Texas Industries of the Future

Institute for Industrial Productivity

Report on the

Technology Forum: Sustaining Industrial Energy Efficiency in Process Cooling in a Potentially Water-Short Future

Held June 19, 2013 in Houston, TX

Prepared by Texas Industries of the Future
The University of Texas at Austin
Kathey Ferland
Project Manager

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Background

Many regions of the US and world face water resource constraints, both in terms of quantity and/or quality. Current solutions to address this constraint at chemical plants and refineries can incur a significant energy penalty. Industry members on the Texas Industries of the Future Chemical Manufacturing and Refining Advisory Committee identified this as a major issue facing the process industries. As an issue, the "energy/water nexus" has been much discussed with respect to electric power generation. For example, the Electric Power Research Institute (EPRI) and the National Science Foundation (NSF) have issued a joint Request for Proposal (RFP).[1] However, there has not been a similar organized effort in the process industries. This *Technology Forum* provided an opportunity to leverage the work on new technologies being funded by EPRI and NSF for the electric power industry, as well as learn about technologies in use outside the US.

The "*Technology Forum: Sustaining Industrial Energy Efficiency in Process Cooling in a Potentially Water-Short Future*" , was convened on June 19, 2013 in Houston, Texas to bring together end-users in chemical plants and refineries with the developers of technologies that provide process cooling. The focus of the Forum was on the energy impacts of cooling applications that use less water. The day-long meeting was organized by the Texas Industries of the Future at the University of Texas at Austin, with the support of the Institute of Industrial Productivity.

Thirty-seven attendees from 11 chemical manufacturing and refining companies, 7 technology developers, and 6 interested organizations gathered to discuss the need for process cooling technologies that use less water. Table 1 lists the organizations in

Table 1: Participating Organizations

BASF Corporation
Center for Research in Water Resources, (UT Austin)
Chevron Phillips Chemical Co. LP
CITGO Petroleum Corp.
DuPont
EPCON International
EPRI
ExxonMobil Chemical Company
ExxonMobil Research and Engineering
Gas Technology Institute
Hudson Products Corporation
Hunton Specialty Products
Institute for Industrial Productivity
Johnson Controls, Inc
LyondellBasell Industries
Nalco Champion
Niagara Blower - Heat Transfer Solutions
Phelps Engineering Company
Phillips 66
Texas Industries of the Future (UT Austin)
Texas Water Development Board
The Dow Chemical Company
TPC Group LLC
Valero

[1] "Potential Game Changing Cooling Technology Development for Power Plant Water Conservation", Jessica Shi, EPRI, Presentation to Technology Forum, June 19, 2013.

attendance. An increased understanding of the development status of alternatives to traditional cooling tower technology and research directions allows end-users to prepare for periodic shortages of water, which can significantly increase production costs and/or curtail production.

It was established at the outset that the Forum could not address all aspects of developing a robust water management strategy. A comprehensive water management strategy would include:

- Reducing water waste—operational excellence
- Installing new technologies that use less water
- Reusing water within the plant (with or without treatment)
- Developing additional fresh water supplies
- Upgrading non-conventional water resources with additional treatment (ex: desalinization)

In order to provide the greatest value to attendees, the Organizing Committee selected the second topic for in-depth coverage at this Forum. The agenda can be found in Appendix 1.

The purpose of the Technology Forum was to increase understanding in the process industries of the available and developing technologies to meet process cooling needs when water is limited. The Organizing Committee identified the following objectives:

- Educate end-users on the status of technologies that provide process cooling and the trade-offs between energy and water use.
- Educate technology developers on the potential market at chemical plants and refineries, as well as end-users' specific concerns.
- Identify/prioritize action items to address barriers to implementation.
- Provide initial contacts for later follow-up between end-users and technology developers.

Results

Participants spent the morning discussing their most pressing issues, re: water availability and impacts on process operations. A common concern across the board was that "water is cheap until it's not there", which makes it challenging to engage management and secure capital for technology investment before there is a crisis. Some plants are already seeing restrictions on water quantity, although for others, this remains a distant threat. The relationship between availability and discharge quality complicates the issue further, as it is not as simple as finding a water source or running higher cycles of concentration in a cooling tower. In most cases, sites must also ensure that they meet discharge limits or return a certain flow to the surface water body. The comments by attendees are listed in Appendix 2.

Presentations covered a broad range of topics, from optimizing existing cooling towers, to technologies such as hybrid and dry cooling, as well as EPRI's research agenda and a methodology for evaluating technology performance. The presentations are available at http://texasiof.ceer.utexas.edu/docs_pres/conferences.htm Throughout the day attendees generated ideas for research, development and demonstration of the

Table 2: Possible Solutions by Topic

Existing Technology & Operations

1. Identify low cost efficiency Improvements.
2. Improve process reliability under water distressed conditions.
3. Identify cooling water mal-distribution opportunities, and resulting fouling and water treatment chemistry improvements.
4. Develop macro- economics for degradation of cooling water return temperature to the process, such as dollars per 1 ºF loss in temperature.
5. Addition of hybrid module systems to existing cooling infrastructure can optimize cooling load between conventional and more efficient systems, as well as, allow flexibility during cooling tower maintenance downtimes.

Next Step: Compile high level installed cost information for each technology so that the most effective retrofit solution may be chosen for a specific objective.

New Technologies

Need a common evaluation template; populate data as available.

Needs a champion site (gutsy end user). Engineering, Procurement, and Construction (EPC) companies traditionally need proven technologies, and revert to existing. Steps: 1. Paper study; 2. Real test (bench scale); 3. Pilot; and 4. Field at commercial scale. Consider consortium approach

Next Step: Tabulate technologies with parameters and attributes: energy impact; water impact; new vs. retrofit applicability; and magnitude cost (applicability and stage)

application of technologies being developed for the power industry or being used at industrial plants in dryer climates.

These ideas were collected, grouped by topic and prioritized by attendees in the afternoon. Attendees then broke up into four small groups to develop an action plan for the highest priority action within their topic.

The four breakout group topics were: Existing Technologies and Operations; New Technologies; Risk and Management, and; Water Reuse. Table 2 displays the possible solutions identified by each breakout group.

Appendix 3 presents additonal detail on the discussions of the breakout groups, including the barriers to action.

Of particular note was the need identified by three out of four breakout groups for a common format for the development of high level information on technology costs and performance. This effort would reduce the resources needed by individual companies interested in comparing options for further consideration. Increasing the availability of standardized performance

Table 2: Possible Solutions by Topic (Cont)

Risk and Management

1. Case study comparing technologies on the same parameters, with "example" plant input.
2. Process to speed demonstration of technologies in chemical plant/refinery applications.
3. Tool to allow an end-user to screen technologies for themselves. High level screening. Default inputs, which can be modified by end user if they have the data.
4. Need to frame this issue in terms of the probability of the following: future water restrictions, the percent and duration of water restrictions, and lost revenue from production curtailments.

Reuse 1: Use of Sea Water, Brackish Water or Brine Water

1. Cooperation on pipeline installation between several companies in order to bring the cost of transporting water down.
2. Proven technology using sea water with information on metallurgy, reliability of the equipment in this service and how to retrofit to a closed loop system.

Reuse 2: Reuse of Wasted Water

Look at 'good enough' cleanup of the water to be used in another part of the plant.

data across a range of options would eliminate one source of uncertainty in the technology adoption process.

Twenty-seven out of 37 attendees, or 73%, responded to an electronic survey sent two weeks post-Forum. All groups of attendees (end-users, technology providers, and other organizations) found the informal discussion of issues and challenges to be the most informative part of the program, with the technology presentations a close second. Seven of the 17 end-users that responded indicated that they would be following up on a technology. The other ten end-users reported that they were undecided, but were still in the evaluation process.

Chart 1 on the next page depicts the responses of all end-users to the question: "Based on what you learned at the Forum, which technologies were you most interested in following up on? Check all that apply." The 17 end-users included chemical companies, refining organizations and firms that characterized themselves as in both chemicals and refining.

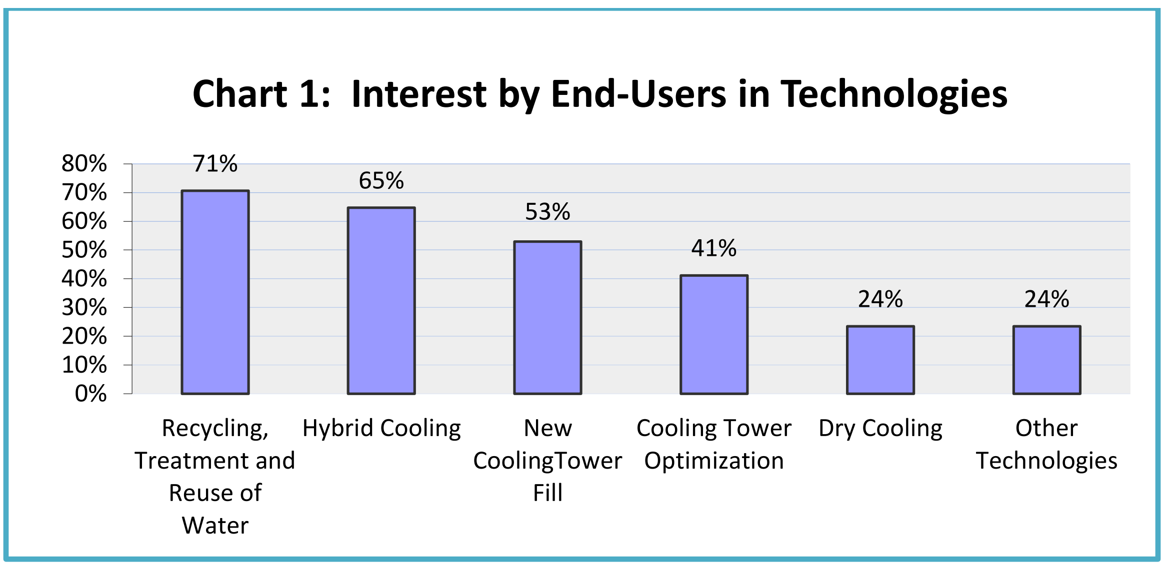
Recycling, treatment and reuse of water garnered the most interest, while at the other end of the spectrum was dry cooling and other technologies presented by EPRI. Between these two ends, hybrid cooling, a new cooling tower fill, and cooling tower optimization ranked in descending order.

Acknowledgements

Texas IOF would like to thank Jim Quinn with the Institute for Industrial Productivity for support of this project and Dr. Danny Reible, Director, Center for Research in Water Resources, The University of Texas at Austin, for his technical guidance. Roxana Darvari, University of Texas engineering graduate student, provided program support.

The program was organized by engineers from the process industries on the Energy/Water Technology Forum Organizing Committee, an ad hoc committee of Texas Industries of the Future. Their vision, technical expertise and commitment laid the foundation for the success of the meeting. The Forum Organizing Committee included:

- Frank Roberto, ExxonMobil Chemical Co.(chair)
- Bruce Murray, Chevron Phillips Chemical
- Claudia O'Rourke, The Dow Chemical Company
- Sumit Chatterjee, LyondellBasell



Appendix 1: Technology Forum Agenda

Texas Industries of the Future
And the Institute for Industrial Productivity Presents

Technology Forum: Sustaining Industrial Energy Efficiency in Process Cooling in a Potentially Water-Short Future

8:30 am-4 pm

June 19, 2013

Houston, Texas

7:30 *Coffee and Visit with Exhibitors*

8:30 *Goals of Forum and Case for Action*
Frank Roberto, Chair, Texas IOF Advisory Committee
ExxonMobil Chemical Co.
Kathey Ferland, Texas Industries of the Future
The University of Texas at Austin

Jim Quinn, Institute for Industrial Productivity

9:10 *Current Situation*
Update from LyondellBasell
Matthew Michnovicz, Principal Engineer
Equistar Chemicals, LP, a LyondellBasell Industries Company

9:45 *Clarifying the Situation*
Attendee go-round on following questions:

- What is your biggest concern and challenge with respect to the energy impacts of water availability/quality?
- How does your plant currently use water?
- What is expected to happen to your water source over time (quantity and quality)?
- How will this impact your plant cooling or plant expansion plans?
- What are you doing to manage this threat?
- Which technologies for process cooling are you evaluating?

10:45 *The Big Picture on Research and Evaluating Trade-offs*

Potential Game Changing Cooling Technology Development for Power Plant Water Conservation
Electric Power Research Institute

Jessica Shi, Ph.D. Technical Lead, Technology Innovation Water Conservation Program

Metrics for Evaluating Alternatives in a Typical Chemical Plant
Johnson Controls, Inc.
Tom Carter, P.E. Senior Program Manager, Heat Rejection Technology

11:45 *Lunch Provided. Brady's Landing Buffet*
Visit with exhibitors and speakers

12:45 *Process Cooling Technologies, Part 1*

Evaporative Cooling Systems
Phelps Engineering, Pete Phelps

Air-cooled Heat Exchangers
Hudson Products Corporation
Robert J. (Bob) Giammaruti, VP & GM - FIN-FAN® Air-Cooled Heat Exchangers

EVAPCO Dual Coil Cooler
Hunton Specialty, Ron Sheppard

1:35 *Process Cooling Technologies, Part 2*

Advanced Dew Point Cooling Tower Fill
Gas Technology Institute
Yaroslav Chudnovsky, Ph.D. Senior R&D Staff, End-Use Industrial Solutions

Wet Surface Air Coolers
Niagara Blower
Chuck Marchetta, Senior Applications Engineer

Thermosyphon Cooler Hybrid System
Johnson Controls, Inc.
Tom Carter, P.E. Senior Program Manager, Heat Rejection Technology

2:40 *Break Out Groups: Discussion on Next Steps*

3:40 *Report Out and Closing*

4:00 *Adjourn*

Appendix 2:
Comments by Attendees in Response to the Following Questions:

- What is your biggest concern and challenge with respect to the energy impacts of water availability/quality?
- How does your plant currently use water?
- What is expected to happen to your water source over time (quantity and quality)?
- How will this impact your plant cooling or plant expansion plans?
- What are you doing to manage this threat?
- Which technologies for process cooling are you evaluating?

Appendix 2

Technology Forum, June 19, 2013

SUMMARY OF ATTENDEES COMMENTS IN RESPONSE TO THE FOLLOWING QUESTIONS:

- What is your biggest concern and challenge with respect to the energy impacts of water availability/quality?
- How does your plant currently use water?
- What is expected to happen to your water source over time (quantity and quality)?
- How will this impact your plant cooling or plant expansion plans?
- What are you doing to manage this threat?
- Which technologies for process cooling are you evaluating?

Organization R=Refining C=Chemical TP=Technology Provider O=Other	**Biggest Concern and Challenge**
C	Biggest issues are developing a water mass balance and a plan to move forward.
C	Biggest concern is how to communicate sense of urgency and importance of conserving water. No problem with quantity currently. There is some challenge with meeting discharge levels with increased cooling tower cycles (now run at 6). Process cooling technology improvement is needed. They have to dilute their wastewater to get the TDS concentrations down to discharge limits.
C	They are trying to mitigate risk and conserve water. The big challenge is to put a cost on water. This will help justify some of the conservation projects.
C	They still need to use clean water. They get short notice when water is unavailable. They use water for chemical dilution. They are also expanding bio plants, which use water. They are trying to use new technology.
C	How we can mitigate the risk and improve efficiency of the existing equipment?
C	The main concerns are quality of water, management of sites with limited water resources, and implementation of low cost changes.

Organization	Biggest Concern and Challenge
C	They use conventional technologies. Their concerns are using less water in the process, improving technology selection for process cooling; and using sea water after desalinization for cooling water.
C	Main concerns are water scarcity and discharge quality.
C	The main concern is trying to implement new technology
C	Decreasing quality and quantity of water. Current approach: recycle the stream and desalt water.
C	They have to curtail by 50 to 60% after a rain.
C	Looking at water needed for future expansions.
C	When cooling towers reach end of life, or are damaged, what technology should be installed?
C	Some ideas they are looking at: alloys in heat exchangers; desalinization; using sea water in steam condensers.
O	Concerns are water conservation and reuse- important for ongoing planning in Texas. 30% of future water demand will be met by conservation.
O	Concerns are with air cooled condensers. The cost of air condenser equipment is high , the foot print and size of air condenser is large. 10% power penalty with dry cooling in power plants.
O	Quality and quantity issues.
O	How much does the best technology cost? Do sites have water balances? How to get top level management attention?
R	The concern is the stage of drought we drop to in the future, as at certain stages, there are mandatory reductions for industrial customers. They are evaluating sending effluent back to the cooling tower, but it's expensive. Expect level 4 f drought in Sept. 2013. This triggers industrial reductions.
R	Company has 6 refineries in Texas, 3 of them are more concerned about water supply than the others. Residential, industrial and commercial sectors are all growing and also need water. For these three sites the major concerns are: Developing a detailed water balance, identifying low cost operational improvements as wells as developing capital projects. They use water for cooling towers and boilers.
R	Poor water quality will increase fouling and need for cleaning. Interested in water recycling and how recycled streams can be used.

Organization	Biggest Concern and Challenge
R	The important challenges are: 1. How the water quality changes during the drought. 2. How to quantify the risk. 3. How to balance the lower price of natural gas vs. high cost of water. 4. How to attract new investments to the area. They are looking at how to recover and recycle wastewater streams inside the plant so that it is clean enough to reuse in the process again.
R	they are trying to run the plant as efficiently as possible. Maintaining energy efficiency is important.
R	How much does a new technology cost?
R	Need to improve understanding of the relationship between water quantity and the TDS of the wastewater discharge
R	They are starting to use the GEMI tool on water risk.
R, C	Three main concerns: 1. There is not enough notice when supplies become unavailable; 2. Water is cheap until it is gone; 3. Poor quality water during drought
R, C	Main issues are economics of water availability, water quality, water usage and threat of water shortage, and technologies that use less water. We don't see the cost of water in the price of gas.
R, C	Need a water balance to know where to initiate water saving projects. Need to model not only where water is used, but also how its use changes with the quality changes that come with limited availability.
R, C	Need to understand the relationship between water usage and discharge quality, specifically in terms of total dissolved solid (TDS). Regulators or suppliers are asking us to reduce the amount of water we use. What new technology is out there to decrease TDS? What is available that can be used for retrofitting existing plants, will reduce water usage and specifically will not increase TDS of the wastewater? Water is used for cooling towers and boilers.
R, C	The biggest concern is developing a water conservation plan.

Organization	Biggest Concern and Challenge
TP	• As a manufacturer we are trying to assess how facility owners will evaluate potential investments in water saving technologies. Is their interest based on a desire to avoid the cost of water and water treatment or is it to mitigate the risk of water scarcity? • The optimal technical solution for mitigating the risk of water scarcity will vary, depending on the degree of water reduction being planned for as well as the duration of the scarcity event. It is important for us to have a clear understanding of the definition of the problem which the industry is seeking a technical solution for.
TP	Poor water quality, water with high mineral content.
TP	How can we change the mechanical, operational and chemical aspects of water treatment technologies? What technology do we need in the future?
TP	They are working on developing cost effective solutions. Developing the advanced cooling system, and produced water treatment technology. New technologies must be cost-effective.

Appendix 3: Breakout Group Results

Appendix 3: Summary of Breakout Group Discussions

Technology Forum: Sustaining Industrial Energy Efficiency in Process Cooling

in a Potentially Water-Short Future

Breakout Group Topic	Priorities	Barriers	Possible Solutions
Existing Technology & Operations	Sustain process reliability under water distressed conditions through low-cost efficiency improvements	1. Economics are not clear. Develop economics for each site on process temperature rise. This will provide justification to help drive implementation 2. Problem not perceived as near term, so planning is weak 3. Therefore not a high priority for resources and implementation 4. Equipment or technology costs are not readily available	1. Identify low cost efficiency Improvements 2. Improve process reliability under water distressed conditions 3. Identify CW misdistribution opportunities and resulting fouling and water treatment chemistry improvements 4. Develop macro- economics for degradation of CW return temp to the process such as – manufacturing dollars per 1 ºF loss in temperature 5. Addition of hybrid module systems to existing cooling infrastructure can optimize cooling load between conventional and more efficient systems, as well as allow flexibility during cooling tower maintenance downtimes. Next Step: Compile high level installed cost information for each technology so that the most effective retrofit solution may be chosen for a specific objective.

Breakout Group Topic	Priorities	Barriers	Possible Solutions
New Technologies	Strong interest in understanding available and developing technologies with respect to. commercial readiness <u>and</u> water/other impacts	Cheapest solution is today's cooling towers • Incentives to implement a "premium" system unclear (timing, magnitude, scope (regional)). • Short term contingency plans do not address issue long tern • Not all solutions are proven or available for contingency/quick deployment Applicability/Cost not known yet • Scale up potentially as well • Reliability	Common evaluation template, populate data as available Needs a champion site (gutsy end user). EPC traditionally need proven and revert to existing 1. Paper study 2. Real test (bench scale) 3. Pilot 4. Field at commercial scale Consider consortium approach Next Step: Tabulate "technologies" with parameters and attributes • Energy impact • Water impact • New vs. retrofit applicability • Magnitude cost o Applicability o Stage
Risk and Management	Information from third parties on cost and performance of technologies would facilitate adoption by end-users.	1. Technologies are not demonstrated and proven in chemical plants/refineries. 2. Confusing presentation of information on different technologies makes their evaluation/comparison difficult.	1. Case study comparing technologies on the same parameters, with "example" plant input. 2. Process to speed demonstration of technologies in chemical plant/refinery applications. 3. Tool to allow an end-user to screen technologies for themselves. High level screening. Default inputs, which can be modified by end user if they have the data. 4. Need to frame this issue in terms of the probability of the following: future water restrictions, the percent and duration of water restrictions, and lost revenue from production decreases or costs of temporary water supplies/treatment.

Breakout Group Topic	Priorities	Barriers	Possible Solutions
Water Reuse	Reuse within the plant	Resources, capital, technology and permits including impact to an outfall (quality and quantity). The discharge permits need to be understood prior to projects being implemented so that there are no unintended adverse consequences. Penalty for Early Actions. Most companies have lists of projects that can be installed to achieve curtailment goals and would like to achieve the benefits now. However, this would reduce their baseline usage, which might penalize them in the future if/when curtailments are called.	
	Use of sea water, brackish water or brine water	1. Pipeline costs. 2. Address need to upgrade metallurgy as well as minimizing particulate drift 3. Need full-scale implementation data, not just a pilot study.	1. Cooperation on pipeline installation between several companies in order to bring the cost of transporting water down. 2. Proven technology using sea water with information on metallurgy, reliability of the equipment in this service and how to retrofit to a closed loop system.
	Reuse of wasted water	Water is cheap and alternate supply sources may adversely impact the quality requiring more and unknown costs	Look at 'good enough' cleanup of the water to be used in another part of the plant.