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Research Commentary

Is Net-Zero a Possible Solution to the Climate Problem?

John M. Deutch

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Commentary

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John M. Deutch

I have noted that many observers of climate policy do not believe that the widely adopted policy of Net-zero emissions by 2050 is possible yet often do not have clear reasons for why they hold this belief. This commentary gives the reasoning that supports the belief.

Historically, the objective of climate policy has been to maintain the global average temperature increase under a specified level. Increasingly, countries and organizations today express the objective as a specific target date for reaching Net-zero emissions. Over ninety countries, including China and India, responsible for 80% of global greenhouse emissions have set Net-zero emission targets; the United States and the European Union have pledged to reach a Net-zero economy by 2050.[1] This commentary explains why achieving global Net-zero is highly unlikely by any certain date and, even if achieved, will not necessarily solve the climate problem. The major obstacles to successful Net-zero are unpredictable, involve significant political issues, and are not easily described in econometric models.

Why are political leaders adopting Net-zero goals? Are these aspirational goals intended to assure the public that the government takes climate change seriously, to encourage the private sector to make investments, and citizens to support aggressive action? Aspirational goals unavoidably fail and result in wasted resources, complex negotiations, and time delays to define a new course, and inevitable loss of confidence in government leadership.

If the Net-zero goals are to be realistic, they require adopting policies, plans and implementation, stable over several decades, accompanied by outlays of trillions of dollars annually. Such an extended, determined national effort is often said to be "the moral equivalent of war" (as described by philosopher William James in his famous 1910 essay).

Net-zero is a possible climate solution only if achieved on a *global* basis. Reaching Net-zero for rich nations of the northern hemisphere maybe possible at acceptable cost to the economy. But, for developing countries in the South, resources spent on reducing emissions compete with expenditures to increase per capita income, to improve public welfare, and to meet basic human needs, such as education, health, and housing. The choices produce understandably massive political opposition to emission reduction efforts. Accordingly, southern nations in Africa, Asia, and Latin America, cannot or will not participate unless substantial resources are transferred from rich to poor nations.

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[1] World Resource Institute, Clea Shumer, Cynthia Elliot, July 6, 2023. https://www.wri.org/insights/countries-taking-action-reach-net-zero-targets

Modeling possible Net-zero pathways

Net-zero is intrinsically a scientific concept with the objective to keep the rise in global average temperatures below certain limits. Atmospheric physics describes how emissions of CO_2 (and related greenhouse gases) build up the concentration of CO_2 in the atmosphere that creates radiative forcing which increases global average temperature. A specified temperature increase cap implies a finite budget for CO_2 (and other greenhouse gases) emitted into the atmosphere. CO_2 concentration exceeding this budget will either increase global average temperature or must be balanced by direct CO_2 removal into sinks to avoid further temperature increase or the development and deployment of negative emission technologies.

Negative emission technologies refer to technologies that remove and sequester carbon from and are equivalent to preventing an equal amount of CO_2 being emitted. Many different approaches are under investigation.[2] Two leading candidates are Carbon Dioxide Removal, CDR, from the atmosphere and Bioenergy with Carbon Capture and Sequestration, BECCS. Negative Emission Technologies, NET, will be a part of a successful Net-zero economy since it is inconceivable that the carbon footprint for all uses can be eliminated, for example long range aviation.

Of course, operational Net-zero functions in the real-world political, economic, and regulatory framework that determines successful implementation. A group at Oxford University has proposed attributes necessary for credible Net-zero efforts.[3]

Many climate research groups have analyzed possible pathways to Net-zero based on econometric integrated assessment models, IAMs, to project how economies evolve with time under different assumptions about

- climate policies, economic activity in different sectors (power, steel, cement, buildings, transportation),
- declining learning curve of the cost of reducing emission footprints,
- market developments in different regions, and
- complex interaction between the many market variables.

In 2021, Julianne DeAngelo and colleagues, in a remarkably valuable study, examined the energy systems underpinning 177 Net-zero scenarios.[4] [This study was based on the 2018 Daniel Huppmann et al. article describing the 177 IAMs prepared to support the IPCC 1.5°C Special Report.[5,6]]

The results of the analysis of the 177 Net-zero scenarios show wide variation: there are regional differences in energy sources, in electrification, and in net emissions. Projected net-zero outcomes show that renewable energy accounts for between 25% to 80% of energy consumption. Unsurprisingly biomass varies widely by region, and electricity accounts for 35% to 80% of energy consumption. The median global energy consumption at Net-zero is 521 EJ (Exajoule range 227 – 857) compared to 523 EJ in 2064, assuming per capita energy consumption remains constant. If per capita energy consumption increases, as expected, energy consumption in Net-zero 2064 would increases to 588 EJ. (1 Exajoule = 278 Terawatts-hours = 278 10^9 kW-hrs)

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[2] National Academies of Sciences, Engineering, and Medicine. 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda Washington, DC: The National Academies Press. https://doi.org/ Academies Press. https://doi.org/10.17226/25259.

[3] Sam Frankhauser *et al., The meaning of net zero and how to get it right*, Nature Climate Change, 12, January 2022, (15 – 21).

[4] Julianne DeAngelo, *et al. Energy systems in scenarios at net-zero CO_2 emissions*, Nature Communications, 12, article number 6096 (2021).

[5] David Huppman et al, Nature Climate Change, 8, 1027-1030 (2018). https://www.nature.com/articles/s41558-018-0317-4.

[6] https://www.ipcc.ch/sr15/

This IAM based study approach compares the outcomes at the date of achieving Net-zero compared to today, not the pathway followed. Some studies include linkage of climate impacts with other sectors beyond energy, notably health, food, and water, but these investigations have yet to yield reliable quantitative relationships. Many of the scenarios include some implicit burden sharing. Ideally all IAM Net-zero studies would include significant linked impacts endogenously in the model.

The conventional IAMs project forward deployment that has highly variable temporal perturbations that must be revised iteratively if the desired final Net-zero outcomes is to be realized. Geoffrey Dolphin *et al.*, propose to replace the conventional IAM process of forward modeling subject to random perturbations, by "backward induction modeling" that acceptable pathways must satisfy the additional constraint to hit the specified Net-zero.[7] This approach maximizes the credibility of Net-zero policy influencing private sector behavior although potentially at the cost of some loss of efficiency. The study compares the influence of the conventional forward approach that seek minimum cost/effective outcomes with the constrained backward induction approach that seeks Net-zero certainty. If developed into a practical policy too, the proposed backward induction approach would address some of the concrete, real world, challenges to global Net-zero discussed below.

The U.S. strategy to achieve Net-zero by 2050

In November 2021, the U.S. Department of State released a report: "The Long-Term Strategy of the United States to Net Zero Greenhouse Gas Emissions by 2050."[8] The Strategy reported representative pathways to 2050 based on the Pacific Northwest Laboratory Global Change Assessment Model IAM under several different scenarios.

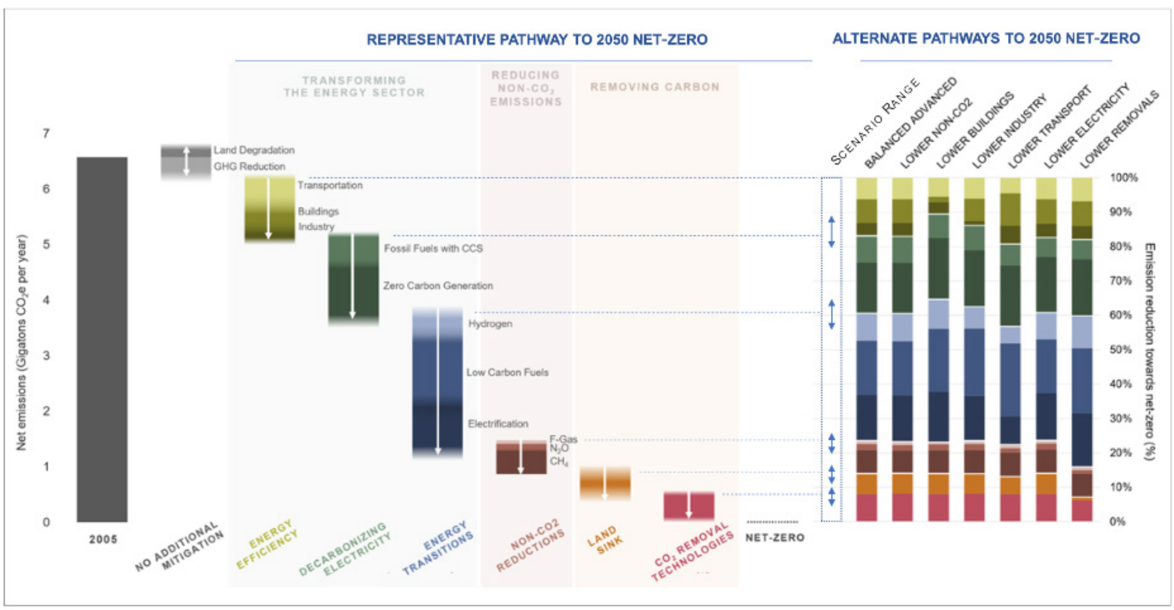

Figure 1. Emissions Reductions pathways to Achieve 2050 Net-Zero in the United States.
Achieving net-zero across the entire U.S. economy requires contributions from all sectors, including: efficiency, clean power, and electrification; reducing methan and other non-CO_2 gases; enhancing natural and technological CO_2 removal. The left side of the figure shows a representative pathway with high levels of action across all sectors to achieve net-zero by 2050. The right side shows a set of alternative pathways depending on variations in uncertain factors such as trends in relative technology costs and the strength of the land sector carbon sink.

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[7] Geoffroy Dolphin, Michael Pahle, Dallas Burtraw & Mirjam Kosch. *A net-zero target compels a backward induction approach to climate policy*, Nature Climate Change, 13, 2023, (1033–1041).
[8] https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

The results confirm that the U.S. can, (not will), achieve Net-zero by 2050. The essential question is whether the globe can achieve Net-zero by 2050.

The major obstacles to successful global Net-zero

The major obstacles are:

1. absence of stable energy polices for several decades,
2. establishing financial mechanisms to transfer and manage more than $100 billion per year from rich countries to developing countries,
3. avoiding international disruptions,
4. developing and widely deploying technical and business practice innovations,
5. reorganization of national and international governance bodies to achieve more rapid and efficient decision making.

The above recognize that each has been a serious impediment to progress over the past half century.

U.S. history illustrates the first obstacle.

Congressional elections occur every two years with frequent changes in political parties that are intent on changing policy through the annual budget cycles. Each new president introduces new energy initiatives: The Carter administration passed a law to make it illegal to burn natural gas in major fuel burning installations to encourage the burning of cheap, plentiful, and domestic coal. Neither Reagan nor Trump believed the federal government had a major role to play in the domestic energy economy.

The rich developed countries and the poor developing countries have been locked in controversy for several decades about relative responsibility for present greenhouse gas concentrations and whether national emission limits should be set on a per capita basis (the emerging country position) or per GDP (the developed country position). There is further controversy about authority and responsibility for how capital transferred to developing countries should be managed.

At the 2009 UN Conference of the Parties, COP, in Copenhagen, the developed countries committed $100 billion per year for assistance to developing countries to reduce emissions.[9] Today developing nations correctly note that rich countries are over $1 trillion in arrears in paying these commitments. In the 2022 COP27 in Sharm-el-Sheikh, Egypt, the pressure from climate vulnerable developing countries successfully broadened the obligation of rich nations, gaining approval for establishment of a "loss and damage fund."

It is naïve to believe that the world will enjoy three decades of peace without a military conflict that creates major disruption without expanding into a global war. The OPEC embargo and the on-going Russian – Ukraine conflict created great disruption in global oil and natural gas markets. North Korea, Iran, and Taiwan are trouble spots where conflict would adversely affect international energy commerce. The calamitous use of a nuclear weapon is another horrific possibility.

There is universal recognition that transition to a Net-zero economy will require development and deployment of significant new technologies and business practices. Decarbonizing industries such as cement, steel, and petrochemicals will require

[9] The commitment included both public and private finance, management of the transfers is contentious. Donor countries see the assistance coming from donor country firms; recipient countries see the assistance as building domestic capability.

both new technologies but also integration of previously independent elements. An example is development of low cost "green" hydrogen, less than $1 per kg at a hydrogen hub that produces, transports, and stores the energy carrier fuel, heat source, or chemical input. Unexpected technology surprises will be both positive, *e.g.*, the existence of commercial natural hydrogen sources, and negative, *e.g.*, excessive cost increase in strategic metals due massive demand growth in a carbon free economy.

Both domestic and international reorganization which is to increase the pace of global emission reductions. Internationally, the Framework Convention on Climate Change (FCCC) which consists of 190+ nations has not made sufficiently rapid progress on reaching agreement on how to reduce worldwide emissions after 27 annual Conference of the Parties, COPs, or reached an understanding on how to implement financial transfer agreements. In contrast, the Intergovernmental Panel on Climate Change (IPCC) which has no decision-making authority, has made a massive contribution through its highly credible research publications reported in its six assessment reports.

Domestic U.S. reorganization needs to align both federal/state and congressional/executive branch authorities to the realities of policy formulation and implementation in a climate change world. The pattern is annual review and approval by multiple bodies. Regarding the latter, different and overlapping federal/state authorities prolong vital siting and licensing decisions. The leading current example is the length of time required to permit, site, and interconnect new electricity transmission at a time when the entire energy system is making a transition from fossil fuels to electricity.

It is improbable that all, or indeed any, of these obstacles will be overcome. If the obstacles are not overcome global Net-zero will not be achieved. Thus, global Net-zero will not be achieved.

What is to be done?

A very likely possibility is that countries will continue to muddle through with existing policies without recognizing or admitting the reality that Net-zero will not happen. A second, less likely possibility is that a group of countries will propose and guarantee a combined emission reduction and payment mechanism to get the globe started on a credible Net-zero path. This is unlikely because it would mean abandoning the UN FCCC and disenfranchising many nations. This possibility of dividing the globe into regions with the larger developed countries taking responsibility for each, *e.g.*, The EU for Africa and the Near East, the U.S. for the western hemisphere, Japan and China for the Far East, the U.K. for India. Of course, there are lots of complications in making such a division.

Given the likelihood that global Net-zero will not be realized the United States should adjust its strategy to place greatly increased emphasis on *adaptation*. Adaptation refers to adjusting to the present and future adverse impacts of climate change. If no effective climate action is taken then individuals, communities, and commerce will of necessity adjust but will experience excessive financial and human damage. If an adaptation policy is in place that makes investments in adaptation measures in advance to lower possible future climate impacts, both public and private damages will be less. Examples of adaptation measures include reducing risks from wildfires, mitigating the effect of sea level rise on coastal communities, protecting regions subject to drought and heat wave (*See supplementary material on adaptation*). The U.S. federal government recognizes the importance of adaptation which is referred to as "building climate resilience."[10] Recent legislation has provided $50 billion for these purposes, although the funds are devoted to reducing damages of existing present climate effects rather than making adaptation to reduce anticipated damages from future extreme climate events.[11]

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[10] White House Press Release, June 19, 2023, FACT SHEET: Biden-Harris Administration Makes Historic Investments to Build Community Climate Resilience.

[11] Provisions included in the Infrastructure and Jobs Act and the Inflation Reduction Act.

In addition to placing greater priority on adaptation, there are positive steps that would improve the chances of long-term solutions, even if we are skeptical that far reaching solutions to the obstacles will occur. The following are five suggestions of actions the U.S. can take unilaterally that potentially can make a difference, but which are by no means easy to accomplish:

1. The United States should make clear that the Net-zero targets they have set apply only to the U.S. and affirm that the U.S. intends to go forward even though it does not foresee these types of Net-zero targets will be adopted globally.

2. The President should begin a dialogue with Congress leading to approval of a more streamlined process for dealing with the challenge of prompt and effective measures to reduce the risks of harmful climate change. Ideally Congress should establish a joint committee with authorization and appropriation of multi-year budgets for federal climate programs.

3. The President should instruct the Special Presidential Envoy for Climate to urge rapid implementation of the UN Net-zero Recognition and Accountability Framework and to begin consultations on a new Framework Convention that gives delegates some decision-making authority.

4. The United States and the European Union should form a partnership for two purposes. First, to forge a common statement about Net-zero policy and the likelihood targets of specific countries will be achieved. Second, to agree on a common approach about global climate policy toward key developing countries, notably China and India.

5. The last and most important step is for the United States to adopt a multi-year schedule of payments for climate reduction assistance to a designated list of recipient countries. [Payments made by the World Bank or other international development organizations for climate action activities attributable to the U.S. should be included in a separate schedule.] Each schedule should include the type of payment *e.g.*, guaranteed purchase from recipient country, investment in recipient country, U.S. company facilities in country, investment in recipient country firms with resulting U.S. ownership position.

Concluding comment

Climate and energy policy professionals should expect that Net-zero will not be guiding policy in the U.S. or elsewhere for decades and there will be major changes in the strategy the world adopts to address the climate challenge. Independent policy experts should critically examine alternative strategies for their cost/effectiveness and fairness. The government officials and the public will rely on their opinions and should hear their voice.

Supplementary Material on Adaptation

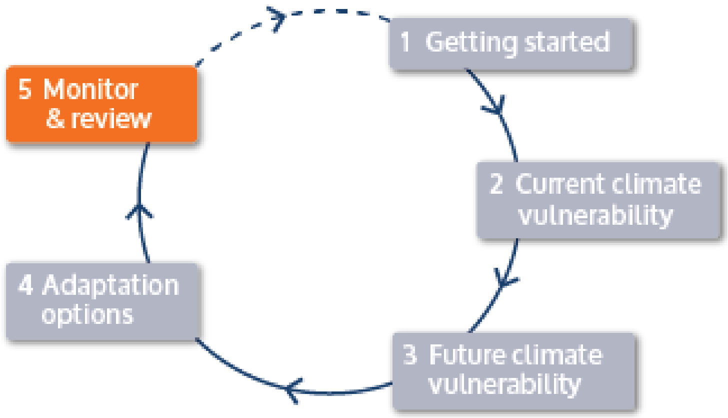
Adaptation refers to human-launched programs taking action to protect communities, commerce, and the environment from anticipated damage and adverse impacts from climate change. In contrast to CDR, adaptation does not rely on development and deployment of technology but rather undertaking projects or procedures to reduce environmental damage and associated cost if a destructive event occurs. Chapter 17 of Working Group II, WG-II, to the UNFCC fifth assessment report is titled "The Economics of Adaptation".[i] WG-II offers these examples of adaptation:

1. Altered patterns of enterprise management, facility investment, enterprise choice, or resource use (mainly private)
2. Direct capital investments in public infrastructure (e.g., dams and water management—mainly public)
3. Technology development through research (e.g., development of crop varieties—private and public)
4. Creation and dissemination of adaptation information (through extension or other communication vehicles—mainly public)
5. Human capital enhancement (e.g., investment in education—private and public)
6. Redesign or development of adaptation institutions (e.g., altered forms of insurance—private and public)
7. Changes in norms and regulations to facilitate autonomous actions (e.g., altered building codes, technical standards, regulation of grids/networks/utilities, environmental regulations—mainly public)
8. Changes in individual behavior (private, with possible public incentives)
9. Emergency response procedures and crisis management (mainly public).

Adaptation does not directly reduce temperature increase, rather it acts like an insurance policy that reduces costs of damage from the impacts of global temperature increase should it occur. The diversity of adaptation actions presents a challenge to its analysis as a control mechanism and to setting a common scale to compare the costs and benefits of different proposed adaptation efforts.

Adaptation has co-benefits which gives it an advantage over other climate control measures. For example, revising building construction codes to make buildings more resilient to extreme weather events also improves infrastructure by conveying longer useful life. Adaptation has a disadvantage compared to emission reduction. For emission reduction the incremental damage attributed one additional kg of CO_2 is usually easily attributed to the emitter. This makes it possible to adopt policies that links emission costs to emitters. An adaptation project usually has a regional project, e.g., ambitious New York and Miami resiliency projects to protect their waterfront from anticipated flooding as sea level rise. Such projects are quite costly, and it is not evident how these costs should be allocated across all city taxpayers.

The literature on adaptation as a climate control mechanism is vast. Because of the complexity mentioned above, the literature stresses general features: the significance of adaptation, tools required for planning, and the importance of gaining community approval for projects. Chapter 29 of the 2018 Fourth U.S. National Climate Assessment, is devoted to describing federal efforts to reduce risks through adaptation actions.[ii] The European Commission's approach to adaptation, carried out by the European Environment Agency, is to "share adaptation information across Europe." The agency issues guidelines, methods and tools, and a handbook for provinces, regions, and an application support tool for this purpose.[iii] The UKCIP adaptation "wizard" tool follows five steps summarized on the wheel:[iv]



The narrative is general; no quantitative measures are proposed to evaluate benefits and costs of alternative adaption projects.

A climate policy optimized among four climate control mechanisms requires an ability to investigate the trade-off between adaptation and emission reduction. Because of the general character of adaptation and precise emission reduction project analysis, the trade-off between these two important climate control mechanisms is rarely attempted.

A notable exception is the work of de Bruin, Dellink, and Tol that bravely undertakes modifying the emission centric Dynamical Integrated Model of Climate and the Environment, DICE, model to allow adaptation and emission to be substitutes, competing for available resources but without explicit consideration of the different time lags for deployment.[v] Figure (4) of the deBruin et al. AD-DICE study displays the climate change control cost over time for four different control strategies: no controls, only adaptation, only emission reduction (mitigation) and the optimal joint control of adaptation and emission reduction. No control is the most costly and optimal control is the least costly. Emission reduction costs more than adaptation over most of the period 1990 to 2200 but a cross-over occurs toward the end of the interval.

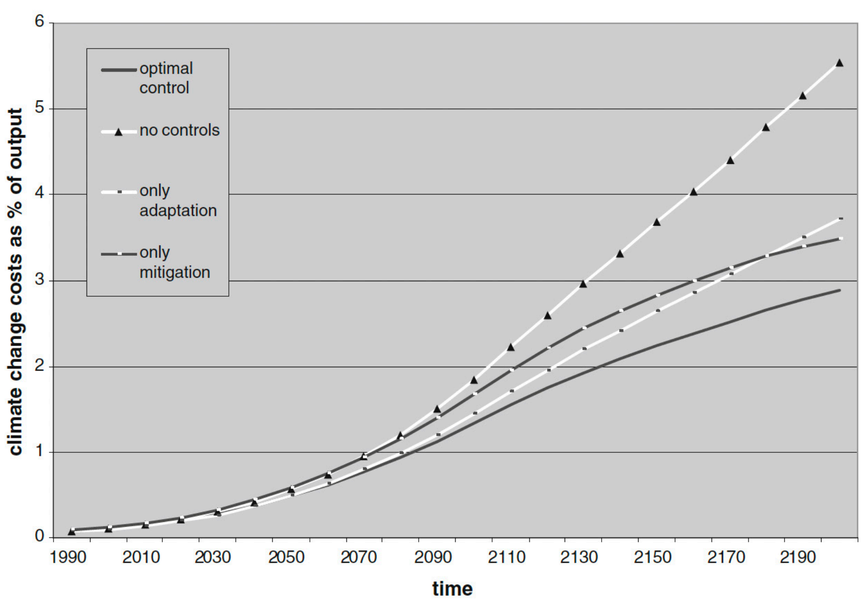


Figure: Climate change costs of different policy scenarios.

Two concluding points: Chapter 1 contains a discussion of the extreme importance of data in climate policy (and science). Empirical data sufficiently reliable to support behavioral and system relationships are frequently lacking. Variability is frequently ignored although there is almost always a large gap between average and best (or worst) of class performance. The difference between global and regional projections are massive.

The discussion of AD-DICE model illustrates data challenges: results are based a single year, 1999; there is no indication of how the global result can be disaggregated to regions; there is no discussion of how technology will influence economic performance parameters out to 2200. The study does include, as it should, sensitivity analysis to test conclusion but only for a few high-level variables: discount rate, climate sensitivity which sets the relationship between warming and atmospheric concentration, adaptation protection costs. Econometric models do provide insights that should guide climate policy deliberations, but the quantitative results do not have sufficient fidelity to support program choices.

The second point concerns adaptation for the rich and poor.[v,i] The United Nations Department of Economic and Social Affairs policy correctly states:

> Climate change has a differential impact on people and communities. The people at greatest risk are the poor, the vulnerable and the marginalized that, in most cases, have been excluded from socioeconomic progress.
>
> Far reaching, transformative policies are needed which simultaneously address immediate vulnerabilities as well as existing structural inequalities.[vi]

Adaptation is the climate mechanism that runs most directly into the vulnerability and adaptive capacity of rich and poor countries. In rich countries, much human adaptation can be expected to be put in place by private sector investment that is guided by a realistic view of future costs and benefits. Firms have access to capital for investment in projects with reasonable expectation of positive financial returns.

In poor countries there is inadequate access to capital and many competing demands for public investment such as health, education, and economic growth. Thus, adaptation projects are generally unaffordable and do not command high priority. The 2018 UNFCC Special Report on Global Warming to 1.5°C is a comprehensive and eloquent statement of these issues.[vii] While the financing problem is acknowledged there has been little progress in agreeing on the mechanism and pace of transfer of funds.

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About the Author

John Deutch is an emeritus Institute Professor at the Massachusetts Institute of Technology. Mr. Deutch has been a member of the MIT faculty since 1970, and has served as Chairman of the Department of Chemistry, Dean of Science and Provost. Mr. Deutch has published over 140 technical publications in physical chemistry, as well as numerous publications on technology, energy, international security, and public policy issues.

John Deutch has served in significant government and academic posts throughout his career. In May 1995, he was sworn in as Director of Central Intelligence following a unanimous vote in the Senate, and served as DCI until December 1996. In this position, he was head of the Intelligence Community (all foreign intelligence agencies of the United States) and directed the Central Intelligence Agency. From March 1994 to May 1995, he served as the Deputy Secretary of Defense. From March 1993 to March 1994, Dr. Deutch served as Under Secretary of Defense for Acquisitions and Technology. From 1977 to 1980, John Deutch served in a number of positions for the U.S. Department of Energy: as Director of Energy Research, Acting Assistant Secretary for Energy Technology, and Undersecretary of the Department.

John Deutch earned a B.A. in history and economics from Amherst College, and both the B.S. in chemical engineering and Ph.D. in physical chemistry from MIT. He holds honorary degrees from Amherst College, University of Lowell, and Northeastern University.

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