TO: Via email to DNRECHearingComments@delaware.gov

December 2, 2022 48-page submission

Secretary Shawn M. Garvin
Delaware Department of Natural Resources and Environmental Control
89 Kings Highway SW
Dover, DE 19901

Submitted to Docket #2022-P-MULTI-0012

RE: DNREC Review of BIOENEGY DEV
STATEMENT SUBMITTED IN OPPOSITION TO:
The Bioenergy DevCo biogas plant proposed for Seaford.

Submitted by: John Mateyko, 55 Sunset Road, Newark, DE 19711
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Dear Secretary Garvin,

I write in opposition to the requested permit for the reason that the application is not consistent with the best available science (BAS).

Introduction

The body of reports by the United Nations' Intergovernmental Panel on Climate Change (IPCC) is described in the science as the global gold-standard, and often, legal 'safe-harbor' for governments, corporations, business executives and boards of directors worldwide, and their development and business advisors in every professional field including, policymakers and regulators, legal, economic, investment and financial professionals and developers, system analysts, risk analysts, engineers and architects (my profession) and all others to depend upon—everyone "reading from the same page" in a newly dynamic world.

The work of the IPCC is recognized by the science professions, and legally in law, as a foundational part of the "best available science" the overall body of work ("Reports" and "Special Reports" over the past decades)

In both private and public sector the IPCC constitutes the "a common book of prayer" for all actors to reference the same physical characteristics such as average and extreme design temperatures, design precipitation, flood design, material and machinery expected lifetimes, projected future soil moisture and crop productivity, human worker productivity and safe workday endurance, and other rapidly changing conditions of nature and human health, supply-chain disruption risk, and evolving economic global market constraints and numerous other projected risks from these newly dynamic physical conditions. This is essential in business and financial planning for the long-term. The science-based reports of the USGCRP, UNEP, and others collectively evaluated in the IPCC literature review constitute a convenient common "roadmap" to navigate new investment in the future of the Earth System, including that part known as Delaware. It is a risk management guide to Sustainable Development in Delaware--a financial planning tool.

The very practical work of the IPCC is likened by some researchers in the American Public Health Association to the phrase of historian Raymond Williams:

"Make hope practical, rather than despair convincing"

Globally, hundreds of thousands, or more actors—international bodies, nations, states and provinces, cities and regulatory agencies, businesses and trade organizations, professionals and investors work from this common IPCC knowledge. The applicant of the project before DNREC should be no exception. But it is.

The fundamental flaw of the application for regulatory review is that it presents no evidence of concern with, or compliance to, the science governing the current and future climate changed conditions in the sectors of technology, nature, society, or economy of Delaware for the lifetime of the proposed project—the period of use before DNREC or review. As such, the application is based upon science, data and knowledge that is NOT reliable as a current basis to protect the public health, safety and welfare as required by law.

It is an application virtually entirely predicated upon the conditions of the former static climate that previously existed in Delaware, and not the current, dynamic, materially different climate as required by the "best available science" and EPA.

The application must be rejected because it is incomplete, or inaccurate—it is not based upon current science-based conditions, or "best available science" as required by Delaware and US law and regulation. It is an application based upon obsolete information. The world they predicate, no longer exists in Delaware, or anywhere on Earth. The IPCC, USGCRP and other science was readily available to the applicant like all other businesses without cost, on-line, or in print, but they present no evidence of having accessed that current and accurate knowledge.

Climate Change Mitigation: Scientists say "It is now, or never."

The ‘Best Available Science’ (BAS), by law, governs this application. The BAS is used, in part, to protect the public health, safety and welfare, and both Lancet medical journal (arguably the most influential in the world), and the American Public Health Association find “Climate change to be the greatest human heath risk of the 21st century.” The federal government’s United States Global Change Research Project, in its hundreds of definitive science reports since 1990 confirms this same finding. Thus, central in the BAS is the extensive interdependent science of climate mitigation, climate adaptation and climate-sensitive Sustainable Development. In BAS the three are one transition, pathway and transformation. The full range of climate science calculated to protect the public health, safety and welfare (HSW) against the several deadly, and increasingly costly, impacts of climate change must be the measure of application. This is because at local, state, national and international levels, public health and disaster officials report climate is now the greatest measure of risk to the public. “ Daily news reports offer popular, daily life confirmation of the science. *Preparation cannot be further delayed*; science reports, *“It is now, or never.” The science-based temporal dimension of “urgency”, “crisis”, and “immediately”, reported in the BAS, including (for convenience) the IPCC science below, is material to consideration of this application.*

Climate science is the 21st century science of public health and safety
Current BAS, including 35 pages of documentation (below) from the 2022 IPCC Mitigation Report makes absolutely clear that climate change mitigation is now public health and safety in Delaware. The Rockefeller Foundation-Lancet Commission on planetary health(July 2015) wrote it this way, “Put simply, planetary health is the health of human civilization and the state of the natural systems on which it depends.”

Compliance with climate science is now compliance with protection of the public HSW and vital safeguarding of land and water-based ecosystems, humanity’s only life support system. Climate change impacts on both society and nature are material to this application.
The BAS (including the IPCC science below) establishes why the application before DNREC was required to frame its submission in terms of climate change mitigation and adaptation of the land- and water-based ecosystems of Delaware, the lowest average elevation of any state and thus especially vulnerable to sea level rise (and related salt water intrusion into fresh drinking water) given land subsidence, coastal storms and flooding, new insect and disease vectors, food and water insecurity, and other climate impacts reported by the IPCC, USGCRP, the Rockeffer-Lancet Commission (2015) and other BAS sources.

It is also clear, under law governing DNREC, that applications not in compliance with the BAS on climate mitigation, adaptation and their interdependent Sustainable Development, cannot “be approved” by DNREC—that would put the public at risk, create public (and financial sector) distrust in government (and possible contempt), worry residents, concern visitors, reduce crop yields, create uncertainty regarding stranded physical assets (like homes), render new investment in Delaware comparatively “high-risk” (and more costly), and damage our economy and reputation. That is why, as daunting as the challenge is, governments all over the world have assumed the challenge: The IPCC reports that some governments have already navigated,--and mastered--the practices of climate mitigation for over a decade on the science-based pathway to net zero GHG emissions. Upon public release of the latest IPCC Mitigation Report, the *Washington Post* reported (4 April 2022) this:

> “The report finds… good news from the world of climate policy: Some 56 countries that generate more than half of global carbon pollution have enacted legislation aimed at reducing greenhouse gasses (GHG). And more than 10,500 cities and nearly 250 regions that are home to more than 2 billion people have made voluntary climate pledges.”

More recently the US federal government enacted law providing nearly $400 Billion in federal subsidies and tax-incentives over a decade to businesses, and others, including in the agricultural sector, with provision for the industrial food system, for various climate-sensitive innovations to their operations. Funding for climate initiatives is available to the applicant to make change practical.

“There is a chance to be successful.”

Climate mitigation has been proven practical, workable, successful (see IPCC, below for some 35 pages of workable examples). Given the business-case for doing so, as discovered and reported in the business media, by other global businesses, there is no technical reason why the applicant could not have adopted a science-based pathway in Delaware in their application, as required by law to protect the public----and their own assets. “There is a chance to be successful.” Leon Clarke, a lead author of the IPCC 2022 Mitigation Report told journalists upon its release in Geneva. “The kind of transformation that might have seemed unimaginable can still happen.”

Well Established in Federal Law

At the federal level this has been law for over three decades: the U. S. Global Change Research Project (USGCRP) Act of 1990 established the science-based metrics of climate change for federal law. Importantly for this application, in 2017 the IPCC explicitly referenced the work product of the United Nations’ Intergovernmental Panel on Climate Change (IPCC) as the ‘foundational” science of their field (as indicated by frequent citation of the IPCC in USGCRP’s references).
Thus, we reference both the USGCRP and IPCC (and Lancet) reports as among the BAS. Below we report some 35 pages of IPCC 2022 climate science relevant to this application, although it is only their full reports that constitute the BAS.

The state, based upon this BAS full record, should evaluate the potential of the application for climate change mitigation, adaptation and compatibility with Sustainable Development for Delaware, based upon the demonstrated compliance of the application with the goals and timelines of BAS, namely, 50% reduction on GHG emissions by 2030, and 100% reduction in GHG emissions by 2040-50, integration with Adaptation and Sustainable Development in Delaware. There is no indication in the Application of such compliance.

Application not consistent with the science-based timelines of "urgency"
Based upon BAS directives for climate mitigation in-time, and at-scale to safeguard the public HSW in Delaware, State policy, investment, subsidies, mandates and regulatory frameworks should be focused on, and limited to, investment and policy support for no-or-low GHG (near-term up to 2030 operations) and net-zero (medium-term after 2030) in businesses and systems, such as the Delaware Industrial Food System. Sarah Kaplan, the Pulitzer-Prize winning, lead climate reporter for the *Washington Post*, in reporting on the release of the latest IPCC report (4 April 2022) wrote this:

> "The science has never more consistent and never more clear," Inger Andersen, executive director of the UN Environmental Program (UNEP), said in an interview. Human carbon pollution has already pushed the planet into unprecedented territory, ravaging ecosystems, raising sea levels and exposing millions of people to new weather extremes. At the current rate of emissions, the world will burn through its remaining "carbon budget" by 2030 -- putting the ambitious goal of keeping warming to 1.5 degrees Celsius irrevocably out of reach."

The documented operations of the current Application are not consistent with this urgent BAS timeline of existentially required goals within required timelines to be in-time and at-scale to protect the public health, safety and welfare (HSW) of Delaware.

I submit that, based upon the science, the current best available climate change science for the interconnected Mitigation, Adaptation and Sustainable Development includes the following:
the full corpus of reports of the IPCC, IPBES, USGCRP, UNEP, UNDP, OECD, Lancet, EAT-Lancet, Rockefeller Foundation-Lancet Report: Safeguarding human health in the Anthropocene epoch, and similar authoritative reports. This is the science widely referred to, in aggregate in the scientific literature, as "the best available science".

The later three Lancet reports focus on required transformation of human diet and food systems, especially industrial food systems (and their required transformation into net zero system,, which is an issue in this application.

The BAS, over many thousands of pages, reports very high confidence that Mitigation, Adaptation and Sustainable Development must be integrated into a transition pathway calculated to achieve fundamental transformation within the required timeline, and at-scale.

In this context, Bioenergy does have context-specific purpose, in such a climate-based framework. While a land-based use, it virtually ignores a regenerative ecosystem approach featured in the BAS. This entire application ignores any transition let alone, transformation, and is predicated on a different paradigm: enabling expansion of BAU.

As such, it presents no demonstration of how "bioenergy" in this "business-as-usual" (BAU) context does anything other than mislabel bioenergy as a GHG emissions "mitigation" system, when in fact its internal logic is as an enabler of otherwise regulated GHG-generating, unsustainable combustion of waste from the industrial poultry industry of four states.

The BAS makes clear that climate mitigation is impossible without systemic integration of climate mitigation, climate adaption and a specific, local, place-based Sustainable Development pathway that integrates all three into one holistic system. The application fails to document this.

Food system: Non-climate science based food system, not Sustainable Development
The largely mono-culture industrial food system does not integrate its "waste" back into the production process, and this application is in effect a "waste combustion" project. Local farm-soil application of the waste in the age-old land-based on-farm disposal of waste, the science reports, would be the superior science-based systemic process when waste is proportional to the soil area, and the soil elevation (unlike the Delaware area) is of appropriate elevation above sea level to avoid flooding. That would avoid new petroleum-based inputs of chemical fertilizer. Overall, this is the less carbon and GHG intensive process, water conserving, and safer, when applied appropriately for better water quality, air quality, human health and wellbeing, and neighborhood preservation but the application does not adopt this science-based holistic well-being, low-carbon pathway.

Because it is predicated on the Delaware (and surrounding three states allied to it) maintaining a BAU (not a transitional solution toward a transformational food system as BAS) framework toward energy, waste, and as well as industrial agricultural production systems it is not consistent with Delaware Sustainable Development—which the BAS reports it must be integral with—but instead constitutes additional lock-in (technological, behavioral and institutional) of incumbent 'maldevelopment' in the Delaware food system and nature system, and energy system. The application is silent on, and thus denies compliance with, the claims of science that transition and transformation is required at his time, by all (without exception, in order to reach net –zero GHG emissions) and going forward—but science-based regulation cannot be.

Elected and appointed officials, under law, to protect the Delaware public HSW, cannot do the same. "People act and contribute to climate change mitigation in their diverse capacities as consumers, citizens, professionals, role models, investors, and policymakers," reports the IPCC, 2022, Mitigation, Chapter Five (ES).

Genuine Land-Use based Mitigation Not in the Application
Such soil-application at science-based application limits might have been considered in the Application as a mitigation transition as part of an overall transformation of the Delaware Poultry but there I not documentation of such a mitigation approach. Such an approach may have constituted an industry to compliance with constraints of energy (including chemical soil inputs), climate, public health and well-being, water, farm soil management consistent with increasing SLR and rainfall flooding, and agronomy based on a warming-planet and the existential requirement that the Delaware Poultry Industrial Food System must operate within a net zero-carbon, zero-GHG constraint—no exceptions, in order to achieve net zero universally. At the same time, the science is clear, the transformation must be locally holistic, place-based, and one integral to overall Sustainable Development. The application fails to comply with the BAS.

Local, "granular" solutions for faster deployment and diffusion
The application is silent on this local knowledge, smaller-scale local solutions and systemic integration, and therefore fails to demonstrate, as required, compliance with the science. It distorts the science. "Greater contextualization and granularity in policy approaches", the IPCC reports (Mitigation 2022), "better addresses the challenges of rapid transitions towards zero-carbon systems."

Social system: Non-equity based health and well-being impacts on the neighborhood
This application concentrates environmental loads of several types in one low-elevation area from an estimate 73,000 heavy truck shipments from parts of four states. The population in the receiving area is Spanish-speaking Hispanic and Creole-speaking Haitians, brown and Black population, both with language barriers raising social and legal concerns.

The applicant fails to demonstrate concern for neighborhood voice inclusion, or the health and well-being of the local residents either in outreach behavior, or the content of the application. The reflects on the application's compliance with BAS , because the BAS (see below is robust and adamant, that any mitigation and Sustainable Development pathway must be focused on well-being and equity in growing social capital, and regeneration in ecosystems' natural capital: the IPCC reports in 5.6 (see below):

> **"Any action towards climate change mitigation," " is best evaluated against a set of indicators that represent a broad variety of needs to define individual well-being, macroeconomic stability, and planetary health. Many solutions that reduce primary material and fossil energy demand, and thus reduce GHG emissions, provide better services to help achieve well-being for all."**

This BAS approach is entirely absent from the application, but central, as the IPCC states, to the BAS. The application is simply *not* consistent with the BAS, as required by law, in order to protect the public HSW.

State Leadership on Climate Change Mitigation and Sustainable Development

The State should led by example in its close bonding to the 'best available science' (BAS), and in its own regulation, investment and setting of norms of compliance with regard to environmental racism. DNREC must guard against "regulation capture" by powerful incumbent interests who do not share the common good.

But DNREC has some 'catching up' to do: The DNREC project review record, in this case, materially contributed to environmental racism because of the lack on on-site community consultation and fact-finding, woefully inadequate steps to bridge the language barrier of both Spanish-speaking and Haitian-Creole speaking neighborhoods. This Hispanic/Haitian community of brown and Black families, only a half-hour drive (about 33 miles) from President Biden's clean-air summer home in Rehoboth, is a case study in environmental racism: these brown/Black bodies were not informed of the projected dirty-air health and well-being impacts on their families at home and in school, nor was their opinion reasonable sought within the application review process. The law must be blind to color or zip code. "Measures that support …safety, equity and environmental protection, and fairness resonate well in many communities and social groups." (IPCC 2022 Mitigation, chapter 5, see below).

The science must be applied equally: Inclusion, Equity, Well-being of all
State-sanctioned exceptions for one business and inspire and enable expansion of maldevelopment pathways, and enable others to place heavier, and sooner burdens on other burdens. It is unjust and inequitable. Further, the 'moving goal-posts' make responsible science-based planning and system design by others purely speculative.

Non-compliance with the BAS of climate mitigation and Sustainable Development
The State has a duty to the public to apply science-based labeling of "mitigation", "Adaptation" and their integration with Delaware 'Sustainable Development" to initiatives clearly consistent with BAS.

Piecemeal mitigation is not possible
The IPCC, Chapter 4 reports: "meeting ambitious mitigation and development goals cannot be achieved through incremental change, hence the focus on shifting development pathways…." The fundamental defect in the application is that frames its so-called "mitigation" too narrowly, in non-science-based systems boundaries instead of the scope of the Best Available Science (BAS). It is piecemeal, not systemic—and the BAS clearly notes that mitigation is simply not possible with that approach: " Piecemeal approaches will not achieve mitigation", the IPCC clearly reports (see below). The framework approach of the application embraces less than

half the BAS: only a trivial amount of overall supply-side GHG emissions pathway are addressed, and the entirely ignores the demand-side pathway so prominent in the BAS.

Circumscribing the scope or system boundary is arbitrary and capricious. It is not permitted by the applicant, nor by the State.

The BAS is now established in businesses and professions, and readily available, without cost, online and in-print; the applicant ignored the BAS at their own risk, but the State cannot: the full and complete scope of BAS must the basis of the State's evaluation of this application because the science repeatedly makes clear that the material issue(the system boundaries of the Earth System) is a vast, dynamic, complex system in which every sector is interdependent and interconnected to every other, especially over time, in the temporal dimension. The application ignores this BAS.

The application must be judged against the entire corpus of the best available science (BAS), and not any selected segments of it.
However, below, for convenient reference, I reprint sections of the current IPCC Mitigation report through chapter Six, the substance of its systemic discussion; I also reprint sections of the UNEP;s Emission Gap Report of 2020, the OECD Report of ----, and sections of Prof Sharon Friel's research, and international expert on food systems, on Industrial Food Systems within the overall the consumtagentic system of society and their relationship to climate mitigation in BAS; this subject is relevant to this application.

The full text of this IPCC Mitigation report (3,675 pages in first edition) and full text of all the other reports that constitute "The Best Available Science" (BAS) are the measure against which this application must be judged, and the boundaries of the science their application, under law, was required to address. Please review the IPCC texts (below) to confirm the extent that the Application is not compatible with the BAS. ###

This climate science—in its complete complexity and full boundaries-- has now been globally embraced by many businesses and trade associations, governments at all levels, and professional institutions (such as my own profession of architecture) and civil society, such as Delaware's Interfaith Power and Light: a Religious Approach to Climate Change (which I also formally chaired).

The applicant advances no reason why their application should to be an exception to the understanding of the Earth System, or the science-based assessment of genuine climate change "mitigation." Nor is such an exception in law.

This application coming some 34 years after Dr. James Hanson in 1988 led a panel of eminent US scientists testifying to Congress that the climate science was now sufficiently matured and confident to state that climate change was *a risk to the* *health, well-being, food and water security and food system of America*, among other impacts. That same year the IPCC was created by the UNEP and IMO; and the same year that President Bush initiated, in the White House a "global change office"—a government function that what the Congress in 1990 enacted into law in expanded form to govern the US governments determination of risks and impacts from global change, or as it is now termed, climate change. The BAS that this application was required to address is long in the making

"Mitigation" for who? And "for what?"

Inclusive equity and well-being growth, rather than the metric of GDP-focused growth, is key to mitigation in the BAS framework three reasons: 1) political trust required for effective mitigation policy, 2) social inclusion enabling 100% participation (logically required to achieve global zero-emissions, and 3) inherent efficiency. For instance, the IPCC, (2022, Chapter 5.2.1, below) reports this:

> ***"There is high evidence and agreement in the literature that human well-being and related metrics provide a societal perspective which is inclusive, compatible with sustainable development, and generates multiple ways to mitigate emissions. Development targeted to basic needs and well-being for all entails <u>less carbon-intensity than GDP-focused growth</u>. Current socioeconomic systems are based on high-carbon economic growth and resource use." (emphasis added)***

The Social-Trust Question: the Appearance of Environmental Racism
Strategically, if climate "mitigation" becomes equated with reduction in the quality of life or well-being, of marginalized brown/Black neighborhoods in Delaware, the state risks an unwelcome association with Robert Moses-like "urban renewal" redesigned for the influential and powerful at the expense of others.

Equity and betterment of everyday well-being--quality of life in neighborhood and local habitat--must lead climate mitigation policy, or climate policy will be stillborn, with zero social trust, and for good reason. This application may set the precedent.

According to the BAS, "Well-being, equity, trust, governance and climate mitigation" are systemically linked as IPCC 2022, Figure 5.5 illustrates:
"Well-being for all, increasingly seen as the main goal of sustainable economies, reinforces emissions reductions through a network of positive feedbacks linking effective governance, social trust, equity, participation and sufficiency."
Environmental racism has just the opposite effect on mitigation efforts, and thus this application is not a "mitigation" initiative.

But this collapse of duty to protect the public HSW—and political opportunity to advance it--can only occur if the science is ignored, as in this application, because "well-designed demand for services scenarios are consistent with adequate levels of well-being for everyone, with high and/or improved quality of life, improved levels of happiness and sustainable human development." All around science-based betterment in well-being or quality of life.

EQUITY in MITIGATION SCIENCE

> "At all scales of governance, the popularity and sustainability of climate policies requires attention to fairness of the health and economic implications for all, and participatory engagement across social groups—a responsible development framing. Far from being secondary or even a distraction from climate mitigation priorities, and *equity* focus is intertwined with mitigation goals."
>
> —IPCC, 2022, Mitigation report figure 5.5

"Mitigation, equity and well-being go hand in hand to motivate actions."
—IPCC below

'Doing more and better with the same': "not only ensure better environmental quality but also directly enhance well-being" —IPCC 2022 below

The application does not exhibit the science of the "best available science" (BAS). The IPCC and other BAS literature reaffirms this over an over: climate policy must emerge out of a value of equity: ""Mitigation, equity and well-being go hand in hand to motivate actions." (IPCC, see below, detailed discussion)

Missing the social dimension of all mitigation approaches
For this reason alone, this application is not based upon BAS.—it is not universal systemic thinking, and thus is intended for the old paradigm of "individualistic" interest rather than society- and nature-wide flourishing. This is key to the science-based systems thinking because universal betterment, growth in well-being, and inclusion is (logically) required to enable reaching global net zero-emissions that only universal buy-in can achieve. The application's specific disregard for local inclusion, neighborhood health and well-being is telling; it reveals its systemic disregard for equity and inclusion in the key logic of climate change mitigation in the BAS. It is not mitigation under BAS. Instead, (in violation of other law) it proposes non-science-based regulatory approval, fresh investment—new assets to be shortly stranded in the new global transformation to net zero emissions –and in maldevelopment, including in this case, egregious environmental racism.

The application perfectly fits the BAS and political culture of the 1970s and 80s,--but not that of today. It swims against the rushing global tide of climate change mitigation targeted at net zero of 2040-50 integrated with local Adaptation to climate change and overall Sustainable Development, including broad equity and inclusion. It is out of step with science, and political reality: " Mitigation policies are politically, economically and socially more feasible, as well as more effective," the IPCC reports (below) when there is a two-way alignment between climate action and well-being." In evidence in this application *is indeed* a "two-way alignment"--around zero climate action and zero improvement in well being.

5.2.1.1 Services for well-being
Well-being needs are met through services. Provision of services associated with low-energy demand is a key component of current and future efforts to reduce carbon emissions.

The Application fails to apply the full system boundaries
Whatever, relatively small quantity of biofuel energy is produced by burning methane in the atmosphere from “waste”, is dwarfed by the fossil fuel energy consumption of the Industrial Food System which, in terms of the BAS, is unsustainable in terms of farm-production energy, transport energy (including four-state heavy truck transport of waste, and largely oversea transport of the finished product (chicken) to Asia; inattention to, and degradation of neighborhood health, well-being and inclusion; creation of an illogical, and inefficient ‘supply chain of waste from high elevations in three non-coastal states to the lowest average elevation state of the fifty states, in a coastal exposure to both sea level rise (SLR) and storm surges, and subject to among the highest relative SLR of combined land subsidence and coastal SLR.

Logically, the waste from Delaware should be trucked out of low-lying areas to one, or more of these high-elevation states (without land subsidence) and safely away from coastal exposure, in order to minimize SLR and flooding disruption of an entire supply chain serviced by the lowest elevation area of the four states.

Even more logically, the organic waste would be treated as farms have done since the birth of human agriculture—as the fertility for next year’s production avoiding the need for petroleum-based fertilizers production and shipment, and diesel for heavy-truck shipments of the waste. This is enhancement of BAU of the high energy, height emissions and inefficient and unsustainable Industrial Food system on Delaware. This application is for inefficient waste processing, mislabeled as biofuel production, and that mislabeled as “mitigation.” The application fails to comply with the BAS and thus must be rejected. ###

IPCC MITIGATION REPORT 2022
Highlights through chapter five.

The IPCC 2022 reports the following:

Meeting the long-term temperature objective in the Paris Agreement implies a rapid turn to accelerating decline of GHG [greenhouse gas]
Emissions toward ‘net zero’, **which is implausible without urgent and ambitious action at all scales.**
.....

While there are some trade-offs, effective and equitable climate policies are largely compatible with the broader goal of sustainable development and efforts to eradicate poverty as enshrined in the 17 Sustainable Development Goals (SDGs).
…..
Transition and transformational frameworks explain and evaluate the dynamics of transitions to low-carbon systems arising from interactions amongst levels, with **inevitable resistance from established socio-technical structure.**
…..
The speed, direction and depth of any transition will be determined by choices in the environmental, technological, economic, socio-cultural and institutional realms….The pace of a transition can be impeded by 'lock-in' generated by existing physical capital, institutions, and social norms. **The interaction between power, politics and economy is central in explaining why broad commitments do not always translate to urgent action.**

Societal and behavioral norms, regulations and institutions are essential conditions to accelerate low carbon transitions.

Achieving the global transition to a low-carbon, climate-resilient and sustainable world requires purposeful and increasingly coordinated planning and decisions at many scales of governance including **local,** sub national, national and global levels.

The greater the inertia in emission trends and carbon-intensive investments, the more that CO2 will continue to accumulate. Overall, the literature points to the need for s more dynamic consideration of intertwined challenges concerning the transformation of key GHG emitting systems.

A comprehensive assessment of climate policy therefore involves going beyond a narrow focus on specific mitigation and adaptation options to incorporate climate issues into the design of comprehensive strategies for equitable sustainable development… Te Special Report on Climate Change and Land (SRCCL) also emphasizes important synergies and trade-offs, bringing new light on the link between healthy and sustainable food consumption and emissions caused by the agricultural sector.

Climate change risk assessments face challenges including a tendency to mischaracterize risks and pay insufficient attention to potential for surprises.

Simultaneously, the literature increasingly emphasizes the importance of multi-objective risk assessment and management.

"[D}eveloped country Parties should continue taking the lead by undertaking economy-wide absolute emission reductions" … and mover over time towards economy-wide emissions reduction or limitation targets in the light of different national circumstances…. The Paris Agreement aims to make 'finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.'

Due to its mush shorter lifetime, methane has disproportionate impact on near-term temperature, and is estimated to account for almost s third of the warming observed to date.

Climate policies also encounter resistance. Corporations and trade associations often lobby against measures they deem detrimental.

Transnational alliances. Partly countering this trend, cities, businesses, a wide range of other non-state actors also has emerged with important international networks to foster mitigation.

Technology.
By sequestering carbon in biomass and soils, soil management, and other terrestrial strategies could offset hard-to-reduce emissions in other sectors. **However, large-scale bioenergy deployment could increase risks of desertification, land degradation, and food insecurity (IPCC 2019a), and higher water withdrawals…**

Finance and investment.
The risks include physical risks related to the impacts of climate change itself; transition risks related to the exposure to policy, technology and behavior changes in line with a low-carbon transition; and liability risks from litigation for climate-related damages. These cold potentially lead to stranded assets (the loss of economic value of existing assets before the end of their useful lifetimes.)

Political leadership is therefore essential to steer financial flows to support low carbon transition.

Political economy.
One factor limiting the ambition of climate policy has been the ability of incumbent industries to shape government action on climate change…. Campaigns by oil and coal companies against climate action in the US and Australia are perhaps the most well known. In other contexts, resistance by incumbent companies is subtler but nevertheless has weakened policy design….

1.4.6 Equity
Equity and fairness can serve a both driver and barrier to climate mitigation at different scales of governance….As equity issues are important for reaching deep decarbinization, the transition towards a sustainable development depends on taking equity seriously in climate policies.

1.4.7 Social innovation and behavior

Social and psychological factors effect both perceptions and behaviors. Ideates can provide powerful attachments to consumption activities and objects that inhibit shifts away from them. Consumption is habit-driven and social practice rather than simply a set of individual decisions, making shifts in consumption harder to pursue. Finally, shifts towards low-carbon behavior are also inhibited by social-psychological and political dynamics that cause individuals to ignore the connections from daily consumption practices to climate change impacts.

Henceforth, some behaviors that are harder to change will only be transformed by the transition itself: triggered by policies, the transition will bring about technologies that, in turn, will entrench new sustainable behaviors.

1.4.8 Policy impacts.

Transformation to different systems will hinge on conscious policy to change the direction in which energy, land-use, agriculture and other key sectors develop. Policy plays a central role in land-related systems, improving energy efficiency in buildings and transport/mobility, and decarbonizing industrial systems.

Policy has been and will be central not only because greenhouse gases emissions are almost universally underpriced in market-economies, and because of inadequate economic incentives to innovation but also due to various delay mechanisms, and multiple sources of path-dependence and lock-in to existing systems… reinforcing the importance of early action for ambitious mitigation.

1.4.9 Legal framework and institutions

Institutions can be formal, such as laws and policies, or informal, such as norms and conventions. Institutions can both facilitate or constrain climate policy-making…. Institutions set the economic incentives for action or inaction on climate change.

Institutions entrench specific political decision-making processes, often empowering some interests over others, including powerful interest groups who have vested interest in maintaining the current high carbon economic structures.

Pathway and 'net zero'

Faster progress in the near term extends the date at which net zero must be reached, while conversely, slower near-term progress brings the date even closer to the present. Some of the modeled 1.5C pathways with limited overshoot cut global CO2 emissions in half until 2030, which allows for a more gradual decline thereafter, reaching net zero CO2 after 2050.

1.6 Achieving mitigation in the context of sustainable development

Climate change and sustainable development as well as development more broadly, are interwoven along multiple and complex lines of relationship as highlighted in several previous IPCC reports (IPCC 2007, 2018b, 2011a, 2014a). With its significant negative impact on natural systems, food security and infrastructure, loss of lives and territories, species extinction, conflict health, among several other risks, climate change poses a serious threat to development and wellbeing in both rich and poor countries. Without serious efforts at mitigation and adaptation, climate change could push millions into poverty and limit the opportunities for economic development. It follows that ambitious climate mitigation is necessary to secure a save climate within development and wellbeing can be pursued and sustained.

This strand of literature emphasizes the importance of economic growth including for tackling climate change itself…. **Yet, others argue that the character of social and economic development produced by the nature of capitalist society is ultimately unsustainable**.

There are at least two major implications of the very close link between climate change and development as outlined above. **The first is that the choice of development paths made by countries and regions have significant consequences for GHG emissions and efforts to combat climate change**(see chapters 2,3,4,5 and) **The second is that climate mitigation at local, national and global level cannot be effectively achieved by narrow focus on 'climate-specific- sectors, actors and policies; but rather through a much broader attention to the mix of development choices and the resulting development paths and trajectories…..**

Shared Socio-Economic Pathways—SSPs, highlight the interaction between development paths, climate change and emissions stabilization(see Section 3.6).
The close links are also recognized in the Paris Accord (PA section 1.3.1) This underpins the conclusion as commonly expressed that climate action needs to be pursued in the context of sustainable development, equity and poverty eradication.

1.6.2 Concepts and frameworks for integrating climate mitigation and development

At one level, sustainable development can be seen as a meta framework for integrating climate action with other global sustainability goals. Fundamentally, the concept of sustainable development underscores the interlinkages and interdependence of human and natural systems and the need to balance economic, social, and environmental (including climate pollution) aspects in development planning and processes…. Most of the literature recognizes that despite its limitations, sustainable development with its emphasis on integrating social, economic and environmental goals, provides a more comprehensive approach to the pursuit of planetary health and human well-being. Sustainable development is not a static objective but a dynamic framework for measuring human progress relevant for all countries….

Much like sustainable development, concepts like low-carbon development, climate-compatible development and more recently climate resilient development (CRD) have all emerged as ideas, tools and frameworks, intended to bring together the goals of climate mitigation and SDGs, as well as development more broadly. [T]he prospects for realizing a climate-resilient and equitable world is enhanced by a process of transformation and development trajectories that seek to limit global warming while also achieving the SDGs… A key feature of development or transformation pathways that achieve a climate resilient world is that they maximize the synergies and minimize the trade-offs between climate mitigation and other sustainable development goals.

Other concepts such as "Doughnut Economics" (Raworth 2018), ecological modernization, and mainstreaming are also used to convey ideas of development pathways that take sustainability, climate mitigation, and environmental limits seriously. Mainstreaming focuses on incorporating climate change into national development activities, such as building infrastructure. The 'green economy' and green growth—growth without undermining ecological systems, partly by gaining economic value from cleaner technologies and systems and is inclusive and equitable in its outcomes—has gained popularity…. Critics however argue that green economy ultimately emphasizes economic growth to the detriment of other important aspects of human welfare such as social justice, and challenge the idea that it is possible to decouple economic activity and growth (measured in GDP increment) from increasing use of biophysical resources (raw materials, energy)

Literature on degrowth, post growth, and post development questions the sustainability and imperative of more growth in already industrialized countries and argues that prosperity and the 'Good Life' are not immutably tied to economic growth…. The concept of 'just transition' also stresses the need to integrate justice concerns so as to not impose hardship on already marginalized populations within and between countries…. The key insight is that pursuing climate goals in the context of sustainable development requires holistic thinking including on how to measure well-being, serious consideration of the notion of ecological limits, at lest some level of decoupling and certainly choices and decision-making approaches that exploit and maximize the synergy and minimizes the trade-off between climate mitigation and other sustainable development goals. It also requires equity and justice within and between countries.

1.6.3 Climate Mitigation, Equity and Sustainable Development Goals (SDGs)

Climate action can be conceptualized as both a stand-alone and crosscutting issue in the 2030 SDGs…. The SDGs also provide a basis for exploring the synergies and trade-offs between sustainable development and climate change mitigation…. [R]egions with high percapita GHG emissions would require rapid transformation in technologies and practices.

Concerns over equity in the context of growing global inequity and very tight remaining global carbon budgets have motivated an emphasis on equitable access to sustainable development.

Below some thresholds of absolute poverty, more consumption is necessary for development to lead to well-being.

In conclusion, achieving climate stabilization in the context of sustainable development and efforts to eradicate poverty requires collective action and exploiting synergies between climate action and sustainable development.

1.7 Four Analytic Frameworks for understanding mitigation response strategies.

Climate change is unprecented in its scope (sectors, actors and countries), depth (major transformations) and timescales (over-generations). As such, it creates unique challenges for analysis. It has been called "the greatest market failure in history" (Stern 2007); the Perfect Moral Storm (Gardiner 2006) and a 'superwicked problem," (Lazarus 2009; Levin et al 2012)—one which appears difficult to solve through the traditional tool and assumptions of social organization and analysis…. [T]his section summarizes insights and developments in key analytic frameworks and tools particularly relevant to understanding specific mitigation strategies, policies and other actions, including explaining the observed if limited progress to date. [t]hese include ***aggregated*** (principally, economic) frameworks to evaluate system-level choices; ***ethical*** perspectives on values and equity including stages of development and distributional concerns; and ***transition*** frameworks which focus on the processes and actors involved in major technological and social transitions. These need to be complemented by a fourth set o approaches which shin more light on ***psychological/behavioral and political*** factors. All these frameworks are relevant, and together they point to the multiple perspectives and actions required if the positive drivers of emission reduction summarized in section 4 are to outweigh the barriers and overcome the constraints.

Damages and risks.
The salience of risks has also been amplified by improved understanding of climate 'tipping points' (Lontzek et al 2015); valuations should reflect that cutting emissions reduces not only average expected damages, but also the risk of catastrophic events. (IWG 2021).

1.7.1.2 Dynamic efficiency and uncertainty

Care is required to clarify what is optimized…. 'Cost-effective' optimizations generate less initial effort than *equivalent* cost-benefit models as **they do not incorporate benefits of reducing impacts earlier.**

'Efficient pathways' are affected by initial and innovation. Inertia implies amplifying action on long-lived investments and infrastructure that could otherwise lock-in emissions for man decades. Chapter 3 (section 3.5) discusses interactions between near, medium and long-term actions in global pathways, particularly *vis-à-vis* inertia. Also, to the extent that early action induces low carbon innovation, it ‘multiplies’ the optimal effort (for given damage assumptions), because it facilitates subsequent cheaper abatement. For example, ‘learning-by-doing’ Analysis concludes that early deployment of expensive PV was of net global economic benefit, due to induced innovation.”

Research thus increasingly emphasizes the need to understand climate transformation in terms of dynamic, rather than static efficiency. This means taking account of inertia, learning and various additional sources of ‘path-dependence’. Including induced innovation in stylized IAMs can radically change the outlook; many more detailed-process IAMs now do include endogenous technical change.

1.7.1.3 Disequilibrium, complex systems and evolutionary approaches

Other approaches to aggregate evaluation draw on various branches of intrinsically non-equilibrium theories. These including long-standing theories from the 1930s (e.g. Schumpeter 19341; Keynes 1936) to understand situations of structurally under-employed resources, potential financial instabilities(Minsky 1986), and related economic approaches which emphasize time dimensions (Stern 2018). More recently developing have been formal economic theories of endogenous growth building on e.g. Romer (1986), and developments of Schumpeterian creative destruction and evolutionary economic theories which abandon any notion of full or stable resource utilization even as a reference concept(Nelson and Winter 1982).

The later are technically grounded in complex system theories (e.g. Arthur 1989, 1999). These take inherently dynamic views of economies as continually evolving systems with continuously unfolding and path-dependent properties, and emphasize uncertainty in contrast to any predictable or default optimality. Such approaches have been variously applied in policy evaluation (Walton 2014; Moore et al 2018), and specifically for global decarbonization (e.g. Barker and Crawford-Brown 2014) using global simulation models.

1.7.2 Ethical approaches

Gardiner’s (211) description of climate change as “The Perfect Moral Storm” indentified three ‘tempests’. Its ***global*** dimension…. Its impacts are ***intergenerational*** but future generations have no voice in contemporary affairs….***theoretical*** failure to acknowledge a central need for ‘moral sensitivity, compassion, transnational and transgenerational care, and other forms of ethical concern to rise to the surface’ to help guide effective climate action.

1.7.2.1 Ethics and values

A large body of literature examines the critical role of values, ethics, attitudes, and behaviors as foundational frames for understanding and assessing climate action, sustainable development and societal transformation.

Another strong theme in the literature concerns recognition of interdependence including the intimate relationship between humans and the non-human world….. A key policy implication of this is moving away from valuing nature only in market and monetary terms to strongly incorporating existential and non-material value of nature in natural resource accounting.

1.7.3 Transition and transformation processes

This report uses the term *transition* as the process, and *transformation* as the overall change or outcome…. Typically, new technologies, ideas and associated systems initially grow slowly in absolute terms, but then 'take-off' in a phrase of exponential growth as they emerge from a position of niche into mainstream diffusion…. These dynamics arise from interactions between innovation (in technologies, companies and other organizations), markets, infrastructure and institutions, at multiple levels. Consequently, interdisciplinary perspectives are needed. Beyond aggregate economic perspectives on dynamics these emphasize the multiple actors and processes involved.

Technological Innovation Systems (TIS) frameworks (chapter 16.4) focus on processes and policies of early innovation and 'emergence', which combine experimentation and commercialization….

1.8.2 Carbon Lock-in

The continued rise of global emissions reflects in part the strongly path-dependent nature of socio-economic systems, which implies a historic tendency to 'carbon lock-in.' An interdisciplinary review (Seto et al 2016) identifies a dozen components organized into four types:

Economic—large investments with long lead-time and sunk costs, made on the basis of anticipated use of resources, capital, and equipment to pay back the investment and generate profits; initial choices account for private but not social costs and benefits.

Socio-cultural—Lock-in through social structure (e.g. norms and social processes); lock-I through individual decision-making (e.g. psychological processes).

Technology and infrastructure—Learning by doing and scale effects, including cumulative nature of innovation, reinforces established technologies. Interaction of technologies and networks (physical, organizational, financial) on which they depend.

Institutional & political—Powerful economic, social, and political actors seek to reinforce the status quo that favors their interest; laws institutions, including regulatory structures, are designed to stabilize and lock-in also to provide long-term predictability; Beneficial and intended outcomes for some actors.

Along with long lifetime of various physical assets detailed in AR5, the AR6 underlines the exceptional degree of path-dependence in urban systems and associated buildings and transport sectors.

The fact that investors anticipate a level of fossil fuel use that is not compatible with severe climate constraints creates a clear risk of 'stranded assets' facing these investors, and others who depend on them, which itself raises issues of equity.

Just Transition. Finally, whilst 'transition' frameworks may explain potential dynamics that could transform systems, a multi-dimensional/multi-framework assessment underlines the motivation for 'just transitions'. This can be defined as a transition from a high-carbon economy which is considered sufficiently equitable for the affected individuals, workers, communities, sectors, regions, and countries. As noted, sufficient equity is not only an ethical issue but also an enabler of deeper ambition for accelerated mitigation. Perception of fairness influences the effectiveness of cooperative action.

1.9 Governing climate change.

Despite the complexities, there are signs of progress including increased societal awareness, change in social attitudes, and policy commitments by a broad range of actors and sustained reductions in some jurisdictions…. The concept of governance encompasses the ability to plan and create the organizations needed to achieve a desired goal and process of interaction among actors involved in a common problem for making and implementing decisions.

1.10 Conclusions

An unfolding technology revolution is making significant contributions in some countries, but as yet its global impacts is limited. Global climate change can only be tackled within, and if integrated with, the wider context of sustainable development, and related social goals including equity concerns. Countries and their populations have many conflicting priorities.

1.11 Knowledge gaps

One scan of future research needs suggests three priority areas: 1. Human welfare focused development (e.g. reducing inequality), 2. How the historic position of states within international power relations conditions their ability to respond to climate change, 3. Transition dynamics and flexibility of institutions to drive towards low carbon development pathways.

Nature is under pressure both at land and at sea as demonstrated by declining biodiversity (IPBES 2019).

Compounding these gaps is the fact that socially oriented, agriculture-related options, where human and non-human systems intersect most obviously, remain under-researched.

Strategic investments may include city planning, public transport, EV charging networks….

FAQ What is climate mitigation?
Climate change mitigation refers to actions or activities that limit emissions of GHG from entering the atmosphere and reduce their levels in the atmosphere…..
The ultimate goal of mitigation is to preserve a biosphere, which can sustain human civilization and the complex of ecosystem services, which surround and support it. This means reducing anthropogenic GHGs emissions toward net zero to limit warming.

Chapter 2. Emissions Trends and Drivers

A growing number of countries have achieved GHG emission reductions longer than 10 years—a few at rates that are broadly consistent with climate change mitigation scenarios that limit warming to ell below 2C. There are about 24 countries that have reduced CO2 and GHG emissions for longer than 10 years. Reduction rates in some countries have reached 4% in some years.

The global wealthiest 10% contribute about 36-45% of global GHG emissions…. The lifestyle consumption emissions of the middle income and poorest citizens in emerging economies are between 5-50X (times) below their counterparts in high-income countries. Increasing inequality within a county can exacerbate dilemmas of redistribution and social cohesion, and affect the willingness of rich and poor to accept lifestyle changes for mitigation and policies to protect the environment.

Estimates of future CO2 emissions from existing fossil fuel infrastructures <u>already exceed remaining cumulative net CO2 emissions in pathways</u> limiting warming to 1.5C with no or limited overshoot.

2.3 Consumption–based CO2 emissions (CBE)

Consumption is increasingly met by global supply chains often involving large geographic distances and causing emissions in producing countries….

Production-based emissions and territorial emissions resulting from the production and consumption of goods and services within a region as well as for export production are often used by authorities to report carbon emissions….
In contrast, CBEs refer to emissions along the entire supply chains induced by consumption irrespective of the place of production. This reflects a shared understanding that a wider system boundary going beyond territorial emissions is important to avoid outsourcing of pollution to achieve global decarbinization.

2.4.2 Sectoral Drivers

Decarbinization gains from improvements in energy efficiency across different sectors and worldwide have been largely wiped out by increases in demand for goods and services. Prevailing consumption patterns have also tended to aggravate energy use and emissions

2.4.2.5. AFOLU

GHG emissions from agriculture, forestry and land use reached 13GtCO2eq globally in 2019. Global diets are a key driver of production per capita, and thus land pressure and AFOLU emissions.

2.4.3 Poverty and Inequality

Increasing economic inequality has given rise to concern that unequal societies may be more likely to pollute… Reduced income inequality between nations can reduce emissions intensity of global income growth…. Increasing income inequality between individuals can translate into larger energy and emissions inequality if higher incomes are spent on more energy-intensive consumption and affluent lifestyles.

There is evidence to suggest that more equal societies place higher value on environmental public goods. Additional research shows that reducing top income inequality in OECD countries can reduce carbon emissions and improve environmental quality and that the effect of wealth inequality, measured as the wealth share of the top decile, on per capita emissions in high-income counties is positive.

2.4.4 Rapid and Large-scale Urbanization as a Driver of GHG Emissions

Economic growth and urbanization go hand in hand and are both influencing GHG emissions.

In many developing countries across the world, the process of urban expansion leads to higher per capita consumption-based GHG emissions.

2.6 Behavioral Choices and Lifestyles

Household consumption is the largest component of a country's gross domestic product (GDP) and the main contributor to greenhouse gas emissions through direct energy consumption for heating and cooling or private transportation and indirectly through carbon emitted during production of final consumption.

In western countries, the largest contribution to the household carbon footprint is from transportation, housing, and consumption of food.

Inequality.

Global inequality within and between countries has sifted over the last decades expanding consumption and consumer culture…..A major pulling apart between top and bottom incomes occurred in parallel within countries. Since 1980, the top 1% richest individuals in the world captured twice as much growth as the bottom 50% individuals. The influence of these dual inequality trends on lifestyles, new consumption patterns and carbon emissions at regional, local and global scale are large and have led to the fastest growth of global carbon emissions…. Emissions remain highly concentrated, with the top 10% per capita emitters contributing to between 35-45% of global emissions, while the bottom 50% emitters contribute 13-15% of global emissions. Furthermore, the top 1% of income earners by some estimates could have an average carbon footprint 175 times that of an average person in the bottom 10%..... Mitigation pathways need to consider how to minimize the impacts of inequality on climate change and different mechanism and effects coming into play between inequality of income and emissions.

Inequality trends catalyses impact at a demand level, mobilizing rapid lifestyle change, symbolic consumption and ideals of material improvements and upward mobility and emulation of high-carbon emissions lifestyle of the wealthy.

2.7 Emissions associated with existing and planned long-lived infrastructure

Carbon lock-in can be inertia in a system that limits the rate of transformation by a path-dependent process (Seto et al, 2016). For example, long lifetimes of infrastructures such as power plants, roads, buildings or industrial plants may influence the rate of transformation substantially and lock societies into carbon-intensive lifestyles and practices for many decades. Infrastructure stock evolution depends not only on technical and economic factors, but also on institutional and behavioral ones that are often mutually reinforcing. That is, physical infrastructure such as the built environment of urban areas can shape behavior and practices of daily life, which in turn change the demand for such infrastructure and lock-in energy demand patterns.

Chapter 3: Mitigation Pathways Compatible with Long-Term Goals

Mitigation pathways limiting warming to 1.5C with no or limited overshoot reach 50% reductions of CO2 in the 2030s, relative to 2019, then reduce emissions further to reach net zero CO2 emissions in the 2050s.

Peak warming in mitigation pathways is determined by the cumulative net CO2 emissions until the time of net zero CO2 and the warming contribution of other GHGs and climate forcers at that time. Cumulative net CO2 emissions from 2020 to the time of net zero CO2 are 510 (330-710) GtCO2 in pathways that limit warming to 1.5C… . These estimates are consistent with the assessment of remaining carbon budgets by WGI….

Rapid reductions in non-CO2 GHGs, particularly methane, would lower the level of peak warming….

Pathways likely limiting warming to 2C and below exhibit substantial reductions in emissions from all sectors. Projected CO2 emissions reductions between 2019 and 2050 in 1.5C pathways with no or limited overshoot are around 77% for energy demand, 115% for energy supply, and 148% for AFOLU.

Delaying or sacrificing emissions reductions in one sector or region involves compensating reductions in other sectors or regions if arming is to be limited. In cost-effective mitigation pathways, the energy supply sector typically reaches net zero CO2 before the economy as a whole, while the demand sectors reach net zero CO2 later, if ever.

Stringent emissions reductions at the level required for 2C and below are achieved through increased direct electrification of buildings, transport, and industry, resulting in increased electricity generation in all pathways.

The measures required to likely limit warming to 2C or below can resulting large scale transformation of the land surface.

The global benefits of pathways likely limiting warming to 2C outweigh global mitigation costs over the 21st century…. This holds true even without accounting for benefits in other sustainable development dimensions or non-market damages from climate change.

The economic benefits on human health from air quality improvement arising from mitigation action can be of the same order of magnitude as mitigation costs, and potentially even larger. Ambitious mitigation can be considered a precondition for achieving the Sustainable Development Goals…. Dimensions with anticipated co-benefits include health, especially regarding air quality, clean energy access, and water availability.
Targeted SDG policies and investments, for example in the areas of healthy nutrition, sustainable consumption and production, and international collaboration, can support climate change mitigation policies .

Decent living standards, which encompass many SDG dimensions, are achievable at lower energy use than previously thought.

Mitigation pathways are associated with significant institutional and economic feasibility challenges rather than technological and geophysical.

Pathways relying on a broad portfolio of mitigation strategies are more robust and resilient.

Chapter 4 Mitigation and development pathways in the near- to mid-term

This chapter focuses on accelerating mitigation and shifting development pathways to increased sustainability. The timeframe is the near-term (now up to 2030) to mid-term (2030 to 2050).

Transformative technological and institutional changes for the near-term include demand reductions through efficiency and reduced activity [sufficiency], rapid decarbonization of electricity sector and low-carbon electrification of buildings, industry and transport. Focus on energy use and supply is essential, but not sufficient on its own—**the land sector and food systems deserve attention**. The literature does not adequately include demand-side options and systems analysis.

Yet meeting ambitious mitigation and development goals cannot be achieved through incremental change, hence the focus on shifting development pathways…. [I[t is possible to shift development pathways through policies and enhancing enabling conditions… overall societal development objectives, such as job creation, macro-economic stability, economic growth, and public health and welfare….Concrete examples assessed in this chapter include high employment and low emissions structural change, fiscal reforms for mitigation and social contract, combining housing policies to deliver both housing and transport mitigation and change economic, social and spatial patterns of development of the agriculture sector provide the basis for sustained reductions in emissions from deforestation.

Mobilizing a range of policies is preferable to single policy instruments.

Equity can be an important enable of deeper ambition for accelerated mitigation, dealing with the distribution of costs and benefits and how these are shared as per social contracts, national policy and international agreements.

In sum…the immediate tasks are to broaden and deepen mitigation in the near-term if the global community is to deliver emission reductions at the scale required to keep temperature will below 2C and pursue efforts at 1.5C. Deepening mitigation means more rapid decarbinization. Shifting development pathways to increased sustainability (SDPS) broadens the scope of mitigation.

Accelerating mitigation. The literature pints to well-understood policy measures and technologies for accelerating mitigation, though the balance depends on country specificities: 1) decarbinizing electricity supply to produce net zero CO_2 including renewable energy; 2) radically more efficient use of energy than today; 3) electrification of end-uses including transport; 4) dramatically lower use of fossil fuels than today; 5) converting other uses to low-or zero-carbon fuels (e.g. hydrogen…) in hard-to-decarbonize sectors; 6) promote bioenergy, demand reduction, dietary changes, and policies, incentives and rules for mitigation in the land sector; 7) **setting and meeting ambitious targets to reduce methane** and other short-lived climate forcers.

4.2.5.3 Bioenergy

While BECCS is needed in multiple accelerated mitigation pathways, large-scale land-based biological CDR may not prove as effective as expected, and its large-scale deployment may result in ecological and social impacts, suggesting it may not be a viable carbon removal strategy in the next 10-20 years (Vaughan and Gough 2016; Boysen et al. 2017; Dooley and Kartha 2018). The effectiveness of BECCS could depend on local contexts, choice of biomass, fate of initial aboveground biomass and fossil-fuel emissions offsets—carbon removed through BECCS could be offset by losses due to land-use change (Harper et al. 2018; Butnar et al. 2020; Calvin et al. 2021). **Large-scale BECCS may push planetary boundaries for freshwater use, exacerbate land-system change, significantly alter biosphere integrity and biogeochemical flows** (Heck et al. 2018; Stenzel et al. 2021; Fuhrman et al. 2020; Ai et al. 2021). See 7.4 and 12.5 for further discussions.

Broadening opportunities by focusing on development pathways and considering how to shift them: Some of the policy measures may yield rapid results, whereas other, larger transformations may take longer**. If we are to overcome obstacles, a near-term priority is to put in place the enabling conditions to shifting development pathways to increased sustainability…. Consider climate whenever you make choices about development, and vice versa.**

Chapter 5: Demand, services and social aspects of mitigation.
Assessment of the social science literature… reveals how social norms, culture, and individual choices, interact with infrastructure and other structural changes over time…. To enhance well-being, people demand services and not primary energy and physical resources per se. Focusing on demand for services and the different social and political roles people play broadens the participation in climate action.

Potential of demand-side actions and service provisioning systems

Demand side mitigation and new ways of providing services can help *avoid, shift*, and *improve* final service demand. Rapid and deep changes in demand make it easier for every sector to reduce GHG emissions in the short and medium term.

The indicative potential of demand-side strategies across all sectors to reduce emissions is 40-70% by 2050. Technical mitigation potentials compared to IEA, WEO, 2020 STEPS baseline amounts up to 5.7GtCO@eq for building use and construction, 8GtCO2eq for food demand, 6.5GtCO2 for land transport, and 5.2GtCO2eq for industry. Mitigation strategies can be classified as *Avoid-Shift-Improve* (ASI) options, that reflect opportunities for socio-cultural, infrastructural, and technological change. The greatest *Avoid* potential comes from reducing long-haul aviation and providing short-distance low-carbon urban infrastructures. The greatest *Shift* potential would come from switching to plant-based diets. The greatest *Improve* potential comes from within the building sector, and in particular increased use of energy efficient end-use technologies and passive housing.

Socio-cultural and lifestyle changes can accelerate climate change mitigation. Among 60 identified actions that could change individual consumption, individual mobility choices have the largest potential to reduce carbon footprints, **prioritizing car-free mobility by walking and cycling and adopting electric mobility could save 2tCO2eq cap yr**

Other options with high mitigation potential include reducing air travel, cooling set point adjustments, reduced appliance use, **shifts to public transit, and shifting consumption towards plant-based diets.**

Leveraging improvements in end-use service delivery through behavioral [diet, walking] and technological innovation [free transit, free cooling/heating by 'the other system': nature], and innovations in market organization, leads to reductions in upstream resource use… potentials range from a factor of 10 to 20 fold improvement in the case of available energy analysis, with the highest improvement potentials at the end-user and service-provisioning levels. Realizable service level efficiency improvements could reduce upstream energy demand by 45% in 2050.

Alternative service provision systems, for example… digitalization, sharing economy initiatives and circular economy initiatives, have to date made a limited contribution to climate change mitigation.

Social aspects of demand-side mitigation actions.

Decent living standards (DLS) and well-being for all are achievable through implementation of high-efficiency low-demand mitigation pathways…positive impacts on well-being outweigh negative ones by a factor of 11.

Demand-side mitigation options bring multiple interacting benefits.

Granular technologies and decentralized energy end-use, characterized by modularity, small unit sizes and small unit costs, diffuse faster into markets and are associated wit faster technological learning benefits, greater efficiency, more opportunities to escape technological lock-in, and greater employment. Examples include solar PV, batteries, and thermal heat pumps. Wealthy individuals contribute disproportionately to higher emissions and have a high potential for emissions reductions…. [and] are capable of reducing their GHG emissions by becoming role models of low-carbon lifestyles, investing in low-carbon businesses, and advocating for stringent climate policies.

Demand-side solutions require both motivation and capacity for change:

Individual behavioral change is insufficient for climate change mitigation unless embedded in structural and cultural change.

Meta-analyses demonstrate that behavioral interventions, including, including the way choices re presented to consumers, work synergistically with price signals, making the combination more effective. Behavioral interventions through nudges, and alternative ways of redesigning and motivating decisions, alone provide small to medium contributions to reduce energy consumption and GHG emissions. Green defaults, such as automatic enrolment in "green energy" provision, are highly effective. Judicious labeling, framing, and communication of social norms.

Coordinated change in several domains leads to the emergence of low-carbon configurations with cascading mitigation effects. Individual or sectoral level change may be stymied by reinforcing social, infrastructural, and cultural lock-in…. **Coordinating the way choices are presented to end users and planners, physical infrastructures, new technologies and related business models can rapidly realize system-level change**.

Cultural change, in combination with new or adapted infrastructure, is necessary to enable and realize many *Avoid* and *Shift* options…. People act and contribute to climate change mitigation in their diverse capacities as consumers, citizens, professionals, role models, investors, and policymakers.

Collective action as part of social or lifestyle movements underpins system change. Collective action and social organizing are crucial to shift the possibility space of public policy on climate change mitigation.

Transition pathways and changes in social norms often start with pilot experiments led by dedicated individuals and niche groups…. Individuals' agency is central as social change agents and narrators of meaning. These bottom-up socio-cultural forces catalyze a supportive policy environment which enables change.

The current effects of climate change, as well as some mitigation strategies, are threatening the viability of existing business practices, while some corporate efforts also delay mitigation action.
Middle sector—professionals, experts, and regulators—play a crucial albeit underestimated and underutilized role in establishing low-carbon standards and practices. Building managers, landlords, energy efficiency advisors, technology installers, and car dealers influence patterns of mobility and energy consumption by acting as middle actors….

Social influencers and thought leaders can increase the adoption of low-carbon technologies, behaviors, and lifestyles. Preferences are malleable and can align with a cultural shift…. Between 10% and 30% of committed individuals are required to set new social norms.

Preconditions and instruments to enable demand-side transformation.

Social equity reinforces capacity and motivation for mitigating climate change…. **High status (often high carbon) item consumption may be reduced by taxing absolute wealth without compromising well-being.**

Policies that increase the political access and participation of women, racialized, and marginalized groups, increase the democratic impetus for climate action. Including more differently situated knowledge and diverse perspectives makes climate mitigation policies more effective.

Greater contextualization and granularity in policy approaches better addresses the challenges of rapid transitions towards zero-carbon systems. Larger systems take more time to evolve, grow, and change compared to smaller ones.

Mitigation policies that integrate and communicate with the values people hold [e.g.. family, home, neighborhood] are more successful. Values differ between culture. Measures that support autonomy, energy security and safety, equity and environmental protection, and fairness resonate well in many communities and social groups.

Changes in consumption choices that are supported by structural changes and political action enable the uptake of low-carbon choices…. Targeted technological change, regulation, and public policy can help in steering…towards climate change mitigation.

5.1 Introduction

Demand-side solutions support near-term…mitigation. [The chapter] builds the AR4, which linked behavior and lifestyle change to mitigating climate change (IPCC 2007). First, well-designed demand for services scenarios are consistent with adequate levels of well-being for everyone, with high and/or improved quality of life (Max Neef 1995), improved levels of happiness and sustainable human development.

Second, demand-side solutions support staying within planetary boundaries: they entail fewer environmental risks than many supply side technologies, and make carbon dioxide removal technologies…less relevant or possibly irrelevant in modeling studies still requiring ecosystem based carbon dioxide removal. The comparison of scenarios reveals that such low-energy demand pathways eliminate the need for technologies with high uncertainty, such as BECCS. [This may be a high-consequence decision for the Delaware legislature.]

Third, interrogating demand for services from the well-being perspective also opens new avenues for assessing mitigation potentials. Arguably, demand-side interventions often operate institutionally or in terms of restoring natural functioning and have so far been politically side-lined… **The well-being focus emphasizes equity and universal need satisfaction, compatible with Sustainable Development Goals progress.**

The requisites for well-being include collective and social interactions as well as consumption-based material inputs. Moreover, rather than material inputs per se, people need and demand services or dignified survival, sustenance, mobility, communication, comfort and material well-being.

Focusing on demand for services broadens the climate solution space beyond technological switches confined to the supply side, to include solutions that maintain or improve well-being related to nutrition, shelter and mobility while (sometimes, radically) reducing energy and material input levels. This also recognizes that mitigation policies are politically, economically and socially more feasible, as well as more effective, when there is a two-way alignment between climate action and well-being.

Sector-specific mitigation approaches emphasis the potential of mitigation via improvements in energy- and materials-efficient manufacturing, new product design, energy-efficient buildings, shifts in diet, and transport infrastructure design shifts, compact urban form (Seto et al 2014).
In the context of transportation services, ASI seeks to mitigate emissions through *Avoiding* as much transport services as possible (e.g., telework to eliminate commutes, mixed-use urban zoning to shorten commute distance),*Shifting* remaining demand to more efficient modes (e.g., bus replacing passenger vehicles), and *Improve* the carbon intensity of modes utilizes (e.g., electric buses powered by renewables). The Avoid-Shift-Improve framing operates in the domains: 'Socio-cultural', where norms, culture, and individual choices play an important role…;'Infrastructure', which provides the cost and benefit landscape for realizing options and is particularly relevant for Shift options; and 'Technologies', especially important for the Improve options. ***Avoid, Shift* , and *Improve* choices will be made by individuals and households, instigated by salient and respected role models and novel social norms,** but require support by adequate infrastructures designed by urban planners and building and transport professionals, corresponding investments, and a political culture supportive of mitigation action.

Sustainable Development is <u>not possible without changes in consumption</u> patterns within the widely recognized constraints of planetary boundaries, resource availability, and the need to provide decent living standards for all.

Inversely, reduced poverty and higher social equity offer opportunities for delinking demand for services from emissions, e.g., via more long-term decision making after having escaped poverty traps and by <u>reducing demand for non-well-being enhancing status consumption.</u>

Throughout this chapter we discuss how people can realize various opportunities to reduce GHG emission-intensive consumption and act in various roles within an enabling environment created by policy instruments and infrastructure that builds on social dynamics.

Demand-side climate change mitigation: Housing, Mobility, Food, and Policy

[T]he literature (99,065 academic peer-reviewed articles) organizes in four clusters of high relevance for <u>demand-side solutions</u>: housing, mobility, food, and policy... [neighborhood and habitat].

Service provisioning and climate change mitigation

Many behaviorial changes due to COVID-19 reinforce sufficiency and emphasis on solidarity, economies built around care, livelihood protection, collective action, and basic service provision, linked to emissions**.**

5.2 Services, well-being and equity in demand-side mitigation

Mitigation, equity and well-being go hand in hand to motivate actions. Action/policies that advance inclusive well-being and build social trust strengthen governance. There is *high evidence and high agreement* that demand-side measures cut across all sectors, and can bring multiple benefits. Since effective demand requires affordability, one of the necessary conditions for acceleration on mitigation through demand-side measures is wide and equitable participation from all sectors of society. **Low-cost low emissions technologies, supported by institutions and government policies, can help meet service demand and advance both climate and well being goals.** (Steffen et al 2018). This section introduces metrics of well-being and their relationship to GHG emissions, and clarifies the concept of service provisioning.

5.2.1 Metrics of well-being and their relationship to GHG emissions

There is high evidence and agreement in the literature that human well-being and related metrics provide a societal perspective which is inclusive, compatible with sustainable development, and generates multiple ways to mitigate emissions. Development targeted to basic needs and well-being for all entails less carbon-intensity than GDP-focused growth. Current socioeconomic systems are based on high-carbon economic growth and resource use. (Steffen et al 2018)

Economic growth is tightly coupled with increasing CO2 emissions although the level of emissions depends on inequality and on geographic and infrastructural constraints that force consumers to use fossil fuels…[i]n most cases energy use and economic growth have a bi-directional causal effect, indicating that as economic growth increases, further CO_2 emissions stimulated at higher levels.; in turn, measures designed to lower GHG emissions may reduce economic growth. However, energy substitution and efficiency gains may offer opportunities to break the bidirectional dependency….Recent trends in OECD countries demonstrate the potential for absolute decoupling of economic growth not only from territorial but also from consumption-based emissions, albeit at scales insufficient for mitigation pathways.

Well-being can be categorized either as 'hedonic' or 'eudaimonic'. Hedonistic well-being is related to a subjective state of human motivation, balancing pleasure over pain… Eudaimonic well-being focuses on the individual in the broader context, associating happiness with virtue allowing for social institutions and political systems and considering their ability to enable individuals to flourish.

Eudaimonic analysis supports numerous development approaches such as the capabilities (Sen 1985), human needs (Max-Neef et al 1991) and models of psychosocial well-being.

5.2.1.1 Services for well-being

Well-being needs are met through services. Provision of services associated with low-energy demand is a key component of current and future efforts to reduce carbon emissions….There is high evidence and high agreement in the literature that man granular service provision systems [bottom-up, everyday living in home, neighborhood, habitat and food focus] can make 'demand' more flexible, provide new options for mitigation, support access to basic needs, and enhance human well-being.
Energy services offer an important lens to analyses the relationship between energy systems and human well-being. (Brand-Correa et al 2018). Direct and indirect services provided by energy, rather than energy itself, deliver well-being benefits. For example, illumination and transport are intermediately services in relation to education, healthcare, meal preparation, sanitation, etc. which are basic human needs.

'Doing more and better with the same'

Sustainable consumption and production revolve around 'doing more and better with the same' and thereby increasing well-being from economic activities by reducing resource use, degradation and pollution along with the whole lifecycle, while increasing quality of life' (UNEP 2010)

Not only ensure better environmental quality but also directly enhance well-being (Roy et l 2012) the correlation between human development and emissions are not necessarily coupled in the long term, which implies prioritized human well-being and the environment over economic growth.

Decent Living Standard (DLS) serves as a socio-economic benchmark as it views human welfare not in relation to consumption but rather in terms of services which together help meet human needs…. Therefore, one key way of thinking about providing well-being for all with low carbon emissions centers around prioritizing ways of providing services for DLS in a low-carbon way.

Human well-being correlates with consumption, but only up to a threshold. High potential for mitigation lies in using low-carbon energy for new basic needs satisfaction while cutting emissions of those whose basic needs are already met.
A mitigation strategy that protects minimum levels of essential-goods service delivery for DLS, but critically views consumption beyond that point of diminishing returns of needs satisfaction, is able to sustain well-being while generating emission reductions….. Provisioning for human needs is recognized as participatory and interrelational; transformative mitigation potential can be found in *social* as well as technological change.

Inequality in access to and availability of services for human well-being varies in extreme degree across countries and income groups. In developing countries the bottom 50% receives about 10% of the energy used in land transport and less than 5% in air transport, while the top 10% use ~ 45% of the energy for land transport and around 75% for air transport.

5.2.2.2 Variations in energy use.
There is *high evidence and high agreement* in the literature that through equitable distribution, well-being for all can be assured at he lowest-possible energy consumption levels.

Consumption is energy and materials-intensive and expands along with income. About half of the energy used in the world is consumed by the richest 10% of people….International trade plays a central role being responsible for shifting burdens in most cases from low-income developing countries producers to high income developed countries as consumers. Wealthy countries have exported or outsourced their climate and energy crisis to low and middle-income countries.

Within the energy use induced by consumer products, household consumption is the biggest contributor, contributing to around three quarters of the global total.

[A]t a given level of energy provided, there is large scope to improve service levels for well-being by modifying social and economic constraints without increasing energy supply.

5.2.2.3
There are large differences in carbon footprints between the poor and the rich. The poorest 50% of the world's population are responsible for only about 10% of total lifetime consumption emissions, in contrast about 505 of the world's GHG emissions can be attributed to consumption by the world's richest 10%, with the

average carbon footprint of the richest being 175 times higher than that of the poorest 10% (Chancel and Piketty 2015)…. [C]onsumption patterns of the affluent people often influence the growing middle class. Across EU countries only 5% of households are living within the 1.5C climate limits and the top 1% emit more than 22 times the target on overage. Per capita carbon footprints average 1.6 tons per year for the lowest income category, then quickly increase to 4.9 and 9.8 ton for the two middle income categories and finally to an average of 17.9 tons for the highest income category.
Global CO2 emissions remain concentrated: the top 10% of emitters contribute ~ 35-45% of the total, while the bottom 50% contribute just 13-15% In wealthy nations, services such as private road transport, frequent air travel, private jet ownership, meat-intensive diets, entertainment and leisure add significant emissions, while considerable fraction of the carbon footprint is imported from abroad, embedded in goods and services.

[The UNEP's Emissions Gap Report, 2020 finds that "the combined emissions share of the top 1% f income earners has been found to very likely be larger than—and perhaps double—that of the bottom 50% (Chancel and Piketty 2015); Oxfam and SEI 2020). Around half the consumption emissions of the global top 10% and 1% are associated with citizens of high-income countries, and most of the other half with citizens in the middle-income countries (Chancel and Piketty; Oxfam and SEI 2020). Per capita consumption emissions of those in the global top 10% of income earners would need to be reduces to about one-tenth of their current level by 2030, while those of the poorest 50% could increase by around #X their current level.]

The food sector dominates in all income groups, comprising 28% [31-37% in more recent studies] of households' carbon footprint, with cattle and rice the major contributors, food also accounts for 48% and 70% of household impacts on land and water resources. Roughly 20-40% of food produced worldwide is lost to waste… 10% of total GHG emissions.
It is also crucial to focus on high-emitting individuals and groups within countries, rather than only those who live in high-emitting countries, since the top 10% of emitters live on all continents and one third of them are from the developing world. The consumption share of the bottom half of the world's population represents less than 20% of all energy…less than what the top 5% of people consume.

Wide inequality can increase status-based consumption patterns, where individuals spend more to emulate the standards of the high-income group (the Veblenian effect); inequality also diminishes environmental efforts by reducing social cohesion and cooperation….

Economic growth in equitable societies is associated with lower emissions that in inequitable societies, and income inequality is associated with higher global emissions.

Relatively slight increases in energy consumption and carbon emissions produce great increases in human development and well-being in less-developed countries, and the amount of energy needed for high global level of development is dropping.

Equitable and democratic societies which provide high quality public services to their population have high well-being outcomes at lower energy use than those which do not, whereas those which prioritize economic growth beyond moderate incomes and extractive sectors display a reversed effect (Vogel et al 2021).

Figure 5.5 Well-being, equity, trust, governance and climate mitigation.
Well-being for all, increasingly seen as the main goal of sustainable economies, reinforces emissions reductions through a network of positive feedbacks linking effective governance, social trust, equity, participation and sufficiency.

Active mobility (Cycling, walking), efficient buildings and prosumer choices of renewable technologies have the most encompassing beneficial effects on wellbeing with no negative outcome detected.

Well-being improvements are most notable in health quality, air, and energy.
In many cases, co-benefits outweigh the mitigation benefits of GHG reductions.
Food, mobility, and water are further categories where wellbeing is improved.
Mobility has entries with highest well-being rankings for teleworking, compact cities, and urban systems approaches.

Better education, health care, valuing social diversity, and reduced poverty—characteristics of more equal societies—all lead to resilience, innovation, and readiness to adopt progressive and locally-appropriate mitigation policies.
Whether high-tech or low-tech, centralized or decentralized. Moreover, these factors art the ones identified as enablers of high satisfaction at lower energy use.
There is less lock-in in more equitable societies (Seto et al, 2016)
There is high confidence in the literature that addressing inequities in income, wealth , and DLS not only raises overall well-being and furthers the SDGs but also improves the effectiveness of climate change mitigation policies.

At all scales of governance, the popularity and sustainability of climate policies requires attention to fairness of their health and economic implications for all, and participatory engagement across social groups.—a responsible development framing. Far from being secondary or even a distraction from climate mitigation priorities, and equity focus is intertwined with mitigation goals.

Demand-side climate mitigation options have pervasive ancillary, equity-enhancing benefits, e.g., for health, local livelihoods, and community forest resources. Limiting climate change risks is fundamental to collective well-being. (Max-Neef et al 1989)

“Super-Rich”, “Polluter Elite”

The distinction between necessities and luxuries helps to frame a growing stream of social sciences… Given growing public support worldwide for string sustainability, sufficiency, and sustainable consumption, changing demand patterns and reduced demand are accompanying environmental and social benefits. Beyond a threshold, increased material consumption is not closely correlated with improvements in human progress. **Policies focusing on the "super-rich", also called the "polluter elite," are gaining attention for moral or norms-based as well as emissions-control reasons.**

Conspicuous consumption by the wealthy is the cause of a large proportion of emissions in all countries, related to expenditures on such things as air travel, tourism, large private vehicles and large homes.

Since no country meets its citizens' basic needs at a level of resource use that is globally sustainable, while high levels of life satisfaction for those just escaping extreme poverty require even more resources, the need for transformative shifts in governance and policies is large.

Inequitable societies use energy and resources less efficiently. Higher income inequality is associated with higher carbon emissions.
Consumption reductions, both voluntary and policy-induced, can have positive and double-dividend effects on efficiency as well as reductions in energy and materials. Less waste, better emissions control and more effective carbon policies lead to better governance and stronger democracies. System dynamics models linking strong emissions-reducing policies and strong social equity policies show that a low-carbon transition in conjunction with social sustainability is possible, even without economic growth….

Hence, nurturing equitable human well-being through provision of decent living standards for all goes hand in hand with climate change mitigation.

There is *high confidence* in the literature that addressing inequities in income, wealth, and DLS not only raises overall well-being and furthers the SDGs but also improves the effectiveness of climate change mitigation policies.

Greater public participation in climate policy processes and governance, by increasing the diversity of ideas and stakeholders, builds resilience and allows broader societal transformation towards systemic change…. Related trends include recognition of the value of traditional ecological knowledge, Indigenous governance principles, decentralization, and appropriate technologies.

More equal societies display higher trust.

Box 5.4 Gender, race, intersectionality and climate mitigation

There is high evidence and high agreement that empowering women benefits both mitigation and adaptation, because women prioritize climate change in their voting, purchasing, community leadership, and work both professionally and at home. Increasing voice and agency for those marginalized in intersectional ways by Indigeneity, race, ethnicity, dis/ability, and other factors has positive effects for climate policy.

Women have a key role in the changing energy economy due to their demand and end use of energy resources in socially-gendered productive roles in food production and processing, health care, education, clothing purchases and maintenance, commerce, and other work both within and beyond the home.

Policies on energy use and consumption are often focused on technical issues related to energy supply, thereby overlooking 'demand-side' factors such as household decision-making, unpaid work, livelihoods and care. Such gender-blindness represents the manifestation of wider issues related to political ideology, culture and tradition….. Women's carbon footprints are about 6-28% lower than men's, mostly based upon lower meat consumption and lower vehicle use….Carbon emissions are lower per capita in countries where women have more political 'voice'…. Gender equity also is correlated with lower per capita CO2eq emissions. In societies where women have more economic equity, their votes push political decision-making in the direction of environmental/sustainable development policies, less high-emission militarization, and more emphasis on equity and social policies e.g., via wealth and capital gains taxes.

Advances in female education and reproductive health, especially voluntary family planning, can contribute greatly to reducing world population growth.

5.3 Mapping the opportunity space

Reducing global energy demand and resource inputs while improving well-being for all requires an identification of options, services and pathways that do not compromise essentials of a decent living…socio-cultural, technological and infrastructural interventions through the avoid/shift/improve (ASI) concepts.

Table 5.1 Avoid-Shift-Improve options
Avoid: Integrate transport & land use planning; Compact cities; Local holidays
Smaller decent dwellings/Shared common spaces; Multigenerational housing
Reduce consumption; Long-lasting fabric, appliances
Food calories in line with daily needs and healthy guidelines; Reduce waste
Shift: Modal shifts, from car to cycling, walking or public transit; from air to high speed rail; Less material-intensive dwelling design; shift from single-family to multi-family dwellings; Design for shading, natural ventilation, daylighting
Dietary shifts from ruminant meat and dairy to other protein sources
Improve: Lightweight vehicles, Hydrogen vehicles, Electric vehicles;

Dwelling design use wood as material; Low-carbon cement, steel; Insulation, heat pumps, district heating, solar thermal, LED lamps; Improved ag practices

Avoid options: teleworking, avoiding long-haul flights, adjusting dwelling size to household size, avoiding short life span products and food waste.
Cities and built environments play an additional role… more compact designs and higher accessibility [proximity & mobility] reduce travel demand.
Lower average floor space and corresponding heating/cooling/lighting demand.

Food waste 2019 globally: ~931 million tons of food waste, 61% by households.
In all sectors, end-use strategies can help reduce the majority of emissions: **44% in food, 67% in land transport, 66% in buildings sector.** These are <u>median</u> estimates.

Coupling food waste reductions with dietary shifts can further reduce energy, land, and resource demand in upstream food provision systems. (The estimated technical potential for GHG emissions reductions associated with shifts to sustainable healthy diets is 0.5-8GtCCO2eq (*high confidence*).
Sustainable food systems providing healthy diets for all are within reach but require significant cross-sector action, including improved agricultural practice, dietary shifts among consumers, and food waste reduction in production, distribution, retail, and consumption.

Reduced food waste and dietary shifts have highly relevant repercussions in the land use sector hat underpin the high GHG emissions reduction potential. Demand-side measures lead to changes in consumption of land-based resources and can save GHG emissions by reducing or improving management of residues or making land areas available for other uses such as afforestation or bioenergy production. Deforestation is the second largest source of anthropogenic greenhouse gas emissions, cause mainly by expanding forestry and agriculture [mainly for beef production]. Cattle and oilseed products accounts for half of the resulted deforestation. Benefits from shifts in diets and resulting lowered land pressure are also reflected in reductions of land degradation.

Increased demand for biomass can increase pressure on forests and conservation and heightened risk for biodiversity. This suggests that demand-side actions hold sustainability advantages over intensive use of bioenergy….

In the transport sector, ASI opportunities exist at multiple levels in (Bongardt et al 2013, Sims et al 2014, Roy et al 2021; see Chapter 10)…active mobility such as walking and cycling has 2%-10% potential in GHG emissions reductions.
Technology adoption, particularly banning ICEs and 100% EV targets and efficient lightweight cars, can contribute between 30 and 70% of GHG emissions reduction in land transport in 2050, with 50% our central estimate.

In the building sector: end use technologies/strategies such as daylighting, passive houses, thermal mass and smart controllers can avoid demand…smaller dwelling can reduce overall demand for lighting and space conditioning, while small dwellings, shared housing, and building lifespan extension can all reduce demand.

Avoid short life span products… a socio-cultural factor.

In summary, specific demand-side mitigation options reflect important role of socio-cultural, technological and infrastructural factors and interdependence among them.

Choosing low-carbon options, such as car-free living, plant-based diets without or very little animal products, low-carbon sources of electricity and heating at home as well as local holiday plans, can reduce an individual's carbon footprint by up to 9tCO2eq. Realizing these options requires substantial policy support to overcome infrastructural, institutional and socio-cultural lock-in.

5.3.2 Technical tools to identify Avoid-Shift-Improve

For each unit of improvement at the end-use point of the service delivery system primary resources inputs are reduced between a factor of 6 to 7 units (water, steel, energy)

5.3.3 Low demand scenarios

Long-term mitigation scenarios play a crucial role in climate policy design in the near term, by illuminating transition pathways, interactions between supply-side and demand-side interventions, their timing, and the scales of required investments needed to achieve mitigation goals. Historically, most long-term mitigation scenarios have taken technology-centic approaches with heavy reliance on supply-side solutions and use of carbon dioxide removal, particularly in 1.5C scenarios. Comparatively less attention has been paid to deep demand-side reductions incorporating socio-cultural change and the cascade effects associated with ASI strategies, primarily due to limited past representation of such service-oriented interventions in long-term integrated assessment models (IAMs) and energy systems models (ESMs). There is ample evidence of savings from sector- or issue-specific bottom-up studies. However, these savings typically get lost in the dominant narrative provided by IAMs and ESMs.

In response to 1.5C ambitions, and a growing desire to identify participatory pathways with less reliance on CO2 removal with high uncertainty, some recent IAM and ESM mitigation scenarios have explored the role of deep demand-side energy and resource use reduction potentials at global and regional levels…. Long-term scenarios that aimed to: minimize service-level energy and resource demand as a central mitigation tenet; specifically evaluate the role of behavioral change and ASI strategies; and/or to achieve a carbon budget with limited/no CO2 removal.

First, socio-cultural changes within transition pathways can offer Giagaton-scale CO2 savings potential at the global scale (heating/cooling set points, shorter showers, reduced appliance use, shifts to public transit, less meat intensive diets, recycling can deliver an additional 1.7Gt and 3 GtCO2 savings in 2050)…a substantial overlooked strategy in traditional mitigation strategies. In Europe…analysis suggests that adoption of low-carbon consumption practices could reduce carbon footprints by 25%, or 1.4Gt. The IEA's Net Zero Emissions by 2050 (NZE) scenario [reported] **behavior changes** lead to 1.7GtCO2 savings in 2030.

Second, pursuant to the ASI principle, deep demand reductions require parallel pursuit of behavioral change and advanced energy efficient technology deployment; neither is sufficient on its own.
Through a combination of behavioral change and energy efficient technology adoption, the IEA's NZE requires only 340Ej…the lowest of IPCC net zero SR1.5

Third, low demand scenarios can reduce both supply side capacity additions and the need for carbon capture and removal technologies to reach emissions targets.
Fourth, the costs of reaching mitigation targets may be lower when incorporating ASI strategies for deep energy and resource demand reduction. The AIMS lifestyle case indicated that mitigation costs…would e 14% lower. In the IEA's NZE, behavioral changes that avoid energy and resource demand save US $4trillion compared to if those emissions reductions were achieved through low-carbon electricity and hydrogen deployment (IEA 2021)…. **Such scenarios can reduce dependence on supply-side capacity additions and carbon capture and removal technologies with opportunities for lower overall mitigation costs**.

If the limitations within most IAMs and ESMs regarding non-inclusion of granular strategy analysis can be addressed, it will expand and improve long-term mitigation scenarios…. Addressing the current significant modeling limitations will require increased investments …with a particular focus on socio-behavioral research that has been underrepresented in mitigation research findings to date.

Table 5.2 Summary of long-term scenarios aimed to minimize service-level energy and resources demand:

Lifestyle change 2C	Set point, smaller houses, reduced plastics & car travel
Lifestyle change 1.5C	Set points, less meat, reduced appliance use
NZE 2050	Set points, vehicle light-weighting, shift air to regional rail Shift cars to walking, cycling, public transport, line drying
Urban Mitigation	shift transport demand to **access, mixed-use** building codes Reuse. [OECD Nov 2021 describes "accessibility" as: "a combination of **mobility and proximity**, i.e., ensuring that

people are able to easily reach jobs, opportunities, goods, services and amenities; proximity between people and places can importantly contribute to enlarging mitigation potential."]

France 2072 — Shift car to walking, biking, transit, and air to rail, longer building/product lifespan, shared housing

EU-27 Lifestyle — Local holidays, less food waste, car sharing, vegan diet, Small dwellings, fewer appliances, less car/air travel

EU Carbon Cap — Consumption shifts, reduced consumption, low-carbon goods

France Negawatt — Increased building capacity utilization, less appliance, shift away from animal protein shift to attached buildings
Reduced speed limits, shift to active mobility, transit {UNEP 2020: "increase convenience and *attractiveness* of active travel"]

Netherland Behavioral change — reduce energy consumption through changing lifestyle, habits
investment in solar PV (prosumers)
investment in

societal 1.5C — reduce energy, material and land use consumption

<u>Policies to enable "Avoid" options</u>

Overcoming existing paradigm and planning practices and car dependence— Integrated city planning to avoid travel growth, taxation of status consumption, reframing of low-carbon (active) mobility as high status'

Food waste—New nutrition guidelines

Reduce size of dwellings—Compact city design, progressive taxation of high status consumption

More walking/less car use—adequate infrastructure, fair street space allocation

Multifamily Housing—Taxation, relaxation of single family zoning

Architectural design with shading, ventilation—density incentives, codes

Material-efficient—Embodied carbon standards in building codes (IEA 2019)

Policies to enable "Improve" options

Lightweight vehicles—car purchase tax calculated by weight X CO2 + NO2

5.3.4 Transformative megatrends

Sharing economy …enables individuals to share underutilized products. Historically, both sharing and circular economies have been commonplace in developing economies, where reuse, repair, and waste scavenging and recycling comprise the core of informal economies.
Digitized consumer services can reduce overall emissions… [but}rebound effects and instigated consumption of digitalization are risking a lead to a net increase in GHG emissions. Widespread digitalization may lead to net increases in electricity use, demand for electronics manufacturing resources, and e-wastes.
In the US ride hailing…has increased road congestion and lowered transit ridership, with insignificant change in vehicle ownership, and may further lead to net increases in energy use and CO2 emissions. Studies of Berlin and Lisbon demonstrate that sharing strategies could reduce cars by more than 90%.

5.4 Transition toward high well-being and low-carbon demand societies

Demand-side mitigation involves individuals (consumption, choices), culture (social norms, values), corporate (investments), institutions (political agency), and infrastructure change. These five drivers of human behaviors either contribute to the status quo of global high-carbon, consumption, and GDP growth-oriented economy or help generate the desired change to a low-carbon energy-services, well-being, and equity-oriented economy. Transformative change will require use of all five drivers…. In particular, socio-economic factors such as equity, public service quality, electricity access and democracy are found to be highly significant in enabling need satisfaction at low energy use, whereas economic growth beyond moderate incomes and extractive economic activities are observed to be prohibiting factors.

5.4.2 Socio-cultural drivers of climate mitigation

Just like infrastructures, social and cultural processes can 'lock-in' societies to carbon-intensive patterns of service delivery. **They also offer potential levers to change normative ideas and social practices in order to achieve extensive emissions cuts.**

Action on climate mitigation is influenced but our perception of what other people commonly do, think or expect, known as social norms. (Infrastructure is thus not only required to make low-carbon travel possible but can also be a pre-condition for the formation of low-carbon mobility preferences.)

Behavioral contagion, which describes how ideas and behaviors often spread like infectious diseases, is a major contributor to climate crisis. But harnessing contagion can also mitigate warming.

Carbon-heavy consumption patterns have become the norm only because in part we're not charged for environmental damage we cause (Pigou 1920). The deeper source of these patterns has been peer influence (Frank 1999).

Harnessing contagion can also underwrite the investment necessary for climate stability. If taxed more heavily, top earners would spend less, shifting the frames of reference that shape spending of those just below, and so on—each step simultaneously reducing emissions and liberating resources for additional green investment (Frank 2020). Many resist, believing that higher taxes would make it harder to buy life's special extras. But that belief is a cognitive illusion (Frank 2020). Acquiring special things, which are inherently in short supply, requires outbidding others who also want them. When top tax rats rise in tandem, relative bidding power is completely unchanged, so the same penthouse apartments would end up in the same hands as before. More generally, behavioral contagion is important to leverage all relevant social points for stabilizing Earth's climate.

Climate social movements advocate new narratives or framings for climate mitigation (e.g., climate 'emergency'); criticize positive meanings associated with high emission technologies or practices; model behavioral change (e.g., shifting to veganism or public transport); demonstrate against extraction and use of fossil-fuels; and aim to increase a sense of agency amongst certain social groups that structural change is possible.

Religion can be an important cultural resource towards sustainability at individual, community and institutional levels, providing leverage points for inner transformation towards sustainability.

5.5.2 Phases in transitions

Transitions often take several decades:
In the first phase, radical innovations emerge in peripheral niches;
In the second phase, social or technical innovations are appropriated or purchased by early adopters, which increases visibility;
In the third phase, radical innovations diffuse into wider communities and mainstream markets;
In the fourth phase, the diffusing innovations replace or substantially reconfigure existing practices and systems. He new system becomes institutionalized and anchored in professional standards, technical abilities, infrastructures, educational programs, regulations and institutional logics, user habits, and views of normality, which crate new lock-ins.

Avoid, Shift and Improve options vary with regard to the four transition phases. Incremental 'improve' options, such as energy-efficient appliances or stand-alone insulation measures, are not transitions but upgrades of existing technologies. They have progressed furthest since they build on existing knowledge and do not require wider changes. Some radical 'improve' options, which have a different technological knowledge base, are beginning to diffuse, moving from phase two to three in multiple countries. Examples EV, LED, passive house designs. Many 'shift' and 'avoid/reduce' options like heat pumps, district heating, passive house designs, compact cities, less meat diets, flight and car use reductions have low momentum in most countries, and are mostly in the first phase of isolated initiatives and projects. **Structural transitions in Dutch cities, Copenhagen, and more recently, Paris, however, demonstrate that transitions towards low-carbon lifestyles, developed around the cycling, are possible.**

Diffusion rates are determined by two broad categories of variables, those intrinsic to the technology/product/practice…and those intrinsic to the a adoption environment (e.g., socio-economic and market characteristics)
First, size matters. Acceleration in transitions is more difficult for social, economic, or technological systems of larger size. Components with smaller unit-scale ("granular" and thus relatively cheap), such as light bulbs or household appliances, turn over much faster (often within a decade) than large-scale, capital-intensive lumpy technologies and infrastructures (such as transportation systems)… Also, the creation of entirely new systems (diffusion) takes longer times than replacements of existing early pioneers.

Arguments about scale in the energy system date back at least to the 1970s when Schumacher, Lovins and others argued the case for small-scale, distributed technologies (Schumacher 1974; Lovins 1976, 1979). In 'Small is Profitable' Lovins and colleagues evidenced over 200 reasons why decentralized energy resources …made good business sense in addition to their social, human-centered benefits (Lovins et al 2003). More recent advances in digital, solar and energy storage technologies have renewed technical and economic arguments in favor or adopting decentralized approaches to decarbinization.
Analyzing the performance of over 80 energy technologies historically, Wilson et al (2020) found that smaller scale, more 'granular' technologies are empirically associated with faster diffusion, lower investment risk, faster learning, more opportunities to escape lock-in, more equitable access, more job creation, and higher social returns on innovation investment. These advantages of more granular technologies are consistent with accelerated low-carbon transformation (Wilson et al 2020a).

Second, complexity matters, which is often related to unit-scale. Acceleration is more difficult for options with higher degree of complexity (e.g., carbon capture or a hydrogen economy) representing higher technological and investment risk that can slow down change. Lower complexity…involve less experimentation and debugging and require less adoption effort and risk.
Third, agency, structure and meaning can accelerate transition. The creation and mobilization of actor coalitions is widely seen as important for acceleration. Changes in meaning and cultural norms can also accelerate transitions, especially when they affect consumer practices, enhance social acceptance and create

legitimacy for stronger policy support. Adoption of most advanced practices can support leapfrogging polluting technologies. ###

5.6
There is high agreement in the literature that the updating of educational systems from a commercialized, individualized, entrepreneurial training model to an education cognizant of planetary health and human well-being can accelerate climate change awareness and action.

Any action towards climate change mitigation is best evaluated against a set of indicators that represent a broad variety of needs to define individual well-being, macroeconomic stability, and planetary health. Many solutions that reduce primary material and fossil energy demand, and thus reduce GHG emissions, provide better services to help achieve well-being for all.

In summary, more equitable societies are associated with high levels of social trust and enables action that reduce GHG emissions. ###

END IPCC 2022 MITIGATION REPORT

(highlights through chap five

Climate Change and the People's Health

The Industrial Food System

Sharon Friel, in *Climate Change and the People's Health*, published by Oxford as part of the book series, Big Ideas in Population Health, edited by Professor Nancy Krieger, of Harvard, captures, as well as any single researcher can both the urgency and the framework of the IPCC AR6 with regard to climate change, the global industrial food system and people's health, well-being and equity—the systemic issues of public health, safety and welfare (HSW) concerning the science relevant to the application before DNREC. Friel is Professor of Health Equity, and Director of the School of Regulation and Global Governance, Australian National University. Friel writes:

"Climate change threatens humanity and the planet on which we live."
She describes, "the evolution of the consumptagenic system through the globalization of a market-based and fossil-fuel dependent economic system…the addition of this system to growth and to forms of consumption that are highly polluting…[specifically] the roles of an industrial food system…that is pushing the planet toward irreparable destabilization."

"It might be fairly argued, however, that too much of the currently available public health evidence is at the technical level, focused on 'pathologies'—for example, the facts of climate change and of health inequities—rather than on an understanding of the political, policy, and social processes that variously enable or hinder remedial action (Catford, 2009; Friedman and Gostin, 2017; Horton, 2018).

Our targets should be the actors, structures, and ideas that embed, facilitate, and normalize the global dominance of a consumptagenic system addicted to growth regardless of the costs."
The current application is arguable the clearest instance of this concern to come before DNREC.

OECD Accelerating Climate Action through a Wellness Lens Nov 2021

"Climate change is an urgent and unprecedented challenge with far reaching implications and it is happening now…. Systematically putting people's well-being at the centre of decision making is therefore key to creating the social and political support for more ambition climate action. This report investigates the potential advantages of adopting a well-being lens to climate.

"Agriculture and the food system comprise nearly 30% of global GHG emissions. ….Integrating wider social objectives as priorities is key for current and future well-being. As the way food systems are shaped strongly affects people's health, the environment (water and air quality) and natural resources (water resources). More particularly, when shaping climate mitigation policies in the agriculture and food sector, a strong focus should be on providing a healthy diet for a growing global population." ###

UNEP Emissions Gap Report 2020

concisely reports the same IPCC science at issue with this application. The overall operations of the industrial food system, which this waste combustion project, is designed to support and potentially expand, *increases* GHG emissions from the outset: this would amount to maldevelopment 'locked-in' with new investment and potential governance approval (institutional lock-in via "regulatory capture")—all of which is clearly the opposite of mitigation or a Sustanable Delevelopment pathway.

The UNEP Report sharpens the point of what the science reports is required in the chapter entitled, "Bridging the gap—the role of equitiable low-carbon lifestyles."
The UNEP reports this:

"Minimizing the impacts of climate change requires rapid transitions in people's lifestyles and how we organize our societies, institutions and infrastructure.

"On the aggregate level, compliance with the 1.5C goal of the Paris Agreement will require reducing consumption emissions to a per capita lifestyle carbon footprint of around 2 to 2.5 tons of CO2 by 2030 [tCO2], and even smaller 0.7 tons by 2050 (IPCC SR 1.5 2018). Average consumption emissions vary substantially between countries. For example, current per capita consumption emissions in the US are ~ 17.6 tons CO2eq per capita, around 10 times that of India at 1.7 tons per capita. By contrast, the EU and UK together have an average footprint of ~ 7.9 tons per capita.

“To help understand the options available to reduce lifestyle emissions, the Avoid-Shift-Improve (ASI) framework provides a useful conceptual categorization….we emphasize emissions reductions from mobility, residential energy use and food influence provision systems e.g. better availability of sustainable products (ie, plant-based alternatives).”

“Patterns of everyday life—the way we eat, travel and occupy our times—are shaped and directed by the built environment…and expectations of normal. High-carbon diets have become established through supply chains and market liberaliztion that has promoted convenience foods, bulk-buying and meat-based meals (Hoolohan et al 2016; Xiong et al 2020).”

The review before DNREC, by law, is not to arbitrate individual’s food choices or (personal decisions), but to determine if, based upon BAS, the applicant demonstrates climate mitigation compliance (a matter of *public* health and well-being not personal preference), more specifically individual carbon footprint reduction from their diet consistent with the science.

UNEP finds, “On the aggregate level, compliance with the 1.5C goal of the Paris Agreement will require reducing consumption emissions to a per capita lifestyle carbon footprint of around 2 to 2.5 tons of CO2 by 2030 [tCO2], and even smaller 0.7 tons by 2050 (IPCC SR 1.5 2018).

The UNEP’s Emissions Gap Report of 2020, at section 6.4.3 (Towards low-carbon diets) adds: “In comparison to current average diets, full or partial vegetarianism has the potential to reduce emissions from food consumption by around 31%, with a pescatarian diet leading to an approximately 27 % reduction.”

The waste combustion application before DNREC does not document that as currently operated, the industrial and globalized food system based in Delaware is itself not sustainable within 1.5C carbon footprint pathways, nor the globalized shipment of product is not compatible, or expansion of GHG in order to enable its continuation and potential expansion is not consistent with the BAS.

This is not the change that is mitigation. It is BAU, expanded and with more GHG. “The problem is getting worse” UN Secretary general Antonio Guterres said upon the release of the IPCC reports, “If we continue with more of the same, we can kiss 1.5 goodby. Even 2 degrees may be out of reach.”

This application should be rejected. ###

END SCIENCE STATEMENTS

END SUBMISSION OF JOHN MATEYKO