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Producing RNG and P2G

How power-to-gas technology is creating renewable natural gas

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on the cover

Nancy Farmer, NREL group research manager, Biological Science and Kevin Harrison, program manager – Research, Energy Systems Integration, lead researchers and guests from NREL, DOE, SoCalGas, Sempra Utilities and Electrochaea, on a tour of the Bioreactor in the hydrogen facility at the Energy Systems Integration Facility at NREL. Image courtesy: Dennis Schroeder, NREL

ESC Energy Solutions Center

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inside

PRODUCING RNG THROUGH POWER-TO-GAS TECHNOLOGY

Power-to-gas (P2G) technology can help produce renewable natural gas (RNG) without creating greenhouse gas emissions, but there are questions about how to make P2G work, mostly related to system optimization and electric grid integration; projects in the field and university research are working to answer those questions

OVER THE LAST SEVERAL YEARS, RENEWABLE ENERGY SOURCES LIKE PHOTOVOLTAIC (PV) SOLAR AND WIND TURBINES HAVE GROWN. In fact, in some states such as California, which have put a greater emphasis on green energy, at certain times of day there is more renewable electricity being generated than can be used. In 2018, California curtailed 461 gigawatt-hours of wind and solar energy due to this mismatch between supply and demand. For system operators and utilities, the challenge is finding a way to store the excess renewable energy produced during peak generation periods so it can be used in future peak demand periods.

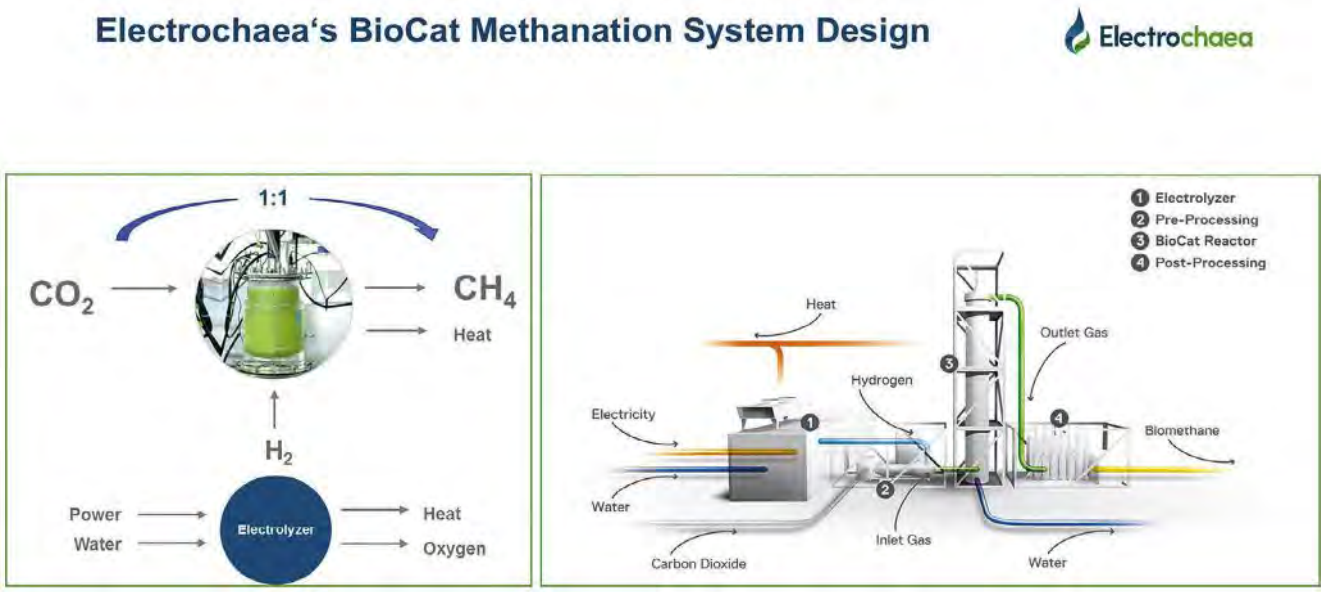
One possible solution to both the renewable energy storage challenge and CO_2 emissions is power-to-gas (P2G) technology. P2G uses surplus electricity to create renewable hydrogen or renewable natural gas (methane) that can then be stored in the natural gas pipeline system and then used to power a variety of end-uses such as boilers, engines and fuel cells. In doing so, P2G saves resources that would be spent on extremely expensive energy and CO_2 capture and storage systems. P2G can harvest excess nuclear, wind, and solar power, which would otherwise be wasted or limited to low-value off-peak markets and recycle CO_2 that would otherwise be emitted into the atmosphere.

There is no getting away from the fact that there is an urgent need and growing political demand to reduce the CO_2 levels globally. It is alarming to note that even with the increasing global focus on reducing CO_2, there is still significant use of fossil fuels and industrial processes causing an unsustainable increase of CO_2 in the atmosphere.

How does it work?

SoCalGas and Enbridge Gas outlined the conversion process. Excess renewable electricity is used to convert water into renewable hydrogen by employing electrolysis. Electrolysis splits water (H_2O) into hydrogen (H_2) and oxygen (O_2). This is a well established electrolyzer technology. While the oxygen is likely released into the atmosphere, the hydrogen is captured and can be blended with natural gas and stored in the pipeline system. However, O_2 could have added value, for instance, if P2G is located at a wastewater treatment plant

Kevin Harrison, program manager – Research, Energy Systems Integration, leads researchers and guests from NREL, DOE, SoCalGas, Sempra Utilities and Electrochaea, on a tour of the hydrogen facility at the Energy Systems Integration Facility at NREL. Image courtesy: Dennis Schroeder, NREL



Electrochaea's BioCat methanation system design is a four-step process involving an electrolyzer, preprocessing, the reactor and post-processing, which turns CO2 into methane. Image courtesy: Electrochaea/Energy Solutions Center (ESC)

(WWTP), which would have use for O_2 for water treatment.

While hydrogen is a non-greenhouse gas that has received a lot of attention as a possible energy source, its main drawback is the lack of experience and regulation blending H2 onto the pipeline.

Until H2 blending processes and protocols are established, companies are better off converting the renewable hydrogen into renewable natural gas (methane) by adding an additional step after the electrolysis process called methanation. When methanation is accomplished using a biological process, it is called biomethanation. In biomethanation renewable hydrogen is mixed with carbon dioxide (CO_2) and fed into a bioreactor containing microbes call Archaea. Archaea consume the H2 and CO_2 and generate methane (CH_4), or renewable natural gas (RNG). The resultant RNG can then be injected into the natural gas pipeline system and then used in everything from home appliances to industrial processes, engines and power plants. Thus, the RNG synthesis process works by reacting the renewable hydrogen with captured CO_2. At landfills and wastewater plants, it is preferable to convert the CO_2 they produce to methane rather than separating from the biogas and releasing it into the air.

Thus, the RNG synthesis process works by reacting the renewable hydrogen with captured CO_2. At landfills and wastewater plants, it is preferable to convert the CO_2 they produce to methane rather than separating from the biogas.

Cost and viability concerns

While P2G technology has been around for some time, it's still considered a "new" technology. However, that may be changing. Several P2G projects have come online in recent years, including:

- In June 2013, Audi announced its 6-MW P2G facility in Germany making it the first automaker to develop a chain of sustainable energy carriers. A press release stated that its e-gas project is a demonstration of how e-gas can be stored efficiently independent of location.

- In 2016, Electrochaea began operating its 1 MW BioCat P2G project in Avedøre, Denmark.

- In 2019, Electrochaea began operating a second 1 MW P2G project in Solothurn, Switzerland.

- In 2019, France announced five P2G demonstrations.https://aer-bfc.com/en/bourgogne-franche-comte/sectors/hydrogen/

- Construction of Japan's first P2G plant was initiated in July 2017 as a key part of its efforts to reduce CO_2 emissions. The press released mentioned how the objective of the facility was to test and prove that large-scale P2G plants are, in fact, feasible from an environmental and economic perspective.

Utility-scale P2G facility developed

A June 2019 presentation to the Energy Solutions Center (ESC) highlighted En-

bridge's Markham Energy Storage Project in Ontario. The project is focused on creating the first utility-scale P2G facility with a 2.5-MW with 8 MWh of H2 storage. Commercial operations, which started in May 2018, are designed to provide stable service to the independent electricity system operator (ISO). The project will evolve to provide renewable H_2 for injection into the local natural gas network.

Technology accuracy is key because minimum to maximum load swings are achieved in milliseconds. It is a very much a "blink and you'll miss it" kind of circumstance and this has a significant impact.

So far, real-life operations confirm the P2G's real-time response to the automatic generator control (AGC) is very fast and accurate. This accuracy, in addition to improving safety, can help integrate more renewables like wind and solar and reduce GHG emissions as well as consumer costs.

The project includes a pilot program for a controlled hydrogen injection area. This is designed to manage hydrogen concentrations to a targeted range to compare against predicted engineering forecasts.

As a result, a portion of the distribution system will be isolated and hydrogen will be injected into the distributed system at controlled levels of less than 5%. The reason for the low level is to confirm this blend can be considered a drop-in fuel and that there won't be any safety or quality issues.

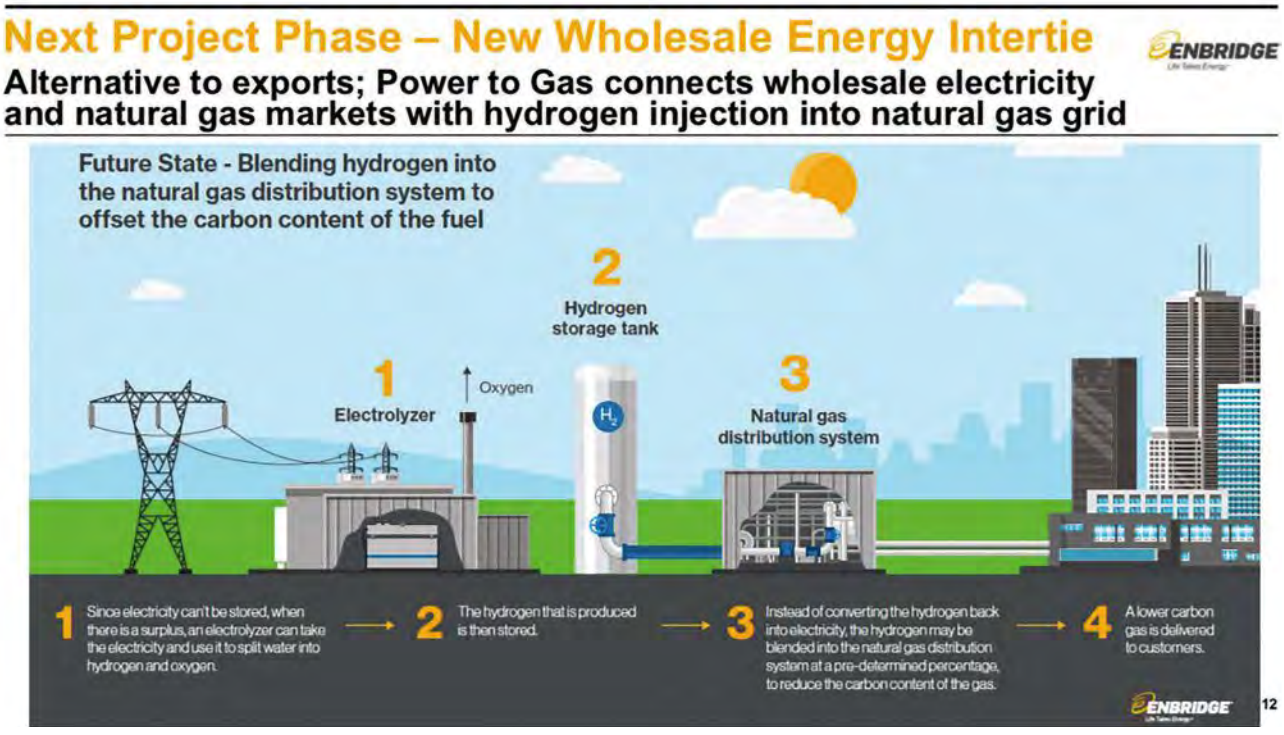
The pilot program will start with 3,500 Ontario-area customers receiving blended gas and it can be expanded to 30,000 customers if additional project learning is needed.

Pilot program launched for bioreactor

In 2014, SoCalGas and Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) collaborated in developing the first U.S.-based P2G project. This project was inspired by the belief that renewable energy curtailments would continue to be a problem and impediment to wind and solar penetration. Integrating the electric grid and natural gas system, which could be used to store energy, could create tremendous long-term value for the project.

Outside NREL's Energy Systems Integration Facility (ESIF), where pipes carrying hydrogen line the exterior of the building, is a 25-foot tall cylindrical bioreactor system is now converting hydrogen and carbon dioxide into methane. After a careful commercialization process, the plant has achieved hydrogen-to-methane conversion rates in excess of 95%. The process relies on a heat- and gas-loving archaon, originally extracted from a geyser basin in Iceland, to accomplish that conversion.

NREL's pilot scale bioreactor is fed hydrogen produced from a 250-kW



Power-to-Gas is a four-step process that connects wholesale electricity and natural gas with hydrogen injection into the natural gas grid using electrolyzers and storage tanks that delivers a lower carbon gas to customers. Image courtesy: Enbridge/Energy Solutions Center (ESC)

Nancy Farmer, NREL group research manager, Biological Science and Kevin Harrison, program manager – Research, Energy Systems Integration, lead researchers and guests from NREL, DOE, SoCalGas, Sempra Utilities and Electrochaea, on a tour of the Bioreactor in the hydrogen facility at the Energy Systems Integration Facility at NREL. Courtesy: Dennis Schroeder, NREL

electrolyzer system designed, built and operated by NREL researchers. The bioreactor is also designed to operate at 260 psig. The higher pressures aid in dissolving the hydrogen and carbon dioxide, making the gases more accessible to the microorganism. During the project, the researchers developed new approaches to tightly integrate the bioreactor with the electrolyzer to reduce costs and improve energy efficiency.

The system is storing unused energy from the ESIF's solar power plants that might otherwise go to waste by using it to make hydrogen, which the microbes then convert into natural gas.

The success of the NREL project has led to several planned commercial projects. The testing campaigns will be used to improve the design and operations of future plans. The NREL project will also be used to help inform future projects through public policies, laws, grid operating protocols and commercial tariffs.

University researchers turning greenhouse gases to liquid fuel

In the laboratory, researchers are working to make greenhouse gases viable energy that can be stored and used for commercial applications.

Rice University researchers, in conjunction with Brookhaven National Laboratory, have developed a catalytic reactor that uses CO_2 as its feedstock and produces highly purified concentrations of formic acid, according to a Rice University press release. In their tests, their electrocatalyst reached an energy conversion of efficiency of 42%. This means nearly half of the electrical energy can be stored in formic acid as liquid fuel.

"Formic acid is an energy carrier," said Haotian Wang, a chemical and biomolecular engineer at Rice University. "It's a fuel-cell fuel that can generate electricity and emit carbon dioxide – which you can grab and recycle again. It's also fundamental in the chemical engineering industry as a feedstock for other chemicals, and a storage material for hydrogen that can hold nearly 1,000 times the energy of the same volume of hydrogen gas, which is difficult to compress. That's currently a big challenge for hydrogen fuel-cell cars."

Two advances made the device possible, according to Rice postdoctoral researcher Chuan Xia. The first was the development of a robust, two-dimensional bismuth catalyst; the second was a solid-state electrolyte that eliminates the need for salt as part of the reaction.

With its current reactor, the lab generated formic acid continuously for 100 hours with negligible degradation of the reactor's components, including the nanoscale catalysts. Wang suggested the reactor could be easily retooled to produce such higher-value products as acetic acid, ethanol or propanol fuels.

Next-generation RNG

RNG can improve customer access and affordability to low-carbon energy supplies, and P2G can help companies achieve this in the short-term. And as RNG solutions evolve, the technologies and methods developed through current projects will allow greater energy savings to be realized. **GT**

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ISO 50001 benefits for manufacturers

The ISO 50001 standards establishes an energy policy and process to achieve energy management objectives for manufacturers

THE ISO 50001 ENERGY MANAGEMENT SYSTEM (ENMS) STANDARD defines an energy management system as a set of interrelated elements to establish an energy policy and objectives, and process and procedures to achieve those objectives. Many sectors, including manufacturing, commercial buildings, utilities, government facilities and military bases use ISO 50001 to improve operational efficiency, save energy and cut costs.

ISO 50001 was developed in 2011 by experts from around the world who participate in the ISO/TC 301, the group that developed the portfolio of ISO 50001 standards and guidance documents. ISO TC 301 has published 16 standards and has seven more under development. As of 2017, nearly 23,000 sites worldwide achieved ISO 50001 certification. The growth of ISO 50001 is expected to accelerate as an increasing number of companies integrate ISO 50001 into their corporate sustainability strategies and supplier requirements.

ISO 50001 is based on the same management system model used for ISO 9001 and 14001. This compatibility makes it easier for organizations to integrate energy management into their quality and environmental management efforts. However, ISO 50001 adds new data-driven sections related to energy planning, operational control and measuring and monitoring.

ISO 50001:2018, the revised version of the standard, was published on August 21, 2018. The revised version improves clarity in regards to its applicability for businesses and organizations around the world. Certification to ISO 50001 provides proof of performance and credibility both internally and externally. The growth of ISO 50001 is expected to accelerate as more companies integrate ISO 50001 into their corporate sustainability strategies and supplier requirements.

ISO 50001 does require continuous energy performance improvement. However, it does not include prescriptive energy performance improvement goals. Instead, the standard provides a general framework that each organization can set and pursue its own goals for improving energy performance.

The key steps to successful ISO 50001 certification include:

- Secure management commitment
- Set an energy policy
- Empower an energy team
- Identify where energy is used
- Create plans to improve significant energy use
- Management approves plans
- Track progress and reassess energy action plans.

The 50001 Ready Navigator has four major steps: Planning, Energy Review, Continual Improvement and System Management – and within those steps are actions companies need to be mostly prepared for to ensure their energy management system (EnMS) is successful. Image courtesy: Department of Energy, Energy Solutions Center (ESC)

Continuous improvement model

The ISO 50001 framework allows for energy-related interests to be prioritized and integrates with smart technologies that provide data and control of energy use through a continuous improvement model.

The model is broken down into four steps: Plan, do, check and act. Each of those steps has additional tasks companies need to emphasize:

Plan. Companies need to understand the requirements involved, get commitments from management, set energy and resiliency goals and structure an energy team that will work on meeting ISO 50001 requirements.

Do. The people involved in the energy team need to know where energy is being used and who is using the most, where the company is most vulnerable and create a list of energy opportunities based on the first three items.

Act. This involves prioritizing energy upgrades, reviewing energy data and conducting internal audits. It also requires the team to meet report requirements.

Check. This final step has the team benchmark energy use, identify the variables impacting energy use, assess energy billing and procurement, ensure proper operations and management (O&M).

Business reasons to enact ISO 50001

Energy management today is an area of growing interest and concern to companies around the world due to its potential to help control costs, boost energy efficiency, improve environmental quality and enhance a company's overall competitiveness. Using energy smarter and better can improve a company's overall bottom line.

The ISO 50001 international energy management system standard offers organizations a proven approach to develop an energy management plan addressing critical aspects of energy performance – including energy use, measurement, documentation, reporting, design and procurement practices, and other variables affecting energy management that can be measured and monitored.

Adoption of ISO 50001 is important to establish a systematic and sustainable approach to managing energy within a facility. Conformance to the standard provides proof that a facility has implemented sustainable energy management systems, completed a baseline of its energy use and committed to continuous improvement in energy performance. The value of certification will be driven by market forces within supply chains, potential utility incentive programs requiring ISO 50001 and the standard's relation to future carbon mitigation policies.

Jeff Allen, a plant manager for Detroit Diesel, said of implementing ISO 50001: "The money we save on energy can be reinvested back into the plant and ultimately create more jobs for the people here in Detroit."

Jean Bennington Sweeney, chief sustainability officer for 3M, added: "The proven performance of our ISO 50001-certified facilities has led 3M to include ISO 50001 and superior energy performance among our strategies to meet our next set of corporate energy efficiency goals."

According to a DOE analysis, the results from 10 facilities certified to ISO 50001 found:

- $36,000 to $938,000 in cost savings per year
- 12% reduction in energy costs (on average) within 15 months of initial implementation
- Energy performance improvements of 5.6% to 30.6% over three years
- $430,000 or more in savings each year from low- or no-cost operational improvements.

EnMS benefits

An ISO 50001 EnMS requires skills from two different communities: management system auditors and energy efficiency experts. Management system experts are often not familiar with energy issues and energy efficiency experts are often not familiar with management system processes. This impasse causes unique problems for both sides they need to bridge.

Energy efficiency professionals without the skills to implement a management system risk establishing an ineffective EnMS without a top management-driven continuous improvement process. Management system auditors that don't have the required skills for assessing an organization's continuous improvement in energy performance risk certifying organizations without measurable energy performance improvement.

The U.S. Department of Energy (DOE), realizing that effective implementation requires a skill set not readily available in the market, initiated the Institute for Energy Management Professionals (lEnMP) in 2010 to offer professional credentials to meet this market challenge. This program, launched in the early days when ISO 50001 was still being worked on, today offers a range of fully-accredited professional credentials to meet this market need.

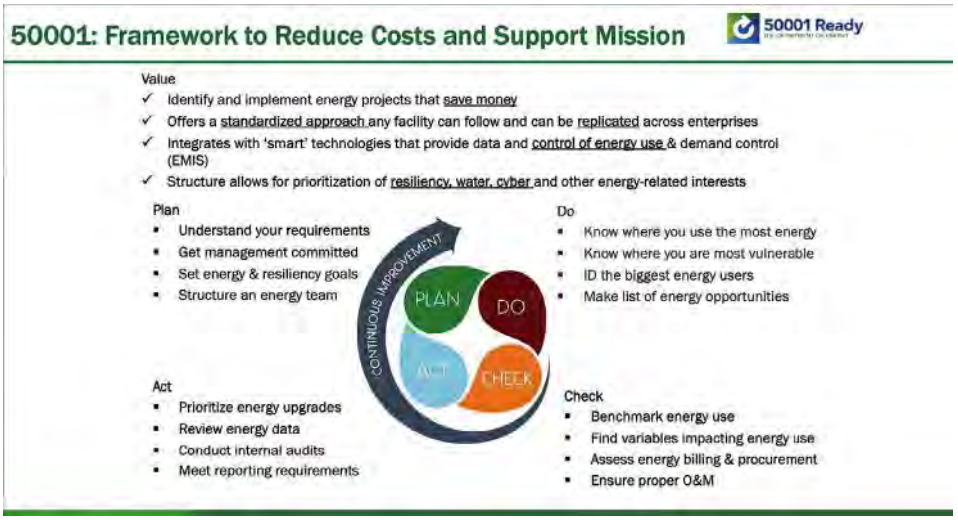
The DOE's initiatives expand to other companies, as well, in their bid to improve energy efficiency. For example, CenterPoint Energy, a domestic delivery energy company based in Houston, Texas, coordinates with the DOE to provide additional resources.

ISO 50001 tools for supporting energy management

There are many tools available to engineers looking to improve their energy efficiency and maximize their potential return on investment (ROI).

50001 Ready Navigator. The 50001 Ready Navigator is an online dashboard that provides guidance to implement and maintain an energy management system in conformance with the principles of ISO 50001. It allows users to submit their facilities for 50001-Ready recognition through the navigator. The free online tools guide users through 25 tasks to set up a comprehensive ISO 50001-based energy management system. The navigator is built on open-source standards and designed for flexibility to allow for re-branding and customization by utilities and other organizations for their specific needs.

Having an EnMS means companies should be more than halfway completed and prepared to provide information in the planning, energy review, continual improvement and system management phases (see photo).



ISO 50001 is designed to identify and implement energy projects that save money by integrating with smart technologies that provide data and help control energy use. A continuous improvement model is divided into four steps: Plan, do, act and check. Image courtesy: Department of Energy, Energy Solutions Center (ESC)

Energy Footprint tool. The energy footprint tool is designed to be easy to use with significant built-in documentation. Detailed labels and pop-up help windows on all sheets allow users quickly to begin using its features. The tool can help manufacturing, commercial and institutional facilities track their energy consumption, factors related to energy use and significant energy end-use. While the tool can be used by anyone interested in tracking their energy footprint, it has specifically been developed to support manufacturing, commercial and institutional facilities implementing energy management plans through the DOE's 50001 Ready Program or implementing energy management through the DOE's Superior Energy Performance Program (SEP).

Energy Performance Indicator (EnPi Lite). EnPI Lite is a companion calculator to the 50001 Ready Navigator. It is designed to enable regression-based energy performance modeling for facilities. EnPI Lite is web-based and maintained by the DOE. It also accepts energy performance improvement data from other available tools and can be adjusted to work with utility program energy performance improvement calculators.

Register of Implemented Energy Performance Improvement. The register assists with implementing an EnMS. Energy savings over the period are reflected; typically, this will be annual savings. The register is designed to summarize key details including:

- Action description
- Actual energy savings
- Source of energy savings
- The party responsible for energy savings.

MEASUR. Manufacturing energy assessment software for utility reduction (MEASUR) is an integrated tool suite designed to aid manufacturers in improving the efficiency of energy systems and equipment within a plant. MEASUR will ultimately contain capabilities to analyze most major support systems found within manufacturing facilities, including process heat, steam and compressed air. This effort, expected to be completed in 2019, provides for an extensively more user-friendly, modern and versatile set of tools. There is interoperability between the individual tools, and the entire suite is accessible in an open-source environment. Several calculators are built into the tool that allows users to independently calculate system parameter estimations and graphical analysis (e.g., converting energy requirements for different heat sources).

There also are education and training programs that can be performed online or on-site and they are available on the DOE's Better Buildings website. The classes can be tailored toward a specific need and does not need to be broadly developed.

Companies like CenterPoint also are providing education on these tools. Earlier in 2019, CenterPoint joined training hosted by a local customer, 3M, in St. Paul, Minn., which had brought in two 50001 CP EnMS Qualified instructors to train 3M staff from around the country on how to prepare for DOE's 50001 Ready recognition program through use of its 50001 Ready Navigator tool.

"CenterPoint Energy is evaluating adding an ISO 50001 component to our upcoming 2020-2022 Conservation Improvement Program," said Todd Berreman, director, energy efficiency, CenterPoint Energy.

MORE info

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Energy efficiency for plants

Energy management software tools help manufacturers increase energy efficiency at the plant-level and in specific systems. The tools also can help utilities find ways to improve their energy output and find new ways to better maximize their returns. It is a process and will not be done overnight. However, the tools are readily available for companies looking to achieve their certification. GT

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Fueling asphalt production with LNG and CNG

Asphalt companies without a readily-available pipeline are turning to LNG and CNG

THE ASPHALT INDUSTRY MIGHT NOT SEEM VERY COMPETITIVE. However, the companies involved in the business are like any other. They're trying to reduce costs any way they can while not skimping on quality or worker safety. They also must abide by current and future standards.

The process for making asphalt is not something many consider. When drivers are on the road, the only thought on their mind is when the trip will be done so they don't have to drive on uneven, bumpy roads. However, it is a very intricate process. The work requires a great deal of precision.

Wolf Paving, a Wisconsin-based company that specializes in asphalt pavement installation for commercial, residential and municipal locations, highlights a seven-step process for making asphalt:

1. **Demolition and removal,** which is completed using heavy machinery such as forklifts, loaders and large dump trucks.
2. **Grading and sloping,** which involves ensuring water will run off because that's a major cause of asphalt damage.
3. **Preparing the sub base,** which provides the stable surface to support the new asphalt pavement.
4. **Proof roll and undercutting,** which helps ensure the sub base is secure and does not have anything that could compromise the structure.
5. **Binder and surface course,** which is a large aggregate layer mixed with oil.
6. **Installing the asphalt surface,** which is the end result people see. The surface is a mix of small aggregate, sand and oil.
7. **Butt joints and transitions,** which is where the asphalt connects to existing driveways, roadways or parking lots and making sure the process goes smoothly.

It is a long, involved process, but it is more involved than paving and cutting. Keeping operations sustainable for a long period of time is just as important as the asphalt production process. If the asphalt plant isn't reliable, it's going to be a long time before drivers are going to have a smooth ride.

The asphalt plant is responsible for the site work required to make their yard able to accept trailers, bring communications, electricity and a new low-pressure gas pipe to the decompression station. A second burner is recommended to attain dual-fuel capability. Dual-fuel capability facilitates supply redundancy and protects against price swings.

LNG and asphalt

Asphalt plants typically are located close to the paving project site to maintain quality. However, these plants often are not located near a natural gas pipeline. This means a greater reliance on fuel sources, which may be more expensive – not just for the fuel, but for secondary costs such as equipment maintenance.

Many asphalt manufacturers have found a solution to address these challenges by using liquefied natural gas (LNG) to fuel their stationary and temporary asphalt production facilities. These manufacturers are finding LNG to be more sustainable in terms of cost and safer than the fuels used to produce asphalt.

LNG is a clear non-toxic liquid that forms when natural gas is cooled to -162 C. According to the U.S. Energy Information Administration (EIA), the cooling process shrinks the volume of the gas about 600 times. This makes it easier and safer to store and ship and will not ignite in its liquid state. When LNG reaches its destination, it is turned back into a gas at regasification plants. It also is environmentally safe. It does not emit soot, dust or fumes and does not require any remediation of soil, groundwater or surface waters like traditional oils would.

LNG is stored in double-walled, vacuum-insulated pressure vessels and is denser than compressed natural gas (CNG), which means more energy can be stored by volume in a given tank.

This is helpful for asphalt manufacturers, who may have to expend more energy in peak summer months when the daily temperature reaches its apex.

However, the upfront costs for aspects like transportation and cryogenic make the initial process quite expensive for companies involved. Also, LNG doesn't have an unlimited shelf life and cannot remain in a liquefied state forever. If a company is going to use LNG, they have to use it quickly. Given the pressing needs of an asphalt project, these are challenges that can be overcome.

LNG is a safe option for asphalt manufacturers

Another important aspect for asphalt manufacturers is what happens if there's a spill. LNG is lighter than helium and quickly dissipates into the atmosphere if there's a spill.

This is in contrast to spills involving propane and diesel. For example, when propane, a heavy fuel, is spilled, it is extremely hazardous until fully mixed with surrounding air. In the interim, the combination of an ignition source and the presence of propane in a low area or corner of an asphalt plant can create an extremely hazardous situation for employees, first responders and others at the scene.

Diesel fuel spills are another major concern. Depending on the amount spilled, they could require a HAZMAT response team and could contaminate the ground, requiring a costly removal and cleanup process.

LNG, because of its gaseous state, does not have these potential drawbacks and is, overall, a safer option for asphalt manufacturers.

LNG is a cleaner energy option

An important reason for the growing use of LNG in asphalt plants is its widespread utility. Any stationary or temporary plant currently operating on recycled fuel oil (RFO) or waste oil is an ideal candidate to convert to LNG.

RFO is a low-cost heavy oil that contains large amounts of sulfur, nitrogen

The 7-Step Process for Successful Asphalt Pavement Installation

STEP 1: Demolition and Removal

The first step in the asphalt installation process is to remove the existing surface, whether it is asphalt, concrete or pavers. Demolition and removal is completed using heavy machinery and large dump trucks and front loaders when necessary.

STEP 2: Grading and Sloping

With a clean slate, technology helps asphalt professionals prepare the surface for appropriate water drainage. Water is a major cause of asphalt damage and can lead to problems such as potholes, cracks and heaving.

STEP 3: Prepare the Sub Base

The sub base provides a stable surface designed to support new pavement and acts as a frost barrier for reduced damage during the winter months.

STEP 4: Proof Roll, Undercutting and Sub Base Repair

Once the sub base is fully graded and compacted a proof roll is performed to ensure the underlying surface is strong and ready to support new asphalt.

If the proof roll finds soft areas in the sub base, repairs in compromised areas are performed to ensure the entire sub base is supportive.

STEP 5: Binder and Surface

Course Once the sub base is laid and any soft areas are identified and repaired, it is time to add the binder.

STEP 6: Install New Asphalt Surface

Once the supportive structures of a new asphalt surface are installed, the top layer of fresh asphalt is added to provide a clean, smooth ride.

STEP 7: Butt Joints and Transitions

It is very rare to install an asphalt surface that does not connect to existing driveways, roadways or parking lots. Asphalt-paving contractors must find a way to smooth the transition from old surface to new.

To Complete the Project: Final Roll

Once the asphalt and butt joints have been laid, the entire surface is smoothed and compacted.

Images courtesy: Energy Solutions Center (ESC)

In addition, it can be costly to switch to a backup fuel, which causes lost revenue when the price of electricity is high during the peak months. CNG also is useful because seasonal weather can be unpredictable. By using peaking supply, power producers can receive supplemental supply only when it is most economical.

CNG, unlike LNG, doesn't require new technological development to implement, which makes it a viable alternative in terms of upfront costs.

To maintain the temperature and consistency of the finished products, asphalt plants typically are located close to the paving project site. In many cases, these plants are not located near a natural gas pipeline, which means reliance on other sources of fuel that may be more expensive, demand greater amounts of equipment maintenance, or emit greater CO2 emissions. A competitor located on a pipeline may be able to underbid the facility not on a pipeline.

CNG is stored on the vehicle in high-pressure tanks – (3,000 to 3,600 psi). Natural gas consists mostly of methane and is drawn from gas wells or in conjunction with crude oil production. As delivered through the pipeline system, it also contains hydrocarbons such as ethane and propane as well as other gases such as nitrogen, helium, carbon dioxide, sulfur compounds and water vapor. A sulfur-based odorant is normally added to CNG to facilitate leak detection. Natural gas is lighter than air and normally will dissipate in the case of a leak.

At first glance, LNG and CNG might not seem like a natural fit for asphalt manufacturers. While there are some up-front challenges with costs, the long-term benefits from energy savings and worker safety make them viable alternatives for companies that don't have ready access to pipelines. **GT**

and heavy metals and is hazardous for the environment and for people in close proximity to the production. Asphalt plants that burn RFO have increased plant maintenance and downtime.

LNG, however, is environmentally safe. It does not emit soot, dust or fumes and does not require any remediation of soil, groundwater or surface waters like traditional oils would.

CNG benefits for asphalt manufacturers

CNG is a flexible, low-cost and clean-burning fuel used to complement pipeline natural gas to provide dynamic supplies of heat and electricity that respond to erratic temperatures and uncertain flows. During peak summer and winter months, when heating and electricity demands are highest, the supply of natural gas can be constrained.

MORE info

ALTERNATIVE FUELS DATA CENTER
https://afdc.energy.gov

ALTERNATIVE FUELS SYSTEMS INC.
www.afsglobal.com

FUEL SPACE
www.fuelspace.org

U.S. ENERGY INFORMATION ADMINISTRATION
www.eia.gov

WOLF PAVING
www.wolfpaving.com

CHP is a cost-effective solution for cannabis production

Combined heat and power (CHP) is a reliable source of electricity and power for cannabis owners, which needs a constant and reliable source to ensure their plants grow quickly

CANNABIS CULTIVATION REQUIRES A MASSIVE ELECTRICITY LOAD TO MAINTAIN OPTIMAL LIGHTING AND OTHER GROWING CONDITIONS. Not only are electricity costs high, but many grow houses require expensive and time-consuming electric service upgrades just to get started. It is not only crucial to grow plants, but to grow them quickly.

Combined heat and power (CHP), also known as cogeneration, is a possible solution because CHP uses natural gas to generate electricity onsite. The waste heat recovered from power generation can be used to meet other energy needs in the facility, reducing overall energy costs. In some applications, CO2 from the exhaust can be recovered and used to provide a CO2-rich atmosphere that enhances growing capability. Waste heat from the engine is captured and delivered to the facility through a hot-water loop that can store the energy and deliver it to the facility when needed for air conditioning and humidity control.

For cannabis producers, relying on CHP rather than traditional power is beneficial if there is an unexpected power interruption, according to a Kinsley Group white paper. The industry, which is full of potential as a growing market, will eventually reach a point where energy efficiency is crucial. CHP is a more efficient and economical way to meet overall energy needs. CHP requires only 100 units of input to supply 85 units of energy available for grow house operation, whereas obtaining the same 85 units of energy conventionally from electric and natural gas utilities requires more than twice as much energy input. The system also must supply all heat and electric needs with a defined peak capacity.

Traditionally, the delivery of heat and power are through separate processes. However, those separate processes can lead to wasted energy and high utility costs. Generating electricity at a distant power plant causes the release of a large amount of energy into the environment, also known as "waste heat."

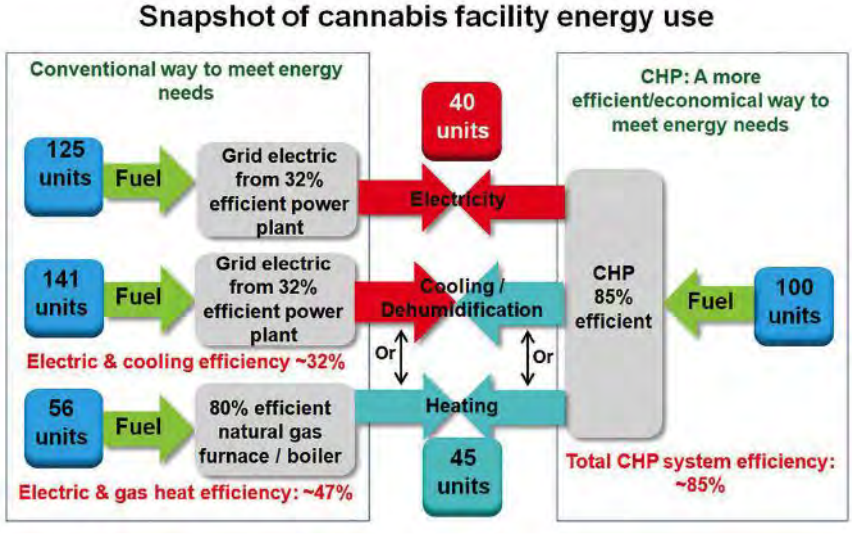
The hot water can directly produce chilled water through an absorption chiller. The chilled water is used for cooling and dehumidification. Some hot water may be needed to reheat the air after moisture has been condensed out.

CHP is used in many other industries and typically has a 3-to-5-year simple payback for a 24/7 operation. It also requires little time to set up and there are no grid availability limitations or electric service upgrades. The system can be designed precisely to meet facility power needs, which is crucial for cannabis producers. The power must be constant and cannot have any unexpected downtime because that could hurt the crop's quality. **GT**

MORE info

ENERGY SOLUTIONS CENTER
www.energysolutionscenter.org

KINSLEY GROUP
http://kinsley-group.com/files/Kinsley%20Energy%20Systems%20-%20CHP%20for%20Greenhouses%20Whitepaper.pdf



This graphic shows two ways to achieve 85 units of energy for cannabis production. On the left, electricity is provided by the electric utility. The electric utility or natural gas supplier, or both, supply energy needed for heating, cooling and dehumidification. Depending on whether the facility needs heating, between 266 and 300 units of energy are needed to supply 85 units of available energy. On the right, CHP generates needed electricity. Resulting thermal waste energy is used for heating, hot water, cooling and dehumidification. Only 100 units are needed to achieve 85 units of available energy. Image courtesy: Energy Solutions Center

Spotlight on Atmos Energy

Atmos Energy Corp. has experienced growth as an energy provider for the distillery market in Kentucky and Tennessee

ATMOS ENERGY CORP., HEADQUARTERED IN DALLAS, TEXAS, IS THE NATION'S LARGEST FULLY REGULATED, NATURAL GAS-ONLY DISTRIBUTOR OF SAFE, CLEAN, EFFICIENT AND AFFORDABLE ENERGY. The Company serves more than 3 million distribution customers in more than 1,400 communities across eight states.

The Atmos Energy service areas in Kentucky and Tennessee, as an energy provider, have experienced industrial growth for the expanding distillery market. Kentucky and Tennessee are home to some of the world's premier brands for bourbon and whiskey production, and as demand for these distilled products has increased, the demand for safe, clean and reliable natural gas to produce these products has followed.

Jack Daniel's in Tennessee, along with O.Z Tyler, Wild Turkey, Four Roses and Diageo in Kentucky, have been recent partners with Atmos Energy in establishing new or expanded natural gas service to their distilleries.

In the instance of Jack Daniel's, which began operations in 1866 in Lynchburg, Tenn., the distillery had previously burned wood and sawdust as its primary fuel source. With Jack Daniel's construction of a new distillery, along with increased production at its original distillery, natural gas was the fuel of choice to allow Jack Daniel's to meet future demand. A large part of the natural gas will be used to produce steam, which in turn is used to cook the mash and distill the whiskey.

Expanding gas capacity

Atmos Energy worked with the team at Jack Daniel's to expand existing gas capacity, and plans on partnering with Jack Daniel's to construct a new gas pipeline for the distillery. This pipeline will be a four-mile extension of an 8-in. natural gas main, enabling Jack Daniel's to meet its goal of doubling production in the next 15 years.

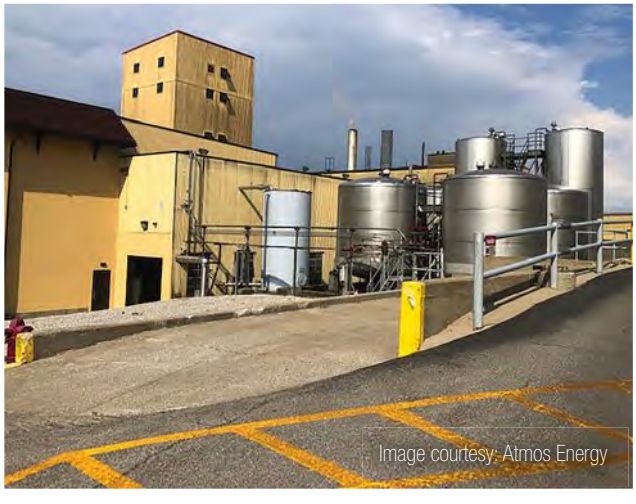


Image courtesy: Atmos Energy

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Four Roses and Wild Turkey, both located in Lawrenceburg, Ky., also previously used wood-burning fuels as their energy source. Like Jack Daniel's, both distilleries have shifted to natural gas due to recent expansions.

In the case of Wild Turkey, the conversion to natural gas required two additional miles of new gas infrastructure. For Four Roses, wood will continue to be used as backup to natural gas, but with production expected to double, the company chose natural gas as its primary fuel choice for the required expansion.

Distillery powered by natural gas

Diageo has built its new distillery in Shelbyville, Ky. At this new facility served by natural gas, Bulleit Bourbon will be produced to meet anticipated customer demand. Atmos Energy partnered with Diageo to construct a two-mile extension from its existing system, part of which included a 600-foot bore of a lake that was along the construction path.

Diageo also has announced plans for a second distillery to be built in Lebanon, Ky. This distillery already has natural gas available at the chosen site due to a recently completed project and will be provided by Atmos.

Finally, Atmos Energy has initiated gas service to O.Z. Tyler Distillery in Owensboro, Ky. This facility uses only natural gas to meet its production needs. In addition to the distillery, the company has constructed six barrel warehouses capable of holding 20,000 barrels of bourbon each.

Serving ancillary businesses

Atmos Energy will deliver an additional 3,000,000 Mcf annually to serve these expansions, new distilleries and their conversions from wood to natural gas.

Whiskey and bourbon production has a long history in Tennessee and Kentucky and Atmos Energy is privileged to help continue the next chapter by partnering with these companies in providing safe, clean, reliable and affordable energy. **GT**