

HIGHWAYS, HOMESTEADS, AND FIELDS:

*Imagining Scenarios
to 2050*

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INTRODUCTION TO THE SCENARIOS PROJECT

Pennsylvania's energy future...will not be determined by an all-seeing, all-knowing rational decision maker pursuing some optimal strategy.

Rather it will be the emergent consequence of many different parties each pursuing their own objectives, responding in ways that are shaped by a variety of local and national incentives and legal and regulatory frameworks.

That means that shaping the future environment in which these many parties operate is probably more important than laying out any specific storylines about the mix of energy sources, uses and technologies.

**PROFESSOR M. GRANGER MORGAN, CARNEGIE MELLON UNIVERSITY
SCENARIO WORKSHOP, SEPTEMBER 18, 2024**

During a twelve-month period beginning in 2017 and culminating in 2018, a group of Pennsylvanians representing a wide range of backgrounds and expertise was convened by the Team Pennsylvania Foundation to answer the question, “How might Pennsylvania’s energy system evolve in 25 years, and what might it mean for Pennsylvanians?” Their work culminated in a document developed using scenarios methodology – *Pennsylvania Energy Horizons*, also known by the scenario names, *Rivers and Roots*.

Throughout 2019 the Energy Horizons Project hosted sessions across the commonwealth with a range of stakeholders – governments, associations,

nonprofits, businesses, and universities – to spark conversation, gain critical input, and arrive at a common understanding that would help shape Pennsylvania’s long-term energy future. We intend to do the same with this set of scenarios.

Much has changed since our 2018 publication.

A “black swan” event in the form of the global COVID-19 pandemic, has had a profound impact on society. And changes have also occurred across the entire energy landscape, including in technology, the economy, society, and government leadership. The Pennsylvania business environment has also changed,

INTRODUCTION TO THE SCENARIOS PROJECT

with a renewed focus on being “open for business.” With the possibility of federal funding for new technology opportunities, there is a strengthened desire among business and government leaders to shore up supply chains, ensure adequate power supplies in the face of increasing demand from industry and consumers, and increase resiliency across all sectors.

Whatever position might be taken at a federal level on energy development and energy transition, we would have been interested in creating a more robust vision for the future of energy in Pennsylvania. The possibility of future dollars for investment means that we need to take a closer look at what the best use of those funds might be. What is the best future for energy in Pennsylvania? How can we ensure that we’re not simply looking at the dollars rather than where the energy future needs to go?

We have also used scenarios to ground the continued energy work at Team Pennsylvania which, since 2018, has

established the Energy Horizons Cross-Sector Collaborative— a statewide network that brings together leaders from industry, government, labor, nonprofits, and academia, all with a stake in the commonwealth’s energy, environmental, and economic future. A diverse and representative subset of the Collaborative’s participants was called upon to produce a new set of scenarios intended to reach a broader audience of business leaders and policymakers, within and beyond Pennsylvania given the Commonwealth’s critical role in meeting the nation and the world’s energy demands.

We hope these new scenarios—*Highways, Homesteads, and Fields*—will serve as a useful launching point for the creation of a new vision for the future of energy in Pennsylvania.

WHY SCENARIOS?

Scenarios are sets of usually two to four hypothetical futures intended to be used as the basis for strategic discussions. They differ from forecasts and policy proposals in that they do not claim to predict what will happen or what should happen but what could happen. Scenarios must be challenging, plausible, and clear in order to be useful.

Our choices and actions today have

already helped to shape elements of our collective future—even if we do not yet know which choices or actions will have been decisive. Can we identify these pivotal decisions? Imagine a flood occurring upstream that will affect us downstream two days into the future. What are the signs and signals that will alert us to what is coming, and what, if anything, can we do to prepare?

Scenarios often require us to look at the same events or circumstances from

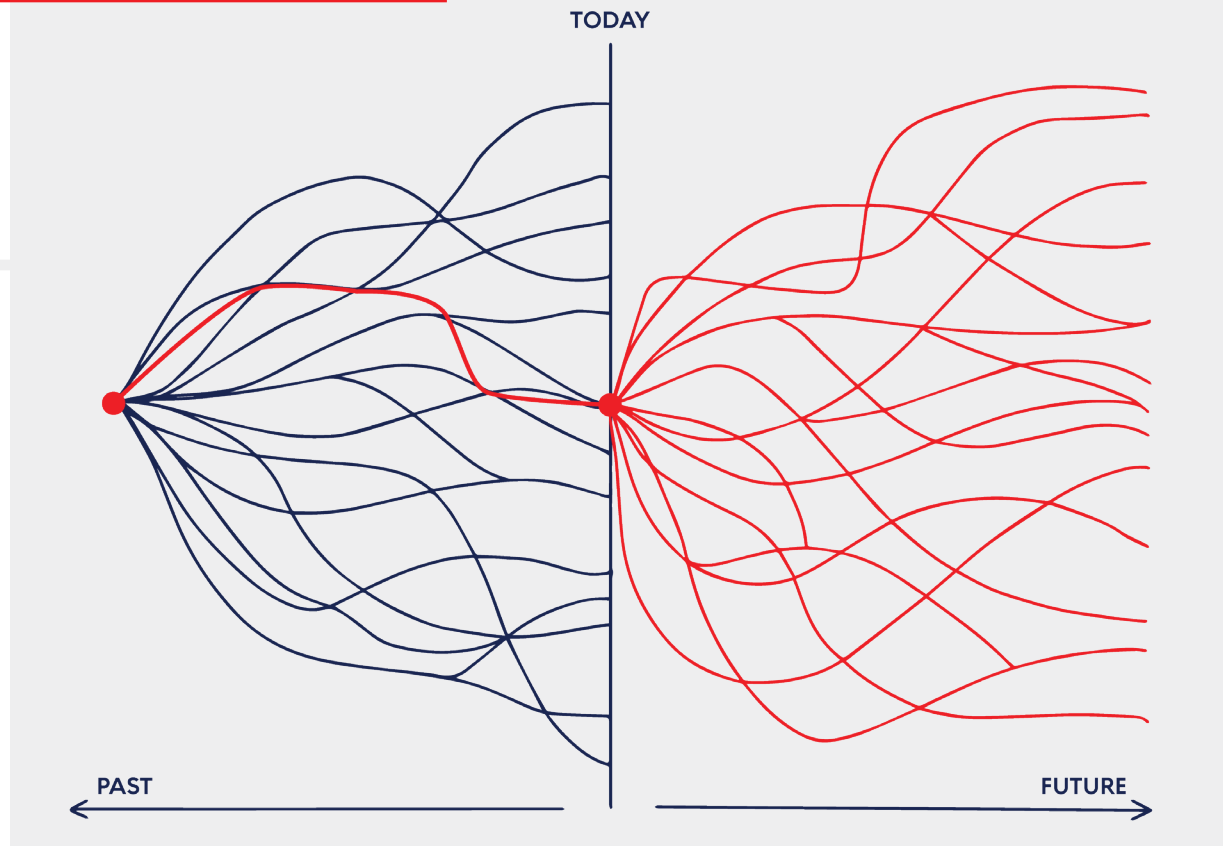
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different points of view. They challenge us to explore our daily transactional environment in relation to the larger contextual environment of the political, social, economic, technological, and environmental forces that impact us.

One of the most powerful functions of scenario work is to shake up the official version of the future that we always carry in our heads, whether we know it or not.

We are storytelling creatures but seldom realize that the unexamined story we hold about the future is always and only a fiction. When we contemplate equally plausible but mutually exclusive fictions, we begin to break the habit of holding our stories of the future as forecasts rather than fictions. And when we participate in a dialogue within different imagined worlds of the future, we create a space in which transformative ideas can emerge.

PATH CHOICE CHART



HOW TO USE THE SCENARIOS

Scenarios are foundations for strategic conversations. In these conversations, the aim is not to decide which is the most plausible future or even which is the most desirable future. The most useful question is “What would be our best course of action if this world turns out to be our future?” Of course, some of the best outcomes of a scenario project are the serendipitous ideas that arise from a conversation in which no

one has to speak from a policy position or choose sides or talk to win a debate.

Consider the questions below as conversation starters. The best conversations aren’t aimed at answering questions—they flow naturally, and insights emerge unexpectedly.

A NOTE ABOUT BLACK SWANS AND GRAY RHINOS

In addition to avoiding heaven and hell scenarios, scenario teams usually do not base stories on unpredictable catastrophic events (black swans) unless specifically asked to do so. A more productive approach could involve a limited amount of time responding to one or two events, whether black swans or simply gray rhinos (probable events with high but uncertain impacts and timing) by asking what effect they would have in each scenario world. Examples of these creatures might include: a new global pandemic; the repeal of all or most environmental laws in the U.S.—perhaps in tandem with significant carbon taxes imposed by European nations; the introduction of a game-changing new energy technology like commercial fusion or molten salt nuclear reactors; or global mercantilism—a tariff-based global trade regime.

PENNSYLVANIA ENERGY: WHAT WE KNOW ABOUT THE PRESENT AND DON'T KNOW ABOUT THE FUTURE

**SETH BLUMSACK, CO-DIRECTOR, CENTER FOR ENERGY LAW AND POLICY,
PENNSYLVANIA STATE UNIVERSITY**

PENNSYLVANIA'S REGIONAL ENERGY CONTEXT

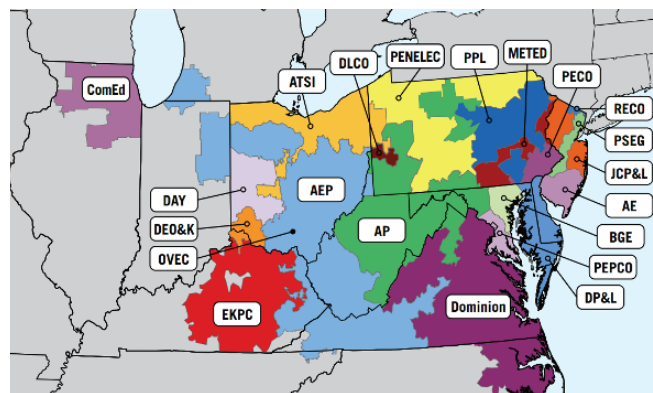
Pennsylvania is, and has been for some time, a major energy state. The commonwealth is the second largest overall energy-producing state in the U.S. and the second largest producer of natural gas. Pennsylvania is also routinely among the top three states for electricity production and is one of the largest producers of electricity via nuclear energy. Currently, nuclear and natural gas make up the bulk of electricity generation in Pennsylvania.

Despite the decline in the use of coal for electricity generation, Pennsylvania remains a major coal-producing state. Among states east of the Mississippi River, Pennsylvania ranks fifth in wind energy capacity. Annual wind energy production in Pennsylvania is the second-highest among states on the Eastern Seaboard. Yet even though Pennsylvania is a significant eastern wind-producing state, the role of renewable energy in Pennsylvania's overall energy mix is low.

Pennsylvania's energy sector is not an island – the commonwealth is an integral part of regional energy distribution systems and is

a major exporter of energy to surrounding states, particularly natural gas and electricity. Pennsylvania has long been the largest exporter of electricity in the United States and is the second largest exporter of total energy (fuels and electric power together). Pennsylvania's power generation and transmission infrastructure is part of the multi-state Pennsylvania-Maryland-New Jersey Regional Transmission Organization (RTO), PJM Interconnection LLC (PJM). PJM manages the flow of electricity throughout its footprint, which includes all or parts of thirteen states and the District of Columbia.

PJM ZONES



Source: PJM Interconnection

While most of Pennsylvania's electricity exports involve transfers to other states

that are part of PJM, it does export some electricity outside of the PJM footprint, particularly to New York. Pennsylvania's Alternative Energy Portfolio Standard (AEPS), which mandates that utilities purchase or generate a minimum amount of renewable- and low-carbon electricity, was enacted in 2004 and has been updated several times over the past two decades before plateauing in 2021. Governor Shapiro's administration has proposed a successor policy to the AEPS that would increase the amount of electricity from clean or alternative energy resources by 2035. While the details of these standards vary by state, the majority of states within the PJM footprint have adopted some sort of clean or alternative energy target or goal focused on electricity production.

Pennsylvania's energy system exists in a context of federal rules and regulations that affect electricity movement, air quality, interstate pipeline siting, the demand for Pennsylvania natural gas for export, and many other things. The Infrastructure Investment and Jobs Act of 2021 and the Inflation Reduction Act of 2022 budgeted billions of dollars to incentivize and accelerate the deployment of clean fuels, low-carbon electricity, and emissions mitigation strategies such as carbon capture, utilization, and storage (CCUS). However, the results of the recent national

election have also led to uncertainty about the future of these programs. Sustained national and international demand for US petroleum products and natural gas suggests that traditional energy businesses will continue to underpin key sectors of the global economy for the foreseeable future.

PENNSYLVANIA'S ENERGY FUTURE

The future of energy in Pennsylvania will be influenced by a highly diverse set of drivers, including developments in technology, markets and policy. Because of Pennsylvania's position as a major producer and supplier of energy and electricity to other states, and its participation in regional networks for the distribution of energy and electricity this energy future will also be influenced by policy decisions that are made in other states or at the federal level (in terms of broader energy policy and because PJM is regulated by the Federal Energy Regulatory Commission and not individual states). Changes in the nature of energy and electricity demand that are part of the broader process of energy technology transition are also likely to influence Pennsylvania's energy sector even if those changes happen most starkly in other states. These factors are also highly uncertain, which complicates the process, but helps underscore the need for developing specific scenarios about the future of energy in Pennsylvania.

PJM — PENNSYLVANIA'S REGIONAL TRANSMISSION ORGANIZATION

Pennsylvania's electricity grid is part of a multi-state regional power transmission network known as the "PJM Interconnection." PJM is a federally-regulated Regional Transmission Organization (RTO) whose operational footprint spans all or parts of thirteen states plus the District of Columbia, as shown in the figure. PJM is one of several RTOs that were established in the late 1990s and early 2000s through a process of industrial reform and deregulation in the electric utility sector. PJM began nearly a century ago, in 1927, as a coordination agreement between Pennsylvania and New Jersey. Utilities in Maryland joined three decades later, giving PJM its original name as the "Pennsylvania-New Jersey-Maryland" interconnection.

As an RTO, PJM is responsible for the reliable operation of the high-voltage power transmission system within its footprint. It manages regional power lines and a large portfolio of power plants in order to maintain grid reliability. PJM manages grid reliability as a neutral not-for-profit network operator and does not own any physical grid assets such as power lines or power plants. In order to procure power generation capacity to meet demand, PJM uses a variety of market mechanisms that are designed to encourage investment and also to encourage power-plant owners to make

their capacity available to meet electricity demand on a real-time basis. PJM's role is limited to management of the bulk power supply system; it is not involved in the retail sale of electricity to households and businesses.

PJM is one of the largest electricity commodity marketplaces in the world, meeting a peak demand of over 165,000 Megawatts (MW) of power, and serving more than 65 million people in the Mid-Atlantic region and the entirety of Pennsylvania. PJM manages a large power generation portfolio of more than 180,000 MW of generation capacity and over 88,000 miles of transmission wires. PJM's power generation fleet consists mostly of natural gas and nuclear power. As a state, Pennsylvania is the largest supplier in PJM and is a major exporter of electricity to other states within the PJM territory.

PJM's markets and operations are regulated by the Federal Energy Regulatory Commission (FERC). While individual states such as Pennsylvania do not have any formal regulatory oversight of PJM, they are involved in the development of market and planning rules. Pennsylvania, through the public utility commission, still retains regulatory oversight of retail electricity sales and the siting and permitting of electricity infrastructure.

THINKING ABOUT THE FUTURE: DRIVERS & UNCERTAINTIES

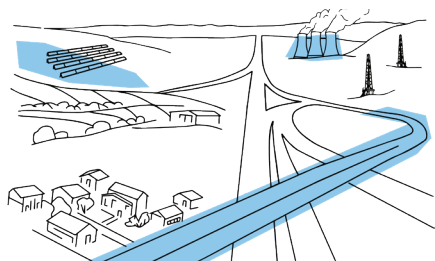
DRIVERS COMMON TO ALL SCENARIOS

- Pennsylvania as energy leader
- Aging native population
- Regional competition
- Need for a just energy transition
- Need for economic growth
- Technology development, including AI
- Primacy of natural gas

UNCERTAINTIES THAT PLAY OUT DIFFERENTLY IN EACH SCENARIO

- Political leadership and alliances
- Urban-rural relationship
- Speed of energy transition
- Rate of economic growth
- Carbon emissions
- Speed and type of technology development
- Population migration into/out of Pennsylvania
- Focus of competition

PENNSYLVANIA ENERGY SCENARIOS TO 2050: OVERVIEW



Highways is a scenario in which the energy transition lurches from a slow start to a sudden acceleration, managed by a short-term, top-down approach with unintended economic consequences.

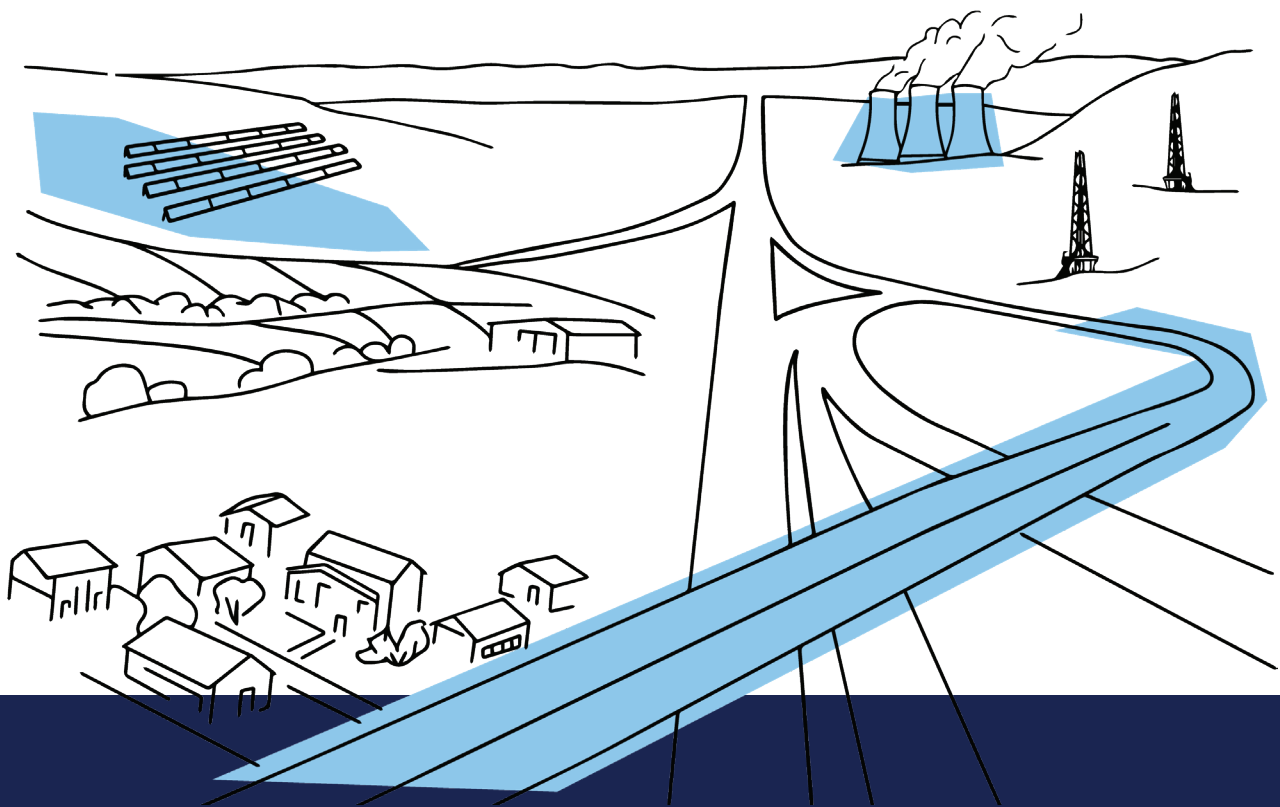
In **Homesteads**, the locus of energy policy and activity moves from the state level to a local and regional level.



Fields is a scenario in which economic strategy takes precedence over energy strategy.

COMPARISON OF THE SCENARIOS

	HIGHWAYS	HOMESTEADS	FIELDS
Policy focus	Energy transition	Local well being	Economy
Lead actor	State government	Regional partnership	State government working with business
Social and political environment	Polarized constituencies	Local civic leaders	Growth-oriented workers and consumers
Annual production of carbon emissions	Up, then suddenly down, then gradually up	Variation from region to region, with an overall reduction in emissions	Short-term rise followed by a slow trajectory downward, then steady as demand grows



HIGHWAYS

Unreasonable haste is the direct road to error.

MOLIÈRE

Highways is a scenario in which the energy transition lurches from a slow start to a sudden acceleration, driven by a short-term, top-down approach with unintended economic consequences.

2025–2030: SPEEDING UP

The growth of artificial intelligence (AI), with its enormous need for power, the disruption of Russian gas to Europe, the revival of domestic manufacturing, and federal legislation that encourages oil and gas production—these and many other factors lead Pennsylvania to double down on fossil fuels. Concerns about reliability of the power grid lead to market and

planning protocols that encourage further investments in natural gas power plants. Shale gas production in the Marcellus Formation is significantly increased, and Pennsylvania’s outsized role in the regional energy economy shows no sign of decreasing, even in spite of regulatory barriers set up by contiguous states.

The Pennsylvania economy also takes off, with new data processing centers and high-tech industries. And with multiple power-hungry projects come announcements of large, behind-the-meter power supply installations—ten or more GWs in the first five years, with

HIGHWAYS

more to come. Many of these initial announcements involve a minimum of low-carbon or zero-carbon technology such as nuclear energy, solar, and battery energy storage. Simultaneously, the lagging demand for H2/CCUS technologies prevents the full development of Pennsylvania's two hydrogen hubs in the east and the west. While the market begins to favor more economical low-carbon technologies, their readiness is tested by various large energy users' continued reliance on smaller gas turbines to meet their demands.

As energy supply and demand both grow, the need for expanding the energy infrastructure becomes increasingly clear. And this raises the question: should the needed investments in new energy infrastructure be geared towards gas supply and demand, or towards renewables?

2030-2035: SLOWING DOWN AND FALLING BEHIND

With the economy apparently going well—at least in the short term—there are few incentives to make major changes or do any long-term planning around energy goals beyond meeting rapidly growing demand. In some parts of the state, opinions about Pennsylvania's new high-tech economy are decidedly mixed. Rural communities, in particular, have seen few economic rewards in hosting nearby development or the buildout of infrastructure, or even indirect benefits, such as upskilling opportunities. Whatever benefits result from new infrastructure being built across their land seems to be felt in other parts of the state. Costs for electricity in particular

have risen amid growth in industrial electricity demand. Although urban centers like Pittsburgh and Philadelphia have generally benefited, a significant number of Pennsylvanians continue to struggle gaining access to affordable energy and economic opportunities. Resentment is rising over the perceived economic costs of the new economy, and the feeling that benefits go largely to a more exclusive, high-tech elite.

By 2030, the original economic boom of the previous decade has begun to slow. A not-in-my-backyard (NIMBY)-based cross-political movement leads to the election of development-skeptical legislators to Harrisburg, further stifling any movement to alter the direction of Pennsylvania's fossil-fuel-based energy system by investing in new infrastructure for renewables. At the same time, surrounding states appear poised to take a substantial lead both in terms of the energy transition and in attracting investment and creating jobs in the industries of the future. The share of gas in the national energy mix is smaller as low-carbon and renewable sources of energy become even more cost-effective and in high demand. As a result, Pennsylvania's focus on natural gas becomes even less attractive to investors. New modular nuclear technologies are especially significant—and almost completely overlooked in Pennsylvania, partly as a result of the lack of new modular nuclear technology incentives as well as the lingering memory of the Three Mile Island incident.

Surrounding states are not interested in building new pipelines or upgrading

other fossil fuel infrastructure and are highly successful at placing restrictions on new fossil fuel development as well as infrastructure for fossil fuel export. Meanwhile, in Pennsylvania, even though environmental awareness is growing, the long-term dependence on shale gas makes any move towards an energy transition extremely difficult. The state has a long way to go to increase renewables in its energy mix.

By 2035, the effects of climate change are felt across the globe. In Pennsylvania, a lot of indecisive commentary at all levels keeps circling around the same questions: we need to increase the speed of our energy transition, but what should we build? Should we allow for a particular type of energy development versus another type of energy development? What laws should we pass? What incentives should we create?

2035-2040: OFFRAMP TOWARDS A NEW DIRECTION

Beginning in 2035, a new generation of leaders comes to power in Pennsylvania, eager to address the issue. These leaders feel they have a strong mandate: rapid, economy-wide decarbonization is an existential priority, renewable energy can and must power Pennsylvania's economy, and Pennsylvania must shift gears to pursue a careful growth trajectory that prioritizes economic and environmental justice for energy communities alongside statewide competitiveness for federal investment and major industrial projects.

By 2040, four aspects of the energy system have become increasingly apparent:

1. Higher in-state energy costs have discouraged the growth of business development seen in nearby states.
2. Reliability issues have increased, in part because so much base load has been directed towards large energy consumers, like data centers, without concomitant capacity being built.
3. The buildout of new clean energy has been too slow, especially because of the relative lack of interest in SMRs.
4. The number of new decentralized power solutions has increased.

The new generation of leaders introduces many top-down reforms, including strict mandates for the power generation mix, introducing statewide requirements for the electrification of new single-family homes, setting targets and funding based on political priorities, and in other ways pushing energy-prescriptive solutions. One reason for the speed with which these reforms are put in place is the widespread feeling that Pennsylvania is behind its neighbors and so must take drastic steps in the short term in order to catch up.

The end result is mixed. Some new projects get built, and some goals for energy transition are realized. A number of successful projects have been built; but there are also failures. A huge amount of money has been spent in a hurry, not always effectively. In addition, there are growing grid reliability and resilience issues that discourage potential investors. And because local communities have not been a part of the planning process, they resist new rules that seem to ignore their best interests. Many new projects grind to a halt at the local level.

As has happened in other states and with other rules—or lack of rules, in some cases—, unintended consequences of new rules pile up. For example, new efficiency requirements on housing construction exacerbate Pennsylvania’s affordable housing crisis and contribute to growing inequality. Ironically, one such consequence is a marked decrease in public support for the energy transition and other environmental causes.

2040–2050: CRISIS AND COURSE CORRECTION

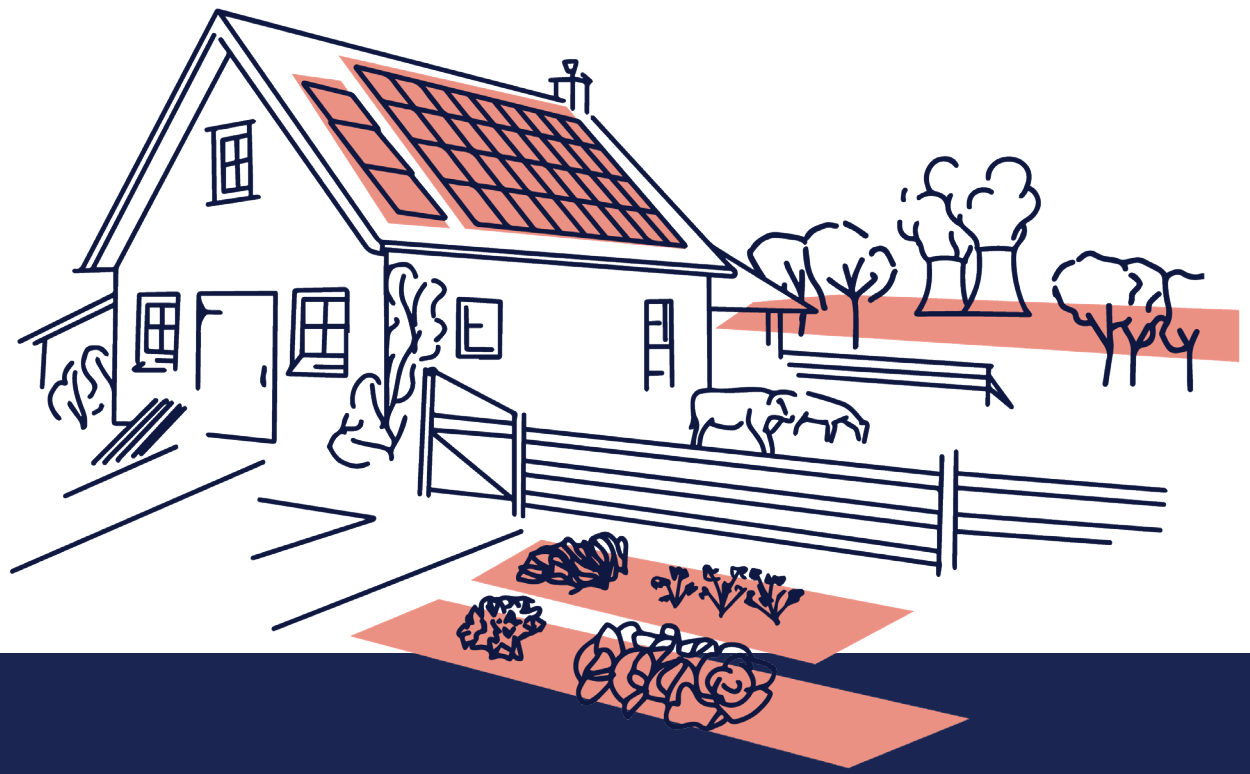
Dissatisfaction continues to build. Rural and exurban communities have long opposed the expansion of wind and solar and have often complained that the targets for phasing out gas are difficult for many people to meet. These communities bridle under the additional requirements for EV sales—there is neither budget nor interest to support charging stations, especially in rural areas, and there are not enough used and low-cost EVs for Pennsylvanians in these areas to choose them over traditional ICE vehicles.

In addition, although mandates and limited tax incentives have been adopted in an attempt to increase the supply of renewable electricity, fundamental problems in the development process, which prevent new energy projects from being built (permitting reform, public objection, prioritization of projects, allocation of costs among various ratepayers, etc.), are left unaddressed. Investors argue that in the long term, renewable technologies will continue to advance, and community resistance will decrease. But in the short term, most announced energy projects do not attract experienced developers or committed partners and never come to fruition. Project

announcements dry up after only one or two years, and very few of those that are announced ever break ground.

The build-out of upstream energy infrastructure is effectively blocked, leading to fewer jobs in that sector. Support for the energy transition suffers when selected winners don’t succeed. In addition, the cost of accelerating decarbonization is higher than expected.

In 2048, unexpected power outages resulting from a dramatic increase in demand lead to a political backlash and the establishment of a commission to examine “What went wrong and what can be done about it?” The commission is created very deliberately to include representatives from all sectors and regions of society, including from both urban and rural geographies. The final report praises the approach state leaders had taken; but it also criticized the speed in which the targets and initiatives had been designed and implemented, the unrealistic expectations, and the top-down nature of the decision-making. The commission concludes that had there been more thought and foresight in strategic long-term planning and more flexibility in the implementation, a better outcome would likely have been achieved.



HOMESTEADS

Homestead:

- a: the home and adjoining land occupied by a family;*
- b: an ancestral home*

MERRIAM WEBSTER

In Homesteads, the locus of energy policy and activity moves from the state level to a local and regional level.

2025-2030: A NEW HOMESTEAD MOVEMENT

In the late 2020s, young adults who had left the state begin to return to Pennsylvania to establish homes and families, even in historically low-growth regions outside Pittsburgh and Philadelphia. One reason for this backward migration is that in a time of increased AI and remote work, employees don't need to live in the big cities where their employers are located. Another driver is an aging population in greater

need of care – both for themselves and the communities and institutions they have built for the past many decades. The quality of life in smaller towns and more bucolic regions, as well as the lower cost of housing, lead young professionals to reinvigorate what had been regarded as hollowed-out towns, especially in the old coal country. This trend is further accelerated by popular movies and television series in which high-income knowledge workers in cosmopolitan settings are no longer held up as high-status role models.

Pennsylvania itself is especially attractive during this time thanks to cultural events

HOMESTEADS

like the All-Star game, the FIFA World Cup, the NFL draft, and the celebration of the 250th anniversary of the Declaration of Independence. In the celebratory atmosphere are tentpole cultural events in films, books and television shows that speak to the countrywide phenomenon of more and more families establishing multi-generational households to support aging parents. But even though Pennsylvania as a state has become more attractive, the real lure for these new homesteaders is the ability to create communities with a large degree of self-regulation and civic pride. In addition, there have been many newcomers to the region from foreign nations, resulting in a diversity of people that is attractive to young professionals, and which also creates a vibrant sense of culture in otherwise remote regions. It's not uncommon to find a Thai or Nepalese restaurant even in a small town.

Another factor contributing to this new homestead movement is the growing awareness of climate change as well as the effects of climate change itself. Water depletion in the American southwest, the growing threat from wildfires, and the increasing number of hurricanes hitting Florida and the Gulf are leading more retirees to choose Pennsylvania, with its many retirement tax advantages, reversing the trend of moving to the sunbelt.

The influx of young professionals quickly adapts to the local traditions of their commonwealth communities – a deep-seated spirit of republicanism with its decentralized town councils, county executive officers, and innumerable public corporations. In the past, these political

subdivisions had found themselves poorly resourced, understaffed, and unprepared for a time of statewide regional turbulence and change. When the manufacturing mainstays of smaller towns were sold or shut down or moved, the community members left behind felt they were losing control. They were too ill-equipped and poorly organized to seize new investment opportunities, but now, with the growing numbers of young people, it looks as if things might change.

2030–2035: CRISIS AND RESPONSE

Beginning in 2030, Pennsylvania suffers a prolonged drought followed by a catastrophic flood that affects the drinking water system and leads to extended power outages. The immediate response from Harrisburg seems less effective than efforts initiated by communities themselves, as the after-action report makes clear.

In response to the issues raised by the crisis, the Governor convenes a commission, not unlike the 9/11 Commission, to evaluate state government's weak performance. The commission's report includes a re-examination of state government structure and operations, and concludes by recommending the delegation of more authority to locally-led, regional commissions that direct infrastructure funding, emergency response, and energy planning.

Following what this crisis reveals about regional power and resilience, leaders in government and industry face a challenge: how to move from a system in which each agency and industry looks at the commonwealth through its own prism. The

environmental community looks through its prism. The energy producing sector looks through its prism. The business community looks through its prism. The public sector looks through its prism, and on and on and on. Each prism sees a one-size-fits all solution for all the regions. How can leaders move from a prism approach to a kaleidoscope approach, in which all the divergent regions form a beautiful, interdependent, ever-moving whole?

In 2035, after initial experimentation with authorizing regional economies to take greater control of planning permitting, and funding decisions, a state constitutional convention is called, leading to the formal authorization of greater regional control of economic and energy futures. Many observers compare these changes to the 1968 state constitutional convention that authorized cities to enact home rule charters, allowing them more control over the delivery of health services and environmental planning.

2035-2045: A GROWING REGIONALISM

One unexpected consequence of this new homesteading movement and the growth of regional authority is an increasing divergence from region to region. Since many of these newcomers work in adjoining states, they often feel closer to their geographical region than to Harrisburg. Portions of southwestern Pennsylvania, for example, have more in common with a West Virginia agenda – very pro-energy with a high level of gas production. Southeast Pennsylvania, on the other hand, is more enthusiastic about nuclear, wind, and

solar, while Pittsburgh is tied into the hydrogen hub related to the Ohio economy. Connections between Philadelphia and South Jersey grow closer while Northeast Pennsylvania is allied to New York, and parts of Lancaster feel a closer cultural affinity to the greater Baltimore metro area. More efficient transportation corridors develop in the East, driven by Acela and expanded service for public transportation in each of the cities. In addition, highways are expanded to accommodate more traffic between Youngstown, Pittsburgh, and Wheeling. Each region begins to develop its own economy and approach to energy, and, unsurprisingly, some regions do better than others.

As these communities become more diverse, homesteaders within them look to their neighbors in adjoining states rather than to the central state government to devise solutions to local problems, in many cases establishing public-private partnerships to get things done.

Decision-making is increasingly devolved to local levels, and public-private partnerships multiply. The energy sector also becomes differentiated, enabled in part by major changes to regulatory constructs across various energy markets, which place a higher priority on state policy preferences than overall market efficiency. With power system planning decisions increasingly driven by the states, a variety of approaches to power generation emerges: some want renewables; some want gas with CCUS, in part to support local manufacturing; CCUS and hydrogen are developed in the southwest part of the state, while solar and

HOMESTEADS

geothermal heating solutions thrive in the southeast.

Other areas develop homestead incentives for electrification through rewarding individual households for selling solar- or wind-generated electricity back to the grid or through allowing renewable power generation to be built on local property—a form of “mimbyism” (money in my back yard) made possible by the inclusion of renewable energy development as a permissible use under the Commonwealth’s Clean and Green Land Preservation Program. In a number of instances, environmental policies that had been directed from the cities and state government are met by resistance from local homesteaders; in other areas, local residents see opportunity in new energy initiatives.

The energy policies of different Pennsylvania localities diverge more and more, in part because these localities have more in common with adjoining, out-of-state neighbors. Cooperation among these cross-state communities leads to regional energy collaborations that prove both more efficient and more innovative than the geographically extensive regional transmission organization. Many of these regions prove quite attractive to manufacturing investment, especially as AI enables scalable and nimble storage-to-grid breakthroughs.

2045-2050: A PATCHWORK OF HOMESTEADS

This new regionalism leads to new dilemmas. Observers remark that the fabric of the commonwealth appears to be tearing

apart. They see that a number of bordering states have “poached” Pennsylvania talent for their own companies. Pennsylvania citizens pay individual taxes at home; but the companies they work for benefit the state next door. Culturally, young people identify as Pennsylvanians; but economically, many of them, in effect, work out of state—under the leadership of other states.

On the other hand, regional leadership has resulted in much more economic growth in areas that were historically behind south-central and southeastern Pennsylvania. But questions for state leadership remain. How can the central government take advantage of the regional strategies to create a whole greater than the sum of its parts? How can it spread best practices from one region to another? How can it promote equity among homesteads while at the same time letting communities act nimbly, leveraging their share of commonwealth resources? How can a long-term strategy be crafted that embodies both coordination between state and local levels and sensitivity to differing local concerns?

By 2050, the commonwealth has made progress in addressing some of these issues. There is moderate growth with a focus on re-shoring manufacturing. There is less individual inequality, although some regions are doing better than others. And decarbonization is happening slowly and unevenly, but in every region throughout the state—even though different regions adopt quite different plans. The pace of decarbonization, however unevenly distributed, leads to more durable emissions reductions and an increase, in more ways

HOMESTEADS

than one, of sustainable manufacturing and agriculture. There are new opportunities in energy investments, with more CCUS and hydrogen in the Southwest, more renewables, especially wind, in the Southeast, and more agri-innovation in the center.

Despite not having a unified energy identity, Pennsylvania's regional patchwork and all-of-the-above approach to energy accelerates Pennsylvania past its competitor states, which went all in on specific technologies like renewables. Increased agency and control at the regional level

enables Pennsylvania's localities to respond quickly to changing trends and to pursue best-fit, rather than one-size-fits-all, solutions. The most effective examples have created jobs and decreased emissions.

Like the homestead movement in the 2020s, leadership is moving in a positive direction, with diverse, transdisciplinary teams using a range of methodologies, and a learning culture emphasizing resilience and innovation. And, like the original homestead communities, neighbors collaborate to help each other prosper.



FIELDS

If you build it, they will come.

FIELD OF DREAMS

Fields is a scenario in which economic strategy takes precedence over energy strategy until the need for cooperation in creating greener fields becomes apparent.

2025–2030: CHOOSING GROWTH

By the late 2020s, energy demand is growing at a rapid pace, both nationally and globally. The rise of AI is only one factor in this growth, but it is a significant one. The further retreat of the world from globalization and free trade leads to a rise in domestic manufacturing capacity in the US and across the Western world, and at least in the near-term, this expansion is powered by low-cost and highly available

natural gas. Federal energy policy at this time is not a significant driver of the energy transition—indeed, the polarization of US energy policy leads the market to pull back from investing in the research, development, and deployment of disruptive energy technologies like advanced nuclear, clean hydrogen, and energy storage for fear of choosing ‘the wrong one’. In addition to the lack of pressure from the federal government, there’s a strong sense that if Pennsylvania is going to lean into economic growth, energy has to undergird that growth, particularly natural gas.

By the middle of the decade,

FIELDS

Commonwealth policies have begun to be effective in promoting Pennsylvania's already robust natural gas industry as well as other energy-dependent industries. With no new pipelines or new LNG terminals being built for out-of-state export, energy production and distribution companies begin to focus on customers and end-users within Pennsylvania, helping the manufacturing sector grow within the state.

Policymakers make a conscious choice to support the energy industry in its ramp-up to meet demand. A common saying of the time is "Pennsylvania is open for business." And indeed, new businesses do move into Pennsylvania, and the improved regulatory environment helps to encourage industry leadership in the development of new opportunities. Energy production ramps up sharply—and so do carbon emissions. But economic growth, not emissions reductions, is the organizing priority.

2030-2040: A WINNER IN MANY FIELDS

By 2030 it's clear that large businesses are doing well, and small businesses are growing to support them. Pennsylvania is quite competitive in many areas. While many states within the region are taking options off the table – doubling down on greenhouse gas emissions reduction goals, for example, and making it more difficult to build power projects and expand industry – Pennsylvania looks more attractive than ever. The Commonwealth continues its "open for business" approach while at the same time supporting additional business-friendly tax policies and offering incentives for new businesses to move into the state.

Pennsylvania's focus on streamlining industrial development contributes to an even stronger position as the major supplier of electricity to the region. As regional power demand grows and other states embrace intermittent renewables, Pennsylvania's willingness to embrace even more new natural gas development pays dividends to developers as revenues through the regional power market reach record levels

What had been an aging population begins to change as Pennsylvania adds young people and working families from other states in the south and west who are attempting to escape the growing effects of climate change that the commonwealth has so far avoided. When the next generation looks for a stable place to settle down, earn a living, and achieve the American dream, safe from seasonal economies and dramatic climate events, they think of Pennsylvania.

One of the tools the Commonwealth uses to encourage energy growth and development is the consolidation of decision-making authority within state government, particularly when it comes to project permitting and environmental review. To take maximum advantage of centralization, Pennsylvania restructures and expands its executive agencies to improve public and business access to information, improve the permit application process by speeding up review times, and create mechanisms to subsidize and expedite priority energy projects that support major economic development opportunities. Pennsylvania State agencies go on a hiring spree, poaching top talent from Pennsylvania, universities, and industry

FIELDS

with competitive salaries and benefits, and consolidating satellite offices in Philadelphia and Pittsburgh, where most young people want to live. In addition, many cooperative alliances of labor and environmentalists working together help new energy sources, such as hydrogen, gain a place in the energy mix, and to find new uses for some of the state's coal deposits.

Following recommendations from an independent commission, the legislature approves a number of measures to raise revenues, improve the effectiveness of state programs, and make Pennsylvania a more attractive place for business investment and new projects. Tech companies come to Pennsylvania because they need energy and a workforce. Streamlined permitting processes have resulted in a rapid rise of housing. Successes are building on themselves. And even though natural gas has been, in part, a natural attractor for new businesses, once they arrive in the state, demands for clean energy increase significantly.

2040–2045: THE RISE OF ALTERNATIVE VOICES

With most workers and industry headquarters gravitating towards the growth poles of Philadelphia and Pittsburgh and the “opportunity belt” between them, many of the rural communities feel left out. The government has made it easier for shrinking municipalities to disincorporate or merge in order to share expensive public resources and invest in full-time, paid public servants. But many communities treasure their independence and unique histories and resist consolidation.

The role of AI continues to expand, replacing not only many manufacturing jobs but also an increasing number of remote-work white-collar jobs. The growing gaps between urban and rural, and rich and poor seem to fall below the notice of the streamlined, centralized, pro-growth government policies. Dissenting voices point out that there are downsides to the relentless focus on economic growth, which serves the interests of capital and business before those of the public. And what about the environment?

Unlike many other states, Pennsylvania has not placed specific measures on carbon reduction, and the growth in clean energy has been steady, but relatively slow and uncoordinated. In the mid-thirties, it looked as if commercially viable CO₂ abatement technology was available, and some state leaders had suggested tax rebates for companies using this technology to lower emissions—but the suggestion hadn't led to tangible legislation. And now, a decade later, Pennsylvania's leaders and citizens see the need to address carbon emissions at least as much as its neighbors have done.

Some of the effects of climate change begin to affect particularly those communities along Pennsylvania's waterways as catastrophic flooding events become more commonplace. Power blackouts during extreme cold weather become commonplace as the rush to build has left oversight of winter-weather preparedness lacking in the natural gas sector. The lack of effective government-led resilience planning and across multiple infrastructures becomes apparent.

2045–2050: THE GROWTH OF GREEN FIELDS

By 2045, environmental activists have long had the loudest voices—but it is the economists who have had the most persuasive arguments that climate change needs to be addressed more effectively. They point out that Pennsylvania is in danger of falling behind those states that have built vast renewable energy sources or have regulated emissions intensity, which effectively penalizes carbon-intensive imports. They also argue that the economic damages from a changing climate are outstripping the benefits of Pennsylvania’s pro-growth policies. Businesses continue to look towards the Commonwealth as a place of growth, but there is a growing realization that to support a more sustainable economic trajectory, Pennsylvania must welcome change.

Both government and the public recognize the need to shift to greener fields. Taking advice from ad hoc commissions of diverse citizens from both rural and urban areas and from business, academic, and the public sector, the Commonwealth finds a surprising advantage in the policy mechanisms it has developed over the years. These government levers are lean, transparent, and speedy. As new incentives and policies are put in place, a transition to a lower-carbon economy moves along surprisingly quickly, even without the top-down mandates or targets common in other states.

One reason for the relatively quick shift towards a more resilient, greener economy and decreasing emissions is that all options for how issues get resolved are on the

table. Another accelerator consists of the many blue-green alliances of labor and environmentalists working together to ensure a balanced approach to possible solutions. Because state government institutions have been operating effectively in the economic sphere for the previous twenty years, the move to increasingly cheap new clean energy technologies happens efficiently and relatively smoothly. This shift is encouraged by investment in supply chains for renewable energy, encompassing manufacturing, assembly, distribution, and installation. This investment not only reduces costs, but also speeds up adoption time, helping to spur economic growth.

While the state may not have been a first-mover in embracing new energy technologies, in the late 2040s, it begins to move quickly on the foundation of two decades of policy flexibility and economic success. By 2050, it is deploying next-generation nuclear microreactors for workforce training at Penn State University, for example; helping to finance shared infrastructure of CO₂ pipelines through new types of partnerships; and allowing test wells for geothermal energy and permanent CO₂ storage. By finding multiple, near-term, and achievable opportunities to partner with private industry, local and regional government, organized labor, and nongovernmental organizations, Pennsylvania shows it is not only open for business, but also open to improving the lives of Pennsylvanians.

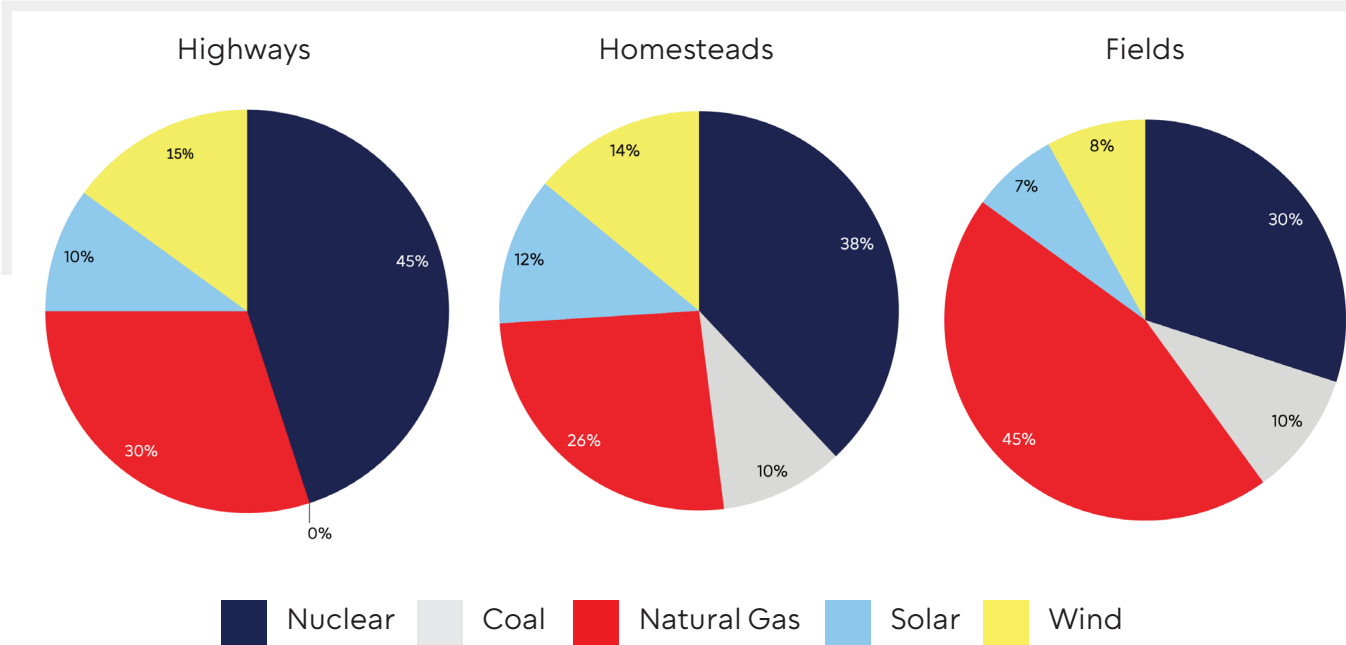
DATA MODELING

CONTEXT FOR THIS DATA:

The three scenarios developed in workshops with participants from the Energy Horizons Cross-Sector Collaborative are stories of different possible futures for Pennsylvania, all of which have implications for energy and the economy. To bring these scenarios to life, Seth Blumsack and his team at Penn State University developed an energy model, and REMI and the University of Pittsburgh utilized their economic policy model, to see how these stories would play out with data. From the energy mix in each scenario to implications for population and the economy, it is easy to see how the different social, political, and economic decisions and events in Highways, Homesteads, and Fields result in vastly different outcomes and opportunities.

Figure 01: Pennsylvania Power Generation Output by Source in 2050

Source: Energy Model, Seth Blumsack, Penn State University



DATA MODELING

Figure 02: Highways Power Generation Output by Source (2030 vs. 2050) (Million GWh)

Source: Energy Model, Seth Blumsack, Penn State University

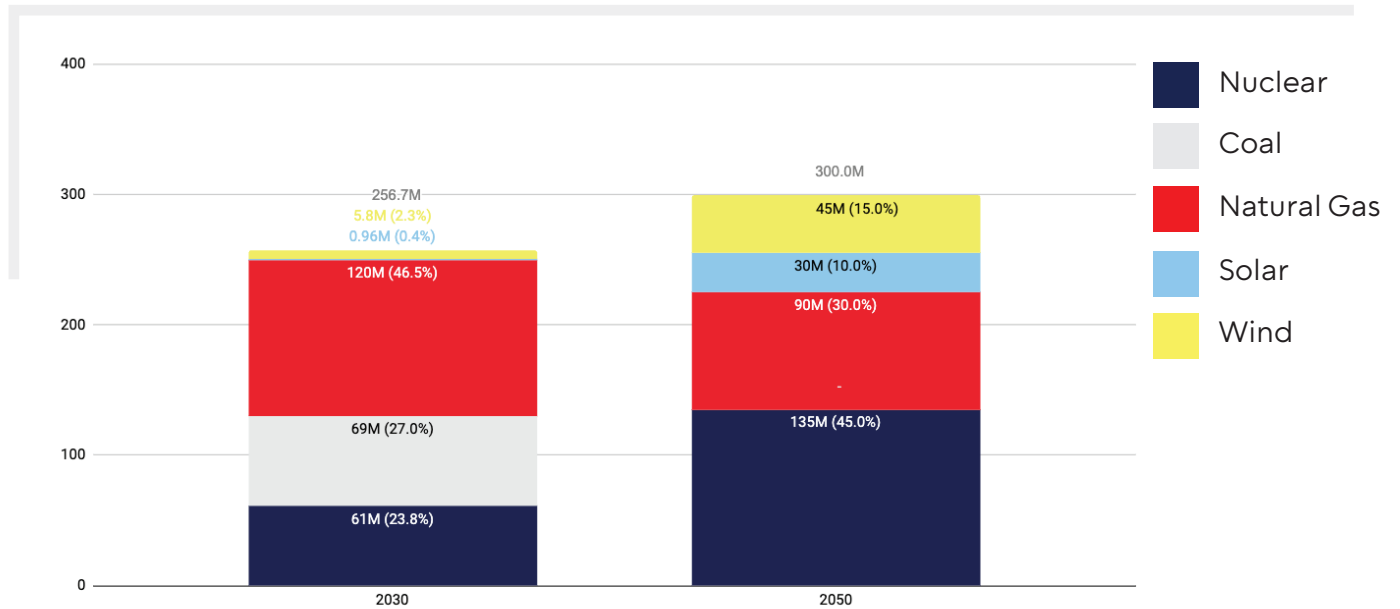
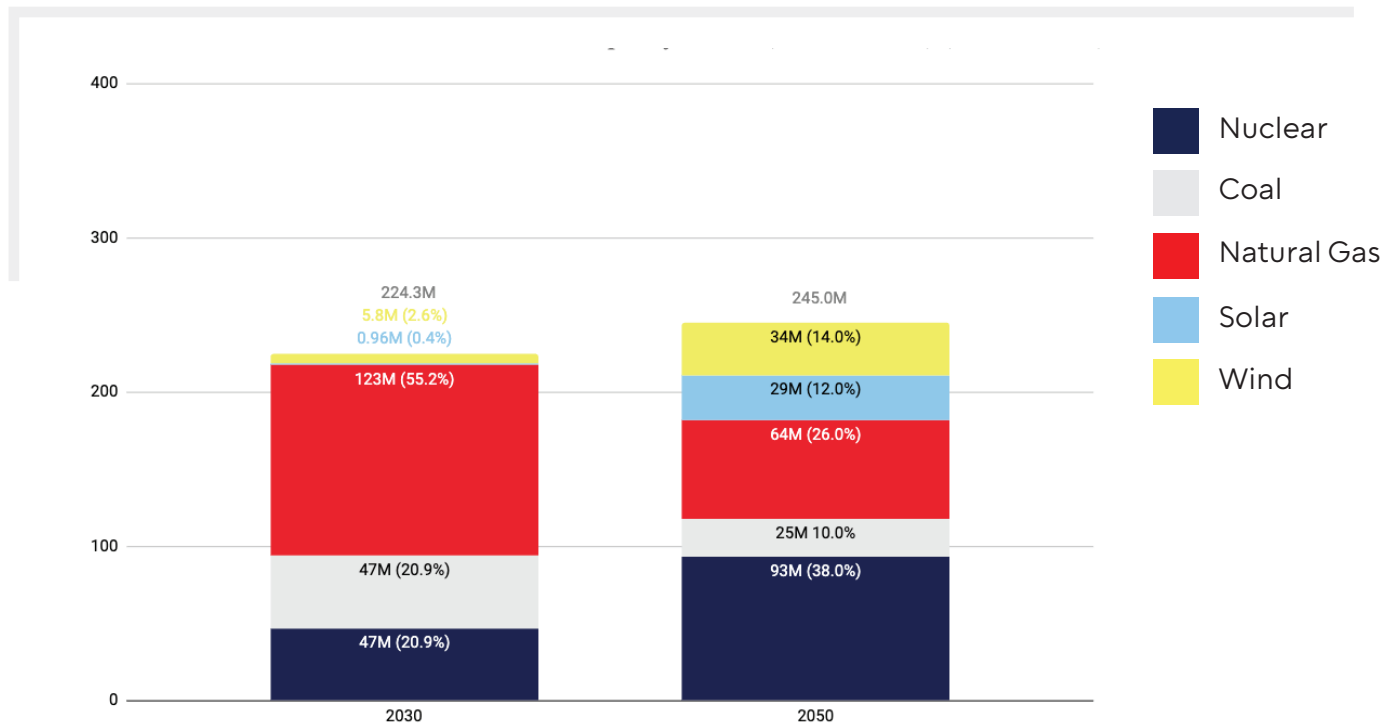


Figure 03: Homesteads Power Generation Output by Source (2030 vs. 2050) (Million GWh)

Source: Energy Model, Seth Blumsack, Penn State University



DATA MODELING

Figure 04: Fields Power Generation Output by Source (2030 vs. 2050) (Million GWh)

Source: Energy Model, Seth Blumsack, Penn State University

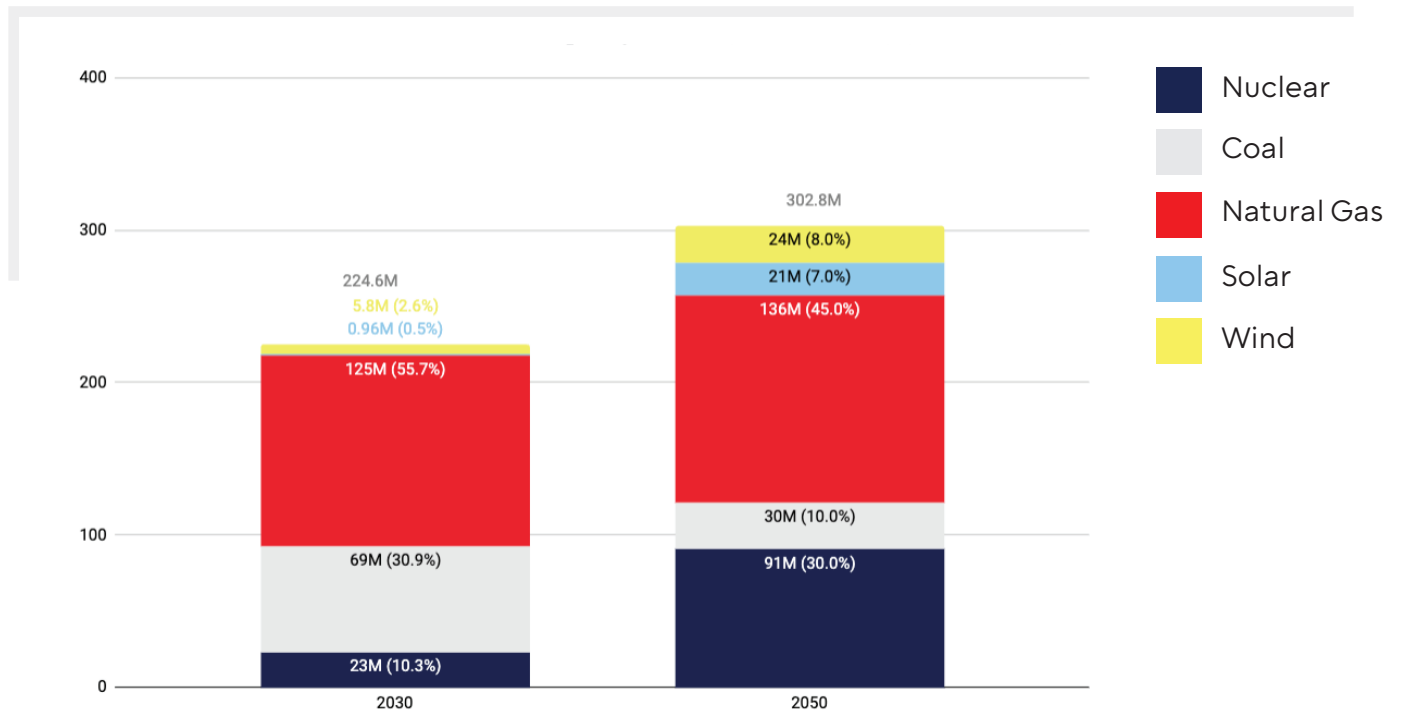
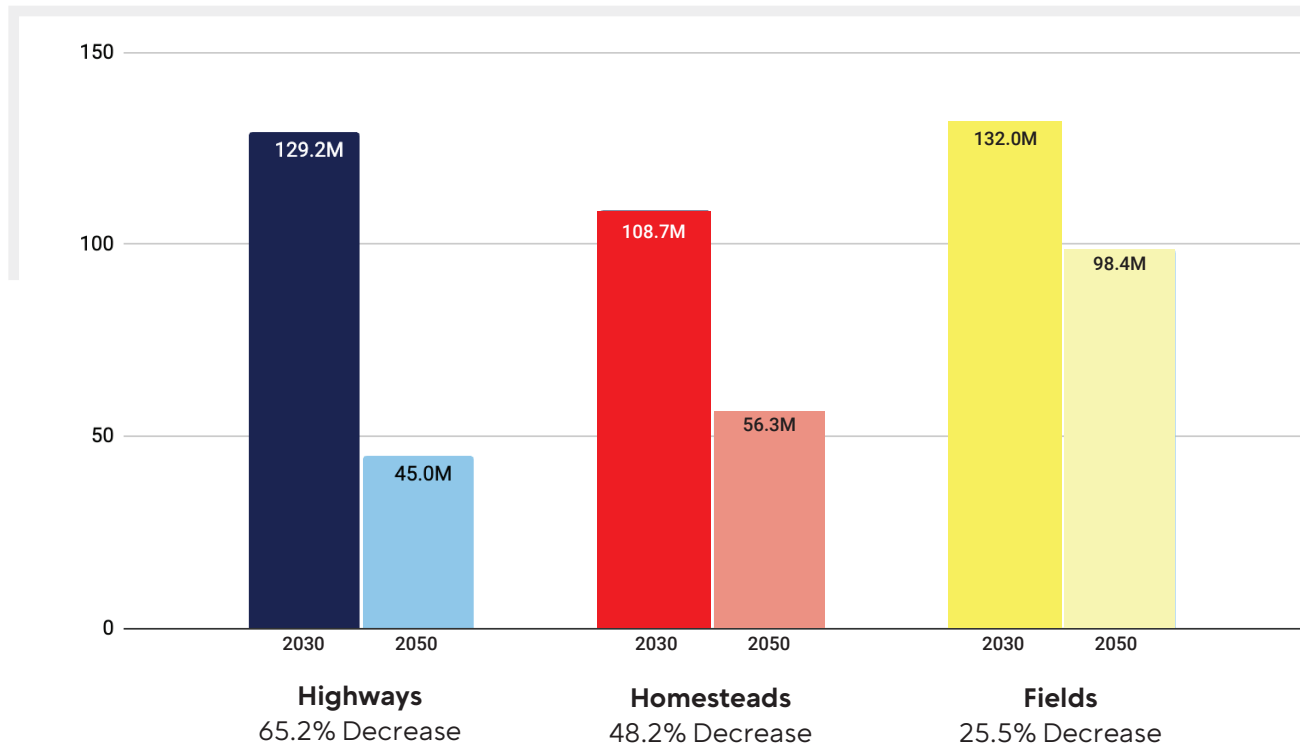


Figure 05: Pennsylvania Power Sector CO₂ Emissions Comparison (2030 vs. 2050)

Source: Energy Model, Seth Blumsack, Penn State University



DATA MODELING

Figure 06: Cumulative Power Generation Capital Expenditures (CapEx) in Pennsylvania (2025-2050)

Source: Energy Model, Seth Blumsack, Penn State University

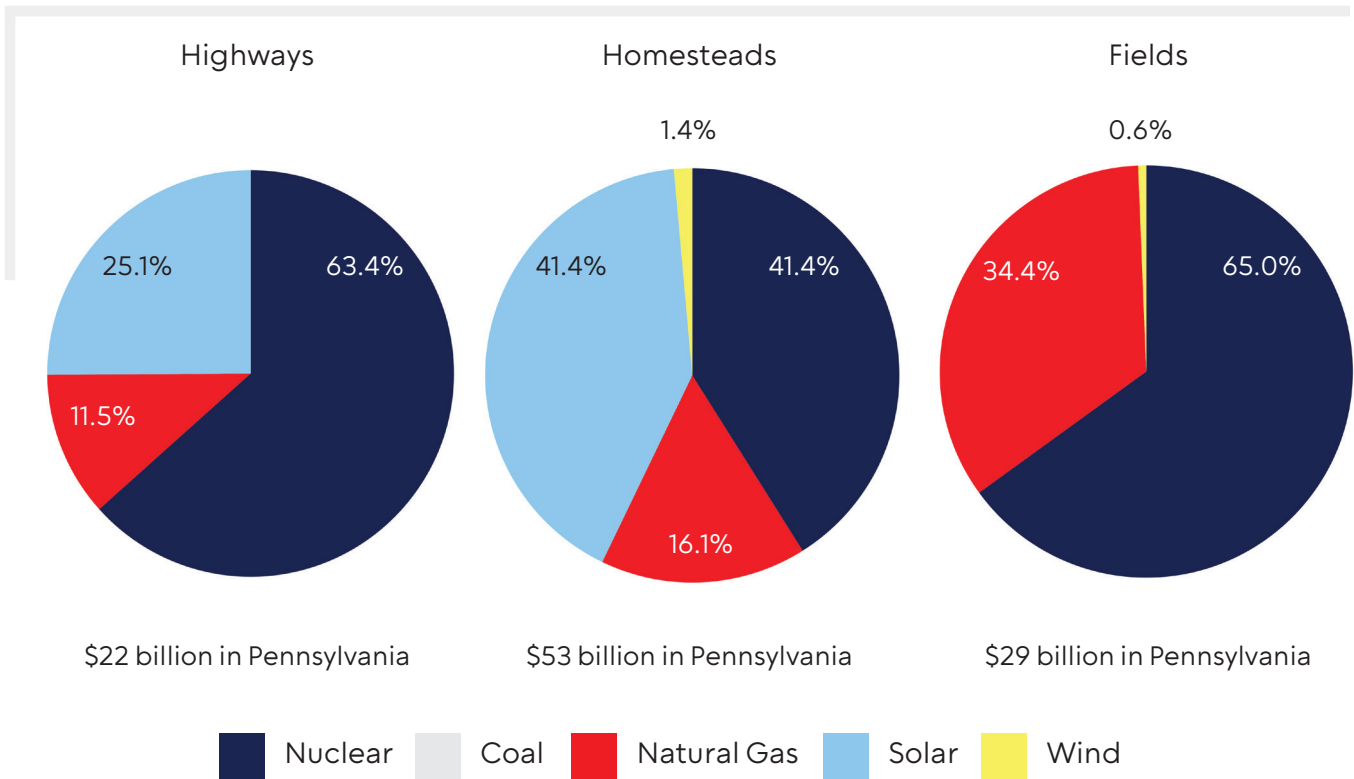
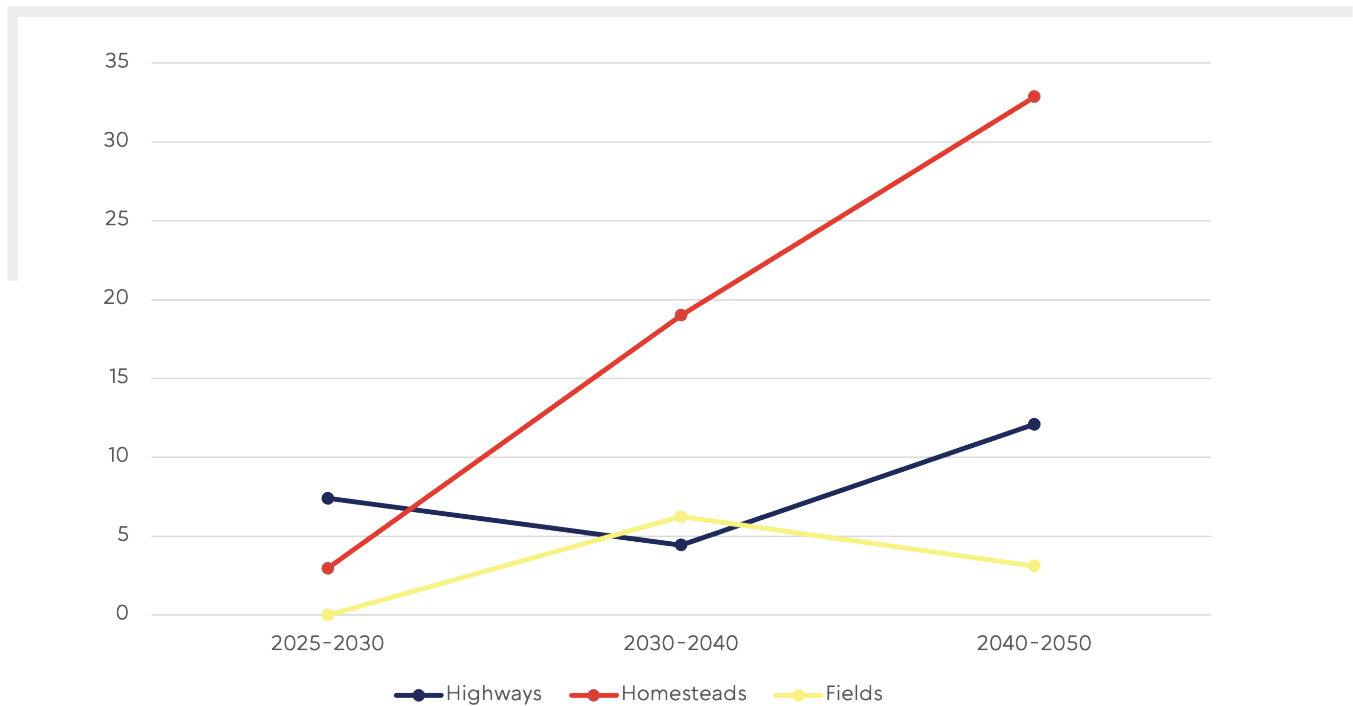


Figure 07: Pennsylvania Power Generation Capital Expenditures (CapEx) (\$bn) (2025-2050)

Source: Energy Model, Seth Blumsack, Penn State University



DATA MODELING

Figure 08: Wholesale Power Prices in Pennsylvania (2025-2050)

Source: Energy Model, Seth Blumsack, Penn State University

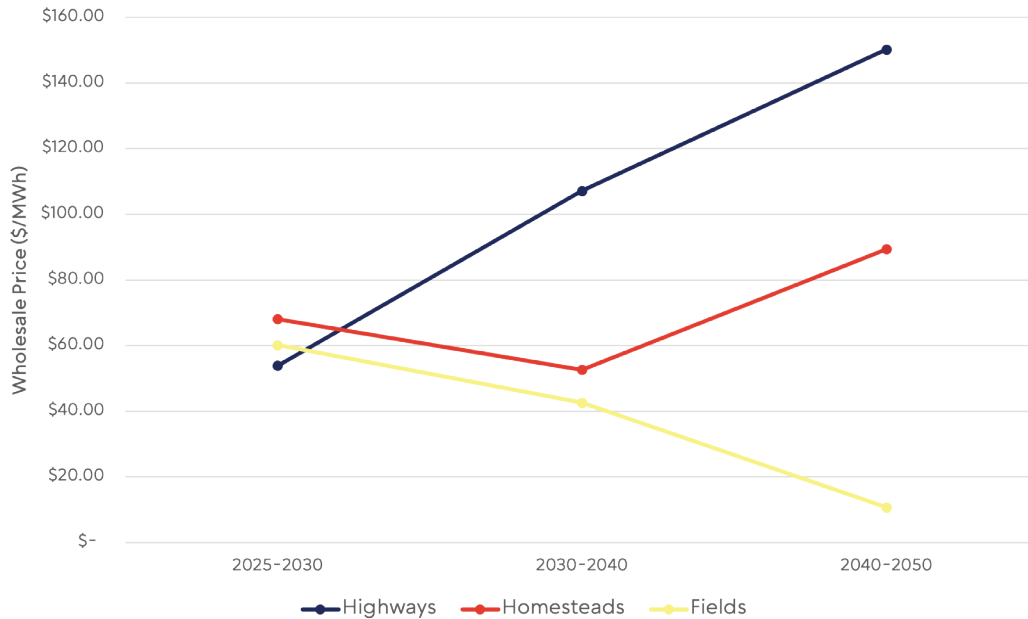


Figure 09: Average Wholesale Power Prices (\$/MWh) in PA vs. Rest of PJM (2025-2050)

Source: Energy Model, Seth Blumsack, Penn State University

	PA Power Prices	Rest of PJM Power Prices
Highways	\$128.67/MWh	\$148.47/MWh
Homesteads	\$71.02/MWh	\$91.57/MWh
Fields	\$26.61/MWh	\$105.56/MWh

Note: Power prices are averages over the simulation period.

Figure 10: Change in Pennsylvania Gross State Product (GSP) (2025 - 2050)

Source: REMI Economic Model, University of Pittsburgh

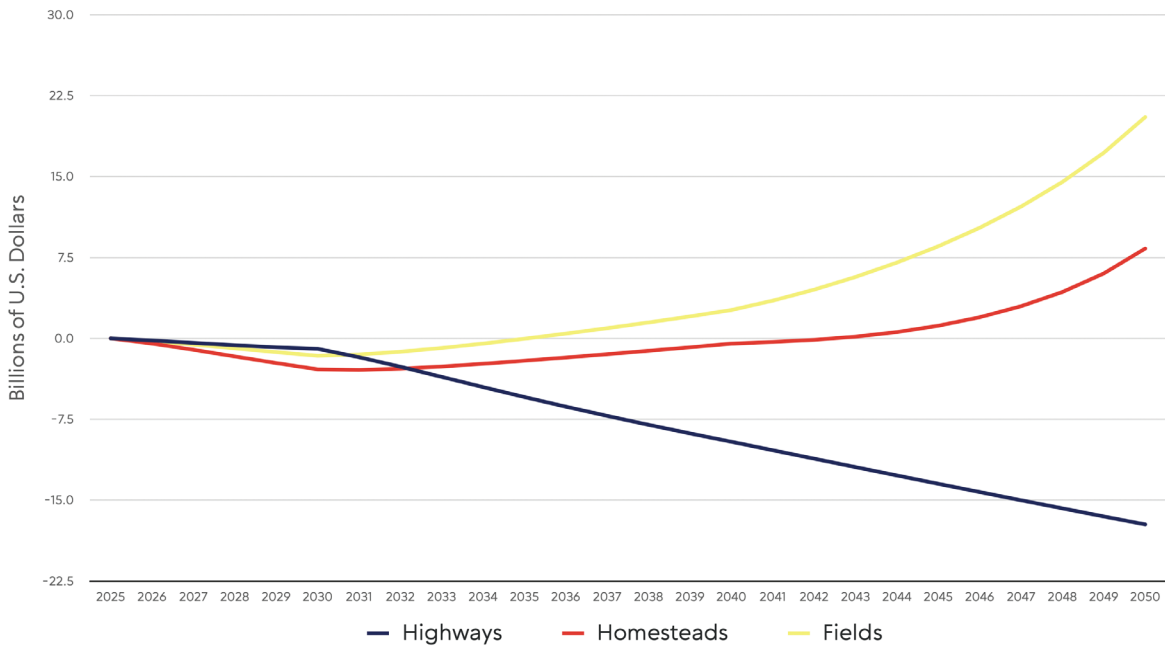


Figure 11: Change in Pennsylvania Employment (2025-2050)

Source: REMI Economic Model, University of Pittsburgh

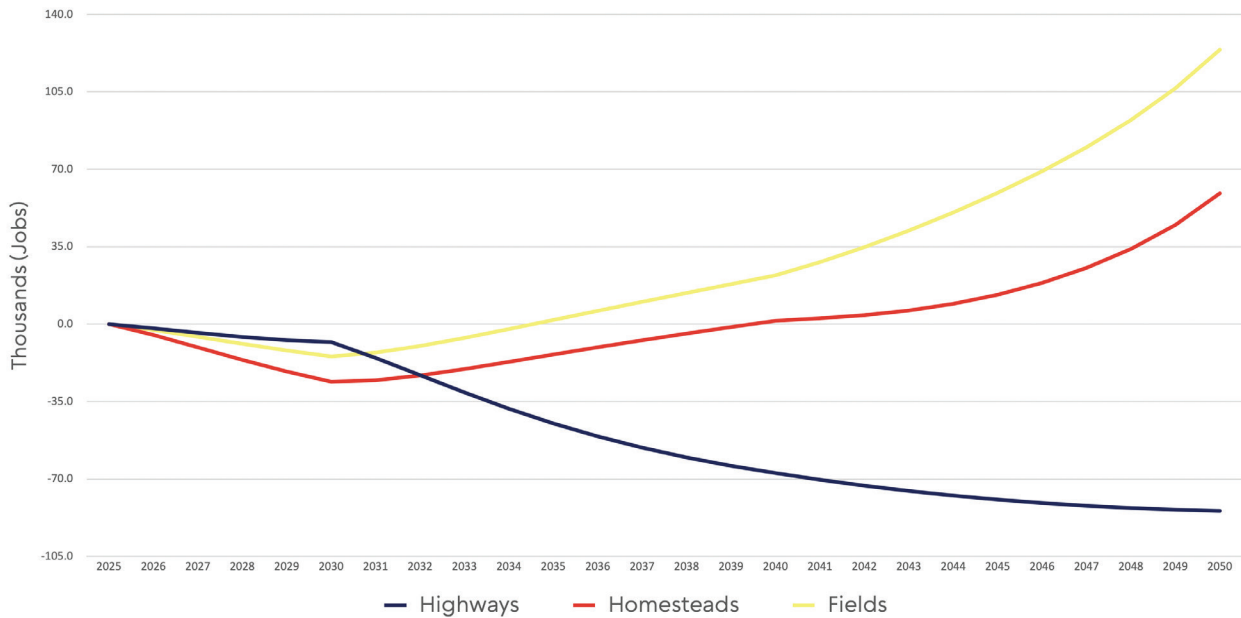
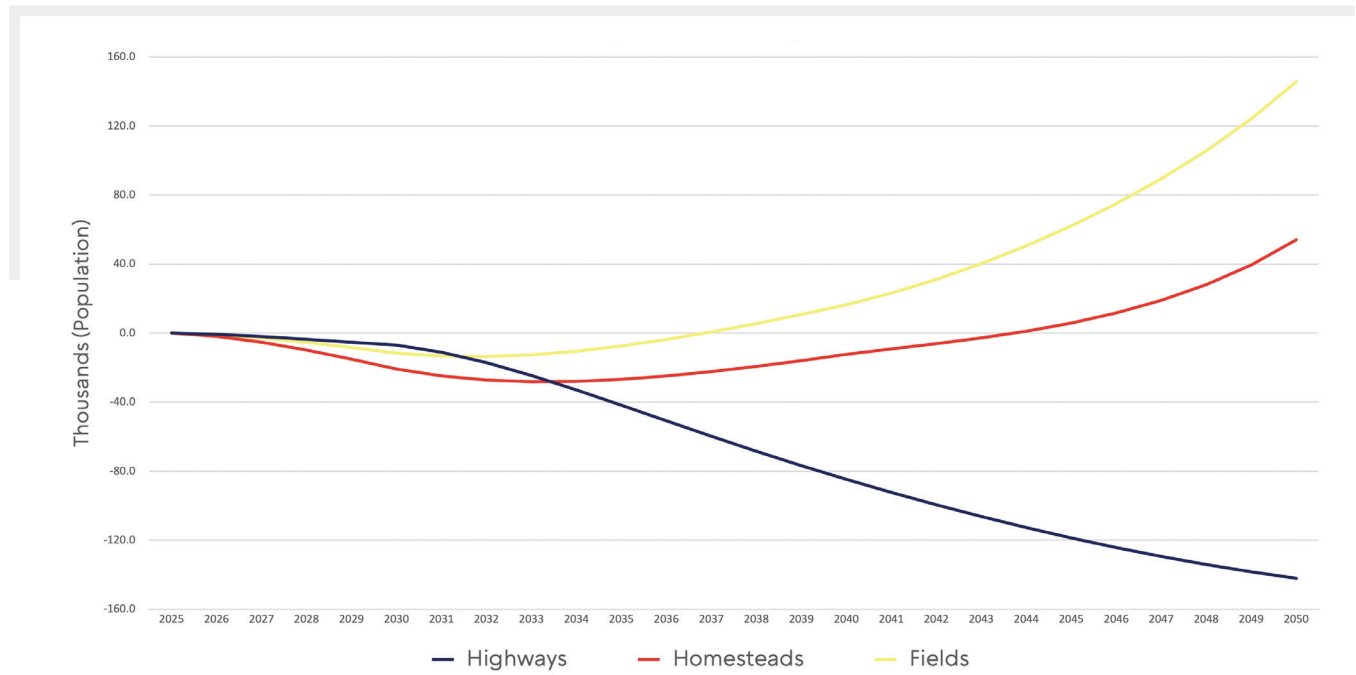


Figure 12: Change in Pennsylvania Population (2025-2050)

Source: REMI Economic Model, University of Pittsburgh



QUESTIONS FOR DISCUSSION

HOW TO USE SCENARIOS QUESTIONS:

GENERAL QUESTIONS FOR DISCUSSION

- Did you consider any of these scenarios to be implausible? If so, why?
- Which scenario is the most challenging for business? For government? For individual Pennsylvanians?

ENERGY-RELATED QUESTIONS FOR DISCUSSION

- How will this scenario affect the portfolio of energy *production* in Pennsylvania?
- How will this scenario affect the portfolio of energy *consumption* in Pennsylvania?
- What has happened with energy technology innovation and costs for this scenario to become reality?
- How will this scenario affect consumer energy costs in Pennsylvania?
(Please remember that energy demand is highly price-*insensitive* in the short run but is highly price-sensitive in the long run.)
- How will this scenario affect electric reliability in Pennsylvania or in the broader region?
(Please remember that grid operators in Texas, the Midwest, and several European countries have kept their grids reliable with very high levels of wind and solar power.)
- How will this scenario affect energy-related greenhouse gas emissions in Pennsylvania?
- What kinds of energy employment changes would be needed for this scenario to become reality?
- What energy infrastructure would need to be built (or removed) for this scenario to become reality?

QUESTIONS FOR DISCUSSION

ECONOMY-RELATED QUESTIONS FOR DISCUSSION

- How are the various trades and educational institutions engaged to address workforce issues?
- Are there supply chain concerns?
- How would this scenario impact the regional economy? State-wide economy?
- Would this scenario result in more “good” jobs than would otherwise exist?

ENVIRONMENT-RELATED QUESTIONS FOR DISCUSSION

- How would this scenario be received by bordering states if they have stricter goals? Looser goals? What difference would it make for PA residents? For business between states?

HIGHWAYS QUESTIONS FOR DISCUSSION:

- How do we embed a long-term policy-making perspective for Pennsylvania’s energy development?
- How do we deal with energy justice concerns, such as access to affordable energy?
- As a reader of this scenario, where do you see yourself, or an entity you represent, adding your voice to influence the direction of this scenario?
- Almost no one saw COVID-19 coming or the Russian invasion of Ukraine—black swan events that caused global reshuffling in politics, the rise of doubts about the future in civil society, energy transition, consumption patterns, and a few other notable outcomes. In a similar manner, what do you see as a possible black swan event in the next 25 years that could impact energy development and utilization in a large-scale fashion, and in a way that could impact this scenario, in real and tangible directions?
- What should regulators be learning now to improve upon the next generation of climate policy?
- How much, if at all, should PA diversify its primary energy sources? What role do external markets play in these choices? What role does the state play?
- How much of this scenario mirrors today’s environment in Pennsylvania?
- Must there be an either/or with regard to natural gas v. renewable development? In

QUESTIONS FOR DISCUSSION

other words, what can the state do to attract certain large load customers with the need for firm capacity while also advancing renewable energy in the Commonwealth?

- Where did things start to ‘go wrong’ in this scenario?
- This scenario takes for granted that the generation that takes political power in the 2040s (Millennials, Gen Z) are singularly focused on addressing climate change – this is motivated, in part, by current data on these generations’ values. Could we see these values changing? What would cause them to change?
- How can PA use its core strengths in fossil energy production to drive sustainable, equitable economic growth in other areas of the economy? What kinds of things do we need to prioritize to avoid some of the worst elements of this story?
- What would be the implications of driving more effort towards carbon capture early in this scenario? Would viability of large-scale storage avoid late-term problems?
- Is regionalization of different economic engines between urban and rural areas bad? Will energy intensive industries peak in urban areas while slow progressive growth of rural area production continues over time? If so, what is the result in 2050?
- What might have been different if a long-term vision had been set in 2025 for 2050?
- How is the US and the world changing while Pennsylvania doubles-down on fossil fuels in the early years?

HOMESTEADS QUESTIONS FOR DISCUSSION:

- Would it matter if Pennsylvania lost energy leadership to other states? What are the consequences of such a loss?
- Should regional alliances and policies be encouraged rather than setting the same policies for all regions?
- What policies might encourage young people to stay in Pennsylvania?
- What is the role of the state in decentralizing energy provisions? If not, who is politically accountable in a decentralized model?
- Are there models outside of the state that local and regional actors could consider?
- Is regionalization of different economic engines between urban and rural areas bad? Will energy-intensive industries peak in urban areas while rural area production continues to grow over time— and, if so, what is the result in 2050?

QUESTIONS FOR DISCUSSION

- Would a regionalized approach provide the best long-term benefit to Pennsylvania as a whole as it leverages each area's strengths?

FIELDS QUESTIONS FOR DISCUSSION:

QUESTIONS FOR DISCUSSION

- What unintended consequences might result from a much greater focus on economic health over energy or environmental health?
- How can the growing gap between rich and poor and urban vs rural be addressed?
- Are there risks to heavy reliance on fossil fuels early in this scenario?

ACKNOWLEDGMENTS

These scenarios would not be possible without the collaboration and contributions of our partners. Team Pennsylvania extends its gratitude to all those whose expertise, collaboration, and support have been instrumental in the development of this report.

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Thank you

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Team Pennsylvania Energy Horizons Scenario Planning 2024-2025 Workshop Participants

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IBEW - Third District
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MHI Hydrogen Infrastructure
National Resources Defense Council (NRDC)
PA Rural Electric Association
Pennsylvania Department of Community & Economic Development
Pennsylvania Department of Environmental Protection
Pennsylvania Environmental Council (PEC)
Pennsylvania Governor's Office of Critical Investments
Pennsylvania Office of the Governor
Pennsylvania Rural Electric Association
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Pittsburgh Works Together
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