Detection of small flows with water meters

Metrology for Real-world Domestic Water Metering – MetroWamet

Dissemination workshop 15.-16. September 2021

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Introduction

- Post-meter leakages in household can have severe impact on water billing and potential create hidden material damages in the building construction.

- Improved water meter measuring technology for low flow and the introduction of smart water meters with frequently automatic meter reading enables the possibility to alert the customer about the leakage shortly after it has occurred.

- Leakage management relies on:
  - ✓ The ability to detect the leakage
  - ✓ Feedback to the customer of the leakages
  - ✓ Action to stop the leakage

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Leakages

- Leakages in the households can come from different sources.
- The more common leakages has flow varying from <1 L/h to >45 L/h.

*Adapted from water waste poster by Association of Danish Water Supply (Danske vandværker)

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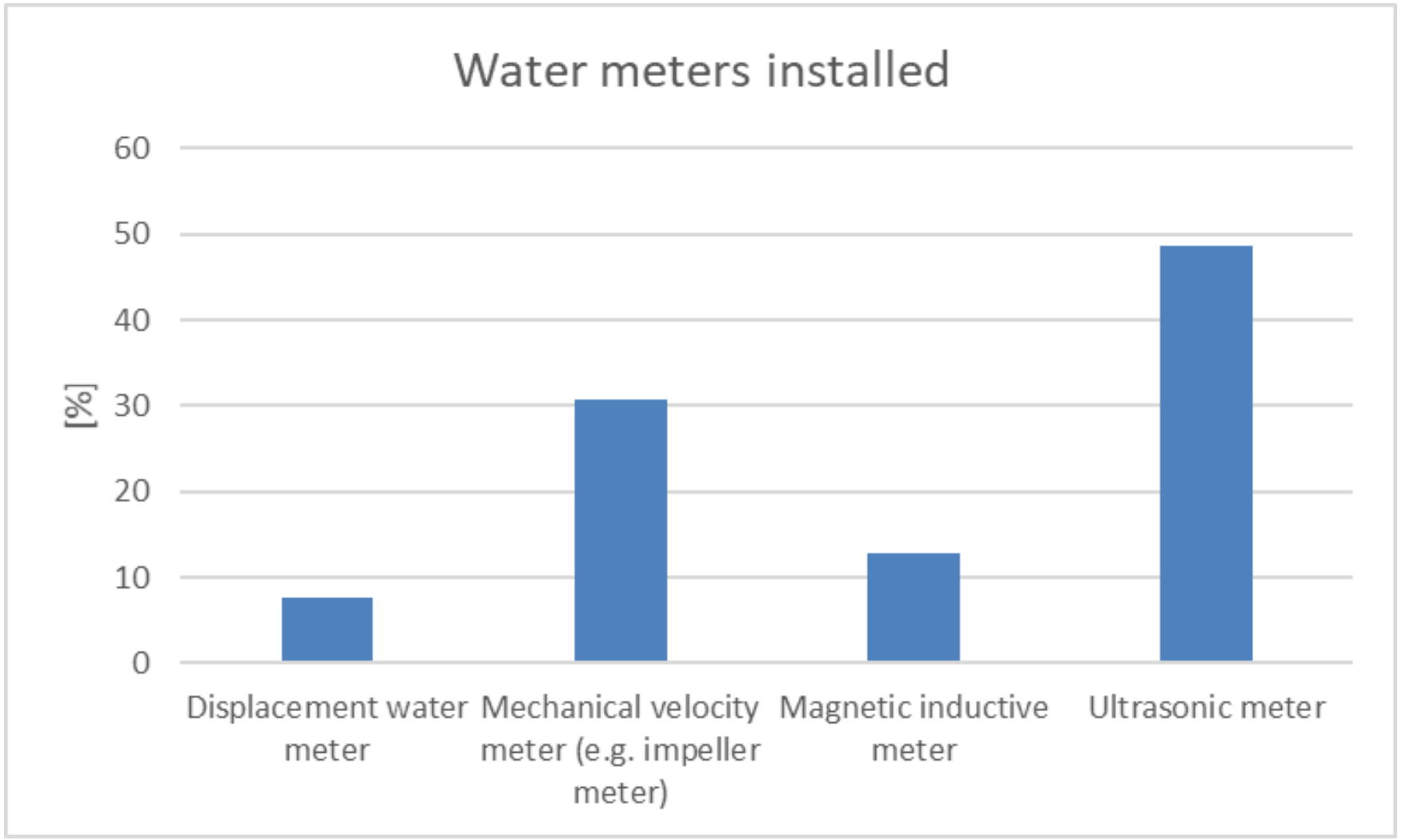
Survey on leakage detection



Replies from 33 water utilities

- 26 Denmark
- 5 Germany
- 1 Turkey
- 1 Italy

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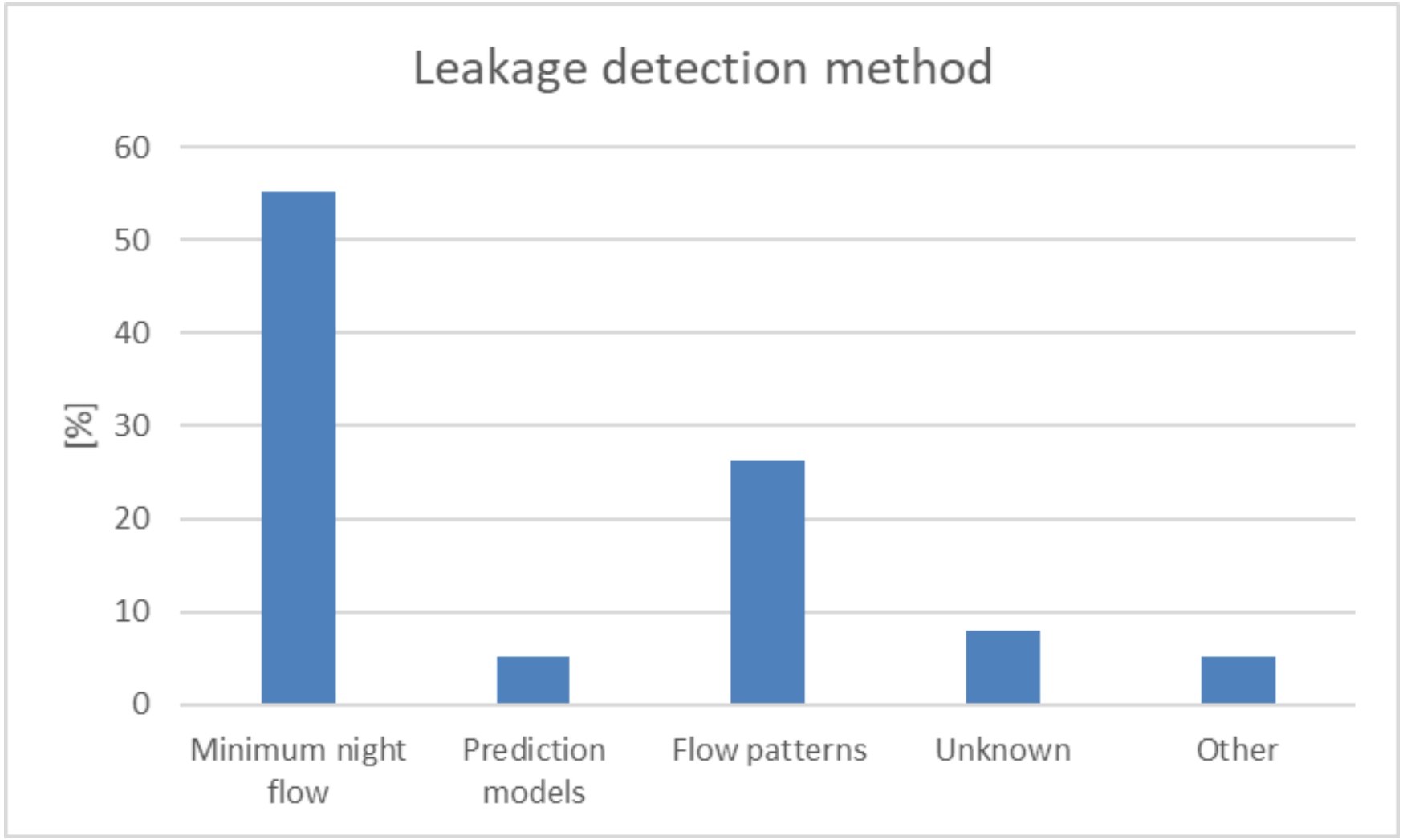
Survey on leakage detection

Approximately 3/4 of the respondents indicated that the do some sort of leakage detection



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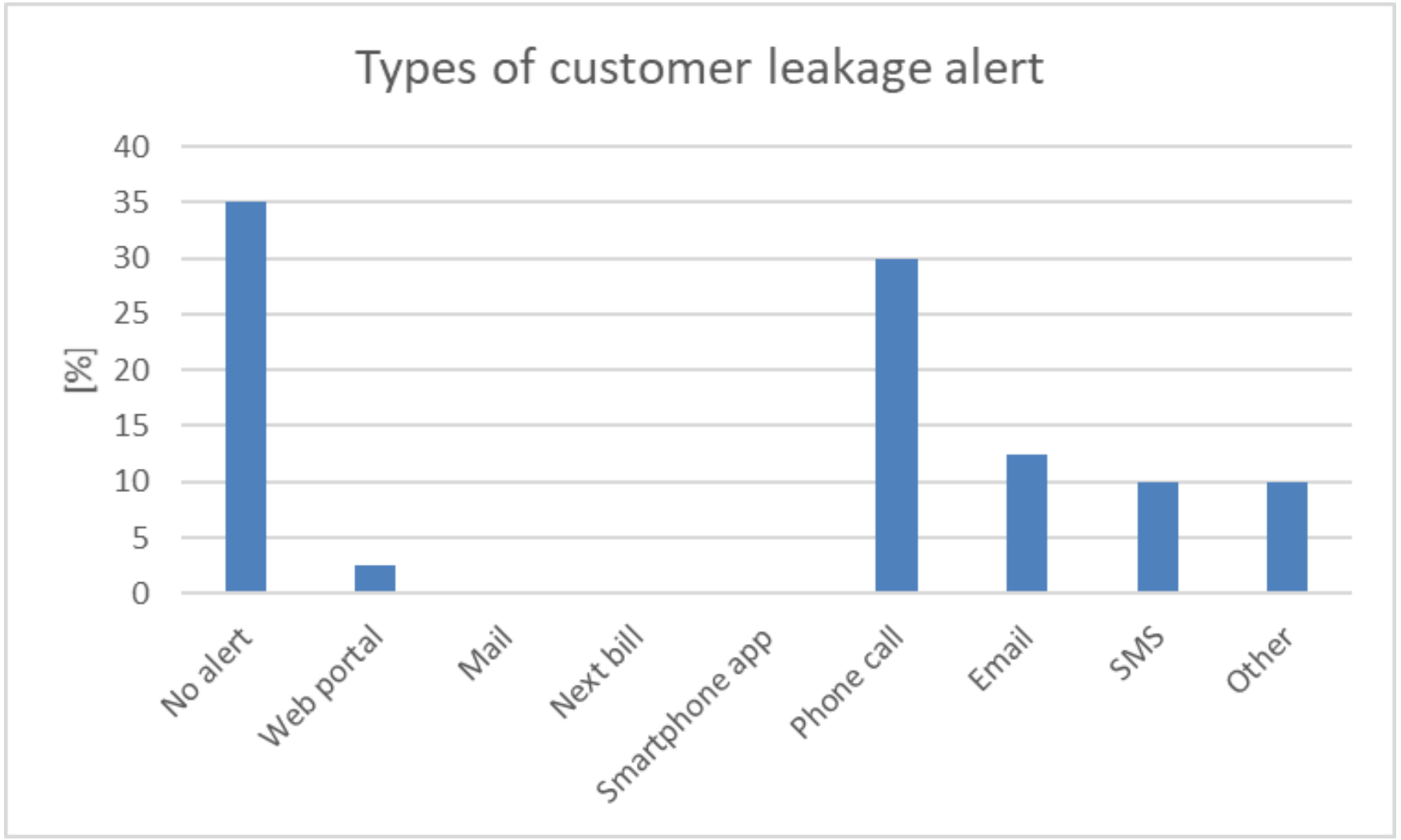
Survey on leakage detection

There are different approaches of feedback of leakages to customer (including none)



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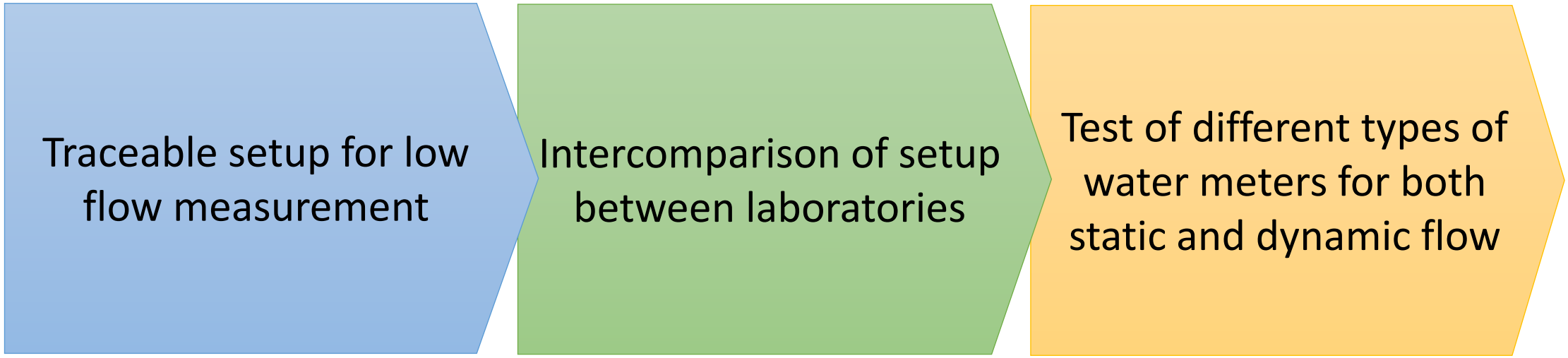
Metrological validation of water meters for leakage detection



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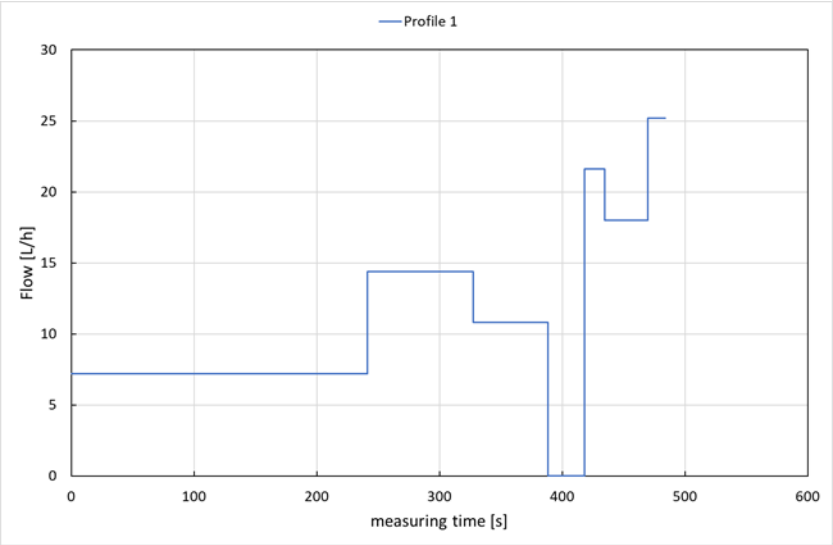
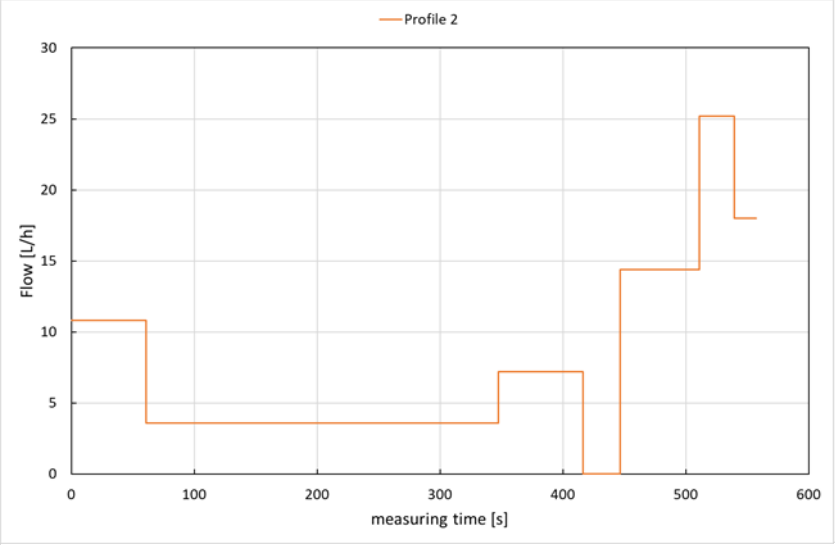
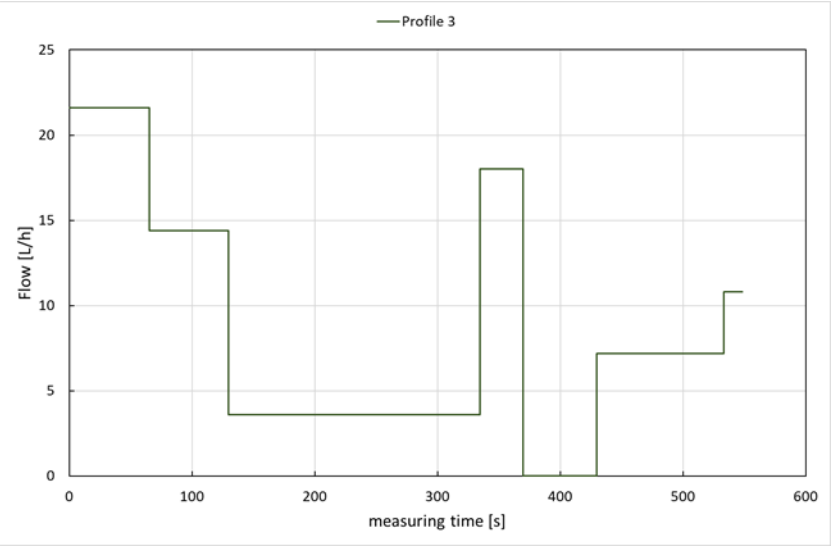
Metrological validation of water meters for leakage detection

- Normal water consumption patterns consists of a sum of individual events with different dynamic patterns.
- Leakage has typical different dynamic characteristics compared to normal events.
- Due to the dynamic patterns and the following analysis the ability to measure dynamic flow at low flow was validated using three standard dynamic flow profiles.
- The dynamic flow profiles was created as presented by Daniel Schumann, PTB, Day 1.

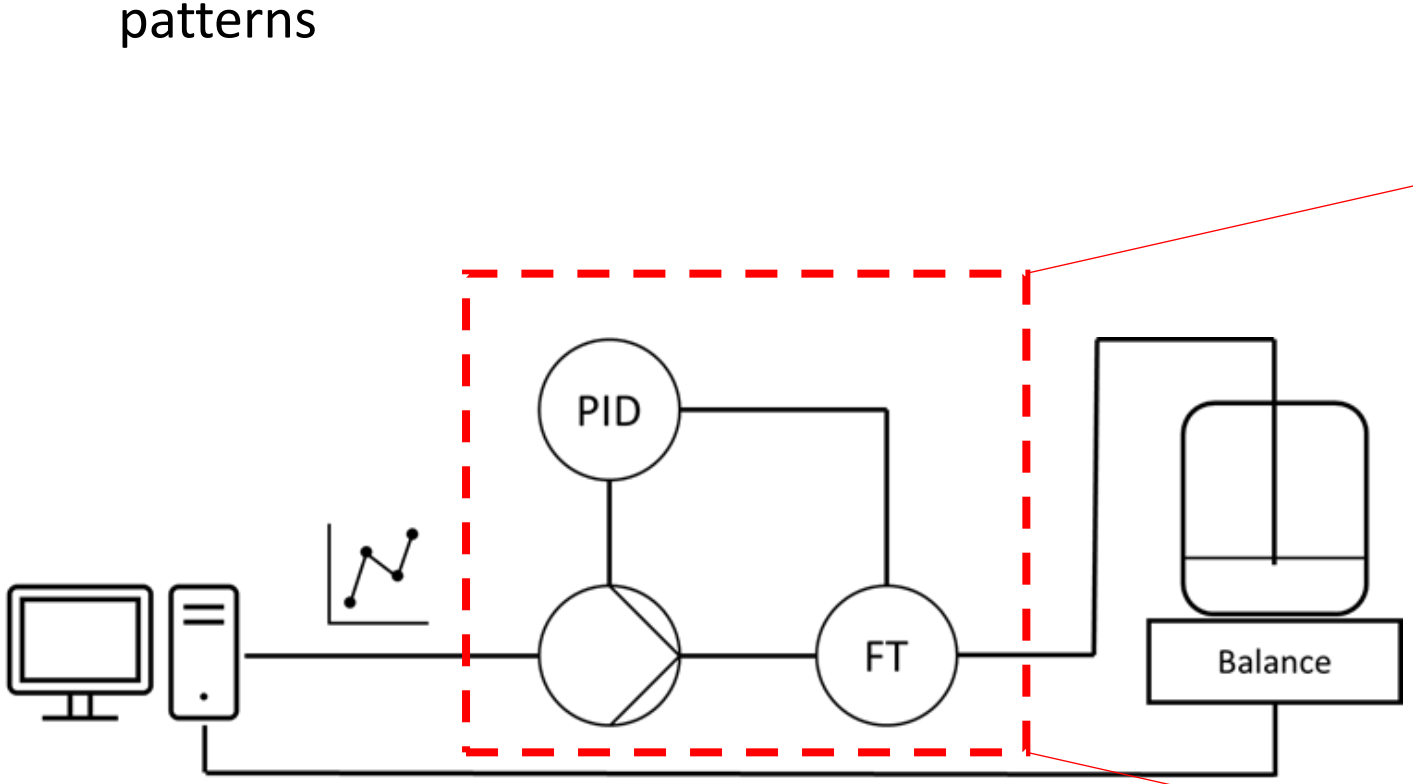






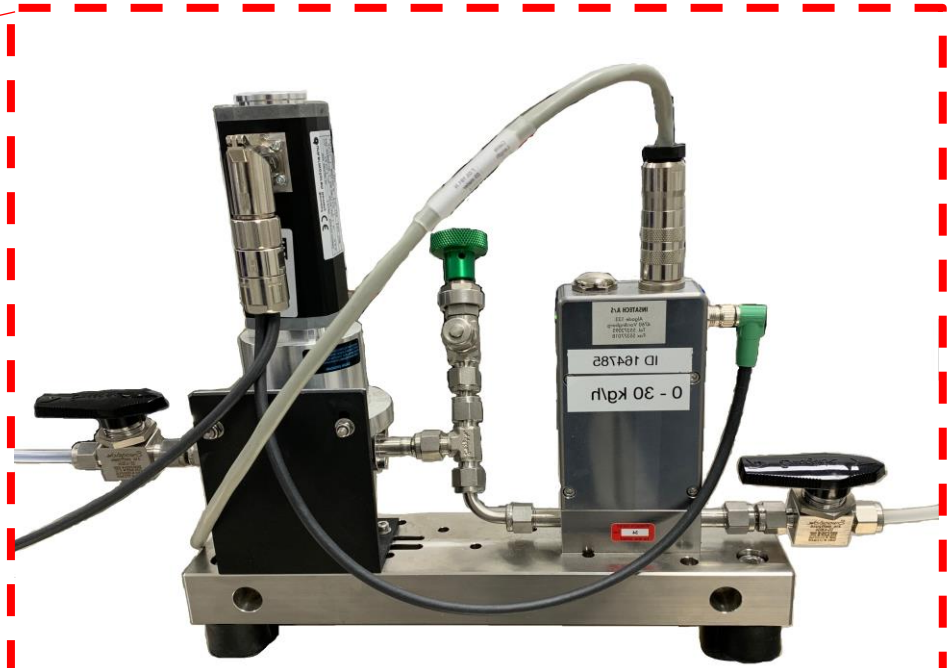
Setup for validation

- An intercomparison between CETIAT and DTI performed for both static and dynamic flow patterns



Pump and regulator

Coriolis Flow meter



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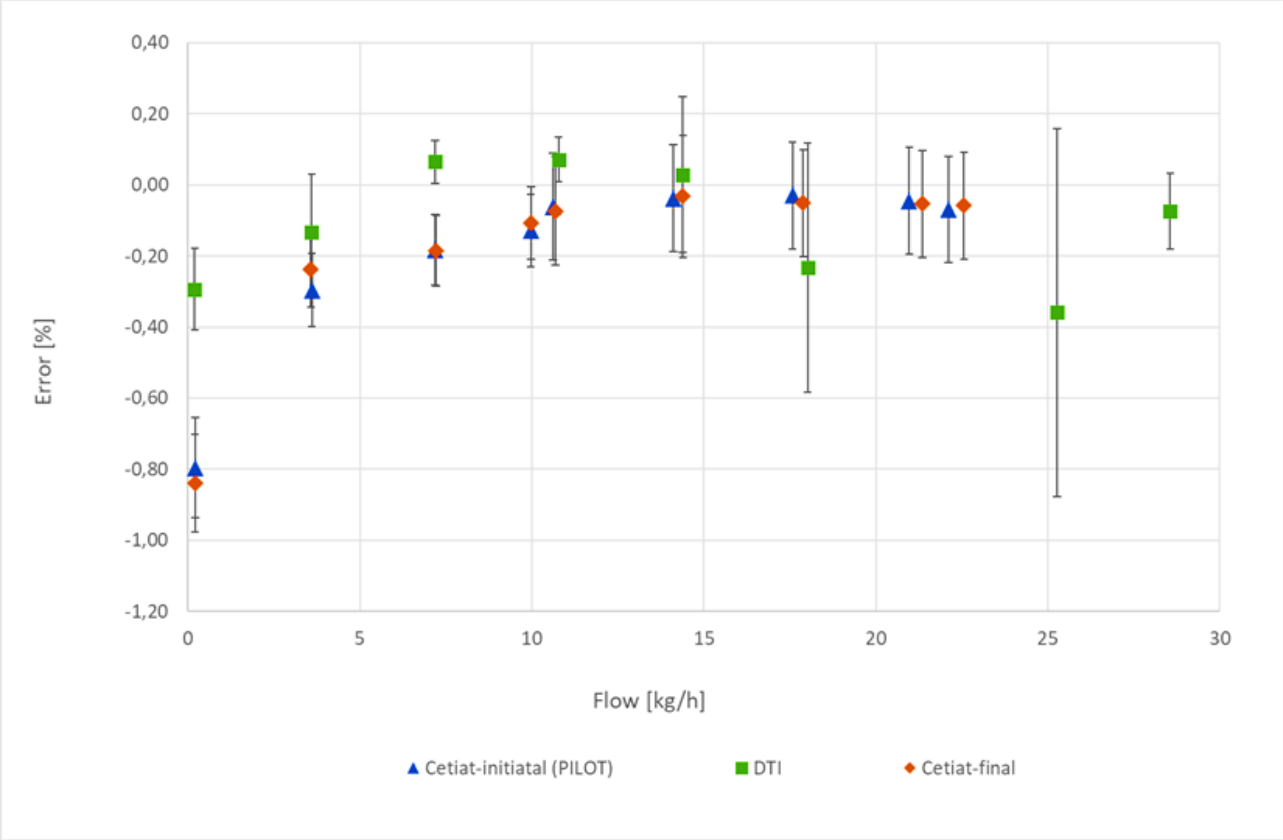
Intercomparison
- Results for static flow



Cetiat (pilot)		DTI		Cetiat		E-value	
Flowrate	Error	Flowrate	Error	Flowrate	Error	DTI-Pilot	Cetiat-Pilot
Kg/h	%	Kg/h	%	Kg/h	%		
0,2	-0,80	0,2	-0,29	0,2	-0,84	2,76	-0,44
3,6	-0,30	3,6	-0,13	3,6	-0,24	0,84	0,79
7,2	-0,18	7,2	0,07	7,2	-0,19	2,11	-0,03
10,6	-0,06	10,8	0,07	10,7	-0,07	0,81	-0,11
14,1	-0,04	14,4	0,03	14,4	-0,03	0,25	0,05
17,6	-0,03	18	-0,23	17,9	-0,05	-0,53	-0,20
22,1	-0,07	25,2	-0,36	22,6	-0,06	-0,54	0,10

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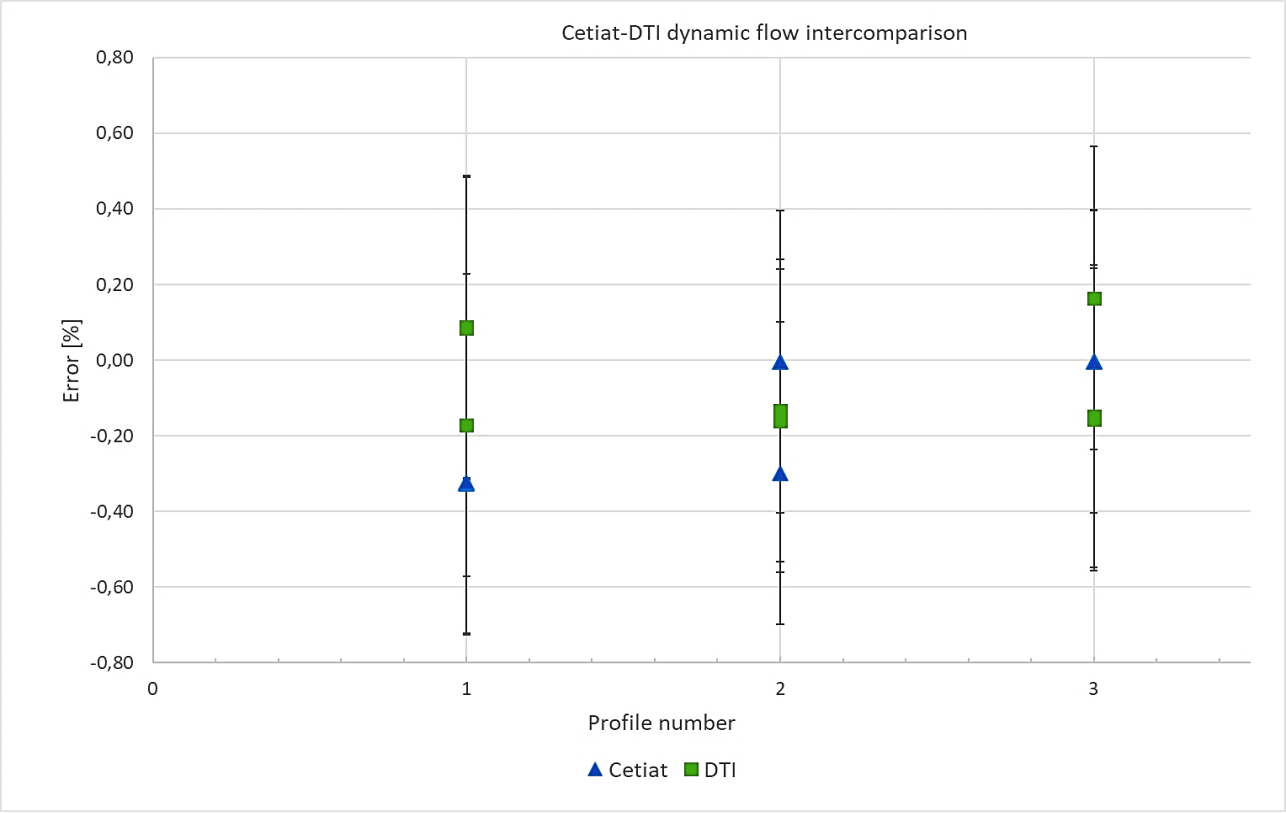
Intercomparison
- Results for dynamic flow



Profile number	Cetiat, error [%]	DTI, error [%]	E-value
1-1	-0,33	-0,17	0,28
1-2	-0,32	0,09	0,73
1-3	-0,32	0,08	0,72
2-1	-0,30	-0,16	0,25
2-2	0,00	-0,13	-0,23
2-3	0,00		
3-1	0,00	-0,16	-0,27
3-2	0,00	0,16	0,30
3-3	0,00	-0,15	-0,25

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Test of water meters for leakage detection

Three different types of water meters were selected for testing, representing different measurement technology

- Multi-jet meter (N = 2)
- Piston meter (N = 3)
- Ultrasonic meter (N = 2).

	Ultrasonic	Multi-jet	Piston	Unit
Resolution, display readout	1	0,05	0,05	L
Nominal flow (Q3)	2,5	2,5	2,5	m3/h
Dynamic range (Q3/Q1)	250	160	400	
Max. flow (Q4)	3,1	3,125	3,125	m3/h
Minimum flow (Q1)	10	15	6,25	L/h
Transition flow (Q2)	16	25	10	L/h
Min. cutoff flow	2			L/h

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Test of water meters for leakage detection
- Results for **ultrasonic** water meter for static flow

Ultrasonic						
ID	Flowrate	Reference volume	Meter volume	Error	Error	U (k = 2)
	[L/h]	[L]	[L]	[L]	[%]	[%]
ID1-1	2	102,11	105,00	2,89	2,83	1,14
ID1-2	2	102,11	99,00	-3,11	-3,04	1,20
ID1-1	5	332,50	345,00	12,50	3,76	0,45
ID1-2	5	332,50	317,00	-15,50	-4,66	0,47
ID1-1	10	234,90	236,00	1,10	0,47	0,57
ID1-2	10	234,90	234,00	-0,90	-0,39	0,58

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Test of water meters for leakage detection
- Results for **multi-jet** water meter for static flow

Multi-jet						
ID	Flowrate	Reference volume	Meter volume	Error	Error	U (k = 2)
	[L/h]	[L]	[L]	[L]	[%]	[%]
ID2-1	5	146,94	0,00	-	-	-
ID2-2	5	146,94	0,00	-	-	-
ID2-1	10	245,34	0,00	-	-	-
ID2-2	10	245,34	0,00	-	-	-
ID2-1	20	464,39	403,95	-60,44	-13,02	0,30
ID2-2	20	464,39	269,35	-195,04	-42,00	0,30
ID2-1	30	2147,44	2027,10	-120,34	-5,60	0,30
ID2-2	30	2147,44	1905,45	-241,99	-11,27	0,30

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Test of water meters for leakage detection
- Results for **piston-based** water meter for static flow

Piston-volumetric						
ID	Flowrate	Reference volume	Meter volume	Error	Error	U (k = 2)
	[L/h]	[L]	[L]	[L]	[%]	[%]
ID3-1	2	82,64	0,00	-	-	-
ID3-2	2	82,64	0,00	-	-	-
ID3-3	2	82,64	0,00	-	-	-
ID3-1	5	139,72	122,20	-17,52	-12,54	0,30
ID3-2	5	139,72	123,25	-16,47	-11,79	0,30
ID3-3	5	139,72	87,75	-51,97	-37,20	0,31
ID3-1	10	908,02	830,30	-77,72	-8,56	0,30
ID3-2	10	908,02	767,75	-140,27	-15,45	0,30
ID3-3	10	908,02	788,45	-119,57	-13,17	0,30

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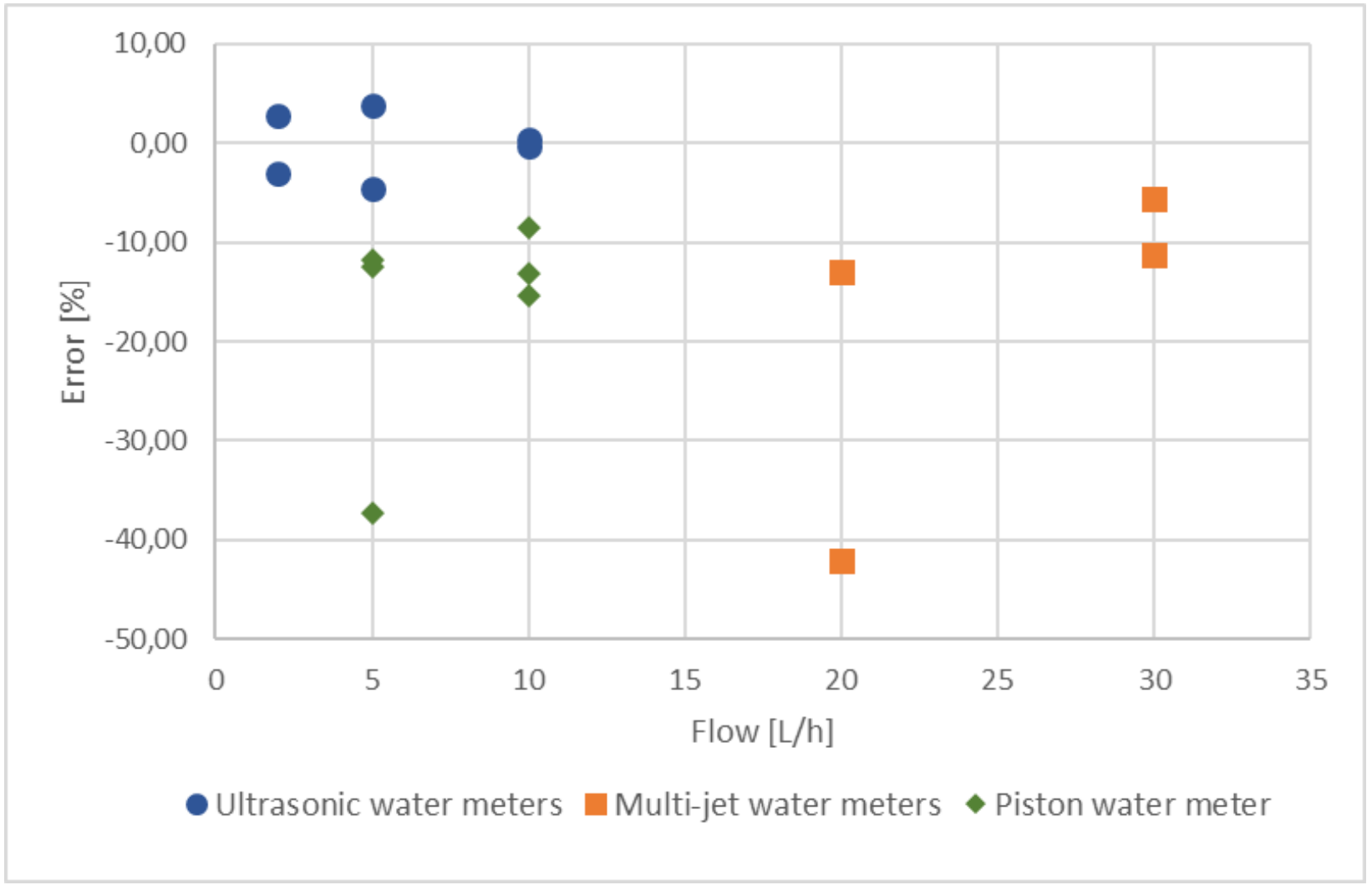
Test of water meters for leakage detection for static flow - Comparison



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Test of water meters for leakage detection - Results for dynamic test of water meters

For each test the profiles were repeated 150 times resulting in a total volume flow of 207 L (profile 1) and 173 L (profile 2), respectively.

	Profile 1		Profile 2	
	Avg. error	Avg. unc. (k=2)	Avg. error	Avg. unc. (k=2)
	[%]	[%]	[%]	[%]
Ultrasonic water meter	-4,15	0,66	-1,97	0,74
Multi-jet water meter	-67,59	0,34	-64,89	0,33
Piston water meter	-0,72	0,30	-4,29	0,30

* The water meters were tested using only profile 1 and 2 due to a hardware error in the power supply to the pump

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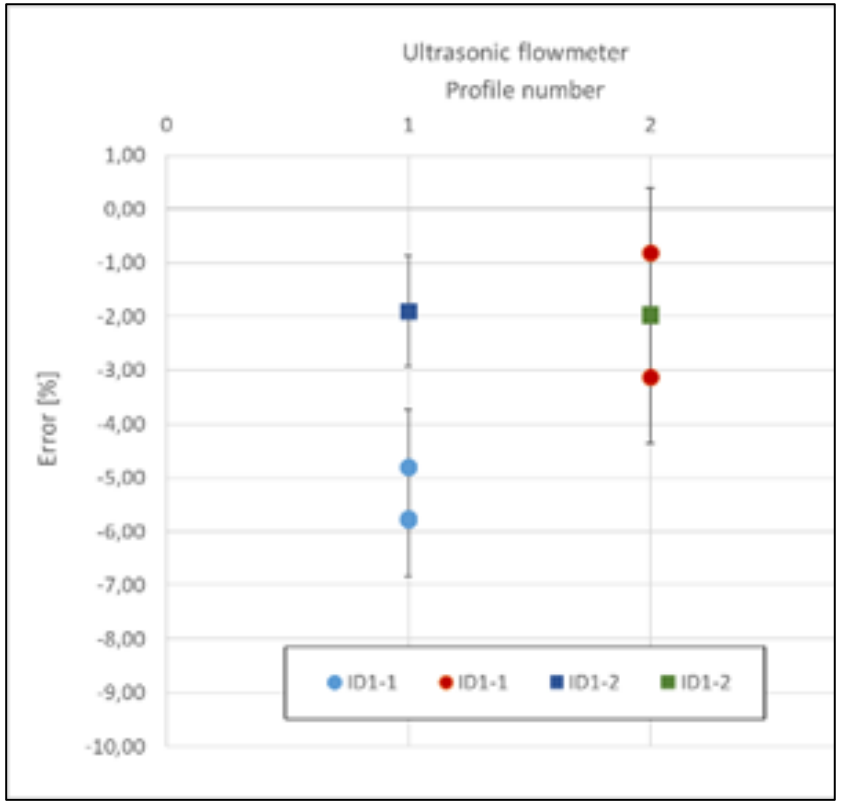
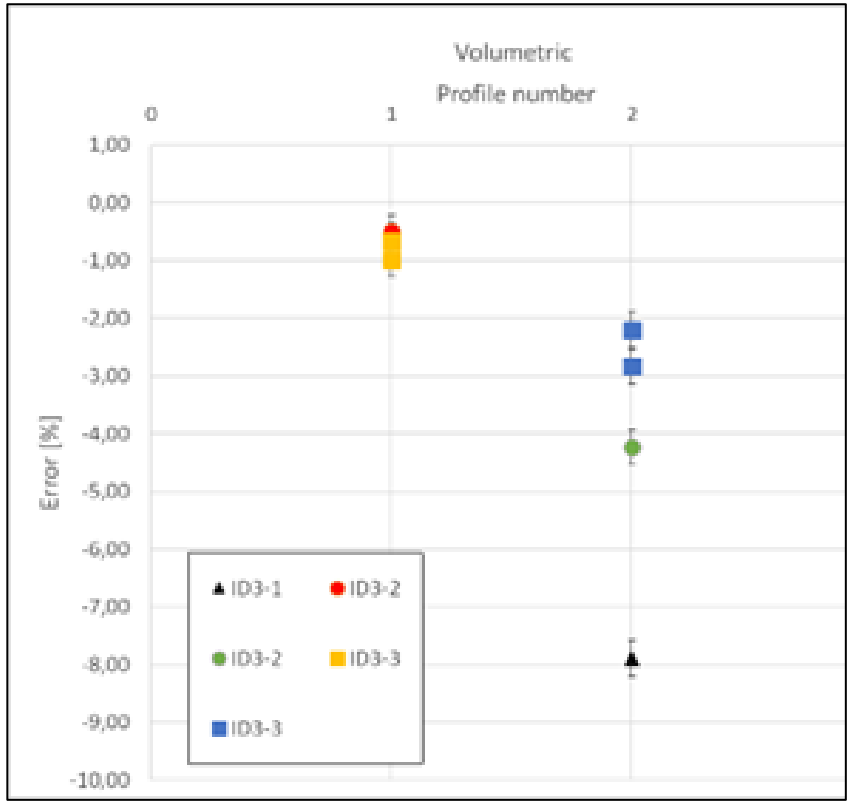
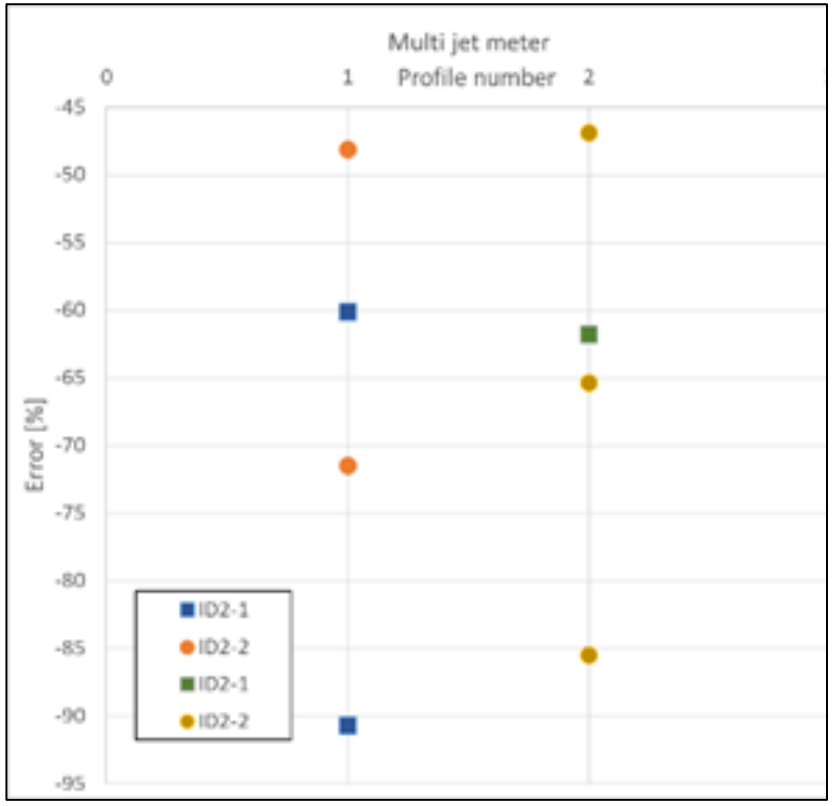
Test of water meters for leakage detection - Results for dynamic test of water meters







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Summary

- ✓ Metrological validation of static low flow intercomparison has been performed.
- ✓ Three dynamic load profiles for low flow has been developed and implemented at two laboratories within the project.
- ✓ Intercomparison of dynamic flow using standard dynamic load profiles has been performed with success.
- ✓ Three different types of water meters has been tested for both for static and dynamic flow
- ✓ The ultrasonic water meters was able to measure the lowest flow among the three types of meters, where the multi-jet water meter required a flow of 20 L/h or more before running.
- ✓ The ultrasonic and piston water meter performed almost similar depending on load profile, where the multi-jet water meter measured > 60% less volume compared to reference.
- ✓ Data from smart water meters capable of measuring low flow can be used for automatic leakage detection and rapid feedback to customer reducing water billing and material damages to building constructions.

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