UNIVERSITY of HOUSTON
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TIEEP

TEXAS INDUSTRIAL ENERGY
EFFICIENCY PROGRAM

Newsletter Volume 1, Number 3, July 2020

Greetings, from the Texas Industrial Energy Efficiency Program!

Upcoming TIEEP Events

August 20, 1:30-4:00 pm: Clean Energy and Efficiency for US Gulf Coast Industry – TIEEP Sessions at Virtual AIChE Spring Meeting

October 1: Fall Energy Forum, at Virtual AIChE Southwest Process Technology Conference

A lot has happened since our last newsletter. This includes our ERCOT Electric Prices webinar in February, our Spring Energy Forum, our May Water Forum – and lots of Zoom meetings! Next up on the TIEEP agenda is our double session on Clean Energy and Efficiency for US Gulf Coast Industry at the Virtual AIChE Spring Meeting on August 20. Our sessions are described in the ***Program Highlight*** on page 2. To participate in real-time you will have to register for the conference, which you can do here. If you can't make it to the conference, we plan to retain copies of slides in the archive on the TIEEP website.

Our next Energy Forum will be at the Virtual AIChE Southwest Process Technology Conference, on October 1. Our topic is cogeneration. ***From the Casebook*** at the end of this newsletter provides an introduction to this topic – with an unusual case study.

Program Highlight: Clean Energy & Efficiency for US Gulf Coast Industry

The American Institute of Chemical Engineers (AIChE) was due to hold their Spring Meeting in Houston in April 2020. That turned out to be bad timing, as we all now know. However, with the prospect of such an important gathering of industry specialists in our own backyard, TIEEP and AIChE planned to use the opportunity to showcase some of the positive things that are happening in industrial energy use in our region. The result was programing for two sessions on "**Clean Energy & Efficiency for US Gulf Coast Industry**."

The AIChE Spring Meeting has been delayed and reconfigured as a virtual meeting, and our two sessions are now rescheduled – online, and with a few modifications – for the afternoon of Thursday, August 20. Here is an overview of the program:

The US Gulf Coast states, and especially Texas and Louisiana, are home to many large, energy intensive industrial complexes - especially oil refineries and chemical plants. Reducing both energy consumption and gaseous emissions is a priority for the industry and the region. These sessions explore the clean energy future of the industry - the business imperative, some recent achievements, and new opportunities.

1:30-1:50: **Ajay Mehta/Joe Powell,** Shell: **Thriving amidst the Energy Transition in the US Gulf Coast: A Shell Perspective**

The world's energy system is in the midst of a fundamental and disruptive transition that will have a direct on impact how energy is produced, processed, transmitted, distributed and consumed. The energy mix of the future will see a substantial penetration of renewables generated from solar, wind, biomass and other natural sources. Conventional oil and gas will remain part of the energy mix but with a relatively lower share and a sharper focus on its generating it at the lowest possible CO2 footprint. Electrification of demand will also play out over the course of the coming decades. This presentation will provide a perspective on how Shell has positioned itself to thrive in the energy transition, especially with respect to its current and planned future operations in the US Gulf Coast. It will also discuss the role of technology in shaping near-term projects such as integrated solar PV and offshore wind, mid-term projects in hydrogen, biofuels, and energy systems integration and storage, and long-term projects designed to make synthetic fuels, utility scale storage systems, and the use of natural gas as an advantaged feedstock to make energy products. The presentation will tie all of the above together and demonstrate that it is possible to provide the world with more and cleaner energy.


Photo Courtesy Alan Rossiter

1:50-2:10: **Brett Perlman,** Center for Houston's Future: **Accelerating the Role of Houston's Energy Industry in the Low Carbon Future**

Center for Houston's Future interviewed stakeholders representing over 30 energy companies, academic institutions and other parties. We also heard presentations by 40 participants at our June 2019 Low-Carbon Energy Summit. Our research shows Houston is uniquely positioned to play a major role in leading the world to a low-carbon energy future and that significant work is underway here to prepare for that future. The size and scale of Houston's energy sector and its deep energy expertise, resources and access to capital all argue that Houston could become the world's Low-Carbon Energy Capital. We also concluded that much more work is needed to unlock this potential. Current initiatives aren't coordinated, lack a coherent vision and plan, and are missing opportunities. The pace of change isn't fast enough to hit a 2°C global carbon emissions pathway by mid-century.

A more substantial effort is required to accelerate progress on two complementary dimensions: Reducing the region's carbon footprint (industrial operations alone account for ~ 1.5% of total U.S. CO_2 emission) and leveraging Houston's substantial competitive advantages in expertise, capital and scale to develop low-carbon energy solutions that can be sold globally. Working with energy stakeholders, we plan to create a coalition to act as a regional coordinating force and to catalyze activities needed for Houston to lead in a low-carbon future. We have identified a series of projects that the Center and/or the coalition should undertake. A sample includes a regional abatement cost curve and setting regional carbon reduction goal, as well as work on carbon recycling and utilization, and hydrogen deployment. We also propose work on creating an innovation hub for low-carbon technologies requiring chemical/process engineering at scale (green chemistry) and on spurring creation of and demand for low-carbon cement, plastics and new transportations fuels.

2:10-2:30: **Carlos Gamarra,** HARC: **Industrial Waste Heat to Power Applications and Market Trends**

Waste Heat to Power (WHP), the process of recovering waste heat and using it to generate power, continues to grow in popularity. Recent industry reports indicate high growth expectations for this market over the next five years. Much of this growth is coming from improvements in waste heat capture and utilization applications and technologies. Further drivers include a growing focus on reducing operation and maintenance expense, the need to mitigate greenhouse gas (GHG) emissions, and a growing need for on-site resilient power systems.

This presentation will introduce the audience to WHP technologies, applications, and market trends in the industrial field. It will also introduce technical assistance resources that are available to end-users looking to deploy WHP at their site. Subsequent presentations will discuss case studies of successful WHP projects, in the USGC and other regions, together with best practices and lessons learned.

2:30-3:00: **Session Break**

3:00-3:20: **Loy Sneary**, Gulf Coast Green Energy: **Three Green Projects from a Gulf Coast Company**

This presentation describes three fuel- and emissions-free waste heat-to-power industry solutions developed by Gulf Coast Green Energy, Bay City, Texas. These include fuel efficiencies for large engines, process fluid cooling, and using flare gas for a beneficial use (making power). All three applications use wasted heat to produce on-site power. This can dramatically reduce emissions and power costs.

The examples include:

- a successful Dept. of Defense funded project to reduce emissions through reduced fuel consumption in large engines;
- a successful flare reduction trial on a Hess Corp. North Dakota well pad.[§]
- an overview of power from produced water.

The presentation will include an overview of the projects from design to installation/commissioning, and through the successful sustained operations.

[§] This project was funded by the Houston Advanced Research Center (HARC) and its Environmentally Friendly Drilling Systems (EFD), the U.S. Dept. of Energy, and Hess Corp.

Power from engine waste heat, DOD/Guantanamo Bay, Cuba.
Photo Courtesy Gulf Coast Clean Energy

3:20-3:40: **Ray Deyoe**, Integral Power, LLC: **Large Scale Industrial Waste Heat-to-Power/Cogeneration: A Case Study**

The benefits and challenges of a large scale industrial waste heat-to-power/cogeneration facility are presented in this case study of the Port Arthur Steam Energy Project. The project recovers 2000^{o}F flue gas energy from a petroleum coke calcining plant and converts it to 350,000 lb/hr of steam and 5MW power which are provided to a neighboring refinery, the host plant and the utility grid. The project is a great example of industrial cooperation and energy efficiency, with the capability of offsetting 159,000 tons CO2 annually.


Photo Courtesy Integral Power, LLC

It may not be pretty – but this turbine-generator set delivers 5 MW and offsets 159,000 ton/yr of CO2.

3:40-4:00: **Laurent Thomas,** Shell: **Options for Carbon Capture from Refineries / Chemical Sites SMR**

IPCC's special report on the impact of 1.5C warming concludes that "early scale-up of industry CCS is essential to achieve the stringent temperature target". CCUS technologies (Carbon Capture and Utilization or Sequestration) are especially of interest for hydrogen production units, which emit significant amounts of CO2 and offer several options to capture this CO2 from otherwise clean gases, such as Pressure Swing Adsorption (PSA) feed gas, PSA purge gas, or Steam Methane Reformer (SMR) furnace exhaust gas. Hydrogen manufacturing units are thus likely to be among the first sources of CO2 that refiners and chemical sites in USGC will look at to reduce their carbon footprint.

Amine-based absorption systems offer a proven, reliable and cost-effective method to capture CO2 from the different SMR gas streams. While the SMR syngas (outlet of shift reactor after heat recovery), characterized by a high CO2 partial pressure, presents the opportunity to capture CO2 at the lowest unit cost ($/tCO2), post-combustion (furnace exhaust) capture maximizes the amount of CO2 captured. Both have been proven at large scale; in particular capture from the high pressure syngas has been successfully applied at the Scotford refinery (Alberta), where the Quest project, using the ADIP-X technology, has already captured and sequestered more than four million tons of CO2 and generated valuable learnings for replication in future SMR CCUS projects.

The presentation will discuss the relative merits and costs of both options, and in particular how integration with an industrial gas SMR located at USGC site can help provide the energy required for absorbent regeneration, which is around 2 GJ/ton of CO2, and for 1,000 KTA CO2 capture unit results in a LPS steam requirement of approximately 110 tonne/hr.

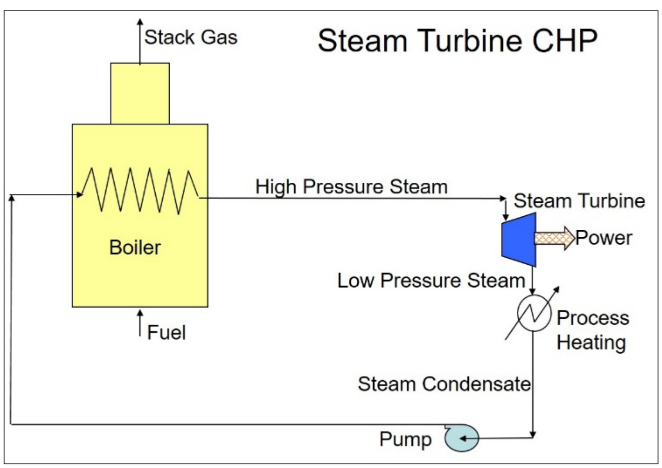
From the Casebook: Cogeneration

Cogeneration is the sequential production of two distinct forms of useful energy from a single primary energy source. Most often, the two different forms of energy are heat and power (i.e., "combined heat and power" or "**CHP**"). In large-scale industrial applications, the heat is typically delivered in steam, and the power is generally produced in either a gas turbine or a steam turbine. The shaft power from the turbine is then either delivered directly to a pump or a compressor, or else converted to electricity.

Most power in the USA is derived from heat engines (e.g., gas turbines, steam turbines, and internal combustion engines) that use fossil fuels and operate in a cycle. These devices are subject to one of the most fundamental principles of physics – the Second Law of Thermodynamics. For our purposes, the simplest statement this law can be stated thus: "Cyclical heat engines can never convert all of the incoming heat to power – they always reject some of it." In other words, the generation of power from heat is inherently inefficient. Raising the temperature of the hot portion of the cycle, and lowering the temperature of the cold portion, can improve the efficiency; but for any given hot and cold temperatures, the efficiency can never be greater than that of an ideal "Carnot cycle" operating between the same temperatures. This is quantified in the equation for Carnot efficiency (η):

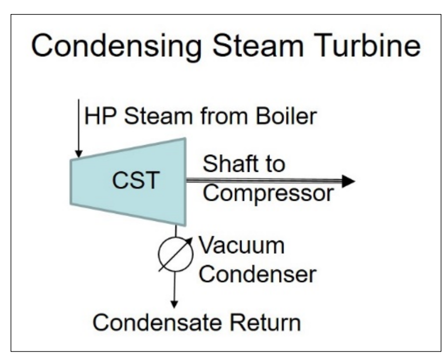
$$\eta = 1 - T_c/T_h$$

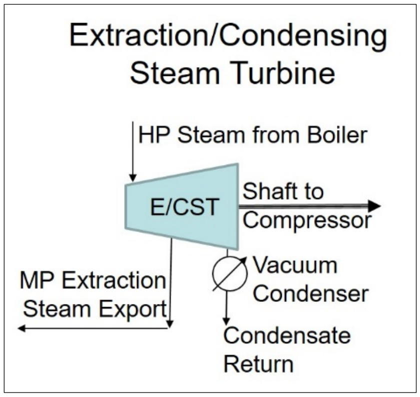
The beauty of the equation is its remarkable simplicity. η depends on just two things – T_h, which is the inlet (hot) temperature, and T_c, which is the exhaust (cold) temperature. T_h and T_c are both assumed to be constant, and they are expressed as absolute temperatures, in either the Kelvin or Rankine scale.



Commercial gas turbines and steam turbines typically reject at least 60% of their incoming heat, so their stand-alone energy efficiency is less than 40%. However, if the exhaust is hot enough, its heat can be recovered for process heating, or for other purposes. In such arrangements, it is sometimes possible to make beneficial use of 80% or more of the primary energy, so the overall energy efficiency – including both useful power output and useful heat output – can be 80% or higher. Steam turbine CHP (illustrated in the figure) is one of the simplest – and most common – configurations. It is found in many oil refineries and chemical plants.

Implementation of new cogeneration projects can be challenging – and many of the challenges are not technical. A number of years ago, I was on the design team for a major hydrocarbon facility. The preliminary design included a large (20 MW) compressor, driven by a **condensing steam turbine**. The steam entered at high pressure (HP), and exhausted below atmospheric pressure, at 3.7 psia (7.5 in Hg). The exhaust steam, at 150°F, was not hot enough to be used beneficially, so it went to a water-cooled condenser, and the heat was rejected to ambient through the cooling water system.





An adjacent plant consumed 100,000 lb/h of medium pressure (MP) steam, which was obtained by passing steam from the HP header through a letdown valve. I saw an opportunity for cogeneration: Replace the condensing steam turbine with an **extraction/condensing turbine**. In this design, all of the steam passes through the front-end of the turbine, after which 100,000 lb/h is withdrawn through the extraction port at medium pressure, for export to the adjacent plant. The remaining steam passes through the back-end of the turbine, and then goes at 3.7 psia to the condenser. The portion of the steam that passes through the extraction port is used sequentially to produce power in the turbine, and then to deliver heat to the adjacent plant, which constitutes cogeneration. The design change reduces both the condenser duty and the overall steam requirement, saving the site more than $1,500,000/year.

Several years later, I returned to the plant with a team to conduct a site-wide energy assessment. We found that they were still producing large amounts of MP steam from HP steam with the letdown valve, and I assumed they must have decided against my extraction turbine recommendation. Not so! The machine had been installed, but the operators didn't know how to operate the extraction port. Consequently, the turbine was running in condenser-only mode. Simply installing the extraction/condensing turbine was not sufficient; operator training was also required. After the assessment, the operators were trained, the extraction port was commissioned, and the site was able to benefit from this cogeneration opportunity.

Adapted from: *Double Up on Cogeneration*, Alan Rossiter, Chemical Processing, Vol. 82, No. 5, p. 12, May 2020.

In Closing…

Thank you for taking the time to read along with us. We hope you found the information useful, and that you'll join us in our upcoming events.

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