Evaluating the Role of Water Metering and Submetering in Reducing Water Consumption in Buildings

Final Report

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Final Report

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1 MANAGEMENT SUMMARY

1.1 Introduction

Water stress is an increasing concern across many regions of Europe. Reducing water consumption, particularly drinking water, is required to ensure sustainable water availability for future generations and to reduce the pressure on freshwater resources. The European Water Resilience Strategy emphasises smart metering, in this study called digital meters, and digitalisation to help EU citizens and businesses manage their water use and reduce consumption.

Households and the services sector account for 28% of water abstraction and 13% of water consumption in the EU (EEA, 2024, State of Water 2024). This indicates that there is significant potential for water savings. According to estimates, the public water supply sector could achieve water savings of between 20% and 50% (EEA, 2025, Water Savings for a Water Resilient Europe).

This study provides evidence for the impact of water metering and submetering on residential drinking water consumption. A submeter is a meter installed downstream of a main utility meter to measure consumption for individual tenants in multi-tenant buildings. Where previous studies focus on specific areas or countries, this is the first pan-European analysis containing multiple countries with multiple years of data. It comprises three main components:

- A literature review
- Expert interviews with professionals from the digital metering industry
- A data analysis based on drinking water consumption data collected from water meters across Europe.

1.2 Study Results

Existing literature

Existing literature on water metering and potential savings reports important reductions in drinking water consumption. Numerous international studies have consistently shown that the introduction of water metering can significantly reduce residential water consumption, often complemented by behavioural interventions, pricing policies, and leak detection capabilities.
A few studies demonstrate that replacing analogue meters with digital meters has an impact of 5 to 8% through the provision of more frequent consumption data. When all facets of digital water metering are combined (leak detection, consumption-based billing, and real-time feedback) and complemented by awareness campaigns, water savings can result in 25% savings compared to no metering, and in some cases, even higher.

Expert interviews[1]

Experts from the metering industry in Denmark, France, Germany, Poland, and Romania confirm that digital water metering results in reduced water consumption. The reduced consumption from water metering is estimated to be between 15% and 30% by changing from no metering to analogue or digital metering. In France, they experienced an 8% decrease in water consumption compared with analogue water meters.

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[1] More information available in Appendix 8.1

The interviews also highlighted that the benefits of digital metering go beyond water savings. A specific example is the risk reduction of a Legionella contamination. Being able to exactly know when enough warm water is flushed to avoid contamination reduces both the Legionella risk and water wastage. The general assumption is that flushing 3 litres is sufficient, but sometimes the approach of flushing 1 to 2 minutes is used, which results in larger water use.

EU wide dataset

We analysed a dataset that combines water meter data (annual cold water consumption values) from seven EU Member States, covering the period from 1990 to 2024.

A threshold of a minimum of 500 samples per country was set to perform the analysis on. When comparing meter type (digital vs. analogue) and leak detection (yes vs. no), countries were removed from the analysis if they were made up predominantly of one category. This left 7 countries, Belgium, Denmark, France, Germany, Slovenia, Spain and The Netherlands, to perform data analysis on.

Two types of analyses were performed. For datasets where long enough time series were available for individual buildings or flats, along with the timing of digital meter installation, a Difference in Difference (DiD) model was applied. In cases where DiD analysis was not feasible due to limited data, a simpler comparison of medians was used ("boxplot analysis"). The results of the data analysis are summarised in Table 1 below. In Germany, consumption-based billing led to a 5.1% reduction in water use. In France, the presence of leak detection systems resulted in a 7.5% decrease; in Belgium, this goes up to 13.6%. For three countries, we estimated the impact of digital versus analogue water meters. Considering these effects can be cumulative, these results are consistent with the literature and industry expectations.

Table 1: Summary results of the data analysis.

Country	Water consumption reduction (%)	Parameter	Method used
DE	5.1	consumption-based vs. floor area billing	box plot analysis
FR	7.5	leak detection vs. no leak detection	box plot analysis
BE	13.6	leak detection vs. no leak detection	box plot analysis
DK	5.2	digital vs. analogue meter type	Difference in Difference
ES	12.3	digital vs. analogue meter type	box plot analysis
NL	6.2	digital vs. analogue meter type	Difference in Difference

1.3 Conclusions

The combined data from the analysis, literature and industry insights quantify water metering savings up to 25%. These savings are in the order of magnitude of the foreseen increase in water efficiency targeted by the European Union by 2030 (see the European Water Resilience Strategy). As of this writing, cold water submetering is only mandatory in Bulgaria and Poland, or required only in new buildings (and/or in buildings undergoing major renovations) in countries such as Belgium (Flanders and Wallonia), France, and Romania. This leaves many EU Member States where submetering could still be introduced - and where the consumption reductions observed in this study could be realised. This study also only considers drinking water at the household level. With the foreseen stress on the overall water balance, smart metering points to a potential for more water savings from other water sources across various sectors.

Despite collecting a considerable amount of data, a key limitation of the analysis is the lack of detailed contextual information, such as socio-economic indicators, regional specifics, and building age, which constrained our ability to perform aggregated analysis and had us resort to a country-specific approach. The forthcoming Smart Water Metering for All initiative may help overcome these limitations by enabling more comprehensive data collection on digital water metering, thereby facilitating richer, EU-wide research and insights.

2 INTRODUCTION

2.1 Context

Water stress is an increasing concern across many regions of Europe, affecting both the environment and human wellbeing. According to the European Environment Agency (EEA), around 34% of the European population are affected by water stress each year (EEA, 2025). Climate change projections indicate that the frequency and intensity of droughts, especially in Southern Europe, will increase. This potentially leads to more frequent events whereby water demand exceeds supply, which results in economic and ecological losses. This underlines the critical importance of sustainable water consumption to ensure sustainable water availability for future generations and to reduce the pressure on freshwater resources.

The European Commission (EC) published a European Water Resilience Strategy in June 2025 (EC, 2025) to set out a pathway to make Europe water resilient. This entails the protection and restoration of aquatic ecosystems, and a fair balance between water supply and water demand responding to current needs, including the realisation of the human right to safe drinking water and sanitation, without compromising the rights of future generations. One of the objectives put forward in this strategy is to improve water efficiency by at least 10% by 2030 in the EU. This strategy emphasises smart metering and digitalisation to help EU citizens and businesses manage their water use and reduce consumption. Deploying smart water metering across all economic sectors will help citizens and businesses to manage their water use more efficiently. Considering this, the EC will develop an EU-wide Action Plan on digitalisation in the water sector including an EU-wide initiative on *Smart Water Metering for All* in 2026.

The open-ended study is performed for WE Data Europe, the European Association for Energy and Water Data Management. It focuses on the potential savings due to the introduction of smart water meters (in this study called digital meters) in buildings. In Europe, the sector accounts for 28% of the freshwater abstracted and 13% of the net water consumption, with 70% of produced drinking water flowing directly into them (EEA, 2024). This makes it a critical sector to achieve the EU water efficiency targets.

Submetering technologies are predominantly implemented within the household and services sector and are primarily used to monitor drinking water consumption. However, the anticipated strain on the overall water balance highlights the need for more efficient utilisation of all available water sources across various sectors. These include, among others, rainwater harvesting, water reuse, wellpoint dewatering at construction sites, leakage reduction in irrigation, industrial processes and public water supply etc. While a comprehensive assessment of submetering's impact across all sectors and water sources lies beyond the scope of this study, it is important to acknowledge the potential benefits that extend beyond current practices.

2.2 Study goals & scope

The objective of this study is to evaluate the role of water metering and submetering in reducing water consumption in buildings. The study aims to analyse the potential of enhanced water management to drive efficiency gains in the households and services sector, contributing to the broader debate on water resilience in Europe.

This study can potentially provide critical evidence supporting the adoption of a European water metering and submetering mandate. By examining the benefits of real-time water usage feedback and early leak detection, the research can contribute to shaping future EU water conservation policies.

Four research objectives are defined:

1. Identify the key contributors to water wastage in buildings (e.g., leaks, inefficient appliances, user behaviour).
2. Quantify the estimated water savings attributable to implementing individual water meters.
3. Evaluate the role of leak detection and abnormal water usage in reducing water consumption.
4. Analyse how individual water metering impacts behavioural drivers of water savings.

The expected outputs are:

- Water Savings: Estimate potential water savings attributable to individual water metering.
- Leakage Reduction: Quantify the possible impact of early leak detection and unusual water usage and subsequent repair, leading to significant reductions in water wastage.
- Behavioural Changes: Provide potential evidence of shifts in consumer behaviour resulting from real-time feedback on water consumption.

To achieve these objectives, this study comprises three main components: a literature review, expert interviews with professionals from the digital metering industry, and a data analysis based on drinking water consumption data collected from water meters across Europe.

2.3 Definitions

To clearly understand the results of this study, we first provide definitions on the different types of meters and applications that are examined.

Submetering
A submeter is a meter installed downstream of a utility's main meter to measure consumption for specific units, dwellings, equipment, or tenants.

Digital water metering and analogue metering
Digital water meters are all water meters that do not require a manual reading of the data at the meter itself. The data is transmitted (via radio signal or WiFi/4G) remotely without the need to do this manually. Digital water meters allow additional “digital” services, such as a dashboard where customers can follow up their consumption in (near) real-time or various alerting services (leak detection).
Meters that do require a manual reading are referred to as analogue meters. In some cases, meters have a digital display but still require a manual reading. These meters are also considered analogue meters in this study.

Consumption-based billing and floor area billing
Consumption-based billing: Charges are based on the metered volume of water consumed, using individual or submeters installed at the dwelling level.
Floor area billing: Charges are based on the size of the dwelling, typically using the floor area (m^2) or number of rooms, regardless of how much water is consumed in the individual dwelling. Floor area-based billing can still be found in parts of Europe, especially in older apartment buildings without individual meters. It is a common way of billing between the landlord and

tenant in the absence of submetering in multi-unit buildings. In countries such as France, Denmark, Poland, Romania and Italy area-based or flat-rate billing in multi-unit buildings is still being used in specific settings.

Leak detection

Leak detection refers to the process of identifying unintended water losses within a building's plumbing system, or any unintended water usage (e.g. a dripping tap) by analysing data collected from digital water meters. By analysing high-resolution, time-stamped consumption data, abnormal usage patterns can be revealed, such as continuous low-level flows during periods when no water use is to be expected. Automated leak detection algorithms or alert systems are often integrated into smart metering platforms to notify users or utilities in real-time, thereby enabling timely interventions, reducing water waste, and preventing damage.

Consumption feedback

Consumption feedback refers to data provided to users about their water usage at a high frequency (e.g. daily, weekly). It can include the volume of water consumed per day, week, or year, patterns or trends in usage, leakage alerts, comparisons to previous periods or similar households, and insights into peak usage times. This information can be delivered in various forms, such as bills, price indications, mobile apps, web portals, emails, or smart meter displays, to help users understand, manage, and potentially reduce their water consumption.

3 LITERATURE REVIEW

3.1 Water metering & savings

Table 2 presents a summary of existing literature on water metering and the potential savings associated with various metering strategies. The percentage savings represents the observed decrease in consumption due to the implementation of the specified intervention.

The results demonstrate that numerous international studies consistently provide evidence that the introduction of (smart) water metering can significantly reduce residential water consumption. In these studies, metering is often complemented by behavioural interventions, pricing policies and leak detection. Across various regions and study types, water metering typically reduces household water consumption by 10 to 25%.

We list the main results, drivers behind water savings, and additional benefits identified in the different studies:

Metering

Many studies demonstrate the effect of water metering on water consumption. The introduction of analogue meters is indicated to result in water savings ranging from 10% to 25%. A few studies demonstrate that replacing analogue meters by digital meters has an additional impact of 5 to 8%. Patten and Richardson (2021) demonstrate savings of 17% when digital meters are installed compared to no metering.

Consumption-based billing

The effectiveness of water metering is closely linked to using water consumption data to perform billing. Grafton et al. (2011) demonstrated that billing water based on actual consumption is a key driver of demand reduction, leading to a 25% decrease in water use on average. National Metering Trials in the UK found an average 11% reduction in water use in households billed by meter (Parker & Wilby, 2012). The EEA (2001) and studies in Denmark and Spain also showed strong impacts when pricing reforms were combined with metering, public awareness campaigns, and technical measures like leak repairs.

Leak detection & additional benefits

Digital meters are effective tools for identifying and preventing unintended water losses: 13,500 leaks were detected in one year by meters installed in the UK (Patten & Richardson, 2021). These interventions also contribute to carbon emission reductions, estimated at 0.5% of total UK emissions if rolled out nationwide (Patten & Richardson, 2021). Two other UK-based studies also quantified loss reductions of 23L/property/day (Godley et al., 2008) and 15% (Francis et al., 2021).

Real-time water consumption feedback

Studies involving digital meters with real-time feedback on consumption, other than leak detection, also demonstrate savings. Davies et al. (2014) observed a 6.8% reduction during a two-year trial, with a sustained 6.4% decrease for three years after removal. Gail et al. (2011) found real-time feedback cut consumption by an average of 39%. A review by Sønderlund et al. (2014) across 13 studies concluded that tailored consumption feedback reduces water use by 19.6% on average. In a study in Southeast Queensland, Australia, 8% reduction was observed (Fielding et al., 2013).

A combination of all the above

In Zaragoza, Spain, a combination of metering, leak detection, pricing, and awareness campaigns reduced total consumption by 27% between 1997 and 2008 despite a 12%

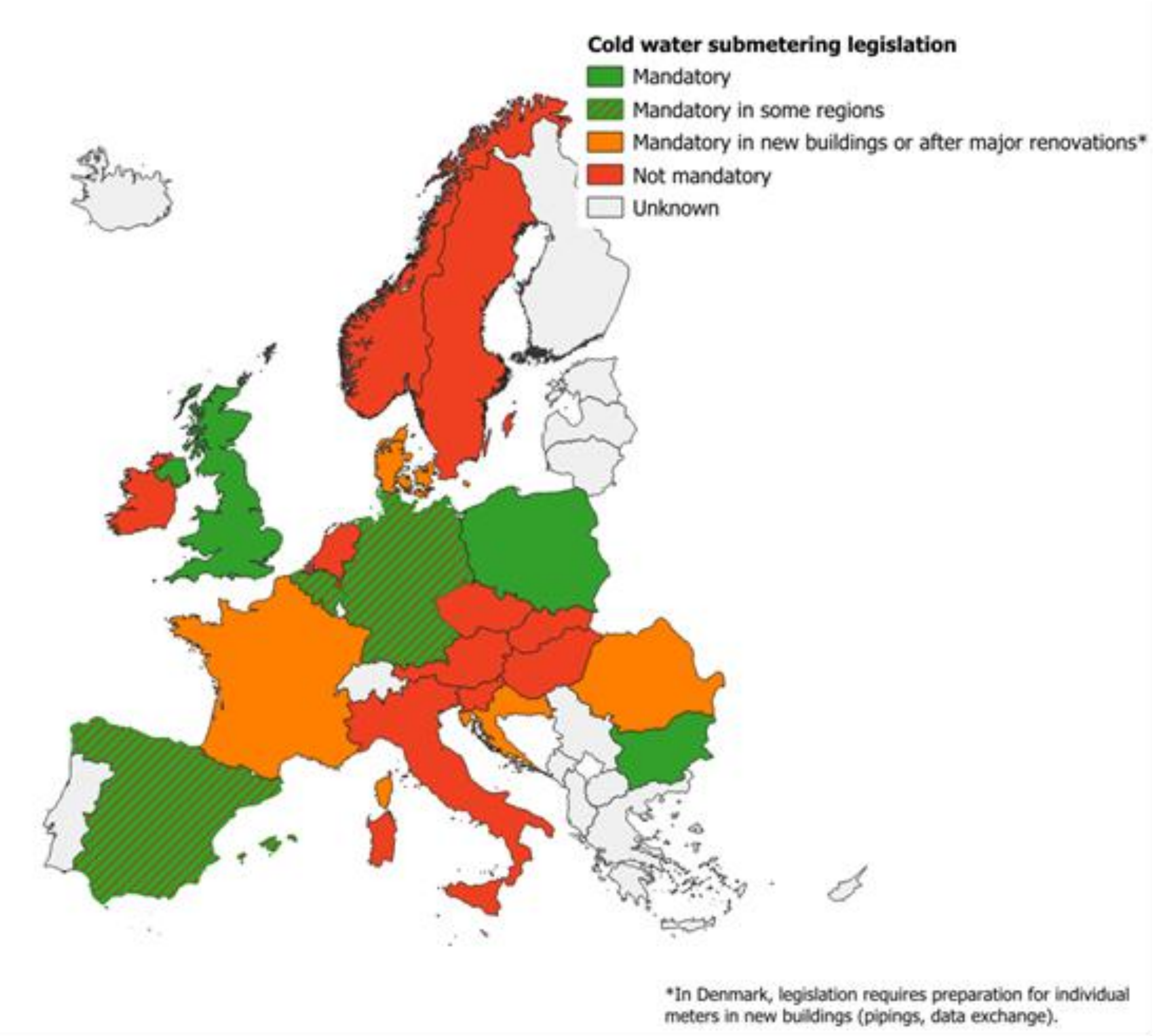
population growth (Ralph, 2011). Tortajada et al. (2019) found that non-pricing measures have had a greater impact on water consumption decisions compared to pricing measures. The replacement of collective water meters with individual meters has been one of the measures with the greatest impact on reducing per capita water consumption, including remotely readable meters alerting the clients when excessive consumption is detected. Water savings observed range from 20 to 25% after the installation of an individual meter. In the US, secretly installed meters did not affect consumption behaviour. Only by raising awareness, on average 20% reduction in water consumption was found (Inman & Jeffrey, 2006).

Table 2: Literature overview on observed water savings due to different types of interventions.

Intervention	Reference	Region	Savings (%)
No metering to analogue metering	EEA, 2001	ES/UK	10-25
	Godley et al., 2008	UK	10-15
	Walker, 2009	UK	10-15
	Francis et al., 2021	UK	12
	Patten & Richardson, 2021	UK	11
Analogue to digital metering	Francis et al., 2021	UK	5
	Ista, 2023	FR	8
No metering to digital metering	Patten & Richardson, 2021	UK	17
Consumption-based billing	Parker & Wilby, 2012	UK	11
	EEA, 2012	DK	19
Leak detection	Godley et al., 2008	UK	23 liters per property per day
	Patten & Richardson, 2021	UK	18 million litres a day (since 2020)
	Francis et al., 2021	UK	15
Real-time water consumption feedback	Gail et al., 2011	US (California)	39
	Davies et al., 2014	AU (Sydney)	6.8
	Fielding et al., 2013	AU (Southeast Queensland)	8
	Sønderlunda et al, 2014	AU, US, EU	19.6
Combination of metering with other interventions	EEA, 2012	DK	19
	Inman & Jeffrey, 2006	US	20
	Tortajada et al., 2019	ES	20-25
	Grafton et al., 2011	OECD	25
	Ralph, 2011	ES	27

3.2 Existing legislation and penetration rates on metering in the EU

An important driver for the installation of water meters in individual dwellings is legislation. An inventory of current legislation in the different EU countries demonstrates a wide variation in how cold water submetering is legislated and implemented.



*In Denmark, legislation requires preparation for individual meters in new buildings (pipings, data exchange).

Figure 1: Cold water submetering legislation in Europe. Data were provided by WE Data Europe (personal communication).

As of writing, only Bulgaria and Poland have a full legal obligation to install cold water submeters at the individual dwelling level. Croatia has recently passed a law mandating remotely readable cold water submetering in new buildings. In Belgium (Flanders region) the introduction of smart water meters will be mandatory for all buildings by 2030. Currently, the obligation is only for new buildings or buildings undergoing major renovations. Similarly, in the Walloon region of Belgium, the obligation is only for new buildings. In France, new buildings must enable individual consumption tracking, though individual billing is not mandatory. In Germany, the legislation varies by state; three out of 16 states do not mandate individual water metering. Hamburg has prescribed retrofitting: all apartments must have their own water meter, regardless of the construction date. In Denmark, legislation requires preparation for individual meters in new buildings (pipings). A complementary prerequisite is the establishment of a data exchange system (for remote reading and backend integration), and such systems are already installed in a large share of buildings with energy billing. For the remaining building stock, this must be in place by 2027. In practice, submeters are typically installed in new buildings, but are not common practice in the social housing sector. In many other countries, submetering of cold water is not mandatory.

In Spain, the legislation provides a framework that allows residents to be equipped with an individual water meter, but the installation remains on a voluntary basis, although several Spanish autonomous regions have mandated individual water metering (i.e. Madrid and Andalucia) to improve the water efficiency of their building stock.

As legislation is different across Member States, penetration rates of submeters show significant variations. Exact numbers are not available, but the following information has been obtained based on estimates from country experts:

- High penetration of submeters: Bulgaria, Great Britain, Poland (95%), France (public sector near 100%, low penetration rate in Paris), Hamburg (Germany)
- Moderate: France (private sector), Denmark (~50%), Croatia (~40%)
- Low: Norway (~15%), Sweden (very low)

Studies on the effect of legal provisions indicate that installing cold water submeters results in substantial water savings, especially when individual billing based on consumption is enforced, smart meters or remote-readable meters are used, or combined with awareness or feedback tools. In Hamburg (Germany), daily per capita use dropped by 31% over 40 years, partly due to submetering and efficient appliances. The Danish Guidelines for the Executive Order on Individual Metering of Electricity, Gas, Water, Heating and Cooling (Social- og Boligministeriet, 2020) estimate 10 to 20% savings following cold water meter installation.

There are, however, barriers to implementation, these vary from technical challenges (e.g., large pipes in high-rise social housing in Belgium); cost-effectiveness (e.g., Austria); or the absence of consumption-based billing mechanisms even when meters are installed (e.g., France).

3.3 Conclusion

Smart water metering has been widely recognised as a cost-effective and environmentally beneficial tool for managing residential water consumption. A review of 16 studies demonstrates that digital meters, combined with volumetric pricing, real-time feedback, and supportive policy measures, can lead to sustained reductions in water consumption between ~10% and 25%. Additional benefits include early leak detection, improved awareness of consumption, and long-term behavioural change.

EU policy level analysis shows evidence that, where cold water submetering is mandated by legislation, penetration rates are higher, and reductions in consumption are observed. Conversely, where legislation is weak or absent, uptake remains patchy and largely dependent on voluntary adoption or local initiatives.

The legislative environment is evolving. Countries like Bulgaria are moving toward comprehensive mandates, including remotely readable meters, while regions like Flanders are targeting full smart meter coverage by 2030.

4 EXPERT INTERVIEWS

To further increase our understanding of the impact of water meters on consumption, structured interviews with experts from the water metering industry were conducted. Interviews were held with experts from Denmark, France, Germany, Poland and Romania.

4.1 The digital transformation timeline

The industry expert provided an overview of the history of water metering in general. We consider three main phases:

- Phase 1: No metering
- Phase 2: Analogue water metering, readings are done manually. There can already be a distinction between consumption-based billing and floor area-based billing.
- Phase 3: Digital water metering (cf. definition above). On top of this, leak detection and real-time user feedback can be added. Consumption-based billing remains important.

Figure 2 below illustrates these phases. It should be noted that not all cases necessarily followed this exact sequence; for instance, some households may have transitioned directly from no metering to digital metering. Moreover, the water-saving impacts associated with each phase are cumulative.

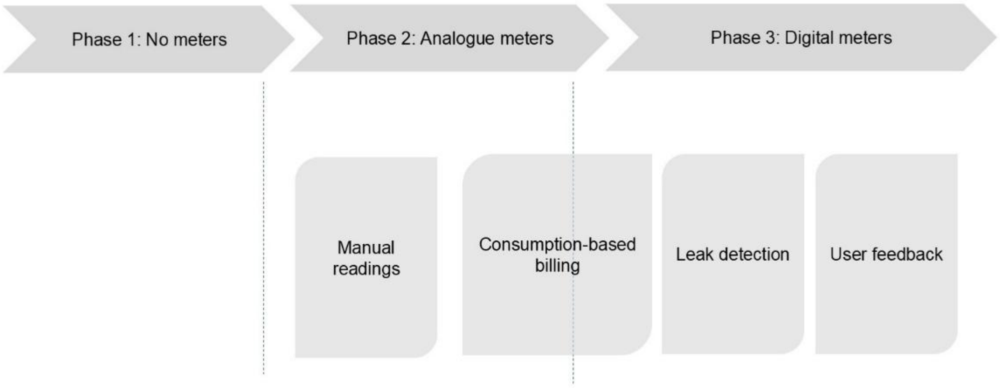


Figure 2: Timeline of the water metering transformation. (Note: this image is illustrative. Not all changes will have followed this pathway).

4.2 Water metering & savings

There is a consensus that digital water metering results in reduced consumption. Experts from France estimate the reduced consumption to be 15% compared to no meters. More specifically, they experienced an 8% decrease in water consumption when users switched to their digital metering management system which includes near real-time consumption information via a web portal and leak detection. Experts from Scandinavia estimate consumption reduction, going from no metering to analogue or digital metering, between 25% and 30%. Experts from Germany estimate this reduction to be around 20%. Danish experts refer to a 2014 study (Social- og Boligministeriet. (2020). containing an in-depth analysis of all the metering data available at that time. They estimate a 20% reduction in consumption when installing analogue or digital water meters. Polish experts attribute a 30% reduction in water consumption to the change from no metering to analogue or digital metering. It was mentioned by French experts that water meters in France are piston-based, making them able to detect very low flow rates of water and this allows for the identification of even minor leakages. This contrasts with velocity-based water meters that are also present in for example, Belgium and Germany. Lastly, immediate visibility of usage (through portals or regular readings) makes consumers more mindful of their water consumption habits.

4.3 Water metering & co-benefits

The interviews also highlighted that the benefits of digital metering go beyond water savings. An example of this can be found in reducing Legionella contamination. Households need to regularly flush enough warm water to reduce the risk for Legionella but letting warm water run for too long also leads to wastage. The general assumption is that flushing 3 litres is sufficient, so being able to measure the 3 litres as enough warm water reduces both the Legionella risk and water wastage. Elderly residents are often mindful of their water consumption to save some money, increasing their Legionella risk. Another example is unoccupied properties (e.g., summer homes) that face this risk. Some more specific country-level details can be found in the appendices.

5 DATA ANALYSIS

Estimates of water consumption in literature vary widely depending on the country, experimental design, and co-occurring factors such as tariff reforms and awareness campaigns. The studies often focus on a single country or region, and not all studies contain multiple years of data. To address this gap, we collected and analysed a dataset that combines cold water meter readings from seven EU Member States, covering the period from 1990 to 2024.

5.1 Data description

Over three million samples were collected. A sample is defined as a yearly cold water consumption value for a specific unit at the dwelling (flat) or building level (depending on what was provided). If consumption data were provided at the building level, they are divided by the building size (i.e. the number of flats) to estimate the average consumption per dwelling, to be able to compare results across samples. If the data were provided at the dwelling level, we would use the yearly consumption of that dwelling.

Some countries provided data for a very long period (25 years), and other countries only provided data for about 4 years (e.g. requirement to delete customer data after a certain period).

Not all samples were retained for data analysis. First, data filtering was performed. After this, a final decision was made on which countries to include based on the number of samples remaining after the data filtering.

The dataset is summarised in Table 3 is the result of the data filtering: on the whole dataset, 1 and 99 percentiles were excluded from the dataset. Negative values, which rarely occurred, were removed. Furthermore, time series were removed where too much variance occurred in the dataset, which could point to people moving in/out of a certain flat or building. For this, we removed every time series where the coefficient of variation exceeded 0.3. The coefficient of variation is calculated by dividing the standard deviation of a time series by its mean. The higher the coefficient of variation, the more jumps there are in the dataset. For Spain, some samples passed these checks but still had very low values (0-5m^3/year), and these almost exclusively occurred for analogue meters. Those were also removed. From this data filtering, 505,013 samples were retained across 16 countries, with data between 1990 and 2025 (Figure 3: Overview figure of the dataset after filtering.). On the whole dataset level, there is a decent split between digital and analogue meters (65% vs. 35%). The presence of leak detection is only present in 1% of the samples.

A threshold of a minimum of 500 samples per country was set to perform the analysis on. When comparing meter type (digital vs. analogue) and leak detection (yes vs. no), countries were removed from the analysis if they were made up predominantly of one category. This left 7 countries, Belgium, Denmark, France, Germany, Slovenia, Spain and the Netherlands, to perform data analysis on.

Table 3: Data overview after data filtering.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection
BE	795	184	3359	6	100	77.11
BU	14,465	3,571	124,229	5	100	0
CZ	995	199	10,045	5	100	100
DE	198,543	60,079	635,868	5	100	0
DK	196,258	8,567	192,632	35	38.55	0
ES	79,253	13,635	147,065	6	30.65	0
FR	4,946	1,093	90,155	6	99.98	90.54
HU	3,064	150	6,701	14	99.22	0
IT	462	91	2884	12	89.18	0
NL	3,022	113	7,29	21	66.94	0
NO	500	82	5884	18	84.8	63
PL	476	87	2735	14	85.92	8.19
RO	194	69	1554	11	88.14	0
SE	411	13	147	17	100	0
SI	704	16	472	15	48.15	0
SK	925	21	875	5	100	0

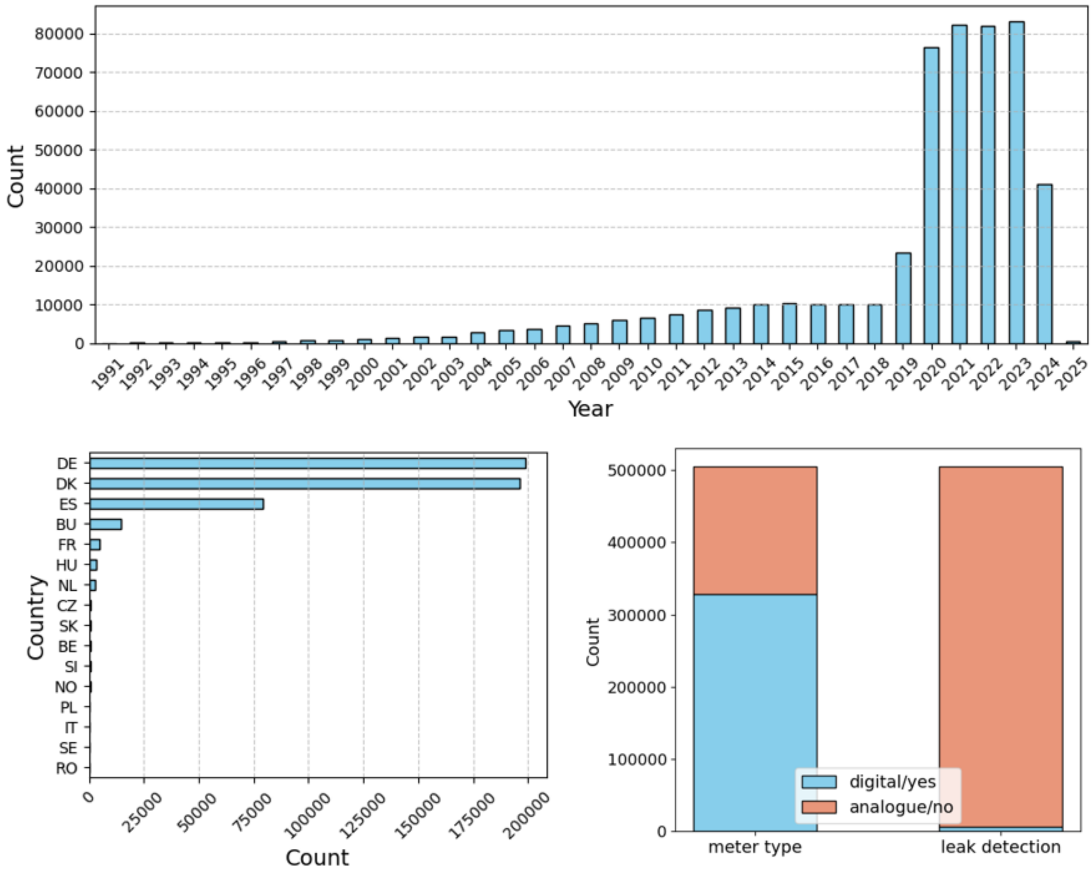


Figure 3: Overview figure of the dataset after filtering.

A special note on the data requirements for the Difference in Difference model: it requires two reference years, and a year before and after the reference period. Any country with less temporal coverage had to be removed. Countries with almost exclusively digital/analogue meters in the dataset also were removed here. We were able to perform a Difference in Difference model for Denmark and The Netherlands

5.2 Methodology

Two types of analyses were performed. For datasets where long enough time series were available, along with the timing of digital meter installation, a Difference in Difference (DiD) model was applied. In cases where DiD analysis was not feasible due to limited data, a simpler comparison of medians was used (“boxplot analysis”).

The following 7 countries were analysed:
- Belgium (BE, leak detection vs. no leak detection, all digital meter)
- Denmark (DK, digital vs. analogue meter type – Difference in Difference)
- France (FR, leak detection vs. no leak detection, all digital meter)
- Germany (DE, consumption-based billing vs. floor area billing, all digital meter)
- Slovenia (SI, digital vs. analogue meter type – box plot analysis)
- Spain (ES, digital vs. analogue meter type – box plot analysis)
- The Netherlands (NL, digital vs. analogue meter type – Difference in Difference)

Results for Slovenia showed a strong decrease of consumption after installing a digital meter. However, results are statistically not significant and not included in the report.

5.2.1 Boxplot analysis

This method compares consumption across groups by comparing the medians of both groups for each parameter. To select the suitable statistical test, each group was tested for normality using a Shapiro-Wilk test. If the groups both passed the normality check, we used an independent two-sample t-test. If the data was not normally distributed, we used a Mann-Whitney U test (a non-parametric alternative). Both tests examine the statistically significant difference in distribution of consumption data. If the p-value is smaller than 0.05, we can reject the null hypothesis (h0: there is no difference between groups), and we can state that there is a statistically significant difference between the two groups.

5.2.2 Difference in Difference model

This model estimates the change in consumption after digital meter installation relative to a baseline (pre-installation) period, while controlling for sample-specific fixed effects and common time trends.

We define the event, or “treatment”, as the installation year: the first year in which a building's meter changes from analogue to digital. Buildings that always had digital meters, never switched, or switched back are excluded from the treatment group (i.e., install_year is set to NaN for them). For each building-year observation, we calculate the event time as the difference between the year of the consumption sample and the installation year so that:

- event_time = 0 corresponds to the year of installation
- Negative values represent years before installation

- Positive values represent years after installation.

We refer to event time -1 and -2 as the reference years (the years before the digital meter was installed). Consumption is modelled the following way:

$$Consumption_{it} = \sum_{j \neq -1} \beta_j \cdot event\_j_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

- β_j measures the “effect of treatment” (installation of digital metering) in year j relative to the reference period
- α_i : entity (building) fixed effects, which absorb all time-invariant characteristics of each building (e.g., size, location)
- γ_t: time (year) fixed effects, capturing year-specific shocks that affect all buildings (e.g., weather, policy changes)
- ε_{it}: error term.

Coefficients $_j$ represent the change in average consumption at event time j, compared to the pre-treatment baseline (years -2 and -1). Including both entity (building) and time fixed effects allows the model to isolate the treatment effect (introduction of digital metering) from unobserved confounding factors. α and γ are not estimated directly as coefficients in the output, but they are accounted for since the model "demeans" the data by entity and time: it subtracts each entity’s and each time period’s average.

5.2.3 Impact of Covid-19

During the Covid-19 period people stayed more at home due to safe-distancing policies, such as lockdowns and work-from-home arrangements. This led to a change in residential water use. Buurman et al. (2022) found that the volume of domestic water use increased by about 3% to 8%, while non-domestic water use decreased between about 2% and 11% in 2020.

Also, the dataset used in this study demonstrates on average an increase of water consumption of 6% during the Covid-19 period. This potentially influences the results on the effects of digital meters. To avoid these effects, some additional checks were performed.

For the box plot analysis, water consumption data with and without digital meter are more or less equally spread across the different years (pre- and post-covid period).

For the difference in difference model, a potential impact of Covid-19 occurs if digital meters are installed during or shortly after Covid-19 which leads to an overestimation as the decrease in water consumption is also related to the cancelation of safe-distancing policies. Conversely, if meters are installed shortly before Covid-19, the effect might be underestimated as water consumption increases due to safe-distancing policies. To avoid Covid-19 influencing the results, long time series are considered whereby multiple years before and after the meter installation are included. Additionally, the year of installation varies between 2008 and 2023.

5.3 Country results

Units of Water Consumption

- 1 cubic metre (m^3) = 1,000 litres (L)
- Typical EU household: 40–60m^3/year/capita (≈ 110–165 L/capita/day)

The following sections present a country-by-country analysis of the results from our study on water savings associated with water metering. For each of the six countries, the analysis is structured in three parts: (1) a brief context description outlining key aspects of national water consumption, pricing structures, policy context, and the current penetration rates of water metering to identify the additional potential of digital water meters; (2) an overview of the data used for the analysis; and (3) a presentation and discussion of the results. For the boxplot analysis, when a difference is statistically significant, this is indicated by "**" in the significant column.

Parameters used for the context are the average drinking water consumption per capita in L/capita/day, the average drinking water price in €/m³, the percentage of inhabitants living in flats, the current policy context metering and the current penetration rate submetering, if known. Drinking water consumption and pricing data is derived from EurEau, 2020. The figures provided are from between 2017 and 2019. The average residential drinking water consumption per capita per day is based on data for the period and available for 26 countries. The main elements of the water tariff (price per cubic meter) are the costs to provide drinking water and wastewater services. Depending on the country, it may comprise additional elements such as taxes, fees or rainwater charges. The report contains pricing data for 24 countries. Consolidated data from EurEau's 2020 report provides residential water consumption per capita per day for 24 countries. EurEau publishes these figures at the country level and does not aggregate them into a single European average. In line with this methodology, we present each country's position in the European ranking for both consumption and price.

The average drinking water consumption per capita varies strongly per country. This depends on different factors such as climate, household composition, behaviour and the use of alternative water sources (e.g. rainwater, groundwater). Also, methodological differences are a possible explanation.

More research is needed to better understand the different elements determining drinking water consumption per country. This does not impact the study results as each country is analysed individually.

5.3.1 Belgium (BE)

Context

With an average drinking water consumption of 85 litres per capita per day, Belgium has one of the lowest consumption levels in the EU. Drinking water billing is consumption-based and drinking water prices are high (4th highest out of 24 EU countries).

The share of inhabitants living in flats is small, but this share is increasing annually. Metering and submetering in individual dwellings are mandatory for new buildings and renovations. The existing penetration rate for submetering is unknown.

Table 4: Context data for BE.

Parameter	Amount (rank in EU)	Data Source
Average drinking water consumption per capita in L/capita/day	85 (23/26)	EurEau, 2020
Average drinking water price in €/m³	5.38 (4/24)	EurEau, 2020
% inhabitants living in flats	22	Eurostat, 2020
Policy context metering	Mandatory in new buildings/major renovations	WE Data Europe survey, 2025
Penetration rate submetering	Unknown	WE Data Europe survey, 2025

Data

The dataset for Belgium is limited to 184 buildings during the period 2019 to 2024 and limited. It only contains data from digital meters. The dataset was tested for the effect of leak detection on consumption, where 77% of the meters had leak detection and 23% did not. The majority of the data is for the years 2020 to 2024.

Table 5: Data overview of the samples from BE.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection
BE	795	184	3,359	6	100	77.11

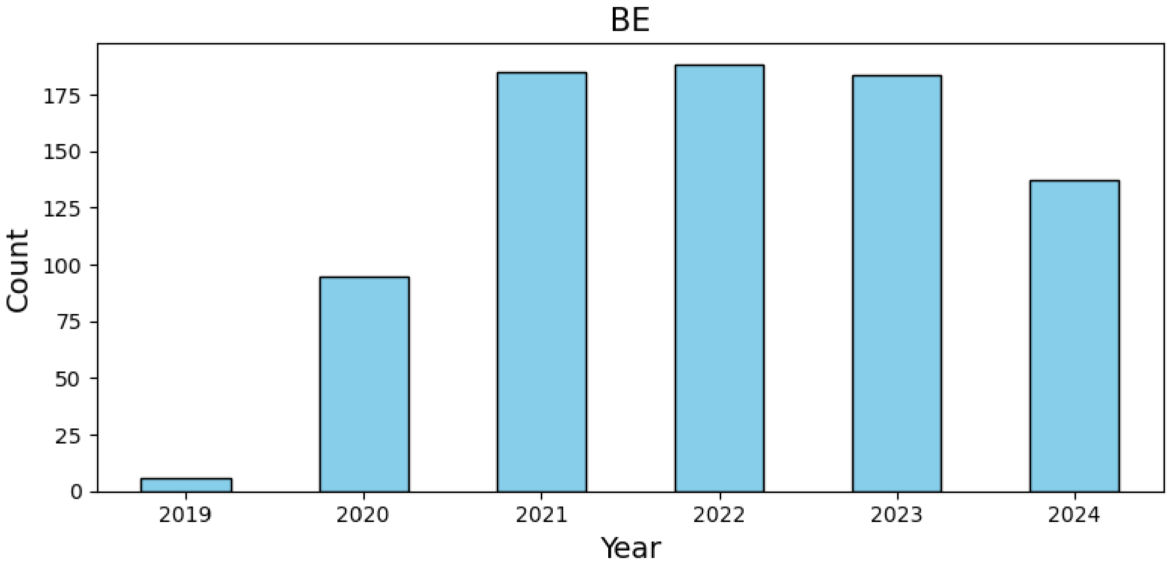


Figure 4: Number of samples per year in the BE dataset.

Results & discussion

With a consumption of approximately 30m³ the median consumption levels per flat are fairly low (average consumption is also approximately 30m³), compared to an average drinking water consumption of 85m³/household/year. As there is no contextual information available for the samples, it is difficult to understand why consumption levels are low.

We observe a significant decrease of 4.5m³ per year or 13.64% in drinking water consumption for the Belgian samples where leak detection was present, which represents a large effect.

Table 6: Boxplot analysis BE.

Country	# samples	% leak detection	Median consumption no leak detection (m³/flat/yr)	Median consumption leak detection (m³/flat/yr)	Absolute difference	% difference	Signif.
BE	795	77.11	33.21	28.67	-4.54	-13.67	**

5.3.2 Denmark (DK)

Context

With an average drinking water consumption of 109 litres per capita per day, Denmark is ranked 17th out of 26 EU countries, consumption is below EU average. Drinking water billing is consumption-based and drinking water prices are the highest in the EU.

Metering and submetering in individual dwellings is not mandatory. Legislation requires preparation for individual meters in new buildings. The technical preparations for a cold water meter to be installed should be foreseen in new buildings, but the meter itself does not need to be in place or used. In practice, submeters are typically installed in new buildings, but are not common practice in the social housing sector.

The share of inhabitants living in flats is low.

Table 7: Context data for DK.

Parameter	Amount (rank in EU)	Data Source
Average drinking water consumption per capita in L/capita/day	109 (17/26)	EurEau, 2020
Average drinking water price in €/m³	9.3 (1/24)	EurEau, 2020
% inhabitants living in flats	34	Eurostat, 2020
Policy context metering	There is legislation on hot water submetering with respect to the energy consumption needed to heat cold water to hot water (part of the heat allocation/billing). For cold water, it should be foreseen in new construction/major renovations that a cold water meter can be installed, but the meter itself does not need to be in place or used.	WE Data Europe survey, 2025
Penetration rate submetering	Moderate	WE Data Europe survey, 2025

Data

Almost 200,000 samples were retained after filtering, making Denmark the second largest dataset in this study, after Germany. The Danish dataset provided the longest time series with data going back as far as 1991. The majority of the data is for the years 2010 to 2024. Almost 40% of all samples provided data from digital meters. The year of installation varies between 2008 and 2024. We were able to perform a Difference in Difference model for the Danish dataset as the dataset contained the timing of installation of the digital water meter.

Table 8: Data overview of the samples from DK.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection
DK	196,258	8,567	192,632	35	38.55	0

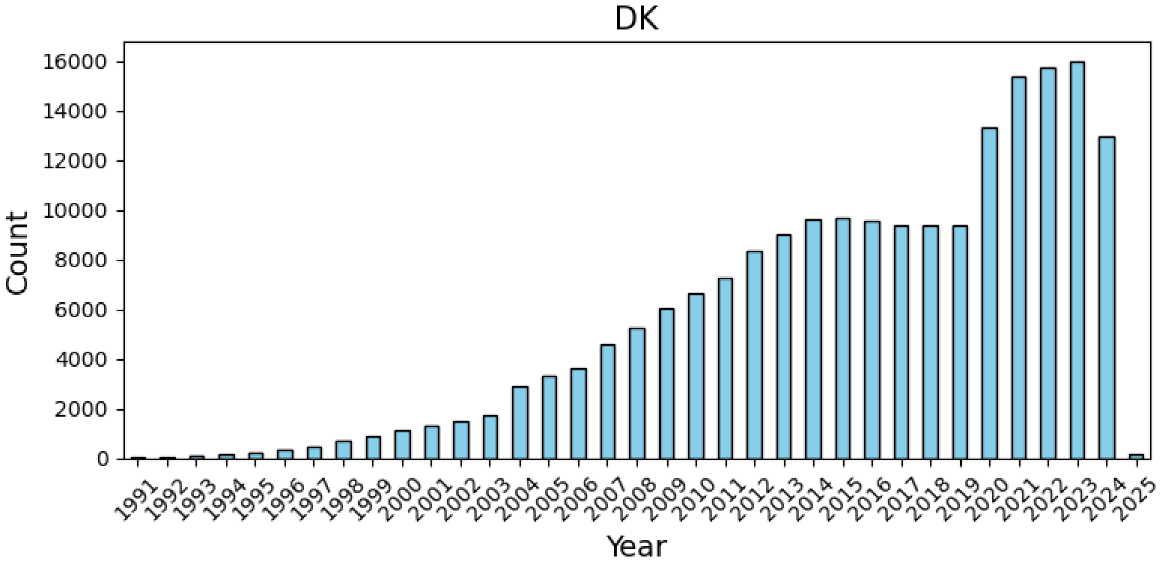


Figure 5: Number of samples per year in the DK dataset.

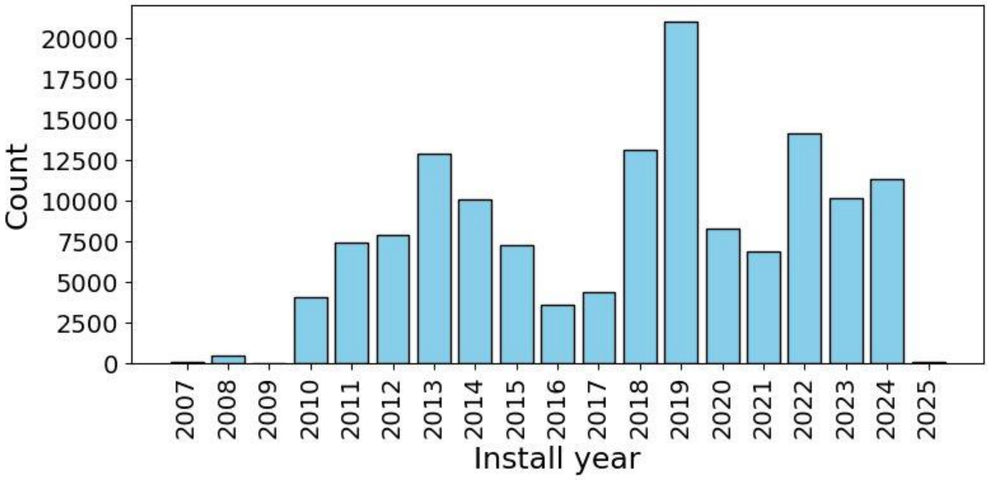


Figure 6: Number of samples per year of installation in the DK dataset.

Results & discussion

The average consumption per flat is 92m³/flat/year which is in line with results from EurEau (2021) (109 L/capita/day or 88m³/household/year). The large difference with the median value indicates that also some high consumption values are present in the dataset.

Figure 7 shows the results of the DiD method for Denmark. The Y-axis represents the change in average consumption at event time, compared to the pre-treatment baseline (years -2 and -1). The model results show the isolated treatment effect (introduction of digital metering) from unobserved confounding factors. We see no pre-treatment trend: consumption values before the reference period are not much different from the reference period. This indicates that there were stable consumption patterns before the installation of the digital meter.
The first year after the reference period, we observe a strong drop of consumption of 13%. After this first year, a rebound effect occurs, and the reduced consumption stays around 2.5%

for some years. On average, consumption after the reference period is still 5.2% lower compared to the reference period.

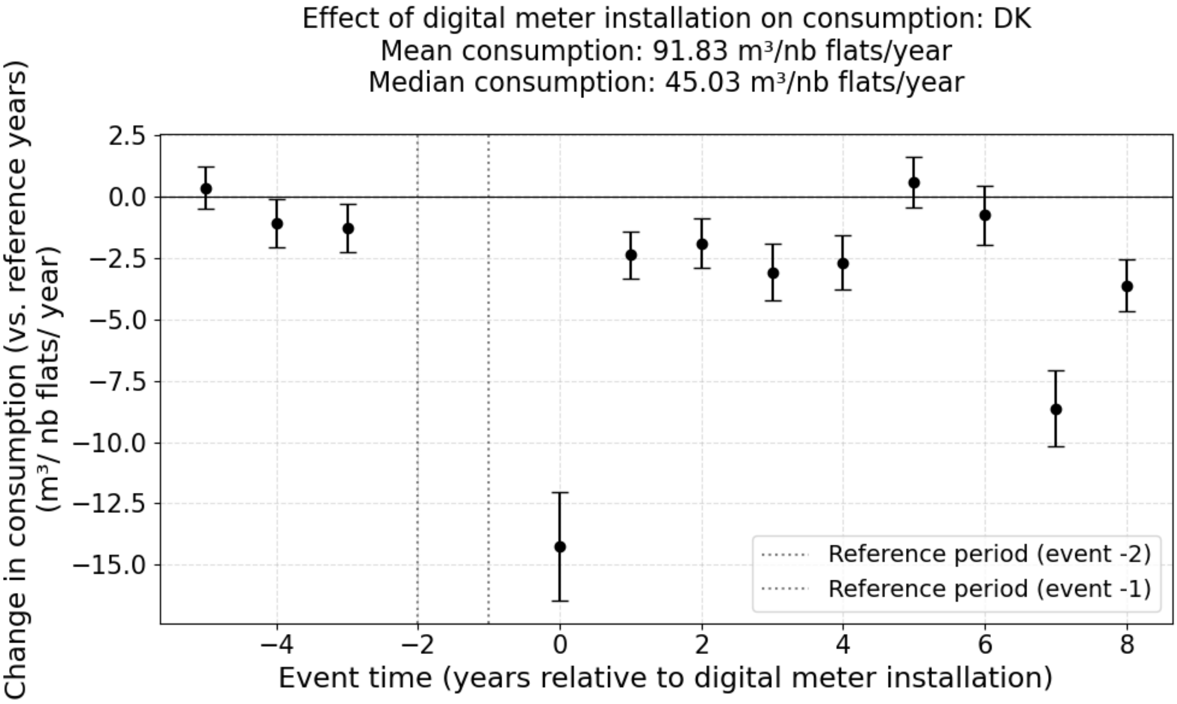


Figure 7: Difference in Difference model results for DK.

5.3.3 France (FR)

Context

With an average drinking water consumption of 165 litres per capita per day, France is ranked 4th out of 26 EU countries, consumption is one of the highest in Europe. However, it should be noted that the methodology used in France to estimate the national domestic water consumption includes drinking water for residential use, but also non-residential use, comprising the drinking water delivered to SMEs. This methodology explains why France reports a higher than average drinking water consumption per capita per day (Commissariat Général au Développement Durable, 2023).

Drinking water prices are high, but still far below the highest prices in for instance Denmark and Belgium.

The share of inhabitants living in flats is low. Metering and submetering in individual dwellings is mandatory in new buildings. Submetering penetration in the public sector is nearly universal (close to 100%). In contrast, data for the private residential sector are scarce; one available reference point is Paris, where penetration has been observed to be low.

Table 9: Context data for France.

Parameter	Amount (rank in EU)	Data Source
Average drinking water consumption per capita in L/capita/day	165 (4/26)	EurEau, 2020
Average drinking water price in €/m³	4.1 (8/24)	EurEau, 2020
% inhabitants living in flats	34	Eurostat, 2020
Policy context metering	Mandatory in new buildings	WE Data Europe survey, 2025
Penetration rate submetering	Low (private sector), High (public sector)	WE Data Europe survey, 2025

Data

The result for France was obtained by comparing data from two companies. Although not explicitly mentioned, all other countries' results are always from one specific company. All samples with leak detection came from one metering company, the samples without leak detection came from the other. A reasonable sample size was still provided by both companies. The majority of the data is for the years 2020 to 2024.

Table 10: Data overview of the samples from FR.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection
FR	4,946	1,093	90,155	6	99.98	90.54

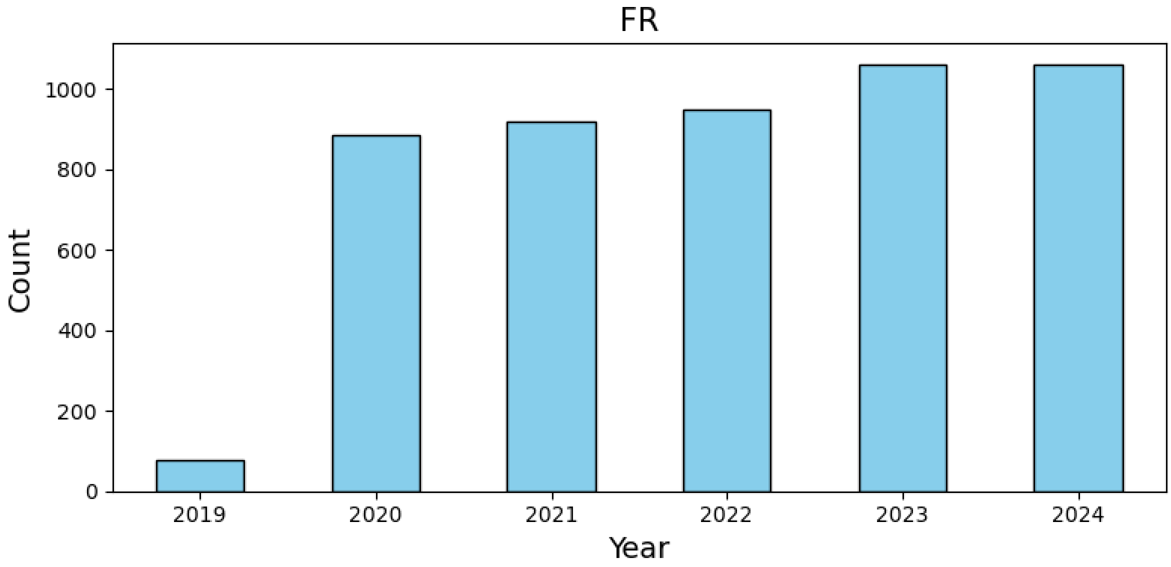


Figure 8: Number of samples per year present in the FR dataset.

Results & discussion

We observed a significant decrease of 6m³/flat/year or 7.5% in water consumption for the FR samples where leak detection was present. Median absolute values dropped from 81 to 75m³/year, mean absolute values dropped from 88 to 79m³/year. In absolute values, this is a higher result compared to Belgium, in percentages this is lower. The literature review indicated a saving potential of up to 15% from leak detection observed in the UK. This is likely due to the newer building stock, though the savings potential is expected to increase over time as these buildings also age, highlighting the value of implementing leak detection measures proactively.

Table 11: Boxplot analysis FR.

Country	# samples	% leak detection	Median consumption no leak detection (m³/flat/yr)	Median consumption leakage detection (m³/flat/yr)	Absolute difference	% difference	Signif.
FR	4,946	90.54	81.35	75.28	6.07	-7.50	**

5.3.4 Germany (DE)

Context

With an average drinking water consumption of 126 litres per capita per day, Germany is ranked 12th highest out of 26 EU countries. Drinking water prices are fairly low.

The share of inhabitants living in flats is high. Metering and submetering in individual dwellings is not mandatory in the entire country, but the legislation varies by state; three out of 16 states do not have legislation. Hamburg does mandate retrofitting: all apartments must have their own water meter regardless of the construction date. The existing penetration rate for submetering is unknown.

Table 12: Context data for DE.

Parameter	Amount (rank in EU)	Data Source
Average drinking water consumption per capita in L/capita/day	126 (12/26)	EurEau, 2020
Average drinking water price in €/m³	2.3	Destatis, 2022
% inhabitants living in flats	56	Eurostat, 2020
Policy context metering	Not mandatory, regional differences	WE Data Europe survey, 2025
Penetration rate submetering	Unknown	WE Data Europe survey, 2025

Data

With almost 200,000 samples retained after filtering, data for more than 60,000 buildings during the period 2020 to 2024, the German dataset is the largest dataset collected across all countries in this study. The German dataset did not contain samples from analogue meters or digital meters with leak detection. The dataset was tested for the effect of consumption-based billing versus floor-based billing. This was the only dataset stating the type of billing. 21% of the buildings in the sample applied consumption-based billing.

Table 13: Data overview of the samples from DE.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection	% cons. based billing
DE	198,543	60,079	635,868	5	100	0	20.97

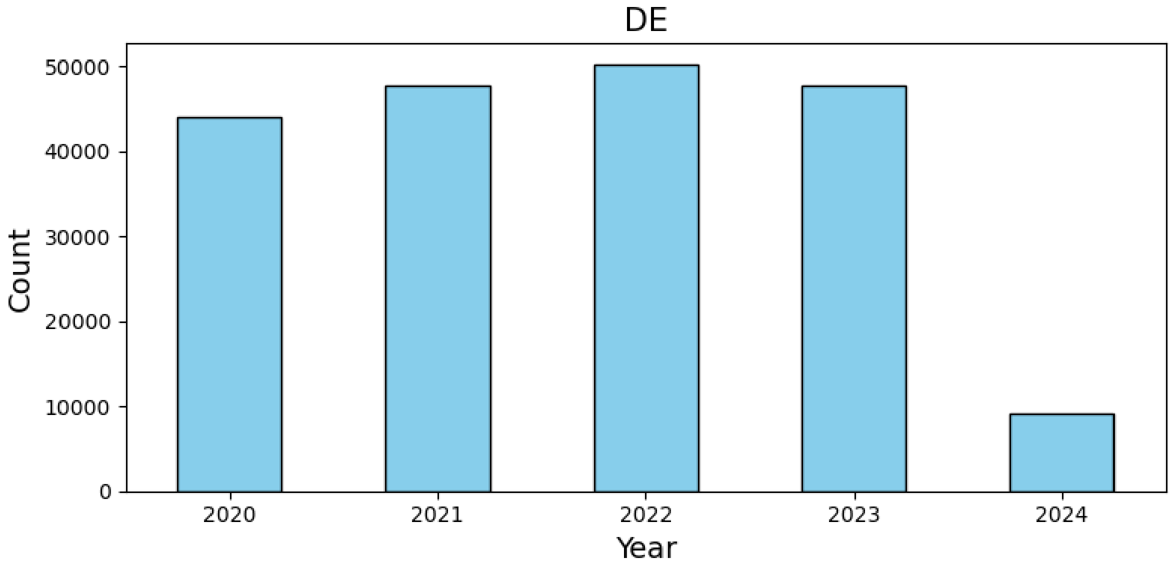


Figure 9: Number of samples per year in the DE dataset.

Results & discussion

The median consumption level per flat is approximately 60m³/year, average consumption is slightly higher, approximately 67m³/year. We observed a significant decrease of 3.13m³/flat/year or 5% in water consumption for the German samples where consumption-based billing was performed instead of floor based billing. This amount of savings is fairly low compared to results from literature, where the introduction of consumption-based billing leads to savings between 11% and 25%. A possible explanation is that results are limited to flats that all are monitored with digital meters, whereas previous studies mostly deal with entire regions with different dwelling types and combine the introduction of consumption-based billing with other measures such as the installation of meters and awareness campaigns.

Table 14: Boxplot analysis DE.

Country	# samples	% cons. Based billing	Median consumption floor based billing (m³/flat/yr)	Median consumption cons. based billing (m³/flat/yr)	Absolute difference	% difference	Signif.
DE	198,543	20.97	61.77	58.64	-3.13	-5.06	**

5.3.5 The Netherlands (NL)

Context

With an average drinking water consumption of 133 litres per capita per day the Netherlands is ranked 10th out of 26 EU countries, consumption is above average in Europe. Drinking water prices are high compared to the average in the EU, but still far below the highest prices in for instance Belgium and Denmark.

The share of inhabitants living in flats is low. Metering and submetering in individual dwellings is not mandatory. The penetration rate of submeters is unknown.

Table 15: Context data for NL.

Parameter	Amount (rank in EU)	Data Source
Average drinking water consumption per capita in L/capita/day	133 (10/26)	EurEau, 2020
Average drinking water price in €/m³	4.3 (7/24)	EurEau, 2020
% inhabitants living in flats	21	Eurostat, 2020
Policy context metering	Not mandatory	WE Data Europe survey, 2025
Penetration rate submetering	Unknown	WE Data Europe survey, 2025

Data

With 21 years, the Netherlands has the second longest time series among all countries. The majority of the data is for the years 2013 to 2023. The year of installation varies between 2011 and 2023. 66.94% of all samples provided data from digital meters. We were able to perform a Difference in Difference model for the Dutch dataset.

Table 16: Data overview of the samples from NL.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection
NL	3,022	113	7,290	21	66.94	0

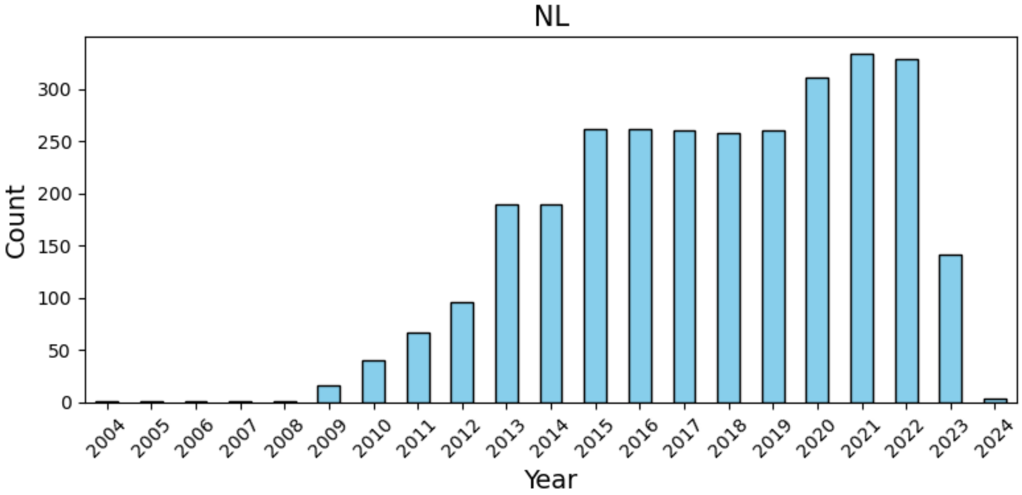


Figure 10: Number of samples per year present in the NL dataset.

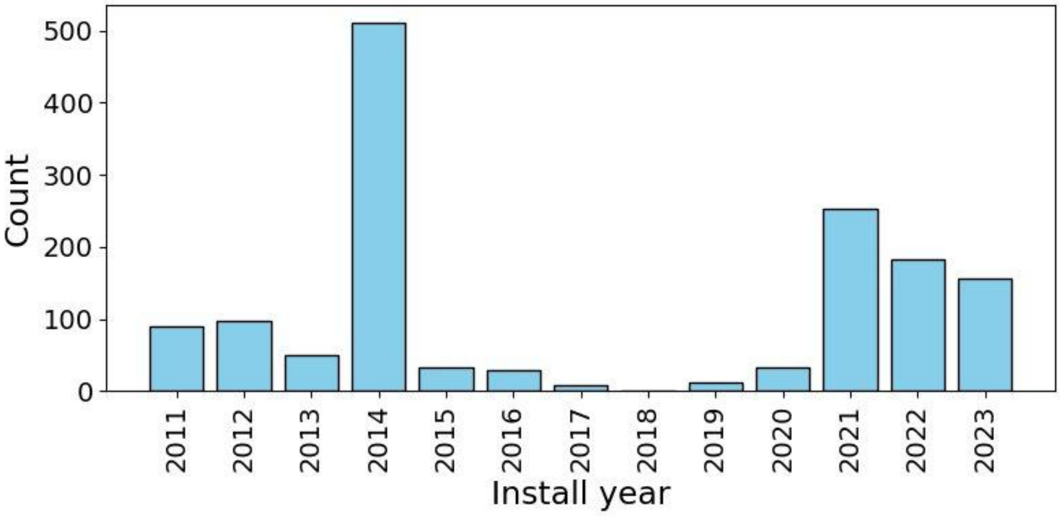


Figure 11: Number of samples per year of installation of the digital meter in the NL dataset.

Results & discussion

The average consumption per flat is 54m³/flat/year, which is far below the results from EurEau (2021) (133 L/capita/day or 107m³/household/year). The dataset consists of a limited amount of buildings with a relatively low consumption level.

For the Netherlands, the change after the reference period is smaller compared to the Difference in Difference model for Denmark, but still noticeable. Error bars are also slightly larger, which is to be expected since the number of samples in Denmark is much higher (almost 200,000 samples vs. ~3,000 samples). During the years after the reference period, on average, consumption reduced by 6.2%. This amount of savings is also observed during a longer period (up to 8 years) which indicates the prolonged effect of the digital meters.

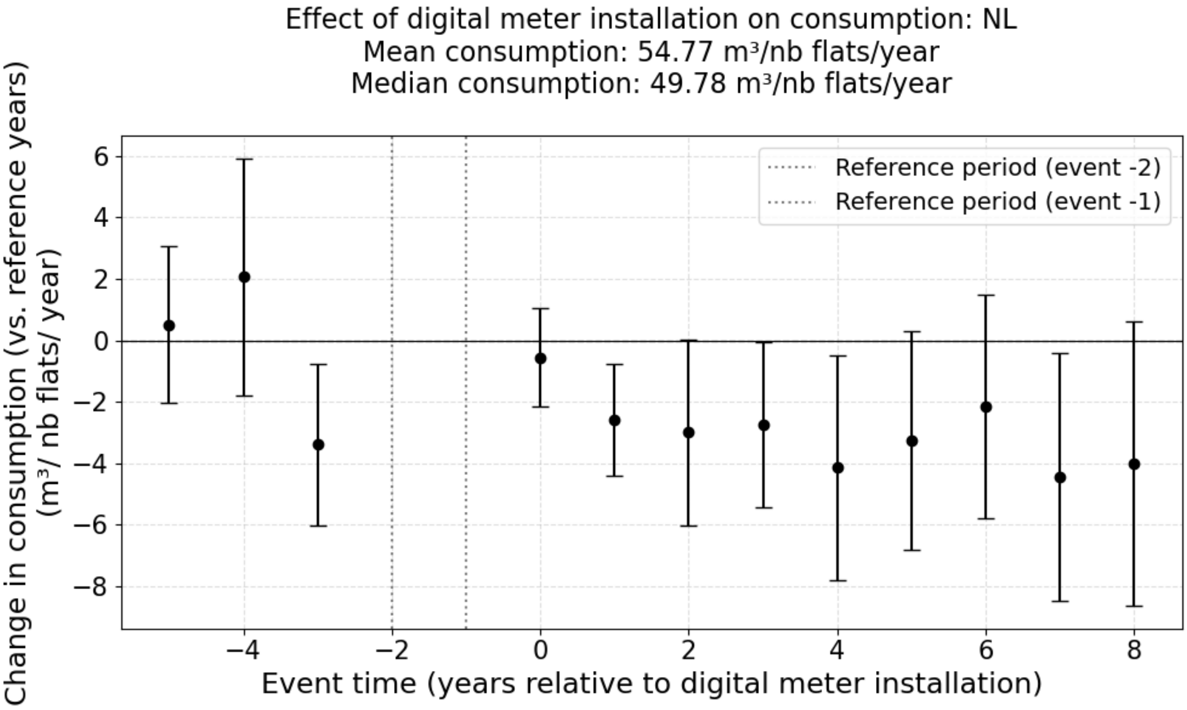


Figure 12: Difference in Difference model results for NL.

5.3.6 Spain (ES)

Context

With an average drinking water consumption of 128 litres per capita per day, Spain is ranked 11th out of 26 EU countries, consumption is above EU average. Drinking water prices are low compared to other countries in the EU.

The share of inhabitants living in flats is high. Metering and submetering in individual dwellings is not mandatory. The legislation provides a framework that allows residents to be equipped with an individual water meter but the installation remains on a voluntary basis, although several Spanish autonomous regions have mandated individual water metering (i.e. Madrid and Andalucia) to improve the water efficiency of their building stock.

Table 17: Context data for ES.

Parameter	Amount (rank in EU)	Data Source
Average drinking water consumption per capita in L/capita/day	128 (11/26)	EurEau, 2020
Average drinking water price in €/m³	2.2 (18/24)	EurEau, 2020
% inhabitants living in flats	66	Eurostat, 2020
Policy context metering	Not mandatory	WE Data Europe survey, 2025
Penetration rate submetering	Unknown	WE Data Europe survey, 2025

Data

Data on both digital and analogue meters from Spain was provided. 30% of all samples are available from digital meters. Since the timing of the meter installation was not provided (i.e. all data for a specific entity came either from a digital or analogue meter), a boxplot analysis was used. Approximately a similar amount of samples are received for six years (2019 to 2024).

Table 18: Data overview of the samples from ES.

Country	# samples	# buildings	# flats	# years	% digital	% leak detection
ES	79,253	13,635	147,065	6	30.65	0

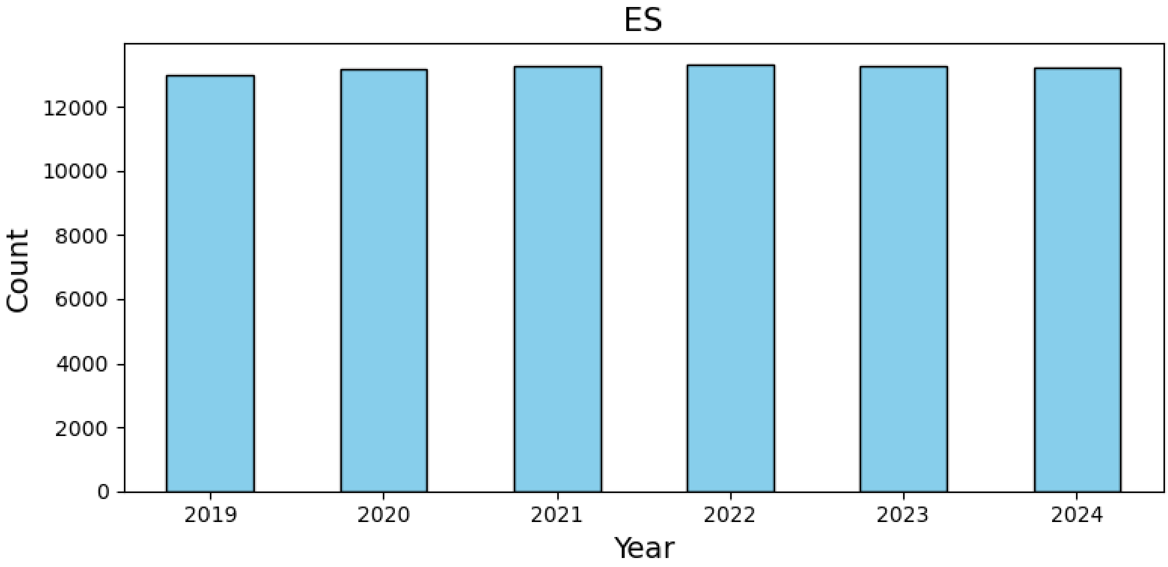


Figure 13: Number of samples per year present in the ES dataset.

Results & discussion

The observed savings in Spain due to digital metering are quite high. We observed a significant decrease of 9m³/flat/year or 12% in water consumption for the Spanish samples where a digital meter was present. Median absolute values dropped from 74 to 65m³/year, mean absolute values dropped from 92 to 67m³/year. In combination with the fact that Spain has a relatively high water consumption, a large proportion of people living in flats, and the absence of country-wide legislation on individual water metering, it can be assumed that the saving potential in Spain through a broader rollout of digital meters is significant.

Table 19: Boxplot analysis ES

Country	# samples	% digital meter	Median consumption analogue (m³/flat/yr)	Median consumption digital (m³/flat/yr)	Absolute difference	% difference	Signif.
ES	79,253	30.65	74.00	64.88	-9.12	-12.32	**

6 SYNTHESIS

6.1 Water Savings

Expected output: *Estimate of potential water savings attributable to water metering and submetering.*

Literature, expert insights and the data analysis show clear evidence of water savings through water metering and submetering.

Previous studies demonstrate that replacing analogue meters by digital meters has an impact of 5% to 8%. In this study, the data analysis demonstrates savings between 5% and 12%. When all facets of digital water metering are combined (leak detection, consumption-based billing, real time feedback) and complemented with awareness campaigns, water savings can reach 25% savings compared to no metering, and in some cases even higher.

The results of the data analysis are summarised in Table 20 below. In Germany, consumption-based billing led to a 5.1% reduction in water use. In France, the presence of leak detection systems resulted in a 7.5% decrease, in Belgium this goes up to 13.6%. For three countries, we were able to estimate the impact of digital versus analogue water meters. By averaging the results for Denmark, Spain, and the Netherlands we calculate an average reduction of 7.9%. Considering some effects can be cumulative, if some of these figures were to be added, the numbers are consistent with literature and industry expectations.

Table 20: Summary overview of the data analysis.

Country	Water reduction (%)	Parameter	Method used
BE	13.6	leak detection vs. no leak detection	box plot analysis
DE	5.1	Consumption-based billing vs. floor area billing	box plot analysis
DK	5.2	digital vs. analogue meter type	Difference in Difference
ES	12.3	digital vs. analogue meter type	box plot analysis
FR	7.5	leak detection vs. no leak detection	box plot analysis
NL	6.2	digital vs. analogue meter type	Difference in Difference

6.2 Leak Reduction

Expected output: *Quantified impact of early leak detection.*

Literature reports on digital meters as effective tools for detecting and preventing water loss, with 13,500 leakages identified in one year in the UK alone (Patten & Richardson, 2021). Additional studies have reported water loss reductions of 23L per property per day (Godley et al., 2008) and 15% overall (Francis et al., 2021). Making them able to detect very low flow rates of water and allows for the identification of even minor leakages. The importance of portals and SMS/email alerts is also emphasised to enable landlords to act quickly on suspected leaks.

Table 21 lists the water reductions quantified from the data analysis. The presence of leak detection reduced water consumption by between 8% and 14%.

Table 21: Summary overview of leak detection savings from the data analysis.

Country	Water reduction (%)	Parameter	Method used
BE	13.6	leak detection vs. no leak detection	box plot analysis
FR	7.5	leak detection vs. no leak detection	box plot analysis

6.3 Behavioural Changes

Expected output: *Potential shifts in consumer behaviour resulting from real-time feedback on water consumption.*

Although the data analysis did not allow to provide insights on specific behavioural changes from real-time feedback mechanisms, we can expect this is the case. Previous studies in the US and Australia suggest short term savings between 7% and 39%. Short term savings are mostly realised by behaviour (e.g. taking showers instead of baths, reduce shower time, turn off the tap while brushing your teeth, shaving, or washing dishes, run washing machines and dishwashers only when they have a full load) and that introducing digital meters including real-time feedback results in shifts in consumer behaviour.

Different studies stress the importance of the feedback mechanism that links consumption measurements to consumer awareness. To better encourage behavioural change, consumers must be kept informed of their usage through monthly reports, comparisons to average consumption, or real-time data via mobile apps. Leakage alerts have an impact if they are sent promptly via SMS or app notifications to both landlords and tenants. Additionally, to increase savings consumers should be shown the financial savings associated with reduced water usage. Recent research, conducted by the Techem Research Institute on Sustainability TRIOS (Techem, 2025) highlighted the significant impact of consumer behaviour on cold water consumption in multi-family housing stock in Germany. The study demonstrates that users equipped with cold water submeters tend to adjust their water usage in response to external factors, such as rising prices.

6.4 Conclusion

The combined data from the analysis, literature and industry insights quantify water metering savings up to 25%. Figure 14 summarises the findings in a single image. These savings are in the order of magnitude of the 10% increase in water efficiency targeted by the European Union by 2030 (EC, 2025).

As of this writing, cold water submetering is only mandatory in Bulgaria, and Poland, or required only in new buildings (and/or in buildings undergoing major renovations) in countries such as Belgium (Flanders and Wallonia), France, and Romania (WE Data Europe, 2025). This leaves many EU Member States where submetering could still be introduced - and where the consumption reductions observed in this study could potentially be realised. This study also only considers drinking water at household level.

With the anticipated stress on the overall water balance, smart metering indicates potential for greater water savings from other sources across various sectors.

Despite collecting a considerable amount of data, the fragmented legislative landscape surrounding cold water submetering across the EU limited the scope and consistency of the dataset. A key limitation of the analysis is the lack of detailed contextual information, such as socio-economic indicators, regional specifics, and building age, which constrained our ability to perform aggregated analysis and had us resort to a country-specific approach. The forthcoming EU Smart Water Metering for All initiative may help overcome these limitations by enabling more comprehensive data collection on digital water metering, thereby facilitating richer, EU-wide research and insights.

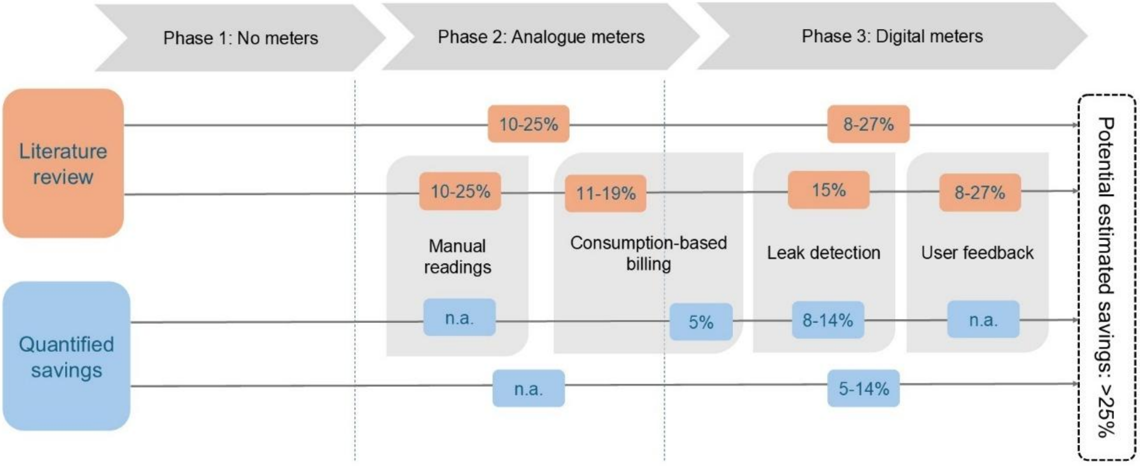


Figure 14: Synthesis of the study.

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8 APPENDICES

8.1 Expert interviews

8.1.1 Interviews

Table 22: Conducted interviews with WE Data Europe partners.

Interview #	Company	Date	List of interviewees
1	Techem	28/01/2025	Jennifer Bruß (Techem Germany)
2	Ista	07/02/2025	Jimmy Thouvenot, Marlene Denis, Antoine Prioux, Laurent Lefay (Ista France)
3	Brunata	12/02/2025	Kees van der Veer (Brunata)
4	Ista	17/02/2025	Benny Mathiesen (Ista Denmark), Marian Sisu (Ista Romania)
5	Techem	26/02/2025	Carsten Hejgaard (Techem Denmark), Patrick Molck-Ude (Techem Germany), Piotr Derkacz (Techem Poland)

8.1.2 Differences across countries

Some country specific insights on digital water metering were shared during the interviews:

France
For some customers in France, consumption can be consulted through a web portal: this information is available to the landlord on a daily base. The landlord can also request to receive info on leak detection by email/text message. The residents get send a water bill by the landlord; they do not have direct access to the online water consumption data.

Denmark
There is legislation on hot water submetering with respect to the energy consumption needed to heat cold water to hot water (part of the heat allocation/billing). For cold water, it should be foreseen in new construction/major renovations that a cold water meter can be installed, but the meter itself does not need to be in place or used.

Poland
Currently 95% of all apartments in Poland are equipped with water meters of which 40% are manually read (walk-in, no radio) and 60% are radio read (walk-by or TSS remote reading).

Romania
We can identify three main periods in Romania's water metering:

- 70s and 80s: district heating and cold water supply were performed by separate companies. No measurements were being made. People assumed an average consumption to construct the bill of $5.1 m^3$/person/month for cold water and $3.3 m^3$/person/month for hot water.
- 1995 onwards: Self-readings are done by the landlord monthly. The building manager makes the bill for the tenants.

- Last seven years: a change occurred to mechanical meters with radio signal. Currently there are 1 million radio devices in place.

Germany

The law in Germany obliges metering companies to send out consumption reports to tenants on a monthly base, if there is an automatic reading.

8.2 Literature review from WE Data Europe

The following overview was provided by WE Data Europe as a basis for the literature review.

Table 23: Literature review.

Title	Author	Main Findings
Determinants of residential water consumption: Evidence and analysis from a 10-country household survey (2011)	R. Quentin Grafton, Michael B. Ward, Hang To, Tom Kompas	Overall, the results suggest that despite the fact that water expenditures account for only about 1% of household income, charging households volumetrically for the water they use and the average price charged for water are the most important variables explaining differences in household water consumption in the 10 OECD countries surveyed. These findings imply that the average volumetric water price is an effective instrument to manage residential water demand in the surveyed countries. The analyses also suggest that water demand management policies that include campaigns to promote water-saving behaviours (i.e. taking a shower instead of a bath) and use water-saving devices (such as dual-flush toilets) would be more effective if households faced a volumetric charge for water, and a higher average water price. The study found on average a 25% reduction of water consumption following the implementation of volumetric water pricing thanks to water metering.
The Role of Communicative Feedback in Successful Water Conservation Programs (2011)	Gail Tom, Gail Tauchus, Jared Williams, Stephanie Tong	Real-time water consumption information provided by smart meters to 50 households (Sacramento, California) during a week was found to reduce water consumption in 84% of the cases, with an average of 39%. More efficient than a 1-hour visit of a water efficiency specialist, which only led to a consumption reduction in 62% of cases, with an average reduction of 20%.
Water-saving impacts of Smart Meter technology: An empirical 5-year, whole-of-community study in Sydney, Australia (2014)	Kirsten Davies, Corinna Doolan, Robin van den Honert, Rose Shi	Based on a long trial with smart meter In-Home Displays (IHDs) that included 1,923 people residing in 630 households (Sydney, Australia), a water saving of 6.8% was observed over the duration of the two-year experiment. A 6.4% reduction of consumption has been maintained for 3 years following the removal of the smart meters, demonstrating the long-term benefits of smart water metering.
The costs & benefits of moving to full water metering (2008)	Godley, A., Ashton, V., Brown, J., Saddique, S.	On average, 10-15% water consumption reduction following the installation of a water meter in the UK. Other benefits include a reduction of supply pipe leakage for external water meters, varying from 0 to 58L per property per day. Overall supply pipe leakage is estimated at 42.5L/property/day for unmetered households and 19.5L/property/day for externally metered households, giving an overall difference of 23L/property/day.
Sustainable water use in Europe Part 2: Demand management (2001)	EEA Pezzey, J. C. V. and Mill, G. A. Emmasa 1999. Report 1999. Empresa Metropolitana de Abastecimiento y	In the UK, immediate reduction from the introduction of revenue-neutral metering is estimated to be about 10 to 25% of consumption, due to the joint effect of information, publicity, and leakage repair, as well as the non-zero marginal pricing. Savings have been observed to be sustainable over time. In Seville, Spain, in 1997, the supplier Empresa Metropolitana de Abastecimiento y Saneamiento de Aguas de Sevilla (EMASESA) implemented a plan to introduce individual metering in the flats of Seville city which had a collective meter. There were 18 300 buildings in this situation (around 225 000

	Saneamiento de Aguas de Sevilla, Spain	households), and individual meters implied a water saving of 5 million m3/year. Different actions were taken: agreement with a credit company to give financial facilities to the users; free telephone information line; free materials granted for 10–20 % of the general works in the buildings; cooperation with different institutions to develop the plan (user and professional associations, manufacturers, etc.). After one year, 6 557 households had an individual meter and the water use had been reduced by approximately 25 % (EMASESA, 1999).
An experimental test of voluntary strategies to promote urban water demand management (2013)	Kelly S. Fielding, Anneliese Spinks, Sally Russell, Rod McCrea, Rodney Stewart, John Gardner	The study was the first to use smart water metering technology as a tool for behaviour change as well as a way to test the effectiveness of water demand management interventions. Participants from 221 households in Australia, Southeast Queensland, were recruited and completed an initial survey, and their houses were fitted with smart water meters which measured total water usage at 5-second intervals. The intervention groups managed to save on average 11.3L per capita per day over the course of the study and for months after. Water consumption returned to pre-intervention levels (removal of the smart water meters) after 12 months.
Quantifying Household Water Demand: A Review of Theory and Practice in the UK (2012)	Joanne M. Parker, Robert L. Wilby	National Metering Trials in the UK found an average 11% reduction in water use in households billed by meter (1991). Survey of Domestic Consumption carried out in 1995 recorded the water use of 1,000 properties on metered tariffs and 1,000 billed by rateable value. The study found a 15% reduction of water consumption.
The Independent Review of Charging for Household Water and Sewerage Services (2009)	Anna Walker	Analysis of the cost efficiency of water metering in the UK. Based on several studies, concluding to about 10 to 15% of water consumption reduction, with the following benefits identified: Fairer tariffs saving about £100 per year per meter installed; incentives to reduce water demand of about $13m^3$ per year on average, bringing a financial benefit from £6 to £13 per meter installed; incentive to identify and reduce leakage: saving $9m^3$ per year per meter installed, resulting in £4.50 to £9.00 saved; reduction in carbon emissions of about 100 kg of CO_2 and a benefit of £1.50 to £6.00 per year per meter installed.
A review of residential water conservation tool performance and influences on implementation effectiveness (2006)	Inman & Jeffrey	Secretly installed meters do not affect consumption behaviour. Metering is effective in raising awareness of the need for water conservation, which is key to actually reducing consumption. An average 20% reduction in water consumption following meter installation has been found in US programs.
Reducing water demand and establishing a water-saving culture in the city, Zaragoza, Spain (2011)	Philip Ralph	The city of Zaragoza, Spain, established a 'water saving culture' through awareness campaigns, tariff reforms, and leakage controls. Despite a 12% increase in population, the water conservation measures employed by Zaragoza achieved a decrease in total water consumption of 27% between 1997 and 2008.
Towards efficient use of water resources in Europe (2012)	EEA, 2012	Denmark's urban water metering and full-cost pricing policies led to a reduction in urban daily per capita water demand from 155L to 125L, one of the lowest water use rates in the OECD.

Water Legislation, cost of non-Europe Report (2015)	Thomas Zandstra	The absence of water meters in households leads to a cost of non-Europe of €200 million per year. Assuming a constant average water price in the EU of €3.70/m^3 and water savings of 22m^3 per household per year, the estimated annual cost savings per household are €81.40.
Using Smart Meters for Household Water Consumption Feedback: Knowns and Unknowns (2014)	A. L. Sønderlunda, J. R. Smith, C. Hutton, Z. Kapelan	Review of 13 studies with different feedback methods: In-Home Display, Mail-based consumption feedback. The study concludes that consumption feedback is most effective when it includes granular time-series data, social and historical comparisons, and is tailored to the household. On average, consumption feedback resulted in a 19.6% decrease in water use.
Water demand management strategies for water scarce cities: The case of Spain (2019)	Tortajada, C., F. González-Gómez, A.K. Biswas and J. Buurman	A study on the most effective water demand strategies at household levels has been carried out in five urban areas in Spain, including the metropolitan areas of Barcelona, Seville, the cities of Malaga and Saragossa and the region of Madrid. In all five areas studied, non-pricing measures have had a greater impact on water consumption decisions compared to pricing measures. The replacement of collective water meters with individual meters has been one of the measures with the greatest impact on reducing per capita water consumption, including remotely readable meters alerting the clients when excessive consumption is detected. Water savings observed range from 20 to 25% after the installation of an individual meter.
Report: Cost benefit analysis of water smart metering (November 2021)	Produced by Frontier Economics and Artesia, supported by Arqiva (Francis et al., 2021)	A study performed in the UK to evaluate the benefits and costs of a smart water metering programme across England and Wales. Based on the findings reported by the local water providers, the following savings were assumed: • No water metering to analogical water metering: 12% reduction of consumption • No metering to smart water metering: 17% reduction of consumption • Analogical to digital meter reading or smart water metering: 5% reduction Additional 5% of reduction in peak demand have been observed when smart meters are installed.
Smart water metering and the climate emergency	Arqiva (Patten & Richardson, 2021)	• Smart water meters installed in 2020 detected 13,500 leaks and saved 18 million of litres a day. • Analogical water meters deliver on average a reduction of water consumption of 11% • Customers with a smart water meter use on average 17% less water than those without a meter • fitting just one million smart water meters in the UK each year for the next 15 years could result in saving at least one billion litres of water a day (1 billion L/d) by the mid-2030s and we could reduce the UK’s current greenhouse gas emissions by 0.5% (2.1MtCO_2e).