Report on the

Technology Forum: Low Temperature Waste Energy Recovery in Chemical Plants and Refineries

Held May 16, 2012 in Houston, TX

Prepared by Texas Industries of the Future
Kathey Ferland
Project Manager

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A project of The University of Texas at Austin Center for Energy and Environmental Resources
10100 Burnet Rd. – CEER R7100
Voice: 512-232-4823 - Fax: 512-471-1720
kferland@mail.utexas.edu
http://texasiof.ces.utexas.edu

Background

Recovery of low temperature waste energy is the holy grail of industrial energy efficiency. In general, the chemical and refining industries have successfully recovered the energy from streams above approximately 400 °F. The Texas Industries of the Future Chemical and Refining Sectors Advisory Committee identified the need for a better understanding of the technologies available to recover energy from streams that are below 400 °F. A Technology Forum was held on May 16, 2012 in Houston, Texas, to address this issue. Texas IOF organized the event with the sponsorship of the Institute for Industrial Productivity.

The purpose of the Technology Forum was to accelerate the adoption of waste energy recovery technologies by:

- Educating end-users on the technologies available for low temperature waste energy recovery, and
- Educating technology developers on the potential market and needs at chemical plants and refineries.

Forty attendees from 17 chemical and refining companies, 5 technology developers, and 7 interested organizations attended the "Technology Forum: Low Temperature Waste Energy Recovery at Chemical Plants and Refineries" held at Brady's Landing in Houston, Texas. Table 1 lists the organizations participating in the Technology Forum. During the morning session, attendees from industry characterized their waste energy streams. The notes from this discussion are found in Appendix 1. There clearly is a significant opportunity for energy recovery below 400 °F at both refineries and chemical plants. However, it was also clear that at today's energy prices in the US, there was not a strong economic driver for recovery of low temperature heat to generate power in the US. Some end-users were familiar with the organic rankine cycle technology, which was developed for geothermal

Table 1: Participating Organizations

BASF Corporation
Braskem
Chevron Phillips Chemical Company LP
CITGO
Eastman Chemical Company
Energy Concepts Company
ExxonMobil Chemical Company
FuelCell Energy, Inc.
GE Oil &Gas
Goodyear Tire and Rubber
Houston Advanced Research Center
Hudson Technologies
Huntsman Chemical
Idaho National Laboratory
Institute for Industrial Productivity
Integral Power, LLC
LyondellBasell
Ormat Technologies, Inc.
Phillips 66
PPG
Sasol North America Inc.
Shell
SI Group
Texas State Energy Conservation Office
TAS Energy
Tesoro Refining & Marketing
Texas A&M University
Texas Industries of the Future
The Dow Chemical Co.
Total Petrochemicals and Refining USA, INC

Table 2:
High Priority Interest Areas
(Based on Attendee Voting)

Identifying Opportunities
- Increase site awareness of energy opportunities

Tools and Analysis
- A better guide to know which technology to apply in each waste heat recovery application

Improving the Economics
- Capital costs need to be reduced to make recovery economical especially for retrofits.

Research
- Further develop hydrogen purification and delivery process
- Support application development for CHHP for petro-chem. industry
- Integrate hybrid system. ORC + fuel cell for higher benefits
- Identify best solution for large mass flow < 200 °F

Policy
- Environmental requirements can be an impediment to project execution.

power production. Prior to the Forum, end-users had less familiarity with the absorption chilling or fuel cell technologies.

Technology developers of organic rankine cycle, absorption chilling, and fuel cells presented a 10 minute overview of their technology, its capabilities, similar installations and costs. All of the Forum presentations are posted at https://TexasIOF.ces.utexas.edu under "Documents and Presentations".

Throughout the day, attendees were asked to record ideas for next steps. These were collected and prioritized by attendees at the end of the day. Table 2 lists the highest priority actions, based on the attendees' input via voting. Appendix 2 contains a complete list of the results from the idea generation and prioritization process.

Results

An electronic survey of attendees after the Technology Forum determined that end-users were interested in following up on all technologies presented. (Due to a last minute scheduling conflict, speakers on the Kalina Cycle were not able to attend, although their presentation is posted on the website.)

Eighteen of the 40 attendees responded to the electronic survey. Of the 18, almost three-quarters (13 of 18) were from chemical or refining companies. Table 3 shown on the next page reports the responses to the technology follow-up question. The number of responses to this question totals greater than 13 as respondents were not limited to only one response.

Seven respondents expressed an interest in following up on the organic rankine cycle and the fuel cell technologies, respectively. Four respondents were interested in further information on absorption chilling and two had interest in chilled water. Only two of the 13 respondents reported that they were not going to follow up on any technologies presented at the Forum.

**Table 3: Response on Technology Follow-up Question
By End-Users**

Based on what you learned at the Forum, which technologies were you most interested in following up on:		
Answer Options	**Response Percent**	**Response Count**
Organic rankine cycle	53.8%	7
Absorption chilling	30.8%	4
Chilled water	15.4%	2
Kalina cycle	0.0%	0
Fuel cell	53.8%	7
Other waste heat recovery not listed above	0.0%	0
Not following up on any	15.4%	2
	answered question	13

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Appendix 1: Notes on Waste Energy Streams

A project of The University of Texas at Austin Center for Energy and Environmental Resources
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Low Temperature Waste Energy Recovery Stream Characterization by End-Users--May 16, 2012

Industry	Process or Flue Gas or Utilities	Liquid, Gas or Either	Temp. (in F)	Opportunities	Other Comments
Chemical	Stack Gas	G	300	Opportunity in Fired Heaters with stack around 300F	
Refineries	Utilities	either	300		Opportunities in Steam Leaks - Numerous leaks which are continuous
Chemical	Stack Gas	G	350	Opportunities in Stack Gas from thermal oxidizers with a temperature of 350F	steam condensate opportunities
Refineries & Chemicals	Process	L		Opportunities in recovering heat from excess quench Water; Heat pumps for installation towers , Exothermic - excess heat, acetic acid, metallurgy issues	
Refineries	Stack Gas	G	300 - 400	Firing rate - 50MMBtus to 200 MMBtus , relatively clean stack gases - 300 F to 400F stack gases	
Refineries	Process	L	180-220	Opportunities in process streams around 180 - 220F	Small for liquid and most of it actual product streams
Chemicals	Utilities	either	180-300		Utilities, Boilers - Regulatory issues need to be eased
Chemicals	Stack Gas	G	400	Process heaters	Boilers and Gas Turbines (GE Frame 7)
Refineries	Process	G		Opportunity in Overhead Condensers which is the target	Stack gas heat capacity not enough
Refineries	Process	L		Possible rundown stream Opportunities too	
Chemicals	Stack Gas	G	400-500	Reduced energy cost $20Million/yr, more energy in stack gas wasted	
Chemicals	Utilities	G			duplicate boiler operations, interested in quick startup units
Refineries	Stack Gases	G	350-450	Fired heaters and cracker units; have identified projects already and step by step implementation is being performed	
Refineries	Process	L	350-450	Run-down and product streams; have identified projects already and step by step implementation is being performed	
Chemicals	Stack gas	G	300-350	Opportunities in several stack gases, 1) Several NG Fired Furnaces at 350 - 400 F Stack, 2) Corrosive gases in the 400F range that are pressurized at 50 psig range, used to generate 15 psig steam	Burn coal, distillation column overheads, identified opportunities but no economic justification

Industry	Process or Flue Gas or Utilities	Liquid, Gas or Either	Temp. (in F)	Opportunities	Other Comments
Refineries	Process	either	235	40MMBtus Hexane goes to finfans - 235 F streams - 15 psig stream	Roughly saved $40Million all over, distillation columns
Refineries	Utilities	Either	300		Steam Leaks - Low pressure steam, excess low pressure steam @ 30-40psig range
Chemicals	Utilities	L			Opportunities in steam condensate - Current condition not recovered.
Chemicals	Stack gas	G		Opportunities in Steam crackers which are very high energy intensive process, Current condition - capture energy only in higher levels still possibility for low level heat capture.	Reaction processes - exothermic - produce LP steam for the finfan
Chemicals	Stack Gas	G		Opportunities in steam crackers totally 8 of them, furnace stack, boilers, Gas turbine, cooling towers, Current Condition - They do small projects like preheat air, preheat water but not entered the big players	Hard to justify the return for ORC - Economics not justified
Refineries	Stack gas and P	G & L	250	Opportunities to capture energy in steam letdown, cutoff point for recovery - 250F rundown temperatures, Capturing stack gas heat maybe an opportunity	Recovering heat back into the process as opposed to WHR, capture of stack gas heat
Refineries & Chemicals					Really Interested to know the Coefficient of performance of both Absorption and ORC technologies
Chemicals	Stack gases		400-450		Smaller Heaters, Economy of scale
					Liquid streams always better, heat transfer coefficient better , regulatory environment is an issue
					Mass Transfer & Liquid Seperation

Appendix 2: Results from Idea Generation and Prioritization Process

Technology Forum:
Low Temperature Waste Energy Recovery in Chemical Plants and Refineries
May 16, 2012

Compilation of Results from Project Identification and Prioritization Session

Tools and Analysis

- Software tool for fast overview economic analysis of project – 4 dots
- Cataloging of industrial waste heat sources (m, T, metallurgy, distances, etc.) – 1 dot
- Create a database of technologies by criteria – 0 dots
- I need a better guide to know which technology to apply in each W.H. application – 9 dots
  - Develop list of criteria for technology. – 1 dot
  - User screening tool to map heat source to applicable technology – 2 dots

Improving the Economics

- Capital costs need to be reduced to make recovery economical, especially for retrofits – 11 dots
- Reduce investment ($/KW installed capacity) – 4 dots
- If electricity costs are key factor, what is solution? Higher conversion efficiency or make a higher value product ? 0 dots
- How to account for ancillary economic benefits from waste heat recovery--0 dots

Policy

Incentives and Rebates

- State incentives – 0 dots
- Rebates? Incentives? – 1 dot

Regulatory Barriers

- Work with regulatory body to allow proj.- 3 dots
- Environmental laws can get in way – 8 dots

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- Remove regulatory hurdles – 1 dot

Policy

- Government encourage energy recovery reorganizing waste heat as renewable – 5 dots
- Create further policy changes supporting H2 – 0 dots

Example industrial projects – 1 dot

Research

- Further develop H2 purification and delivery process – 8 dots
- Support application development for CHHP for petro-chem. industry – 10 dots
- Integrated hybrid system. ORC + fuel cell for higher benefits – 5 dots
- Better heat exchangers – 0 dot
- Conduct demo projects – 2 dots
- Integration of research into operations – 4 dots
- Identify best solution for large mass flow but < 200 °F – 9 dots
- Multi-purpose demo. – convert low-level heat to FC power and higher value co-products – 1 dot
- All gas comp have either intercoolers or and/or after coolers. This energy is generally wasted thru cooling water. Can this not be used for process stream heating in cold weather? - 0 dots

Identifying Opportunities

- Keep interaction going to ID opportunities – 1 dot
- Opportunity assessments? – 0 dots
- Increase site awareness of energy opportunity – 8 dots

Miscellaneous

- Mechanisms for partnering (honest broker eval. of technology and potential savings) – 0 dots
- Can we run waste water anaerobically to feed fuel cell – 0 dots
- Cold weather area—heating building/work places or other energy recovery? – 0 dots
- Can we use ammonia to cool unipol cycle gas, then recover from purge – 3 dots