**The Evolution of Renewable Energy Viewpoints,**
**What It Means for Algae Biofuels, And How It Affects the Energy Gap**

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Cynthia Bing-Wo

Spring 2024

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for These-Related Assignments

Advisor
Rider W. Foley, Department of Engineering and Society

## Introduction

We will run out of oil and gas by 2050. Or at least, that is what Shahriar Shafiee and Erkan Topal found in their 2009 projection of fossil fuel use. If we assume that statement is true, we only have about thirty years to fully develop alternatives. Thankfully, we have already begun the transition with 20% of all electricity in the United States being sourced from renewables (Renewable Energy, n.d.). However, there are many industrial machines that are still configured for or require a liquid fuel like diesel or gasoline to perform at the level consumers desire. Specifically, when it comes to vehicle capabilities like towing, electric vehicles and trucks may have large towing capacities, but they are still not yet recommended as this activity greatly decreases the range on the battery (Valdes, 2023). For example, Rivian produces a truck with an 11,000-pound towing capacity, but during a towing situation with that weight, the range on the vehicle is reduced by half to 164 miles from 328 miles (Valdes, 2023). This means that electricity will not satisfy a large group of consumers, and they will be forced to either lower their expectations or put their faith in alternative liquid fuels.

Unfortunately, even though biofuels have long been touted as viable alternatives to fossil fuel, they require copious amounts of land and water to sustain. Because of the upfront costs, the price of the final fuels also ends up being quite high (Ogg, 2007). To help mitigate this issue, algae biofuels can be employed. Algae can be cultivated on land that is not suitable for farming, ensuring no conflict with other areas of the agricultural industry; however, algae biofuel remains relatively expensive to produce due to the intensive harvesting and separation processes and their lack of efficiency (Milledge, 2013). In short, while algae is cheaper than other biofuels, it is still not as cheap as traditional oil and gas, but its scale-up potential still puts it as a front-runner as a major fuel feedstock that can aid the transition from fossil fuels. But with the increased cost, will

people be willing to pay? Simply put, fuel must be cheap enough to burn. Some people are willing to spend a little more money to stay "green," but that opinion does not apply to everyone (Degirmenci, 2017). Furthermore, exactly how much more are supporters of the energy transition willing to pay? And what about those who are unwilling to spend more money? If the people unwilling to spend make up the majority of the population, how can we expect to transition to renewable energy? The collective opinion of the people on renewable energy will shape the future of biofuels. My thesis will seek to identify current views on renewable energy across the political spectrum in the United States, predict how widespread algae biofuels would be received in today's market, and see how both of those culminate in a successful energy transition.

**Fuel Use in The U.S.**

Although the goal is to transition from fossil fuels to renewables, the implications and constituents of algae biofuel are vast. Consumers, oil and gas employees, policymakers, and energy leaders are all stakeholders. Consumers are used to paying the price of fossil fuels, and an increase in dependence on biofuels may see higher energy costs. They have also slowly been introduced to renewable energy through solar and wind electricity sources, often finding them to be cheaper than burning fossil fuels (Marcacci, 2020). But even then, there are those that are still staunchly against renewable energy. How do we achieve buy-in from the opposition when the next step in the transition could include higher cost energy?

Looking towards the future for cost and availability, it is predicted that oil and gas will still dominate the fuel industry in 2040 (Magill, 2022). If use remains the same while supplies run low, diesel costs could surpass that of biodiesel whose costs are expected to fall in the coming years (OECD & Food and Agriculture Organization of the United Nations, 2020). It is

not a simple inverse relationship, though. In the past, biodiesel and diesel prices have been intricately linked trending up and down together with demand (Gervani et al., 2022). A high demand for diesel drives both of the prices, making a transition even more complicated. As the fuel landscape is continuously changing, consumers may find themselves grappling with sustainability and costs more often than they would think. A choice between biodiesel and fossil fuels will not be made only once in a consumer's lifetime.

Additionally, as we move to renewables, oil and gas employees that have dedicated lengthy periods of time to their specialized work would be out of jobs. Oil and gas lobbyists also have a profound effect on policymakers who may be divided in their support for renewable energy. At the top, the leaders of energy giants stand to lose or gain a significant amount of money and power depending on if they intend to pursue biofuels and if so, the scale at which the biofuels will be produced. Furthermore, there are longstanding ideals about the reliability of fossil fuels. This is all to say that while a transition to renewable energy is necessary, it will not happen quickly.

Focusing on the United States, some people are even resisting solar and wind energy. Only 24% of Americans would live within a mile of a solar farm, and only 17% for a wind farm (Tankersly et al., 2023). This is often due to these farms being implemented in agricultural areas, and because the agricultural industry has a large familial aspect, the people who have roots in these places are resistant factors that could economically change the community. This early resistance coupled with the increased cost of biofuels is a bad indicator of how realistic an energy transition is. But does this apply to all forms of renewable energy? Heterotrophic algae (algae that does not need the sun to grow), can greatly reduce land area and avoid using

agricultural land entirely. Will these people still be apprehensive when the renewables are not so close to home?

**Technological Momentum of Renewable Energy and Biofuel**

In connecting biofuel technology with these stakeholders, the theory of *technological momentum* can be applied. This is the idea that technological systems exhibit patterns of growth and evolution that adapt to and merge with social and environmental systems (Hughes, 1987). One aspect of technological momentum is the idea of *transfer* where a system or artifact is adapted to fit into a different structure. Oil refineries can be modified and repurposed to refine biofuels where biocrudes can serve as a feedstock for these "new" systems (Su, 2022). Transfer is portrayed through this updated use of old technology; while the end goal remains the same (energy), the overall impact on the environment is vastly changed. As the upfront costs of biofuels are steep, transfer within the industry is essential to creating a fuel that could be comparable to the current options, let alone competitive. Identifying areas where this has taken place for other renewable energies is essential to evaluating the feasibility of the transition as their tactics may be what wins over the opposition in biofuels. How these communities reacted to economic and social changes can be a large indicator of how other communities in the U.S. will welcome or reject the change.

Another aspect of technological momentum is *competition* where multiple systems are trying to solve the same problem and become the standard. Renewable energy as a whole has a large amount of competition in terms of different energy sources i.e. wind vs. solar vs. biofuels. Algae biofuel itself can also be produced in different ways with each system having its own unique benefits and costs which ultimately affect the final product. For example,

photobioreactors can support higher cell densities but have much higher capital costs or raceways can support larger volumes but are limited in terms of variable control (Banerjee & Ramaswamy, 2019). There is also competition in the algae biofuel manufacturers whose different production methods will determine the price of the biofuel. Contextually, examining the scale and market for algae biofuel start-ups will help to craft the scenario of a widespread algae biofuel initiative today. It is also likely that a fossil fuel giant may invest in an algae biodiesel division. In which case, the specific company that wins out could influence people's support.

This leads into technological momentum's *consolidation* where subsets are actually merged into one standardized system. Biofuels, in general, are remarkably diverse which helps currently in solving specific energy needs, but with so many companies, methods, and forms, it is difficult to synthesize a fully renewable energy system that has the perceived reliability that the current fossil fuel network does. To actually complete a transition to renewables, consolidating the fuel solutions will be necessary. If consolidation happens under a fossil fuel giant, support becomes much more complicated. Environmental activists up until this point have openly and sometimes dramatically criticized oil and gas companies. What will happen if one of these becomes the next renewable energy giant? Refusal to support consolidation will preserve a fractured industry and many small companies may struggle to support the current infrastructure of the energy industry. On the other hand, the more traditional, conservative longtime supporters of fossil fuels and consequently oil and gas companies may reject the change in production. In the end, will there still be enough support to sustain the energy transition?

Finally, technological momentum's facet of *growth*, where there is a period of expansion in the scope or scale of a technological system, is also exemplified by biofuels now and hopefully in the future. As renewable energy technologies in general have exhibited massive

amounts of growth with renewable energy capacity increasing by 50% in 2023 alone, so have biofuels (IEA, n.d.). First and second generation biofuels were extremely limited due to cost and land availability while third and fourth generation biofuels have circumvented the land issue, greatly increasing potential production and with that, applications of biofuels (Cavelius et. al., 2023). Growth is modeled through the increased scale and application potential of these newer biofuels. As biofuels have developed, so has their ability to compete in the fuel market. Research stimulated by growth in the renewable energy field has allowed for financially competitive biofuels to be within the realm of possibility. This growth will need to continue to successfully create a cost-effective biofuel, but it does have the potential to also establish a reliable, trusted process. More access to information will certainly help sway opinions of those unsure about biofuels' ability to support energy needs. Additionally, tracking growth and opinions of renewable energy in general may allow for transferable predictions to biofuels, specifically the size of their role in closing the energy gap.

**Research Question and Methods**

This culminates in my question: How have values surrounding energy changed in the US with the increased prevalence and accessibility of renewable energy? In answering this question, the goal is to then predict how a widescale transition to algae biofuels would be received should it happen today, and finally discuss what all of this information indicates for the energy transition. A complete transition to renewable energy is necessary for the continuation of our electricity-based lives and that transition is not feasible without substitutes for fossil fuels like biofuel and majority buy-in from constituents. To complete this research, I reviewed various news sources with different biases (left, left-leaning, right-leaning, right) to understand the

reasoning of positive and negative views on renewable energy. I specifically chose pieces throughout the past five years to show how *growth* has impacted opinions. Additionally, I researched algae biofuel ventures of large oil companies with the intention of seeing how *competition* and *consolidation* would influence the success of a present-day switch from fossil fuels to algae biofuels. Finally, I identified a promising piece of energy technology and associated case studies where the implementation of renewable energy affected public opinion and analyzed what ultimately led to that shift in opinion using Yin's method (2009). From these cases, I identified key tactics, including *transfer* where fossil fuel infrastructure was converted to renewable infrastructure, that either helped win over public opinion or resulted in a successful implementation of renewable energy particularly on a community level. Using this information, I then proposed solutions to close the energy gap.

**Results**

Over the past five years, the reasoning for whether or not someone supports renewable energy has not undergone a drastic change while renewable energy has reached major milestones like a record 5.1 exajoule increase in 2021 (Rapier, 2022). Interestingly though, there has been an increase in the diversity of renewable energy supporters with more conservative buy-in. In general, those who supported renewable energy did so due to perceived economic benefits like increased jobs in conjunction with aiding climate change and reducing pollution. Those who were against renewable energy generally felt this way due to a perceived unreliability of renewable energy over fossil fuels but did have a positive opinion on expanding nuclear energy. If there were a large-scale algae biofuel implementation and transition, the current opinions on renewable energy do not indicate that it would be even remotely successful. Ultimately, the

transition to clean, renewable energy hinges on reliable, cost effective technology implemented at the community scale.

### *Renewable Energy Growth and Supporters in 2024*

In a depiction of *growth*, renewable energy supporters have become a more diverse group over time with people of different political backgrounds as the technology has become more advanced. Democrats have been quite consistently supportive of climate change initiatives and this has not changed drastically in recent years with solar and wind energy consistently achieving approval ratings over 90% (Kennedy, Funk, and Tyson, 2023). Historically, Republicans in the United States have been more conservative in politics, including government energy initiatives. They tend to support technology which has been extensively proven to be reliable, which oftentimes means oil and gas. But in recent years, younger voters have started to show a large shift in the party. The Pew Research Center found that two-thirds of young GOP voters 18–29 support solar and wind implementation and research over fossil fuel production, a marked difference from older Republicans (Robles, 2024). Republicans 50 and over are much more likely to support offshore oil ventures and fracking (Kennedy and Tyson, 2024).

Farmers are a predominantly conservative population with 85% supporting Donald Trump in a 2020 study of 5,000 farmers (*Infographic: Farmers Support Trump*, 2020). They also tend to be older with the average age of a farmer in the U.S. being 57.5 years old (From the Ground Up, 2023). These two factors make them unlikely to support renewable energy, particularly solar as solar farms can have negative implications for agricultural land. And for the most part, farmers and rural communities don't support large-scale solar energy. Recently in Mason County, West Virginia, there was a large pushback from the community over a plan to

put solar panels on three hundred acres of farmland (Saunders, 2023). The community wanted to support solar but was confused as to why places like the landfill could not have solar panels instead of agricultural land (Saunders, 2024). Cases like these are not isolated; however, growth in the field has helped some recent renewable energy projects see increased support from farmers.

These new initiatives take care to integrate renewable energy technologies into rural communities rather than building isolated renewable energy farms. An opinion piece in *modern farmer* detailed how one of these projects, community solar, can actively benefit the community while causing minimal disruption to their way-of-life. The piece was written by the CEO of a solar company aiming to sell farmers on the idea of community solar, but the overall idea is valid. The piece describes how solar panels are installed throughout the community in places like school rooftops, sheep pastures, and the properties of those who buy-in (Stewart, 2024). Community solar subscribers can then enjoy discounts on their energy bills with no disruption to their daily lives (Stewart, 2024). In this case, the technology itself has not necessarily undergone extensive growth, but the implementation methods have to such a degree that the projects achieve widespread support. This is true across the U.S. too with interest in the Rural Energy for America Program increasing massively in the past year (USDA, 2024). Projects like this solve the dispute over agricultural land while providing discounts, but more importantly are also based on the will of the community, winning over tough constituents like older, more conservative farmers.

Linking all of the supporters, old, young, conservative, and progressive, though, is an economic benefit that has increased with the growth in the field. Experiments with older technology that saw increased personal costs were widely rejected, but recent technology has

allowed for the price of electricity from some sources to fall dramatically (Gustafson, 2020). Farmers supporting community solar do not have to worry about projects taking up agricultural land, and they get additional energy savings and tax credits. The Nature Conservancy, whose mission is to fight climate change for the sake of the planet, writes about the benefits clean energy can provide like investments that can support over half a million new jobs every year for ten years (Clean Energy…, 2024). While the reasons as to why someone supports renewable energy may be extensive and those reasons may not be the same across the board, for the most part, each person believes that renewable energy can provide some sort of individual benefit particularly from the economic growth of the industry.

### *Growth and a Stagnant Renewable Energy Opposition*

Those who do not support renewable energy initiatives are a markedly less diverse group than the supporters, but still have some variances in reasoning with the underlying thought process being believe renewable energy has not had sufficient growth. Some actively promote a higher dependence on fossil fuels, citing their reliability. For example, Texas's harsh early 2021 winter weather proved to be too much for the electric grid, and many critics of solar and wind energy took it as an opportunity to lament the shortcomings of green energy (Mena, 2021). Dissenters widely believed that frozen wind turbines contributed to the deaths of Texans (Collier, 2021). A conservative think tank, the Texas Public Policy Foundation, stated that renewable energy involvement in the electric grid was the only reason the winter storm caused a problem; had it only relied on fossil fuels, there would have been no outage (Domonoske, 2021). Across the board, critics of renewable energy firmly believed that it was an unreliable energy solution which actively caused deaths. This is not an isolated belief with Republicans next year, in 2022,

stating that a premature push towards renewable energy would cause mass blackouts in the summer months (Lee).

In the same vein, a large population of renewable energy dissenters consists of Republicans who are not necessarily against renewables but vote against initiatives due to a hesitancy to adopt seemingly unproven energy technologies. Later on in 2023, the same rhetoric persisted with Representative Jeff Duncan, a Republican from South Carolina, writing about the potential negative consequences of Biden's "rush-to-green" policies. He states his and his colleagues' support of renewable energy sources such as wind and solar but emphasizes a need for "always-on baseload power generation" to provide power consistently due to their intermittent tendencies (Duncan 2023). For that, they strongly recommend the use of dispatchable power sources like coal, natural gas, or hydropower; however, he does specify that this pertains to current technology, suggesting that their views may shift as new innovations are made but this will not be soon (Duncan, 2023). This indicates some interest, but they are still waiting until their perception of renewable energy's growth in the energy grid is extensive enough to support communities.

Additionally, it is important to note that those who are wary of renewable energy are not necessarily against cleaner energy solutions, often supporting increased nuclear power generation initiatives. Republicans in the House of Representatives passed a bill that would reduce funding for some clean and renewable energy initiatives but did support domestic uranium ventures (Christian, 2023). This culminates in the uniting view that renewable energy, particularly solar and wind, is unreliable and insufficient for the energy needs of Americans without the aid of a longstanding energy source, usually fossil fuels.

### *Algae Biofuel Implementation*

If algae biofuels were implemented today using current technology, they would not be well-received. Renewable energy supporters like to see an economic benefit in addition to the historical belief in bettering the planet. Algae biofuels cannot offer a personal savings over fossil fuels as there is simply not enough growth in the field to produce a cost-effective algae biofuel. Renewable energy opposers would also be discouraged by the newness of the technology. In terms of *competition* and *consolidation*, all major oil companies pulled funding from their research by Spring 2023. ExxonMobil was the last to end research on green algae biofuel because ultimately wild strains of algae had low lipid yields resulting in small quantities of fuel (Westervelt, 2023). This means that an algae biofuel roll-out today would not be spearheaded by an oil giant. A switch from fossil fuels would happen with algae biofuel startups as the system builders. Competition between the different systems and companies would lead to a highly fluctuating market which renewable energy opposers would like even less considering the Texas storms and how they believed the diverse grid failed, preferring a fewer, highly reliable sources. Consolidation of these companies and systems would likely be the only way more wary constituents would support algae biofuels, but without a clear leader, this would not occur in the near future.

This does not paint a promising picture for algae biofuels. It is clear that the current technology is lacking when it comes to aiding the energy transition and because of this, they will struggle to achieve widespread support. To make algae biofuels a viable energy solution they would need to address the current issues of economic benefits and a standard, reliable system.

### *Transfer in New Technology*

As mentioned earlier, community solar is becoming more prevalent as an energy solution. Not only does it involve *transfer* using old fossil fuel energy infrastructure, community solar also repurposes older renewable energy technology into an energy source that bridges political divides depicting *transfer* in the solar panels themselves by using new implementation methods.

As demand for coal fades and minelands and brownfields are left unused, Sun Tribe Solar of Charlottesville, Virginia is using these as sites for large solar farms (Zullo, 2023). Whereas large solar projects have been a problem in the past, using sites that have been disturbed has had a lot less pushback from the public (Zullo, 2023). This takes advantage of old fossil fuel resources, transferring the area to renewable energy infrastructure and uses reliable solar technology in an area that may have rejected it before. This also focuses efforts on communities that have historically supported the coal industry, revitalizing their economies. In particular, Sun Tribe Solar initiated a project in 2021 to convert five different sites previously used for coal mining to solar farms (Kluck, 2021). The local utilities companies had a direct input to integrate the upcoming systems while Sun Tribe also highlighted the environmental and economic benefits like no need to clear land and a large construction site with lots of new technology (Kluck, 2021). The project successfully convinced the community of its merit while using *transfer* to reuse old infrastructure and implement existing technology in a different way. This is not a unique occurrence with 43 states having at least one successful community solar project and 17 states including legislation on supporting low income families (Community Solar Basics). Each of these projects hinged on achieving support from the local community.

To win over the communities, the leaders of the projects tried to actively involve the locals. In the case study, they used land that was previously associated with damage from the fossil fuel industry and put a positive clean, renewable energy spin on it. Importantly, they made sure to emphasize the economic benefit that the communities stood to gain. Whereas a large construction site can prove to be a nuisance, they framed it as a job opportunity for the community which was especially important for areas that were dependent on coal. Sun Tribe took care to know their audience, which proved to pay off. Across the board, the cases of community solar highlight the economic benefit and heavily involve voluntary engagement from the locals.

**Discussion**

Ultimately this means the energy gap will involve targeted effort on the community level. Supporters of renewable energy are united by an economic benefit, but to win over the majority, that benefit needs to be seen at the personal level. Dissenters are wary of the reliability of renewable energy systems and the newness of the technology. While solar has been proven to be reliable, breaking the grid down into communities could allow for increased storage of energy alleviating concern for a lack of dispatchable energy, and as more communities adopt community solar, the technology will get a chance to prove itself. Communities will need to be actively involved in their energy sourcing with an open dialogue between the public, officials, and companies. We will, however, have to be careful with complete integration into existing energy technologies and meeting the needs of a growing population. As seen in particular with electric vehicles where many drivers have been stuck with slow, outdated charging stations, or a complete lack of charging stations, we cannot experience the same issues with household energy (Domonoske, 2023). All of this serves not to solve climate change, as at this point there is no

solution, but ideally this research could support the push for community-based energy solutions which will ultimately help to mitigate the effects we will see due to climate change.

This research does depend on the public's ability to trust and follow the guidelines of new research. If trust is not established, economic and environmental benefits likely will not be enough to win over opinions. This goes along with a willingness to believe in the negative consequences of climate change. Fossil fuels do provide good jobs that communities depend on, if people have no reason to believe that they are bad for the future, they will not buy-in to programs that seek to put these facilities out of business. All this is to say that while diverse opinions are important to long-lasting renewable energy solutions, people must be willing to challenge those opinions.

In the future, I would like to research more updated implementation methods for existing renewable energy technology. Biofuels are not viable for mass-production and the current technology does not provide a cost-effective pathway for harvesting. This, coupled with the fact that reliable technology will win over more supporters, indicates that finding ways to leverage our existing renewable infrastructure will be what wins the most buy-in. Solar, wind, and hydropower have been extensively researched meaning their reliability can be more easily proven than a previously untapped energy source. Finding ways to fit that technology into communities would offer the least disturbance to locals and actively involve the community in their energy sourcing.

As I progress in my career as an engineer, I will use this research as a framework to consider the multifaceted nature of my projects and my potential constituents. A successful solution to an engineering issue within the community hinges on not only the ability to see things

from another point of view, but to sympathize with their reasoning and rectify any valid underlying fears that could signify a flaw in the process. I will also retain this framework as a way of considering existing infrastructure as an asset to problem solving rather than a hindrance. In integrating past technology with new solutions, I will be forced to consider the lifetime of my own additions and how they may someday be merged with future technologies.

## Conclusion

Overall, this research indicates that small scale efforts on the community-level have the potential for wide success in the energy transition due to their more personal nature. It highlights the need for an open dialogue between the government, the public, and the energy companies and how energy solutions must be tailored to the communities which they serve. This research also finds that algae biofuels are not a feasible renewable energy solution and likely will not become widely available in the near future. It shows how attention is directed away from biofuels in large oil companies all ending their ventures. From there, I recommend decreased focus on renewable combustible energy sources. The research is not presently promising for mass production of algae biofuels, and the infrastructure to support a large implementation of those biofuels is not in place. Meanwhile, solar, wind, and hydropower all have existing systems and can be integrated into communities. More energy storage techniques should be created to support renewable energy systems that may not be able to produce energy constantly. In conclusion, the transition from fossil fuels to complete renewable energy is necessary and the most viable way to achieve that in the United States will be through concerted community efforts to source renewable energy locally.

**References**

Ag Science Magazine. (2023). *From the Ground Up (Ag Science Magazine)*. Penn State College of Agricultural Sciences. Retrieved April 14, 2024, from https://agsci.psu.edu/magazine/articles/2023/fall/from-the-ground-up

Banerjee, S., & Ramaswamy, S. (2019). Comparison of productivity and economic analysis of microalgae cultivation in open raceways and flat panel photobioreactor. Bioresource Technology Reports, 8, 100328. https://doi.org/10.1016/j.biteb.2019.100328

Baumhardt, Alex. (2023, December 3). USDA grows solar power in rural Oregon despite limited transmission, assistance. *Opb*. Retrieved February 28, 2024, from https://www.opb.org/article/2023/12/03/oregon-rural-solar-power-energy/

BP Global. (n.d.). *Bp expands investment in bioenergy, collaborating with US biofuels developer WasteFuel | News and insights | Home*. Retrieved February 28, 2024, from https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-expands-investment-in-bioenergy-collaborating-with-us-biofuels-developer-wastefuel.html

Cavelius, P., Engelhart-Straub, S., Mehlmer, N., Lercher, J., Awad, D., & Brück, T. (2023). The potential of biofuels from first to fourth generation. *PLOS Biology*, *21*(3), e3002063. https://doi.org/10.1371/journal.pbio.3002063

Christian, M. (2023, October 27). *US House passes energy spending bill with climate law cuts; Biden vows to veto*. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/102723-us-house-passes-energy-spending-bill-with-climate-law-cuts-biden-vows-to-veto

Collier, Kevin. (2021, February 17). Fact check: Renewable energy is not to blame for the Texas energy crisis. *NBC News*. https://www.nbcnews.com/news/us-news/fact-checkrenewable-

energy-not-blame-texas-energy-crisis-n1258185

*Community Solar Basics*. (n.d.). Energy.Gov. Retrieved April 14, 2024, from https://www.energy.gov/eere/solar/community-solar-basics

Degirmenci, K., & Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range? *Transportation Research Part D: Transport and Environment*, 51, 250–260. https://doi.org/10.1016/j.trd.2017.01.001

Domonoske, C. (2021, February 18). No, The Blackouts In Texas Weren't Caused By Renewables. Here's What Really Happened. *NPR.* https://www.npr.org/sections/live-updates-winter-storms-2021/2021/02/18/968967137/no-the-blackouts-in-texas-werent-caused-by-renewables-heres-what-really-happened

Domonoske, C. (2023, September 10). Electric cars have a road trip problem, even for the secretary of energy. *NPR*. https://www.npr.org/2023/09/10/1187224861/electric-vehicles-evs-cars-chargers-charging-energy-secretary-jennifer-granholm

Duncan, J. (2023, December 8). Biden's crazy rush to green energy will push us to endless blackouts. *Fox News.* https://www.foxnews.com/opinion/bidens-crazy-rush-green-energy-will-push-endless-blackouts

Gerveni, M., Hubbs, T., & Irwin, and S. (2023). Biodiesel and Renewable Diesel: It's All About the Policy. *Farmdoc Daily*, *13*(27). https://farmdocdaily.illinois.edu/2023/02/biodiesel-and-renewable-diesel-its-all-about-the-policy.html

Gustafson, A., Goldberg, M. H., Kotcher, J. E., Rosenthal, S. A., Maibach, E. W., Ballew, M. T., & Leiserowitz, A. (2020). Republicans and Democrats differ in why they support renewable energy. *Energy Policy*, *141*, 111448. https://doi.org/10.1016/j.enpol.2020.111448

Hughes, T. (1987). The evolution of large technological systems. *The social construction of technological systems. New directions in the sociology and history of technology*, edited by W. E. Bijker, T. P. Hughes and T. Pinch. Cambridge, Massachusetts & London, England: MIT Press, 51-82.

IEA. (2024, January 11). *Massive expansion of renewable power opens door to achieving global tripling goal set at COP28—News*. Retrieved February 25, 2024, from https://www.iea.org/news/massive-expansion-of-renewable-power-opens-door-to-achieving-global-tripling-goal-set-at-cop28

Kennedy, B., Funk, C., & Tyson, A. (2023, June 28). 1. What Americans think about an energy transition from fossil fuels to renewables. *Pew Research Center Science & Society*. https://www.pewresearch.org/science/2023/06/28/what-americans-think-about-an-energy-transition-from-fossil-fuels-to-renewables/

Kennedy, B., & Tyson, A. (2024, March 1). How Republicans view climate change and energy issues. *Pew Research Center*. Retrieved April 14, 2024, from https://www.pewresearch.org/short-reads/2024/03/01/how-republicans-view-climate-change-and-energy-issues/

Kluck, Kaylyn. (2021, June 3). Former coal mine land to be transformed into solar energy sites in Wise County. *WJHL | Tri-Cities News & Weather*. https://www.wjhl.com/news/local/former-coal-mine-land-to-be-transformed-into-solar-energy-sites-in-wise-county/

Lee, Michael (2022, July 4). Rush toward green energy has left US "incredibly" vulnerable to summer blackouts, expert warns. *Fox News*. Retrieved February 28, 2024, from

https://www.foxnews.com/us/rush-green-energy-has-left-us-incredibly-vulnerable-summer-blackouts-expert-warns

Magill, B. (2022). *Global 2040 Forecast Sees Only Slight Fall in Fossil Fuels | Climate Central*. Retrieved December 3, 2023, from https://www.climatecentral.org/news/global-2040-forecast-slight-fall-fossil-fuels-20340

Marcacci, Silvio. (2020). Renewable Energy Prices Hit Record Lows: How Can Utilities Benefit From Unstoppable Solar And Wind? Retrieved October 26, 2023, from Forbes website: https://www.forbes.com/sites/energyinnovation/2020/01/21/renewable-energy-prices-hit-record-lows-how-can-utilities-benefit-from-unstoppable-solar-and-wind/

Mena, B. (2021, February 18). *Gov. Greg Abbott and other Republicans blamed green energy for Texas' power woes. But the state runs on fossil fuels.* The Texas Tribune. https://www.texastribune.org/2021/02/17/abbott-republicans-green-energy/

Milledge, J. J., & Heaven, S. (2013). A review of the harvesting of micro-algae for biofuel production. *Reviews in Environmental Science and Bio/Technology*, *12*(2), 165–178. https://doi.org/10.1007/s11157-012-9301-z

The Nature Conservancy. (n.d.). *Clean Energy and Climate Policies Benefit America's Economy and Communities*. Retrieved February 28, 2024, from https://www.nature.org/en-us/about-us/who-we-are/how-we-work/policy/clean-energy-climate-policy-economic-benefits/

Neupane, D. (2022). Biofuels from Renewable Sources, a Potential Option for Biodiesel Production. *Bioengineering*, *10*(1), 29. https://doi.org/10.3390/bioengineering10010029

OECD & Food and Agriculture Organization of the United Nations. (2020). *OECD-FAO Agricultural Outlook 2020-2029*. OECD. https://doi.org/10.1787/1112c23b-en

Ogg, C. (2007). *Environmental Challenges Associated With Corn Ethanol Production*. Retrieved October 26, 2023, from epa.gov website: https://www.epa.gov/sites/default/files/2014-12/documents/environmental_challenges_associated_with_corn_ethanol_production.pdf

Rapier, R. ( 2022, August 23). *Renewable Energy Grew At A Blistering Pace In 2021*. Forbes. Retrieved February 28, 2024, from https://www.forbes.com/sites/rrapier/2022/08/23/renewable-energy-grew-at-a-blistering-pace-in-2021/

Renewable Energy. (n.d.). Retrieved October 26, 2023, from Energy.gov website: https://www.energy.gov/eere/renewable-energy

Robles, C. (2024, March 5). *Most Republicans support expanding clean energy—Survey*. E&E News by POLITICO. https://www.eenews.net/articles/most-republicans-support-expanding-clean-energy-survey/

Saunders, A. (2023, December 5). *Mason County solar farm project faces opposition from some neighbors, farmers*. WCHS. https://wchstv.com/news/local/mason-county-solar-farm-project-faces-opposition-from-some-neighbors-fellow-farmers

Shafiee, S., & Topal, E. (2009). When will fossil fuel reserves be diminished?, *Energy Policy*, *37*(1), 181-189. https://doi.org/10.1016/j.enpol.2008.08.016.

Statista Daily Data. (2020, October 21). *Infographic: Farmers Support Trump*. https://www.statista.com/chart/23242/farmers-presidential-election

Stewart, B. (2024, January 24). Opinion: With Community Solar, It's Not Renewable Energy vs. Rural Character. *Modern Farmer*. https://modernfarmer.com/2024/01/opinion-community-solar/

Su, J., van Dyk, S., & Saddler, J. (2022). Repurposing oil refineries to "stand-alone units" that

refine lipids/oleochemicals to produce low-carbon intensive, drop-in biofuels. *Journal of Cleaner Production*, *376*, 134335. https://doi.org/10.1016/j.jclepro.2022.134335

Tankersley, J., Plumer, B., Swanson, A., Penn, I., Dominguez, L., & Popovich, N. (2023, August 13). The Clean Energy Future Is Roiling Both Friends and Foes. *The New York Times*. https://www.nytimes.com/interactive/2023/08/12/climate/wind-solar-clean-energy.html

Valdes, R. (2023). Towing with Electric Vehicles: Everything You Need to Know. Retrieved October 26, 2023, from Autotrader website: https://www.autotrader.com/car-shopping/electric-vehicle-towing-guide

Westervelt, A. (2023, March 17). Big oil firms touted algae as climate solution. Now all have pulled funding. *The Guardian*. https://www.theguardian.com/environment/2023/mar/17/big-oil-algae-biofuel-funding-cut-exxonmobil

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). Sage.

Zullo, R. (2023, December 31). New life for old coal: Minelands and power plants are hot renewable development spots ⋆ Michigan Advance. *Michigan Advance*. https://michiganadvance.com/2023/12/31/new-life-for-old-coal-minelands-and-power-plants-are-hot-renewable-development-spots-2/