Electrifying Ohio

Insights from Princeton University's *Net-Zero America* Report

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by Natalie Reichert,[1] Abigail Rudolph,[1] Jason Keiber[2]
Baldwin Wallace University[3]

The Earth's climate continues to warm. The professional consensus is that we need to keep average temperatures from reaching 1.5 °C over pre-industrial temperatures. The threshold is fast approaching; 2020 was ~1.2 °C warmer than pre-industrial averages.[4] Our current path of business-as-usual greenhouse gas emissions will result in an intolerably hot world that lashes humanity with rising sea levels, unforgiving weather events, and ecological turbulence.

To avoid catastrophe, humanity must make profound changes in energy production and consumption. As the International Energy Agency explained in May 2021, "the world has a viable pathway to building a global energy sector with net-zero emissions in 2050, but it is narrow and requires an unprecedented transformation of how energy is produced, transported and used globally."[5] The United States is one of the most significant *per capita* and *total* contributors of greenhouse gases. As a result, the U.S. has a lot of work to do, and Ohio is an important part of this effort.

In late 2020 Princeton University released a report detailing the changes necessary for the United States to achieve net-zero greenhouse gas emissions by 2050. The report, *Net-Zero America,* is an extraordinary and technical document which lays out five different pathways states can pursue to reach the net-zero goal. The pathways are all informed by recent data and state-of-the-art modeling which provides granular state-specific insights.

The purpose of the Princeton report is to provide policy makers and other stakeholders with data and guidance on the possibilities of reaching net-zero targets by 2050. The various paths illustrated in the report are *not* intended to be strict lanes within which policy makers must adhere with utmost fidelity. Rather, the models and the paths help us understand what can be done, the associated opportunity costs, and how different features of the economy may be affected—for better or worse.

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[1] Natalie Riechert is working on a degree in International Studies, and Abigail Rudolph is working on a degree in National Security at Baldwin Wallace University. https://www.bw.edu/
[2] Jason Keiber is an Assistant Professor of National Security at Baldwin Wallace University
[3] Work was done as part of the Center for New Security Voices, a pilot "think tank" at Baldwin Wallace University featuring exceptional student work on national and human security topics. Learn more at www.newsecurityvoices.com
[4] The World Meteorological Organization, "The State of the Global Climate 2020." April 20, 2021 https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate
[5] IEA Press Release, May 18, 2021 https://www.iea.org/news/pathway-to-critical-and-formidable-goal-of-net-zero-emissions-by-2050-is-narrow-but-brings-huge-benefits

The Princeton report, however, is not user friendly. A deluge of tables, maps, and charts can aid in data interpretation, but the reader is often left without the information and context to quickly make sense of the visual flood. Readers—especially those not steeped in climate science—will find themselves combing through annexes and making triangulated inferences to understand the data.

To assist policy makers and other interested parties in understanding the insights of Princeton's report, students working in Baldwin Wallace's Department of Politics and Global Citizenship have summarized and "translated" one of the pathways detailed in the report. Under the supervision of Professor Jason Keiber, the students—Natalie Reichert and Abigail Rudolph—poured over the report and its annexes to write this policy brief. The full Princeton report deserves a close read, and we believe that our policy brief can ease readers into the technical language and detailed results of the Princeton work. The full *Net-Zero America* report can be found here.

CHOOSING THE PATHWAY FOR OHIO—HIGH ELECTRIFICATION.

Of the five decarbonization pathways outlined in *Net-Zero America* (hereafter, "NZA") we focus on the High Electrification pathway (what NZA refers to as E+) for Ohio to adopt in order to reach net-zero carbon emissions by 2050. The pathway sees nearly full electrification of transportation and all buildings by 2050, allows for both fossil fuels and renewables, but accepts limits on the adoption of biomass as an energy source. Each pathway presents its own set of challenges, but the High Electrification pathway often occupies a middle ground of sorts in the requirements put forth. Furthermore, the "E+ pathway" is used as the go-to example path throughout the NZA report. This pathway is also one of the least expensive, so it would put less strain on the economy.

By way of summary, here are a few highlights of the report for Ohio. Further details are below.

High Electrification

- End-users (e.g. consumers and businesses) transition to electric vehicles, and electric heating and cooking. Electricity demand will go up. Critically, this requires an energy-supply system built to match. Infrastructure matters.
- Gasoline is out. Electric Vehicles (EVs) are in. Ohio will need to think about incentivizing EV purchases and fostering the financing required to build public charging stations.
- Pipeline Gas for heating and cooking is drastically cut. End-users shift significantly to heat-pumps and electric resistance (e.g. electric stoves and electric water heaters).
- By 2050, residential and commercial final energy use will increase to 85% and 90% electric respectively. (NZA pages 57, 63)

- Industry in Ohio will need to change too. Steel production needs to move away from blast furnaces to electric arc furnaces, cement and lime making will need to incorporate CO_2 capture, and new efficiencies should be sought in bulk chemicals production.

Wind & Solar

- By 2040 Ohio needs over 25,000 MW of solar capacity. (For comparison, this would be the equivalent of matching the capacity of *35* Avon Lake coal power plants.) Ohio has roughly 270 MW of solar capacity today. (This doesn't include rooftop residential panels.) The rate of scaling-up the capacity depends on land use assumptions.
- By 2040 Ohio needs to have brought online over 30,000 MW of wind capacity. Ohio is currently at about 900 MW of wind capacity.
- The NZA report does not account for the potential of off-shore wind capacity for Lake Erie. There is potential here.

Biomass

- The High-Electrification pathway does not recommend bold recommendations for utilizing biomass. However, there is nothing to stop Ohioans from taking advantage of biomass to help transition away from fossil fuels. According to EIA data, Ohio ranks 24th in energy generation from biomass at utility scale.[6] Ohio can do better.

CO_2 Capture and Transmission

- Ultimately 1260 miles of pipeline will be required to transport CO_2 to storage basins in neighboring states.

Land Sinks for Capturing Carbon

- Aggressive use of agriculture and forest land sinks can reduce CO_2 emissions in the energy and industry sectors. Ohio could potentially capture over 13% worth of its 2018 emissions.

Job and Health Impacts

- With proper planning and investments Ohio can offset the jobs lost in this transition with new jobs in the clean energy sector.
- The positive health impacts are unequivocal. With reduced air pollution lives will be saved and associated economic costs of air pollution will decrease.

Costs

- Through 2030, Ohioans can expect to spend an additional $6.1 billion dollars on electrifying residential and commercial cooking, and space and water heating. (NZA pages 62, 65)
- Electricity distribution investment costs for Ohio are a bit more eye-popping.
    - Through the 2020s: $13 billion
    - Through the 2030s: $28 billion
    - Through the 2040s: $27 billion

[6] EIA "Utility Scale Facility Net Generation from Biomass by State by Sector," released July 24, 2019.

- Required capital investment in solar and wind generation will exceed $80 billion with the bulk of that investment rolling out in the 2030s. (NZA page 121)
- Ohio will require a total investment of over $3 billion in CO_2 pipeline construction

It is worth repeating that the modeling in NZA is not meant to predict the future and has its limits. The models in the full report are limited in their ability to map local conditions, but this is the best effort to date. Furthermore, the Princeton report was based on the current resources and capabilities available to make these sustainable changes and cannot account for continued innovation. Ohio can, and should, support innovative efforts to mitigate and adapt to climate change.

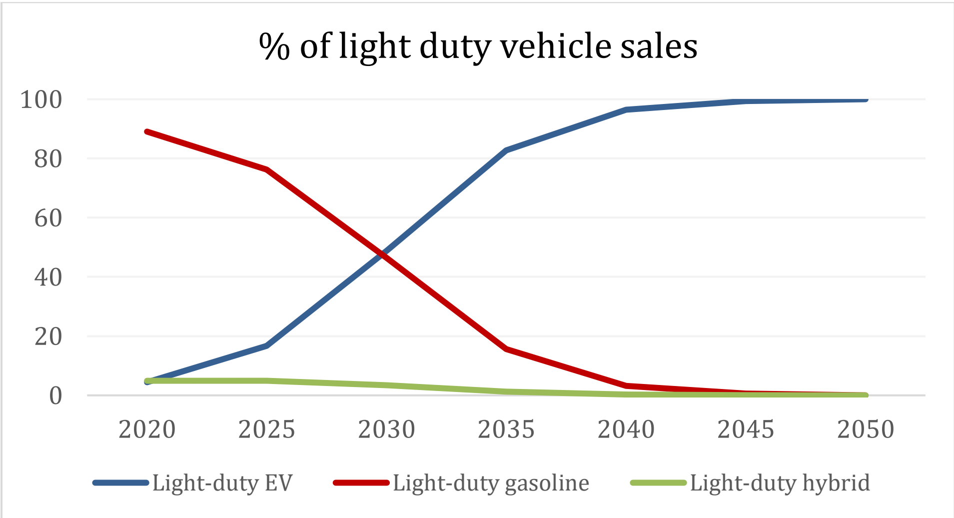
Finally, the projections are based on acting now. The dire truism of climate change is unshakable: the longer we wait to make substantive changes, the more costly the necessary substantive changes will become. More challenging still, Ohio will need to coordinate with neighboring states to assess interstate supply and demand issues concerning, for example, biomass and CO_2 transport. “Urgency” is the watchword of this report.

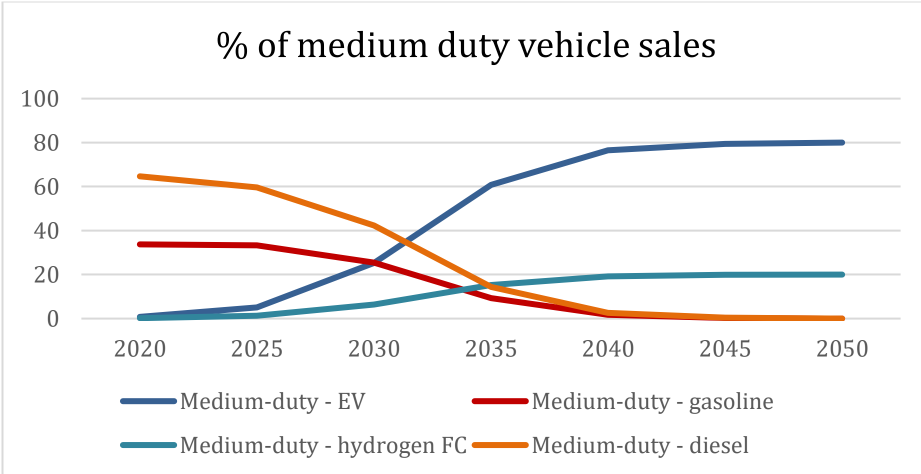
The rest of the document provides more details on what Ohio should strive towards for the selected High-Electrification pathway.

END-USE ENERGY EFFICIENCY AND ELECTRIFICATION.

Transportation Sector

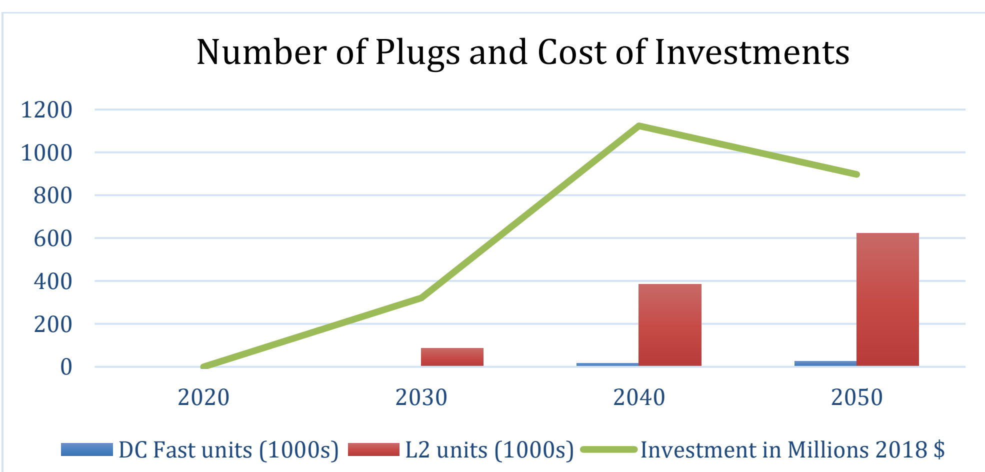
For Ohio to reach net-zero emissions by 2050 investments in the transportation sector are essential. These investments are needed in vehicle capital costs and proliferating electric vehicle (EV) charging plugs. Ohio needs to hit ambitious electrical vehicle (EV) sales targets. In light-duty vehicle sales, 48.8% of sales need to be EV by 2030 and 100% by 2050 (Ohio State Report 2). Gasoline, light-duty vehicles need to see a decrease in sales from 89% of car sales today to 46.4% by 2030 and 0% by 2050 (Ohio State Report 2).





For medium-duty vehicles, the transition happens from gasoline vehicles to both EVs and Hydrogen Fuel Cell Vehicles (H_2FCVs). The sales for EVs in 2030 need to account for 25.3% and H_2FCVs need to account for 6.33% (Ohio State Report 2). By 2050, EVs should reach 80% and H_2FCVs should reach 20% (Ohio State Report 2). In contrast, the gasoline vehicle sales should reduce from 25.5% in 2030 to 0% by 2050 (Ohio State Report 2). Financially, the priority should be on adapting light- and medium-duty vehicles as the upfront cost to change over all heavy-duty vehicles in Ohio to EVs is substantial. It is likely more cost effective to invest in light- and medium-duty EVs while focusing on making heavy-duty trucks and public transit buses EVs in the future.

Charging infrastructure is critical to pave the way for large scale EV adoption. There are two different types of EV charging plugs that require investments from the state for public use: DC Fast and L2. Most of the investment will be put into the L2 systems (87,700 units by 2030 and 624,000 units by 2050) (Ohio State Report 2). In contrast, the DC Fast systems will have less units (3,650 units by 2030 and 25,900 units by 2050) (Ohio State Report 2) but are still an important investment. The investments for these EV charging plugs are noted in the figure below. Overall investment will total over a $2.3 billion through 2050 (NZA 52).



The aggressive electrification pathway projects a dramatic decrease in energy demands in transportation. Total energy use (summing across all transportation modes) in the High-Electrification scenario is 20% less than that of “Less aggressive” electrification scenario run by Princeton, and 46% less than the status quo “reference” scenario (NZA 44). By far most of the decrease reflects electrification of automobiles. Decreases in energy use in other modes, like aviation, are less pronounced and are more due to efficiency gains.

<u>Key Takeaways:</u>

1. Ohio must increase availability of EV charging plug units from 2030 to 2050 by 611%.
2. 100% of all light-duty vehicles sold by 2050 must be electric, and 80% of medium-duty vehicles must be electric by 2050.

Buildings Sector

By 2050, the use of natural gas for space and water heating and cooking is nearly all replaced by electricity in residential buildings. Heating and air conditioning will be done by air-source heat pumps (NZA 56). In residential buildings, 85% of energy use will be electricity by 2050 (NZA 57). Heating unit types in residential buildings will move away from pipeline gas and other source of fossil fuels. Electric heat pumps will take over as the main source of home heating (NZA 59).

Electric Heat Pump Adoption			
	2030	**2040**	**2050**
Electric Heat Pump	13%	52%	82%
Electric Resistance	14%	11%	7%

In commercial buildings, electricity will replace natural gas in heating and cooling and electricity for cooking will grow. Heat pumps will be in use but do not have as significant of efficiency gains as in the residential buildings (NZA 56).

Ohio capital expenditures from 2021-2030 for residential space and water heating have an incremental capital cost of $3.2 billion over the projected baseline, an increase of 17% (NZA 62). Similarly, Ohio capital expenditures from 2021-2030 for commercial HVAC and water heating have an incremental capital vs. current level of $2.9 billion, an increase of 4% over the current amount (NZA 65).

<u>Key Takeaways:</u>

1. 85% of residential and commercial buildings must be electrified by 2050.
2. Capital expenditures for residential space and water heating and commercial HVAC and water heating must increase by 17% and 4%, respectively, related to current levels.

Industrial Sector

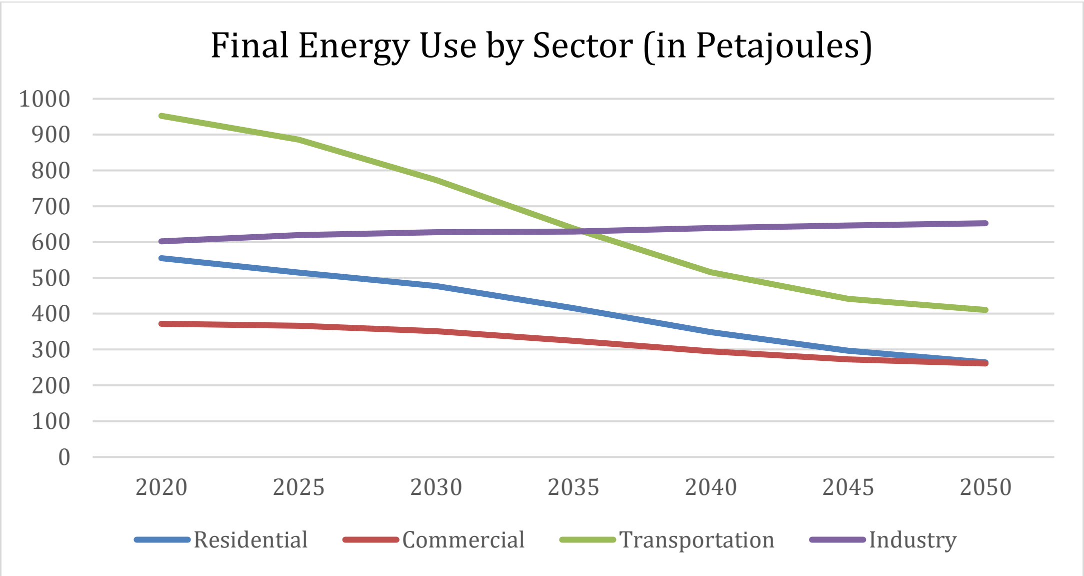
The energy demand in the industrial sector is pretty constant in transition to net-zero plans. The MJ (mega-joulles)/$ of Gross Industrial Output only decreases 1% more in the high electrification pathway plan than the reference *status quo* pathway (from 2020 to 2050) (NZA 68). Final energy use will decrease 15-20% below reference *status quo* pathway. Consistent with other sectors, electricity and hydrogen will increase at the expense of pipeline gas and distillate oil (NZA 70). Bulk chemicals remain the largest source of industrial energy use, while petroleum refining energy use decreases (NZA 71).

<u>Key Takeaway:</u>

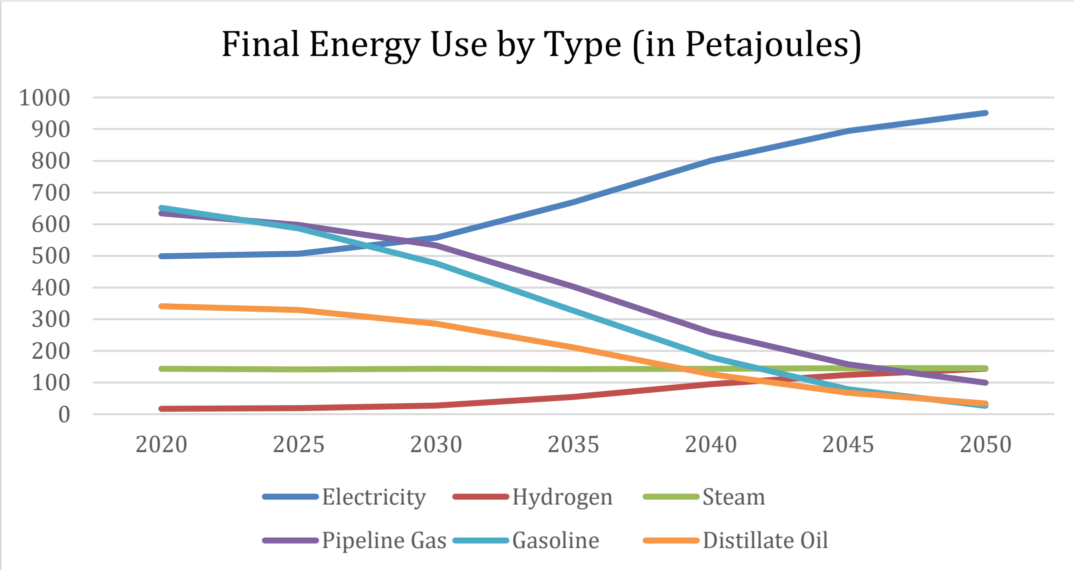
1. Industrial sector energy demands only decrease by 1% compared to current models, while use in electricity and hydrogen increases over liquid gas use.

Final Energy Use

How Ohioans use energy will change dramatically. By far the most significant decrease in energy use will be in transportation. Again, this highlights the impact of transitioning to EVs. Reflecting the required changes in residential heating and cooking, residential energy use will need to decline by over 50% by 2050.



Unsurprisingly, electricity as the final energy type increases dramatically at the expense of pipeline gas and gasoline.



Economy-wide Electricity Demand and Demand-Supply Balancing

Nationally, end use demand for electricity will grow about 90% in E+ scenarios which is driven by a large increase in electrification of transportation and heating (NZA 75). In fact, the *total* electricity demand (which includes electricity for industrial processes) more than doubles by 2050 across *all* five scenarios to net-zero. For Ohio end use demand grows 81% (as measured by peak electricity distribution load).

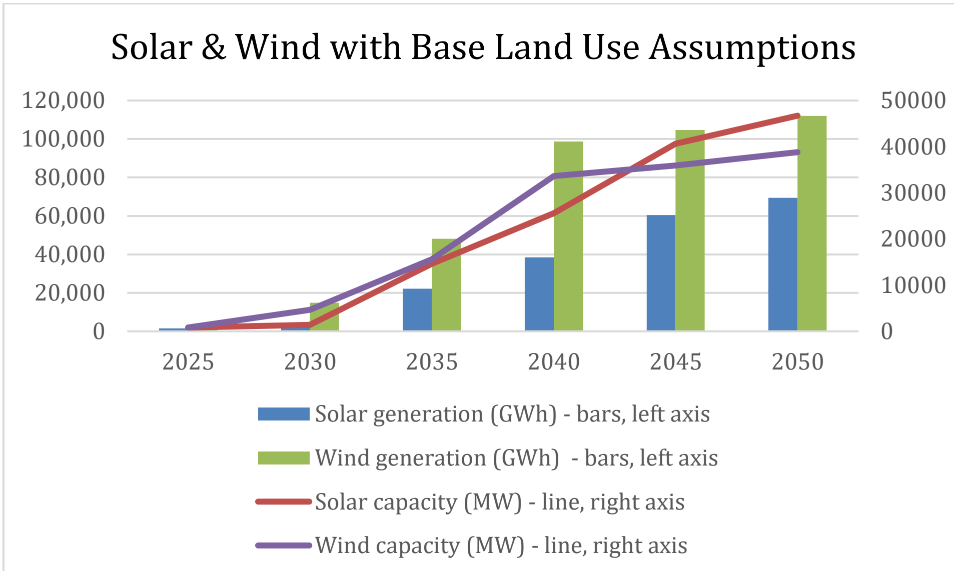
With an increased reliance on electricity Ohio will need to get creative in establishing best practices to ensure continuous balance between supply and demand. For example, to compensate for any variability in wind and solar power there must be flexible scheduling of things like EV charging and electric water heating, large intermediate flexible loads, batteries, and firm generation technologies (NZA 75). The grid battery capacity must also be developed to handle flexibility of capacity during the day in 5-7 hour storage intervals to handle intraday flexibility (NZA 84). These numbers are based on estimates for the United States but could be adaptable to Ohio: the average duration of battery capacity must last for 6.7 hours and the installed capacity of batteries must increase to almost 180 gigawatts by 2050 (NZA 84).

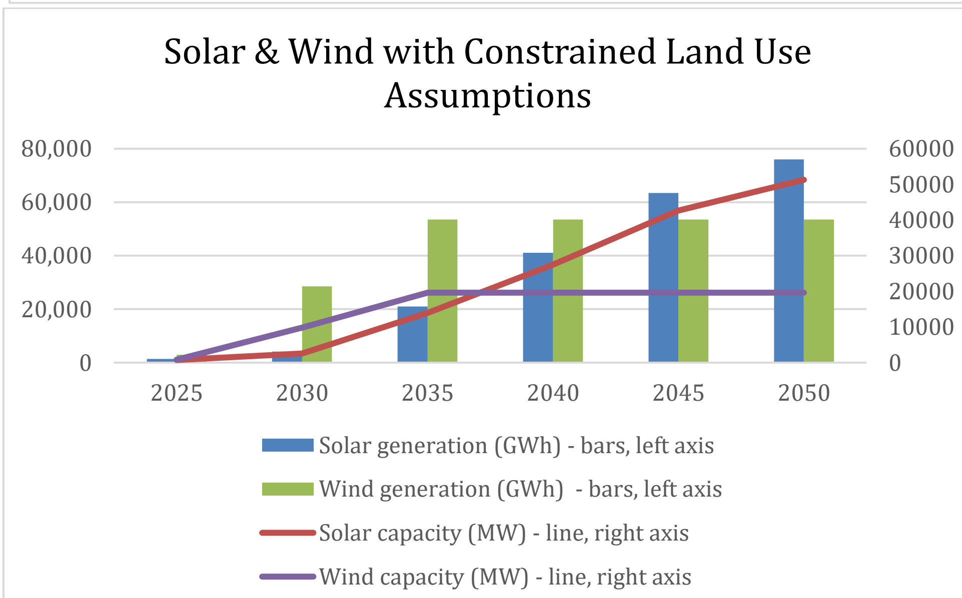
<u>Key Takeaways:</u>

1. An increased demand for electricity means that there must be creativity in grid utilization, and Ohio will need to develop battery capacity.

CLEAN ENERGY

"Expanding the supply of clean electricity is a linchpin in all net-zero paths." (NZA 87) Regardless of which portfolio of policies Ohio chooses, Ohio will need solar and wind power. The Net Zero report derives its recommended clean energy amounts based not only on demand, but also on restrictions on where solar panels and wind turbines can be placed—i.e. land use assumptions. For example, utility scale wind farms will not be built in heavily populated areas or within 3km of an airport. The Princeton report provides numbers based on two different sets of land restrictions—base land use assumptions and constrained land use assumptions. The latter is more restrictive than the former. The details of the land use assumption and other siting details should be referenced in the report. Below, we give the generation and capacity trajectories for the two different land use assumptions.





<u>Key Takeaways:</u>

1. Ohio's wind energy on base land use must see a 563% increase in GWh production from 2030 to 2040 and a 13.6% increase from 2040 to 2050. Wind energy on constrained land

use must see a 87.38% increase in GWh production from 2030 to 2040 with no increase from 2040 to 2050.

2. Ohio's solar energy on base land use must see a 1,520.64% increase in GWh production from 2030 to 2040 and an 80.62% increase from 2040 to 2050. Solar energy on constrained land use must see a 903.61% increase in GWh production from 2030 to 2040 and a 84.92% increase from 2040 to 2050.

Power Plant Transitions

Under the report's scenario, all existing nuclear plants can operate through 80 years when safe to do so (NZA 87). As mentioned earlier, Coal power is to be phased out by 2030. Picking up the slack will be renewable energy sources. Therefore, insofar as the expansion of wind and solar is constrained (e.g. by land use restrictions), then nuclear and CO_2 capture will need a second look (NZA 87). Gas power plants will *not* be eliminated entirely, though older plants may need to be retired. Combustion turbines and combined cycle plants with carbon capture will be required. The siting of plants with carbon capture requires close attention to infrastructure that can transport and store CO_2—the development of which is itself an infrastructural feat that requires planning and investment.

When the nuclear power plants are ready to be retired they can then be redeveloped as new zero-carbon thermal power plants (NZA 339). This provides a good opportunity for Ohio to preserve the jobs that may otherwise be lost after the nuclear power plants shut down- when those sites are changed to zero-carbon thermal power plants job prospects can still be increased through this new development.

<u>Key Takeaway:</u>

1. All nuclear power plants in Ohio need to be inspected to see how long they will be safe to operate (up to 80 years) and a retirement plan must be created for the sites.
2. Coal will be phased out by 2030.
3. Newer gas power plants will need to be considered.

BIOMASS ENERGY

To achieve net-zero carbon emissions by 2050 Ohio will rely on biomass as an energy source and as a means to produce hydrogen for fuel cell power. The biomass supply "consists of agricultural and forest residues, plus transitioning land area growing corn for ethanol to growing perennial grasses or equivalent for energy. This supply scenario thus includes no conversion of land currently used for food or feed production." (NZA 200) Biomass has low net-emissions because growing it removes CO_2 from the atmosphere. Adding carbon sequestration to process of producing biomass derived fuels can result in negative-net emissions.

Somewhat surprisingly the NZA's High Electrification pathway does not see biomass ramp up in Ohio as heavily as one might expect given the availability of biomass in the Buckeye state. Policy makers would be wise to consider ways to utilize biomass, especially as Ohio corn-derived ethanol will phase out as electric vehicles phase in. Leveraging biomass in ways not anticipated by the high electrification pathway can give policy makers some wiggle room in how they approach some of the other more challenging areas requiring reform.

Nevertheless in our pathway Ohio does make investments in biomass, but they are more marginal and only kick in later. Ohio can anticipate purchasing $402 million of biomass by 2045 and $1.858 billion by 2050 (Ohio State Report 3). Ohio also needs to focus on conversion capital investment in “bioenergy with carbon capture and storage” (BECCS) facilities that can not only produce energy while capturing carbon, but may also have potential for Hydrogen production. The report anticipates over roughly $28 billion in investments between 2040-2050 (Ohio State Report 3).

Transporting the biomass long distances is expensive. The Princeton report focuses on locating biomass conversion facilities near areas of higher biomass supply and—for facilities that capture CO_2—near CO_2 storage and transport pipelines. (NZA 208)

Biomass has the potential to produce hydrogen fuel Around 2030, Hydrogen production coupled with carbon capture should begin to see a rise and continue for the next 20 years in Ohio (becoming the biggest source of biomass-energy by 2040). The combination of using bioenergy (H_2) and carbon capture and storage is favored in our pathway. By 2045, about 16 facilities with the capabilities to produce H_2 biomass energy with carbon capture should be in Ohio. By 2050, that number should jump to about 50 facilities (NZA 214-215).

Key Takeaways:

1. Ohio must begin to rely on biomass as an energy source by investing $27 billion throughout the 2040s in biomass and focusing on Hydrogen production and carbon capture.
2. Farmers can profit from the sale of biomass. By 2050 Ohio should expect to see 50 H_2 biomass energy and carbon capture facilities which will create more jobs.

CO_2 CAPTURE, STORAGE AND TRANSPORTATION

Capturing CO_2 from fossil fuel burning processes is important in all of the scenarios run by Princeton. This will require a good deal of new infrastructure, and for Ohio the bulk of investment lies with CO_2 pipelines. By 2030, around 300 miles of pipeline should be constructed. This will increase to 1260 miles of pipeline by 2050.

Around 2026-2030, Ohio should have a major trunk line constructed running east-west along northern Ohio for delivery of CO_2 to storage basins in Indiana and Illinois. (Ohio will not be a destination for the storage of CO_2.) The Princeton report estimates the trunk line to cost $1.56 billion. From 2041-2045 the first bioenergy with carbon capture and storage (BECCS) plant should be expected to appear in Ohio. Additional spur lines will connect these plants to the main trunk line at an additional cost of roughly $1.5 billion.

Ohio will end up capturing millions of metric tons (MMT) of CO_2. On an annual basis, all CO_2 capture should reach 7.93MMT by 2045 and 36.7MMT by 2050 (362.8% increase from

2045). These numbers for Ohio come entirely from BECCS, so it is possible for policy makers to expand on these numbers by increasing the sources from which they capture CO_2.

Key Takeaways:

1. Ohio must construct CO_2 pipelines (spurlines and trunklines) for the carbon capture, utilization, and storage plan. Ultimately 1260 miles of pipeline will be required.
2. Ohio will require a total investment of over $3 billion in CO_2 pipeline construction.
3. Ohio's CO_2 capture and transport will start to come online by 2045 and really ramp up by 2050. There is opportunity for innovation here in expanding the sources of CO_2 captured.

LAND SINKS – AGRICULTURE & FORESTS FOR CARBON CAPTURE

"Land sinks" refer to how the land can absorb carbon through vegetation and soil. Utilizing land sinks takes away some of the pressure of mounting manmade carbon. Ohio should continue to develop land sinks today. That being said, the Princeton report only records data for Ohio for 2050, and the report separates out the sink potential for agriculture and forests.

Agriculture land sinks with aggressive deployment have a total carbon sink potential of -6.932 million tCO_2e/y with the total land impacted for carbon sink equaling 4.44 million hectares (Ohio State Report 4). With *moderate* deployment, the total carbon sink potential equals -4.245 million tCO_2e/y and the total land impacted for carbon sink equals 2.578 million hectares (Ohio State Report 4). The moderate deployment is 61% of the aggressive posture.

In terms of forest land sinks, in a high potential scenario all methods (e.g. reforestation, retention of harvested wood products) have a total carbon sink potential of -21.474 million tCO_2e/y which means that in forested regions dedicated as land sinks the vegetation and soil will be taking almost 22 million tons of CO_2 out of the atmosphere. The total land impacted for carbon sink potential (over 30 years) is 3.362 million hectares (Ohio State Report 5-6). In a mid potential scenario, all methods have a total carbon sink potential of -13.699 million tCO_2e/y with the total land impacted for carbon sink potential (over 30 years) being 2.902 million hectares (Ohio State Report 5-7). In a low potential scenario, all methods (not counting overlap) have a total carbon sink potential equaling -5.927 million tCO_2e/y with the total land impacted for carbon sink potential (over 30 years) equaling 1.696 million hectares (Ohio State Report 5-6).

	Sink Potential (millions tCO_2e/y)	Land Affected over 30 yrs (millions hectares)
Agricultural Sinks – Aggressive	-6.932	4.439
Agricultural Sinks – Moderate	-4.245	2.588
Forestry – High Potential	-21.474	3.362
Forestry – Mid Potential	-13.699	2.902
Forestry – Low Potential	-5.927	1.696

For perspective, in 2018 Ohio emitted 208 MMT of CO_2 (EIA). With the aggressive agricultural and high potential forestry scenarios, Ohio could knock off over 13% of its emissions.

To unlock the potential for land sinks Ohio must put laws in place to modify how agricultural and forestry land is used and maintained (NZA 258). Forests must be protected, enhanced, and allowed to mature for there to be the maximum amount of CO_2 removed from the atmosphere. Similarly, agricultural practices must be modified along the lines of utilizing biomass growth to have a higher potential amount of carbon extracted from the atmosphere. This is especially important when decreasing the corn for ethanol production and instead growing biomass which absorbs more CO_2 from the atmosphere.

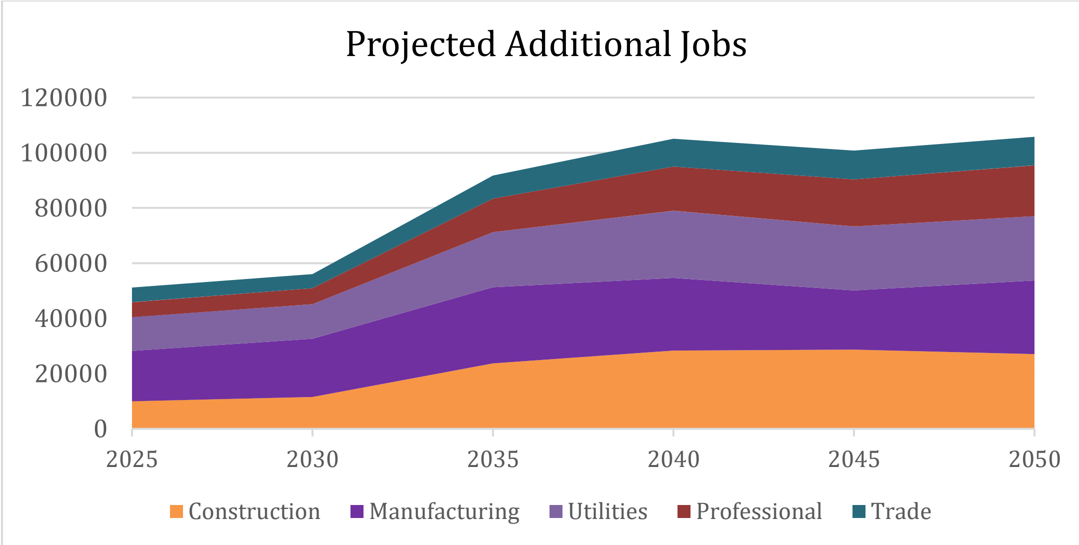
Land carbon sinks "are critical for net-zero emission scenarios, because they offset positive greenhouse gas emissions from elsewhere in the economy" and "...land sinks avoid using the most costly measures for CO_2 emissions reductions in the energy/industrial system" (NZA 57). Policy makers must keep in mind that if the CO_2 emission goals fall short there needs to be additional carbon sequestration done to offset these emissions. Ohio has a lot of natural carbon sink potential, and, consequently, we recommend more aggressive approaches to developing land sinks so as to provide overall resiliency to the net neutral plan Ohio pursues.

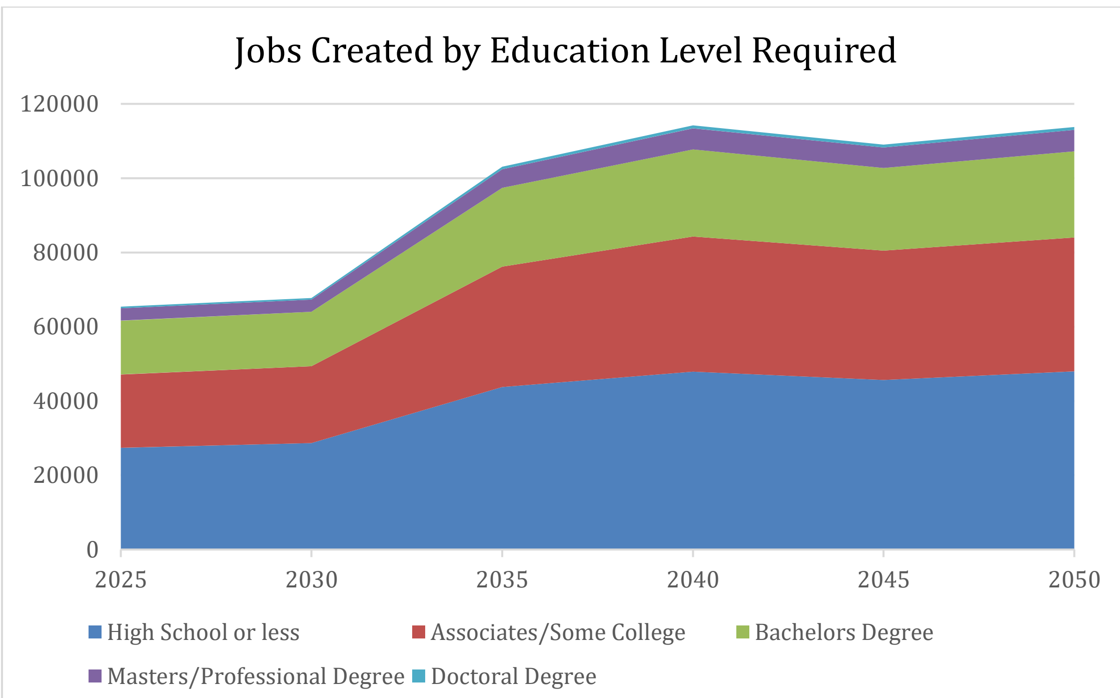
Key Takeaway:

1. Intentional agricultural and forestry practices are essential to capturing CO_2 from the atmosphere.
2. Aggressive approaches can "buy" Ohio more slack in the pursuit of reducing CO_2 emissions in the energy and industry sectors. Ohio could potentially capture over 13% worth of its 2018 emissions.

JOB IMPACTS

Net job losses should be offset by increases in other—e.g. low carbon—sectors. Natural gas, oil, and coal jobs will decrease. However, wind, solar, biomass, and grid jobs will increase. Ohio should see an increase in construction, manufacturing, professional, and utilities jobs. Agriculture jobs will increase slowly at first, lull, and then majorly increase by 2050. Additional pipeline jobs can be expected, but will not be significant. Below is a projection of additional jobs by the top-impacted sectors for Ohio according to the Princeton modeling. The additional jobs will require a variety of educational backgrounds. There is opportunity across the board.





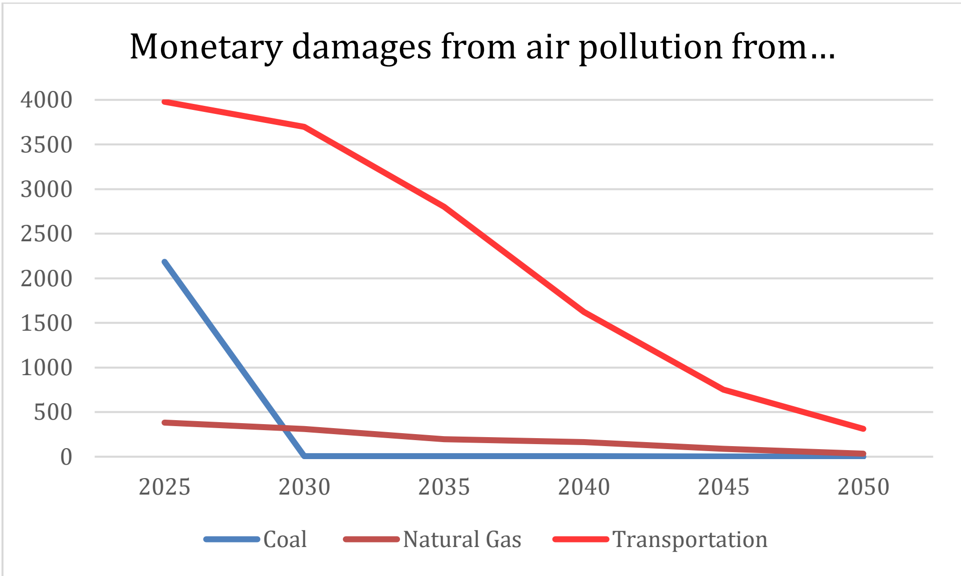
The Princeton report emphasizes that in order to take advantage of employment potentials, Ohio should craft policies (e.g. occupational skills training, job placement assistance) to ease transitions, avoid bottlenecks, and ensure equity of opportunity.

<u>Key Takeaways:</u>

1. Ohio jobs in fields such as construction, manufacturing, biomass, solar, and wind sectors will increase while jobs in coal, mining, and natural gas jobs will decrease.
2. There will remain jobs that require a diversity of educational backgrounds.

HEALTH IMPACTS

In addition to positive economic benefits, all net zero pathways will have a positive impact on the health of Ohioans. Consider the amount of lives saved by reducing air pollution. Premature deaths from coal air pollution will fall dramatically with 247 in 2025 to *less than one* in 2030 and thereafter. Premature deaths caused by natural gas air pollution will similarly decrease from 43 in 2025 to 4 in 2050. Premature deaths that are caused by transportation air pollution will decrease from 448 in 2025 to 35 in 2050 (Ohio State Report 7). Monetary damages from air pollution will also decrease.



While the health benefits ramp up dramatically, the improvements are contingent on moving on the recommendations immediately.

<u>Key Takeaways:</u>

1. Health of Ohioans will be positively impacted in all net zero scenarios.
2. Premature deaths from and the monetary costs of air pollution will decrease substantially.

CONCLUSION AND FINAL THOUGHTS

Achieving net zero emissions by 2050 is critical to prevent catastrophic climate change. Ohio needs to do its part to help the country and the international community meet this goal. The Princeton *Net-Zero America* report tells an important story. Monumental changes are necessary, these changes need to begin now, and while the changes will be costly, there are also substantial benefits.

Our goal in writing this policy brief is to translate parts of the technical *Net-Zero* report into a more accessible format. The hope is that policy makers and other interested stakeholders will get a sense of what the original Princeton report has to offer and then read it with a closer eye.

We focused our attention on the report's "High Electrification" pathway. The future of Ohio will be one in which vehicles, residential buildings, and commercial enterprises are all "electrified." Ohio will make strides in renewable energy production and sustainable land use. While this plan is costly, the future benefits to health, job markets, and the environment make the investment worth it. We further recognize the work that Ohio has done partnering with small businesses and nonprofits to make the state more sustainable. While this work is not reflected in the Princeton study, we encourage lawmakers to continue to develop these efforts. All Ohioans need to work toward the net-zero goal.

For more information on the report and to find links to Ohio specific data, please visit:
https://netzeroamerica.princeton.edu/the-report

The International Energy Agency has also just released its own "Net-Zero" report which addresses the global energy sector. It can be found here:
https://www.iea.org/reports/net-zero-by-2050