California's Clean Energy Future

Imagine the Possibilities

SoCalGas

A Sempra Energy utility

What's Inside

Introduction

California has set its boldest goal yet.

California has led the way in setting goals to reduce greenhouse gas (GHG) emissions and in getting consumers to be more energy efficient. In fact, California's energy efficiency efforts—which began in the 1970s—have been a significant factor in the state's per capita electricity use remaining relatively flat over the last 40 years.

Landmark legislation passed in 2006, known as AB 32, set into law requirements for California to reduce its GHG emissions, mandating the state reduce its GHG emissions to 1990 levels by 2020. California accomplished this goal four years ahead of schedule in large part because of investments in wind and solar technologies, aggressive energy efficiency goals, and the movement away from coal to natural gas.

In the fall of 2018, California set its sights on achieving an even more ambitious goal: carbon neutrality and 100 percent clean energy by 2045. Making this vision a reality will not be easy. As Governor Brown put it, 100 percent clean energy and carbon neutrality by 2045: "[puts] California on a path to meet the goals of Paris [Climate Accord] and beyond. It will not be easy. It will not be immediate. But it must be done."

For many, California is a test case to determine whether it's possible to drastically cut GHG emissions while still enjoying robust economic growth. It's a venture on which California is staking its leadership, and other states are watching closely to inform future policy decisions. To have any meaningful impact on global GHG emissions, California—which emits less than 1 percent of global GHG emissions—will need to develop scalable solutions that can work and are likely to be adopted by California energy consumers, as well as other regions of the country and around the world.

There is no clear path today to reach California's carbon neutral vision. The state's investment in solar and wind technologies has made them price competitive and is a proof point of renewable energy innovation. Similar policies and investments have led to advances and adoptability in battery technology. But solar, wind, and batteries alone will not get California where it wants to go.

A more inclusive approach is going to be needed—one that is technology-neutral, welcomes all ideas, considers all forms of energy, and that encourages and allows for innovation. Any energy solution will also need to factor in cost: for people to be able to work and live here and businesses to remain, California must find a way to achieve the state's ambitious climate goals that is affordable.

Such an approach requires California to think more broadly about other forms of renewable energy, such as renewable natural gas (RNG). We will also need to learn from and collaborate with others in the U.S. and abroad to advance other forms of energy, such as hydrogen, to further "decarbonize" our energy streams. These ideas, along with technology-neutral policies that allow for the advancement of nascent and future innovations, are what will be needed for California to realize its carbon-neutral vision.

SoCalGas is focused on becoming the cleanest gas utility in North America, and is committed to 20% RNG being delivered in our system by 2030.

California's Energy Landscape

Answering Three Fundamental Questions

California has reduced its GHG emissions by 11 percent[1] since the passage of the landmark Global Warming Solutions Act of 2006 (AB 32). These results were fueled by innovation on a number of fronts:

Energy Efficiency

The state pioneered demand response and energy efficiency as a central strategy to reduce its carbon footprint. Per capita energy use has remained flat since the 1970s due to California's energy efficiency programs. Energy use in the rest of the U.S., by contrast, has increased by about 33 percent.[2] Legislation passed in 2015, known as the Clean Energy and Pollution Reduction Act (SB 350), set California on an even more ambitious path, requiring the state to double its energy efficiency savings by 2030—a mandate equivalent to avoiding the annual electricity use of 12 million households and the natural gas consumption of more than 3 million homes.[3]

Renewable Electric Generation

The Renewable Portfolio Standard (RPS), along with the use of natural gas instead of coal as a base fuel, has helped to reduce the GHG footprint of California's electricity sector. From 2007 to 2015, California's consumption of coal-generated electric power dropped 96 percent—the steepest percentage decrease of any state.[4] Still, coal has not yet been eliminated as a source of electricity in the state. California also has reduced its use of nuclear power. The state's last operating nuclear power plant is slated to close in August 2025.

Through policies, investments and incentives, the state has built the largest solar market in the nation. Wind energy projects totaling at least 5,454 megawatts (MW) of capacity are operating in California today[5], providing enough electricity to power more than 2 million California households.[6] This represents more than a tripling of wind energy capacity since California's RPS law was adopted in 2002. Today, 20 percent of California's total in-state generation comes from solar and wind.

Natural gas has enabled the growth in renewable generation by addressing intermittency issues and ensuring a continuous power supply when renewable sources go down. For long-term reliability, most policymakers understand that natural gas will need to continue to play a role.

Transportation

The transportation sector continues to be California's biggest emissions challenge and opportunity. Since 2006, the state has reduced emissions from the sector by nearly 10 percent.[7] California introduced the Low Carbon Fuel Standard (LCFS) during the same period, establishing the most stringent fuel standards in the U.S. Despite these efforts, emissions from the transportation sector increased 2 percent from 2015 to 2016, in line with post-recession economic growth.[8]

Much of the state's strategy to reduce on-road emissions has centered on the transition to electric vehicles, but consumer adoption has been slower than anticipated. As of May 2017, only 300,000 zero emissions vehicles (ZEVs) and plug-in hybrids (PHEVs) had been sold in California.[9] Governor Brown challenged California to do more, by issuing Executive Order B-48-18. It set a target of 5 million ZEVs on California roads by 2030, supported by a network of new electric charging and hydrogen fueling stations.

On the economic front, California's Gross Domestic Product (GDP) during this same period increased by almost 16.5 percent, from $1.97 trillion to $2.3 trillion.[10] Californians, however, have not reaped all of the benefits. By a number of other important measures, quality of life in California is not keeping pace with the state's GDP: Housing prices continue to climb—with only 3 in 10 Californians able to afford a median-priced home.[11] Rent prices have increased 18 percent since 2006—with California renters paying almost 50 percent more than the U.S. median price.[12] Even with California's leading efficiency efforts, residents in the state still pay some of the highest electricity rates in the nation. In November 2018, households in the South Coast Basin paid 18.4 cents/kWh for electricity—37 percent more than the national average.[13]

Californians are also experiencing a growing chasm in income disparity, according to the U.S. Census Bureau's 2017 American Community Survey. California has the fourth highest level of income inequality in the nation and ranks second in terms of the rate in which income inequality is growing.[14]

Energy policy directly relates to many of these costs and presents state policymakers with a challenge of addressing competing (although not mutually exclusive) priorities—environmental leadership, economic growth at the macro level and the cost of living for average California families.

Extending California's Leadership

Today, the state is looking to expand its leadership—accelerating its climate goals by mandating emissions reductions to 40 percent below 1990 levels by 2030 (SB 32), committing to achieve 100 percent clean energy by 2045 (SB 100) and aspiring to achieve economy-wide carbon neutrality in the same timeframe (Executive Order B-55-18).

For many, California is a test case for the rest of the country—an experiment to determine whether it's possible to drastically cut GHG emissions while still enjoying robust economic growth. It's a venture on which California is staking its leadership, and other states are watching closely to inform their future policy decisions

Success will depend on addressing three fundamental challenges to expanding the state's use of renewable energy:

01 How will we store it? Addressing intermittency

The solution to California's renewable future is not as simple as generating more solar and wind power and adding them to the grid. Wind and solar are intermittent forms of energy—they do not provide a reliable, continuous power supply—and, most importantly, the power they generate is not always available when people need it most.

In fact, California today produces excess wind and solar power that cannot be used. To avoid overloading the grid, California either pays other states to take the excess renewable electricity or curtails production—exactly when wind and solar are most available. California is wasting a lot of energy. The California Independent System Operator (CAISO), which is responsible for managing the state's electricity grid, reported curtailments of the state's solar and wind generation more than doubled from 2015 to 2017.[15]

This energy waste is expected to grow: CAISO estimates that by 2025, California will be wasting between 3,300 to 7,800 GWh/year generated by solar and wind due to storage constraints. That equates to 4 percent to 11 percent of all the electricity used in Los Angeles County every year.[16] Put in another context, that's enough energy to power L.A. County for more than a month.

As the RPS requirement climbs to 50 percent and above, these curtailments are likely to increase even more sharply. Renewable storage is the foundation of our 2045 goal to source all of the state's electricity from renewable sources. Batteries, while a part of the solution, cannot solve the intermittency challenge alone. Batteries only hold and discharge energy for short periods (four to six hours).

To achieve dramatic GHG reductions, we must dramatically shift our thinking and foster an environment that fuels breakthrough innovation.

02 How will we pay for it? Addressing affordability

Expanding renewable energy in any form will be more expensive than relying solely on traditional energy sources. California will need to make smart decisions so that the pursuit of the state's climate goals does not undermine efforts to address another important priority—namely, affordable living.

The real cost of living is already too high for too many Californians. According to The United Way's 2018 *The Real Cost of Living Report*, nearly 40 percent of California households are rent burdened and spend more than 30 percent of their income on housing. After housing, utility bills are Californians' next biggest financial concern. This is particularly an issue for low-income families, who spend 20 percent or more of their monthly income on energy costs.[17]

It is true that the state's investments in the wind and solar markets have driven down the costs of wind turbines and solar panels. Between 2009 and 2017, the price of solar panels per watt declined by 75 percent[18] while the price of wind turbines per watt declined by 50 percent.[19] That, however, has not equated to lower electricity costs: During roughly that same period, the price of electricity in California increased 24 percent.[20]

California is not an anomaly. The price of electricity soared in other places where significant quantities of renewables were deployed—a 51 percent increase in Germany during its expansion of solar and wind energy from 2006 to 2016;[21] and more than a 100 percent price jump in Denmark since it began deploying renewables (mostly wind) in 1995.[22]

A large portion of the future cost challenge ties back to storage. A recent Black & Veatch analysis, found that without gas-fired generation or significant curtailment, achieving 100 percent renewable electricity in California will require about 25,000 GWh of capacity to store energy for weeks or months. Current technologies are not able to store energy for extended periods at this scale. The cost of battery storage in California will likely be very high—$2.5 trillion by one estimate.

California for All

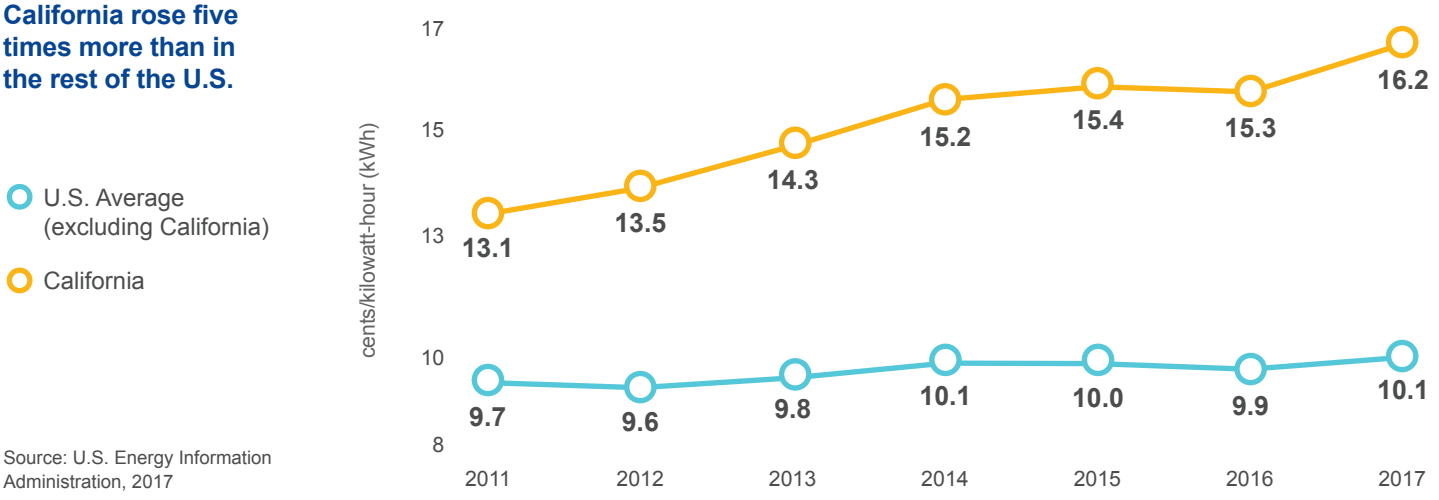
Enacting energy policy that works for every Californian.

California's high cost of living is the most important issue facing the state, according to a public poll conducted by the University of Southern California's (USC) Dornsife Center for Economic and Social Research and the Los Angeles Times.[23] It is also one of the primary reasons people are leaving the state.[24] The state's GDP growth paints a picture of financial stability, however, it presents a misleading view. Today, many Californians are struggling to make ends meet—escalating costs for housing, healthcare, education, utilities and food are making it difficult for them to cover the costs of their most basic needs.

As California's leaders look to the future and set policy to reach the 2045 climate goals, it is critical to look beyond the limited economic indicator of GDP and consider affordability as a key factor in policy decisions. For Californians on a fixed income, an increase in a monthly utility bill could literally put them out of house and home.

Achievement of the state's environmental goals should not come at the price of deepening the state's affordability crisis and widening income disparity levels. Developing a clean, renewable and affordable energy system should guide California's policies to meet the 2045 climate goals. If California is an unaffordable place to live, we not only burden our residents, but we are limiting our future and our ability to keep the California dream alive.

Electricity prices in California rose five times more than in the rest of the U.S.



Source: U.S. Energy Information Administration, 2017

> **These aren't merely policy problems, they are moral imperatives. And so long as they persist, each and every one of us is diminished."**

Gavin Newsom,

Inaugural Address; January 7, 2019

California's Affordability Crisis: Why Energy Policy Cannot Be Addressed in a Vacuum

1/3 of California households can't pay for their basic needs[25]

In 2016, health spending grew 1.5 percentage points **faster** than the economy[33]

People spent **12% more** on health-related costs in 2018 than 2016[34]

Health spending is projected to grow at a rate of **5.5% per year** from 2017-2026[35]

Nearly **40%** of California households are rent burdened[26]

75% of Californians cannot afford to buy a typical home in Los Angeles County[27]

1 in 5 Californians pay **more than half** of their income on housing[28]

On a given night, **130,000** Californians are homeless[36]

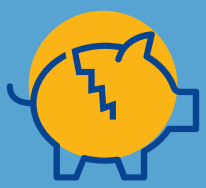
California accounts for **25%** of the entire nation's homeless population[37]

Since 2016, California experienced a **larger increase** in homelessness than any other state[38]

It fluctuates, but Californians pay up to **45%** more for their electricity than other states[29]

Low-income families spend **20%** of their income or more on energy costs[30]

Californians pay the **2nd-highest** gasoline prices in the nation.[31]



California has the **highest** effective poverty rate in the nation[32]

With a path to 2030 in sight, the road to California's 2045 goals is less clear. The total expense of reaching the 2045 target, as well as the full implications to California's consumers, is unknown. What is certain is that the decisions California makes today will have far-reaching consequences across many facets of Californians' daily lives. Success will depend on remaining open to all technologies and resources that can help create a realistic and affordable path to carbon neutrality.

03 How will we get people to adopt it? Addressing consumer behavior

To meet the 2045 goals, California must change consumer thinking and behavior to increase energy conservation, shift energy use to different times of the day and embrace clean vehicles.

To date, California's Clean Vehicle Rebate Project has distributed nearly $525 million in rebates for electric vehicles.[39] Despite policy efforts and investments, emissions from cars and trucks, already California's biggest source of GHGs, have increased over the last several years.

The increase in vehicle emissions has been attributed to a combination of low gas prices, a growing economy, consumers' preference for roomier, less-efficient vehicles and a slower-than-anticipated transition to electric models.[40] As of May 2017, only 300,000 ZEVs and plug-in hybrids (PHEVs) have been sold in California.[41] That number represents just over 1 percent of the nearly 25.5 million automobiles on California's roads.[42]

One lesson from the slow adoption of ZEVs in the transportation sector is that the more California's GHG reduction targets rely on consumer behavior change, the more these targets are at risk. Preserving choice, providing affordable options and minimizing disruption to people's daily lives are all important strategies to inspire consumer adoption.

How we innovate matters.

As California policymakers set the path to achieve carbon neutrality in less than three decades, storage, affordability and consumer adoption should weigh significantly in the conversation. California has the fifth-largest economy in the world,[43] even though its carbon footprint is quite small (less than 1 percent of global GHG emissions[44]). To lead on the global stage—beyond setting an example—California will need to develop scalable solutions that can work and are likely to be adopted both here in California and elsewhere.

A Cautionary Tale: Germany's Rush to Renewables

Germany is considered in many ways to be a leader in addressing climate change and reducing harmful emissions. In 2010, German leaders made the bold declaration that they would dramatically increase renewable energy sources with the country's Energiewende policy. The aggressive move to have renewable energy sources represent 80 percent of gross electricity consumption by 2050 went well beyond legislation passed by the European Union.

Why is it then that GHG emissions in Germany have not decreased for the last nine years and emissions from the transportation sector have not fallen since 1990?

The short answer is the government decided to shut down all nuclear power in the country by 2022 and moved to a renewable energy future before its infrastructure was ready.[45]

With renewable sources such as wind and solar, spikes of supply and demand are often out of sync. On a sunny or windy day, more than enough energy may be produced when most people are away at work or school, but by the time families return home and turn on their lights, dishwasher and air conditioning, the sun has set, the wind has died down and the energy generated during the day has not been stored.

In these instances, Germany has had to turn to coal plants to provide reliability. In fact, more than one-third of the country's energy supply in 2017 came from coal. The situation is likely to be exacerbated as the country phases out nuclear power.

Despite spending more than $600 billion on green energy subsidies and infrastructure investments (costs which have passed on to residential customers who pay the highest electricity rates in the EU—about 130 percent more than California consumers pay today), Germany is going to miss its 2020 target of reducing CO_2 emissions by 40 percent over 1990s values. Officials admit the country will reach 32 percent at best.

Achieving Environmental Goals 2030 and Beyond

Achieving carbon neutrality in less than three decades will require:

- Building a reliable and resilient infrastructure with utility-scale, seasonal storage for wind and solar power;
- Inspiring rapid consumer adoption with scalable and affordable energy options;
- Setting technology-neutral policies that will drive innovation to reduce GHG emissions.

California's carbon-neutral future depends on leaders in the private and public sectors embracing and developing diverse technology solutions, bolstered by policies that foster innovation. If California limits its options, it limits its future. Creating an integrated, multi-faceted strategy will provide the innovation necessary to realize California's bold vision and facilitate national and global adoption.

A more integrated energy system will be needed, where the natural gas and electric systems work together to achieve maximum emissions reductions and reliability. It will also need to draw on the collective power of natural gas, renewable natural gas, wind, solar, hydroelectricity, batteries, and Power-to-Gas—as well as yet-to-be-developed technologies—to meet the state's energy demands, while reducing GHG emissions and minimizing disruption and costs for Californians.

Today, there are technologies that have been tested and proven in other parts of the world that are untapped here in California. Complementing the state's robust build-out of wind and solar generation, these technologies will help maintain a reliable, resilient and renewable energy system. They also do not require consumers to change out existing infrastructure.

Leaders in the private and public sectors have the opportunity to work together and re-imagine how our energy infrastructure can operate as one integrated system.

Reducing Our Waste

Renewable Natural Gas (RNG)

For every methane molecule we take out of the atmosphere, it's the equivalent of removing 25 molecules of carbon dioxide (CO_2).[46] Today, more than 80 percent of California's methane emissions come from daily human life activities that create waste.[47]

Renewable natural gas gives us a way to mitigate and reduce emissions from the state's largest methane emitters.

Here's How RNG Works

Capture waste from dairies, farms and landfills

Convert it into biogas, using anaerobic digestion

Process the biogas to make it pipeline-ready (biomethane)

Inject the biomethane into the pipeline for future use

Use it to fuel clean trucks, our homes, businesses and meet other natural gas needs

Natural gas is essentially methane (CH_4)—an organic, naturally occurring gas that comes from decomposing matter. You can procure natural gas from the ground through drilling under-ground (thermogenic) sources or, like electricity, you can generate it from renewable, above-ground (biogenic) sources.

Methane is a natural byproduct of our farms, our kitchens, and our toilets. In other words, you produce methane every day. The largest sources of methane emissions in California—more than 80 percent—come from agriculture, dairies, landfills and waste water.[48] We can capture those emissions, prevent them from going into our atmosphere, and convert them to renewable natural gas to fuel our homes and vehicles.

RNG is created by re-purposing the methane that otherwise would be escaping into the atmosphere. This means its overall impact on the climate is carbon-neutral or even carbon-negative. For example, when a clean heavy-duty truck is fueled with RNG created from a dairy, more carbon is removed from the atmosphere than is emitted from the tailpipe.[49]

In addition to reducing the carbon content of our natural gas supply, RNG gives us a clear and practical path to help California achieve the goals set in the Short-Lived Climate Pollutants Reduction Plan (SB 1383), by targeting the state's largest methane emitters. Reducing methane emissions represents a significant portion of the California Air Resources Board's Scoping Plan to achieve the state's GHG reduction goals.[50]

Driving Down Emissions Through Efficient, Distributed Generation

Electricity is an inefficient form of energy—it loses power as it travels over distance. Most of California's solar fields, wind farms and power plants are located far from major population centers. We end up having to generate a lot more electricity to make up for the power that is lost over transmission and distribution lines.

Distributed generation helps to address this challenge—it is small-scale electric generation located in the community where the energy is used. The most familiar example of distributed generation is rooftop solar panels (photovoltaic systems).

Twenty years ago, opponents of solar claimed it would never be viable in California—that the costs would be too prohibitive. After the state invested and created incentives, California finds itself in the situation where distributed solar generation is a growing and critical part of the state's energy mix. California has similar opportunity with other forms of distributed generation. In fact, these technologies can enable renewable generation and make cleaner electricity:

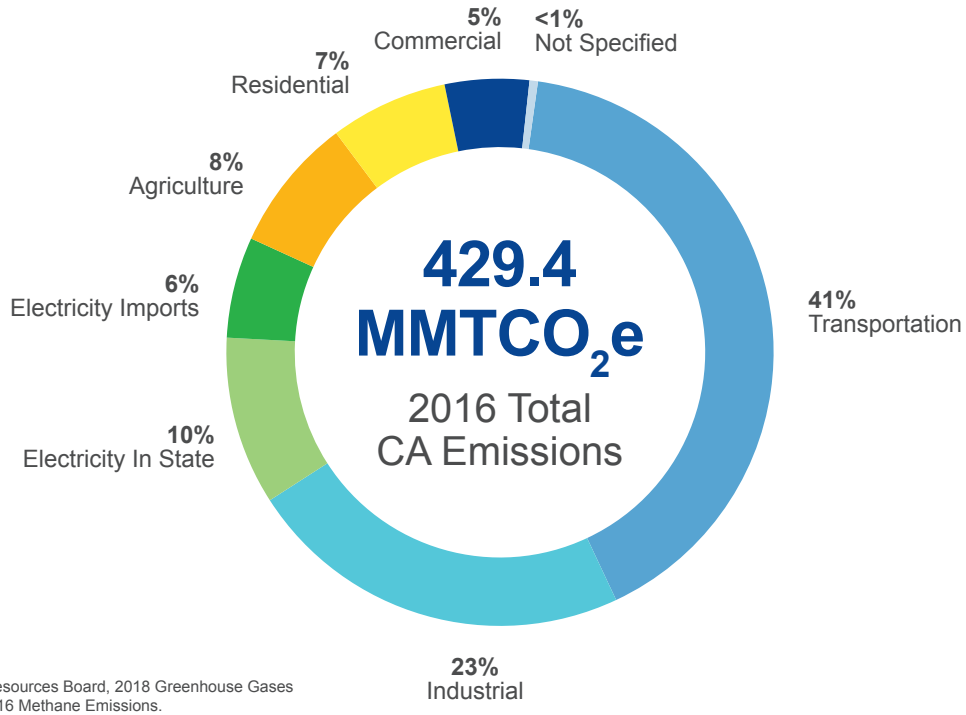
Fuel Cells - A battery stores electricity, but a fuel cell can generate it. Similar to a battery, a fuel cell is comprised of many individual cells that are grouped together to form a fuel cell stack. When a hydrogen-rich fuel such as clean natural gas or renewable natural gas enters the fuel cell stack, it reacts electrochemically with oxygen (i.e. ambient air) to produce electric current, heat and water. While a typical battery has a fixed supply of energy, fuel cells continuously generate electricity as long as fuel is supplied. Fuel cells can help to mitigate California's fire risk as well—by supplying power in backcountry locations using natural gas where available, or hydrogen created through power-to-gas technology.

Combined Heat and Power (Co-Generation) - Distributed co-generation sources use steam turbines, natural gas-fired fuel cells, micro turbines or reciprocating engines to turn generators. The hot exhaust is then used for space or water heating, or to drive an absorptive chiller for cooling such as air-conditioning. The technology can run on renewable natural gas or low-carbon fuels to further reduce emissions.

Waste-to-Energy - When municipal solid waste and natural waste such as sewage sludge, food waste and animal manure decompose, they discharge a methane-containing gas that can be collected and used as fuel in gas turbines or micro turbines to produce electricity as a distributed energy resource. This power can be used in lieu of grid power at the waste source (a treatment plant, farm or dairy).

Focusing Our Efforts

Understanding the opportunities to reduce California's carbon footprint begins with understanding the overall landscape of the state's GHG emissions. The transportation sector is the largest contributor to California's GHG emissions, contributing 41 percent of the total. Next is the industrial sector at 23 percent, followed by electricity at 16 percent, and several sectors with relatively smaller contributions, including residential buildings and commercial buildings at 7 percent and 5 percent respectively.



Source: California Air Resources Board, 2018 Greenhouse Gases Emissions Inventory, 2016 Methane Emissions.

Some state leaders are pushing to transition California's energy supply to a single source: renewable electricity. This strategy is perhaps most prominent in discussions around decarbonizing California's building sector, which receives a disproportionate amount of attention given that the sector represents 12 percent of the state's total emissions,[51] and that it would require replacing existing infrastructure in millions of California homes and businesses. But that doesn't need to happen.

A 2018 study by Navigant Consulting shows that there is no need to electrify California's building sector to meet state climate goals. The study concludes that California "should address the role of renewable gas as part of its low-carbon building strategy."

Adding less than 20 percent renewable gas to California's gas supply by 2030 can achieve the same outcome as electrifying the entire building sector; while continuing to allow consumer choice to meet their energy needs, as well as avoiding future building and appliance change-out mandates.

Importantly, the study finds that reducing the carbon content of the gas supply by adding renewable gas to displace traditional gas can be significantly less costly, and is far more cost effective in reducing GHGs, than building electrification.

A balanced mix of both in- and out-of-state resources (reflecting today's reality with both renewable electricity and renewable gas) is three times more cost effective in reducing GHGs than any electrification pathway.

Achieve the same GHG reductions as overhauling 100 percent of California's buildings to all electricity with

<20% RNG

Sourced from the likely mix of in- and out-of-state feedstocks,

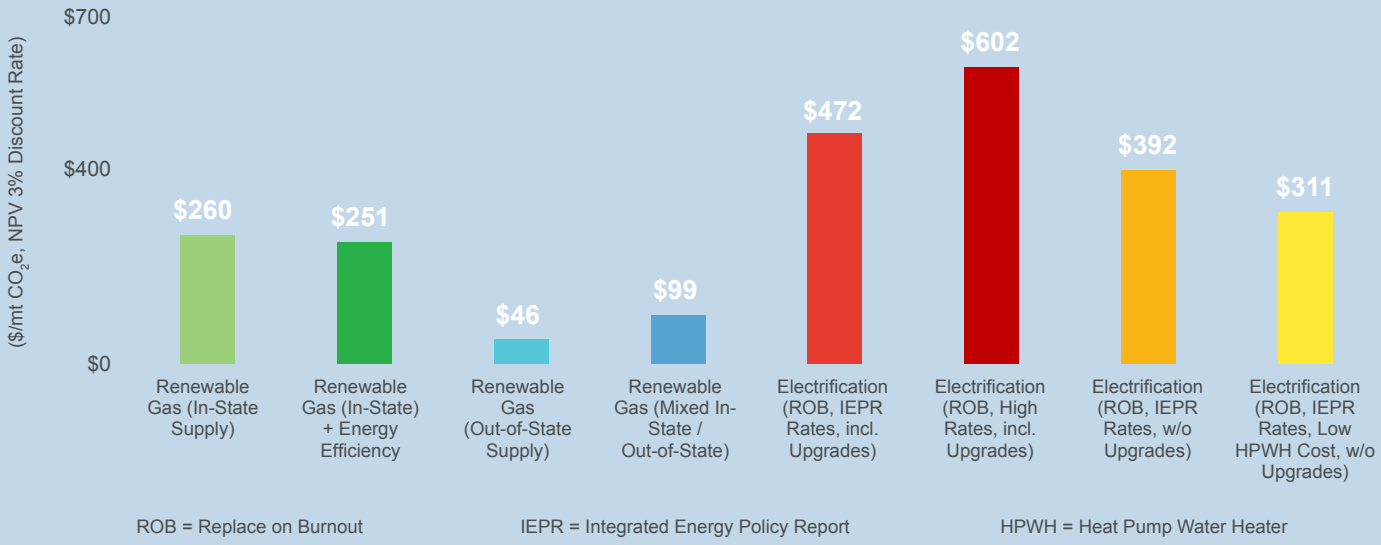
RNG is significantly more cost effective

Source: Analysis conducted by Navigant Consulting based on its 2018 report, "Gas Strategies for a Low-Carbon California Future." The analysis from the original published report has been updated to reflect the 2030 60 percent RPS goal established in SB 100.

RNG Is More Cost-Effective

A new study demonstrates how California can reduce building sector emissions without significant disruption to consumers.[52]

Cost Effectiveness, 2018-2030



ROB = Replace on Burnout IEPR = Integrated Energy Policy Report HPWH = Heat Pump Water Heater

Reducing Emissions Today

CR&R Environmental provides a view into what's possible.

CR&R, one of the largest waste and recycling companies in Southern California, has successfully put RNG to work. They've built what is believed to be the world's largest and most automated anaerobic digester, which allows them to produce RNG from organic waste.

The RNG CR&R produces is injected into the SoCalGas system and used to fuel approximately 400 of their waste hauling trucks. Converting just one of CR&R's trash trucks from diesel to natural gas is the pollution reduction equivalent of taking 325 cars off the road, which means CR&R's fleet of RNG trucks is reducing GHG emissions by the same amount as taking approximately 130,000 cars off the road!

This story is one example of the 40 RNG projects occurring right now in California. RNG also allows for waste products to be converted into new revenue streams, boosting the economy of regions of the state—like the San Joaquin Valley—where there are feedstock opportunities.

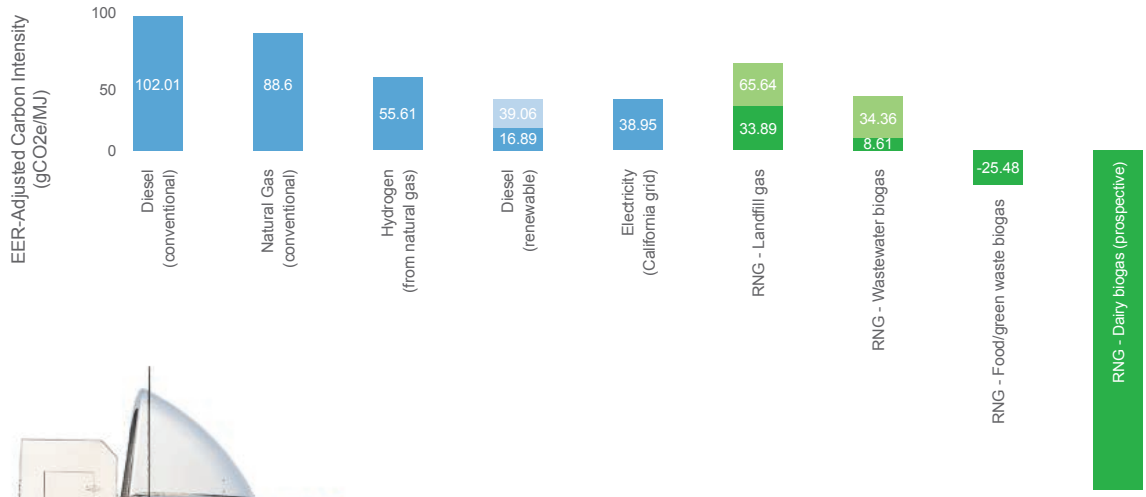
Near-zero-emissions natural gas engines reduce NOx emissions up to 90 percent and GHG emissions up to 80 percent compared to diesel.[53]

CR&R's RNG is fueling 400 waste trucks. That's the equivalent of taking 130,000 cars off the road.[54]

RNG as a transportation fuel has a negative carbon intensity

- By switching to renewable natural gas, we can reduce vehicle GHG emissions by 80 percent.[55]
- Renewable natural gas gives us a way to prevent emissions from biogenic sources from going into the atmosphere, by capturing and converting them into a renewable fuel to power our vehicles.
- Renewable natural gas produced from food and green waste has a negative carbon intensity. That means it's not just carbon-neutral, it actually takes carbon out of the air.[56]

Carbon Intensity Rating of Key Transportation Fuels



The natural gas truck will meet California's ambitious 2045 targets decades before any other technology.

Source: California Air Resources Board (ARB), LCFS Fuel Pathways Table, February 2017. Adjusted for heavy-duty truck applications.

Decarbonizing Agriculture: RNG – From Poop to Power

“If cows were a country, they would be in the top five emitters in the world.”

In one succinct statement, Microsoft founder Bill Gates[57] illustrated the scope of the environmental challenge and opportunity to reduce emissions from animal agriculture. In California alone, livestock and dairies represent 8 percent of the state’s GHG emissions, and more than half—55 percent—of the state’s methane emissions.[58]

In October 2018, Renewable Dairy Fuels opened the nation’s largest dairy renewable natural gas plant, in Jasper County, Indiana. The operation collects dairy waste from 16,000 milking cows on four farms, turning 945 tons of cow manure each day into fuel for transportation, delivered through Northern Indiana Public Service Company‘s (NIPSCO) natural gas pipeline system.[59]

In early 2019, renewable natural gas produced at a digester facility built by Calgren Dairy Fuels in Pixley, California began flowing into SoCalGas pipelines. Calgren’s facility, known as a dairy digester pipeline cluster, will eventually collect biogas from anaerobic digesters at 12 Tulare County dairies, then clean it to produce pipeline-quality renewable natural gas. This is the first such dairy digester pipeline cluster in California, and is expected to be the largest dairy biogas operation in the U.S. when Calgren adds nine additional dairies later in 2019. The facility will capture the methane produced from the manure of more than 75,000 cows, preventing about 130,000 tons of GHGs from entering the atmosphere each year—the annual equivalent of taking more than 25,000 passenger cars off the road. SoCalGas will be capable of adding up to 2.26 billion cubic feet of renewable natural gas each year to its pipeline system from the facility.

These are examples of the many renewable natural gas projects happening across the country. With current regulation and incentives, it’s estimated that California has about 100 billion cubic feet (Bcf) of renewable natural gas supply.[60] Outside of California’s borders, the U.S. is producing 1 trillion cubic feet (Tcf) of renewable natural gas. That number is expected to increase tenfold by 2030.[61]

By investing in in-state renewable natural gas projects and expanding feedstocks to include out-of-state sources, California can make significant progress in achieving the goals set in the Air Resource Board’s Short-Lived Climate Pollutants Plan. It will also provide California residents with a cost-effective way to power their homes, businesses and cars with a clean-burning, renewable fuel.

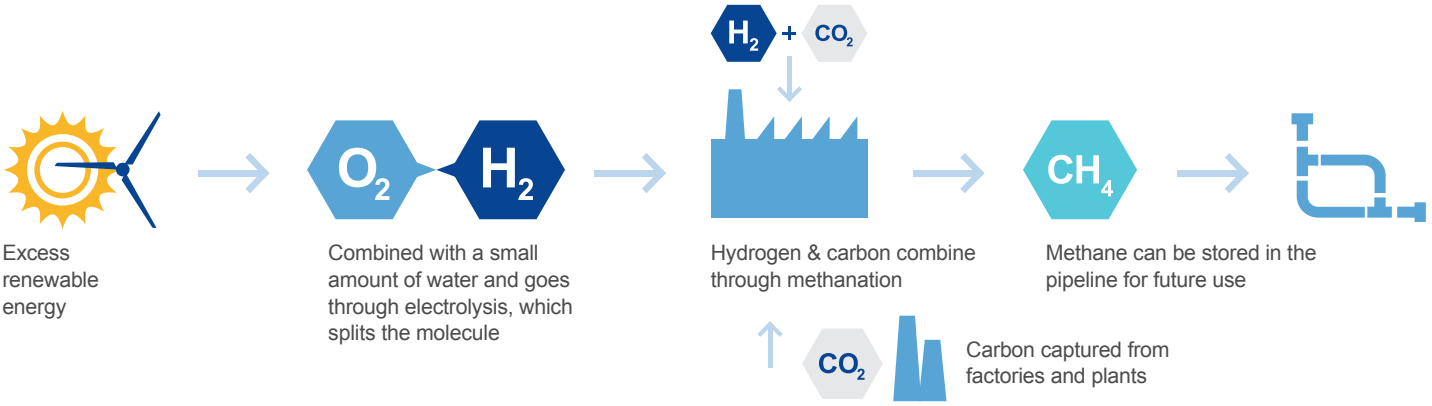
Utilizing Current Infrastructure

Power-to-Gas (P2G) Technology

Today, when excess electricity is generated from solar and wind, California either has to dump it or pay other states like Arizona to take it from us. While batteries can help store some of this excess energy, they will not solve the storage problem alone, especially for long-term storage needs.

Rather than wasting the energy batteries cannot store, we can convert it into renewable gases using a process called “Power-to-Gas.” Through this process, we can use our existing natural gas infrastructure to store the renewable energy and make it available where and when people need it.

Here’s How P2G Works



Power-to-Gas works by taking excess electricity generated from solar and wind, combining it with a small amount of water and running it through electrolysis. The electrolysis process converts the electrical energy into chemical energy and splits the molecules into pure hydrogen and oxygen.

The oxygen can be sold and used for other applications—such as healthcare. The hydrogen gas can be used as a fuel or some of it can be stored in existing pipelines. Additionally, the hydrogen can be combined with CO_2 and run through the process of methanation to create renewable methane. The clean, renewable methane produced through the Power-to-Gas process can be stored in the existing pipeline system for use when people need it. That means infrastructure is already in place to store and deliver the renewable energy at any time of day, during any season.

We can use the hydrogen produced through electrolysis in the Power-to-Gas process to fuel power plants and for other industrial applications, such as metal refining and fertilizer production. Hydrogen is also a zero-emissions fuel that can help reduce emissions from the millions of cars and trucks on California’s roads. Some percentage of hydrogen also can be injected into the natural gas stream to further reduce the carbon content of the natural gas supply.

The renewable gas produced through methanation in the Power-to-Gas process can be delivered to Californians through the existing pipeline infrastructure and used for cooking, as well as for space and water heating. And, as a fuel for mobile generators, renewable gas supports system reliability during emergency situations. It can also be used as a transportation fuel.

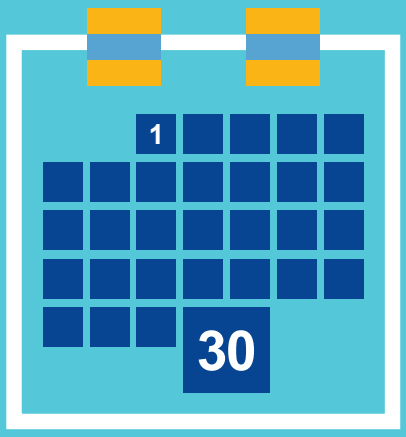
Comparing Storage Technologies

Power-to-Gas provides large-scale, multi-day and seasonal grid storage.

Batteries

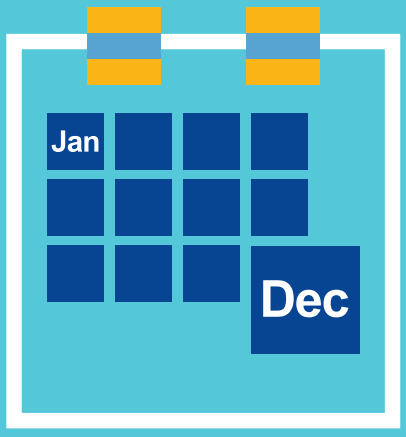
Hours

P2G Hydrogen



Days

P2G Methane



Months

Hydrogen is a scalable solution to address long-term energy storage needs and help meet the goals set in SB 100.

Reality Check: The Real Impact of 100% Renewable Electricity

When SB 100 was signed by Governor Brown, it challenged the California Energy System to transform to 100 percent clean energy by 2045. To date, state leaders have focused on electrification to achieve this transformation—policies aimed at transitioning home appliances, equipment and vehicles to electricity, and decarbonizing electricity sources through increased wind and solar power generation. Implementation of SB 100, however, could create unintended economic hardships and actually increase GHG emissions.

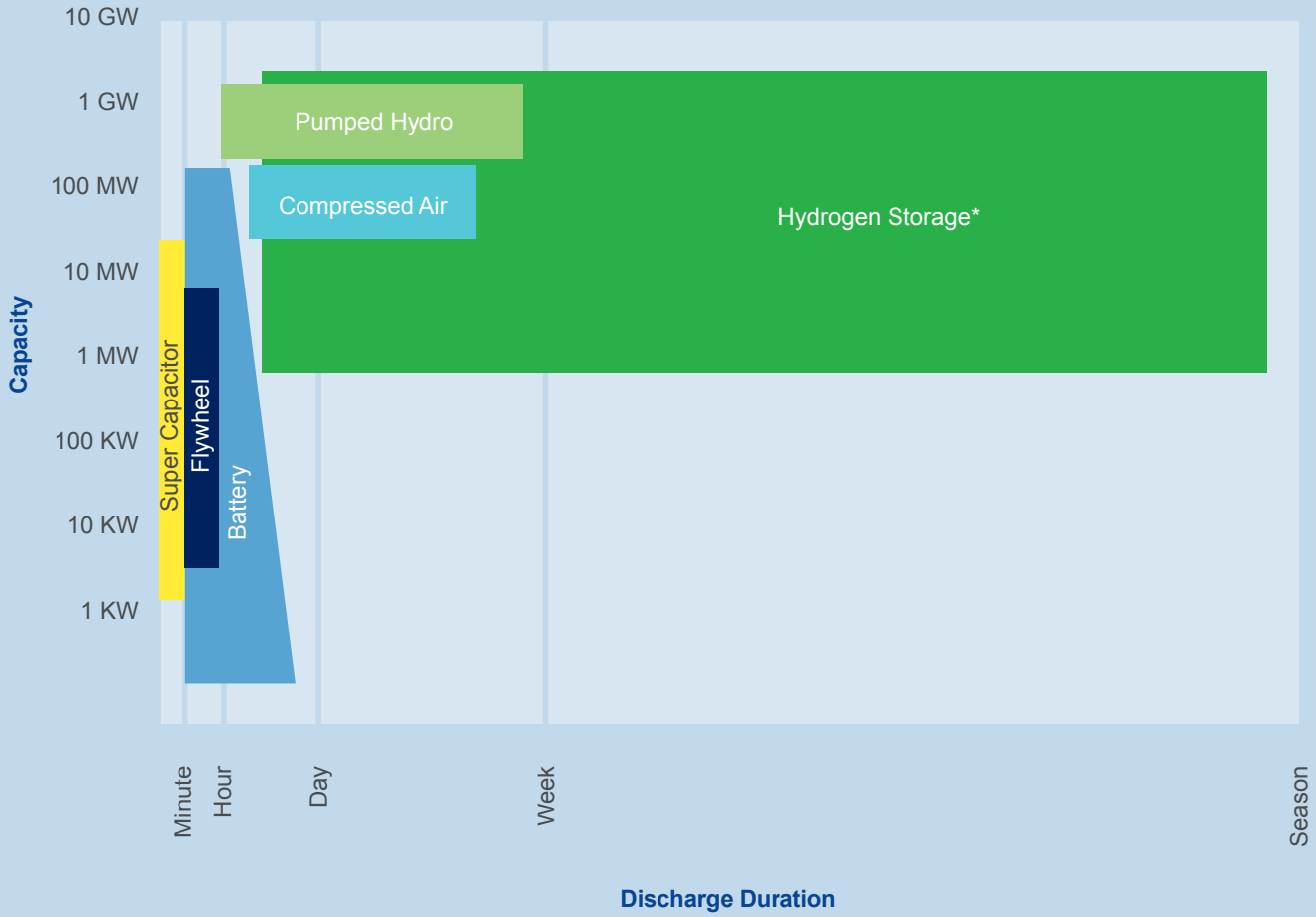
An analysis conducted by Black & Veatch underscores the potential impact of 100 percent renewable electricity on California, based on several scenarios with high-level assumptions to facilitate qualitative discussions. The findings indicated a significant cost elevation and technical challenges associated with 100 percent renewable electricity.

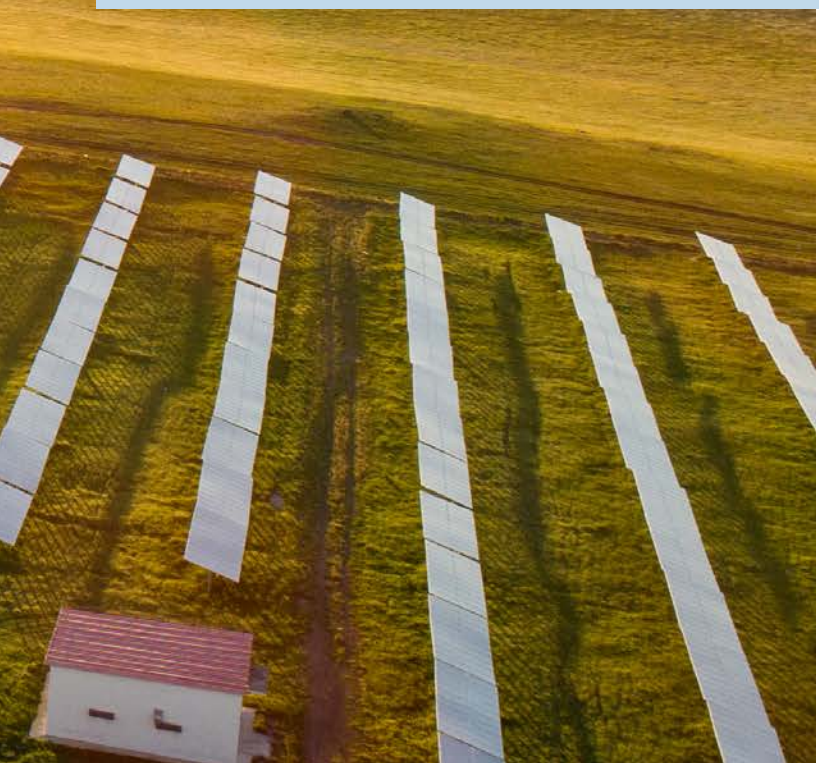
All scenarios in the analysis indicate that 100 percent renewable electricity requires a significant increase in renewable capacity, storage and transmission build-out beyond California's current infrastructure. When specifically looking at wind, solar and energy storage, California needs nearly a six-fold increase beyond current wind and solar capacity at a cost of approximately $135 billion. Additionally, there are land availability issues associated with battery storage. Assuming a horizontal build-out, land required for energy storage and solar panels would be approximately 1,600 square miles, which is four times the size of the City of Los Angeles. Cost and land availability are only two variables; we must also look at the technological aspects. Current battery storage technology is limited, only allowing for a few weeks of storage. Extended storage capability is needed to ensure reliability and resiliency to meet variable demand loads at various times of day and across seasons.

The analysis also warns of potential unintended consequences of an all-electric strategy. The electrification-only pathway will increase the cost of electricity, which will in turn increase the cost of electrical vehicle (EV) ownership. The increased EV cost will drive up the sales of gasoline vehicles based on affordability, which will likely increase emissions from the transportation sector.

This reality check on the unintended consequences of using a single source for energy generation highlights the importance and the need for a robust balanced energy policy in California. If infrastructure cost combined with increased residential usage costs occur because of electrification, we may solve one problem, but create another: that is, making energy costs unaffordable for many Californian residents and businesses.

Comparison of Energy Storage Alternatives





*As hydrogen or synthetic methane
Source: IEA Energy Technology Roadmap, Hydrogen and Fuel Cells

The UK's First Practical Demonstration of Hydrogen

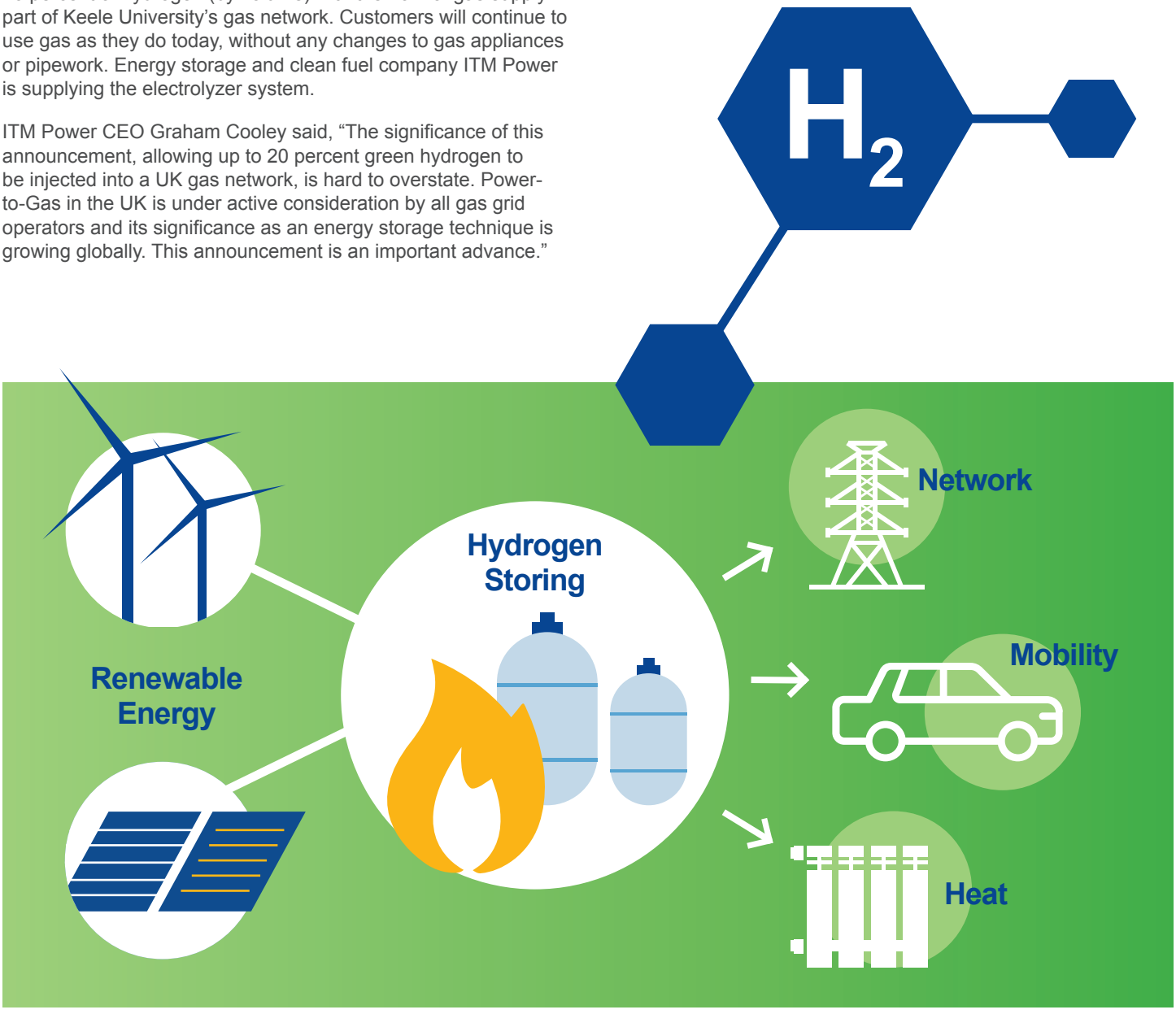
Britain explores Power-to-Gas and green hydrogen to reduce emissions.

A groundbreaking trial that could help Britain dramatically cut its carbon emissions and open the door to a low-carbon hydrogen economy was recently approved by the Health & Safety Executive (HSE).[62] The United Kingdom's HyDeploy project will inject hydrogen into an existing natural gas network.

In a year-long pilot due to start in 2019, HyDeploy will blend up to 20 percent of hydrogen (by volume) with the normal gas supply in part of Keele University's gas network. Customers will continue to use gas as they do today, without any changes to gas appliances or pipework. Energy storage and clean fuel company ITM Power is supplying the electrolyzer system.

ITM Power CEO Graham Cooley said, "The significance of this announcement, allowing up to 20 percent green hydrogen to be injected into a UK gas network, is hard to overstate. Power-to-Gas in the UK is under active consideration by all gas grid operators and its significance as an energy storage technique is growing globally. This announcement is an important advance."

Announced in November 2018 and backed by Ofgem's Network Innovation Competition, the £7 million project is being led by gas network Cadent, in partnership with Northern Gas Networks, Keele University and a consortium of technical experts.



> **Battery storage may feel like a headline act in the transition. But ultimately it will play second fiddle to hydrogen.”**

Francis O’Sullivan,
Head of Research at the MIT Energy Initiative

UC Leads the Way to Carbon Neutrality

The University of California recently announced ambitious plans to be carbon neutral by 2025—and renewable natural gas and hydrogen will play a significant role in achieving its goal.

As part of its strategy, UC has set a target for at least 40 percent of the natural gas combusted on-site at each campus and health location to be fueled by biogas by 2025.[63]

The UC system is already a consumer of biogas at multiple campuses. For example, UC San Diego purchases biogas credits from a sewage treatment plant on Point Loma, about ten miles away. Biogas from the plant is injected into the natural gas pipeline system on Point Loma where it displaces conventional gas; UC San Diego then draws conventional gas to power a fuel cell. The credits allow the fuel cell to qualify as a renewable energy source, earning valuable financial treatment under California policy.

UC also is a leader in pioneering Power-to-Gas technology. Research conducted at the University of California Irvine (UCI) and funded by SoCalGas demonstrated in 2017 that the campus micro-grid could increase the portion of renewable energy it uses, from 3.5 percent to 35 percent, by implementing a Power-to-Gas strategy.[64]

Using Power-to-Gas, UCI demonstrated it could increase its renewable energy use from 3.5 percent to 35 percent.

The study used data from the UCI campus micro-grid, which includes solar panels that produce about 4 megawatts of peak power. Simulations showed that by storing excess solar power on sunny days and using an electrolyzer to produce renewable hydrogen, the micro-grid could support an additional 30 megawatts of solar panels.

“The ability to increase the mix of renewables on campus by tenfold is truly significant,” said Jack Brouwer, professor of mechanical & aerospace engineering and civil & environmental engineering at UCI and associate director of the Advanced Power & Energy Program (APEP). “With Power-to-Gas technology, you don’t need to stop renewable power generation when demand is low. Instead, the excess electricity can be used to make hydrogen that can be integrated into existing natural gas pipeline infrastructure and stored for later use. The Southern California Gas Company system alone is made up of over 100,000 miles of pipeline. This study suggests that we could leverage that installed infrastructure for storage and significantly increase the amount of renewable power generation deployed in California.”

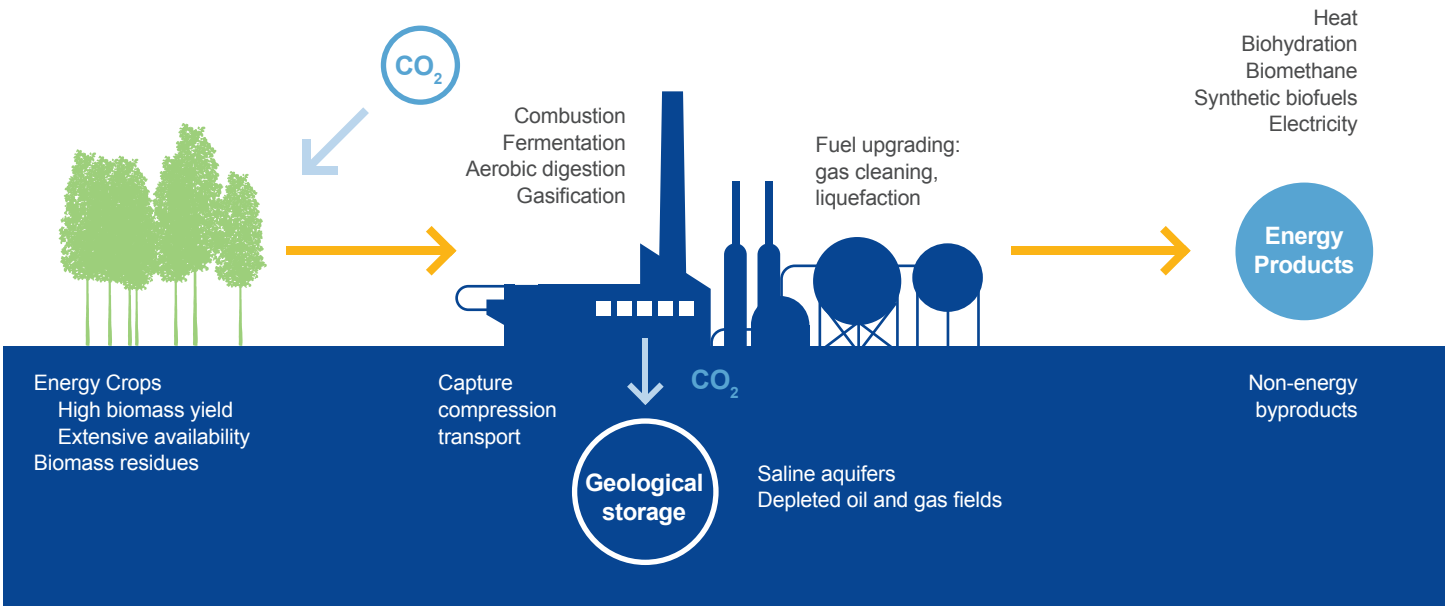
Capturing and Using Carbon

Carbon Capture and Utilization (CCU)

Carbon is the building block of life. Many of the products we use every day—our computers and smart phones, our cars and the plastic Tupperware in our kitchens—are made with carbon.

With CCU, we can take the carbon dioxide (CO_2) released from industrial processes, capture it and recycle it as a raw material to produce these products. The carbon can also be combined with hydrogen to form renewable gas to fuel homes, businesses and vehicles.

Here's How CCU Works



CCU is a simple concept: Gas and particle waste produced from industrial sources like power plants, steel making or other factories is first captured. The carbon from that waste is then extracted using chemical processes and reused as the raw material for new products. Reusing this carbon not only decreases CO_2 emissions into the atmosphere, but also decreases fossil fuel use.

Many CCU technology companies are beyond the development stage and in the market growing their businesses. One California-based company is making plastics from captured carbon instead of petroleum. A Canadian company is using carbon captured from power plants to make stronger concrete. And a German company uses waste CO_2 to make polymers. According to the Global CO_2 Initiative, the market for products made from CO_2 could be more than $800 billion and use 7 billion metric tons of CO_2 per year by 2030—the equivalent of approximately 15 percent of current annual global CO_2 emissions.

CCU technologies follow the sustainability principles of reduce, repurpose and recycle—they simply recycle the carbon in fossil fuels: Once the fuel releases energy, the waste is saved to be reused where it is needed, and the use of fossil carbon is reduced. CCU will become an increasingly important strategy for California to achieve carbon neutrality.

Carbon to Value

An innovative process technology is producing clean hydrogen and solid carbon.

The potential of hydrogen as a transportation fuel is great, based on its ability to power zero-emission fuel cell electric vehicles (FCEVs), its fast filling time and high efficiency. But sourcing the hydrogen has been a barrier to the market really taking off.

Today, almost all of the world's hydrogen is produced from natural gas through the process of steam methane reforming—in this process, methane reacts with steam under pressure in the presence of a catalyst to produce hydrogen and carbon dioxide (CO_2), a greenhouse gas.

John Hu, West Virginia University's Statler Chair Engineering Professor, recently invented a technology to convert natural gas into CO_2-free hydrogen and solid carbon. A commercialization team has received funding from the U.S. Department of Energy to further develop the innovative new process technology.

The objective of the team—which includes, C4-MCP, LLC (C4), a Santa Monica-based technology start-up, West Virginia University, Pacific Northwest National Laboratory, and SoCalGas—is to bring to market cost-effective ways to drive down emissions from hydrogen production, ultimately making hydrogen fueled cars and trucks cost-competitive with conventional gasoline and diesel vehicles.

In addition to CO_2-free hydrogen, the other by-product of the innovative process technology is solid carbon, which can be used as a raw material to manufacture a number of products we use every day, from the batteries in our computers, to the tires on our cars, to the inks in our printers.

"The research will lead to transformative advancement in science and engineering, in addressing not only climate change issues but also energy inefficiency issues in natural gas conversion to value-added products," said Hu.

It's just one example of many research projects underway today that showcase the tremendous environmental and economic potential of CCU technologies.

It's Time to Put California on the Map

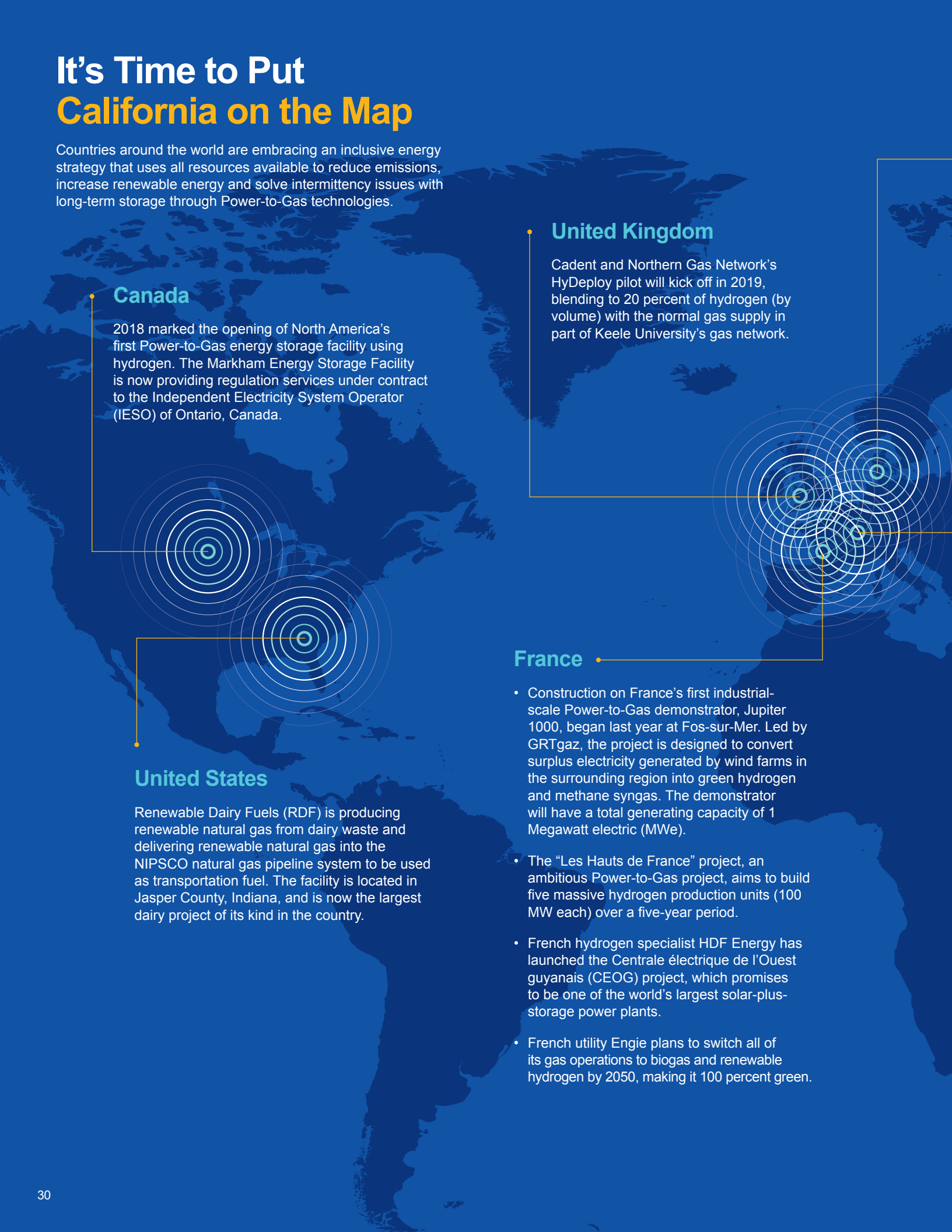
Countries around the world are embracing an inclusive energy strategy that uses all resources available to reduce emissions, increase renewable energy and solve intermittency issues with long-term storage through Power-to-Gas technologies.

Canada

2018 marked the opening of North America's first Power-to-Gas energy storage facility using hydrogen. The Markham Energy Storage Facility is now providing regulation services under contract to the Independent Electricity System Operator (IESO) of Ontario, Canada.

United Kingdom

Cadent and Northern Gas Network's HyDeploy pilot will kick off in 2019, blending to 20 percent of hydrogen (by volume) with the normal gas supply in part of Keele University's gas network.



United States

Renewable Dairy Fuels (RDF) is producing renewable natural gas from dairy waste and delivering renewable natural gas into the NIPSCO natural gas pipeline system to be used as transportation fuel. The facility is located in Jasper County, Indiana, and is now the largest dairy project of its kind in the country.

France

- Construction on France's first industrial-scale Power-to-Gas demonstrator, Jupiter 1000, began last year at Fos-sur-Mer. Led by GRTgaz, the project is designed to convert surplus electricity generated by wind farms in the surrounding region into green hydrogen and methane syngas. The demonstrator will have a total generating capacity of 1 Megawatt electric (MWe).
- The "Les Hauts de France" project, an ambitious Power-to-Gas project, aims to build five massive hydrogen production units (100 MW each) over a five-year period.
- French hydrogen specialist HDF Energy has launched the Centrale électrique de l'Ouest guyanais (CEOG) project, which promises to be one of the world's largest solar-plus-storage power plants.
- French utility Engie plans to switch all of its gas operations to biogas and renewable hydrogen by 2050, making it 100 percent green.

Denmark

Denmark could be the first European country to become independent of natural gas and cover its consumption entirely through gas produced from food waste, industrial waste and agricultural by-products.

Germany

- The German grid operators TenneT, Gasunie Deutschland and Thyssengas have put forward detailed plans for coupling the electricity and gas grids and advancing the energy transition. The three grid operators are planning to build a power-to-gas pilot plant in Lower Saxony. With an output of 100 megawatts, it will be the largest of its kind in Germany.
- Major German power and gas grid firms Amprion and Open Grid Europe (OGE) are jointly building large Power-to-Gas plants in the next decade.

India

India plans to build 5,000 compressed biogas plants over the next four years to curb oil imports and improve farm incomes. The move is in line with the government's target of reducing crude oil imports by 10 percent by 2022.

Africa

The Africa Biogas Partnership Programme (ABPP)—a partnership between Hivos and SNV—is working to construct 100,000 biogas plants in Ethiopia, Kenya, Tanzania, Uganda, and Burkina Faso providing about half a million people access to a sustainable source of energy.

Australia

The Australian government is providing half the funding for the country's largest facility to produce hydrogen using solar and wind energy. The project is being run by gas pipeline company Jemena, which plans to build a 500 kilowatt electrolyzer in western Sydney that will use solar and wind power to split water into hydrogen and oxygen.

The Case for An Integrated Approach

Preserves Consumer Choice

Today, Californians enjoy a choice of energy sources for their homes and businesses, including gas, electricity and propane. Millions of Californians use natural gas in their homes. In SoCalGas' service territory, roughly 90 percent of the homes use natural gas because it's an efficient, reliable and affordable option for home and water heating, drying clothes and cooking.[65] Energy users should have a choice of which appliances and energy to use in their daily lives, especially if it can be done in an environmentally friendly way.

Minimizes Disruption & Cost

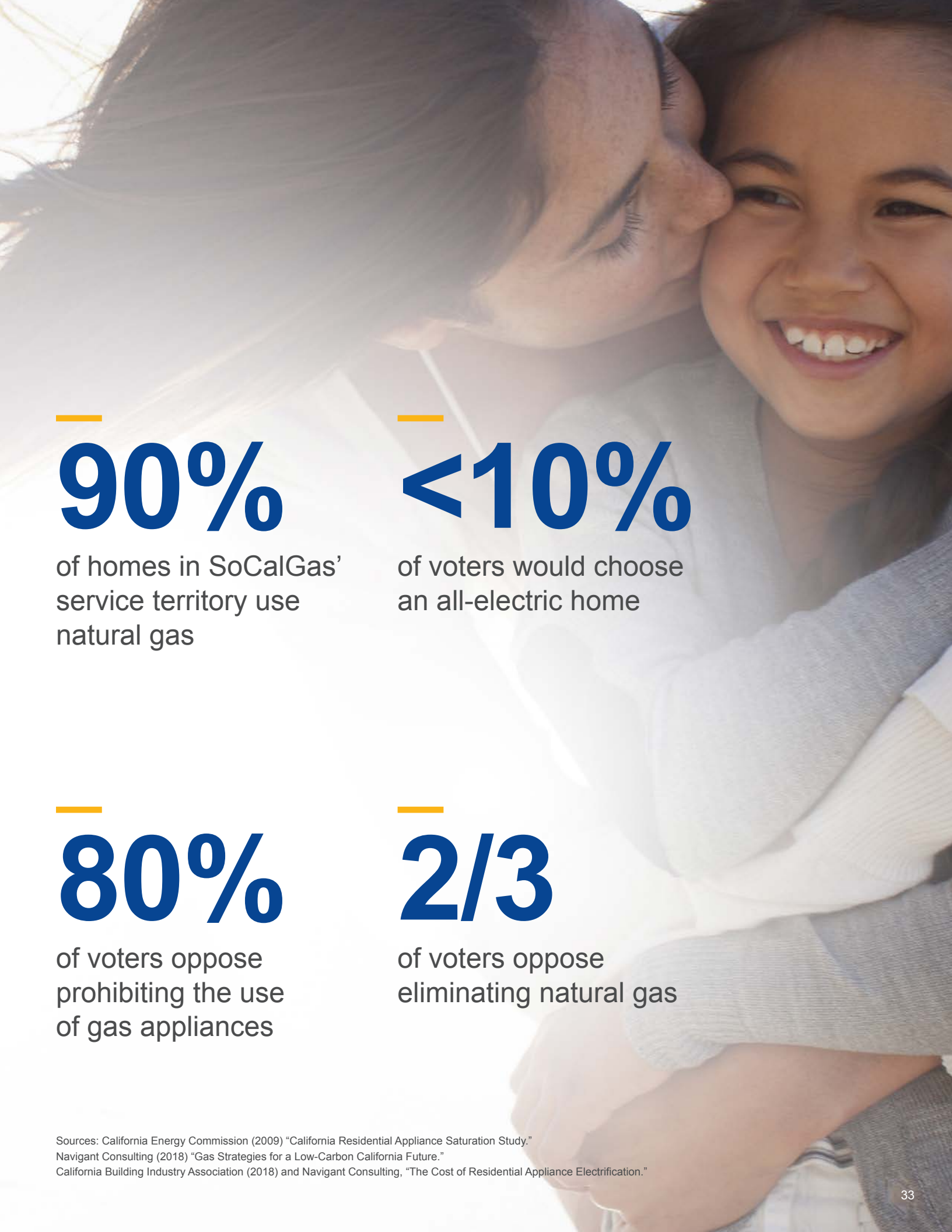
An inclusive, integrated pathway that includes natural gas and renewable natural gas as a continuing source of energy to meet the state's energy needs is minimally disruptive to consumers. By replacing less than 20 percent of California's natural gas supply with renewable natural gas, California can achieve the same GHG reductions as electrifying 100 percent of the state's buildings.[66] The implications are profound: consumers do not need do anything—no mandates to switch out appliances, no need for costly upgrades to homeowners' electrical panels. Mandating electrification would require millions of people to retrofit their homes and replace their natural gas appliances, costing the average family $19,000.[67]

Promotes System Resiliency

Resiliency in the energy system is critical. By maintaining a diverse energy portfolio, California can minimize interruptions in energy supply caused by climate change impacts, such as increased wildfires. Communities over-reliant on the electric grid risk losing critical tools needed for emergency response. Natural gas gives communities the resiliency to respond to nature's worst disasters.

Strengthens California's Economy

The Los Angeles area is the largest manufacturing region in the United States. Many industrial processes, from manufacturing steel to producing fertilizer, cannot be electrified. If those jobs are to remain in the state, California will need to create policies that allow energy options for these businesses and industries. An inclusive approach that does not limit current energy options, is technology neutral, expands nascent technologies, allows for innovation and factors in costs will help keep these industries and their associated jobs in the state.



90%

of homes in SoCalGas' service territory use natural gas

<10%

of voters would choose an all-electric home

80%

of voters oppose prohibiting the use of gas appliances

2/3

of voters oppose eliminating natural gas

Sources: California Energy Commission (2009) "California Residential Appliance Saturation Study."
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Working together, we can create

measurable progress toward a carbon-neutral future

To achieve a dramatic decrease in GHG emissions, leaders in California's private and public sectors must dramatically shift their thinking and foster an environment that will fuel breakthrough innovation. We need to use all technologies available to us today and should not close the door on potential technology pathways that may lead to exponential emissions reductions in the future.

Creating a clean, decarbonized and sustainable energy future requires an inclusive technology strategy if California is going to meet its climate goals and maintain system resiliency. Implementing a balanced energy approach allows California to minimize disruption, manage cost and preserve consumer choice.

Our Vision

To become the cleanest gas utility in North America

Our Commitments

2022

5% RNG being delivered in our system

2030

20% RNG being delivered in our system

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53. The Cummins-Westport 2018 ISX12N engine is certified to the California Air Resources Board (CARB) and Environmental Protection Agency’s (EPA) Optional Low NOx emissions standard of 0.02 g/bhp-hr and has 90% fewer NOx emissions than the current North American EPA standard. Cummins-Westport ultra-low-NOx trucks are virtually GHG emissions-free when fueled with renewable natural gas.

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SoCalGas

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