

LCRI FREQUENTLY ASKED QUESTIONS

WHAT IS THE IMPORTANCE OF THE LCRI?

The pathway for transition to a deeply decarbonized economy will require cost-effective, reliable, and diverse solutions. The Low-Carbon Resources Initiative (LCRI) is designed to inform and guide the energy sector as consumers, government entities, and stakeholders increasingly push for a low- to no-carbon future.

The LCRI will identify, research, develop, and demonstrate the technology advancements needed to achieve this decarbonized future. The program is designed to provide participants with confidence and experience in technical understanding, economics, operational considerations, and regulatory implications required for deep decarbonization in order to better serve customer interests, deploy affordable and reliable solutions, and manage business and technical risk.

WHAT BENEFITS WILL LCRI PARTICIPANTS GET?

Participation in LCRI offers a significant stream of benefits that span operations, planning, and stakeholder engagement. LCRI will provide detailed information to inform corporate strategy while also demonstrating stakeholder commitment to environment, governance, and sustainability (ESG). In addition, LCRI will provide a comprehensive analytical framework and robust data sources for tailored deep decarbonization scenario analysis that, coupled with technology advancements, will leverage existing assets to provide an economical transition to the low-carbon future. Additional expected benefits include, but are not limited to:

- Enhanced value of existing carbon-free generation sources (e.g., nuclear, renewables) through production of low-carbon resources like hydrogen, liquid ammonia, synthetic fuels, etc. during times when electricity is in surplus supply.
- Increased value in existing gas pipeline assets which may serve as the carrier for low carbon resources, transporting and storing a combination of hydrogen and natural gas in the near term and low-carbon resources further in the future
- Improved electric and gas grid utilization where the grid will support production of alternative energy carriers needed to decarbonize industry (chemical, steel, cement, etc.) and bulk transportation.
- Identification, assessment, and advancement up the technology readiness scale of emerging low-carbon technologies, enabling participants to quickly deploy new technologies as they are commercially ready.
- Establishing requirements for transitioning end-use technologies to run on low-carbon resources.

HOW WILL LCRI PROVIDE THESE BENEFITS AND WHAT KEY PRODUCTS WILL BE DELIVERED?

LCRI will focus on leveraging a combination of resources to accelerate the development and deployment of technologies that enable the previously mentioned benefit streams. Examples of some of these resources include:

- Comprehensive FEED studies for future demonstration projects
- Materials and support for advancing ASTM/ASME/NRC/NFPA/ASHRAE and other code packages for integration of these new technologies for evaluation of safety and performance implications
- Evaluations of emerging low-carbon resource technologies in field laboratories like the National Carbon Capture Center as well as field demonstrations on funder sites
- Functional and design specifications for conducting pilot projects across the energy value spectrum
- A repository for credible, verified lessons learned from demonstration projects worldwide along with approaches that can be applied for unique funder applications

WHAT ARE THE PUBLIC BENEFITS?

LCRI will provide general societal benefits that fit into four categories:

- **Environment and Health:** Cleaner energy supports reduced air pollution, healthier quality of life, and broad environmental protection.

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- **Energy Security and Resiliency:** New and sustainable options, with a focus on alternative energy carriers, drives both a more secure energy system less dependent on fuel imports, as well as a more resilient system with increased optionality and diversity.
- **Economic Growth:** Coupling of industries through decarbonization leads to the expansion of infrastructure and local jobs.
- **Reputation:** Provides a pathway to realize sustainability expectations from stakeholders, investors, and customers.

WHAT SPECIFIC BUSINESS-BASED FINANCIAL BENEFITS (ROI) WILL RESULT?

The LCRI effort will provide a variety of financial benefits, many of which will begin to accrue in the years after completion of the project. As industry transitions to a low- to no-carbon future, work from LCRI may enable repurposing of some capital assets, as well as life extensions and better utilization of existing assets, helping to drive overall financial health. In a similar manner, the decarbonization of end uses across the economy will result in top line growth opportunities for providers/carriers of alternative energy sources and electric utilities.

WHY ESTABLISH A PARTNERSHIP BETWEEN THE ELECTRIC INDUSTRY THROUGH EPRI AND THE GAS INDUSTRY THROUGH GTI?

The electric and gas industries are intimately linked and have been for many years. A significant number of utilities provide both electric and gas service to their customer bases and the use of natural gas in the production of electricity is at an all-time high. We will increasingly have an integrated energy system, and the solutions to decarbonization will be integrated as well. The challenges of achieving a low- to no-carbon economy are enormous and the ability to have two of the leading international R&D organizations partnered together is highly beneficial to drive success.

HOW WILL EPRI AND GTI LEVERAGE LCRI?

EPRI and GTI business models have always been based on collaboration and leveraging the power of multiple companies with common challenges and interests. As these international entities partner together, we will have the ability to multiply the initial \$100 million invested by seeking and securing alternate funding mechanisms, federal and state government funding in the United States, international opportunities, and private industry. We strive to leverage the initial investment up to tenfold in order to even better address the challenges of the low- to no-carbon economy.

HOW WILL LCRI ENSURE THAT IT IS NOT DUPLICATING EFFORT WITH OTHERS?

LCRI will be a worldwide effort with the intent of leveraging activities around the globe to most effectively find solutions for a low- to no-carbon future. Some of the initial stages of our efforts will be assessments of work taking place in LCRI space across the world in order to inform our road-mapping process and ensure a clear path to reach the needs of the future. Where gaps exist, we will move to fill them, and where existing work provides value, we will look to joint opportunities for maximum leverage.

WHAT ABOUT INSTANCES WHERE OTHERS, SPECIFICALLY COMBUSTION TURBINE MANUFACTURERS, ARE ALREADY WORKING ON HYDROGEN-FIRED TURBINES?

Many manufacturers are indeed working on opportunities to run existing gas turbines with a mixture of hydrogen and natural gas. Still others are working further ahead on future designs for 100% hydrogen-fired combustion turbines. For the mixture example, LCRI will be able to offer support to funders as the owner's engineer, providing unbiased analysis and assessments, as well as support for plant integration. In the case of work towards future 100% hydrogen-fired machines, LCRI may work directly with manufacturers in the development of those new products, as well as cost effective retrofit of existing machines. Lastly, one of the key technical challenges in this space is around the integration and holistic system understanding of impacts, beyond any individual asset. Integrated approaches and

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solutions are the foundation of both the EPRI and GTI R&D approaches and will be critical as we implement new and novel technologies.

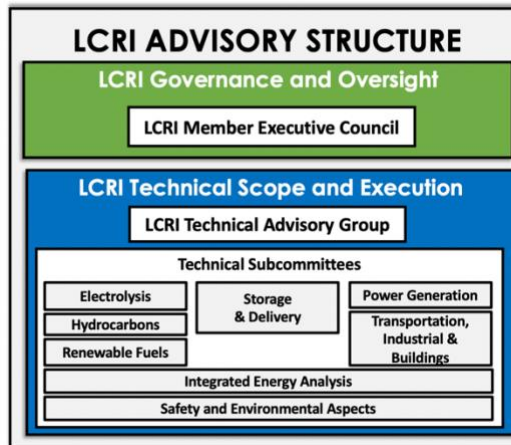
WHAT WILL IT COST? HOW IS PRICING DETERMINED?

LCRI is targeted to be a \$100 million, five-year effort funded by energy companies and other related businesses or interests. Pricing is metrics-based and consists of a variety of considerations including generating capacity, miles of gas distribution pipeline, and miles of gathering and transmission pipelines. Prices are individually provided to interested funders upon request.

WHAT WILL BE THE GOVERNANCE FOR LCRI?

The LCRI will be governed and overseen by a variety of groups to ensure the vision and objectives of the overall initiative are met. The LCRI will be advised by a variety of technical and strategic thinkers across the energy economy.

- Engagement at a Board of Director level has been established to focus on strategic direction and engagement with the global stakeholder engagement.
- A technical advisory and governance structure has been established to represent the perspectives and input of the funding members of the LCRI and set the direction and prioritization of decarbonization pathways.



- **Executive Council (EC):** is comprised of funding executives of the LCRI. The EC is responsible to inform and advise the vision and objectives of the LCRI. It will be utilized as a governing body to set objectives and metrics while overseeing reporting of project status and direction. Each funding member of the LCRI will have one seat on the EC if it is a single-fuel company (electric or gas only) and two seats if it is a dual-fuel company. EC members will engage with EPRI and GTI in regular Advisory Board meetings, as well as through opportunities in both stakeholder and public forums.
- **Technical Advisory Group (TAG):** is a team of technical advisors from funding organizations who will inform and provide ongoing guidance on the technical scope and execution of the initiative while providing additional guidance to the EPRI and GTI technical teams. Each LCRI funding member will have one seat on the TAG if it is a single-fuel company (electric or gas only) and two seats if it is a dual-fuel company (electric and gas). Each seat will have a vote for advice and project prioritization guidance. TAG members are considered the prime technical interface for a company to the LCRI. It is the responsibility of TAG members to engage technical teams across their respective organizations, as they relate to LCRI technical scope, for engagement in the Technical Subcommittees.
- **Technical Subcommittees (TS):** will guide the deep technical work of the LCRI. TSs may transition and evolve, with approval from the TAG and EC. The role of the TS is to support, enable, and assist in the technical scoping and direction of a specific technical area. As applicable, it is recommended that TS members be engaged in related EPRI/GTI R&D to ensure the technical scope is complementary and not duplicative. Each TS will have an EPRI and GTI lead who will work with the TS to identify the technical needs, gaps, and strategic focus.

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- A Technical Collaboration Network will be utilized to vet technical strategy and content and inform technical challenges and pathways, providing independent perspectives and feedback in order to strengthen the overall approach and plan. The Technical Collaboration Network is geared toward the global research community—this includes government agencies, research organizations, universities, and other interested subject matter experts in the low-carbon resource space.

WHY HAVE A TECHNICAL COLLABORATION NETWORK?

Expanding the contributions of the LCRI from a broad range of organizations brings holistic consideration and evaluation of the challenges to address to provide the diverse set of solutions needed for deep decarbonization. There will not be a one size fits all solution—rather a diversity of technology options coupled with technically-rigorous decision-making processes that will allow for best option decisions given a variety of decarbonization pathways. For example, these can take into account availability of natural resources, geographic limitations and opportunities, existing infrastructure capability, industry-coupling, workforce needs, and economies of scale.

HOW WILL EPRI AND GTI SPEND THE MONEY? WHO WILL HAVE OVERSIGHT ON SPENDING THE MONEY?

The prioritization and allocation of resources will be decided by the funder advisory groups noted in the governance section. In general, money will be spent on analysis, technology proof-of-concept, and technology demonstration with some project management associated expenses. Each funding member of the LCRI will have the ability to allocate a certain percentage of their funding to specific research areas of interest. Each funding member will inform prioritization of individual projects in various technical areas.

WHAT DOES SUCCESS LOOK LIKE IN THE FIRST YEAR? SECOND YEAR?

Early stage success certainly includes achieving our funding objective of \$100 million and engaging leading utilities from around the world. Another key achievement will be completion of the LCRI roadmap to guide efforts going forward. As part of the road-mapping effort, the LCRI will develop a comprehensive and focused body of research across the alternate energy carrier supply chain, understanding current state of technology cost and performance, worldwide efforts and demonstrations underway, and identifying R&D gaps and needs. This will be communicated across the LCRI membership through a series of LCRI: Technology Insights and LCRI: Global Insights, focused to inform a variety of interested stakeholders. In conjunction with that effort, firmly establishing the advisory structure and putting it to work guiding R&D efforts to close gaps needed for a low- to no-carbon economy is also a key criterion for success. Lastly, identification of no-regrets technologies that we can begin to evaluate and potentially demonstrate, through leverage of other funding opportunities, will be a focus.

EPRI'S ANALYSIS TO-DATE HAS BEEN BASED LARGELY A US FOCUS. WHY SHOULD GLOBAL ORGANIZATIONS CONSIDER PARTICIPATION?

Progress toward a decarbonized economy varies around the world. To truly achieve this vision, worldwide collaboration will be required. While we expect many of the funders to be US-based companies, we also expect to have many international funders. Additionally, we will engage any entities where progress is evident and beneficial to the overall effort, regardless of geography.

WHAT DO EPRI AND GTI SEE AS THE KEY CHALLENGES TO REALIZING THE VISION OF THIS PROJECT AND HOW WILL THESE BE ADDRESSED?

In order for LCRI to be successful, we must secure not only the initial funding required, but we must also engage the proper leading organizations in the energy industry. Fortunately, the companies that EPRI and GTI work with on a daily basis are industry leaders and well positioned to make this a success through their participation. The challenges of developing viable, affordable, and sustainable options for a low- to no-carbon future are enormous. LCRI as a platform for global collaboration can lead us to success in overcoming these challenges.

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EVEN IF SUCCESSFUL, THIS INITIATIVE IS UNLIKELY TO GO ANYWHERE WITHOUT ENGAGEMENT WITH POLICYMAKERS, REGULATORS—HOW WILL THE LCRI ENGAGE THESE ORGANIZATIONS? DOES THE LCRI ANTICIPATE TAKING POLICY POSITIONS BASED ON THE RESULTS?

LCRI intends to engage all stakeholders around the electric and gas industries. This will include regulators, policymakers, and other government entities. As is our standard practice, we will seek to educate, inform and engage stakeholders, regulators, policymakers, etc. on the technology-related aspects of deep decarbonization in the first days of this initiative all the way through completion.

HOW WILL LCRI ENGAGE OTHER STAKEHOLDERS, THAT IS OTHER INDUSTRIES, ACADEMIA, GOVERNMENT, NGOs?

We will seek to educate, inform, and engage stakeholders through-out the initiative. A stakeholder engagement plan will be developed and vetted with all funding members. A Strategic Alliance will be created to invite key stakeholders to the table to provide input and be part of the conversation.

ISN'T THIS INITIATIVE SEEKING TO, IN EFFECT, "BOIL THE OCEAN"?

Economy-wide decarbonization is indeed a broad challenge and the LCRI effort will initially cast a broad net so as to provide far-reaching solutions. The road-mapping effort, informed by LCRI participants, will focus future efforts on the highest priorities to the industry. Our ability to remain focused and deliver solid results is enabled by the governance/advisory structure comprised of funders who will guide the way to the most important topics to address. Funding prioritization and allocation by individual members will ensure critical areas get the proper level of scope and attention.

WHY DO THIS, AT LEAST IN THE US, WHERE THERE ARE NO POLICY DIRECTIVES DRIVING DEEP DECARBONIZATION?

The lack or minimum presence of policy directives for decarbonization does not mean work should not begin to achieve a low- to no-carbon economy. Around the world, we have seen many utilities make significant corporate commitments to decarbonization. A range of technical solutions that are both affordable and scalable are needed to help achieve those goals.

SHOULDN'T EPRI AND GTI LEAVE THIS WORK TO THE MARKET AND LET COMMERCIAL ENTITIES MAKE THESE INVESTMENTS?

A primary role of both EPRI and GTI has always been as a technology accelerator. However, that role is focused on providing economically viable and sustainable solutions, not a on the singular intent of commercialization. In addition, the unique positions of EPRI and GTI in their respective industries has enabled both organizations to provide leverage of R&D funding through collaboration. The timeframes for the work required for decarbonizing the economy are such that most commercial entities will wait until there's a market before entering. Technology development and validation, as well as equipment procurement and integration, are such that not beginning work now would put utilities at high risk in the future.

DOESN'T THIS INITIATIVE IGNORE THE IMPORTANCE OF RENEWABLES, NUCLEAR POWER, ELECTRIFICATION, EVs?

Not at all. EPRI, GTI and the industry see all of these factors as crucial to the success of achieving economy-wide decarbonization and will be working in these areas as part of LCRI.

AREN'T EPRI AND GTI ALREADY DOING MUCH OF THIS WORK IN ITS STANDARD R&D PORTFOLIO?

LCRI moves well beyond the current EPRI and GTI R&D portfolio with a focused and comprehensive look at low-carbon energy carriers, beyond what either organization has done previously or can do alone. LCRI will fill in the technical and market gaps that the current R&D portfolios are not focused on, specifically applications where the technologies to decarbonize them are nascent or do not yet exist.

IS LCRI SEEKING TO "SAVE THE GAS INDUSTRY"?

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No. The LCRI seeks, where appropriate, a strategy that leverages all existing assets to ensure least cost, reliable, resilient, and sustainable energy for consumers. LCRI will be focused on these objectives for both the electric and gas industries.

MANY ELECTRIC UTILITIES WILL OR ALREADY HAVE ACHIEVED DEEP DECARBONIZATION—WHY SHOULD THEY BE ENGAGED?

While some utilities have made great strides towards decarbonization, all have an opportunity to do more and support the overall effort to decarbonize the full economy. Even those well on their way can discover new technologies and techniques to improve their effectiveness and will likely find new business opportunities as the industry moves in a common direction.

THE ENERGY SECTOR HAS CONSIDERED THE NOTION OF HYDROGEN SINCE THE 1970S. WHY REVISIT THIS NOW?

Technologies in the energy sector take a long time to develop and commercialize. Fracking started in the 1940s and horizontal drilling was developed in the 1980s, but it took until the mid-2000s for the technology to take off. Similarly, solar PV was powering satellites in the early 1970s and began terrestrial deployment in the 1980s but did not gain significant market traction until the 2010s. Generally, technologies in the energy space take more than a decade of development in order to identify market need and scale to economic competitiveness. Hydrogen technologies have now sufficiently developed and market need is beginning to emerge, making now the right time to scale-up.

WHAT TYPE OF WORK WITH THE LCRI PERFORM?

The LCRI will lead and support a variety of projects. Below is an overview of the expected types of work the LCRI may undertake in three primary categories – General Research, Foundational Research and Development, and Demonstration and Applied Research and Development.

General Research

General research and reviews will be performed on overarching issues associated with low-carbon fuels, including driving factors, regulatory issues, safety, and regional economic modeling. This research will lead to white papers and peer-reviewed publications.

- **Roadmapping:** Roadmap documents will be created for the evolution of low-carbon fuels, including separate roadmaps for creation, transportation, storage, and end use.
- **Research Synthesis:** This will include the identification and initial review of all candidate technologies and processes in each space. This will be done through web searches, periodical reviews, relevant conference attendance and participation, and examination of prior EPRI and GTI work. Summaries will be written on each process or technology reviewed using a consistent style. The goal of this work is to identify and provide background information on all candidate technologies and processes. A list of criteria will be established to determine which candidates will undergo the next round of analysis.
- **Initial Engineering Assessments:** Engineering review of technologies or processes to assess technical feasibility and determine technology readiness levels will be documented.
- **Techno-Economic Analyses:** Each analysis will involve a high-level assessment of performance, costs, and benefits based on a developed design and cost basis. These analyses will be on the order of an AACE Class 5 basis. A summary report containing all underlying assumptions and results will be developed for each.
- **Gap Assessments:** These will involve the review of potential gaps that must be addressed and the documentation of a high-level assessment of the viability, cost, and timeline to address them.
- **Comparisons:** A detailed methodology will be created to compare technologies and processes using a consistent basis to determine those that will be advanced to Phase II of the LCRI for more detailed analysis. The methodology and the results of its application will be documented.

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Foundational Research and Development

Processes and technologies in this stage will be accelerated toward final demonstration stages through design reviews and improvements, bench- and laboratory-scale demonstrations, detailed techno-economic analyses and their use to update system-level economic modeling, assessment of any remaining gaps, and pre- or final front-end engineering design development (FEED), which may include environmental assessments and hazardous and operability (HAZOP) studies. The scope includes:

- **Design Reviews:** Experts will conduct engineering reviews focused on improving the technology or process and tailoring it for its intended use. Computer models may be developed for these assessments. These designs should be used for and lead to the next level of demonstration. Summaries of the design reviews will be produced.
- **Bench- and/or Laboratory-Scale Demonstrations:** This will involve the development of test plans and test protocols that provide data to verify and improve modeling, update the design for the next stage of demonstration, better assess performance, and reduce or eliminate identified gaps. If demonstration at this scale has already been performed, assessment of the data and resultant modeling should be undertaken. Detailed reports for each demonstration will be produced, documenting all important activities, results, and analyses.
- **Techno-Economic Analyses:** Each analysis will involve a detailed assessment of performance, costs, and benefits based on a developed design and cost basis. These analyses will be on the order of an ACE Class 4 basis. A detailed report containing all underlying assumptions and results will be developed.
- **Gap Assessments:** Review of remaining gaps that must be addressed and detailed assessment of the viability, cost, and timeline to address them will be documented.
- **Economic Modeling:** Dispatch modeling will be updated based on new cost and performance data to assess the impact of technologies and processes. A summary of modeling results will be developed.
- **Pre-FEED or FEED:** This will involve the development of detailed design and engineering documents and any required environmental/regulatory work, code approvals, and/or HAZOP studies for the next (final) stage of demonstration. Process flow diagrams and piping and instrumentation diagrams will be provided.
- **Comparisons:** An updated methodology will be created to compare technologies and processes using a consistent basis to determine those that should or need to be advanced to Phase III of the LCRI for more detailed demonstration. The methodology and the results of its application will be documented.

Demonstration and Applied R&D

Processes and technologies in this stage will be accelerated towards commercial readiness by larger-scale demonstrations, development of sequences of operations where applicable, updated techno-economic analyses, development of maintenance and safety practices, and updated system-level economic modeling. The scope includes:

- **Larger-Scale Demonstrations:** This involves the development of test plans and test protocols that provide data to validate the technology or process, design of training programs to provide industry the opportunity to get hands-on operating experience, update the design for the next stage of demonstration, better assess performance, and eliminate any remaining gaps. If demonstration at this scale has already been performed, assessment of the data and performance should be undertaken.
- **Maintenance and Safety Handbooks:** This involves the development of procedures for safely operating and maintaining the process or technology.
- **Techno-Economic Analyses:** Each analysis will involve a commercial-scale assessment of performance, costs, and benefits based on a developed design and cost basis. These analyses will be on the order of an ACE Class 3 basis. A detailed report containing all underlying assumptions and results will be developed.

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- **Economic Modeling:** Dispatch modeling will be updated based on new cost and performance data to assess the impact of technologies and processes. A summary of modeling results will be developed.