Advanced Metering Infrastructure
Water and Energy Efficiency

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EBMUD Operations and Maintenance Group

Baywork Training Buffet November 14, 2018
What are we going to talk about?

- A little background on meters and AMI
- AMR/AMI history at EBMUD
- The Blackhawk Project
- The Water/Energy Projects
- Our current deployment
- Business case going forward
Automated Meter Reading (AMR) Benefits and Savings

- Labor savings
- Monthly reads
- Billing accuracy
- Reduced estimated reads
- Hard to read meters
- Ability to datalog
- Leak flags
• **Advanced Metering Infrastructure (AMI)** are systems that measure, collect and analyze water usage, and communicate with metering devices such as water meters, electric meters, pressure sensors and other instrumentation either on request or on a schedule. These systems include hardware, software, communications, consumer water displays and controllers, customer associated systems, Meter Data Management (MDM) software, and supplier business systems.
## Notable Recent Deployments

<table>
<thead>
<tr>
<th>City</th>
<th>Total</th>
<th>Status</th>
<th>Vendor</th>
<th>Web Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>178k</td>
<td>100%</td>
<td>Aclara</td>
<td>Yes</td>
</tr>
<tr>
<td>Eastern MWD</td>
<td>153k</td>
<td>82%</td>
<td>Sensus</td>
<td>Planned</td>
</tr>
<tr>
<td>Sacramento</td>
<td>140k</td>
<td>79%</td>
<td>Badger</td>
<td>Yes</td>
</tr>
<tr>
<td>Fresno</td>
<td>133k</td>
<td>100%</td>
<td>Badger</td>
<td>Yes</td>
</tr>
<tr>
<td>Hayward</td>
<td>35k</td>
<td>100%</td>
<td>Aclara</td>
<td>No</td>
</tr>
<tr>
<td>DSRSD</td>
<td>23k</td>
<td>100%</td>
<td>Sensus</td>
<td>Yes</td>
</tr>
<tr>
<td>Pleasanton</td>
<td>22k</td>
<td>100%</td>
<td>Aclara</td>
<td>Yes</td>
</tr>
<tr>
<td>New York</td>
<td>830k</td>
<td>95%</td>
<td>Aclara</td>
<td>Yes</td>
</tr>
<tr>
<td>Houston</td>
<td>1,007k</td>
<td>95%</td>
<td>Aclara/Badger/Itron</td>
<td>Planned</td>
</tr>
<tr>
<td>Albuquerque, NM</td>
<td>200k</td>
<td>50%</td>
<td>Sensus</td>
<td>Planned</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>100k</td>
<td>0%</td>
<td>Aclara</td>
<td>Planned</td>
</tr>
<tr>
<td>Memphis, TN</td>
<td>255k</td>
<td>71%</td>
<td>Honeywell/Elster</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Evolution of Meter Reading

- Straight read
- Touch read
- Telephone based systems for commercial customers
- Walk by or handheld technology
- Mobile bubble up one way
- Mobile bubble up with datalogging
- Two way mobile system
- One way fixed network
- Mesh network two way
- Two way fixed network
Building an AMI Network

- Meter Interface Units
- Collectors
- Main Computers
- End Uses

Diagram showing connections between devices such as Meters, Collectors, Sensus, Network Server, Client Workstations, CIS, WMS, OP Data, Customer Portal, and Utility Water.
Types of Fixed Data Collection

- Star Network-Line of Sight
  - Long or short range
- Mesh Network
  - Full mesh or partial mesh
- IoT-Lora, Wisun
- Cellular
- Licensed or Unlicensed
- Hybrid
What is Mesh Network?

“Modified” or “Partial” Mesh Network

Source: Don Schlenger, SAIC

“Full” Mesh Network

Meter Interface Unit

Radio Receiver/Collector
What is the “A” in AMI?

- 2-way fixed communication
- The ability to connect to other devices besides meters
- High power high bandwidth backhaul
- Web interface that customers can access granular data
- The potential ability to operate SCADA
- A sophisticated database that can mine information
- Expandability and adaptability
Foundation of A“M”I is Meters

- Types of meters and registers
- Meter accuracy and resolution
- Frequency of output
- Meter data
- Meter sizing
- New information
# Types of Meters

<table>
<thead>
<tr>
<th>METER</th>
<th>TYPE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutating disc</td>
<td>Volumetric/Positive</td>
<td>Most Common. Wide range of flows but have higher head loss.</td>
</tr>
<tr>
<td>Oscillating Piston</td>
<td>Displacement</td>
<td></td>
</tr>
<tr>
<td>Single and Multi Jet</td>
<td>Inferential/Velocity</td>
<td>Low End flows accuracy, can handle sand with lower head loss. Pulse flow issues.</td>
</tr>
<tr>
<td>Turbine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid Oscillating</td>
<td>Static</td>
<td></td>
</tr>
<tr>
<td>Magnetic</td>
<td></td>
<td>No moving part meters with AMI compatible registers</td>
</tr>
<tr>
<td>Acoustic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compound</td>
<td>Mixed</td>
<td>Two meters in one for low and high flow accuracy</td>
</tr>
</tbody>
</table>
Nutating Disc - Most Common in U.S.

Nutting Disc—Most Common in U.S.

Source: Neptune Meter.
Oscillating Piston

Sources:
- Red Seal Measurement

- Most common meter in UK
- Also common in U.S
- Sizes ½ to 3 inches.
Turbine Meter

- Larger flows
- Lower head Loss
- Limited low end accuracy
- Part of compound meters
- Sizes 1.5-20 inches
- Axial flow

Source: Metron Farnier
Single Jet Meter

Source: Metron Farnier
Multi Jet Meter

Source: Master Meter
Magnetic Flow Sensors
Sealed Electronic Register
Flowtube
Strainer

Source: Sensus
EMF Theory: In Motion

\[ \text{Emf} = BLv \]

Source: Sensus
Acoustic Meter

Source: Badger Meter
Four Main Types of Meter Registers

1. Manual Read
2. Pulse
3. Encoded
4. Solid State
Considerations of Meter Accuracy

- AWWA standards down to 1/4 gpm
- Many NEW 5/8 meters can beat that
- Meters decay at the low end first
- Older meters often not accurate at low flows
- What Percent of water is low flow?
  - Early studies suggest at least 5% less than ¼ gpm-mostly leaks.
- AMI can help with Meter Sizing
Slow Meter Decay = Lost Revenue

Average Meter Registration Before/After Changeout Based on 13,584 Stuck Meters

Percentage of Average Usage Metered

Increase Metered Consumption

Months Before or After Change

-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Dave’s Top 10 Types of Low Flows that might go Unmeasured

1. Houseline Leaks
2. Irrigation Valve Stuck Open
3. RO Systems
4. Automatic Pool Fill Valves
5. Hot Water Tanks Pressure Relief Valve
6. Faucet drips
7. Refrigerator Water Supply Line
8. Broken Appliances
9. Water Treatment Systems
10. Whatchamacallit!!
What does a small leak look like?
1/8 GPM
1/37 gpm (lower end of ability to measure)
1/150 gpm is still 10 gallons per day
How much does an undetected leak really amount to?

<table>
<thead>
<tr>
<th>Flow gpm</th>
<th>CF/Hr</th>
<th>GPD</th>
<th>CCF/mo</th>
<th>$/mo*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/32</td>
<td>0.25</td>
<td>45</td>
<td>1.83</td>
<td>$8.80</td>
</tr>
<tr>
<td>1/16</td>
<td>0.5</td>
<td>90</td>
<td>3.66</td>
<td>$17.60</td>
</tr>
<tr>
<td>1/8</td>
<td>1.0</td>
<td>180</td>
<td>7.31</td>
<td>$35.2</td>
</tr>
<tr>
<td>¼</td>
<td>2.0</td>
<td>360</td>
<td>14.6</td>
<td>$70.4</td>
</tr>
<tr>
<td>½</td>
<td>4.0</td>
<td>720</td>
<td>29.3</td>
<td>$140.8</td>
</tr>
<tr>
<td>1</td>
<td>8.0</td>
<td>1,440</td>
<td>58.6</td>
<td>$280.7</td>
</tr>
</tbody>
</table>

· Assume water cost about $4.81/unit or $6.43 per thousand gallon
Unmeasured Flow Study
Unmeasured Flow Study

- Replaced approximately 431 meters with Sensus Iperl Mag Meters and Metron M2 radios
- Over 200 pulled meters tested at discrete flows 1/32, 1/16, 1/8, ¼ gpm and up to 20 gpm
- Iperl Meters start registering at 1/37 gpm
- Meter resolution is 0.001 CF = 1 ounce of water
- Datalogging at 1 minute intervals
- Two 11-day downloads per season
- 55 million meter reads!
Residential Low Flow Rate Changes by Season

Percent of Flow

Early summer
Late spring
Early spring
Mid winter
Early winter
Late fall
Early Fall

0 gpm  Flow rate less than GPM  1 gpm

1/4 gpm
General Observations

- 1/3 of all minutes had consumption
- Larger meters less accurate at low flows
- Unmeasured flow by method 4-7%, by pre and post comparison 8%
- Surprisingly some older meters better than newer ones
- Some very high flows
- Leaks were at very low flows
- AMI can help with meter sizing
• Meters decay at the low end first
• Larger meters less low-flow accuracy
• Surprisingly some older meters better than newer ones.
Example Accuracy Calculations

Measured = sum[(% of flow)X(accuracy of flow)]

<table>
<thead>
<tr>
<th>Range</th>
<th>Midpt</th>
<th>Log Midpnt</th>
<th>Accuracy</th>
<th>% of Flow</th>
<th>% Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/32-1/24</td>
<td>1/28</td>
<td>-1.447</td>
<td>20%</td>
<td>0.3</td>
<td>0.06</td>
</tr>
<tr>
<td>1/24-1/22</td>
<td>1/23</td>
<td>-1.362</td>
<td>29%</td>
<td>0.4</td>
<td>0.116</td>
</tr>
<tr>
<td>1/22-1/20</td>
<td>1/21</td>
<td>-1.322</td>
<td>34%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1/20-1/18</td>
<td>1/19</td>
<td>-1.279</td>
<td>38%</td>
<td>0.4</td>
<td>0.152</td>
</tr>
<tr>
<td>1/18-1/16</td>
<td>1/17</td>
<td>-1.23</td>
<td>44%</td>
<td>0.3</td>
<td>0.132</td>
</tr>
<tr>
<td>1/16-1/14</td>
<td>1/15</td>
<td>-1.176</td>
<td>48%</td>
<td>0.2</td>
<td>0.096</td>
</tr>
</tbody>
</table>
General Observations

- 1/3 of all minutes had consumption
- Larger meters less accurate at low flows
- Unmeasured flow by method 4-7%, by pre and post comparison 8%
- Surprisingly some older meters better than newer ones
- Some very high flows
- Leaks were at very low flows
- AMI can help with meter sizing
Synergies with Water & Energy

- Energy to pump and treat water & wastewater
- Saving water encourages energy saving
- Hot water leaks are energy wasters
- Efficient devices
- Promote on line data.
- Intertie with HANs
AMI can lead to energy savings
## Water-Energy Studies

### $6.4 M Project

<table>
<thead>
<tr>
<th>UC Davis-PG&amp;E-EBMUD Study</th>
<th>US Bureau of Reclamation-EBMUD Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant Funding: $250,000</td>
<td>Grant Funding: $1,000,000</td>
</tr>
<tr>
<td>Up to 10,000 meters</td>
<td>Up to 3,000 meters</td>
</tr>
</tbody>
</table>
Randomized control trial
- "Gold standard" of evaluation
  - Isolation of impact
- Treatment and control groups
- Water, electricity and gas data
- Can PG&E Fund AMI water Conservation?
- What about pumping and treatment?
• CPUC mandated study. Electricity/gas/water together
• Redundancy in AMI network coverage
• Targeted for residential customers (randomly selected)
• 5,000 water AMI with web portal (treatment)
• 5,000 water AMI with no web portal (control 1)
• 5,000 customers with no water AMI (control 2)
• UC Davis to evaluate:
  • Water saved from AMI
  • Gas and Electricity saved as a result
  • Statistical significance
USBR Water and Energy Study

• 3,000 meters from 5/8- to 8-inch
• Primarily retrofitted existing meters
• Consumption ranges from 1k-500k gpd. Avg. 6k
• Wide variety of customer types and uses
• Learn more about embedded energy uses.
• PG&E not a direct partner but will benefit
• Only 1 collector communication required
• No control group needed for this one.
RFP Requirements

• Phase 1 (20k meters)
• Phase 2 (full)
• Mobile and fixed hybrid
• 2-way communication
• Hourly meter reads
• Compatibility with all meters
• Upgradeable
• Performance guarantees
The Vendor Contract

Typical Agreement

Phase I AMI Agreement
Key Milestones

- Received grants Jun 2016
- Released RFP Sep 2016
- Awarded Phase 1 contract Dec. 2017
- MIU Installations June 2017-Dec 2018
- Collector Installations Oct. 2018
- Go Live Anticipated Jan. 2019
Radio Wave Propagation
Sensus Coverage Area (1-Min.)
San Pablo WTP
Gwin Reservoir
Meter and MIU Installation
Meter and MIU Installation
Meter and MIU Installation
Meter and MIU Installation
Integration with Sensus
WaterSmart Software (WSS)

CUSTOMER
1. HOME WATER REPORTS / ALERTS &
2. WATERSMART CUSTOMER PORTAL & WEB APP

UTILITY
3. DASHBOARD & PROGRAM OUTCOMES
Consumption: 1 Year

History

Aug 14, 2017 — Aug 14, 2018

- Normal Use
- Possible Leak
- Probable Irrigation
- Data Unavailable

Gallons

<table>
<thead>
<tr>
<th>Date</th>
</tr>
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<tbody>
<tr>
<td>Oct 17</td>
</tr>
<tr>
<td>Oct 18</td>
</tr>
<tr>
<td>Oct 19</td>
</tr>
<tr>
<td>Oct 20</td>
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<td>Oct 21</td>
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<td>Nov 1</td>
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<td>Nov 27</td>
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<td>Nov 28</td>
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<tr>
<td>Nov 29</td>
</tr>
<tr>
<td>Nov 30</td>
</tr>
</tbody>
</table>

Tuesday, July 10, 2018
778 Gallons

66
Consumption: 2 Months

History

Jun 14, 2018 — Aug 14, 2018

DAY WEEK 2 WEEKS 2 MONTHS YEAR

- Normal Use
- Possible Leak
- Probable Irrigation
- Data Unavailable

Thursday, July 5, 2018
Total Use: **2,857 Gallons**
Possible Leak: **2,227 Gallons**
Probable Irrigation

67
### History

**Aug 9, 2018** — **Aug 9, 2018**

<table>
<thead>
<tr>
<th>DAY</th>
<th>WEEK</th>
<th>2 WEEKS</th>
<th>2 MONTHS</th>
<th>YEAR</th>
</tr>
</thead>
</table>

- Normal Use
- Possible Leak
- Probable Irrigation
- Data Unavailable

---

**Thursday, August 9, 2018**

8:00 AM - 9:00 AM

Total Use: 329 Gallons

Possible Leak: 295 Gallons

---

Gallons

<table>
<thead>
<tr>
<th>Thu, Aug 9 12:00 AM</th>
<th>3:00 AM</th>
<th>6:00 AM</th>
<th>9:00 AM</th>
<th>12:00 PM</th>
<th>3:00 PM</th>
<th>6:00 PM</th>
<th>9:00 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

---

2015 2016 2017 2018
Customer Web Portal (WaterSmart Software)

You used 12% less water
Since April 2015, you used 12% less water than during the same period(s) in 2013. During the last period (Feb 12 – Apr 15), you met your water-saving goal of 320.

You’re 9.00 CCF from crossing into Tier 2 water rates
These estimates are informational only, and may rely on estimated billing period start and end dates.
Evaluating AMI Business Case

- Water conservation
- Water loss control
- Demand forecasting
- Facility sizing
- Climate change considerations
- Predictive Maint.
- System water quality improvements
- SCADA Integration

- Energy management
- Customer service
- System reliability
- Security
- Revenue loss recovery
- Asset management
- Meter management and replacement
AMI Business Case Will Include Many Departments in a Utility

- Metering and Billing
- Water Conservation
- Customer Services
- Engineering
- Operations
- Regulatory
- Planning
- Finance
## Stakeholders We Have Met With

**Operations and Maintenance**
- Meter Division
- Construction
- Facilities
- Distribution
- Water Quality
- Regulatory and Security
- Supply

**Engineering**
- Water Distribution Planning
- Mapping

**Water and Natural Resources**
- Planning
- Water Supply Improvements
- Recycled Water
- Environmental Affairs

**Customer and Community Services**
- Water Conservation
- Contact Center
- Field Services
- New Business
- CIS Control

**Finance**
- Purchasing
- Risk Management
- Auditing
- ISD

**Wastewater**
- Engineering
- Planning
- Waste Water control
- Environmental Services
<table>
<thead>
<tr>
<th>Issue</th>
<th>How AMI Helps</th>
<th>Who Affected</th>
</tr>
</thead>
</table>
| Customer awareness of water use   | • Web access  
• Hourly data  
• Leak and high bill notification  
• On line calculators         | • Conservation  
• Contact Center  
• Public outreach  
• Customer Service  
• Customers               |
| More granular demand data needed  | • More accurate/timely reads  
• Improved data management (MDMS)       | • Operations  
• Planning  
• Conservation  
• ISD                  |
| Reduce Injury and claims          | • Fewer field trips  
• Locking meter caps  
• Leak detection  
• Remote shutoff       | • Risk Mgmt  
• Operations  
• Meter Reading  
• Field Services |
| Field Instrumentation monitoring  | • Ancillary equipment  
• Networked telemetry  
• Improved hydraulic modeling  
• Backup communications | • Operations  
• Wastewater  
• Maintenance  
• Water Quality  
• Security         |
<table>
<thead>
<tr>
<th>Issue</th>
<th>How AMI Helps</th>
<th>Who Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue protection (e.g. write-offs, theft, adjustments, estimated reads)</td>
<td>• Meter alarms&lt;br&gt;• Leak notification&lt;br&gt;• MDMS&lt;br&gt;• Monthly billing</td>
<td>• Billing&lt;br&gt;• Metering&lt;br&gt;• Finance&lt;br&gt;• Customer Service&lt;br&gt;• Field Services</td>
</tr>
<tr>
<td>Improved meter accuracy</td>
<td>• More accurate meters&lt;br&gt;• Data mining&lt;br&gt;• Increased work order response</td>
<td>• Billing/Metering&lt;br&gt;• Finance&lt;br&gt;• Customer/Field Service&lt;br&gt;• Water Supply Audits</td>
</tr>
<tr>
<td>Water loss control</td>
<td>• Remote leak detection&lt;br&gt;• DMAs&lt;br&gt;• MDMS&lt;br&gt;• Pressure mgmt/sensors</td>
<td>• O&amp;M&lt;br&gt;• Conservation&lt;br&gt;• Distribution Planning&lt;br&gt;• Risk Mgmt&lt;br&gt;• Public Affairs</td>
</tr>
<tr>
<td>Staff development</td>
<td>• New technologies transforms skill sets needed</td>
<td>• Meter Reading&lt;br&gt;• Field Services&lt;br&gt;• Billing&lt;br&gt;• Operations</td>
</tr>
</tbody>
</table>
## Strategic Issues Discussed

<table>
<thead>
<tr>
<th>Issue</th>
<th>How AMI Helps</th>
<th>Who Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Demand Management</td>
<td>• Time of use billing</td>
<td>• Operations</td>
</tr>
<tr>
<td></td>
<td>• Improve conservation</td>
<td>• Water Distribution Planning</td>
</tr>
<tr>
<td></td>
<td>• Better facility sizing</td>
<td>• Water Quality</td>
</tr>
<tr>
<td></td>
<td>• Identify peak users</td>
<td></td>
</tr>
<tr>
<td>Stricter Water Quality and Backflow Regulations</td>
<td>• Real time modeling</td>
<td>• Office of Water Quality</td>
</tr>
<tr>
<td></td>
<td>• In field-instrumentation</td>
<td>• Backflow/Meter Reading</td>
</tr>
<tr>
<td></td>
<td>• Backflow alarms</td>
<td>• Security/Reg compliance</td>
</tr>
<tr>
<td>Customer Satisfaction</td>
<td>• Accurate, timely billing</td>
<td>• Customer Services</td>
</tr>
<tr>
<td></td>
<td>• Consumption website</td>
<td>• Customers</td>
</tr>
<tr>
<td></td>
<td>• Better water quality</td>
<td>• Public Outreach</td>
</tr>
<tr>
<td></td>
<td>• System reliability</td>
<td>• Water Conservation</td>
</tr>
<tr>
<td></td>
<td>• Faster leak repair</td>
<td>• System Water Quality</td>
</tr>
</tbody>
</table>

**IT’S ALL ABOUT THE (Internal/External) CUSTOMER**
What might EBMUD AMI look like

- 63 collectors facilities
- 400k meters, lids, piping
- Typically hosted SaaS services
- Integration with new customer service tools and web features
- A public outreach campaign
- Conversion of many District practices
- Addition of new field instrumentation?
- AMI team
Next Steps

• Operate the USBR and PG&E projects through Dec 2019
• Begin billing AMI meters through AMI-2019
• Develop the business case for full system-2020
• Continue to test and develop specifications for new meter technology-Ongoing
• Pursue additional AMI grant and partnering opportunities-Ongoing
Questions & Comments

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