Today’s Webinar Topics

- Beneficial use of LFG and project types
- Typical landfill gas collection system & gas well components
- Challenges managing the LFG well field
- How leachate/condensate affect collection system efficiency
- Benefits and economics of LFG well dewatering systems
- Monitoring liquid levels in LFG wells
- Pumps used to dewater LFG wells
- Traditional LFG wellheads – types and limitations
- Advancements in LFG flow control and measurement
- QED Precision Control Valve and Wellhead Systems
- Question and answer session
**LFG Collection & Control System Benefits**

- Comply with federal, state & local air quality regulations
- Control odors from gas, minimize neighbor complaints
- Use LFG as a fuel to offset a fossil fuel source
- Generate electricity, sell to utility or end user (LFGTE)
- Collect carbon credits for destruction of gas (flare)
- Investment Tax Credits or Production Tax Credits for renewable energy or fuel made from LFG
- Generate tradable credits for renewable energy generation or biofuel from LFG
  - Renewable Energy Credits (RECs) for LFGTE plants
  - Renewable Identification Numbers (RINs) for alternative fuels

**Direct Use of LFG: Medium Btu Projects**

- Gas is used with **minimal treatment** to run boilers and kilns or heat buildings, replacing fossil fuels
  - Key is to find a potential user close enough to make pipeline cost pay off
- Gas can be used on site to evaporate leachate or liquid wastes
- Gas can be flared for carbon credits
  - Market for carbon credits has dropped sharply since 2009
  - In USA, future credits are lost if LFG collection is required by regulation
Landfill Gas to Energy (LFGTE) Projects

- Revenue from sale of electricity to power grid or to an end user
- In USA, Renewable Portfolio Standard (RPS) regulations are a major economic driver
  - Renewable Energy Certificates (RECs) can be worth more than electric power
  - Still generate RECs if LFG collection system becomes mandatory
- Gas pretreatment is typically limited to removing moisture and particulate
- High siloxanes or hydrogen sulfide (H₂S) level may require greater pretreatment
- High O₂ or air in gas can result in engine damage, typically not removed by pretreatment

High-Grade LFG Uses: High Btu Projects

- High quality and high-Btu gas can be sold to utility pipeline or to an end user
- High Btu gas can also be used to make fuel – CNG, LNG, methanol feedstock
- Often requires significant gas treatment to remove O₂, N₂, H₂S, and siloxanes
  - can be expensive ($1M or more), which can increase gas production cost as much as 50%
- Better field practices and well field maintenance can pay off – it costs much less to prevent air leaks into system than to remove O₂ and N₂ later through gas treatment
LFG Well Field Management Challenges

- Maximize LFG energy content (combined flow rate and methane concentration) where gas is utilized
- Avoid NSPS exceedances for pressure, temperature & oxygen (PTO)
- Maintain compliance with LFG emission regulations
- Avoid odor complaints from neighbors
- Reduce time and labor spent for well field management
- Reduce and simplify well field maintenance and repairs

Maximize gas collection efficiency while maintaining regulatory compliance, all at the lowest possible cost.
Typical Landfill Gas Well Components

- Rock or Gravel Backfill
- Perforated Pipe/Screen
- Annular Seal
- Gas Collection Header Pipe
- LFG Wellhead Flow Control Valve

Leachate Flow in Typical MSW Landfill

- Gas Header Pipe
- Flare/ LFGTE Plant
- Daily Cover Material
- Leachate Flow
- Gas Extraction Wells
- Waste Cells
- Monitoring Probes
Benefits of Increased Moisture Content and Leachate Recirculation

Landfill Methane Generation Model
(250,000 Tons Per Year Disposal; Closure Year 30)

- Dry Site (k=0.02)
- Wet Site (k=0.06)
- Bioreactor LF (k=0.5)

Problem:
- Leachate/condensate accumulate in gas wells, blocking screen openings and reducing gas flow
- Long-term accumulation can clog the well screen and backfill, leading to permanent reduction in gas flow from the well
- Leachate recirculation can accelerate leachate buildup in gas wells
Liquid in LFG wells and surrounding waste causes gas and liquid to compete for pore spaces in waste and results in high shut-in gas pressure, causing leachate seeps or blowouts and forces silt into wells while reducing gas collection rates.

Gas Flow vs. Liquid Levels in Wells (Clarke, 2007)

- **White Areas = High gas flow**
- **Blue Areas = Low/no gas flow**
- **Blue Areas = High Liquid Levels**
Solution:

- Install a dedicated pumping system to dewater the well to increase gas flow and maintain long-term viability of the well

- Dewatering increases the zone of influence around well, reducing LFG emissions and odors and air leaks into system, improving gas quality and NSPS regulatory compliance

Zone of Influence

- Leachate accumulation effectively shortens the length of the well intake and reduces the “zone of influence” in the waste

- Dewatering the well and surrounding waste can increase the zone of influence with no increase in vacuum, reducing the risk of air infiltration and maintaining gas quality
### LFG Collection Rate Improvement:
**Gramacho Landfill, Brazil**

<table>
<thead>
<tr>
<th>Well</th>
<th>LFG Flow (SCFM) Before Pumping*</th>
<th>LFG Flow (SCFM) After Pumping†</th>
<th>Change in LFG Flow SCFM</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>25</td>
<td>40</td>
<td>15</td>
<td>59%</td>
</tr>
<tr>
<td>39</td>
<td>243</td>
<td>335</td>
<td>91</td>
<td>38%</td>
</tr>
<tr>
<td>43</td>
<td>25</td>
<td>49</td>
<td>24</td>
<td>95%</td>
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<td>44</td>
<td>43</td>
<td>58</td>
<td>15</td>
<td>35%</td>
</tr>
<tr>
<td>45</td>
<td>17</td>
<td>27</td>
<td>10</td>
<td>61%</td>
</tr>
<tr>
<td>47</td>
<td>26</td>
<td>73</td>
<td>46</td>
<td>176%</td>
</tr>
<tr>
<td>54</td>
<td>40</td>
<td>79</td>
<td>39</td>
<td>99%</td>
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<tr>
<td>55</td>
<td>37</td>
<td>82</td>
<td>45</td>
<td>120%</td>
</tr>
<tr>
<td>64</td>
<td>59</td>
<td>98</td>
<td>39</td>
<td>66%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>554</strong></td>
<td><strong>898</strong></td>
<td><strong>344</strong></td>
<td><strong>62%</strong></td>
</tr>
</tbody>
</table>

* Average of 6-8 flow measurements taken over 30 days (August 2009)
† Single flow measurement taken after dewatering (October 2009)

### Gas Well Dewatering - Economics

**Additional Annual Gas Value @ 50% Methane**

<table>
<thead>
<tr>
<th>Gas Value ($/mmBtu)</th>
<th>1 CFM</th>
<th>5 CFM</th>
<th>10 CFM</th>
<th>25 CFM</th>
<th>50 CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.50</td>
<td>$394</td>
<td>$1,970</td>
<td>$3,940</td>
<td>$9,850</td>
<td>$19,700</td>
</tr>
<tr>
<td>$2.00</td>
<td>$525</td>
<td>$2,625</td>
<td>$5,250</td>
<td>$13,125</td>
<td>$26,250</td>
</tr>
<tr>
<td>$2.50</td>
<td>$657</td>
<td>$3,285</td>
<td>$6,570</td>
<td>$16,425</td>
<td>$32,850</td>
</tr>
<tr>
<td>$3.00</td>
<td>$788</td>
<td>$3,940</td>
<td>$7,880</td>
<td>$19,700</td>
<td>$39,400</td>
</tr>
<tr>
<td>$3.50</td>
<td>$920</td>
<td>$4,600</td>
<td>$9,200</td>
<td>$23,000</td>
<td>$46,000</td>
</tr>
<tr>
<td>$4.00</td>
<td>$1,050</td>
<td>$5,250</td>
<td>$10,500</td>
<td>$26,250</td>
<td>$52,500</td>
</tr>
</tbody>
</table>

As little as 5 CFM additional gas flow per well at $2.50/mmBtu can pay for a $3,300 dewatering pump system in just one year, with additional annual revenue generated thereafter.

Try the latest QED LFG Calculator at www.qedenv.com/landfillgas
Benefits of LFG Well Dewatering

- Maximize gas collection rates and zone of influence
  - Increase revenues where gas is utilized
  - Reduce fugitive emissions, odors
  - Maintain regulatory compliance in gas wells
- Reduce liquid accumulation in collection piping & sumps
- Maintain steady operation of generators and flares
- Prevent damage to blowers, engines, and flares
- Increased useful life of LFG wells by reducing clogging and encrustation of well screens and backfill

Common Gas Well Dewatering Pumps

- Electric submersible (centrifugal) pumps
- Air-powered automatic pumps
- Piston pumps

*Each is affected differently by site factors*
Air-Powered Automatic Pump Advantages

- High-clearance design for solids handling
- Built-in level control, no level sensors required
- Low-speed moving parts minimizes wear
- Gentle pumping action reduces foaming
- Bottom inlet can pump down to 15” (38 cm)
- Handles high-viscosity liquids, high temperatures
- Wide range of materials handles low pH, high chlorides, aggressive chemicals
- Soft failure mode – simply flush solids out
- Explosion-proof, no shock hazard
- Light weight eases installation and service
- Longer warranties than electric or piston pumps

Air-Powered AP4+ Pump Components
AutoPump® AP4+ Design Features

**Easier disassembly:** removing four bolts from the bottom inlet allows complete disassembly of the pump in minutes – no multiple turns of the inlet or O-ring hang-up

**Easier service:** A quick-release clip on the actuator rod stop allows quick float removal for easier cleaning of the center rod. The pump body has a high-polish ID finish to reduce solids buildup and precision bore sizing to improve O-ring fit

**Increased durability:** All metal parts are 304SS or higher for improved corrosion resistance; plastic parts are high-strength & high-temperature Kynar® PVDF

**Increased warranty:** The industry’s only 5-year full warranty with no prorating in later years provides unparalleled coverage

Monitoring Liquid Levels in LFG wells

- Tracking liquid levels over time can identify wells that could benefit from a dedicated dewatering pump system.
- QED survey shows more than half of all landfills don’t routinely measure liquid levels due to problems with access or level measurement devices.
- Wells without a cap access port require shutting down gas flow, removing the cap, then rebalancing the well after the cap is replaced. Techs are also exposed to LFG and leachate.
- Installing a dedicated liquid level probe or indicator can save valuable field labor and improve data collection.
QED Easy Level™ High Level Indicator

- Works without opening the well – no air gets in, no gases get out, no vacuum interruption
- Bright orange indicator pops up when liquid level in well rises above set point
- Self-powered – no batteries, electric power supply or air compressor needed
- Not affected by foam – only reacts to liquid
- Can be used with optional hand-held gauge or digital display for liquid level measurement when the level probe is submerged
- About $250 per well – much lower cost than transducer systems and no labor to access the well like manual level tapes

Easy Level System Components

The Easy Level system consists of an indicator at the wellhead, ¼-inch nylon tubing and a short, hollow stainless steel probe positioned at the alert level
Digital Liquid Level Measurement System

- The Digital Level Meter uses a compact, lightweight compressor powered by rechargeable batteries.
- Probe installed below liquid level allows quick-and-easy level readings without opening wells or interrupting vacuum
- Range to 100 feet (30 meters) of liquid level change at any well depth
- Accuracy not affected by foam in wells or vacuum in the well
- Level probe kits about $100 for 50-foot (15m) well; Digital Level meter $1,225

Traditional LFG Wellhead Designs

- **PVC gate valve** for flow control is most commonly used due to low cost and wide availability
- **Union orifice plate, pitot tube or venturi** used for flow measurement (calculated from differential pressure)
- **Flexible rubber couplings** used for connections between the gas well casing and wellhead
Problems with Traditional Wellheads

- **Gate valves were designed for controlling liquids, not for regulating gas flow** – small adjustments in valve opening can result in large changes in applied vacuum and resultant flow, often resulting in “over-pulling” on the well and air leaks into the landfill and the gas system.

- **Field techs can’t determine valve position**, so recording changes in valve settings is reduced to counting “valve turns” – highly subjective, not truly reproducible.

- **Gas flow measurement can be highly inaccurate** - pitot tubes, venturis, and orifice plates can have accuracy limitations or can be difficult to use, resulting in flow measurement and reporting errors.

Flow Control Using Gate Valves

**Advantages**
- Lower initial cost than other valve designs
- Widely available

**Disadvantages**
- Non-rising stem, so operator can’t observe valve opening position
- Plastic threads can strip, plastic handle can break off with age
- Seals can fail, dirt and grit can get into threads and gate track, and extreme cold and heat can make valve difficult or impossible to adjust or cause the valve stem to break when excessive force is applied
- **Gate valve is fully open in just 3 – 4 turns, flow adjustment isn’t linear and can be difficult to regulate, especially at low flow rates**
Traditional Gate Valve

- Patented flow-tuned valve design provides precise, linear control of flow from fully closed to maximum flow.
- Rising stem design and highly visible metered scale allows observation of valve position setting, making it easy to quickly return to the exact setting if the valve must be closed.
- Rugged stainless steel valve stem and handle make it more durable in harsh outdoor environments.

Precision Fine Tune Control Valve™

- Patented flow-tuned valve design provides precise, linear control of flow from fully closed to maximum flow.
- Rising stem design and highly visible metered scale allows observation of valve position setting, making it easy to quickly return to the exact setting if the valve must be closed.
- Rugged stainless steel valve stem and handle make it more durable in harsh outdoor environments.
Precision Fine Tune Control Valve™

- PVC gate valve offers very little flow control, especially at lower flow rates, with maximum flow achieved at just four turns.

- QED Precision Valve has nearly linear flow control across entire range of valve opening, with unparalleled control at flows under 20 CFM.

QED Precision Valve vs. PVC Gate Valve

<table>
<thead>
<tr>
<th>CV2000 - 2&quot; Valve</th>
<th>Flow Rate (SCFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Turns</td>
<td>0.15 cfm 0.150 cfm</td>
</tr>
<tr>
<td>QED</td>
<td>3 8</td>
</tr>
<tr>
<td>Other</td>
<td>1 3</td>
</tr>
</tbody>
</table>

- PVC gate valve offers very little flow control, especially at lower flow rates, with maximum flow achieved at just four turns.

- QED Precision Valve has nearly linear flow control across entire range of valve opening, with unparalleled control at flows under 20 CFM.
Case Study: South Texas Landfill – Well 54

The QED Precision Fine-Tune Valve eliminated wide swings in methane concentration and air leaks into the well, improving the overall gas quality while avoiding NSPS exceedance.

Better Flow Control = Higher Gas Heat Content

<table>
<thead>
<tr>
<th>Gas Value ($/mmBtu)</th>
<th>1 CFM</th>
<th>5 CFM</th>
<th>10 CFM</th>
<th>25 CFM</th>
<th>50 CFM</th>
<th>100 CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.50</td>
<td>$8</td>
<td>$40</td>
<td>$80</td>
<td>$200</td>
<td>$400</td>
<td>$800</td>
</tr>
<tr>
<td>$2.00</td>
<td>$11</td>
<td>$55</td>
<td>$110</td>
<td>$275</td>
<td>$550</td>
<td>$1,100</td>
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<tr>
<td>$2.50</td>
<td>$13</td>
<td>$65</td>
<td>$130</td>
<td>$325</td>
<td>$650</td>
<td>$1,300</td>
</tr>
<tr>
<td>$3.00</td>
<td>$16</td>
<td>$80</td>
<td>$160</td>
<td>$400</td>
<td>$800</td>
<td>$1,600</td>
</tr>
<tr>
<td>$3.50</td>
<td>$18</td>
<td>$90</td>
<td>$180</td>
<td>$450</td>
<td>$900</td>
<td>$1,800</td>
</tr>
<tr>
<td>$4.00</td>
<td>$21</td>
<td>$105</td>
<td>$210</td>
<td>$525</td>
<td>$1,050</td>
<td>$2,100</td>
</tr>
</tbody>
</table>

As little as a 1% increase in methane concentration at a gas value of $2.00/mmBtu in a 50 CFM well can pay for a QED Precision Wellhead and Stabilizer Well Cap in just one year.

☞ Try the latest QED LFG Calculator at www.qedenv.com/landfillgas2
Common LFG Flow Measurement Methods

**Pitot Tubes** are intended to fit a wide range of flow rates, but can easily clog with condensate, mineralization and corrosion, and have poor accuracy at flows under 20 CFM (± 5-10% at best, ± 20% worst)

**Venturis** are also a “one size fits all” device, but create significant pressure drop at high flows (>12” WC @100 CFM) and insufficient pressure drop for accurate measurement at flows under 20 CFM

**Orifice Plate** sizes can be selected to match changes in flow rates, but changing plates can be time consuming, requires shutting off gas flow and breaking pipe connections, and gas techs can’t see the plate size without opening the pipe union

Quick-Change™ Orifice Plate

- Utilizes proven orifice plate technology for accurate and repeatable flow rates

- Plates can be swapped out by one person in seconds to achieve desired ΔP with changes in gas flow rate

- No time wasted shutting down the control valve, breaking pipe connections, or rebalancing the well

- Removable dust cap allows for easy confirmation of orifice plate size, reducing measurement and reporting errors

- Durable PVC construction with stainless steel orifice plates
Quick-Change™ Orifice Plate can be changed in less than 60 seconds by one person without interrupting LFG flow, saving as much as 1-2 labor hours over traditional union orifice plates.

Problems with Traditional Well Caps

- Flexible coupling “stacks” and “donuts” tend to leak air into gas system and leachate from foaming wells.
- Couplings aren’t very strong, so wellheads lean and wobble.
- Liquid level measurement requires cap removal, shuts down gas flow, and exposes operator to LFG emissions.
QED Stabilizer™ Well Caps

- First engineered LFG well cap that aligns and stabilizes the wellhead, minimizing air leaks and reducing the cost of gas treatment for LFG-to-energy and high-Btu projects
- Unique support ring molded directly into the cap takes the side load off Fernco® and flex hose
- Ports to accommodate AutoPump fittings and bubbler line for dedicated liquid level measurement or QED Easy Level™ high-level indicator
- Caps are molded in high-visibility bright yellow to reduce potential for well damage
- Durable, heavy-walled polyethylene construction makes it ideal for any climate
- Fits 6” and 8” wells with 2” or 3” LFG wellheads

QED Precision™ LFG Wellheads Designs

All featuring the Precision Fine-Tune Control Valve

Vertical with Quick-Change Orifice Plate System

Horizontal with Quick-Change Orifice Plate System
Quick-Change™ Orifice Plate Wellheads

**Specifications:**

<table>
<thead>
<tr>
<th>2” (50 mm)</th>
<th>3” (80 mm)</th>
<th>2” horizontal (50 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model:</td>
<td>Model:</td>
<td>Model:</td>
</tr>
<tr>
<td>ORP215</td>
<td>ORP315</td>
<td>ORP215HV and ORP215HL</td>
</tr>
<tr>
<td>0-125 SCFM</td>
<td>0-300 SCFM</td>
<td>0-125 SCFM</td>
</tr>
<tr>
<td>0-212 m³/h</td>
<td>0-560 m³/h</td>
<td>0-212 m³/h</td>
</tr>
<tr>
<td>Vertical</td>
<td>Vertical</td>
<td>Vertical</td>
</tr>
</tbody>
</table>

**Wellhead Materials:** PVC, Stainless Steel, Viton®

**Fitting Options:** Brass barbs, quick connects

**Quick-Change Orifice Plates**

<table>
<thead>
<tr>
<th>2” Plate Kit</th>
<th>3” Plate Kit</th>
<th>2” horizontal Plate Kit</th>
</tr>
</thead>
<tbody>
<tr>
<td>40640</td>
<td>40660</td>
<td>40690</td>
</tr>
<tr>
<td>set of 6 plates:</td>
<td>set of 3 plates:</td>
<td>set of 6 plates:</td>
</tr>
<tr>
<td>0.40” (10 mm)</td>
<td>1.25” (31 mm)</td>
<td>0.40” (10 mm)</td>
</tr>
<tr>
<td>0.50” (13 mm)</td>
<td>1.75” (44 mm)</td>
<td>0.50” (13 mm)</td>
</tr>
<tr>
<td>0.75” (19 mm)</td>
<td>2.10” (53 mm)</td>
<td>0.75” (19 mm)</td>
</tr>
<tr>
<td>1” (25 mm)</td>
<td>1.25” (31 mm)</td>
<td>1” (25 mm)</td>
</tr>
<tr>
<td>1.25” (31 mm)</td>
<td>1.25” (31 mm)</td>
<td>1.40” (36 mm)</td>
</tr>
<tr>
<td>1.40” (36 mm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Available in 2” and 3” pipe sizes for flows up to 300 CFM
- Brass barbs or quick-connects for flow measurement and LFG sampling
- Orifice plate kits contain a range of plate sizes to match flow range of valve

Resources: QED Online Tools

- **Overview and Specifications for all QED products**
  - [www.qedenv.com/Products/Equipment/Products_Overview](http://www.qedenv.com/Products/Equipment/Products_Overview)

- **Calculators** for LFG Flow & Methane Concentration, Gas Well Dewatering, AutoPump Flow Rate & Air Usage, E-Z Tray® Air Stripper Online Modeler
  - [www.qedenv.com/Online_Tools](http://www.qedenv.com/Online_Tools)

- **Engineering Specifications and Drawings**
  - [www.qedenv.com/Service/Support/Engineering_Specs](http://www.qedenv.com/Service/Support/Engineering_Specs)

- **QED Webinars** – Free Online Training and Q&A
QED Wellhead Trial Offer

Try a QED Precision Wellhead for 60 days at no charge.

At the end of the Trial Offer, you may purchase the unit or return it to QED.

To take advantage of this offer, visit us at www.qedenv.com/LFGControl

Questions?

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