



Our 2024 R&D Strategy: Leveraging the power of Al to achieve our True North Strategy

Last year marked a bold shift in PG&E's approach to Research and Development (R&D) and innovation. With the launch of PG&E's inaugural R&D Strategy Report, we shared our biggest innovation challenges and invited problem solvers from all corners of the world to join us in building the energy system of the future, together.

This brighter future is described by our True North Strategy (TNS), PG&E's 10-year enterprise transformation roadmap that guides us towards a future where we play a pivotal role in California's transition to a net zero emissions, climate-resilient future.

In 2024, PG&E's Research and Development strategy builds on the progress made in 2023 with an ambitious vision to leverage the transformative powers of Artificial Intelligence (AI) to accelerate our progress towards achieving our True North Strategy.

This vision embodies our commitment to developing an intelligent and resilient energy system capable of dynamically responding to the evolving needs of both customers and the energy system.

This year, we explore how integrating AI across our operations can help us tackle some of the most complex challenges faced by PG&E in building a net zero and climate-resilient future. AI offers transformative potential to drive automation, enhance predictive capabilities, and deliver personalized customer experiences. By embracing AI responsibly, we aim to accelerate our goal to provide clean and resilient energy for all.

Our R&D strategy remains **problem-focused**, and the **67 problem statements identified in this report represent the critical obstacles to achieving our TNS**. From managing unprecedented load growth to navigating risk across our energy system, these problem statements serve as the roadmap for our innovation efforts. Innovation at PG&E is not about technology for technology's sake; instead, it is about using the right tools, including but not limited to AI, to address these challenges in the most effective and cost-efficient way possible to deliver for our customers, our communities, and the planet.

Al can play a pivotal role in addressing the challenges that we must address to create a future-proofed PG&E capable of delivering on our responsibilities to our customers today, meeting their needs of tomorrow, and adapting to the continually evolving challenges beyond. It will enable us to anticipate operational risks and optimize energy delivery, helping us move from reactive to predictive operations.

By harnessing AI, we can improve grid performance, reduce operational costs, and provide more personalized services to our customers. However, AI is just one part of the solution that we plan to pursue in bringing TNS to life. For some challenges, traditional technologies, policy interventions, or operational improvements will be more appropriate. Our goal is to ensure that AI complements, rather than replaces, other solutions, with human oversight remaining an essential component to guarantee safe and ethical operations.

We are committed to ensuring the safety, accuracy, and reliability of work performed with the assistance of Al.



PG&E's commitment to stabilizing customer bills

As California continues its ambitious transition to a clean energy future, PG&E is committed to ensuring that this transformation is both **affordable** and **equitable** for all customers.

These investments, while crucial, must be balanced with the responsibility of stabilizing customer bills. Emerging technologies can be vital tools to stabilizing customer bills, a core focus of our True North Strategy. By optimizing operations, streamlining energy distribution, and improving the efficiency of resource allocation, AI can help lower operational costs and help stabilize customer bills. Additionally, AI-driven predictive maintenance and grid resilience enhancements have the potential to help prevent outages and reduce the need for costly repairs, contributing to the overall goal of keeping energy affordable while advancing towards a net zero energy system.



2024 R&D strategy: What has changed since 2023?

Building on the foundation of our **2023 R&D Strategy Report**, PG&E has made significant strides in addressing the key challenges laid out last year.

In 2023, we identified **67 problem statements**, which highlighted the most critical barriers to achieving our long-term energy system goals. Through a combination of innovation, collaboration, and strategic investments, we are now on a clear path to addressing many of these challenges and have signaled that PG&E feels optimistic about our existing partnerships for resolving several problem statements. In other cases, original problem statements evolved so substantially that we replaced them with problem statements that are considered new to the 2024 report. In total, we have **"graduated" 17 original problem statements**.

However, new challenges continue to emerge as the energy landscape evolves. Readers of our 2023 R&D Strategy Report will also observe that we have added two new focus areas to this year's strategy report: "Net Zero Energy System & Environmental Stewardship" and "Climate Resilience." These additions highlight our commitment to decarbonization and our recognition of the urgent need to prepare for the impacts of climate change.

In 2024, we **added 17 new problem statements** that reflect new priority challenges, such as the growing need for climate adaptation and the elimination of residual carbon emissions.



Just as in 2023, PG&E remains committed to a **multi-faceted approach** that leverages diverse technologies and partnerships to overcome obstacles and deliver on our True North Strategy. This problem-focused approach ensures that we prioritize solutions that address the most urgent and important issues across the utility.



Across these business areas, the responsible use of AI will help us **supercharge progress**, driving the transformation of PG&E towards a decarbonized, resilient future to deliver for our hometowns and help heal the planet.

Electric Vehicles (EVs)

Electrifying the transportation sector is a cornerstone of California's strategy to reduce greenhouse gas emissions.

PG&E is committed to enabling the widespread adoption of EVs, with a target of **3 million EVs** connected to the grid by 2030. For California to connect these vehicles while also delivering on load growth from other emerging sectors, customers must be able to connect their EVs affordably and quickly while also leveraging EVs as assets that enhance grid stability. As EV adoption accelerates, PG&E must facilitate this transformation while managing increased electricity demand and grid integration.

Al's potential to supercharge progress

- **Simplifying customer connections:** All has the potential to enhance site assessments and grid upgrade requirements, speeding up the process for connecting EV chargers and reducing associated costs.
- **Disaggregating load for load management:** All has the potential to analyze charging patterns and predict demand spikes, enabling better load management across the grid to avoid congestion.

THEME 1

Ensure affordable and timely connection for every customer

The surge in EV adoption requires rapid expansion of charging infrastructure. PG&E aims to ensure that customers can connect to the grid affordably and without long delays. This theme focuses on streamlining the connection process for residential, commercial, and fleet charging to meet the growing demand efficiently.

THEME 2

Unlock potential of EVs as grid assets

EVs have the potential to act not just as massive sources of load but also as valuable grid assets. Vehicle-to-everything (V2X) technology enables EVs to discharge electricity back into the grid during periods of excess demand, supporting grid stability, or to provide backup power to businesses, homes, and communities. PG&E is focused on unlocking this potential to ensure that EVs contribute to both transportation decarbonization and grid resilience and to enable customers to maximize the value of EV ownership.



Integrated Grid Planning (IGP) & Transmission Strategy

With California's increasing electrification, PG&E is reimagining how it plans, builds, and upgrades the grid.

Electric demand is expected to double by 2040, driven by vehicle and building electrification, data center load growth, and more. PG&E's IGP efforts focus on reducing the need for conventional capacity upgrades while ensuring new connections to the grid are efficient and cost-effective.

- Optimizing the grid for real-time and future needs: At has the potential to integrate data from smart meters and grid operations to enhance real-time predictive analytics, maximizing asset capacity and identifying potential grid congestion. It can also analyze historical and forecasted data to better identify necessary upgrades for maintaining grid reliability, all of which are critical to making necessary T&D investments neither too early nor too late.
- Accelerating new interconnection recommendations: All has the potential to speed up interconnection studies by analyzing demand data, infrastructure lifespan, and grid constraints. It can use simulations to better identify optimal interconnection points, ensuring investments are directed to high-benefit locations for both PG&E and the community.
- Streamlining project design and estimation: All has the potential to greatly reduce the manual effort and time associated with the design and estimation process for routine work across our energy system by creating initial project designs and estimates for review and approval by engineers and estimators, reducing time spent on routine jobs and freeing up valuable resources for more complex projects.

Reduce conventional capacity upgrades

To accommodate projected load increases, PG&E seeks to minimize expensive, traditional capacity upgrades. It is necessary for PG&E to increase the utilization of the existing T&D infrastructure to delay, defer, and mitigate the need for conventional capacity upgrades where possible. PG&E seeks novel technologies to safely increase the flexibility and/or thermal rating of grid assets, improve power quality on the T&D system, or otherwise increase the efficiency of T&D assets on the grid.

THEME 2

Optimize prioritization and reduce costs for unavoidable capacity upgrades and new interconnections

As new load and generation come online, it is crucial to streamline the interconnection process beyond the current state. Additionally, identifying novel technologies that enable us to complete required capacity upgrades with minimal waste and at the lowest possible cost will be essential to our efforts to accommodate new load while maintaining affordability. This theme focuses on ensuring that new interconnections are planned and executed in a timely and cost-efficient manner, optimizing the use of grid assets, and that capacity upgrades are designed for affordability and efficiency.

THEME 3

Optimize system-level decision making

As electrification accelerates and grid infrastructure ages, a consolidated view of current transmission constraints and future demand is essential for optimizing investments, avoiding stranded assets, and ensuring reliability. PG&E is seeking to enhance its ability to integrate data from interconnection studies, load forecasts, and other sources across the electric and gas systems to improve strategic planning for transmission, distribution, and storage needs, to augment decision-making, and support reliable, affordable grid operations.



Supply and Load Management

Managing the increasing load on the grid and balancing the supply from renewable sources is a growing challenge for PG&E.

As electrification and penetration of intermittent renewables like solar and wind increase, the need for real-time load management becomes ever more critical. PG&E's strategy focuses on ensuring load becomes more flexible as supply becomes more inflexible, while also deploying new supply technologies at the right place and time to meet system needs.

- Enhancing real-time visibility: Al-driven analytics have the potential to process data from DERs, smart meters, and sensors, providing accurate demand forecasts and grid flexibility insights. This real-time visibility can help the grid adapt quickly to supply and demand changes, reducing costly upgrades and operational risks.
- Optimizing resource orchestration: All has the potential to intelligently coordinate DERs by analyzing grid conditions and demand, enabling dynamic adjustments that balance supply and load. This reduces reliance on carbon-intensive peaker plants and minimizes the need for costly infrastructure expansions, ensuring efficient use of resources.

Expand load management capabilities across all levels of the system

Expanding load management capabilities across all levels of PG&E's system is crucial for maintaining reliability and meeting decarbonization goals. As Distributed Energy Resources (DERs) proliferate, the focus shifts from simply monitoring to actively managing these assets as key tools for grid operations. PG&E aims to intelligently orchestrate DERs in real time to balance supply and demand, reduce infrastructure costs, and enhance grid efficiency. However, challenges remain, such as the lack of visibility to the grid flexibility potential of DERs and the lack of standardized, interoperable interfaces between devices and the grid.

THEME 2

Deploy new clean supply and energy storage technologies

As PG&E works towards a net zero grid by 2040, the integration of new clean supply and energy storage technologies is essential for balancing renewable energy intermittency and meeting peak demand. A key challenge lies in effectively incorporating solutions like long-duration storage, enhanced geothermal, and grid-edge technologies to ensure reliability, affordability, and scalability. PG&E aims to strategically deploy these zero-carbon resources in high-value locations to enhance grid flexibility, reduce reliance on fossil fuels, and avoid costly infrastructure upgrades. By understanding the operational characteristics of these technologies, PG&E can optimize their use during critical hours while ensuring utility-owned generation and procurement processes are optimized to provide maximum benefit to customers and the system.





Undergrounding

PG&E's undergrounding efforts are aimed at reducing wildfire risks in California's High Fire Threat Districts (HFTDs). However, undergrounding power lines is a challenging and time-consuming process.

PG&E's plans to underground thousands of miles of distribution lines where fire risk is highest. To achieve this goal with the lowest impact on rates, PG&E is focused on prioritizing high-risk areas and optimizing resource deployment to make these projects more efficient and cost-effective. Tools to improve the efficiency of underground construction and deploy novel, resilient system components are key themes driving PG&E's long-term efforts to lower costs and streamline operations.

- Streamlining project selection: PG&E currently uses predictive models to assess wildfire and reliability risks for selecting circuit segments for undergrounding. Advanced AI has the potential to enhance this process by optimizing project portfolios, improving wildfire risk reduction, and mitigating the reliability impacts of outage programs like Enhanced Powerline Safety Settings (EPSS) and Public Safety Power Shutoffs (PSPS).
- Optimizing supply chain planning: Novel AI capabilities have the potential to drive cost and time savings by simultaneously understanding the evolving needs of current and upcoming projects, our existing inventories, and dynamic supplier lead times in real-time to proactively suggest materials orders to avoid inventory shortfalls and ensure that our crews in the field always have what they need when they need it.

Improve the efficiency of underground construction across project lifecycle

PG&E's undergrounding projects face several challenges across varied terrain, from steep grades to rocky areas, requiring a range of construction methods. While innovative technologies have shown promise, further advancements are needed to reduce costs and complexity, especially in remote, fire-prone areas. The primary cost driver, civil construction, varies greatly based on geography. PG&E is seeking novel approaches, particularly for smaller-scale projects, that are less disruptive than traditional methods. Additionally, reducing the volume and handling of construction spoils, especially in compliance with regulations for hazardous materials, is critical for cutting costs and improving project efficiency.

THEME 2

Deploy novel system components to reduce cost and complexity

PG&E's undergrounding efforts rely on conventional technologies for cables, conduit, and splicing, but innovations in these areas could significantly lower costs and streamline operations. Extending the length of cable pulls would reduce the need for frequent splices and primary boxes, cutting both time and expenses. New splicing technologies and enclosures could minimize onsite manual labor and maintenance needs, offering substantial savings across PG&E's undergrounding projects.





Wildfire

Wildfires have long been a part of California's history, but recent fire seasons have become increasingly intense and prolonged due to rising temperatures and lower precipitation.

Destructive wildfires can cause significant harm to residents, property, and public health, making PG&E's efforts to reduce wildfire risk more critical than ever. With over half of our service area and a third of our assets in High Fire-Threat Districts, we have implemented a comprehensive wildfire mitigation strategy. This includes initiatives focused on eliminating ignition sources through asset monitoring and vegetation management, using proactive de-energization to mitigate external risks, and rapidly identifying any fires that occur near PG&E's infrastructure. Additionally, PG&E relies on a suite of innovative technologies, including hundreds of weather stations and high-definition cameras, and cutting-edge meteorology and fire science to provide real-time situational awareness of evolving risks across our service area.

- Improving asset health assessments: PG&E regularly inspects a wide range of assets to identify degradation requiring maintenance. All has the potential to significantly enhance the precision and efficiency of these inspections by supplementing existing processes and predicting degradation based on factors like asset type, weather, and grid conditions. This would improve asset management by optimizing interventions and reducing risks through intelligent predictions.
- Enhancing diagnostics of vegetation health: PG&E conducts extensive vegetation management patrols to identify trees that pose ignition risks. Al has the potential to greatly improve these efforts by analyzing species-specific indicators of tree health and predicting failure at the individual tree level, especially in response to changing environmental conditions.

Improve monitoring, inspection, and analysis of asset condition

PG&E uses a variety of tools, such as LiDAR, infrared imaging, and drones to monitor the health of transmission and distribution assets, particularly in HFTDs. While PG&E continues to implement innovative means and methods for enhancing our inspection processes, current solutions can be expensive and reliant on human judgment, and they often fail to detect internal asset degradation or emerging issues between inspections. PG&E seeks advanced technologies to more precisely and frequently assess asset conditions and predict failures, allowing for more accurate, cost-effective, and timely interventions.

THEME 2

Eliminate and rapidly suppress ignitions

While PG&E has reduced wildfire ignitions significantly, particularly on EPSS-enabled circuits, challenges remain in preventing all ignitions from equipment failures. PG&E is looking for innovative technologies to further enhance EPSS and improve electrical asset design to safely manage faults. Additionally, PG&E seeks real-time detection and suppression solutions to prevent ignitions from spreading.

THEME 3

Eliminate customer impacts from PSPS/EPSS

PSPS and EPSS events, though effective in preventing wildfires, create outages for customers. PG&E aims to reduce the impact of these events through improved meteorological models, sectionalizing devices, and localized automation for faster power restoration. Additionally, PG&E is pursuing clean backup power solutions to eliminate reliance on fossil fuels for backup generation, ensuring minimal disruption to customers while maintaining fire safety.

THEME 4

Enhance understanding of tree health to optimize vegetation management

Vegetation management is essential to reducing wildfire risks, yet current tools lack the precision to assess tree health accurately and target high-risk areas. PG&E is seeking technologies that can better evaluate tree health at the individual and forest levels, predict when trees should be removed, and direct vegetation management efforts more effectively. These innovations will help reduce wildfire risks, minimize unnecessary tree removal, and improve the efficiency of vegetation management patrols while preserving California's natural landscapes.



Gas

PG&E operates one of the largest natural gas systems in the U.S., with nearly 50,000 miles of pipelines serving 4.5 million customers. Currently, natural gas makes up nearly 100% of the 880,000 million cubic feet of annual throughput.

As part of PG&E's Climate Strategy, the company aims to achieve a net zero energy system by 2040, five years ahead of California's mandate. This transition involves integrating cleaner fuels like renewable natural gas (RNG) and hydrogen while ensuring the safety and reliability of gas operations. However, this transition presents challenges, including adapting existing infrastructure to clean fuels such as hydrogen, managing decreasing demand due to electrification, and ensuring affordability as maintenance costs spread across fewer customers.

- Enhancing safety through proactive maintenance: All has the potential to enable predictive maintenance by analyzing sensor data to detect early signs of equipment failure, reducing downtime and safety risks. It also may help identify anomalies in gas quality, allowing for early intervention to prevent leaks and equipment failures, improving both efficiency and safety.
- **Optimizing system planning:** All has the potential to optimize pipeline project planning by considering weather, traffic, and resource availability.
- Enhancing personnel training and field work: All and augmented reality (AR) have the potential to enhance training by simulating inspections and offering immersive learning experiences. In the field, All can optimize task assignments, while AR can help provide real-time guidance and hazard alerts, improving safety and efficiency.

Maintain and increase the safety and reliability of the system while reducing operations and maintenance (0&M) costs

PG&E seeks to enhance safety and reliability while reducing O&M costs by implementing new technologies that increase automation, data-driven decision-making, and remote monitoring. Managing a vast 50,000-mile pipeline network requires significant investment in inspections, maintenance, and repairs, often relying on advanced technologies like drones and in-line inspection tools. However, with growing electrification and decarbonization efforts, it is more critical than ever to optimize these operations. PG&E aims to leverage innovative solutions to target maintenance more effectively, reduce the need for frequent inspections, and address developing issues proactively, ultimately lowering costs without compromising safety or service reliability.

THEME 2

Operating a clean fuels system

As part of our commitment to decarbonization, PG&E is exploring the integration of clean fuels like hydrogen and the increasing integration of RNG into our gas system. While clean fuels are expected to play a major role in future energy systems, there are still uncertainties about how they will interact with existing infrastructure. PG&E is investing in foundational research to understand the impacts of clean fuels on pipelines, system components, and end-user applications. This research will help identify solutions for safety risks, such as hydrogen leaks and pipeline embrittlement, and guide the transition to a cleaner, more sustainable gas system that aligns with PG&E's True North Strategy and California's decarbonization goals.



Climate Resilience

The increasing impacts of climate change, such as extreme temperatures and storms, flooding, sea level rise, and wildfires, are placing significant pressure on PG&E's energy system and challenging our ability to provide safe, reliable service.

To address these challenges, PG&E is prioritizing climate resilience, defined as the ability to anticipate, absorb, recover, and learn from climate-driven hazards. By systematically incorporating climate risks into planning, operations, and investments, PG&E aims to make the energy system safer, more reliable, and adaptable. This includes hardening infrastructure, improving maintenance practices, and using advanced technologies to detect and mitigate outages. Climate resilience will also reduce long-term costs by optimizing investments based on evolving risks and helping avoid costly emergency repairs and disruptions. Recognizing that climate resilience is a shared goal across the energy sector, PG&E advocates for common frameworks and regulatory support to bolster grid resilience in the face of growing climate risks. These efforts are central to PG&E's commitment to building a safer, more resilient, and affordable energy system for the future.

Al's potential to supercharge progress

- Optimizing infrastructure planning for climate: Al-driven models have the potential to analyze climate and operational data to predict potential risks to assets. This foresight enables PG&E to take preemptive actions, protecting infrastructure and communities, and improving safety while reducing damage costs.
- Optimizing field team operations: All has the potential to assist with predicting the timing and location of extreme climate-driven hazards, allowing PG&E to better prepare and deploy resources, ensuring worker safety and faster emergency responses in affected communities.

THEME 1

Improve and integrate climate and hazard data into utility planning for enhanced resilience

As climate impacts intensify, PG&E must incorporate advanced climate and hazard data into our utility planning to improve system resilience. Current infrastructure was not designed to withstand future climate hazards, making it critical to understand how varying conditions will affect operations. By enhancing localized climate data and filling gaps in historical and observational records, PG&E can improve risk assessments, scenario-based planning, and tactical operational response. More accurate and granular modeling of climate impacts on infrastructure and communities will help optimize investments, minimize outages, and plan for extreme events like heatwaves, floods, and sea-level rise. PG&E seeks innovative solutions to enhance data and modeling accuracy and to develop cost-effective adaptation strategies for long-term resilience.



Net Zero Energy System & Environmental Stewardship

PG&E is dedicated to supporting California's goal of achieving carbon neutrality by 2045 **through our commitment to be net zero by 2040**.

The company's focus is on reducing greenhouse gas (GHG) emissions across our operations while also enhancing environmental stewardship through responsible resource management and sustainable practices. PG&E's commitment to decarbonization extends beyond the energy system itself to include initiatives for sustainable land use, water conservation, and habitat protection.

- **Predicting and detecting methane leaks:** All has the potential to assist with detecting methane leaks in real-time and predict where future leaks may occur based on historical patterns.
- Quantifying forest management value streams: All has the potential to integrate data to assess and optimize land use treatments like controlled burns or selective logging, helping PG&E prioritize investments by quantifying wildfire risk reduction, ecological benefits, and economic returns.
- Enhancing carbon capture efficiency: All has the potential to enhance the efficiency of carbon capture systems by continuously adjusting operational parameters in real-time, maximizing CO₂ capture rates while minimizing energy consumption.

Reducing gas supply chain emissions

PG&E is committed to reducing methane emissions from our gas supply chain as part of our journey toward net zero by 2040. To meet its net zero goals, PG&E aims to cut methane emissions by 45% by 2030 through enhanced leak detection, repairs, and mitigation of routine maintenance emissions. Achieving these goals requires innovation in leak detection technologies, reducing emissions from pipeline blowdowns, and the integration of growing volumes of RNG and hydrogen into the gas system. PG&E also seeks cost-effective technologies, like carbon capture and storage (CCUS), to abate the remaining hard-to-remove emissions, supporting a cleaner and greener gas system.

THEME 2

Holistically manage forest ecosystems

PG&E is expanding our approach to forest management by embracing holistic interventions that go beyond fire risk mitigation to promote overall ecosystem health. The goal is to improve forest longevity, reduce wildfire risks, and deliver ecological benefits through innovative forest management practices. By leveraging advanced analytics and models, PG&E seeks to better optimize interventions based on local conditions and broader outcomes like GHG reductions. Engaging a wider array of stakeholders who benefit from healthier forests is key to amplifying these efforts, ensuring that PG&E's approach supports both wildfire prevention and environmental stewardship.





Conclusion: a futureproofed energy system

As PG&E advances our R&D strategy, we are committed to building a future-proofed energy system that is **safe**, **clean**, **resilient**, and **affordable**.

Our vision of an Al-enabled utility is grounded in solving the 67 problem statements that are key to decarbonizing, electrifying, and fortifying California's grid. Our full report highlights how Al and other novel technologies have the potential to accelerate progress across our operations, optimizing efficiency, reliability, and safety while preparing the grid for future demands.

While AI is a powerful tool, our problem-focused approach ensures that we apply the right technologies to the right challenges. By addressing emerging and ongoing issues across the gas and electric systems, PG&E is ensuring that California's energy system is not only clean and reliable but also equipped to adapt to the future.

We encourage you to explore the **full report** and the detailed problem statements that guide our work. Additionally, to foster collaboration and explore the potential of AI in creating this future-proofed energy system, PG&E will host an **Innovation Summit on November 13, 2024**. This event will bring together utilities, vendors, experts, and regulators to discuss solutions that can drive the transformation of our energy infrastructure.

Together, we can innovate and create a **future-proofed energy system** that delivers for our customers, our communities, and the planet.