streamSAVE+ Dialogue Meeting #02

Streamlining Energy Savings Calculations

Assessing energy savings from water conservation measures

MINUTES OF THE MEETING

Date: 14 November 2024 **Duration:** 11:00 – 12:15 CEST
Online

Short summary

The second dialogue meeting of streamSAVE Plus discussed energy savings from water conservation measures. Water services require energy, from intake to wastewater treatment. Water conservation measures thus represent a significant energy savings potential. This meeting discussed scopes of energy consumption, data sources, examples of water conservation measures and how the related energy savings can be assessed.

The presentations began with an overview of recent research, followed by the contribution of water efficiency in buildings in Portugal (AQUA+ programme), and concluded with practical experience from Malta on water conservation approaches and related energy savings. Key points include:

- The ENR network of national energy agencies includes a water-energy nexus' working group.
- In most cases, the largest energy savings from water conservation measures are related to hot water end-use. However, the use of desalination as water source may also represent a significant energy consumption. Potentials and priorities thus depend on the national, or even local, context.
- Comprehensive conservation programmes at building level can deliver energy savings of about 30 kWh/m^3 (considering a mix of cold and hot water). But such energy saving ratio should be used with caution. Considering national or local specificities is recommended.
- The Portuguese AQUA+ programme found that water conservation measures at building level could help saving about 18% of the energy used by water utilities (i.e. 60% of the 2030 target for the water sector). Specific final energy consumption related to water supply and wastewater treatment is about 1 kWh/m^3, with a ratio rather stable over time.
- Malta's experience shows an about 90% reduction in water leakage thanks to network leakage management, also delivering savings of about 9% of the water utility's electricity consumption. Efficiency improvements in desalination plants reduced specific energy consumption of water production by about half between 2000 and now (from 6 to 3 kWh/m^3). The related investments are driven by the specific context of water scarcity (limited sources of freshwater compared to the demand), and thereby the need for desalination plants.
- Using rainwater or reusing greywater could represent further interesting potentials, especially in context of water scarcity.

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- Overall, energy savings calculation for water conservation measures at building level often imply the use of assumptions or benchmark values. Whereas energy savings from measures done by water utilities can often be calculated from metered data.
- Useful sources of data about conservation measures at building level include market data, standards for water-using products and water heating systems, benchmark values of water consumption data and water demand profiles from water utilities or research/literature.
- To assess energy savings from water conservation measures at building level, top-down (based on energy bills analysis) and bottom-up (based on end-use analysis) methods have both pros and cons, and different sources of uncertainties. Energy bill analysis can be more relevant for assessing energy savings at project level, or for programmes implemented by energy or water utilities (easier access to consumer data). End-use analysis can be easier for national programmes.

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11:25	Contribution of water efficiency in buildings to primary energy savings: example of the AQUA+ programme in Portugal (and short information about the Water Energy Nexus Working Group of the ENR network) **Patrícia Malta Dias** (AQUA+ programme manager, ADENE)
11:30	Q&A
	PART 2: Practical experience from a Member State where water conservation is essential – Malta
11:45	Malta's experience with water conservation measures and related energy savings **Manuel Sapiano** (CEO, Malta's Energy and Water Agency) and Ing **Stefan Cachia** (Malta's Water Services Corporation)
12:05	Q&A
12:10	Open discussion and closing

Part 1 - Water conservation measures at building level and related energy savings

Evaluating water-related energy savings within buildings: insights from research studies Hugo Jacque (University College of Dublin)

(see also presentation file available on the streamSAVE+ website)

Hugo Jacque presented an overview of water usage and reminded the audience that **energy consumption in buildings** are the primary source of energy consumption (up to 80%) when considering the whole cycle to supply water to buildings, from raw water to wastewater treatment. Mostly because of water heating (for domestic hot water), cooling systems and to a lesser extent for white appliances (e.g. washing machine and dishwashers) and pumping.

Hugo then briefly showed the main types of water conservation measures in buildings, with three categories: technical measures (e.g. systems reducing water flow), non-technical measures (e.g. measures to reduce the duration of shower) and measures to use alternative water sources (e.g. using rainwater).

Hugo distinguished two main approaches to estimate water-related energy savings in buildings:

- **Top-down**, i.e. based analysis of energy bills at the building level. This is approach is only possible ex-post and requires aggregating energy data from energy utilities or building owners. This can be difficult, as these data are sensitive. It might also be difficult to separate changes in energy consumption related to water use from other changes in energy consumption.
- **Bottom-up**, i.e. considering energy consumption at the end-use level (e.g. shower, or washing clothes). This approach can be ex-ante. It starts with estimating the total volume of water saved and then disaggregating the water savings per water end-use.

For the bottom-up approach, the typical data sources to assess the **total volume of water saved** include billing/meter data (e.g. from water utilities) or benchmark data about average consumption per person combined with population data. Then this total volume is **disaggregated per end-use**, for example using benchmark data of water demand profile, or data from survey of building occupants.

Then it is required to define the **baseline situation**, i.e. the water-using equipment or behaviours before implementing the water conservation measures. This can be assessed through water audits, market trends or building codes and standards. The baseline performance is **compared with the performance of the efficient option** (in terms of water efficiency), to assess a ratio of water savings per volume (e.g. $\%/m^3$). This approach also includes uncertainties, for example when using benchmark data not necessarily representative of the local context or assuming that the efficient option will perform as specified by manufacturers, which might not fully be the case (cf. performance gaps, possibly due to defaults in the installation or bad use).

Moreover, while the energy bills analysis will directly capture **possible rebound effects** (e.g. longer shower after installing efficient showerhead), this would need to be assessed when using an ex-ante bottom-up approach.

The **ex-post bottom-up** approach can be based on historical water consumption data (from water utilities or building owners). However, these data are not always available, especially at building level (e.g. depending on the country or region, water meters might not be mandatory).

An alternative is **market penetration analysis**, which may be used at the national level by defining a Business-As-Usual scenario (estimating initial stock and sales from market trends) and then comparing with the programme scenario (using sales data from manufacturers data). Then assumptions are made on the water saved per new efficient equipment, based on benchmark data.

More specifically to calculate **energy savings** from the volume of water saved, the **largest part is related to domestic hot water**. First step is therefore to estimate the **volume or share of hot water use per end-use** (for example that share of hot water in the total water used for showers). Then a ratio is used to estimate the **energy used to heat water** (e.g. in kWh/m^3). While more specific data can be found for an assessment at the building level, when assessing energy savings from a programme at national level, a standardised approach can be used, based on average values (especially when assessing the baseline / stock) and market trends at national level. Sources of uncertainties include seasonal and regional variations.

Energy used for pumping at building is usually neglected, because it is much smaller and very site-dependent (average values would not be appropriate). Then for white appliances, energy consumption data are usually available from manufacturer data.

Savings observed for comprehensive conservation programmes would be in **order of magnitude 30 kWh/m^3** (energy savings in the whole urban water cycle, considering a mix of cold and hot water). However, **such ratio should be considered with a lot of caution**. The factors influencing the energy savings include water efficiency standards, energy calculation methods, building insulation standards, water supply source, region topography, wastewater treatment process, etc.

Further references are included at the end of the presentation file.

Q&A

— *Can you tell us more about the availability of data on water consumption?*

This varies by country. It mostly relies on if and where water meters are installed and to which extent the relevant agencies disclose the data. Another issue can be when water utilities commission contractors, making data sharing more difficult (e.g. due to GDPR), at least for researchers. The situation in question is somewhat comparable to any other data collection, such as for energy use.

— *Is it relevant to use the benchmark of 30 kWh/m^3 for water conservation programmes in European countries?*

The estimate of 30 kWh/m^3 was found in two national studies, in the US and in Australia. It is noticeable that both studies found results in the same range. Both studies also gathered data from various areas in each country. Therefore, this indicative value already reflects broad variations (major differences among the different areas in the US for example). It could thus serve as a first approximation for a European country with no major specificity about water demand, production or treatment. However, in case of specific energy requirements, for example, for water treatment or water production (as in the case of Malta), specific data are needed.

Part 2 - Insights from the Energy-Water Nexus' working group of the EnR network

Contribution of water efficiency in buildings to primary energy savings: example of the AQUA+ programme in Portugal, by Patrícia Malta Dias (AQUA+ programme manager, ADENE)

(see also presentation file available on the streamSAVE+ website)

Patrícia Malta Dias introduced the **water-energy nexus' working group of the ENR network**, as well as ADENE, the Portuguese Energy Agency. A complementary presentation file provides more details about the ENR working group.

The Portuguese context is defined in the roadmap to carbon neutrality by 2050, and in the National Energy and Climate Plan 2030, setting targets of 35% reduction in primary energy consumption and 30% emissions reduction in the water and wastewater sectors.

The water and wastewater sector represents **4% of the global electricity consumption** (worldwide), and **6 to 18% of energy demand consumption in cities**. It is thus important to understand how implementing water efficiency measures in residential buildings can contribute to achieving climate neutrality by 2050.

ADENE has launched the **AQUA+ programme** two years ago, to evaluate water efficiency in buildings (new, existing and retrofitted). The **water efficiency audits** assess the water class of the buildings (similarly to energy performance certificates about energy), and more importantly, identify improvement measures and assess related potentials. The audits performed within this programme in 2022 showed a **potential** of water saving of **55 m^3/year per household**, (**32%** reduction in water consumption). Which would represent about 218 million m^3/year (4 million households in mainland).

To assess energy savings, energy consumption is firstly estimated in terms of final energy to deliver 1 m^3 of water to consumers. Based on available data from water services, overall energy consumption for water services is divided by authorized water usage (disregarding water losses), and similarly the energy consumption for wastewater services is divided by the volume of collected wastewater. The sum gives the **specific energy consumption** (in kWh/m^3). It is subsequently converted into primary energy (as it is related to electricity consumption) using a factor of 2.5 kWh_{PE}/kWh. Which is the conversion factor from final to primary specific energy consumption, from the Portuguese Energy Certificate System. The average specific energy consumption was found to be a rather constant ratio over time: a bit less than **1 kWh/m^3 (final energy)** and **2.5 kWh/m^3 (primary energy)**.

It can therefore be applied to the estimated potential of water savings (218 million m^3/year), giving an estimate of energy savings potential of **193 GWh/year final energy savings** (484 GWh/year in primary energy), which would represent **18% of the energy consumed by the water utilities**, and 0.41% of the total final electricity consumption in Portugal. For the water sector, this would also represent about 60% of the reductions in GHG emissions to be achieved by 2030.

A previous study by the European Commission found that the water saving potential would range from 30% in new buildings to 50% in renovated buildings. This is in line with the results from the AQUA+ audits (32% potential), as more audits were done in new buildings than existing ones (because the water audits are voluntary). As most current existing buildings will still be in use in 2050, this means that the 32% estimate is conservative. The **actual potential is likely higher**, when considering that the potential is larger in existing buildings than in new buildings.

The potential for savings would also be significantly higher when considering commercial buildings, including hotels (hotels and offices are now in the scope of AQUA+). Likewise, this assessment is about energy consumption related water supply and wastewater treatment. It does not include energy savings from heating water.

Q&A

— *Why are water usage and savings higher in the office buildings than residential buildings?*

The figure was provided per household, not per person. The commercial buildings have a greater occupancy rate. For example, hotels include water consumption by tourists. The AQUA+ audits provide real data. We observed for example that there is a significant opportunity for reconstruction in existing hotels and offices (compared to new buildings), resulting in significant energy and water savings.

— *Could you clarify the conversion factor used for final to primary energy?*

The main source of energy in the water sector is electricity. Therefore, the conversion factor used is the primary energy factor for electricity.

Part 3 – Practical experience from a Member State where water conservation is essential – Malta

Malta's experience with water conservation measures and related energy savings Manuel Sapiano (CEO, Malta's Energy and Water Agency), and Ing Stefan Cachia (Malta's Water Services Corporation)

(see also presentation file available on the streamSAVE+ website)

Manuel Sapiano emphasized the high population density of Malta, as well as the scarcity of natural water supplies. Therefore, water management is extremely crucial. But even with efficient water use, natural freshwater resources are insufficient. Hence the need to do both, be as efficient as possible, and diversify water supply, including desalination plants. Which has major impacts on the energy consumption of the water sector.

The water-energy nexus in Malta is thus the inverse of that in most European countries where the water-energy nexus is first seen from the need in water for energy (e.g. for cooling thermal plants or for hydropower): in Malta, energy is required to produce and distribute water. As a result, the links between energy and water are stronger in a context of water management under water scarcity conditions.

The 3rd River Basin Management Plan (RBMP) is Malta's water management plan from 2024 and includes measures addressing the energy and water sectors, as well as links to food and ecosystems. For example, 11% of the RBMP measures deal directly with energy, and more generally every cubic meter of water saved (e.g. from reducing leakages) also saves energy. The RBMP also investigates water links to SDGs (UN Sustainable Development Goals). Not just SDG6 related to water, but across all SDGs. This demonstrates how water is interconnected with various areas.

Manuel briefly discussed the Retouch Nexus project (Horizon programme) that aims at tackling water scarcity issues by promoting an integrated Water-Energy-Food-Ecosystems (WEFE) nexus approach with ecological and social considerations..

Stefan Cachia focused the presentation on practical examples of energy savings from water conservation measures in portable water sector. He started his presentation by introducing the Malta's Water Services Corporation (WSC) and showing the energy profile of the water utility, highlighting that desalination process represents 67% of WSC energy consumption (followed by wastewater treatment: 15%). Desalination accounts about 65% of the portable water blend. As a result, the most essential energy efficiency strategies are to reduce energy consumption during the desalination process and to reduce water leaks in water networks.

Water production increased significantly during the 1980's to satisfy water demand but also due to leakage in the distribution networks. This growing demand was met with the development of new desalination plants. A strong plan to reduce water leakage, as well as measures for increasing efficiency in usage were implemented from 1995, resulting a rapid reduction in water demand, and thereby water production (from 49 million m^3 in 1995 to about 31 million m^3 in 2001, i.e. -37%). This made possible to decommission some of the desalination plants built in the 1980's. Water conservation indeed goes hand in hand with the development of the water infrastructure.

Stefan additionally showed planned upgrades in the capacity of the desalination plants, going from 95000 m^3/day to 127000 m^3/day. This is consistent with the improvements of the energy efficiency, for example: development of membranes that can run with lower operating pressure (about 20% reduction in energy consumption), or applying energy recovery devices (increase in their efficiency from 75% to 95%). These measures result in significant reductions in specific energy consumption per m^3. The new desalination plant (operating since 2021) achieves less than 3 kWh/m^3, compared to an average of 4 kWh/m^3 for existing regular plants, and an average of 6 kWh/m^3 in 2000.

Stefan also mentioned the impressive results in reducing water leakages in the network from the year 1995 (leakage rate of about 3900 m^3/hour) to 2020 (389 m^3/hour). He provided an overview of measures for water leakage management, including active leakage localisation, pressure control, replacement of critical pipework, dynamic leakage repair and network rationalisation.

Stefan presented the calculation formula to assess energy savings for two main types of interventions: efficient desalination plant, and network leakage management.

In both cases, the first step is to calculate the specific energy consumption (kWh/m^3) for water supply, obtained as a ratio between energy consumption and water production or water supply. For desalination plant, this is assessed from data metered at plant level (considering water production). For network leakage management, this is the average value for the network area considered (considering water supply).

Then the specific consumption is multiplied by the annual water production, metered either at plant level (for efficient desalination plant) or network level (for network leakage management).

For efficient desalination plant, the energy savings come from the difference in specific energy consumption (lower in efficient plant vs. baseline plant = average efficiency of the plants operating in

2004). For water leakage management, the energy savings come from the difference in the annual water production (lower when leakages are reduced).

Looking at the results reported for 2014-2020, energy savings from leakage reduction were rather stable about 15 GWh/year (about 100 GWh cumulative savings over the period), and energy savings from energy efficiency in desalination plants increased from about 20 GWh/year to about 25 GWh/year (about 158 GWh cumulative savings over the period). The total annual savings of about 40 GWh/year represent a reduction of about 24% of WSC electricity consumption.

In addition to water conservation measures, the Water Services Corporation invests in RES technologies, to offset their electricity consumption from the grid, particularly with PV systems currently producing 5.5 GWh/year, and expected to increase to 11.6 GWh (which would represent about 7% from WSC total electricity consumption). The electricity demand is also offset by optimising energy for water production and distribution network through AI.

Q&A

— *Did you also look at energy savings potentials other than in desalination plants?*

We focus on energy related to water desalination because it requires high energy demand. Other aspect for the Water Services Corporation and the consumers become important. When looking at energy consumption alone, the largest energy savings potential is likely related to heating water, and is therefore on consumers' side. The easiest energy saving option in this field is for consumers to reduce their consumption of hot water. For a long time already, Malta has implemented a progressive tariff for water (first block at lower price, then increasing prices for the next blocks). This makes that the average consumption per person is already low (about 100 L per day). Going lower is difficult. The challenge is actually to keep the consumption per person to the current level (to avoid new increase).

Then we are looking at further options, and especially reusing grey water (e.g. from shower to flushing), as it can significantly reduce the water consumption and related energy consumption. Energy required for grey water treatment is much lower than in desalination process. This could represent up to 30% of water consumption by households.

— *Do you use average national values? Or do you consider more local values (if the whole water network is not interconnected)?*

Even if regions in Malta are smaller, there are indeed regional differences, for example due to differences in population distribution/density (cf. lower water consumption of in lower density areas). Moreover, in urban areas, there are more single-person households, especially foreign workers. Tourism is another source of variations. Overall, foreign workers or tourists come with their own habits, which usually means much higher consumption levels (up to twice more) than Maltese inhabitants.

We have therefore to consider also the social implications of using water. For example, it is more difficult to communicate about water conservation to foreigners who will stay in Malta for short periods. Information measures need to be different to the ones meant for permanent inhabitants who are already aware of Malta's challenge with water scarcity.

Further readings

- Cabrera, D. J., Njem Njem, H., Bertholet, J.-L., Patel, M. K. (2023). Simple solutions first - Energy savings for domestic hot water through flow restrictors. Energy Efficiency, 17(1), 1.
- Faia, V., Newton, F., Dias, P. Simões, M. (2023). Water-Energy Nexus: Contribution of water efficiency in buildings to primary energy savings. Proceedings of the CEES 2023 conference. Available at: https://www.cees2023.uc.pt/projectos/cees2023/index.php?module=atas
- Jacque, H., Mozafari, B., Dereli, R. K., & Cotterill, S. (2024). Implications of water conservation measures on urban water cycle: A review. *Sustainable Production and Consumption*, 50 (2024), 571–586.
- Sapiano, M. (2022). “Energy and Water” links in the provision of Water Services - Case Study: Malta. Presentation at the Concerted Action EED, March 2022.

List of participants:

52 participants

Name	First name	Organisation	Country
Agius	Matthias	The Energy and Water Agency	MT
Altmann	Naghmeh	Austrian Energy Agency	AT
Broc	Jean-Sébastien	IEECP	FR
Bukarica	Vesna	EIHP	HR
Cabrera	Daniel	Université de Genève	CH
Cachia	Stefan	Water Services Corporation	MT
Condell	Aidan	Sustainable Energy Authority of Ireland	IE
Costa	Massimo	Water Services Corporation	MT
Čižikienė	Gabrielė	Lithuanian Energy Agency (LEA)	LT
Ellul	Noel	Building and Construction Authority	MT
Gerbelová	Hana	SEVEn, The Energy Efficiency Center	CZ
Gynther	Lea	Motiva Oy	FI
Hartman	Vanja	EIHP	HR
Hudetz	Lana	Sustainable Energy Authority of Ireland	IE
Jacque	Hugo	University College Dublin	FR
Jukame-Kerus	Laura	Ministry of Climate and Energy	LV
Karásek	Jiří	SEVEn, The Energy Efficiency Center	CZ
Kreišmonas	Matas	Lithuanian Energy Agency (LEA)	LT
Kunigėlienė	Egida	Innovation agency	LT
Lequai	Angélique	French ministry in charge of energy	FR
Madžarević	Valentina	APN	HR
Malamatenios	Charalampos	Centre for Renewable Energy Sources and Saving (CRES)	GR
Malta Dias	Patrícia	ADENE	PT
Masiulionis	Ričardas	Lithuanian Energy Agency	LT
Mazėtis	Dainius	EMEA	LT
Melninkaitiene	Agniete	Lithuanian energy agency (LEA)	LT
Mizutavicius	Mindaugas	Lithuanian Energy Agency (LEA)	LT
Mizzi	Veronica	Government services and information	MT
Moura	Pedro	University of Coimbra	PT
Nekić	Iva	HEP-ESCO d.o.o.	HR
Newton	Filipa	Infinite.ε consulting	PT
Palmer	James	Sustainable Energy Authority of Ireland	IE
Perednis	Eugenijus	Lietuvos energetikos institutas	LT
Pereira	Isabel	ADENE - Agência para a Energia	PT
Pestana	Rita	ADENE	PT

Pinho	Carlos	JCI	GB
Pinturić	Davor	APN	HR
Pranckevičius	Darius	Lithuanian Energy Institute	LT
Pusnik	Matevz	Jozef Stefan Institute	SI
Raklevičiūtė	Alina	Lietuvos Energetikos agentūra	LT
Sapiano	Manuel	Energy and Water Agency	MT
Seinre	Erkki	RKAS	EE
Sikk	Aser	Estonian Environmental Research Centre	EE
Stergis	Janis	AS RĪGAS SILTUMS	LV
Stonienė	Agnė	Lithuanian Energy Agency (LEA)	LT
Szabo	Julia	IEECP	DE
Tamm	Riina	Ministry of Climate	EE
Toum	Solenne	ATEE	FR
Vella	Annabel	VITO	BE
Verheyen	Jan	VITO/EnergyVille	BE
Vilne	Ilona	Ministry of Climate and Energy	LV
Vorobjova	Jūratė	Lithuanian Energy Agency (LEA)	LT