TECHNOLOGY

SUSTAINABLE OPTIONS FOR REDUCING EMISSIONS FROM THERMAL ENERGY:

SHOWCASING SUCCESSFUL OUTCOMES FROM SIX CASE STUDIES

A report to the Renewable Thermal Collaborative
by the Center for Climate and Energy Solutions

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

RENEWABLE THERMAL COLLABORATIVE

by

Jessica Leung
Nancy Meyer
Center for Climate and Energy Solutions

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EXECUTIVE SUMMARY

This series of case studies showcases successful outcomes from the use of renewable thermal technologies at several different large companies and in a major city. It also provides some understanding of the potential benefits and challenges when considering different renewable heating and cooling technologies. In each of the case studies, significant cost and emissions savings were generated by investments in renewable thermal solutions.

One key theme across all of the case studies was that each organization had clearly established sustainability goals that supported a renewable approach. Other factors that facilitated implementation of renewable thermal solutions included high and volatile fossil fuel costs or the phaseout of older capital investments, which offered an opportunity to review renewable options for heating and cooling needs.

Another common theme shared by each of the case studies was the availability of a local resource. This makes the projects more difficult to replicate since local circumstances can greatly vary the project economics or viability of a certain technology for a given application. However, facilities co-located with each other may offer expanded possibilities for renewable thermal solutions.

Most projects included in this report were self-financed and achieved their expected return on investment. However, one technology facing more economic barriers is renewable natural gas (RNG). RNG projects in the United States have been stalled due to low domestic natural gas prices. In the RNG case study included in this report, the market for the renewable fuel standard program was used to mitigate this cost barrier, but broader federal programs may be needed to help support RNG over the long term. The introduction of a thermal renewable energy certificate could also make tracking and claims easier and more standardized for these types of projects.

The goal of the Renewable Thermal Collaborative is to raise awareness and build greater supply and demand for renewable thermal options. Increasing the availability and cost competitiveness of these solutions is key to deploying them at scale. With greater scale, more organizations in the industrial and commercial sectors will be able to make dramatic cuts in their carbon emissions.

INTRODUCTION

Many climate solutions to date have focused on reducing power sector emissions. However, thermal energy use is another significant source of greenhouse gas emissions, accounting for 50 percent of final energy demand and 39 percent of energy-related greenhouse gas emissions globally.[1] Certain sectors with high thermal loads, such as the industrial and commercial sectors, have significant opportunities to reduce emissions by employing renewable energy resources for thermal heating and cooling, in addition to using it for electricity generation.

Thermal energy results when a primary energy source is converted into heat. Unlike electricity, which is distributed to end users through a transmission system, thermal energy is produced on-site or nearby and distributed locally. Natural gas is the most readily used fuel in producing thermal energy and can be distributed over long distances using a pipeline network. The energy load at a production facility dictates its temperature needs or thermal load requirement, which can narrow the renewable thermal options that are viable.

Process heat in industrial processes or heating and cooling of buildings are the most common uses of thermal energy. Process heat is used to produce basic materials and manufacture value-added products. Buildings require thermal energy to heat water, produce heat, and to serve as an energy source for refrigeration and air conditioning.

This report presents case studies that encompass a range of solutions across an array of industries. They highlight renewable thermal technologies that have been deployed globally in: a consumer goods production plant using geothermal energy; a corn and starches facility using solid biomass; a cosmetics company purchasing renewable natural gas from a landfill; an automotive assembly plant using waste-to-steam energy; and two wastewater treatment plants using biogas, one for a food processing facility and the other to generate electricity at a wastewater treatment plant for a major city.

Each case study provides details about the organization's project and how it uses renewable thermal technology for their specific sector's application. Unique financing strategies, project challenges, and lessons learned are also shared from each project.

SUMMARY OF RENEWABLE THERMAL TECHNOLOGIES

This section provides an overview of the key renewable thermal technologies available today and previews the technologies to be covered in the subsequent case studies.

BIOGAS

Biogas systems use the natural, biological process of anaerobic digestion to recycle organic waste, turning it into biogas, which is used for energy. Biogas is composed primarily of methane (50–70 percent) and carbon dioxide (30–50 percent), with trace amounts of other particulates and contaminants.[2] Biogas can be produced from a variety of sources, including agricultural digesters, wastewater treatment facilities, and landfills. The city of Philadelphia uses biogas for both thermal and electricity needs at its municipal wastewater treatment plant. Additionally, Mars Inc., a confectionary and pet food manufacturer, uses biogas for thermal and electricity needs at its wastewater treatment plant inside their food processing facility in Sochaczew, Poland.

BIOMASS

Biomass energy is derived from combustion of organic material. Sources of biomass include forest wood and crop residues; organic, animal and municipal waste; crops cultivated to serve as biomass fuel; and byproducts such as black liquor, from the pulp and paper industry. Direct combustion is the most established and commonly used technology for converting biomass to heat.[3] Cargill, a food and agricultural manufacturer, uses biomass for thermal and electricity needs at its corn and starches facility in Uberlandia, Brazil.

RENEWABLE NATURAL GAS

Renewable natural gas (RNG) is a pipeline-quality gas that is fully interchangeable with traditional natural gas and compatible with U.S. pipeline infrastructure.[4] There are two principal technology platforms for producing renewable gas: (1) thermal gasification and (2) anaerobic digestion.[5] Each platform involves the production of raw gas (i.e., biogas) that is then upgraded (i.e., impurities like carbon dioxide are removed).[6] L'Oréal USA, a cosmetics company, plans to purchase renewable natural gas from a landfill in Ashland, Kentucky to cover natural gas demand from its 19 production and distribution facilities in the United States.

WASTE-TO-ENERGY

Waste-to-energy is created when municipal solid waste is combusted and the heat from the resulting combustion converts water to steam, which is sent to a turbine to generate electricity and thermal heat. After this combustion process, remaining ash from waste is processed to remove particulate matter before being trucked to a landfill. General Motors, an automotive company, uses waste-to-steam energy for thermal and electricity needs at its assembly facility in Detroit.

GEOTHERMAL

Geothermal energy is heat from the Earth. It includes reservoirs of hot water that exist at various temperatures and depths below the Earth's surface, as well as energy in the ground at shallow depths. Current geothermal energy production techniques for thermal applications usually provide lower temperature energy (typically ranging from 122–302°F than is required by many manufacturing industries. Procter and Gamble, a consumer goods company, uses geothermal at its production facility in Xiqing, China, that makes personal care products.

SOLAR THERMAL

Industrial process heating may utilize several different types of solar thermal systems such as glazed/unglazed solar collectors, flat plate solar collectors, evacuated tube solar collectors, and concentrating solar power systems (CSP). Flat plate and evacuated tube solar collectors are usually used for lower temperature heat demands (up to 212°F); whereas, CSP collectors and parabolic troughs are used for higher temperature heat demands (up to 752°F). This collection of case studies does not feature this technology, but companies such as PepsiCo, a food and beverage company, have implemented it at their Tolleson, Ariz. facility where it produces products such as Gatorade.[7]

RENEWABLE ELECTRIFICATION

Renewable electrification of industrial processes is another approach to achieve carbon dioxide emissions reductions. This approach entails continued electrification of energy for motion and force and electrification of heat and steam production via a series of technologies. Some technologies, such as heat pumps, are particularly effective.[8] This collection of case studies does not feature this technology, but companies such as Google, a technology company, have plans to use geothermal heat pumps in its new Bay View campus in Mountain View, Calif., which is expected to meet nearly all of the company's heating and cooling needs for offices.[9]

BIOMASS CASE STUDY: CARGILL

UBERLANDIA

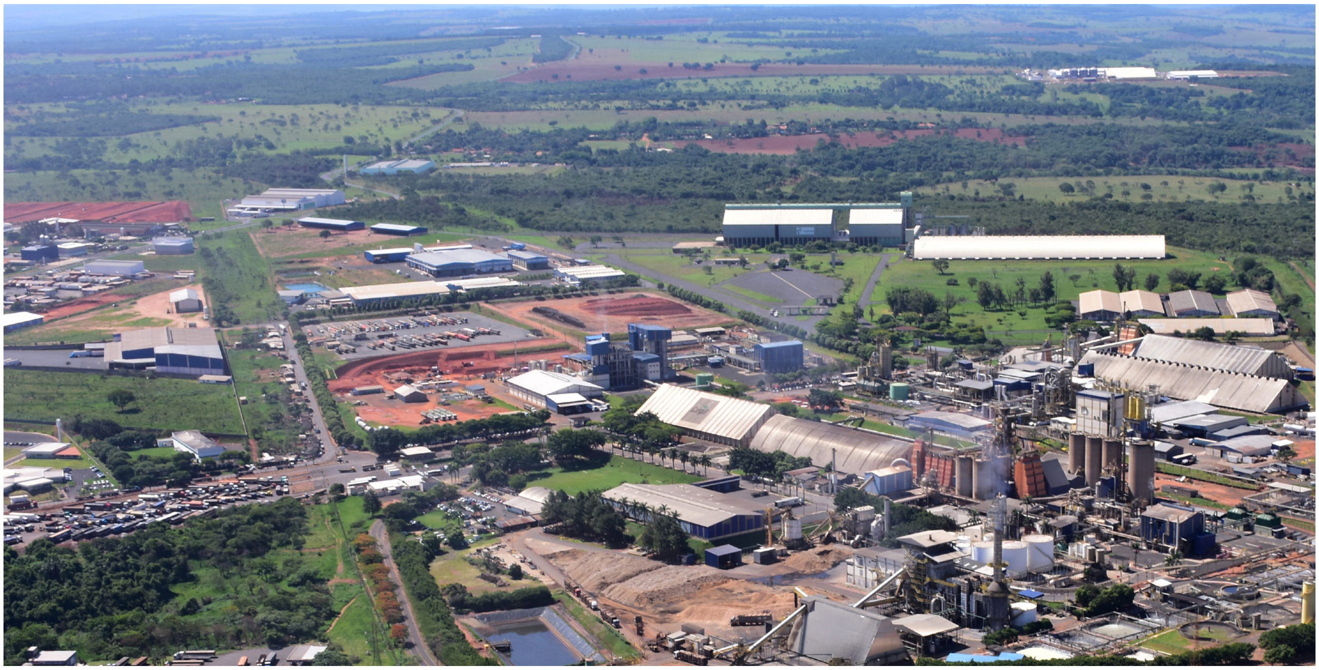
OVERVIEW

Cargill's Uberlandia project in Uberlandia, Minas Gerais, Brazil is a biomass facility that produces industrial and pharamaceutical starches, corn products, and proteins for animal feed. Cargill replaced its fuel oil-powered boiler with a biomass-powered steam boiler and turbine in 2011. In addition to reducing greenhouse gas emissions by 67,000 metric tons carbon dioxide per year, the switch from fuel oil to biomass allowed plant capacity to increase by 70 percent, which would not have been possible given the high cost of fuel oil. The Uberlandia project helps Cargill to meet several of its sustainability targets, including greenhouse gas intensity and renewable energy targets in place since 2005 as well as energy efficiency targets in place since 2000.

PROJECT DESCRIPTION

The Uberlandia project is located in Uberlandia, southeastern Brazil approximately 400 miles from São Paulo. Previously, fuel oil was used to produce heat for this facility, but the price of fuel oil was high and volatile, resulting in high operational costs and constrained expansion of the facility. To counteract that operating hurdle, Cargill switched to a combined heat and power (CHP) technology, where a single source of energy is used to produce both heat and electricity. Cargill installed a biomass-powered steam boiler and turbine to generate thermal energy for process heat as well as electricity. The boiler generates steam that is roughly 950 degrees Fahrenheit (65 bar steam).[10] The fuel oil boilers were previously only used to generate process heat and not electricity, so the project's ability to generate power resulted in additional benefits.

FIGURE 1: Aerial view of the Uberlandia Facility.



COSTS AND FINANCING

This project was self-financed with capital through the Brazilian National Bank of Development (BNDES). When the investment decision was made, Cargill expected the project to have a payback period of 4.7 years, 6.4 percent net present value, and an internal rate of return of 18 percent. Now in its seventh year of operation, the project has successfully met its financial projections and operating expectations. In fact, over the last five years, Cargill has saved more than $20 million in electricity costs by having the cogeneration system in operation.

OUTCOMES

- Uberlandia avoids about 5 million gallons of fuel oil per year and has reduced carbon dioxide emissions by 67,000 metric tons per year.
- The steam turbine has improved overall source energy efficiency and generates up to 75 percent of the power consumed by the plant. The remaining 25 percent of the plant's power needs are supplied by the local grid.[11]
- Cargill sustainably sources the biomass from its own land, which contributes to local afforestation efforts.

BARRIERS AND LESSONS LEARNED

- Switching to a biomass boiler required new technical capacity; however, Cargill had pre-existing knowledge on operating biomass boilers and steam turbines within the company; therefore, additional expertise related to operations and maintenance of the biomass boiler and turbine was not needed.
- Securing a local, long-term, sustainable biomass supply was the project's biggest barrier. Cargill overcame it by acquiring a plot of roughly 8,000 hectares to grow eucalyptus trees, which are harvested approximately every five to seven years. The company's business team uses forward planning to ensure a regenerative supply of biomass is available on a continual basis.

BIOGAS CASE STUDY: CITY OF PHILADELPHIA

NORTHEAST WATER POLLUTION CONTROL PLANT—COMBINED HEAT AND POWER FACILITY

OVERVIEW

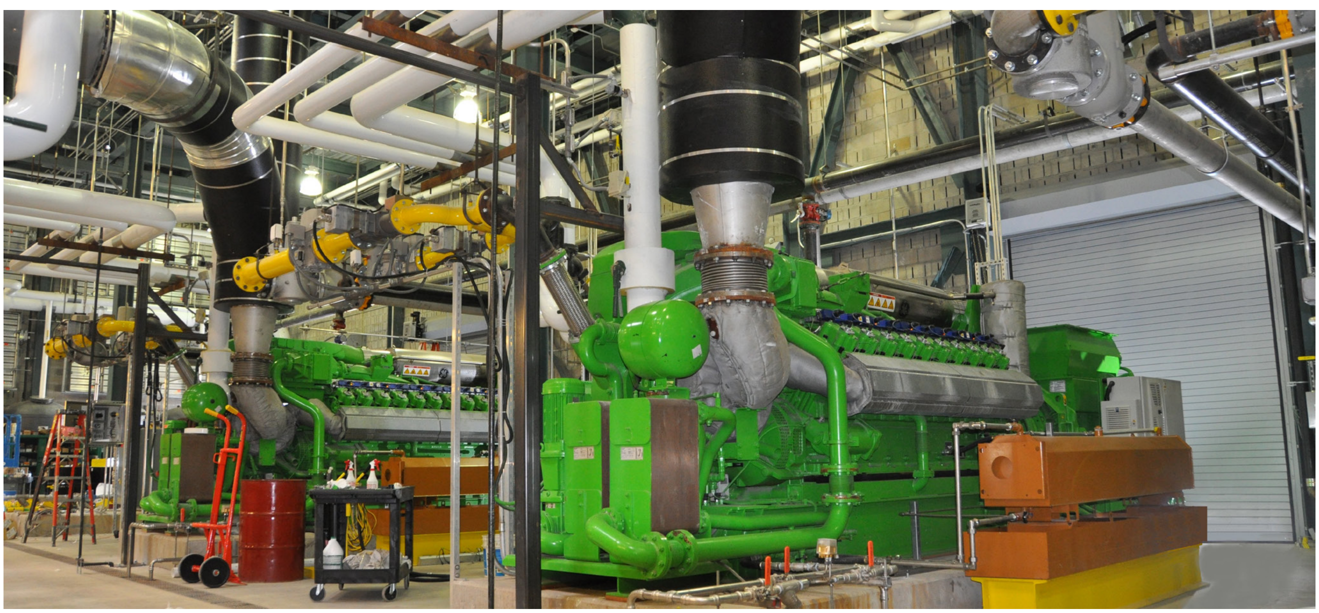
Greenworks, the city of Philadephia's sustainability plan, envisions a sustainable city for all Philadelphians and includes goals to reduce carbon emissions, increase renewable energy generation, and achieve zero waste. In an effort to accomplish these goals, the city completed a biogas project at its Northeast Water Pollution Control Plant in 2013. Prior to this project, approximately half of the biogas produced by the facility was flared. The Philadelphia Water Department identified an opportunity to use the flared biogas to generate electricity for the wastewater treatment plant by using a combined heat and power (CHP) system.[12] The Philadelphia Water Department considers biogas recovery and use key to resilient wastewater treatment operations, since biogas insulates the plant from energy market volatility and provides a reliable onsite fuel source while offering environmental benefits. The production of electricity has resulted in emission reductions of about 20,000 metric tons of carbon dioxide equivalent each year.

PROJECT DESCRIPTION

The Northeast Water Pollution Control Plant—CHP Facility is located in Philadelphia. The facility is powered by a combination of biogas derived from the anaerobic digestion of wastewater and supplemental natural gas. Biogas accounts for 85 percent of the fuel supply to create electricity and heat, and traditional, pipeline natural gas is used to compensate for restrictions in the biogas supply, which fluctuates depending on the amount of waste coming into the facility and the performance of the digesters. Prior to the installation of the CHP system, biogas was used to heat anaerobic digesters and excess biogas was flared when thermal loads were not present.

On average, the project produces 33.2 million kWh of electricity, of which 28.8 million kWh are generated from biogas and 5.4 from purchased pipelined natural gas. In addition, 38 percent of the fuel is converted to electricity while 42 percent gets captured as useable heat. More heat is needed in the winter than the summer, and the city is working to use excess summer heat to run an absorption chiller that will provide air conditioning for certain buildings in the future.

FIGURE 2: Inside the facility, viewing two of the four cogeneration engines.



The thermal energy generated by the CHP unit is delivered to an internal plant heat loop that provides heat to several buildings, pipes, and the digesters while the electricity generated provides energy for the entire wastewater treatment process. The original controls for the heat loop were kept in place so that if the biogas CHP did not supply enough heat, a boiler would come online to provide supplemental heat. Heat leaves the CHP system at approximately 200 degrees Fahrenheit and is run through a heat exchanger to provide roughly 180 degrees of heat within the treatment plant's internal heat loop.

COSTS AND FINANCING

The project was financed in a unique public-private lease agreement, which allowed tax credits to be used toward the project. The project received an investment tax credit from the federal government of approximately $12 million and a utility rebate of approximately $3 million for cogeneration from the local electric distribution company, PECO. The facility is owned by Bank of America Merrill Lynch, but was built and is maintained by the renewable energy company, Ameresco, while the city operates the facility.

The Philadelphia Water Department designed the project, and in accordance with the agreement the Department sold the design plans to Ameresco through a series of agreements. The city issues fixed lease payments to a Banc of America Securities special purpose entity. The maintenance costs, which vary over the life of the project, are paid to Ameresco. Ameresco took the risk of system integration, operability and project schedule, which results in less risk to the city than standard public works.

The city planned the project with a 20-year investment horizon; however, to qualify for the tax credits under the American Recovery and Reinvestment Act, the lease needed to retain 20 percent of its original value at the end of the lease. Therefore, the lease was contracted over 16 years.

OUTCOMES

- Renewable energy certificates from the project are sold, with a portion retained for compliance with Pennsylvania's alternate energy portfolio standard laws.
- The project provides renewable energy for up to 85 percent of onsite electricity needs and has generally performed near expected levels of energy savings.
- Avoided cost of electricity purchases per year is approximately $2.6 million.
- Value of heat produced at the facility per year is approximately $560,000.
- Emissions have been reduced by approximately 20,000 metric tons of carbon dioxide equivalent each year as a result of on-site electricity generation.
- The value of the biogas increases as it is converted into a monetizable renewable energy form which increases the value and importance of the overall anaerobic digestion process.

FIGURE 3: Diagram of the Relationship for Operation of Biogas Generation.

BARRIERS AND LESSONS LEARNED

- The viability of the CHP project hinged on having a steady stream of underutilized biogas combined with a large electrical demand load needed to process wastewater.
- The project provided the city an overall positive experience in public private partnerships, which could open the way for future opportunities using that structure.
- The value of longer-term opportunities such as this biogas CHP project are sometimes not easily understood by senior decisionmakers due to their complex, technological nature. An opportunity exists to better educate local stakeholders on these opportunities and how they provide value.

RENEWABLE NATURAL GAS CASE STUDY: L'ORÉAL USA

KENTUCKY RENEWABLE NATURAL GAS PURCHASE AGREEMENT

OVERVIEW

L'Oréal USA, a wholly owned subsidiary of the L'Oréal Group, has committed to make its 19 U.S. manufacturing and distribution facilities in 12 states carbon neutral by 2019. Reducing the company's environmental footprint (carbon emissions, waste, and water use) is a key component of the L'Oréal Group's global sustainability program, *Sharing Beauty with All*.[13] By 2017, L'Oréal USA had already reduced its carbon dioxide emissions by 84 percent from a 2005 baseline and achieved 100 percent renewable electricity to address its Scope 2 emissions.[14] However, the company was driven to be even more ambitious and examined opportunities to reduce its Scope 1 emissions associated with thermal energy use. Motivated by a desire to create a positive local impact while intentionally providing support for a project (known as "additionality"), beginning in December 2018, the company will purchase renewable natural gas produced from the Big Run Landfill in Ashland, Kentucky, a site that is currently flaring its produced landfill gas. With the completion of this project, L'Oréal USA Operations will be able to obtain 100 percent of its energy from renewable sources and meet its carbon neutrality commitment.

PROJECT DESCRIPTION

The Big Run Landfill produces landfill gas. Ultra Capital Partners is currently constructing a landfill gas processing facility that will remove impurities from the landfill gas to produce pipeline quality renewable natural gas (RNG). The RNG will be piped into the existing natural gas pipeline infrastructure for purchase by any offtaker in the market. L'Oréal USA signed a 15-year purchase agreement beginning in December 2018 to purchase RNG from the landfill to cover its thermal energy needs for all its manufacturing and distribution facilities in the United States.

COSTS AND FINANCING

L'Oréal USA's 15-year purchase agreement was a key financial component of the project that enabled the RNG processing plant at Big Run to move forward. For L'Oréal USA to commit to the long-term purchase, the company needed to have a financially viable proposal. RNG projects typically have high production costs — up to eight times that of natural gas.

To help offset the premium paid for the RNG coming from this project, L'Oréal USA plans to sell the RNG into the transportation fuels market for approximately five years. RNG is eligible to create renewable identification numbers (RINs), the credits used for compliance with U.S. EPA's Renewable Fuel Standard. Since RNG and the associated RINs have a high market value, the income from the sales of RINs make the project economically viable. While selling the RINs, the company will buy carbon offsets from the Seneca Meadows Landfill Gas to Energy project to meet its carbon neutrality goals. The financial structure of using RINS and offsets for the first five years made the investment possible for L'Oréal USA while providing the flexibility needed to get the project off the ground.

Other economic factors that made this project viable include:

- Big Run Landfill has ample renewable natural gas resources to fulfill L'Oréal USA's operational demand requirements. L'Oréal USA will purchase approximately 40 percent of the renewable natural gas produced by the Big Run facility, but can increase the quantity of renewable natural gas purchased over time if needed.
- Since Big Run Landfill can be connected to the natural gas pipeline network, it creates a single solution for all of L'Oréal USA's 19 manufacturing and distribution facilities, eliminating the necessity for individual on-site biodigesters.

OUTCOMES

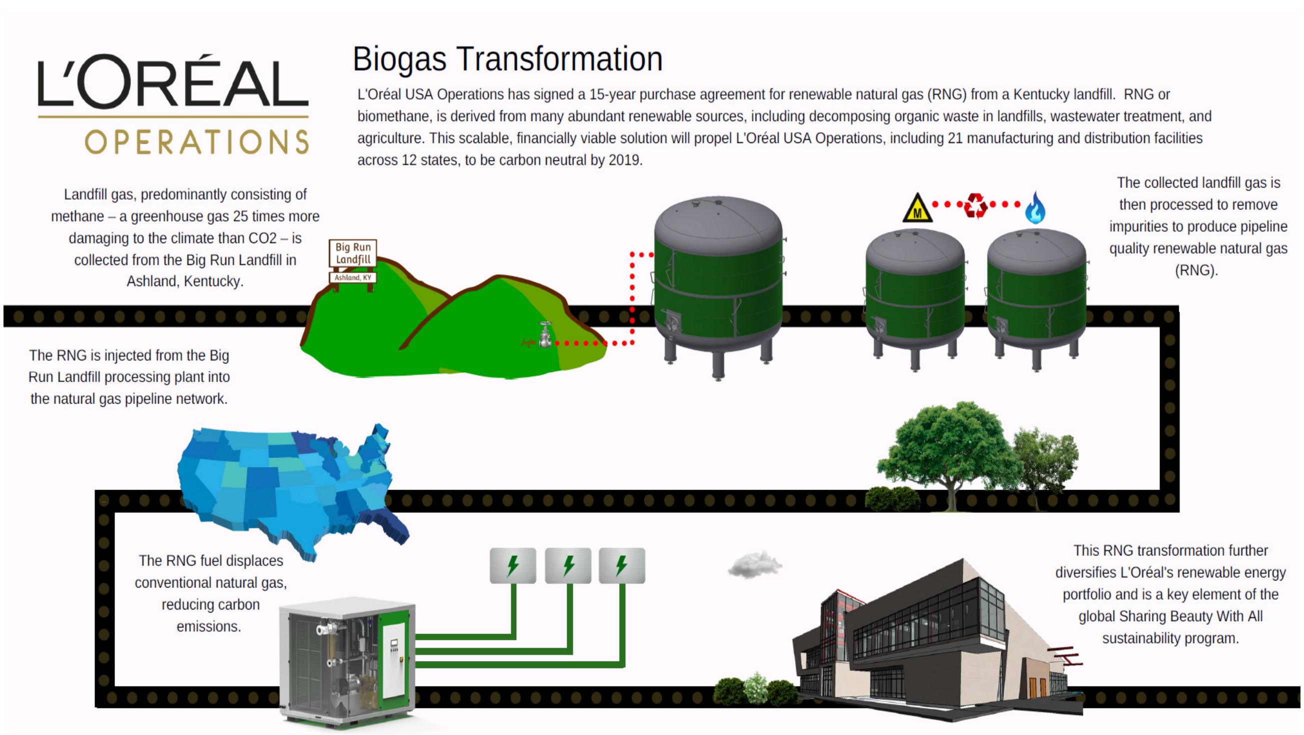
- L'Oréal USA selected a project that would bring additional capacity to the market, and one where its investment was a key underwriting component that led to the financing of the project. This was motivated by the company's desire to support a project that would have a positive and local impact. The project will add approximately 100 construction jobs and seven full-time jobs to the community, which is 140 miles from its plant in Florence, Kentucky.
- This project eliminates L'Oréal USA's Scope 1 carbon dioxide emissions, representing the last 16% of emissions necessary to achieve carbon neutrality.

BARRIERS AND LESSONS LEARNED

- Finding a project that would be financially viable was challenging because natural gas is much less expensive than renewable natural gas. The team had to find a financial structure that would be financially sustainable for the company.
- Addressing Scope 1 and 2 emissions separately allowed L'Oréal USA to be successful in achieving carbon neutrality for its operation facilities. By focusing on Scope 2 emissions initially and achieving 100 percent renewable electricity, the company was able to focus solely on tackling Scope 1 emissions through this project. Solving the Scope 1 issue was more difficult and required a multi-dimensional team of technical, financial, environmental and public policy experts to develop and execute the strategy.

- With the RNG project, the company is also working to address other Scope 1 emissions in the future, including retail, research, and administrative buildings-related emissions. Furthermore, L'Oréal USA is continuing to explore ways it can further reduce its carbon footprint by addressing its Scope 3 emissions associated with transportation.

FIGURE 4: An overview of how the RNG project will work to help L'Oréal USA attain its sustainability goals.



BIOGAS CASE STUDY: MARS INC.

MARS CHOCOLATE POLAND WASTE WATER TREATMENT EXPANSION

OVERVIEW

The Mars Inc. campus in Sochaczew, Poland, produces a variety of chocolate and pet food products. As part of a factory expansion in 2015, Mars decided to incorporate a biogas system into the factory's wastewater treatment plant. By replacing natural gas with a renewable resource, the project enabled the company to reduce costs for electricity, steam, water, and waste. This project helps Mars reduce its total thermal and electricity load from fossil fuels and has provided Mars a foundational framework for future on-site waste-to-energy or waste-to-gas recovery projects. The project also contributes to a company goal of consuming 100 percent fossil fuel free energy by 2040.

PROJECT DESCRIPTION

Mars Inc.'s wastewater treatment plant in Sochaczew, Poland uses biogas recovery from on-site process waste to produce electricity and steam to power its operations. There is also an anaerobic reactor, a combined heat and power (CHP) system, and reverse osmosis capabilities on-site.[15] Food processing waste is used for generating renewable electricity and steam for the factory, while hot water is used for the wastewater treatment plant. The CHP system produces steam at 365 degrees Fahrenheit (12 bar steam), which is supplied to the rest of the factory for process and heating, ventilation, and air conditioning purposes.[16] The plant uses a technology developed by Veolia Environment S.A. (Mars' contractor) known as ANITA Mox Anammox to remove nitrogen from wastewater.

COSTS AND FINANCING

This facility was self financed as a direct investment by Mars. The project anticipated reductions in electricity and water costs of approximately 35 percent, which contributed to this investment decision. In addition, since Mars' pet food factory was located nearby, the economics of the combined facilities resulted in a

FIGURE 5: An aerial view of the Mars Production Campus, which includes the wastewater treatment expansion.

decrease in waste disposal costs by 50 percent and a 40 percent decrease in operating costs. The project had a payback horizon of approximately four years.

OUTCOMES

- Fossil fuel consumption decreased by 34 percent, by 21,000 metric tons of CO_2.
- Electrical energy costs were reduced by 35 percent.
- Steam costs were reduced by 20 percent.
- Water costs were reduced by 36 percent.
- Solid waste production was reduced by 65 percent.

BARRIERS AND LESSONS LEARNED

Mars has gained a new perspective on how to develop renewable energy projects based on this successful experience and has shared best practices with other production facilities using wastewater treatment and biogas. Engineers at Mars regularly collaborate on sharing best practices by working within and across the different product segments of the company, with an ultimate goal of developing a standard template for designing different types of factories.

GEOTHERMAL CASE STUDY: PROCTER & GAMBLE

XIQING GEOTHERMAL

OVERVIEW

Procter and Gamble (P&G) has a goal of sourcing 30 percent renewable energy by 2020 and 100 percent renewable electricity by 2030 for its plants worldwide. The company has been working toward accomplishing that goal by evaluating renewable energy sources at its facilities. In Xiqing, China, P&G discovered a substantial geothermal resource located underneath its facility. Since 2012, the facility has sourced approximately 10 percent of its energy needs from a deep geothermal well. The water extracted from the well is used in both non-contact hot and chilled applications before it is reinjected back into the aquifer below the property. The geothermal project lowers the facility's natural gas and electricity requirements, resulting in more than $1 million dollars in net energy reduction savings. The company now evaluates other survey sites for renewable energy opportunities.

PROJECT DESCRIPTION

The Xiqing Geothermal project is a deep geothermal well owned and operated by the company and located at a P&G plant in Tianjin, China that produces a variety of personal care products. The well is 9,800 feet below ground and extracts water at 176 degrees Fahrenheit. Once brought to the surface, the water is either used in non-contact heat exchangers providing heat to buildings and process operations or chilled via an absorption chiller to create cold water for use in the plant.[17] After the fluid is cooled, it is returned to the reservoir via an injection well.

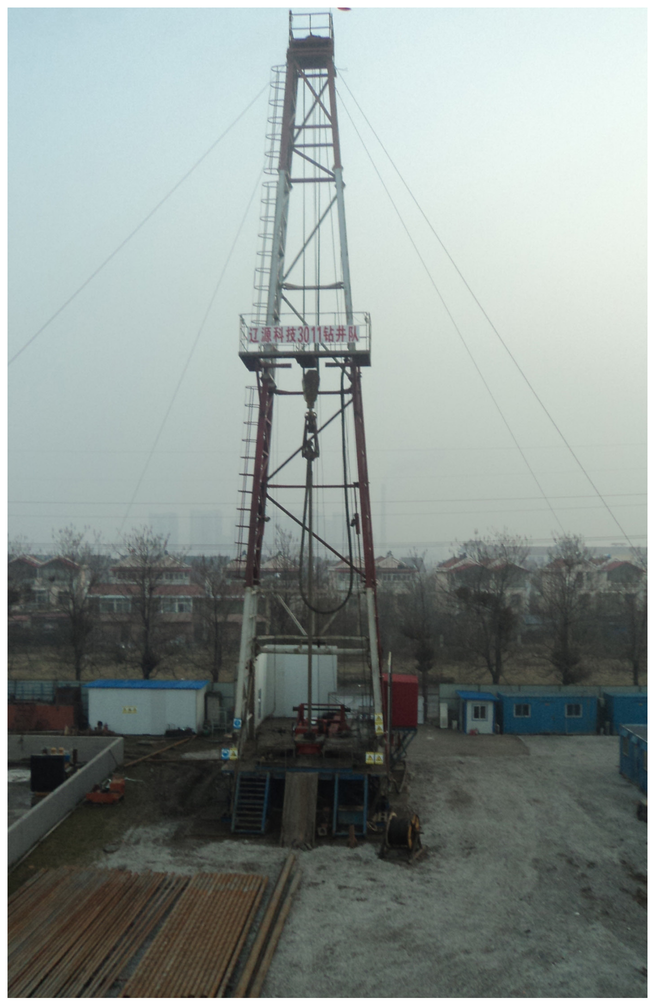
The use of this geothermal well reduced the need for natural gas. The project uses flow and temperature meters at the production and reinjection wells to determine the exact amount of renewable energy that site is harnessing.

COSTS AND FINANCING

This project was self-funded by P&G and used no financial incentives. The local availability of deep well geothermal water was key to the project's success. This vast resource reduced the upfront risk of the project and provided a high probability that drilling a well would return a productive temperature and flows. The project was assessed over a 10-year time horizon and had an internal rate of return 10 points above P&G's normal hurdle.

The well's cost was much lower than industry standards, a result of the local economy and the existing local geothermal industry. P&G confirmed with U.S. geothermal experts that the well's construction would be comparable to U.S. norms and adhere to the company's reliability requirements.

FIGURE 6: The drilling of the geothermal well at the Xiqing facility.



Another market factor that influenced the project's success was the high local price of natural gas, which ranges two to three times higher than U.S. natural gas prices.

OUTCOMES

- Project reduces the load on boilers and provides approximately 10 percent of the site's energy needs.
- Low drilling costs and minimal geophysics work before construction led to an overall rate of return greater than any other renewable energy project at P&G.
- The switch to geothermal energy reduced carbon dioxide emissions by approximately 4,000 metric tons per year.

BARRIERS & LESSONS LEARNED

- P&G needed to drill a reinjection well in addition to the production well so that water could be returned to the geothermal resource after heat was extracted. There are requirements for the distance between these two wells, but fortunately, P&G had enough space on the property to meet these requirements.
- For parties interested in geothermal projects, sampling well water during test drilling and throughout the project helps to foresee potential corrosion issues that may occur from substances like iron building up in the pipeline. In addition, it is recommended to work with a geochemist to design the drilling process, install monitoring and treatment technologies, and implement ongoing corrosion monitoring.
- P&G now surveys sites for renewable energy opportunities and includes inquiries to local and expert consultants to determine if there are thermal springs or geothermal resources nearby to other production facilities that would warrant investigation.

WASTE-TO-STEAM CASE STUDY: GENERAL MOTORS

DETROIT-HAMTRAMCK ASSEMBLY WASTE-TO-STEAM

OVERVIEW

Driven by a goal to reduce carbon intensity by 20 percent from a 2010 baseline by 2020, and to have a positive impact on the local community, General Motors moved away from steam generated from coal and connected its Detroit-Hamtramck Assembly facility to the Detroit Renewable Energy (DRE) plant. DRE operates a waste-to-steam project, where waste products from the City of Detroit are converted to steam. The steam produced is used for heating and cooling applications at the General Motors facility. Since switching to renewable thermal, the company saves approximately $800,000 per year in operation and maintenance costs while reducing 72,580 metric tons of carbon dioxide equivalent annually.

PROJECT DESCRIPTION

The Detroit-Hamtramck Assembly Waste-to-Steam facility is located in Detroit, Michigan. The DRE power plant is located very close to General Motors' facility, but 8,300 feet of pipeline had to be installed to connect the facilities. 58 percent of the Detroit-Hamtramck facility is powered by renewable energy from DRE's steam, which is used to heat and cool portions of the assembly plant. The delivered working temperature of the facility is 396 degrees Fahrenheit and 17 bar of saturated steam [18] is produced. General Motors has a 15-year energy purchase contract with DRE, with potential for renewal in the future should the economics continue to be positive.

There are uses for the steam depending on the season. In the summer, steam is used to power steam condensing turbine chillers. [19] In the chillers, pressure is reduced from 245 pounds to 35 pounds, which reduces available heat and allows two percent of the available energy from steam to flow into a backpressure turbine. This pressure reduction drives a compressor which then results in the generation of approximately one megawatt of power. In the winter, when there is demand for steam at 35 pounds, the compressor turbine is used. Steam enters the compressor turbine at 245 pounds and the backpressure turbine exhausts the 35 pound steam, which then gets sent to the rest of the facility.[20]

FIGURE 7: The Detroit-Hamtramck Assembly Facility.

The provision of steam from DRE's waste-to-energy facility allowed General Motors to shut down its onsite steam generator, previously run on coal. To ensure production would not be compromised in the event there was a disruption in steam delivery, there is a natural gas boiler for backup. This backup option provided General Motors the necessary security to shut down the coal-fired boilers. Additionally, DRE has a backup boiler that can serve General Motors from another facility.

COSTS AND FINANCING

General Motors needed to phase out the use of coal as a result of the U.S. Environmental Protection's Agency's boiler maximum achievable control technology rule. General Motors had the option of either investing in the capital to switch from coal to natural gas-fired boilers or enter a contract with DRE for steam. General Motors found the business case for installing a steam line extension to be most cost effective, while also providing environmental benefits to the local community. Such benefits included cleaner air from shutting down the coal boilers and reduced truck traffic since coal deliveries and ash pickups would no longer be required. Other benefits to General Motors include the avoided cost of capital, since DRE used various funding sources to provide General Motors a solution that was lower in cost than if General Motors invested its own capital. By avoiding the cost of capital on this project, General Motors refocused that capital to other parts of the company.

DRE used tax-exempt financing that was available to specialized industries like the renewable energy sector from the Michigan Strategic Fund. The proximity of General Motors' plant to DRE and availability of some existing steam line infrastructure made the project appealing, since minimal infrastructure was needed to tie a new steam line with the existing one.

OUTCOMES

- As a cogeneration facility, the renewable energy certificates associated with the project go to the utility provider, DTE.
- Reduces the Detroit-Hamtramck Assembly plant's carbon emissions by 72,580 metric tons of carbon dioxide equivalent annually due to the switch from coal.
- Anticipated savings of $800,000 per year in operations and maintenance.

BARRIERS AND LESSONS LEARNED

- One major hurdle DRE encountered was obtaining the Michigan Department of Transportation permit to install steam pipe under the Interstate-94 highway due to the underground utility interference in the public right-of-way. The permit required DRE to install the steam pipe in a very deep location, which led to groundwater challenges. DRE had to change from open cutting in the street to a jack and bore operation to navigate around a number of utilities, including a concrete sewer line. Additionally, soil conditions on General Motors' property led to design changes that increased the cost of the pipe support stanchions.
- Contract negotiations associated with entering a long-term contract for steam raised questions, but those concerns were overridden given the strong business case. Emphasizing the community, public and environmental health benefits of the project also helped support the long-term contract.
- State incentives for tax-exempt financing were very helpful to bringing the costs of projects down and making it financially viable.
- Stakeholder groups presented concerns about using waste-to-energy, especially as the Detroit-Hamtramck and DRE facilities are located in a low-income area. However, General Motors addressed the response by engaging with the community and outside groups to discuss concerns and present the project's community and environmental benefits, including reduced traffic, eliminated risks of coal ash, and improved air quality.

CONCLUSION

These case studies, while all unique to solving each organization's specific needs, provide some understanding of the potential benefits and challenges when considering different renewable heating and cooling technologies. Table 1 provides an overview of some of the operational drivers, benefits and financing options used by each of the organizations profiled.

Investment decisions were made for a variety of reasons for each of the projects showcased. However, each organization has clearly established sustainability goals that supported a renewable approach. In addition, high and volatile fossil fuel costs often drove companies toward renewable solutions. In other cases, such as the General Motors plant, environmental regulations required the phase-out of older capital investments and offered the company an opportunity to review renewable options for their heating and cooling needs.

In each of the case studies, significant cost and emissions savings were generated by the investments. Most projects were self-financed and achieved their expected return on investment. The city of Philadelphia used a public-private partnership to allow for the use of a federal tax credit, while also derisking some of the operational aspects of the project for the city.

One technology that faces more economic barriers are renewable natural gas (RNG) projects in the United States due to low domestic natural gas prices. L'Oreal USA found a unique solution to this problem by using renewable identification number (RIN) credits to help pay for the investment. However, it is unlikely that the RIN market would support a large-scale, long-term buildout of other RNG projects across the United States, so broader federal incentives may be needed to help support RNG over the long term. The introduction of a thermal renewable energy certificate (tREC) could also make tracking and claims easier and more standardized for these types of projects. Biogas faces fewer barriers since it is often developed from an existing waste stream and does not need to have as many impurities removed.

Another common theme shared by the case studies was the availability of a local resource. This makes the projects more difficult to replicate since local circumstances can greatly vary the project economics or viability of a certain technology for a given application. However, facilities co-located with each other may still offer a possibility for a project to be developed if the renewable thermal potential and adequate infrastructure exists.

The goal of the Renewable Thermal Collaborative is to raise awareness and build greater supply and demand for renewable thermal options. Increasing the availability and cost competitiveness of these solutions is key to deploying them at scale. With greater scale, more organizations in the industrial and commercial sectors will be able to make dramatic cuts in their carbon emissions.

TABLE 1: Summary of Renewable Thermal Projects

PROJECT	RENEWABLE RESOURCE USED	SOURCE OF AVOIDED EMISSIONS	USE	STEAM TEMPERATURE*	EMISSIONS REDUCTION	FINANCING AND INCENTIVES USED	ALIGNMENT WITH SUSTAINABILITY GOALS
Cargill: Uberlandia	Biomass	Fuel oil	Steam boiler	950* /65 bar steam	67,000 MT CO_2/year	Self-financed	Source 18 percent renewable energy by 2020
City of Philadelphia: Northeast Water Pollution Control Plant	Biogas	Flared biogas	CHP system	180	20,000 MT CO_2e/year	Public-private lease agreement; Federal tax credits under the American Recovery and Reinvestment Act and a utility rebate	Generate or source 100 percent renewable energy by 2030
L'Oréal USA: Kentucky Renewable Natural Gas Purchase Agreement	Renewable Natural Gas	Natural gas	Pipeline-quality renewable natural gas	N/A	16 percent reduction in Scope 1 CO_2e/year	Self-financed; Renewable Identification Number credits used to pay off the investment	Make US manufacturing and distribution facilities carbon neutral by 2019 and to decrease carbon emissions for manufacturing and distribution facilities by 60 percent by 2020
Mars Inc.: Mars Chocolate Poland Waste Water Treatment Expansion	Biogas and Waste-to-Steam	Natural gas	CHP system	365 /12 bar steam	21,000 MT CO_2	Self-financed	Ensure 100 percent of energy consumption will be fossil-fuel free by 2040
Procter & Gamble: Xiqing Geothermal	Geothermal	Natural gas/ grid electricity	Boiler and absorption chiller	176	4,000 MT CO_2/year	Self-financed	Source 30 percent renewable energy by 2020, 100 percent renewable energy by 2030
General Motors: Detroit-Hamtramck Assembly Facility	Waste-to-steam	Coal	Steam turbine chiller and compressor turbine	396 / 17 bar saturated steam	72,580 MT CO_2e/year	Tax exempt financing from the Michigan Strategic Fund	Reduce carbon intensity by 20 percent from 2010 levels by 2020

*degrees Fahrenheit

GLOSSARY OF TERMS

Bar—a unit of measurement for atmospheric air pressure, equivalent to 100,000 Pascals

Chiller—a system using a refrigerant within an evaporator to absorb heat from water in order to cool the water[21]

Combined heat and power (CHP)—also known as cogeneration, it can be: 1) a single source of energy used to produce both electricity (or mechanical power) and thermal energy; 2) a type of distributed generation where the generation source is located near its point of consumption; 3) a collection of technologies that produce electricity and allows for excess heat to be used elsewhere[22]

Compressor—a device that draws air in and then pressurizes it[23]

Reverse osmosis—a water treatment process where water is forced through a membrane in order to sort out molecules larger than the porous openings in the membrane[24]

Scope 1 emissions—direct greenhouse gas emissions from an organization's emitting source[25]

Scope 2 emissions—indirect greenhouse gas emissions from the purchased electricity used to power the emitting source

Scope 3 emissions—all other indirect greenhouse gas emissions from sources not owned or directly controlled by an organization

Source energy—the total amount of raw fuel required to operate a system and incorporates all transmission, delivery, and production losses[26]

Saturated steam—steam that exists when the rate of water vaporization is the same as the rate of condensation, also known as dry steam

Superheated steam—steam at a temperature greater than its boiling point at the absolute pressure of the steam

ENDNOTES

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10 See Glossary of Terms

11 See Glossary of Terms

12 See Glossary of Terms

13 L’Oréal’s environmental footprint includes carbon emissions, waste, and water use.

14 See Glossary of Terms

15 See Glossary of Terms

16 See Glossary of Terms

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ABOUT THE RENEWABLE THERMAL COLLABORATIVE

The Renewable Thermal Collaborative (RTC) serves as the leading coalition for organizations that are committed to scaling up renewable heating and cooling at their facilities and dramatically cutting carbon emissions. RTC members recognize the growing demand and necessity for renewable heating and cooling and the urgent need to meet this demand in a manner that delivers sustainable, cost-competitive options at scale.

As a coalition, the RTC offers value to members by providing “power in numbers.” The RTC is the only place to focus on renewable heating and cooling and where large thermal energy users come together collaboratively to understand the problems in the market, learn from each other, and overcome these barriers to renewable heating and cooling. The RTC offers an implementation-focused, collaborative platform operating under the umbrella of the Renewable Energy Buyers Alliance (REBA) to advance the needs of manufacturers and state and local governments to tackle barriers to renewable thermal energy.

The Renewable Thermal Collaborative is facilitated by the Center for Climate and Energy Solutions, David Gardiner and Associates, and World Wildlife Fund.

For additional resources by the RTC, please visit www.renewablethermal.org.

The Center for Climate and Energy Solutions (C2ES) is an independent, nonpartisan, nonprofit organization working to forge practical solutions to climate change. We advance strong policy and action to reduce greenhouse gas emissions, promote clean energy, and strengthen resilience to climate impacts.

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