Systematic methodology to estimate apparent losses due to water meters inaccuracies
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Systematic methodology to estimate apparent losses due to water meters inaccuracies

Francisco Arregui
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IWA - Water balance

Systematic methodology to estimate apparent losses – F. Arregui

Water Losses

- Authorized Consumption
- Unbilled Authorized Consumption
- Billed Authorized Consumption

- Unbilled Consumption
- Billed Unmetered Consumption
- Unbilled Metered Consumption
- Unbilled Unmetered Consumption

Water Balance

- Authorized Consumption
- Unbilled Authorized Consumption
- Billed Authorized Consumption

Non-Revenue Water

- Unauthorized Consumption
- Customer Meter Inaccuracies
- Billing & Accounting Errors
- Leakage on Transmission and/or Distribution Mains
- Leakage and Overflows at Utility’s Storage Tanks
- Leakage on Service Connections

Revenue Water

System Input Volume

- Water Losses
- Real Losses
- Apparent Losses

Authorized Consumption

- Billed Exported Consumption
- Billed Metered Consumption
- Billed Unmetered Consumption

Authorized Consumption

Customer Meter Inaccuracies

Billing & Accounting Errors

Leakage on Transmission and/or Distribution Mains

Leakage and Overflows at Utility’s Storage Tanks

Leakage on Service Connections
<table>
<thead>
<tr>
<th>System Input Volume</th>
<th>Authorized Consumption</th>
<th>Billed Authorized Consumption</th>
<th>Unbilled Authorized Consumption</th>
<th>Billed exported consumption</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Water Losses</td>
<td></td>
<td>Apparent Losses</td>
<td>Unbilled Authorized Consumption</td>
<td>Unbilled Metered Consumption</td>
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<td>Unbilled Unmetered Consumption</td>
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<td>Unauthorized Consumption</td>
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<td>Customer Meter Inaccuracies</td>
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</tbody>
</table>
# IWA - Water balance

## Water Losses

<table>
<thead>
<tr>
<th>System Input Volume</th>
<th>Authorized Consumption</th>
<th>Billed Authorized Consumption</th>
<th>Unbilled Authorized Consumption</th>
<th>Apparent Losses</th>
<th>Real Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue Water</td>
<td>Billed exported consumption</td>
<td>Billed Metered Consumption</td>
<td>Billed Unmetered Consumption</td>
<td>Unauthorized Consumption</td>
<td>Customer Meter Inaccuracies</td>
</tr>
<tr>
<td></td>
<td>Unbilled Metered Consumption</td>
<td>Unbilled Unmetered Consumption</td>
<td>Billing &amp; Accounting Errors</td>
<td>Leakage on Transmission and/or Distribution Mains</td>
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IWA - Water balance

System Input Volume

- Authorized Consumption
- Unbilled Authorized Consumption
- Billed Authorized Consumption

Water Losses

- Real Losses
- Apparent Losses

Revenue Water

- Billed Exported Consumption
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- Billed Unmetered Consumption
- Unbilled Metered Consumption
- Unbilled Unmetered Consumption

Non Revenue Water

- Unauthorized Consumption
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- Customer Meter Inaccuracies
- Unbilled Unmetered Consumption
- Unbilled Authorized Consumption
- Billed Unmetered Consumption
- Billed Metered Consumption
- Billed Authorized Consumption
How accurate is a brand new domestic meter?
How accurate is a brand new commercial meter?
How accurate is an old domestic meter?
How accurate is an old commercial meter?
Metering errors vary with flow rate

- New meter
- Leaks

Class B
Velocity meter
Metering errors vary with flow rate

15 l/h, 22.5 l/h, 3000 l/h

Flow rate (l/h)

Error (%)

Class C - PD

New meter
Metering errors also vary with time!!!

- Flow rate (l/h)
  - 30 l/h
  - 120 l/h
  - 3000 l/h

- Error (%)
  - New meter
  - Old meter

- Class B
  - Velocity meter

Leaks

Flow rate (l/h)
Finding real field performance of a meter

Error curve

Water consumption pattern

Weighted error
Understanding weighted error of a meter

- $-X\%$ weighted error means that every 100 litres consumed, $X$ litres are not measured.

- It is strictly associated to:
  - One meter (or type of meter)
  - One customer (or type of customer)
Understanding weighted error of a meter

- If the weighted error of all installed meters is known then the Customer Meters Inaccuracies term is also known.

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<tr>
<th>System Input Volume</th>
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- Customer Meter Inaccuracies

- Billing & Accounting Errors
- Leakage on Transmission and/or Distribution Mains
- Leakage and Overflows at Utility’s Storage Tanks
- Leakage on Service Connections

Unauthorized Consumption
Finding the error curve of water meters

- There are large differences between meter types

![Graph showing error curve for different flow rates]

- Error (%) vs. Flow rate (l/h)
Finding the error curve of water meters

- There are large differences between meter types
- Metering errors depend on the flow rate

Which flow rates do I test?

- Use standards (ISO 4064, AWWA)?
  - Minimum, Transition, Permanent, Maximum
- Other criteria
Selecting flow rates based on the standards

Class B – Qn 1.5 m³/h

- 30 l/h
- 120 l/h
- 1500 l/h
- 3000 l/h

Flow rate (l/h)
Selecting flow rates based on the standards

Class C – Qn 1.5 m³/h

Class B – Qn 1.5 m³/h
Selecting flow rates based on the standards

R100 – Q3 1.6 m³/h

R100 – Q3 2.5 m³/h
Selecting flow rates based on the standards

With the new ISO 4064:2006 there are too many options for domestic meters

Using standards to select testing flow rates is impractical!!!
Selecting flow rates based on the standards

Class B – Qn 1.5 m³/h
Re-constructiong the error curve

Class B – Qn 1.5 m³/h
Do you think these curves are the same?

Class B – Qn 1.5 m³/h
Example 1

- One meter was tested at two set of flow rates:
  - 30 l/h, 120 l/h, 750 l/h and 1500 l/h
  - 15 l/h, 60 l/h, 500 l/h and 1500 l/h

- The error curve was reconstructed from the information of the tests using two different methods

- The weighted error was calculated using the same consumption pattern
1\textsuperscript{st} reconstruction method
2\textsuperscript{nd} reconstruction method

![Graph showing the 2\textsuperscript{nd} reconstruction method with error (%), Flow rate (l/h), Curve A1, Curve A2, and Starting flow rate.](image-url)
Calculating the weighted error

- From the same error curve and the same consumption pattern very different results are obtained!!

<table>
<thead>
<tr>
<th>Curve</th>
<th>Weighted Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detailed curve</td>
<td>-4.33%</td>
</tr>
<tr>
<td>1st reconstruction</td>
<td>-2.72%</td>
</tr>
<tr>
<td>2nd reconstruction</td>
<td>0.80%</td>
</tr>
</tbody>
</table>

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<tr>
<th>Curve</th>
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</thead>
<tbody>
<tr>
<td>15 l/h, 60 l/h, 500 l/h, 1500 l/h</td>
<td>-3.75%</td>
</tr>
<tr>
<td>1st reconstruction</td>
<td>-3.75%</td>
</tr>
<tr>
<td>2nd reconstruction</td>
<td>-0.66%</td>
</tr>
</tbody>
</table>

Such differences are not acceptable!
Example 2
Weighted errors of new domestic meters

- Results for 10 different brands of domestic meters
   (meters were tested at 10 flow rates)

<table>
<thead>
<tr>
<th>Brand</th>
<th>Pattern 1</th>
<th>Pattern 2</th>
<th>Pattern 3</th>
<th>Pattern 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3.09</td>
<td>-3.91</td>
<td>-2.11</td>
<td>-7.44</td>
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<tr>
<td>2</td>
<td>-1.35</td>
<td>-1.67</td>
<td>-0.85</td>
<td>-3.54</td>
</tr>
<tr>
<td>3</td>
<td>-2.55</td>
<td>-2.83</td>
<td>-1.72</td>
<td>-5.43</td>
</tr>
<tr>
<td>4</td>
<td>-6.13</td>
<td>-7.02</td>
<td>-5.24</td>
<td>-11.47</td>
</tr>
<tr>
<td>5</td>
<td>-5.26</td>
<td>-6.24</td>
<td>-4.16</td>
<td>-10.03</td>
</tr>
<tr>
<td>6</td>
<td>-3.99</td>
<td>-4.75</td>
<td>-3.18</td>
<td>-8.43</td>
</tr>
<tr>
<td>7</td>
<td>-0.04</td>
<td>-0.64</td>
<td>-0.03</td>
<td>-0.79</td>
</tr>
<tr>
<td>8</td>
<td>-2.84</td>
<td>-3.1</td>
<td>-2.12</td>
<td>-5.43</td>
</tr>
<tr>
<td>9</td>
<td>-0.1</td>
<td>-0.56</td>
<td>-0.02</td>
<td>-0.76</td>
</tr>
<tr>
<td>10</td>
<td>-0.11</td>
<td>-0.69</td>
<td>-0.08</td>
<td>-0.92</td>
</tr>
</tbody>
</table>
Weighted errors of new domestic meters

![Graph showing weighted errors of different meter brands](image-url)
How accurate is a brand new domestic meter?

Maybe now you do not give an answer so easily
IWA - Water balance

- **System Input Volume**
  - Authorized Consumption
  - Unbilled Authorized Consumption
  - Water Losses
  - Real Losses

- **Billed Authorized Consumption**
  - Billed exported consumption
  - Billed Metered Consumption
  - Unbilled Metered Consumption

- **Billed Unmetered Consumption**
  - Unbilled Unmetered Consumption
  - Unauthorized Consumption

- **Relevant Water**
  - Billing & Accounting Errors
  - Leakage on Transmission and/or Distribution Mains
  - Leakage and Overflows at Utility’s Storage Tanks
  - Leakage on Service Connections

- **Non Revenue Water**
  - Unbilled Unmetered Consumption
  - Unbilled Authorized Consumption
  - Unbilled Metered Consumption
  - Billed exported consumption
  - Real Losses
  - Apparent Losses
  - Authorized Consumption
  - Customer Meter Inaccuracies
Conclusions

- Calculated meter performance can dramatically change depending on the methodology used for the calculation.

- A standard methodology for calculating meters inaccuracies is needed. This include:
  - Selection of testing flow rates
  - Consumption patterns to be used
  - How errors should be weighted with consumption patterns

- Maybe standardization will not produce the most accurate results but figures will be comparable.
Systematic methodology to estimate apparent losses due to water meters inaccuracies