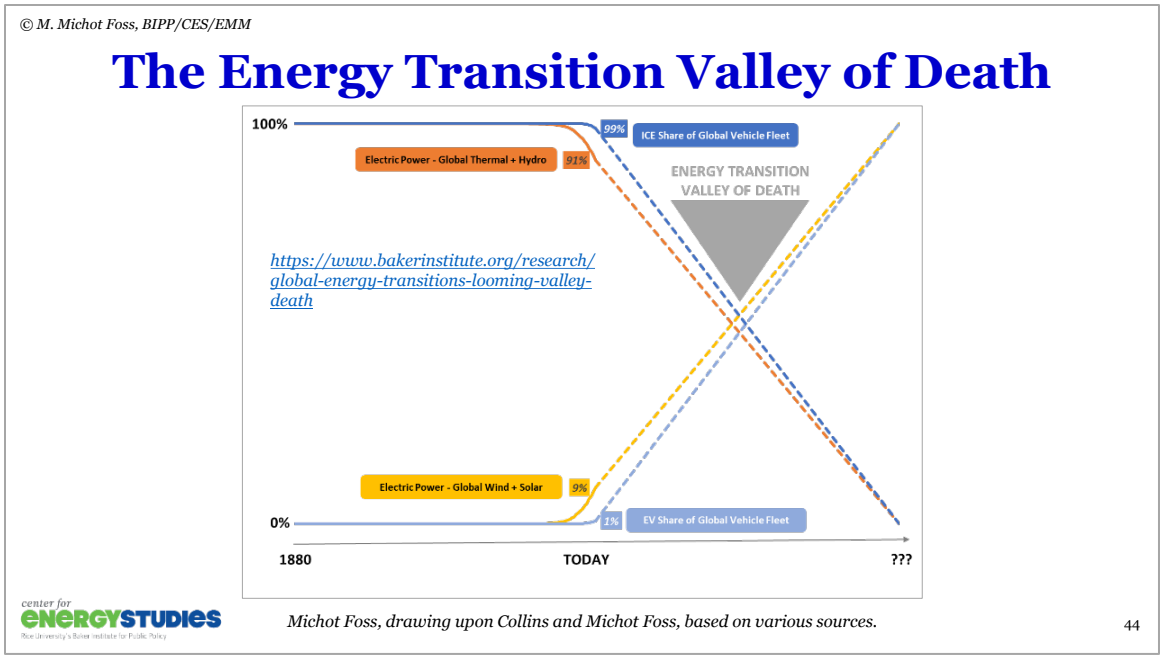
pertinent and important question: *will the pursuit of alternatives, as defined today, make us better off?* We use legacy fuels and technologies much more cleanly than decades ago, and there is considerable room for improvement. Modern fossil fuels offer vast improvements over energy sources in developing countries. Meanwhile, an accelerated pursuit of alternatives could result in increased and persistent emissions beyond current levels, vacating a fundamental goal and premise. It could threaten stability in resource rich nations. We already see these pressures in Indonesia, Chile, DRC and other nations, along with notions of producer associations, cartels, use of export bans to force investment in hoped-for value added industries and formation of powerful state owned monopolies (as China has done to consolidate its rare earths industry). Greater honesty about full costs and financial realities would help to mitigate political risk on down the road. As the national debt clock ticks, we face doing more with a lot less.

- **An important option is to put materials first.**

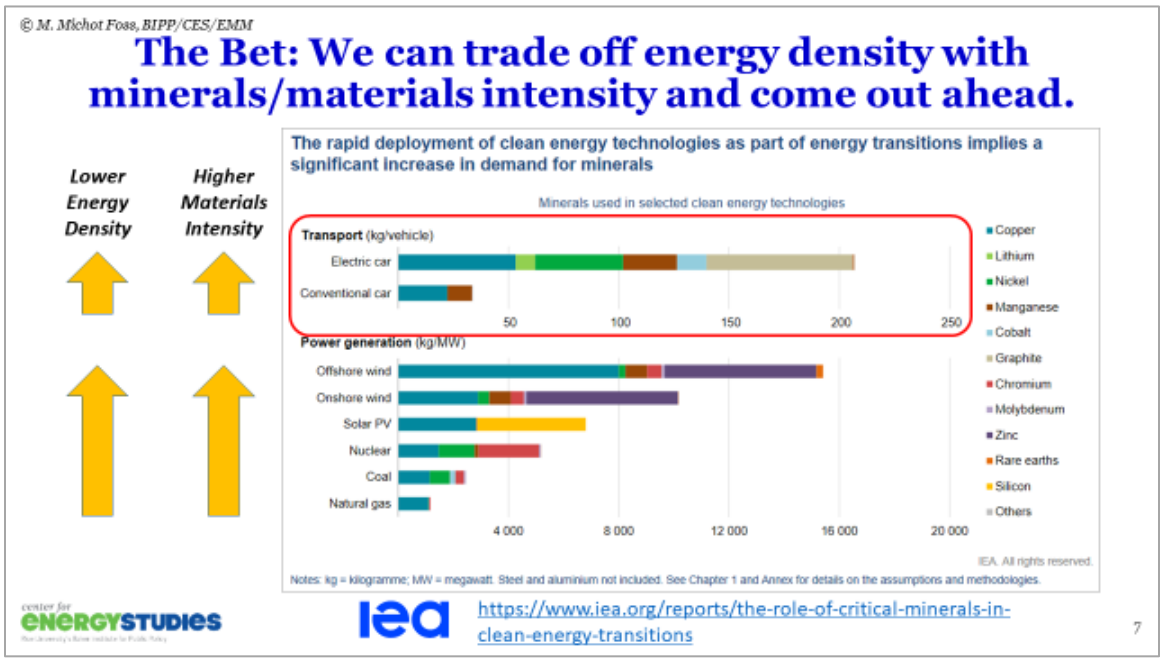
Policy initiatives that target specific results within political timeframes – wind and solar additions, electric vehicles on roads, semiconductor fabrication capacity – are inconsistent with supply chain realities. We need to hone supply chains before placing more obligations into service than can be met. Materials science is moving in fascinating directions, including those that recognize the value of carbon. Life on earth is carbon based. We are creatures of carbon. We can pursue advanced materials that afford opportunities to displace metals with advanced carbon materials, like carbon nanotube products. For instance, we are capturing carbon through methane pyrolysis for hydrogen. We can deploy that carbon as lightweight CNT, with superior electrical and thermal conductivity and strength, to reimagine energy, vehicles, batteries, wind turbine components, construction materials and much more.[8] CNT materials already are finding their way into civilian and defense applications, providing hints of what developers could accomplish at larger scale. All it takes is imagination, risk capital, and clear thinking about novel nanomaterials.

[8] Dr. Matteo Pasquali, Director, Rice University Carbon Hub, 2022 Chevron Lecture on Energy, https://vimeo.com/user112401966/review/697554103/43f25c583f.

Supplemental Information



See footnote 7.



Note – witness was a peer reviewer for the IEA report.

U.S. 2020 Electric Power Generation and Sources

Energy Source	Number of Generators	Number of Generation Locations	Generation per Location ('000 MWh)	Share of U.S. Power Generation
Nuclear	96 reactors	55	14,361	20%
Coal	668 thermal units	244	3,170	19%
Hydro	4,014 dams	153	1,865	7%
Natural Gas	6,020 thermal units	1,793	906	41%
Wind	78,008 turbines	1,422	238	8%
Solar CSP		18	174	0%
Wood		332	109	1%
Geothermal		170	93	0%
Solar PV (grid)	Unknown	4,599	19	2%

U.S. EIA, USGS (wind turbine database). Updated, see footnote 7.