energies

Editorial

Intersection of Climate Change, Energy, and Adaptation

John P. Abraham [1,*] and Lijing Cheng [2]

[1] School of Engineering, University of St. Thomas, St. Paul, MN 55105, USA
[2] Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China
* Correspondence: jpabraham@stthomas.edu

Climate change is a complex process that exists at the intersection of many human endeavors. Human emissions of greenhouse gases have caused an undisputed change in the Earth's climate. These changes are already having tremendous consequences on human society and biological systems. Climate change is a broad term that encompasses global warming of both the atmosphere and the oceans, changes to the hydrological cycle with rainfall pattern changes, sea level rise, and ocean acidification, among others. These changes are causing, and will continue to cause, impacts on agriculture, biological diversity and distribution, increases in extreme weather events (heat waves, droughts, more intense storms, etc.), challenges in infrastructure, climate refugees (as some areas become inundated with rising waters, for example, or persistent extreme weather), and the sourcing and distribution of energy.

At this point, humans must attempt to both mitigate and adapt to climate change. Mitigation generally refers to actions taken to reduce the emissions of greenhouse gases, and thus lessen future warming. Adaptation relates to actions that make society more resilient to the effects of change (generally, extreme weather). Some recent and important research in this area deals with proposals to deliver clean energy to users in an economic manner so that a transition away from fossil fuels can be implemented. Because of this, we have selected a number of recent publications to review this very topic.

In [1], the authors focus on Central and Eastern European (CEE) countries in the context of European Union efforts to move to a climate-neutral economy. As noted in [1], the inclusion of intermittent renewable energy presents challenges to an electrical grid that requires a stable baseline load. In particular, as wind power functions at times when the wind blows, wind power is maximized at certain time periods (spring and fall, or during dry times as opposed to the rainy season, and at night). Solar power, on the other hand, performs best with clear skies and during the daytime. Depending on the latitude, solar energy is most efficient in the summer; however, significant amounts of energy can be generated even during wintertime when skies are clear, provided systems are not occluded by snow fall. In this context, the authors of [1] use taxonomic methods to classify CEE countries and anticipate future complications that may arise in Romania, Poland, and Bulgaria.

CEE is an excellent case study because of the robust commitment to increasing clean energy supply in this area (80% of electricity to be sourced from renewable, clean sources). Recent conflict in Eastern Europe and the consequences on energy imports to Europe from Russia will potentially increase the rate of transition away from fossil fuels. As part of their analysis, [1] identifies the energy structure of CEE countries and classifies the countries using an index metric. This effort is important because there is no one-size-fits-all method for the deployment of clean energy. The concept of such metrics will be helpful for ranking various solution strategies in different countries and to help optimize a particular solution for a particular case. It is less clear how to identify the best metric, however, and it is possible that refinements to taxonomic classifications will further improve results.

The next study of this group deals with the nexus between energy sources, economic growth, trade, and tourism [2]. The authors again consider European countries. Through

check for updates

Citation: Abraham, J.P.; Cheng, L. Intersection of Climate Change, Energy, and Adaptation. *Energies* **2022**, *15*, 5886. https://doi.org/10.3390/en15165886

Received: 27 July 2022
Accepted: 11 August 2022
Published: 13 August 2022

the application of various statistical tests (the unit root test, the Pedroni cointegration test, and the Kao residual cointegration test, among others), the authors find that increases in trade reception and renewable energy are associated with a decrease in climate change as well as decreases in other environmental costs. Not surprisingly, a positive relationship is found between economic growth and carbon dioxide emissions. Lastly, tourism is found to be negatively related to emissions (increased tourism is associated with lower emissions). The authors then explore the cause–effect relationships between these factors and validate the following hypotheses:

1. There is a positive relationship between income per capita and carbon dioxide emissions;
2. Climate change decreases among economies that use renewable energy;
3. Sustainable tourism practices promote environmental awareness and a decrease in climate change;
4. Trade openness promotes the environmental system.

The first conclusion should not be surprising, particularly because economic growth has occurred in the presence of fossil fuel sources. Only recently have clean energy alternatives become economically competitive with traditional fossil fuels. Consequently, it would not be surprising if hypothesis 1, based on historical data, is upended by more recent data from economic growth coincident with greater renewable energy availability. This hypothesis also underscores that, with rapid economic growth, it is a great challenge to provide a reliable energy supply using intermittent and low-density wind and solar sources compared to dirty but concentrated fossil fuels, particularly in countries where economic growth is fast and/or based on increased manufacturing. These cases are a harder sell for clean energy supply. On the other hand, for countries that experience moderate economic growth (the developed world), and transition from manufacturing to service economies, the adoption of clean energy is a much easier pathway.

This interpretation is supported by the second hypothesis, which relates renewable energy and economic growth. Simply put, growing economies need more energy. Whether that energy is fossil fuel-based or renewable, it is crucial to supply nations' economies. The takeaway from hypotheses 1 and 2 is that energy, supplied by either dirty or clean sources, is associated with economic growth.

The last two ideas are related to the reception of a nation to tourism and trade; both of these factors lead to improved ecological outcomes. The authors of [2] suggest that increased tourism is often associated with biodiversity and a social respect for the environment. In fact, in many cases of ecotourism, the health of the tourism industry relies, in part, on the health of the local biological system (which includes climate). Similar results are found in the connection between a nation's openness to trade and the environment.

This study is a solid contribution to the state of the art regarding how various indicators within a country or region are linked to climate change. It will be interesting to extend this analysis to other regions, particularly outside of the EU. This study provides a starting point for exploring similar findings elsewhere.

The third paper reviewed here deals with the limitations of various renewable energy sources and the interrelationship between reduced emissions, economic growth impact, and health [3]. Additionally discussed is the economic reception of consumers for these new energy sources. Lastly, [3] discusses the intersection between policies and clean energy adoption strategies. The authors of [3] report that clean, renewable energy produces little, if any, greenhouse gas emissions and provides a number of benefits to society associated with energy security, energy poverty, and environmental stewardship. The negatives of these energy sources are their high initial costs of deployment, as well as their intermittent nature, which requires improved energy storage strategies. Considering both the benefits and the detractions, [3] suggests that renewable energy sources are the best option to meet the worlds increasing energy demands.

While solar and wind energy are garnering the majority of attention for clean energy deployment, in [3] other forms of clean energy, including bioenergy, geothermal, hydro, and oceanic, are discussed. The descriptor "oceanic" refers to energy stored in ocean waters

and includes currents, ocean thermal, and even salinity-based energy sources. As already stated in connection with [1], it has been found that the deployment of renewable energy is associated with improvements in human health and economic growth. While this fact should not be surprising, it contradicts the common misperception that clean energy is an antithesis to economic growth. Rather, increased energy supply, whether from clean or dirty sources, can be a basis for growth. The authors of [3] also discuss the willingness of consumers to pay for renewable energy and the positive role that financial incentives play. While currently small, the energy component provided by renewable energy sources grew significantly from 2017 to 2020, with the most rapid increases in wind and solar energy.

Next, [4] provides case studies of emission reductions from renewable energy adaption. This study focuses on BRICS countries; these countries share commonalities in their economic development, population sizes, and willingness to adopt renewable energy sources. As with other countries, a tension exists between the need for increased energy supply in developing economies and the need to reduce greenhouse gas emissions. While there is extensive literature available on the global emission adoption of renewable energy, the authors of [4] note that very few studies focus on particular case studies (such as the BRICS nations) and the implementation of renewable energy so that economic development is not sacrificed has not been studied. The authors of [4] develop a conceptual model to relate factors such as physical capital, labor force, human capital, energy, and efficiency into an integrated calculation of economic growth. The authors also disclose relations between greenhouse gas emissions and economic activity, urbanization, energy consumption, and efficiency. The authors conclude that not all BRICS countries are identical, in fact, there is a significant ternary relationship between energy, output, and emissions in Brazil, more so than China and India, for example. That is, even though the sampled nations share numerous similarities, there are differences in outcome. Such differences reinforce the notion that there is not a one-size-fits-all approach for countries as they work to maximize clean energy without hindering development.

The last paper discussed here focuses on various mitigation policies to deal with energy poverty in the EU. As with other papers reviewed here, this study focuses only on a select set of countries (European). The results are expected to differ amongst countries within the EU, and certainly for countries beyond the EU. The central focus of [5] is on household activities and their power to reduce emissions; the authors find that household efforts have not yielded their full potential in terms of climate improvement. On the other hand, benefits are achieved in terms of reducing energy poverty. A finding noted in [5] is that older citizens are generally more resistant to clean energy adoption than younger citizens. As energy efficiency plans are adopted, often by making homes and businesses more energy efficient, a paradox becomes apparent. The paradox is that the actual efficiency improvements are less than expected. The study considers how policy makers could remove barriers to the adoption of clean energy and improve overall efficiency, particularly in the presence of energy poverty that is caused by growing energy prices, decreasing income, and energy inefficiency. The overall importance of behavioral changes within the energy/climate nexus indicates that the adoption of clean and renewable energy is a multi-faceted issue.

The five papers provide a window to a research world that is situated at the intersection of climate science and energy policy. Social, behavioral, geographic, economic, and cultural considerations all play important roles. A major takeaway message is that access to clean and inexpensive renewable energy may be a prerequisite to adoption, but other factors also matter. Furthermore, with clear differences amongst nations that are otherwise similar to each other, it is imperative to design solution strategies that are tailored to a particular country or region. This targeted solution approach will improve outcomes (i.e., reduce greenhouse gas emissions) while improving the deployment of clean energy and increasing national economies.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Pakulska, T. Green Energy in Central and Eastern European (CEE) Countries: New Challenges on the Path to Sustainable Development. *Energies* **2021**, *13*, 884. [CrossRef]
2. Leitao, N.C.; Lorente, D.B. The Linkage Between Economic Growth, Renewable Energy, Tourism, CO_2 Emissions, and International Trade: The Evidence for the European Union. *Energies* **2021**, *13*, 4838. [CrossRef]
3. Halkos, G.E.; Gkampoura, E.C. Reviewing Usage, Potentials, and Limitations of Renewable Energy Sources. *Energies* **2020**, *13*, 2906. [CrossRef]
4. Liu, J.L.; Ma, C.Q.; Ren, Y.S.; Zhao, X.W. Do Real Output and Renewable Energy Consumption Affect CO_2 Emissions? Evidence for Selected BRICS countries. *Energies* **2020**, *13*, 960. [CrossRef]
5. Streimikiene, D.; Lekavicius, V.; Balezentis, T.; Kyriakopoulos, G.L.; Abrham, J. Climate Change Mitigation Policies Targeting Households and Addressing Energy Poverty in European Union. *Energies* **2020**, *13*, 3389. [CrossRef]