The unexpected and stunning success of the shale plays in the United States over the past decade has dramatically changed the nation’s energy picture for years, if not decades, to come.

For instance, about 40% of the natural gas produced in the nation now comes from shale, and that percentage is predicted to go even higher in the decades ahead (see Figure 1).

Figure 1: U.S. natural gas production by source (in Tcf per year), according to April projections by EIA.

Compare this to less than a decade ago, when U.S. natural gas reserves and production were on the decline and it was expected that the United States would soon begin importing large quantities of natural gas to meet demand.

Now, instead, natural gas reserves are increasing and production is about to create a surplus. In the not too distant future, the United States may begin exporting large quantities of natural gas to meet demand.

Knowing the compositional makeup of natural gas is critically important in most instances because processes that use natural gas either as a fuel (as part of a combustion process) or as feedstock (for industrial or commercial processes, such as the production of fertilizer, methanol, chemicals and pharmaceuticals) are optimized for a specific gas composition or a small range of gas compositions.

Interchangeability

Natural gas is a mixture of various hydrocarbons such as methane, ethane, propane, diluents—such as nitrogen and carbon dioxide—and other components, including water and hydrogen sulfide, in lesser amounts. The proportion of each component in produced natural gas can vary widely. These variations can affect combustion processes, when the gas is burned, and chemical reactions, when the gas is used as feedstock.

To understand how much variability in gas composition can be tolerated for a given application, we must assess the interchangeability of one gas composition for another.

A landmark white paper on the subject of natural gas interchangeability and non-combustion end use was published in 2005 by the Natural Gas Council and other stakeholders (NGC+). The NGC+ working group examined the issues related to maintaining adequate and reliable gas supplies for consumers in a manner that would enable system integrity, operational reliability and environmental performance.

The NGC+ working group defined the term interchangeability as “the ability to substitute one gaseous fuel for another in a combustion application without materially changing operational safety, efficiency, and performance or materially increasing air pollutant emissions.” The white paper specified several technically based quantitive measures that can be used to define the acceptable range of gas compositions in pipelines. These interchangeability measures can ensure broad application of gas compositions to end uses and can be applied without discrimination of either end-users or individual suppliers in the United States. The white paper also detailed the adverse effects associated with natural gas compositions outside the interchangeability limits specified.

The natural gas interchangeability limits specified by the NGC+ are:

- A maximum variation of ±4% in the Wobbe Index (WI) from the local historical average gas or, alternatively, the established adjustment or target gas for the service territory. (WI is the higher heating value (HHV) of the gas divided by the square root of its specific gravity. Using this ±4% formula in combination with the compositional limits will result in a local WI range that is above 1,200 Btu per standard cubic feet (scf). In addition, the maximum WI limit should be 1,400 Btu/scf and the maximum higher heating value limit at a gas pressure of 14.73 psia and a temperature of 60°F (on a dry, real basis) should be 1,110 Btu/scf.

- Additional composition limits include (1) a maximum total C4+ content (such as the sum of normal butane, iso-butane, and heavier hydrocarbons) of 1.5 mole percent (mol%) and (2) a maximum total inert gas content of 4 mol%, based on the HHV at a gas pressure of 14.73 psia and a temperature of 60°F (on a dry, real basis).

An exception to these specifications can be made when a service territory has demonstrated experience with gas supplies exceeding these WI, heating value, or composition limits such as actual end-use experience established by end-use testing and monitoring programs, as
long as those gas supplies do not unduly contribute to safety and use problems of end-use equipment.

**Interchangeability**

The NGC+ interchangeability white paper was produced at a time when it appeared that the nation would be importing substantial amounts of natural gas. Most foreign sources of natural gas had significantly different chemical compositions than that produced domestically at the time.

Although the need to import natural gas seems to have passed, the subject of interchangeability is still an important topic because natural gas produced from various shale plays around the country is proving to have substantially different chemical compositions than the historical range of gas compositions from traditional sources.

Figure 2 illustrates this point. On this data plot, the NGC+ interchangeability limits are denoted by the green-shaded box. Any gas composition meeting the NGC+ interchangeability specifications will fall within this box. Any composition not meeting the specifications will fall outside the box and require some type of processing to get within allowable limits.

**Composition Variation**

Not only can shale gas composition vary from region to region around the country, it can vary substantially even within a given shale play. Whether a shale formation yields oil, hydrocarbon condensate or natural gas depends on several factors, including the organic makeup of the kerogen that produces the hydrocarbon gas or liquid and the formation depth, which determines the local pressure and temperature.

In general, shale yields primarily oil at shallower depths and primarily natural gas at greater depths, where the formation temperature is high-

![Figure 2: Unprocessed shale compositions from U.S. shale plays.](image)

Also, for reference, the historical range of gas compositions from traditional U.S. gas supplies is shown on the figure as a light red oval. Note the traditional gas supplies fall well within the NGC+ interchangeability limits.

To illustrate how unprocessed shale gas compositions compare to the NGC+ interchangeability limits, the yellow dots shown on Figure 2 are sample shale gas compositions from various production areas around the country, including the Barnett and Eagle Ford plays in Texas, the Haynesville play in Louisiana, and the Marcellus and Appalachian Basin plays in the Northeast. Many of these compositions tend to be relatively “rich,” that is, they have HHVs above 1,100 Btu/scf.

Rich gas can be an operational challenge for a number of reasons, and usually requires the heating value to be reduced via some form of processing before delivery. Rich gas also tends to have a relatively high hydrocarbon dew point temperature (in many cases, well above 80°F at pipeline pressure), causing it to be susceptible to phase change from gas to liquid — known as “hydrocarbon dropout” — before reaching its final destination. Finally, rich gas can be dif-

![U.S. PIPELINE, INC.](image)

**MAINLINE PIPELINE**

- Diameters from 8-inch to 48-inch
- 4+ Large Spreads - Several Hundred Miles
- Small, Complex or Challenging Projects
- Broad Capability

**STATIONS AND FACILITIES**

- Compressor, Pump and Meter Stations, Terminal and Other Facilities
- Greenfield, Additions and Modifications

**PIPELINE INTEGRITY**

- Hydrostatic Testing
- Pipeline Replacements
- Mainline Valve and Launcher/Receiver Projects

**QUALITY...LIKE IT’S IN OUR OWN BACKYARD**

281-531-6100 WWW.USPIPELINE.COM

---

All Pipeline & Gas Journal editorial content is copyright protected by law. Oildom Publishing Co. must grant proper authorization in order to reuse any article, photograph or illustration. Foster Printing is the exclusive reprint provider for Pipeline & Gas Journal and gains copyright permissions for you. For more information contact Foster at: 866-879-9144.
er. Hydrocarbon condensate is usually produced in the region between the oil-yielding shale strata and the gas-yielding strata. Figure 3 (prepared by the U.S. Energy Information Administration (EIA) in 2010) illustrates the Eagle Ford shale play production zones in South Texas.

In the Eagle Ford, natural gas heating value can vary by several hundred Btu/scf from one part of the formation to another. This particular formation generally produces richer gas (i.e., higher HHVs) as one moves farther north in the formation. The southern segment of the formation yields primarily “leaner” gas (with HHVs below about 1,100 Btu/scf).

Moving north, the formation begins to produce hydrocarbon condensate along with the gas with heating HHVs of 1,100-plus Btu/scf. Moving farther north, mostly crude oil is produced. Since the Eagle Ford play becomes shallower as one moves north, the play follows the trend of producing natural gas from greater depths and oil from shallower depths.

Another example is provided in Figure 4 for the Barnett shale play in North Texas, near Fort Worth. This is the oldest, most mature shale play in the United States, with drilling activity dating back to the early 1950s. As a side note, the first horizontal well drilled in the Barnett play was in Wise County in the early 1990s.

The eastern portion of the Barnett produces the lowest heating value (“driest”) gas, which generally increases heading west across the formation, where it becomes shallower.

Both maps in Figure 4 denote a “gas maturation limit,” which is an approximate demarcation line. Generally, natural gas is produced east of this line. Figure 4 shows approximate HHV contours for the area east of the gas maturation limit line.

Variation Over Time

Another challenge with producing, processing and transporting shale gas is that flow stream composition can change over time. This is a particularly challenging aspect for gathering and transmission pipeline operators who are continually dealing with source changes as time passes.

For instance, gathering pipeline operators have to deal with individual well streams periodically coming on or off line for various reasons. Individual well stream composition can also change as a well depletes.

Tables 1 and 2 illustrate this situation. The datasets presented in the tables are from two gathering system pipelines in the Eagle Ford, both upstream of a nearby processing plant. Composition data for May 31 of five consecutive years are listed.
Extended gas analyses were performed on each gas sample using a gas chromatograph. Values in the tables highlighted in red fall outside the NGC+ interchangeability. Interestingly, in the case of both stations, the HHV and WI values were lowest at the outset and rose significantly over time, particularly from the first to the second year, as shown in Figures 5 and 6. The increases in HHV and WI were due, primarily, to increases in the percentages of ethane through pentane, rather than increases in hexane and heavier hydrocarbon constituents.

The hydrocarbon dew point temperature was relatively high for both station flow streams, well above 70° F at a pipeline pressure of 700 psia.

**Conclusions**

Shale gas has become a significant portion of natural gas being produced in the United States and will account for an even greater percentage of future production. Shale gas can be significantly different than the historical compositions of domestic gas produced from other sources. Without proper processing, many shale gases have compositions that are outside the NGC+ interchangeability limits, often with heating values higher than historical norms and high WI values. These rich gas compositions are more susceptible to phase change from gas to liquid, known as hydrocarbon dropout. This can be problematic to gathering and transmission pipeline operations. Hydrocarbon dropout can also cause problems in the gas sample acquisition and analysis process, resulting in incorrect characterization of the gas mixture.

If left unprocessed, rich shale gas compositions can lead to problems with end-user equipment. Pipeline operators and gas measurement technicians must remain vigilant and be aware of potential pitfalls and operational problems associated with shale gas that falls outside the NGC+ interchangeability limits, otherwise operational upsets and measurement errors can result.

---

**Table 1:** Eagle Ford gathering line gas composition history – Station No. 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gas Sample Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Value (BTU/scf)</td>
<td>1,107.7</td>
</tr>
<tr>
<td>Wobbe Index (BTU/scf)</td>
<td>1,371.8</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.6520</td>
</tr>
<tr>
<td>Hydrocarbon Dew Point at 700 psia (°F)</td>
<td>78.8</td>
</tr>
<tr>
<td>(C_2) (mo%)</td>
<td>88.7402</td>
</tr>
<tr>
<td>(C_3) (mo%)</td>
<td>5.2514</td>
</tr>
<tr>
<td>(C_4) (mo%)</td>
<td>2.0159</td>
</tr>
<tr>
<td>Iso-(C_5) (mo%)</td>
<td>0.4264</td>
</tr>
<tr>
<td>Normal-(C_6) (mo%)</td>
<td>0.5306</td>
</tr>
<tr>
<td>Iso-(C_6) (mo%)</td>
<td>0.2104</td>
</tr>
<tr>
<td>Normal-(C_7) (mo%)</td>
<td>0.1514</td>
</tr>
<tr>
<td>(C_8) (mo%)</td>
<td>0.1490</td>
</tr>
<tr>
<td>(C_9) (mo%)</td>
<td>0.1110</td>
</tr>
<tr>
<td>(C_{10}) (mo%)</td>
<td>0.0540</td>
</tr>
<tr>
<td>(CO_2) (mo%)</td>
<td>2.2266</td>
</tr>
<tr>
<td>(N_2) (mo%)</td>
<td>0.1331</td>
</tr>
<tr>
<td>(C_{10+}) (mo%)</td>
<td>1.6328</td>
</tr>
<tr>
<td>Total (CO_2 + N_2) (mo%)</td>
<td>2.3597</td>
</tr>
</tbody>
</table>

**Table 2:** Eagle Ford gathering line gas composition history – Station No. 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gas Sample Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Value (BTU/scf)</td>
<td>1,293.9</td>
</tr>
<tr>
<td>Wobbe Index (BTU/scf)</td>
<td>1,486.2</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.7580</td>
</tr>
<tr>
<td>Hydrocarbon Dew Point at 700 psia (°F)</td>
<td>79.4</td>
</tr>
<tr>
<td>(C_2) (mo%)</td>
<td>74.6498</td>
</tr>
<tr>
<td>(C_3) (mo%)</td>
<td>13.8239</td>
</tr>
<tr>
<td>(C_4) (mo%)</td>
<td>6.3995</td>
</tr>
<tr>
<td>Iso-(C_5) (mo%)</td>
<td>0.9978</td>
</tr>
<tr>
<td>Normal-(C_6) (mo%)</td>
<td>1.6245</td>
</tr>
<tr>
<td>Iso-(C_6) (mo%)</td>
<td>0.3842</td>
</tr>
<tr>
<td>Normal-(C_7) (mo%)</td>
<td>0.3082</td>
</tr>
<tr>
<td>(C_8) (mo%)</td>
<td>0.0826</td>
</tr>
<tr>
<td>(C_9) (mo%)</td>
<td>0.0615</td>
</tr>
<tr>
<td>(C_{10}) (mo%)</td>
<td>0.0299</td>
</tr>
<tr>
<td>C1 (mo%)</td>
<td>0.0000</td>
</tr>
<tr>
<td>C2 (mo%)</td>
<td>0.0000</td>
</tr>
<tr>
<td>(CO_2) (mo%)</td>
<td>1.4261</td>
</tr>
<tr>
<td>(C_{10+}) (mo%)</td>
<td>23.7120</td>
</tr>
<tr>
<td>Total (CO_2 + N_2) (mo%)</td>
<td>3.4886</td>
</tr>
</tbody>
</table>
John Lansing Measures The Pulse Of Natural Gas

By Jeff Share, Editor

Real experts in the tricky field of natural gas measurement don’t come along every day. Those who do emerge find that their names and reputations precede them, be it in the operational, commercial or research side of the business. And that is where we find John Lansing today.

Lansing, 64, is vice president of Global Operations for CEESI, Colorado Engineering Experiment Station Inc., a leading research center that specializes in flow meter testing and meter calibrations. One of CEESI’s specialties concerns ultrasonic flow meters, a device that came to market in the late 1990s and has helped revolutionize the measurement business. In fact, a recent series of studies from Flow Research found that the market for ultrasonic meters totaled $632 million in 2011, and is projected to grow at a compound annual growth rate of 9.6% through 2016.

As the industry has grown, so has Lansing’s reputation as a measurement guru. A graduate of California State Polytechnic Institute-Pomona where he would eventually earn his BS in mechanical engineering, he joined CEESI in August 2012. Previously Lansing worked for a number of prominent suppliers including Instromet, Emerson and SICK Maihak. In this interview, the native Californian talks about the measurement business and suggests that it offers plenty of opportunities for young engineers to thrive in.

**P&GJ:** John, where did you grow up and what were your interests as a young man?

**Lansing:** I was born in Upland, CA. We lived in Ontario, a neighboring town, until September 1958 when we moved to Denver. In January 1960 we moved to Arroyo Grande, CA and continued moving every year or two until we returned to Ontario in 1965 where we lived for many years. I enjoyed electricity from as far back as I can remember. Later I also became interested in automotive.

**P&GJ:** How did you end up in the energy industry? Did you follow someone else from your family into the business?

**Lansing:** My father worked in the aerospace industry (electronics technician) starting in Denver in 1958. He worked as a “job shopper,” so we traveled to where the next job was. Typically we never lived in a city more than two years, sometimes just six months. After several years of constantly changing jobs, we returned to Ontario in 1964 and my father went to work for Douglas Aircraft where he took a position that was much steadier.

I wanted to be an electrical engineer somewhat following in my father’s footsteps, and also a mechanical engineer, so I enrolled in Cal Poly University (a college at that time) in September 1967. After two+ years of college, I ran out of money and needed a job to continue. During 1968 and 1969 I had summer jobs at Lockheed (electronics division). I was a general electronics technician the first year. In 1969 I was prototyping the first flight data recorders (black boxes) under the direction of one of my electrical engineering instructors.

This was a very interesting assignment but I needed to continue working part time during the school year in order to pay for college. Unfortunately, the aerospace industry was very slow that year, and HR would not allow me to continue working part time. I had enough money to remain in school another six months. When I ran out of money, I left school to look for a full-time job. Deciding that the aerospace industry was just too volatile for a career, I applied at public utility companies figuring they were much more stable. I applied at telephone companies (GTE), Southern California Edison, and Southern California Gas (SoCalGas). SoCalGas offered me a position which I accepted. Thus my career in the gas industry began in April 1970.

**P&GJ:** So, how did you finally end up at CEESI?

**Lansing:** I enjoyed my 16+ years with three gas USM (ultrasonic meter) manufacturers after my 26+ years at SoCalGas. During my USM career my responsibilities included everything from technical support manager to sales to product manager to technician to trainer and more. I really enjoy presenting at conferences on diagnostics for USMs. Steve Caldwell (president and co-founder of CEESI) approached me and discussed working for CEESI to do training, and to help promote CEE SmaRT, a new product that had been developed by CEESI and RT Technical Solutions. CEE SmaRT intrigued me because it helps clients to take full advantage of USM diagnostics in a way never done before. It would be a good opportunity for me to do more training while promoting a product that helps clients realize the full value of their gas USM.

**P&GJ:** What are your responsibilities at CEESI, what projects will you be involved in, and why did you decide to make this move from private industry to a research organization?

**Lansing:** I was born in Upland, CA. We lived in Ontario, a neighboring town, until September 1958 when we moved to Denver. In January 1960 we moved to Arroyo Grande, CA and continued mov-
**Lansing:** As anyone who has worked for a small, privately held company knows, everyone will have many varying responsibilities. Of course I do some training in gas ultrasonics from time to time at industry conferences like ISHM (International School of Hydrocarbon Measurement) and ASGMA (American School of Gas Measurement Technology). I also assist in CEESI training classes for clients by working with Bill Frasier and Joel Clancy on our staff. One of my major roles is to assist in sales and marketing of CEESmaRT on behalf of CEESI. Here I work closely with Ed Hanks and Laura Lawton and all the other folks at RT Technical Solutions. I give client presentations and seek out additional sales opportunities. Additionally I offer client ideas to the CEESmaRT team for product improvement consideration.

I attend the AGA TMC (American Gas Association Transmission Measurement Committee) meetings, and also am a committee member for ISHM and AGMSC. Other activities include providing technical assistance on gas ultrasonic questions users have from time to time (analyze maintenance reports). And like everyone who enjoys learning, I enjoy spending time “going back to school” on liquid and multiphase measurement by working with some of the most talented people in the industry like Dr. Richard Steven and Terry Cousins.

**P&GJ:** What professional achievements are you most proud of?

**Lansing:** After leaving SoCalGas I had the good fortune of joining the fast-growing gas ultrasonic metering industry in 1996. I was able to share my ideas with three manufacturers that I worked for during this 16+ year period. I saw these companies grow and each one become the market leader during my time of employment with them. I am very proud to have had the opportunity to utilize some of my electronics, mechanical and measurement experience in the product development side of the business, along with experiencing the sales and marketing aspects.

**P&GJ:** Many segments of the energy industry complain about a lack of qualified personnel. Is this also true in the measurement? What is the industry doing to try and attract more young people to the business?

**Lansing:** Today I believe most field technicians are tasked with doing a variety of job activities in addition to measurement. In the past measurement technicians really learned their trade and were 100% focused on all aspects associated with the operation and maintenance of a measurement facility. They really were experts at what they did. I don’t think the majority of technicians now are given the time to develop their knowledge as was the case years ago.

Recently I’ve seen increased attendance at the major gas and liquid conferences like ISHM and ASGMA. It appears that companies now realize they need to focus more effort on getting their employees better educated and are willing to send them to these conferences for training.

**P&GJ:** What are the most pressing issues today involving natural gas measurement?

**Lansing:** I think the rate of change for new products being developed and introduced into the gas industry makes it harder for companies to keep up with improved technology. Additional emphasis on training will be needed in order to take full advantage of these products.

**P&GJ:** Where have the greatest advances in gas measurement been made since you began your work, and how have you seen the business change?

**Lansing:** Both the primary and ancillary devices have improved significantly during the past 40+ years of my measurement career. Going from chart recorders on turbine and orifice meters to using ultrasonic and Coriolis meters, along with electronic flow computers incorporating pressure and temperature transmitters, is a significant advancement in gas measurement. All of these technologies, through the use of diagnostics, reduce maintenance costs, so the client realizes a second benefit.

**P&GJ:** What do you think might be the next breakout technology in measurement?

**Lansing:** Possibly the ability of a device to replace the gas chromatograph (GC) and maintain the same level of uncertainty, if not improve on it. Of course we have devices today that can provide energy and some level of information needed to determine compressibility. However, most companies are staying with the gas chromatograph as their standard for a variety of reasons. Much like the GC replaced both the calorimeter and gravimetric devices from the 1980s, I see newer technology poised to replace the GC in the coming years.

**P&GJ:** Is enough money being spent on measurement research, especially when issues like integrity management and cybersecurity seem to draw the most attention?

**Lansing:** It does seem that the focus on research by the industry has diminished over the last decade. This is probably due to changes in funding mechanisms that once supported more independent research. I believe there is much more competition today in new measurement technologies. We only have to look back 10 years when there were far fewer gas ultrasonic meters on the market than today.

With the continued strong sales growth in the gas ultrasonic arena during the past 10 years, most manufacturers have allocated significantly more money to develop new and improved products. This all translates into more choices for the consumer, which can be a good thing, but it can also make the decision one that may not be based only technical merit, but more on price and service.

**P&GJ:** Do operating companies truly understand the importance of accurate measurement, especially when it might affect their lost and unaccounted for gas?

**Lansing:** Most companies do understand the importance of accurate measurement. I know many in our industry grumble that upper management doesn’t seem to put enough importance on this subject. However, when I ask about the level of their lost and unaccounted for gas, they all agree it is far less today than 10-15 years ago. If it were excessive, I’m sure more emphasis would be placed on lowering it. Through the use of all the newer technologies, it might seem that measurement isn’t as important as it once was. However, it’s my view that companies are just doing a better job of managing and maintaining their measurement facilities.

**P&GJ:** What are some of your interests away from work?

**Lansing:** Away from work I enjoy listening to analog music, the occasional round of golf, and still look forward to the time when I can get back into working on 1960s muscle cars.

**P&GJ:** I find that when I talk to people involved in measurement, there is nothing they would rather be doing. Why so?

**Lansing:** Perhaps a single word — passion — explains why most folks enjoy this industry. I don’t think someone who really doesn’t care about their job will be happy working around others who feel their job is very important to the success of their company. If someone joins the measurement team, which is a fairly small community, it simply gets in their blood to learn more, and before long it becomes a career they don’t want to change. **P&GJ**
Wet gas meter calibrations are usually done using natural gas, kerosene, and water. Increasingly, gas producers are questioning a meter’s ability to measure wet gas entrained with the unique liquids found on platforms and wellheads (viscous hydrocarbons, paraffin-based/high-wax liquids, sea water, brine solutions, MEG and other custom liquids).

Colorado Engineering Experimental Station, Inc. (CEESI) has recently added custom liquid testing capabilities to its wet gas facility, using versatile variable frequency drive (VFD)-controlled magnetic-drive centrifugal pumps.

**Measuring Wet Gas**

Gases from platforms and wellheads are often laden with liquids. Many produce a mixture of gas, liquid hydrocarbons (often called condensate) and free water. By volume, this wet gas mixture is mostly gas with small amounts of hydrocarbon liquids and water. Gas flow meters are principally designed for dry gas. When small amounts of liquids are present in a gas flow stream, large flow measurement errors often occur.

In the past two decades flow meter manufacturers have worked hard to produce flow meters that are immune to measurement errors caused by liquids in a wet gas flow stream; their success has been limited. The search continues for a wet gas flow meter or combination of flow meters and technologies that can adequately measure wet gas over the wide range of flow rates and liquid loadings commonly found in the field.

While the search continues for the perfect wet gas meter, some progress has been made. Wet gas is being successfully measured by using a combination of technologies and flow calibrations. Successful wet gas meters typically require a calibration at a wet gas test facility (WGTF) where a surrogate hydrocarbon liquid and water are pumped into the gas flow stream. The flow meter is installed in a section of pipe flowing the wet gas mixture.

By measuring the liquid flow streams and the dry gas flow streams separately, the wet gas meter readings can be compared to the actual amount of gas and liquid flowing in the pipe. The meter’s recorded output is compared to the actual flow rates and adjustments are made to the meter’s readings.

The meter’s performance is characterized and software adjusts are made based on the wet gas calibration and several correlating parameters, including gas velocity, gas density, the liquid’s properties, liquid loading, flow pattern, the Reynolds number and the Lockhart-Martinelli number.
Need For Custom Liquids

While most wet gas meters can be successfully calibrated and characterized using water and surrogate hydrocarbon liquids, some technologies are influenced by the unique fluid properties at wellheads. For example, seawater and brine solutions can affect water detection capacitance readings. Paraffin and high-wax content hydrocarbons have unusual surface tension properties that can influence flow patterns, the Reynolds number, emulsification formation and gas-liquid mixing relationships. Gas producers are now questioning the ability of meters to perform in field conditions based solely on water, surrogate hydrocarbon liquid calibrations and theoretical fluid property corrections.

In 1999, CEESI set out to quantify two-phase flow measurement errors by building a wet gas test facility (WGTF). CEESI’s WGTF is a closed-loop system that circulates high-pressure natural gas in a loop and injects hydrocarbon liquids and water into the gas stream. The combined multiphase liquid and natural gas fluid travels past the meter being calibrated, called the meter under test (MUT).

By separately measuring the injected liquid flow rates and the dry natural gas flow rates before they combine, the over-registration/under-registration of the MUT can be accurately determined. CEESI’s facility uses a bank of liquid Coriolis meters, along with gas turbine and ultrasonic gas meters in series, to determine the individual liquid and gas flow rates.

While the engineering principles of a multiphase test facility are simple, the operation is complicated and involves gas-liquid separators, liquid-liquid separators, heat exchangers, chillers, charging and recirculating compressors, dozens of pressure and temperature measurements, real-time gas chromatography, and level and quasi-steady state balancing.

New Multi-Phase Demands

As the value of oil and gas increases, the need for lower uncertainty flow measurement increases. Gas companies are becoming increasingly concerned that the diverse liquids coming out of the ground from different gas formations cause flow measurement errors not captured by just mixing natural gas with water and immiscible hydrocarbons.
Gas formations contain varying amounts of aromatic hydrocarbons and paraffin-based condensate liquids. Offshore wells bring sea water and brine solutions to platforms and measurement locations. These various liquids have a wide range of densities, viscosities and fluid properties that can affect a flow meter’s performance in unpredictable ways.

High velocities and elevated turbulence levels can cause liquids to combine with different natural gas components to form emulsifications, a foamy mixture of gas and liquids. At lower temperatures, water molecules can combine with methane molecules to create hydrates — methane ice-snowballs that can plug pipes and shut down operations.

**Custom Liquids In WGTF**

To meet these demands, CEESI had to modify its facility. Injecting salt water, brine solutions, or waxy paraffin liquids into the existing facility would foul the piping and contaminate the next test setup. Building separate test facilities for the vast number of liquids was economically impossible.

The solution was to build an additional adaptable test facility that could inject an array of liquids over a wide range of flow rates into the gas stream, and then capture the injected liquids immediately after the MUT. CEESI’s Custom Liquids Wet Gas Test Facility (CL-WGTF) was built and commissioned in 2013.

While many of the design and operational features of the CL-WGTF remain proprietary, the diagram below shows the general layout.

One of the biggest engineering challenges facing the CL-WGTF was moving the many and diverse liquids from pressurized holding tanks to the liquid injection site. The injecting liquids have densities ranging from 1.03 g/ml (sea water and brine solutions) to 0.74 g/ml light hydrocarbons (kerosene, Exxsol D-80). The viscosities range from 0.5 cP to 150 cP.

The flow rates need to be controlled from 0.5 gpm to 42 gpm with operating temperatures varying from 50° F to 125° F. Many of the liquids are flammable and toxic. Standard piston-style positive displacement pumps produce pulsations in the flow stream that can influence a flow meter’s performance. Electrical power availability and operational economic constraints limit pumping horsepower ranges.

**Proper Pump Design**

The solution was to use three magnetic-drive, centrifugal pumps for the low-flow,
high-suction pressure (1,000 psi) application. The pump design included a high nickel alloy rear casing material for corrosion resistance and the high static pressure rating needed to minimize hysteresis losses. Custom high-torque inner and outer magnets were also used.

To further reduce power consumption and to control the flow rates over our wide operating range (0.5 to 42 gpm), programmable variable frequency drives (VFDs) were used. Maximum-diameter pump impellers were used, which resulted in higher efficiencies at the lower speeds and gave the facility greater flexibility in other applications requiring high flow rates and non-favorable specific gravities and viscosities. Maximum-diameter pump impellers provided a significant improvement over the original plan to use trimmed impellers with constant speed drives.

Because the liquids being pumped have such a wide range of viscosities and lubricity, the pumps were supplied with special silicon carbide (SiC) bearings for protection during startup. Additionally, the bearings incorporated a hydrodynamic bearing design in which the pumped liquid acts like a “cushion” (similar to car tires hydroplaning on wet pavement).

The seal-less design eliminated potential leak-path issues and provided an added level of safety for the flammable liquids. The pumps were supplied with close-coupled motors, eliminating alignment issues and making the footprint smaller.

The curve shows the theoretical pump performance for the initial liquids used in commissioning the CL-WGTF (water, monoethylene-glycol and hydrocarbon condensate).

The table illustrates the importance of properly calculating head for various fluids – failure to do so could mean the pump selected is not large enough. CEESI was pleasantly surprised that the pump supplier met its extremely tight delivery schedule and during the commissioning of the CL-WGTF all three pumps either met or exceeded the manufacturer’s predicted performance curves.

### Lessons Learned

While this article discusses custom liquid wet gas testing, several lessons were learned in the building of the CL-WGTF that gas producers and processors should find valuable:

1. Spend the extra money on the critical components that drive your system.

<table>
<thead>
<tr>
<th>Liquid Specific Gravity</th>
<th>Desired pressure</th>
<th>X 2.31 / sp. gr. = head</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>100 psi</td>
<td>231 feet</td>
</tr>
<tr>
<td>0.85</td>
<td>100 psi</td>
<td>272 feet</td>
</tr>
<tr>
<td>0.74</td>
<td>100 psi</td>
<td>312 feet</td>
</tr>
</tbody>
</table>
CEESI spent the extra money on quality pumps and VFD controllers and it paid big dividends in operating costs, long-term maintenance and safety.

2. Flush your system prior to startup and install witches hat strainers on the pump inlets. While CEESI installed 30-micron high-pressure filters and flushed all of the pressure vessels prior to startup, piping runs leading from the filters to the inlet of the pumps could not be flushed in situ. As Josh Kinney, WGTF operations director, said, “We installed witches hat strainers on the pump inlets and that saved our bacon. Unexpected weld slag and pipe rouge lodged in the witches hat strainers, which would have damaged our new pumps.”

3. Use a VFD to control pumps. If you operate over a wide flow range a programmable VFD controller is a must. It saves time and money in the long run. Pump bypass systems are more difficult to control and consume a lot more energy at lower flow rates.

4. Get your vendors onsite and have face-to-face meetings early in the design process. CEESI worked hard designing the CL-WGTF, but vendor input proved even more valuable early on in the design stage. CEESI had several onsite, face-to-face meetings with vendors that altered and improved the design of the CL-WGTF.

5. Use a pump supplier that has a lot of applications knowledge and is willing to take the time to understand your process and its challenges. CEESI learned a lot from its pump supplier.

Understanding how a pump is integrated into an entire system is critical. The relationship between head, flow rate, horsepower required, motor rpm, efficiency and VFD control on a performance curve was the difference between success and failure. Having a supplier with the experience to size the right pump based your system requirements is key.

CEESI CL-WGTF Specifications

- Maximum pressure: 1,050 psi
- Operating temperature: 60-125°F
- Nat. Gas flow rates: 10-60 feet/sec (4-inch sch 80 pipe)
- 0.8-4.8 actual cubic feet/sec
- Hydrocarbon flow rates: 10-100 lbs./min
- Water/salt water/brine flow rates: 10-120 lbs./min
- MEG/methanol flow rates: 4-40 lbs./min

CEESI History

The year was 1951: a gallon of gas cost 20 cents; Harry Truman was president; Mickey Mantle and Willie Mays were rookies and the University of Colorado’s Engineering Experiment Station (CEESI) was born.

Originally a nonprofit organization, CEESI tested rockets for the U.S. Navy. In 1966, Professor Tom Arnberg, head of the Mechanical Engineering Department at CU, moved operations to a decommissioned Atlas E missile facility and began testing flow meters. Arnberg developed some of the first high-pressure gas flow standards in the world, including the critical flow venturi (CFV). Several CFVs developed during that time are still in use at CEESI.

In 1986, CEESI reincorporated as a for-profit company, becoming the largest commercial flow test facility in North America testing both air and water.

In 1999, CEESI added natural gas and multiphase fluids testing capabilities.

In 2013, the single-pass multiphase wet gas test facility was commissioned using magnetic-drive centrifugal pumps to handle a wide range of fluids.

Authors: Eric Harman has been a project specialist and staff engineer at CEESI since 2008 and has worked in the flow measurement field for 33 years. He holds a bachelor’s degree in biochemical engineering from the University of Colorado. Harman can be reached at (970) 897-2711 or eharman@ceesi.com.

Mike Clark has been a sales and engineering manager at Magnetex Pumps, Inc. for nine years and been in the pump business for 37 years, including serving as one of Pipeline & Gas Journal’s first contributing editors. Clark holds a bachelor’s degree in engineering administration and can be reached at (713) 972-8666 or mclark@magnetexpumps.com.
Ensuring the integrity of subsea pipeline welds is vital for the oil and gas industry, with potentially damaging practical and economic consequences resulting otherwise. Vigorous testing before the pipe is placed into service is crucial and can be the difference between a successful project and an expensive disaster.

However, such testing comes with challenges. Modern techniques used in the installation of subsea pipelines can impose relatively high levels of plastic strain in the pipes being laid. Therefore, to assess the properties of pipes and associated girth welds after installation, it is necessary to simulate the straining process in a laboratory environment.

Traditional methods of simulating plastic strains generated during installation have used bonded strain gauges. However, work has been carried out at Exova’s specialist mechanical and fatigue testing plant in Daventry, UK, to measure the limitations of this type of gauge. Most notably, the gauges may vary in performance when subjected to multiple reversed plastic strain cycles, which is not surprising, given that bonded strain gauges are essentially elastic devices. Consequently, the team researched improved methods of measuring applied strains and carried out performance comparison tests on two optical strain measurement (OSM) systems.

The results showed that the alternative systems offered more accurate and reliable performance with reduced consumable costs and specimen preparation times. These findings could have a lasting effect on the way subsea pipelines are tested in the future.

An increasingly significant number of offshore installation vessels employ pipe reeling systems, making them an industry-wide trend. This method employs a string of pipes welded together onshore and wound onto the vessel around a large-diameter storage reel for transportation. Installation involves the pipe string being “overboarded,” a technique that sees the string wound out of the storage reel over a similarly large-diameter aligner reel and then into a clamping mechanism that straightens the pipe before it enters the water.

While efficient, this method is demanding upon the pipeline and its welds as the reeling cycle process imposes high levels of plastic strain in the pipe and weld material. For any post-installation assessment of fracture toughness and material properties, the imposed strain of the installation must be taken into account.

One way of achieving this has been to simulate the reeling cycle of the whole pipe in the laboratory before test specimens are extracted from the sample pipe material. This is expensive and limits the number of samples that can be extracted. An alternative is to remove relatively small strip samples from across the weld and impose the strain on individual sections of material loaded to a set of target strain values. These are usually calculated using reeling parameters such as reel radius, pipe diameter and pipe wall thickness.

Industry standards must be adhered to during this process; for example, DNV-OS-F101, requiring the strain to be measured either side of the weld and on the inner and outer wall of the sample.

Since 2010, the Daventry facility has assessed alternative methods of measuring strain that aim at mitigating some of the limitations found in strain gauges. Particular focus has been placed on two optical variants: laser light source and high-resolution cameras.

Through testing and experimentation, it has been found that OSM systems offer several benefits. Crucially, they are not susceptible to mechanical degradation during testing, so accuracy can be maintained, regardless of the loading and cycle length of testing.

Being almost completely non-contact, they are also extremely flexible with virtually no limitations on the types of rigid materials that can be tested, allowing for greater scope in analysis and practicality.

Timing and costs are important factors in testing. Both systems offer quicker test coupon preparation when compared to bonded strain gauges, requiring only removal of surface mill scale, spraying with low-reflection paint and installation of contrasting adhesive-backed markers where gauges would usually be located.

Laser System

The first system tested was laser-based. The apparatus used a pair of laser-light source generators, one aimed at the outer “cap” surface of the test coupon, the other aimed at the inner...
Reinforced Scraper Pig Cup gives more mileage per cup, provides tighter wall seal, and continued wall contact. A series of patented gussets flex with wall diameter, helps support pig as cup lip wears. Provides stronger support, requires fewer passes. Field tested with excellent results.

Mechanical and Electrical Pig Passage Indicators are easily installed and may be interchanged with existing equipment. Only one moving part, stainless steel construction, completely pressure balanced, without requiring dynamic seals. The first virtually completely pressure balanced, without re-verification work proved that the laser system measures strain to within, at most, 0.05% to a magnitude of 3% strain. While these figures were considered accurate, some challenges were identified during the trials. Some variation in precision, due to changes in ambient light conditions and local temperature fluctuations, was noted, and precautions had to be taken for future testing to avoid these influences.

Following the investigation, trial and verification process, finalized system specifications were provided to the manufacturer by the team and, after a final shakeout, the complete system was installed in the Exova Spijkenisse, Netherlands laboratory and has been in use in the Netherlands since 2012.

Real-Time Strain Sensor System

The second system examined was a camera-based module. Named “Real-Time Strain Sensor” (RTSS), it consisted of two high-resolution cameras aimed at the test coupon and operating at a frame rate of about 200 Hz. The system identifies significant contrast change to determine the position of the markers.

This is similar in principle to the marker-detection process of the laser system. The software tracks the pixel change between markers during loading by comparing the latest frame to the previous frame. This then converts the change into a real-time strain output.

In both cases, verification work has shown

In the testing industry for both the consumer and industrial markets. Major has managed several significant project testing programs in support of subsea pipeline ECA projects across the world.

Ed Fowkes is a technical specialist and production manager based at Exova’s Daventry facility. He is responsible for ensuring test programs meet the clients’ technical and commercial needs. Fowkes has overseen multi-stage testing projects, predominantly for the oil and gas industry.
Workforce Housing For Pipeliners, Planet And Profit

By Richard Rothaus, Research Associate, North Dakota State University, Fargo

Well-organized workforce housing can be a valuable partner for companies pursuing their sustainable development goals, as well as a component of long-term profitability.

Such housing can assist companies in recruiting and retaining skilled workers, as well as insulating workers from the daily life disruptions that are common in areas with insufficient or nonexistent infrastructure. Reusable modular structures offer a green building solution for housing, and have built-in conservation and cost-saving features.

Workforce housing also can offer essential services that reduce the environmental footprint of company operations, including wastewater treatment and transportation services. By providing an independent and largely self-sufficient infrastructure, such accommodations can significantly reduce negative effects on smaller communities caught up in rapid industrial development.

By addressing the triple bottom line (TBL) of social responsibility (people), natural capital (planet) and economic prosperity (profit), appropriate workforce housing can be an important component of both short- and long-term business success.

Natural And Social Capital

Structured workforce housing presents a valuable opportunity for companies to meet operational goals of sustainable development. Sustainable development has been recognized as necessary for medium- and large-sized companies to remain competitive in a global marketplace.

Successful businesses must be both “eco-efficient” (with the economic value added being proportional to environmental impact) and “socio-efficient” (with the economic value added being proportional to social impact).

In other words, long-term business success requires attention to not only short- and long-term economic capital, but also long-term natural and social capital.

Companies that ignore this reality run the risk of issues in supply chains, workforce availability and access to areas with desirable natural resources. Sustainable development is not an abstract principle, but a real component of 21st century business success.

This type of housing has its origins in the Texas oil booms of the 1930s and ’40s, when oil companies attempted to address the untenable situations of workers living in squalor and small towns overrun and paralyzed by sudden population booms.

Well-organized workforce housing is an area in which businesses easily can address sustainable development goals. Such accommodations serve to protect the health and safety of workers, as well as the health and safety of the communities where companies do business. At the heart of long-term health and safety is sustainable development, as it helps guarantee clean air, water, land and communities for future generations.

‘Triple Bottom Line’

Well-organized workforce housing solutions address the three pillars of sustainable development: social, environmental and economic. For businesses, these translate into the “triple bottom line.” None of these can be easily substituted for the other.

Social Responsibility: Companies recognize they have a responsibility to be positive participants in the communities where they work. For remote industrial operations where workforce housing is required, the influx of workers and their effect on existing infrastructures is a focal point of community interaction and concern.

Good relationships with these communities are essential for continued operations in such areas, and quality workforce housing offers solutions to real problems. An influx of workers plays havoc with housing availability and pricing, often creating hardships for locals who can be squeezed out of the market. While this effect is perhaps inevitable in any boom economy, companies that use workforce housing keep the majority of employees out of the housing market, reducing the negative aspects of housing economics.

Workforce housing that’s professionally managed also can address major and very real infrastructure concerns. Workers, for example, do not overwhelm the existing water and sewage systems, because the housing provides its own. Further, local retailers aren’t overwhelmed, causing periodic shortages and long waits for goods and services.

One of the biggest, and largely unnoticed, benefits of such accommodations is reduced road traffic. Like water and sewage, road infrastructure is expensive and slow to catch up with a boom environment.

While the majority of the wear and tear comes from truck traffic, the thousands of workers also have a major impact, especially on traffic congestion, dust control issues and emissions. By getting thousands of workers out of private vehicles and onto buses and into van pools, workforce housing can be a strong contributor to reducing strain on local transportation infrastructure.

With reduced traffic and centralized living, quality workforce housing also directly addresses the safety and security concerns of employers, employees and locals. Companies that place workers in such accommodations effectively keep them in a secure and monitored environment nearly 24 hours a day.

Over the long term, these benefits help alleviate issues about pricing for housing and consumable goods, waits at stores and service industries, traffic issues and water quality. State and local governments are limited in their ability to address these issues, as they must exercise caution about overbuilding and overstaffing for a temporary situation.

Centralized workforce housing, when done correctly, offers great assistance by providing the infrastructure when needed, and removing it when no longer needed. While the degree of...
actual versus perceived impact on these issues can be difficult to determine, there is no doubt that the issues are quite real.

Natural Capital: Companies that require workforce housing are frequently focused on resource extraction and know the costs of wasting natural capital. Such accommodations can help these companies meet environmental protection goals by adhering to the standard principles of reduce, reuse and recycle.

Appropriate workforce housing uses multiple strategies to reduce consumption of resources in the living arrangements of workers. Some reductions are obvious: low-flow faucets, showers and toilets; energy-efficient washers and dryers; thermostat controls and energy-efficient lighting. When housing is supplied for thousands of workers, the reduction in usage of water and electricity can be substantial. So can savings.

Other reductions in the use of resources are less obvious but equally important. When providing centralized food services, workforce housing reduces the packaging and shipping used in feeding workers. Workforce housing providers also can be well-positioned to collect cardboard, glass and plastics for recycling, something shift workers in makeshift housing are not inclined to do. Many lodging solutions provide centralized transportation for workers to job sites, replacing hundreds of vehicles with a handful of buses.

The greenest building is, of course, the building that is never built, and workforce housing that uses reusable modular structures is always a greener solution than building permanent structures for a temporary housing need. When the structures are no longer needed at one location, they can be moved to another. Operated by Target Logistics, the Muddy River Lodge in North Dakota was moved there after serving as a housing facility for the 2010 Winter Olympics in Whistler, British Columbia.

Modular structures are also standardized, which means that not only the structures but the parts within structures can be more easily reused. When all the sinks are the same, for example, it is easy to replace a broken one with a used one. Modular prefabricated buildings (for example, steel-constructed housing) also are made out of materials that are easier to reuse and recycle once a building has reached the end of its life cycle.

Wastewater treatment is often a major challenge for housing at remote industrial sites. When housing is decentralized, existing systems are not likely capable of handling the massive increase in gray water and sewage. The result is a haphazard network of septic systems, overwhelmed local sewage systems, and questions of illegal dumping practices. When worker accommodations are centralized, so is the collection of grey water from cooking, bathing and laundry, as well as sewage. A responsible workforce housing provider is thus able to use the best available treatment techniques.

In North Dakota, Target Logistics proactively built its own state-of-the-art wastewater treatment facility, capable of treating 180,000 gallons per day, when it became apparent the town’s existing infrastructure was insufficient to handle the increased volume from the housing facilities.

The wastewater treatment plant is located at the company’s largest facility, and wastewater and sewage from its other facilities are transported to the location for treatment.

With more than 4,000 beds spread across several facilities in North Dakota, this represents a sizeable effort. The facility also treats its sewage wastewater sufficiently to reuse for other purposes, including road dust control and agriculture. The importance of this effort is emphasized when put into context: Tioga, the town closest to this facility, has a population fewer than 1,500 and relies on a lagoon system.

In an area that suffers from major water supply and treatment issues, the service provider quickly established a functional treatment system of a sort regional cities are now trying to build. Such an effort, associated with workforce housing, represents a major contribution in sustainable development.

Economic Prosperity: While a relative term, economic prosperity is the value created by the organization after deducting the cost of all inputs. Well-organized workforce housing is key to helping companies gain multiple benefits. These include the ability to recruit and retain qualified staff and products, reduce costs by partnering with efficient and quality superior to that locally available; and hardship issues; motivate workers with housing quality superior to that locally available; and reduce costs by partnering with efficient and experienced workforce housing professionals.

Good Business Practice: Businesses of the 21st century should keep an eye on social justice, environmental quality and economic vitality. A focus only on the bottom line will no longer suffice, as clients, customers and the demands of regulation and the international marketplace require more.
The market is driven not by compliance with minimal standards, but by delivery of superior product design and quality. At the same time, companies both small and large continue to incorporate ethical values and policies into business plans; these values are reflected by choosing partners and suppliers that share similar value systems.

Rapidly increasing global communication has generated levels of transparency and accountability that cannot be ignored. Businesses, customers, employees and communities are increasingly insistent that the environmental impact of products and services be minimized.

An MIT Sloan Management Review notes that the benefits of sustainability can be intangible and hard to quantify. However, two areas that the benefits of sustainability can be intangible and hard to quantify. However, two areas of benefit are of particular concern:

- Consumers are willing to pay a premium for products associated with sustainable development efforts.
- Employee commitments to sustainability make it an important element in recruiting and retaining quality employees.

The study, which surveyed 2,600 executives, reports that 60% of companies that changed business models and had sustainability as a permanent agenda item added profitability from those sustainability efforts.

Conclusion

Sustainable development that addresses the “triple bottom line” is an important component of professional workforce housing for businesses in areas with insufficient infrastructure. Because workforce housing is a resource-intensive business, sustainable solutions are cost-saving solutions that increase profitability and lower housing costs for clients.

Many of the clients that require workforce housing solutions are involved in resource extraction and environmentally sensitive activities. By partnering with companies that prioritize environmental quality, these clients protect and enhance their own environmental quality standards and initiatives.

When managed properly, workforce housing also directly addresses two major social justice issues. First, it provides safe, affordable and healthy living conditions for the skilled workers who are essential for successful business. Second, it minimizes the effect of “booms” on existing communities, which is key to both continuing operations and upholding the industry’s responsibility of doing no permanent harm to the locations where it operates. P&GJ

Author: Richard Rothaus is president of Trefoil Cultural and Environmental and a research associate at North Dakota State University. He has expertise in the history of housing and vernacular architecture, and has conducted historical and archaeological surveys of North Dakota’s oil boom. He can be reached at rothaus@trefoilcultural.com.

Study Shows Technology Best Solution For Utility Transformation

Mu ch of the world’s developed gas, water and electric infrastructure is aging and in need of modernization. Many utilities still rely on the same electric grid that was built 100 years ago, and many of the water and gas pipes that were laid decades ago.

Increasingly, the traditional utility business model is being challenged, and innovations are constantly changing the energy mix and how resources are used, particularly in natural gas. Every day, utilities are asked to be more efficient and resourceful.

To help quantify the challenges facing gas, water and electric utilities, Spokane, WA-based utility metering giant Itron conducted a world-wide study of the utility industry — the Itron Resourcefulness Index. This annual index surveyed countries around the world to gauge how resourceful each considers the industry, what current challenges each face and what might present barriers to advancing the industry.

The findings indicated that a majority of utility executives and consumers believe utilities need greater operational efficiency with almost universal agreement among utility executives that the industry needs to be transformed to meet the changing landscape.

Technology innovation has transformed the natural gas sector over the last five years. On the supply side, hydraulic fracturing and horizontal drilling have resulted in a production boom that has dramatically changed gas reserves and forecasts. The United States has led the boom, but other countries have begun to experiment with new drilling approaches and are seeing significant shifts in the potential for supplies.

The huge increase in supply has decreased prices and led to increased use of fuel. Natural gas use in the electricity sector alone rose by more than 20% in 2012, according to the U.S. Energy Information Administration (EIA), and forecasts are so positive that the fuel is being used in an increasing number of homes and for an increasing number of purposes, such as powering cars.

But the revolution in supply has not led to increased adoption of gas usage measurement tools or advanced measurement technology. In fact, the increased supply has made efficiency improvements seem less pressing. While the windfall energy supply has eased concern over resource shortages, the extra gas supply should be used responsibly.

The Resourcefulness Index found that 94% of utility executives across gas, water and electric utilities believe the industry needs to be transformed to achieve operational efficiencies. Within the natural gas sector, utility executives are least concerned about a definite need for industry transformation, with 29% noting concern, compared to 48% in electricity.

But that doesn’t mean the sector has no worries. Four out of 10 natural gas executives remain uneasy about their ability to deliver adequate services to meet demand. Meanwhile, only 13% of customers feel they receive an adequate level of information from gas utilities; this was the lowest stated consumer engagement rate of utility types surveyed.

Even though the resource is abundant and

A typical dining area at a workforce housing location.

The huge increase in supply has decreased prices and led to increased use of fuel. Natural gas use in the electricity sector alone rose by more than 20% in 2012, according to the U.S. Energy Information Administration (EIA), and forecasts are so positive that the fuel is being used in an increasing number of homes and for an increasing number of purposes, such as powering cars.

But the revolution in supply has not led to increased adoption of gas usage measurement tools or advanced measurement technology. In fact, the increased supply has made efficiency improvements seem less pressing. While the windfall energy supply has eased concern over resource shortages, the extra gas supply should be used responsibly.

The Resourcefulness Index found that 94% of utility executives across gas, water and electric utilities believe the industry needs to be transformed to achieve operational efficiencies. Within the natural gas sector, utility executives are least concerned about a definite need for industry transformation, with 29% noting concern, compared to 48% in electricity.

But that doesn’t mean the sector has no worries. Four out of 10 natural gas executives remain uneasy about their ability to deliver adequate services to meet demand. Meanwhile, only 13% of customers feel they receive an adequate level of information from gas utilities; this was the lowest stated consumer engagement rate of utility types surveyed.

Even though the resource is abundant and