

Supplementary Materials for

**Estimating the Economic Level of Water Losses (ELWL) in the Water Distribution System of
the City of Malang, Indonesia**

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S1. Cost for reducing real losses

A. Operational Cost

The step test was conducted every week: one group was sent for the east region and the other group for the west region. The step test team consisted of internal staff and plumbers (outsourcing workers). The number of internal and outsourcing staff assigned for step test from 2011 – 2015 is shown in table S1. The internal staff were paid monthly, and the outsourcing staff were paid daily. Before the step test was performed, another group of plumbers performed the valve installation.

Table S1. Active Leakage Detection Operational Cost: PDAM Kota Malang

Item	Year				
	2011	2012	2013	2014	2015
Internal Staff	3	4	4	4	6
Total cost/month for internal staff (EUR)	1,508	2,212	2,354	2,354	3,381
Outsourcing workers	2	2	4	4	4
Daily cost for outsourcing workers/day (EUR)	4.33	4.67	4.67	5.33	6.00
Overtime cost for outsourcing/hour (EUR)	0.67	0.67	0.67	0.67	0.67
Meal cost for overtime/day (EUR)	1.00	1.00	1.00	1.33	1.33
Total cost/month for outsourcing (IDR)	98.7	104.0	208.0	234.7	256.0
Outsourcing workers for installing valve before ALC	6	6	6	8	10
Total cost/month for installing valve	528.00	560.00	560.00	853.33	1,173.33
Labour Cost for ALC/year	25,615	34,517	37,459	41,299	57,729
Vehicles (rent) (EUR)/year	467	467	533	533	600
Fuel (EUR)/year	1280	1280	1440	1440	1600
Training cost (EUR/year)	400	533	533	533	800
Total ALC Operational Cost (EUR)	27,761	36,797	39,966	43,806	60,729

*Exchange rate Euro/Rp = 15,000

In every step test, the outsourcing workers worked for two days: one day for the step test only and the second day to repair the leaks. The overtime hours were estimated to 4 hours for step test activity and every personnel got one meal. Installing the valves is estimated to need 4 days. With all of these estimations and the value for the daily cost of outsourcing workers, overtime and meal costs obtained from the financial department, the labour costs for one year were calculated as shown in table S1.

Each group (East Region and West Region) had one car that was rented from Koperasi. The rent and fuel costs which were obtained from the financial department are depicted in table S1. By summing up the labour cost, vehicle cost, fuel cost and training cost, the annual operational cost can be calculated.

B. Investment Cost

On the other hand, there is also the investment cost related to the activity to reduce the physical losses. The investment for the DMA establishment contributes to the active leakage detection activities and pressure management. The investment cost for leakage detection equipment was also considered. The investment cost was spread based on the lifetime of the equipment. For DMA, the lifetime was estimated from the equipment with the highest cost (PRV); that is, 5 years. The leakage detection equipment's lifetime was estimated to be 10 years.

The investment costs for DMA establishment were estimated from the number of DMA created each year and the average cost to build one DMA. From the waterworks, the estimated cost to build one DMA was 16,667 EUR. The total investment costs for one year were spread to the next five years, and this became the average annual costs. The number of DMA established each year, the investment costs and the annual costs for DMA are shown in table S2.

Table S2. DMA cost: PDAM Kota Malang

Item/Year	2011	2012	2013	2014	2015
Number of DMA	12	20	40	47	16

Investment costs (EUR)	200,000	333,333	666,667	783,333	266,667
Annual costs (EUR)	40,000	106,667	240,000	396,667	450,000

In every step test, one step test team used one set of leakage detection equipment (one multipoint correlator and one ground microphone). PDAM Kota Malang bought the multipoint correlator in 2014 and five ground microphones in different years (one in 2011, one in 2014 and three in 2015). The investment costs for the leakage detection equipment are spread for the next 10 years, as shown in table S3.

Table S3. Leakage detection equipment cost: PDAM Kota Malang

Item/Year	2011	2012	2013	2014	2015
Price of leakage detection equipment (EUR)	10,000	-	-	10,000	20,000
Annual cost (EUR)	1,000	1,000	1,000	2,000	4,000

Another associated cost related to the reduction of real losses is the maintenance of the transmission and distribution pipes. For this data, the financial division of PDAM Kota Malang did not separate the costs that were directly related to leakage reduction and the costs that were not directly related. All of the costs for the maintenance of the distribution pipes were assumed to be directly related to the leakage reduction. The total cost for the reduction of the real losses are summarized in Table S4.

Table S4. Cost for controlling the real losses: PDAM Kota Malang

Item/Year	2011	2012	2013	2014	2015
Active leakage detection cost (EUR)	27,761	36,797	39,966	43,806	60,729
Annual DMA cost (EUR)	40,000	106,667	240,000	396,667	450,000
Leakage detector equipment (EUR)	1,000	1,000	1,000	2,000	4,000
Maintenance for distribution pipe (EUR)	316,381	327,682	380,209	306,737	442,659
Annual Cost for Real Loss Reduction (EUR)	385,142	472,145	661,175	749,209	957,388

S2. ELL Calculation

A. Total Cost Method: ELL

Table S5. Cost of the lost water from real losses and total cost: PDAM Kota Malang

Item	Year				
	2011	2012	2013	2014	2015
Real losses (m ³ /year)	9,320,882	8,629,240	8,048,657	5,928,759	4,604,143
Cost of water lost from RL (EUR)	2,423,429	2,243,602	2,092,651	1,541,477	1,197,077
Real Loss Control Cost (EUR)	385,142	472,145	661,175	749,209	957,388
Number of house connections	106,578	116,184	125,614	134,630	140,320
RL/connection (m ³ /conn/year)	134.94	104.44	87.76	71.89	62.89
Total Cost (EUR)	2,808,571	2,715,747	2,753,826	2,290,687	2,154,465

Table S6. Extended calculation based on the curve equation for the real loss control cost, the cost of lost water and the total cost.

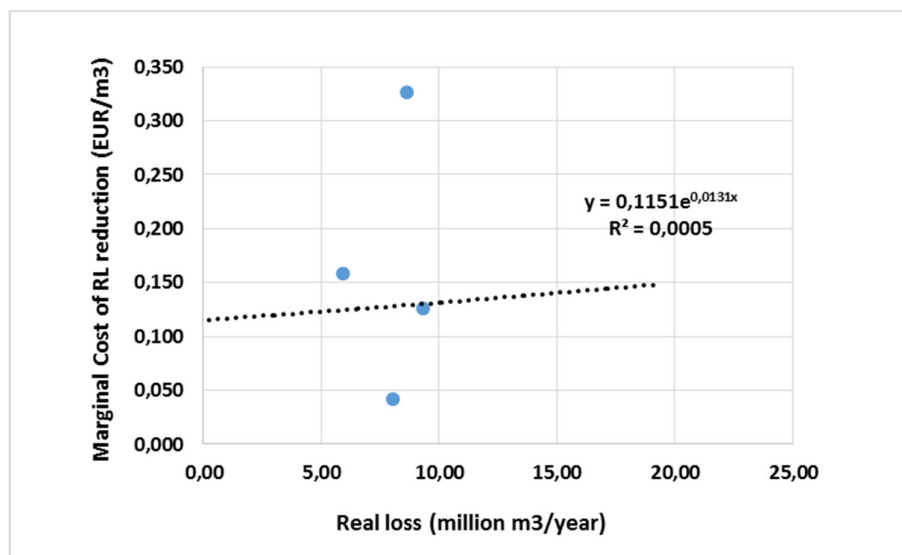
Real Loss Volume (million m ³ /year)	2,00	3,00	4,00	4,60	5,93	8,05	8,63	9,32
Real loss control cost (thousand EUR)	2.590	1.630	1.174	957	749	661	472	385
Cost of lost water from real loss(thousand EUR)	520	780	1.040	1.197	1.541	2.093	2.244	2.423
Total cost (thousand EUR)	3.110	2.410	2.214	2.154	2.291	2.754	2.716	2.809

B. Marginal Cost Method: ELL

Table S7. Marginal cost of real loss reduction

Item	2011	2012	2013	2014	2015
Real loss Control Cost (EUR)	385.142	472.145	661.175	749.209	957.388
Incremental control cost (EUR)		87.003	189.030	88.034	208.179
Volume of real loss (m3/year)	9.320.882	8.629.240	8.048.657	5.928.759	4.604.143
Volume of real loss (million m3/year)	9,32	8,63	8,05	5,93	4,60
Real loss reduction over previous year (m3)	-	691.642	580.583	2.119.898	1.324.616
Marginal cost of real loss reduction	-	0,126	0,326	0,042	0,157

Figure S1. Marginal cost of real loss reduction curve

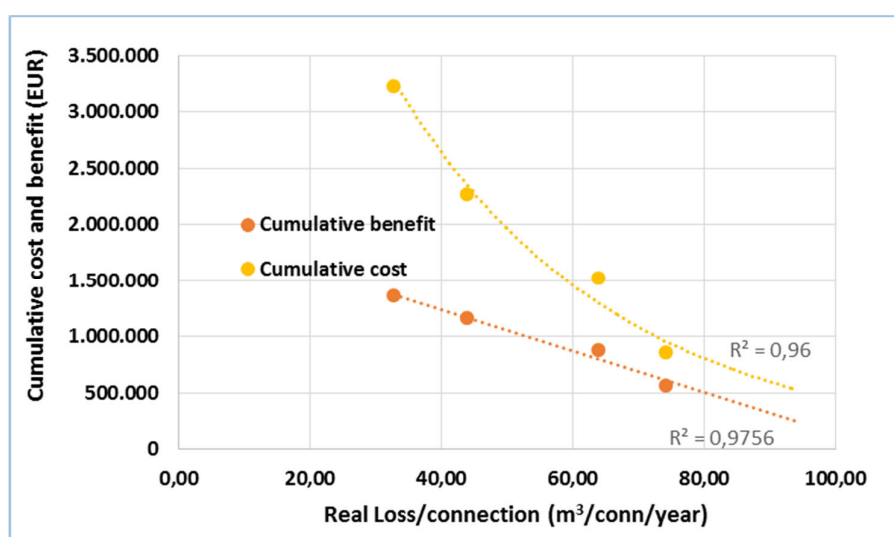


C. Cumulative Cost–Benefit Method - ELL

Table S8. The cumulative benefit and cost for real loss reduction

Item/Year	2011	2012	2013	2014	2015
Total Benefit (EUR)	218,684	246,031	274,958	257,499	186,191
Cumulative benefit (EUR)		464,716	739,674	997,173	1,183,364
Total Cost (EUR)	385,142	472,145	661,175	749,209	957,388
Cumulative cost (EUR)		857,287	1,518,462	2,267,672	3,225,060

Figure S2. ELL Estimation with the Cumulative Cost and Benefit method



S3. ELAL Calculation

Table S9. Optimum meter replacement period calculation

Year	Weighted error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	€0.08	€0.08	€0.08	€32.67	€32.75
2	0.20%	0.163	€0.24	€0.12	€16.33	€16.46
3	0.30%	0.245	€0.49	€0.16	€10.89	€11.05
4	0.50%	0.408	€0.90	€0.22	€8.17	€8.39

5	0.80%	0.653	€1.55	€0.31	€6.53	€6.84
6	3.00%	2.448	€4.00	€0.67	€5.44	€6.11
7	5.00%	4.080	€8.08	€1.15	€4.67	€5.82
8	7.50%	6.120	€14.20	€1.77	€4.08	€5.86
9	9.00%	7.344	€21.54	€2.39	€3.63	€6.02
10	11.00%	8.976	€30.52	€3.05	€3.27	€6.32
11	13.00%	10.608	€41.13	€3.74	€2.97	€6.71

S4. ELWL Calculation

A. Total Cost Method: ELWL

Table S10. Water loss control cost

Cost (EUR)	Year				
	2011	2012	2013	2014	2015
Active Leakage Detection (Step Test)	27,761	36,797	39,966	43,806	60,729
Maintenance of distribution pipe	316,381	327,682	380,209	306,737	442,659
Leakage Detection Equipment	1,000	1,000	1,000	2,000	4,000
DMA Annual Cost	40,000	106,667	240,000	396,667	450,000
Meter Replacement	-	19,721	112,882	206,043	299,204
Software for meter reading with android	-	-	2,000	2,000	2,000
Water Loss control cost (EUR)	385,142	491,866	776,057	957,252	1,258,592

Table S11. Water loss and the cost of the lost water

Item	Year				
	2011	2012	2013	2014	2015

Water loss (%)	36.69%	29.99%	26.97%	22.61%	20.42%
Water loss (m3/year)	14,382,067	12,133,866	11,023,529	9,678,697	8,824,725
Water loss/connection (m3/conn/year)	134.94	104.44	87.76	71.89	62.89
Cost of Water Lost (EUR)	4,889,903	4,125,514	3,748,000	3,290,757	3,000,407

Table S12. Extended calculation based on the curve equation for the water loss control cost, the cost of lost water and the total cost

WL/connection (m3/conn/year)	15.00	20	30	40	50	62.89	64	65	66	67	68	69	70	71.89	87.76	104.44	134.94
WL control cost (thousand EUR)	11,814	7,499	3,952	2,508	1,763	1,227	1,194	1,165	1,137	1,110	1,085	1,060	1,036	993	725	551	367
Cost of water lost (thousand EUR)	1,808	1,938	2,196	2,455	2,714	3,048	3,076	3,102	3,128	3,154	3,180	3,206	3,232	3,281	3,691	4,123	4,912
Total cost (thousand EUR)	13,622	9,437	6,148	4,964	4,477	4,275	4,270	4,267	4,265	4,264.26	4,264.46	4,266	4,268	4,274	4,416	4,673	5,280

B. Cumulative Cost-Benefit Method: ELWL

Table S13. Cumulative cost and benefit

Item	Year				
	2011	2012	2013	2014	2015

Cumulative cost					
Water Loss control cost (EUR)	385,142	491,866	776,057	957,252	1,258,592
Cumulative control cost (EUR)	385,142	877,008	1,653,065	2,610,317	3,868,909
Cumulative benefit					
Water Loss (m3/year)	14,382,067	12,133,866	11,023,529	9,678,697	8,824,725
Water Loss reduction over previous year (m3/year)	-	2,248,201	1,110,337	1,344,832	853,972
Cumulative WL Reduction (m3/year)	-	2,248,201	3,358,538	4,703,370	5,557,342
Marginal cost of water (EUR/m3)	-	0.260	0.260	0.260	0.260
Cumulative benefit	-	584,532	873,220	1,222,876	1,444,909

S5. Sensitivity Analysis

A. Sensitivity analysis of ELWL: Total cost method

Water tariff decrease 20%

WL/connection (m3/conn/year)	67	68	69	70	71	72	73	74	75	76
WL control cost (thousand EUR)	1,110	1,085	1,060	1,036	1,013	993	970	949	929	910

Value of water lost (thousand EUR)	2,523	2,544	2,565	2,585	2,606	2,624	2,647	2,668	2,689	2,710
Total cost (thousand EUR)	3,633	3,628	3,624	3,621	3,619	3,618	3,617.0	3,617.1	3,618	3,619

Water tariff decrease 10%

WL/connection (m3/conn/year)	67	68	69	70	71	72	73	74	75	76
WL control cost (thousand EUR)	1,110	1,085	1,060	1,036	1,013	993	970	949	929	910
Value of water lost (thousand EUR)	2,839	2,862	2,885	2,908	2,932	2,952	2,978	3,002	3,025	3,048
Total cost (thousand EUR)	3,949	3,946	3,945	3,944	3,945	3,946	3,948	3,951	3,954	3,958

Water tariff increase 10%

WL/connection (m3/conn/year)	61	62	63	64	65	66	67	68	69	70
WL control cost (thousand EUR)	1,288	1,255	1,224	1,194	1,165	1,137	1,110	1,085	1,060	1,036
Value of water lost (thousand EUR)	3,299	3,327	3,356	3,384	3,412	3,441	3,469	3,498	3,526	3,555
Total cost (thousand EUR)	4,586	4,582	4,579	4,578	4,577	4,578	4,580	4,582	4,586	4,591

Water tariff increase 20%

WL/connection (m3/conn/year)	61	62	63	64	65	66	67	68	69	70
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WL control cost (thousand EUR)	1,288	1,255	1,224	1,194	1,165	1,137	1,110	1,085	1,060	1,036
Value of water lost (thousand EUR)	3,599	3,630	3,661	3,692	3,723	3,754	3,785	3,816	3,847	3,878
Total cost (thousand EUR)	4,886	4,885	4,884	4,885	4,888	4,891	4,895	4,901	4,907	4,914

Water loss control cost decrease 20%

WL/connection (m3/conn/year)	60	61	62	63	64	65	66	67	68	69
WL control cost (thousand EUR)	1,057	1,030	1,004	979	955	932	910	888	868	848
Cost of water lost (thousand EUR)	2,973	2,999	3,025	3,050	3,076	3,102	3,128	3,154	3,180	3,206
Total cost (thousand EUR)	4,030	4,028.9	4,028.6	4,029.4	4,031	4,034	4,038	4,042	4,048	4,054

Water loss control cost decrease 10%

WL/connection (m3/conn/year)	60	61	62	63	64	65	66	67	68	69
WL control cost (thousand EUR)	1,190	1,159	1,130	1,101	1,074	1,048	1,023	999	976	954

Cost of water lost (thousand EUR)	2,973	2,999	3,025	3,050	3,076	3,102	3,128	3,154	3,180	3,206
Total cost (thousand EUR)	4,162	4,158	4,154	4,152	4,151	4,150	4,151	4,153	4,156	4,160

Water loss control cost increase 10%

WL/connection (m3/conn/year)	65	66	67	68	69	70	71	72	73	74
WL control cost (thousand EUR)	1,281	1,251	1,221	1,193	1,166	1,140	1,114	1,090	1,067	1,044
Cost of water lost (thousand EUR)	3,102	3,128	3,154	3,180	3,206	3,232	3,258	3,283	3,309	3,335
Total cost (thousand EUR)	4,383	4,379	4,375	4,373	4,372	4,371	4,372	4,373	4,376	4,379

Water loss control cost increase 20%

WL/connection (m3/conn/year)	65	66	67	68	69	70	71	72	73	74
WL control cost (thousand EUR)	1,398	1,364	1,332	1,301	1,272	1,243	1,216	1,189	1,163	1,139

Cost of water lost (thousand EUR)	3,102	3,128	3,154	3,180	3,206	3,232	3,258	3,283	3,309	3,335
Total cost (thousand EUR)	4,500	4,492	4,486	4,481	4,478	4,475	4,473.19	4,472.50	4,472.74	4,474

B. Sensitivity analysis of ELWL: marginal cost method

B.1. Change in the marginal cost of water

Curve equation from figure 3: $y = 3.4146 e^{-0.038x}$

where: y = marginal cost of water (EUR/m³)

x = ELWL (m³/conn/year)

From the equation, it can be derived that $x = (1.228 - \ln y)/0.038$

Marginal cost of water		ELWL (m ³ /conn/year)
Value changed	EUR/m ³	
-20%	0.208	73.6
-10%	0.234	70.5
0%	0.26	67.8
10%	0.286	65.3

20%	0.312	63.0
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B.II. Change in the Water Loss Control Cost

The curve equation changes when the water loss control cost changes. The ELWL is calculated from that equation with the same γ (marginal cost of water) value; that is, 0.26.

Marginal cost curve		ELWL (m ³ /conn/year)
WL control cost value changed	Equation	
-20%	$y = 2.7317e^{-0.038x}$	61.9
-10%	$y = 3.0731e^{-0.038x}$	65.0
0%	$y = 3.4146e^{-0.038x}$	67.8
10%	$y = 3.756e^{-0.038x}$	70.3
20%	$y = 4.0975e^{-0.038x}$	72.6

C. Sensitivity analysis on ELWL: Cumulative cost–benefit method

Figure S3. Cumulative cost and benefit curve : tariff increase 20%

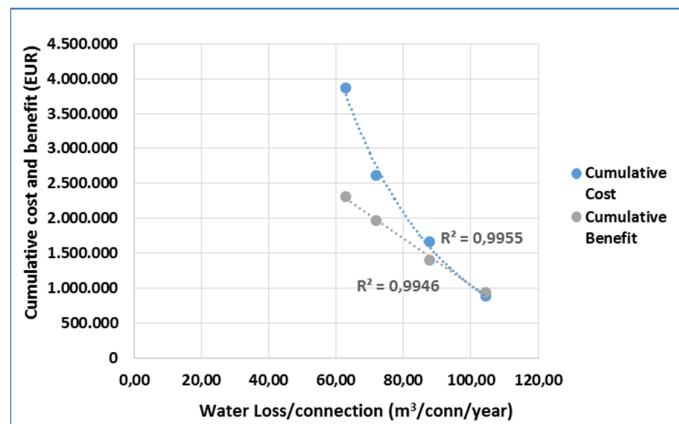
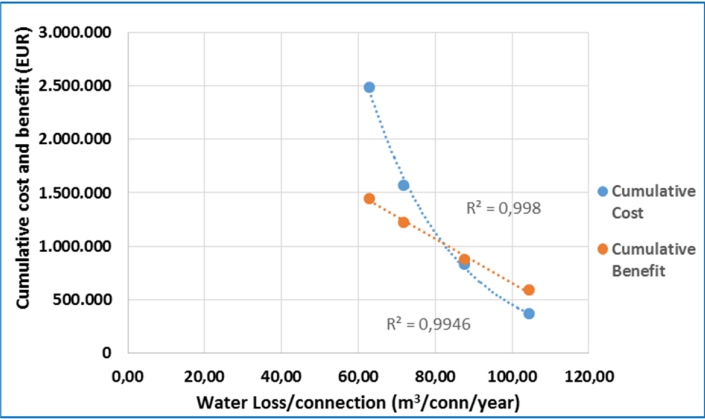


Figure SError! No text of specified style in document.. Cumulative cost and benefit curve:
water loss control cost decrease 5%



D. Sensitivity analysis on ELL: Total cost method

Cost of Production decrease 20%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.2	4.4	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
Real loss control cost (thousand EUR)	2,590	1,630	1,174	1,110	1,053	1,000	953	910	870	833	749	661	472	385
Cost of lost water (thousand EUR)	416	624	832	874	915	958	998	1,040	1,082	1,123	1,233	1,674	1,795	1,939
Total cost (thousan EUR)	3,006	2,254	2,006	1,984	1,968	1,957	1,951	1,950	1,951	1,956	1,982	2,335	2,267	2,324

Cost of Production decrease 10%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.2	4.4	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
Real loss control cost (thousand EUR)	2,590	1,630	1,174	1,110	1,053	1,000	953	910	870	833	749	661	472	385
Cost of lost water (thousand EUR)	468	702	936	983	1,030	1,077	1,123	1,170	1,217	1,264	1,387	1,883	2,019	2,181
Total cost (thousan EUR)	3,058	2,332	2,110	2,093	2,082	2,077	2,076	2,080	2,087	2,097	2,137	2,545	2,491	2,566

Cost of Production increase 10%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.1	4.3	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
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Real loss control cost (thousand EUR)	2,590	1,630	1,174	1,141	1,081	1,000	953	910	870	833	749	661	472	385
Cost of lost water (thousand EUR)	572	858	1,144	1,173	1,230	1,317	1,373	1,430	1,487	1,544	1,696	2,302	2,468	2,666
Total cost (thousan EUR)	3,162	2,488	2,318	2,314	2,310	2,316	2,326	2,340	2,357	2,378	2,445	2,963	2,940	3,051

Cost of Production increase 20%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.1	4.3	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
Real loss control cost (thousand EUR)	2,590	1,630	1,174	1,141	1,081	1,000	953	910	870	833	749	661	472	385
Cost of lost water (thousand EUR)	624	936	1,248	1,279	1,342	1,436	1,498	1,560	1,622	1,685	1,850	2,511	2,692	2,908
Total cost (thousan EUR)	3,214	2,566	2,422	2,420	2,422	2,436	2,451	2,470	2,492	2,518	2,599	3,172	3,164	3,293

Real loss control cost decrease 20%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.10	4.2	4.4	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
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Real loss control cost (thousand EUR)	2,07 2	1,30 4	913	888	842	800	762	728	696	667	599	423	390	357
Cost of lost water (thousand EUR)	520	780	1,06 6	1,09 2	1,14 4	1,19 7	1,24 8	1,30 0	1,35 2	1,40 4	1,54 1	2,09 3	2,24 4	2,42 3
Total cost (thousand EUR)	2,59 2	2,08 4	1,97 9	1,98 0	1,98 6	1,99 7	2,01 0	2,02 8	2,04 8	2,07 1	2,14 1	2,51 5	2,63 4	2,78 1

Real loss control cost decrease 10%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.1	4.3	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
Real loss control cost (thousand EUR)	2,33 1	1,46 7	1,05 6	1,02 7	973	900	858	819	783	750	674	475	439	402
Cost of lost water (thousand EUR)	520	780	1,04 0	1,06 6	1,11 8	1,19 7	1,24 8	1,30 0	1,35 2	1,40 4	1,54 1	2,09 3	2,24 4	2,42 3
Total cost (thousand EUR)	2,85 1	2,24 7	2,09 6	2,09 3	2,09 1	2,09 7	2,10 6	2,11 9	2,13 5	2,15 4	2,21 5	2,56 8	2,68 3	2,82 5

Real loss control cost increase 10%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.1	4.3	4.60	4.8	5	5.2	5.4	5.93	8.05	8.63	9.32
Real loss control cost (thousand EUR)	2,849	1,793	1,291	1,255	1,189	1,099	1,048	1,001	957	916	824	581	537	491
Cost of lost water (thousand EUR)	520	780	1,040	1,066	1,118	1,197	1,248	1,300	1,352	1,404	1,541	2,093	2,244	2,423
Total cost (thousand EUR)	3,369	2,573	2,331	2,321	2,307	2,297	2,296	2,301	2,309	2,320	2,365	2,674	2,780	2,915

Real loss control cost increase 20%

Real Loss Volume (million m ³ /year)	2.00	3.00	4.00	4.1	4.3	4.60	4.7	4.9	5.2	5.4	5.93	8.05	8.63	9.32
Real loss control cost (thousand EUR)	3,108	1,956	1,408	1,369	1,297	1,199	1,172	1,117	1,044	1,000	899	634	585	536
Cost of lost water (thousand EUR)	520	780	1,040	1,066	1,118	1,197	1,222	1,274	1,352	1,404	1,541	2,093	2,244	2,423
Total cost (thousand EUR)	3,628	2,736	2,448	2,435	2,415	2,397	2,394	2,391	2,396	2,404	2,440	2,726	2,829	2,959

E. Sensitivity analysis on ELAL: Economic meter inaccuracies

E.1. Water tariff decrease 20%

Price of the meter	26.67	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.272	EUR/m3

Year	Weighed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.07	€0.07	€32.67	€32.73
2	0.20%	0.131	€0.20	€0.10	€16.33	€16.43
3	0.30%	0.196	€0.39	€0.13	€10.89	€11.02
4	0.50%	0.326	€0.72	€0.18	€8.17	€8.35
5	0.80%	0.522	€1.24	€0.25	€6.53	€6.78
6	3.00%	1.958	€3.20	€0.53	€5.44	€5.98
7	5.00%	3.264	€6.46	€0.92	€4.67	€5.59
8	7.50%	4.896	€11.36	€1.42	€4.08	€5.50
9	9.00%	5.875	€17.23	€1.91	€3.63	€5.54
10	11.00%	7.181	€24.41	€2.44	€3.27	€5.71
11	13.00%	8.486	€32.90	€2.99	€2.97	€5.96

Economic Replacement Frequency 8 years

Economic meter

inaccuracy 2.18%

E.2 Water tariff decrease 10%

Price of the meter	26.67	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.306	EUR/m3

Year	Weighed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.07	€0.07	€32.67	€32.74

2	0.20%	0.147	€0.22	€0.11	€16.33	€16.44
3	0.30%	0.220	€0.44	€0.15	€10.89	€11.04
4	0.50%	0.367	€0.81	€0.20	€8.17	€8.37
5	0.80%	0.588	€1.40	€0.28	€6.53	€6.81
6	3.00%	2.203	€3.60	€0.60	€5.44	€6.04
7	5.00%	3.672	€7.27	€1.04	€4.67	€5.71
8	7.50%	5.508	€12.78	€1.60	€4.08	€5.68
9	9.00%	6.610	€19.39	€2.15	€3.63	€5.78
10	11.00%	8.078	€27.47	€2.75	€3.27	€6.01
11	13.00%	9.547	€37.01	€3.36	€2.97	€6.33

Economic Replacement

Frequency 8 years

Economic meter

inaccuracy 2.18%

E.3 Water tariff increase 10%

Price of the meter	26.67	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.374	EUR/m3

Year	Weigthed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.09	€0.09	€32.67	€32.76
2	0.20%	0.180	€0.27	€0.13	€16.33	€16.47
3	0.30%	0.269	€0.54	€0.18	€10.89	€11.07
4	0.50%	0.449	€0.99	€0.25	€8.17	€8.41
5	0.80%	0.718	€1.71	€0.34	€6.53	€6.87
6	3.00%	2.693	€4.40	€0.73	€5.44	€6.18
7	5.00%	4.488	€8.89	€1.27	€4.67	€5.94
8	7.50%	6.732	€15.62	€1.95	€4.08	€6.04
9	9.00%	8.078	€23.70	€2.63	€3.63	€6.26
10	11.00%	9.874	€33.57	€3.36	€3.27	€6.62
11	13.00%	11.669	€45.24	€4.11	€2.97	€7.08

Economic Replacement Frequency 7 years

Economic meter

inaccuracy

1.41%

E.4 Water tariff increase 20%

Price of the meter	26.67	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.408	EUR/m3

Year	Weighed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.10	€0.10	€32.67	€32.76
2	0.20%	0.196	€0.29	€0.15	€16.33	€16.48
3	0.30%	0.294	€0.59	€0.20	€10.89	€11.08
4	0.50%	0.490	€1.08	€0.27	€8.17	€8.44
5	0.80%	0.783	€1.86	€0.37	€6.53	€6.91
6	3.00%	2.938	€4.80	€0.80	€5.44	€6.24
7	5.00%	4.896	€9.69	€1.38	€4.67	€6.05
8	7.50%	7.344	€17.04	€2.13	€4.08	€6.21
9	9.00%	8.813	€25.85	€2.87	€3.63	€6.50
10	11.00%	10.771	€36.62	€3.66	€3.27	€6.93
11	13.00%	12.730	€49.35	€4.49	€2.97	€7.46

Economic Replacement Frequency 7 years

Economic meter

inaccuracy 1.41%

E.5 Meter price decrease 20%

Price of the meter	21.33	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.34	EUR/m3

Year	Weigthed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.08	€0.08	€27.33	€27.41
2	0.20%	0.163	€0.24	€0.12	€13.67	€13.79
3	0.30%	0.245	€0.49	€0.16	€9.11	€9.27
4	0.50%	0.408	€0.90	€0.22	€6.83	€7.06
5	0.80%	0.653	€1.55	€0.31	€5.47	€5.78
6	3.00%	2.448	€4.00	€0.67	€4.56	€5.22
7	5.00%	4.080	€8.08	€1.15	€3.90	€5.06
8	7.50%	6.120	€14.20	€1.77	€3.42	€5.19
9	9.00%	7.344	€21.54	€2.39	€3.04	€5.43
10	11.00%	8.976	€30.52	€3.05	€2.73	€5.79
11	13.00%	10.608	€41.13	€3.74	€2.48	€6.22

Economic Replacement Frequency 7 years

Economic meter

inaccuracy 1.41%

E.6 Meter price decrease 10%

Price of the meter	24.00	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.34	EUR/m3

Year	Weighed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.08	€0.08	€30.00	€30.08
2	0.20%	0.163	€0.24	€0.12	€15.00	€15.12
3	0.30%	0.245	€0.49	€0.16	€10.00	€10.16
4	0.50%	0.408	€0.90	€0.22	€7.50	€7.72
5	0.80%	0.653	€1.55	€0.31	€6.00	€6.31
6	3.00%	2.448	€4.00	€0.67	€5.00	€5.67
7	5.00%	4.080	€8.08	€1.15	€4.29	€5.44
8	7.50%	6.120	€14.20	€1.77	€3.75	€5.52
9	9.00%	7.344	€21.54	€2.39	€3.33	€5.73
10	11.00%	8.976	€30.52	€3.05	€3.00	€6.05
11	13.00%	10.608	€41.13	€3.74	€2.73	€6.47

Economic Replacement Frequency 7 years

Economic meter

inaccuracy 1.41%

E.7 Meter price increase 10%

Price of the meter	29.33	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.34	EUR/m3

Year	Weigthed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.08	€0.08	€35.33	€35.41
2	0.20%	0.163	€0.24	€0.12	€17.67	€17.79
3	0.30%	0.245	€0.49	€0.16	€11.78	€11.94
4	0.50%	0.408	€0.90	€0.22	€8.83	€9.06
5	0.80%	0.653	€1.55	€0.31	€7.07	€7.38
6	3.00%	2.448	€4.00	€0.67	€5.89	€6.56
7	5.00%	4.080	€8.08	€1.15	€5.05	€6.20
8	7.50%	6.120	€14.20	€1.77	€4.42	€6.19
9	9.00%	7.344	€21.54	€2.39	€3.93	€6.32
10	11.00%	8.976	€30.52	€3.05	€3.53	€6.59
11	13.00%	10.608	€41.13	€3.74	€3.21	€6.95

Economic Replacement Frequency 8 years

Economic meter

inaccuracy 2.18%

E.8 Meter price increase 20%

Price of the meter	32.00	EUR
Cost of installation	3	EUR
Administration cost	3	EUR
Average consumption/year	240	m3
Water tariff	0.34	EUR/m3

Year	Weighed error	Cost of Lost Water	Cumulative Cost of Lost Water	Annual Cost of Lost Water	Annual Cost of Meter	Total Annual Cost
1	0.10%	-	€0.08	€0.08	€38.00	€38.08
2	0.20%	0.163	€0.24	€0.12	€19.00	€19.12
3	0.30%	0.245	€0.49	€0.16	€12.67	€12.83
4	0.50%	0.408	€0.90	€0.22	€9.50	€9.72
5	0.80%	0.653	€1.55	€0.31	€7.60	€7.91
6	3.00%	2.448	€4.00	€0.67	€6.33	€7.00
7	5.00%	4.080	€8.08	€1.15	€5.43	€6.58
8	7.50%	6.120	€14.20	€1.77	€4.75	€6.52
9	9.00%	7.344	€21.54	€2.39	€4.22	€6.62
10	11.00%	8.976	€30.52	€3.05	€3.80	€6.85
11	13.00%	10.608	€41.13	€3.74	€3.45	€7.19

Economic Replacement Frequency 8 years

Economic meter

inaccuracy 2.18%

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