Green Guide for Buildings Water-Energy Nexus

A 3.1.3 Solutions For Improving Water-Energy Nexus For Buildings

Funded by the European Union

meetMED
Mitigation Enabling Energy Transition in the MEDiterranean region
Together We Switch to Clean Energy

adene
Agência para a Energia

MED ENER

RCREEE
Regional Center for Renewable Energy and Energy Efficiency
المركز الإقليمي للطاقة المتجددة وكفاءة الطاقة

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Abbreviations/Acronyms

ADENE	ADENE – Portuguese Energy Agency
CRC's	Climate Ready Certificates
DHW	Domestic Hot Water
IEA	International Energy Agency
KPI	Key Performance Indicator
meetMED II	Mitigating Enabling Energy Transition in the MEDiterranean region
WEN	Water-Energy Nexus
WRI	World Resources Institute

1. Summary

The Green Guide was developed on the scope of the activity "pilot new technologies for improving energy management and thermal comfort: solutions for improving water-energy nexus for buildings" of phase II of project meetMED.

The Mitigation Enabling Energy Transition in the Mediterranean region "meetMED II" is an EU-funded project developed by the Mediterranean Association of the National Agencies for Energy Management (MEDENER) and the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE). With the objective of contributing to energy and climate transition Southern Mediterranean Neighbourhood through a multi-scale, multi-partner inclusive approach, meetMED II activities aim at developing a more stable, efficient, competitive, and climate-resilient socioeconomic environment in Southern Mediterranean countries, by fostering regional cooperation for Energy Efficiency measures and implementing demo actions.

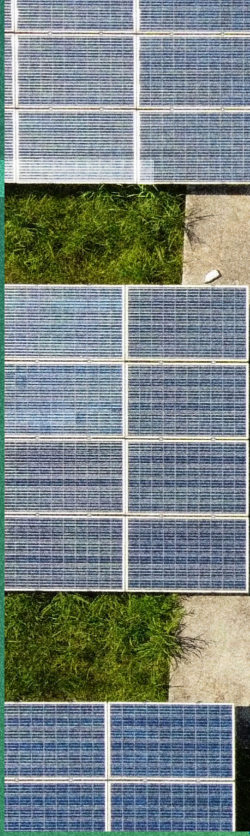
The current guide aims to contextualise, describe and guide the application of the Water-Energy Nexus Evaluation Methodology for the Mediterranean Basin to residential and small services buildings located in Mediterranean countries.

Furthermore, it compiles and highlights the different behavioural and infrastructural measures that lead to a more efficient building on the three water-related dimensions: water efficiency, water-energy nexus, and local climate adaptation.

The WEN (Water and Energy Nexus) methodology was developed and adapted by ADENE – the Portuguese Energy Agency. Its implementation was made possible with the support of ADENE in collaboration with the energy agencies of three South Mediterranean countries. Each of these agencies applied the methodology to one residential and one small service-sector pilot building. The participating agencies were the National Energy and Research Centre (NERC) from Jordan, the National Agency for the Promotion and Rationalisation of Energy Use (APRUE) from Algeria, and the Moroccan Agency for Energy Efficiency (AMEE) from Morocco. This collaborative implementation contributed to testing and validating the methodology across different national contexts.

The contextualization of the water-energy nexus in the world and in the Mediterranean region is the focus of section 2. Section 3 details the WEN Evaluation Methodology for the Mediterranean Basin, how it was developed, its main considerations and the several phases of its application. Section 4 compiles the recommended infrastructural and behavioural measures which improve a buildings' efficiency on the scope of the WEN Methodology.

Finally, Section 5 presents the results of the application of the methodology to four of the pilot buildings.



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The Water-Energy Nexus in buildings of the Mediterranean basin

2. The Water-Energy Nexus in buildings of the Mediterranean basin

The water-energy nexus refers to the interdependency relation between the water and the energy sectors. According to it, water and energy are two interdependent resources with bidirectional impacts. In fact, water is a critical factor to the production of energy, and energy a critical factor to the water cycle and to water heating. Water security and energy security go hand in hand.

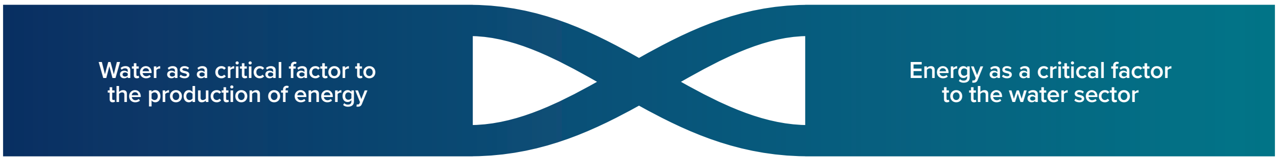

Figure 1: The water-energy nexus

On one hand, water is necessary at all phases of energy production and electricity generation. It is needed to the production of energy in hydroelectric power plants, to the production and distillation of biofuels, to fossil fuel extraction and to the cooling down processes that occur in power plants and refineries, amongst others. The energy industry is responsible for about 10% of total freshwater consumption worldwide[(1)].

Furthermore, the estimated total amount of water used to produce one terajoule of energy, also known as the water footprint, is different according to the energy source. First generation biodiesel requires around 137.624 m^3 of water, reservoir hydropower 9.114 m^3, oil 249 m^3 and solar 117 m^3 while run-of-river hydropower and wind energy only consume around 1m^3[(2)].

On the other hand, energy is necessary to the production, abstraction, purification, treatment, transport, and distribution of water and to the collection and treatment of wastewater.

In fact, the water sector is responsible for 4% of the world's electricity consumption, a value predicted to double by 2040 according to the International Energy Agency[(1)(3)].

Additionally, throughout the world, the water and wastewater sectors correspond to 30-50% of the total municipal expenses[(3)].

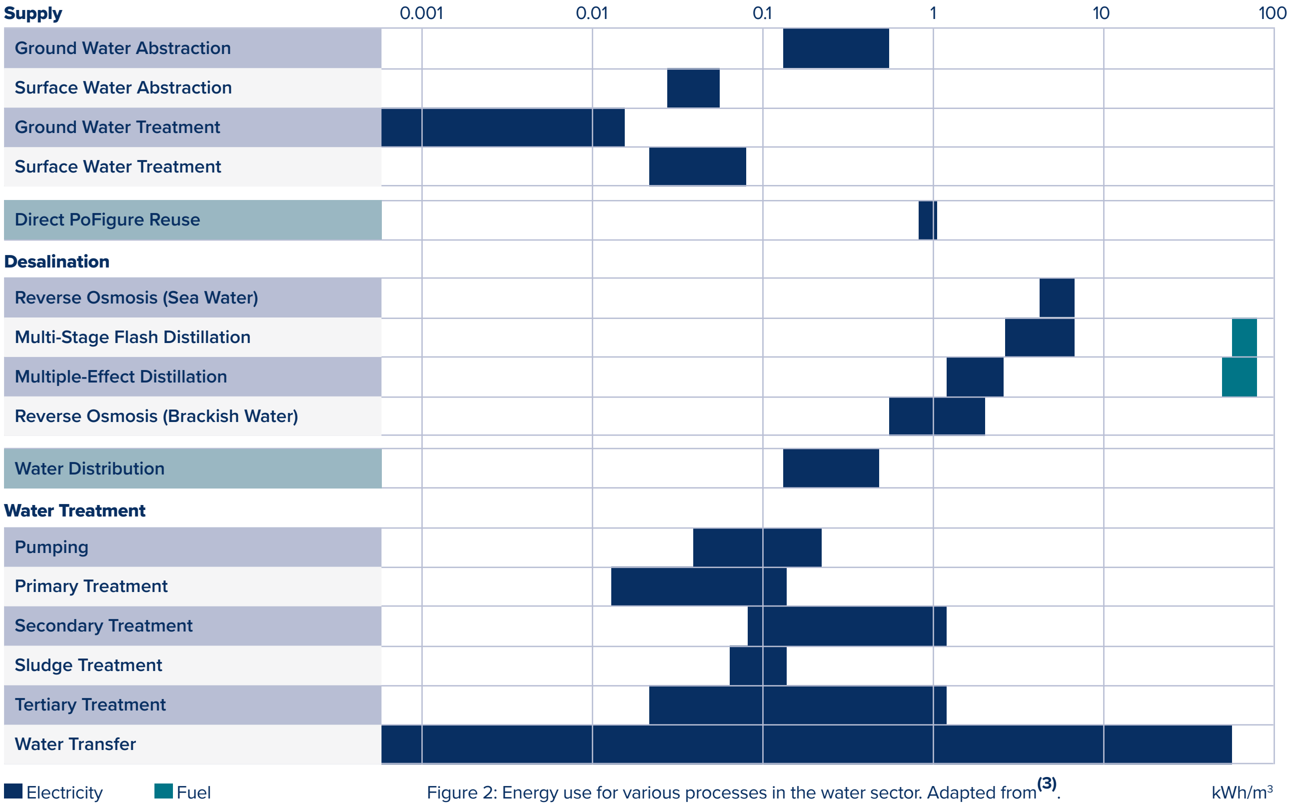

Figure 2: Energy use for various processes in the water sector. Adapted from[3].

Desalination of seawater and treatment of wastewater are the processes that consume the most energy in the water industry[3]. It is estimated that in 2014 around 120 million tonnes of oil equivalent of energy was used worldwide in the water sector. Around 60% of that was consumed in the form of electricity - 820 terawatt-hours, while around 20% corresponds to fuel used to pump groundwater, and the remaining corresponds mostly to natural gas used for desalination in the Middle East and North Africa regions[3].

Worldwide, demographic growth, economic development and population migration to urban centres are increasing water consumption and competition, putting pressure on the water system demand side. According to UN WATER, the inadequate treatment of domestic wastewater, the use of chemical fertilizers and pesticides in irrigation, and the industrial waste dumped directly into watercourses, increase pollution throughout the water cycle, reducing the quality of the available water[4]. Furthermore, effects of climate change, which are expected to worsen in the coming decades, such as the increase in average global temperature, the change in precipitation regimes and the increase in the frequency, intensity and impact of extreme weather events such as droughts, floods and heat waves, alter the water cycle in various ways. All these factors contribute to a decline in both water quality and quantity, as well as an often-unpredictable temporal and geographic variability in water availability. As a result, the balance between human needs and water supply is increasingly disrupted in many regions, placing greater pressure on existing water resources. Water scarcity impacts not only human consumption, agriculture, and industry but also energy production. The growing variability and uncertainty of water availability call for an integrated approach to managing water and energy systems. After all, water cannot be produced without energy, nor can energy be generated without water.

On the supply side of the energy sector, integrated water-energy nexus strategies include the optimisation of water efficiency and cooling systems in energy production and electricity generation, reducing water needs and introducing renewable and nontraditional water sources, as well as privileging energy sources with a low water footprint and more efficient cooling systems.
On the supply side of the water sector, integrated strategies encompass a more efficient management of the sector, including the optimisation of energy recovery and of energy efficiency in water production, treatment, and distribution as well as in wastewater collection and treatment. Strategies on the water sector also include the optimisation of the water capacity storage, and the reduction of the non-revenue water, by diminishing leaks, bursts, and thefts[1][5][6] According to IEA, wastewater holds enough embedded energy that, if utilised, could cover over half of the electricity requirements of municipal wastewater facilities[1].

On the demand side, a more efficient use of energy and water by the end users and the end use systems, reducing the consumed water and energy, will lead to relevant savings. If users consume less water, not only will they spend less water but also less energy – the energy used to produce, treat and distribute that water, and consequently less wastewater to treat and collect will be produced.

In this context, relevant water-energy nexus strategies include not only behavioural but also infrastructural and water-use equipment-related measures. The use of water-efficient equipment (e.g. laundry machines and dishwashers) and fixtures (e.g. taps and shower systems) in houses and businesses, the adoption of water and energy efficient technologies (e.g. hot water recirculation systems, water networks with good thermal insulation and optimised configuration) and use of alternative water sources (e.g. rainwater and greywater) with passive or energy renewable source systems for their exploitation and distribution, will lead to both water and energy savings.

The Mediterranean region is characterised by dry summers often associated with long drought episodes, alternated with autumns and winters with rainfall that can be very intense[7]. Both precipitation and average seasonal temperatures exhibit significant spatial and temporal variability. Furthermore, there are areas with groundwater depletion and rivers with low flow issues.

In this area, water serves multiple purposes such as drinking and sanitation, agricultural irrigation, cooling of power generation plants, industrial processes, hydropower production, and livestock farming.
During the summer water usage in the region nears its maximum capacity, which means that all available freshwater is being utilised, frequently involving a significant portion of fossil groundwater sources, resulting in further groundwater depletion.

The North of Africa Mediterranean region is characterised not only by water scarcity, but also by a strong reliance on fossil fuels, namely oil products and natural gas, for energy generation. In fact, in North Africa, renewables still play a small role, totalizing only around 4,6% of the energy generation mix on average, a low value comparing with the global average of 25%[6].

Desalination of seawater and treatment of wastewater are the processes that consume the most energy in the water industry[3]. It is estimated that in 2014 around 120 million tonnes of oil equivalent of energy was used worldwide in the water sector.

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increase in average global temperature, the change in precipitation regimes and the increase in the frequency, intensity and impact of extreme weather events such as droughts, floods and heat waves, alter the water cycle in various ways.

All these factors contribute to a decline in both water quality and quantity, as well as an often-unpredictable temporal and geographic variability in water availability. As a result, the balance between human needs and water supply is increasingly disrupted in many regions, placing greater pressure on existing water resources.

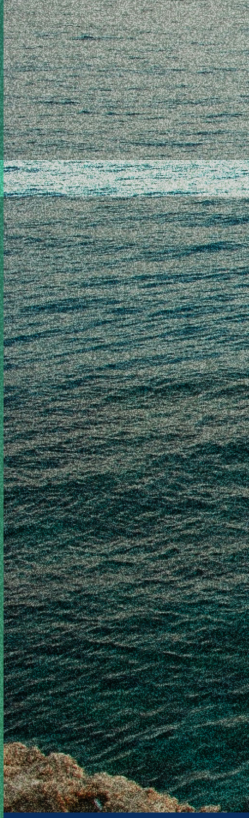
Water scarcity impacts not only human consumption, agriculture, and industry but also energy production.
The growing variability and uncertainty of water availability call for an integrated approach to managing water and energy systems. After all, water cannot be produced without energy, nor can energy be generated without water.

Country	Baseline Water Stress in 2019 (%)	Share of Fossil Fuels in total Final Energy Consumption in 2022 (%)	Share of Modern Renewables in Final Energy Consumption in 2021 (%)
Jordan	91%	68%	10,6%
Morocco	78%	73%	8,0%
Algeria	74%	87%	0,1%

Table 1: Baseline water stress in 2019, that is, the average ratio of total withdrawals to total renewable water supply[8] and share of fossil fuels and of modern renewables in final energy consumption[9] for the pilot-countries

The Water-Energy Nexus Evaluation Methodology for the Mediterranean Basin was developed aiming to intervene on the demand and infrastructural side of the water-energy nexus on buildings.

It aims to evaluate and rate the water-energy nexus efficiency of residential and small service buildings on a region characterised by water scarcity and high-dependency on fossil fuels, where the balance between water demand and water supply is currently already under stress[7].



3

The Water-Energy Nexus evaluation methodology for the Mediterranean basin

3. The Water-Energy Nexus evaluation methodology for the Mediterranean basin

The WEN Evaluation Methodology for the Mediterranean Basin is based on the Climate Ready Certificates' methodology and on the AQUA+® system, which were adapted for the reality of the south Mediterranean countries – Jordan, Morocco and Algeria – on the scope of the activity "pilot new technologies for improving energy management and thermal comfort: solutions for improving water-energy nexus for buildings solutions for improving water-energy nexus for buildings" of phase II of project meetMED.

3.1 Development of the Water-Energy Nexus methodology for the Mediterranean basin

The CRC's methodology is a water efficiency, water-energy nexus, and climate adaptation performance standard against which households, buildings, and neighbourhoods in Europe, at various stages (design phase, new construction and in-use) can be assessed and achieve a pre-established rating (from F to A+). It was developed by ADENE - the Portuguese Energy Agency, on the scope of the European Union's Horizon 2020 project B-WaterSmart – Accelerating Water Smartness in Coastal Europe[10].

The water efficiency dimension of the methodology is based on the AQUA+® system[11], also developed by ADENE. AQUA+ is a voluntary water performance certificate that rates and improves indoor/outdoor water use/reuse in buildings based on infrastructural evaluation. It assesses, in a simple and agile way, water use efficiency and identifies opportunities to increase water efficiency, water reuse and water-energy savings, and reduce water losses.

AQUA+ index, ranging from the well-known efficiency scale F (least efficient) to A+ (most efficient), is issued and comprehensively detailed for each property, providing guidance on good practices for buildings design and renovations, quantifying resulting water, energy, and economic savings, and allowing for greater choices of equipment and solutions. AQUA+ Residential, for households, was launched in 2020, AQUA+ for the hotel industry in 2022 and AQUA+ for office buildings in 2024.

The WEN Methodology for the Mediterranean basin is applicable to residential, small service (including public administration) and small commercial buildings in their different life-cycle phases: design, new construction, operation, and rehabilitation.

Both individual dwellings and buildings may be accessed. The evaluation methodology focuses on different assessment areas, themes, and criteria, related to each of three dimensions: Water Efficiency, Water-Energy Nexus and Climate Adaptation.

The Water Efficiency Dimension comprises five areas, thirteen themes and twenty-four evaluation criteria, as depicted in Figure 2.

Figure 3: Evaluated areas and themes of the Water Efficiency Dimension.

The Water-Energy Nexus Dimension encompasses seven areas, eleven themes and twenty-two evaluation criteria, as shown in Figure 3.

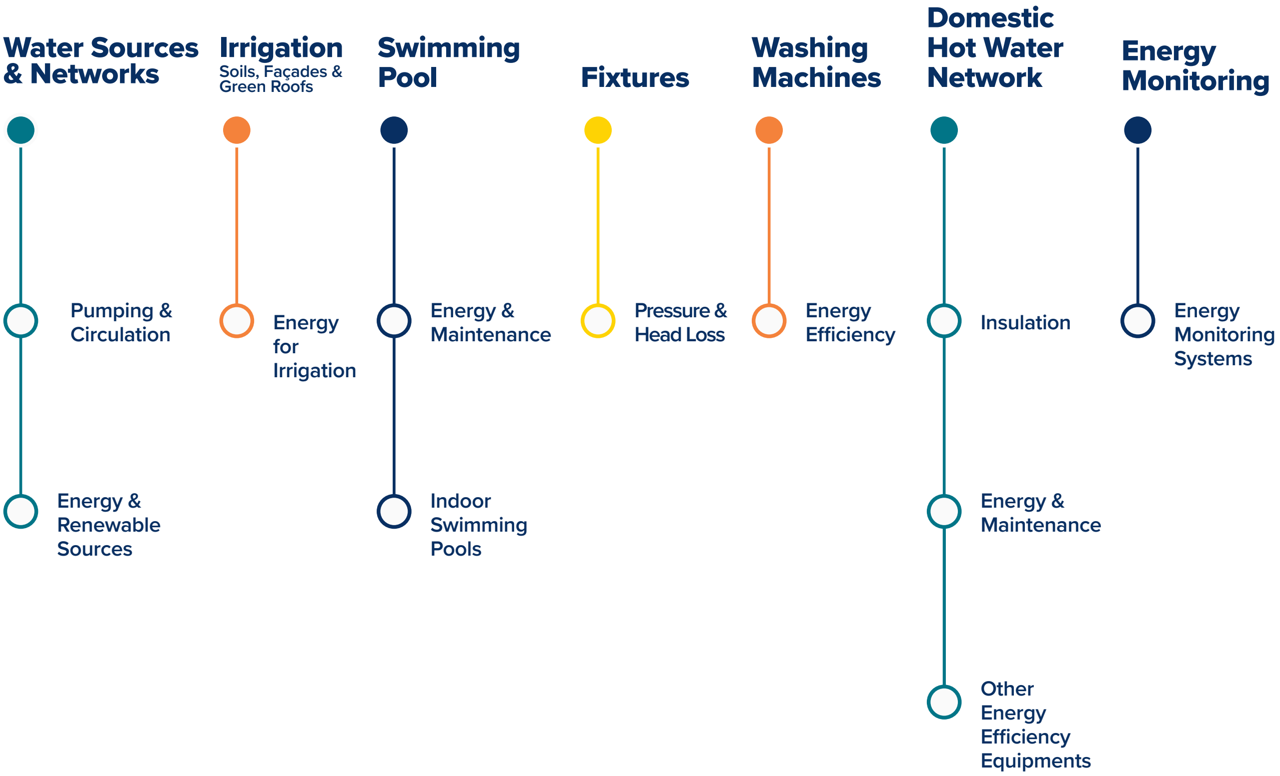


Figure 4: Evaluated areas and themes of the Water-Energy Dimension.

The Climate Adaptation Dimension comprises three areas, 11 themes and 20 evaluation criteria, as shown in the Figure 5.

Figure 5: Evaluated areas and themes of the Climate Adaptation Dimension.

Every assessed criterion for a given dimension has a corresponding value (in percentage) that adds up to the dimension's overall score, which ranges from 0% to 100%. The higher the value, the more efficient the building is. The distribution of the weightings across the assessment areas per dimension is presented in Figure 3. The total weighting for each dimension is 100%.

	ID	Assessment Area	Weightings
Water Efficiency	W1	Water Sources & Networks	30%
	W2	Other Uses	20%
	W3	Fixtures Efficiency	30%
	W4	Appliances (Washing Machines)	10%
	W5	Water Monitoring	10%
Water-Energy Nexus	N1	Water Sources & Networks	25%
	N2	Irrigation (Soils, Green Roofs, Green Façades)	5%
	N3	Swimming Pools	15%
	N4	Fixtures	5%
	N5	Appliances	10%
	N6	Domestic Hot Water Networks (DHW)	30%
	N7	Energy Monitoring	10%
Climate Adaptation	C1	Local Policies & Strategy	20%
	C2	Project Area	40%
	C3	Project Response	40%

Table 2: Weighting of the methodology's assessment areas.

The building will also have a global score (in percentage terms) determined according to the weights shown on Table 2. The global score will vary between 0% and 100%.

Dimension	Weightings
Water Efficiency	34%
Water-Energy Nexus	33%
Climate Adaptation	33%

Table 3: Weighting of the methodology's dimensions for the global score.

Both the total scores for each dimension, and the global score translate into classes that range from F (least efficient) to A+ (most efficient), according to the distribution presented in Figure 6.

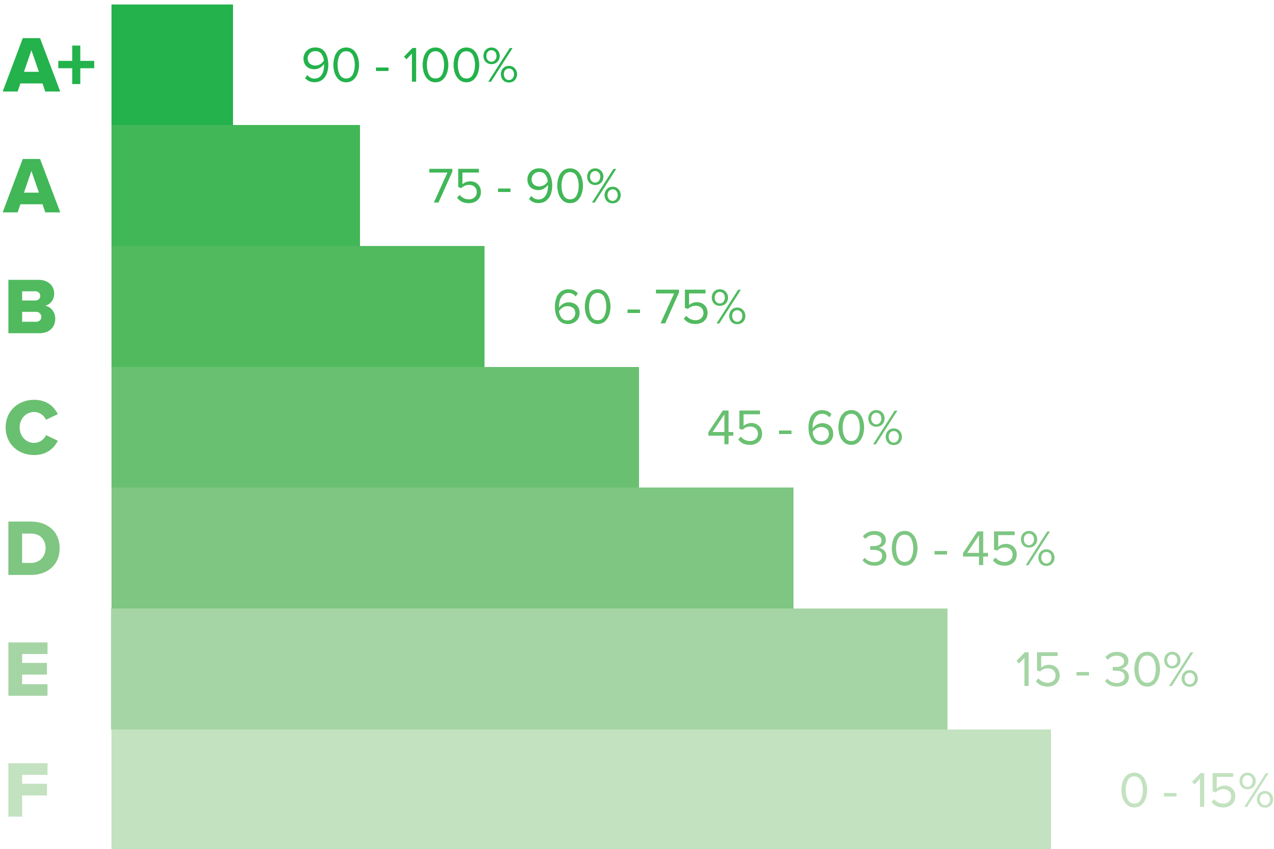


Figure 6: Distribution of the evaluation intervals per class. Adapted from[11].

Each building will then have three partial classifications (one for each dimension) and a global classification.

For a particular building, certain themes/criteria may not be applicable. The maximum score foreseen for those "non-applicable" criteria will be distributed (normalised) in an automatic and proportional way by all the remaining criteria of the same dimension, thus ensuring the comparison of all cases on the same scale from 0% to 100%.
The criteria that may be considered non-applicable and thus be excluded of the evaluation are detailed in Table 4. The remaining criteria are always applicable thus should always be answered.

Theme / Criteria		**Specific Situations where it can be considered "unverifiable"**
W2.1 **N2.1**	Irrigation	No outdoor area of cultivated soil/garden/green roofs/green façades Outdoor cultivated/gardened area without irrigation needs
W2.2, N3.1, N3.2.1, N3.2.2, N3.2.2.3	Swimming Pool	Non-existence of this equipment in project or installed
W3.1 **W5**	Showers	Non-existence of showers in project or installed
W3.4, W3.5, or W3.6	Kitchen taps, Bidet Taps or Service Taps	Non-existence of the specific fixtures in project or installed
W4.1 **N5.1.1**	Dishwashers	It can only be zero scored on non-residential buildings without kitchen nor pantry
W4.2 **N5.1.2**	Laundry Machines	Non-existence of this equipment in project or installed.
N1.1	Pump for water distribution	Non-existence of pumps for water distribution in project or installed
N4.1.3, N6.1, N6.2	Domestic Hot Water Systems & Networks	Non-existence of domestic hot water system nor network in project or installed
N6.2.4	Circulation pump for the DHW network	Non-existence of circulation pumps for the domestic hot water network in project or installed
N6.3	Other energy efficiency equipment	Non-existence of other energy-efficient equipment for water uses (e.g. heat transfers of wastewater, circulation ring, EVVs) in project or installed
C3.1.1, C3.1.2, C3.1.3 or C3.1.4	Climate risk mitigation for coastal flooding, floods, droughts or heat waves	If the household/building is located outside of a coastal flooding, floods, droughts or heat waves risk zone according to the answers in the parameters C2.1, C2.2, C2.3, or C2.4, then the corresponding parameters (C3.1.1, C3.1.2, C3.1.3 or C3.1.4) are automatically zero-scored

Table 4: Themes and criteria that may be considered non-applicable and zero-scored.

Note that the criteria related to the dishwashers are mandatory for residential buildings and for commercial/service buildings where there is a kitchen, pantry, or equivalent, where meals are prepared or served, even if the building is not equipped with such electric appliance. The main reason for this approach is the fact that dishes are still washed (hand-washed) on the household/building itself, which results in higher water consumption than when using the dishwasher.

The evaluation matrix is available on an Excel workbook. For a selected household/building at the current situation and at the situation after the implementation of improvement measures, the data collected to evaluate each criterion should be uploaded, as well as the water and energy consumption data to create a baseline scenario for the current situation.

This Excel file will deliver as a result the total scores (in %) and classifications for each dimension (water efficiency, water-energy nexus and climate adaptation), as well as the global score (in %) and the global classification for the household/buildings for both the current situation and the situation after the implementation of the improvement measures.

The evaluation of each criterion is performed by selecting one or more options in its ranking grid. Depending on the selected option(s), a percentage of the maximum contribution assigned to the criterion will be attributed (or calculated by accumulation) and added to the total score of the dimension for a given household/building. All criteria must have at least one option selected, excluding the non-applicable criteria referred in Table 5.

Note that most criteria have as options “none of the above” or “it was not possible to determine (justify)”, both of which are zero-rated. In these cases, there should be a written justification to why these criteria could not be evaluated with the available options or why they could not be determined on the fields “justification for the current situation”.

There are 4 different types of answers on the evaluation matrix as indicated in Table 5. The type of answer is referred on the matrix on column J, next to each criterion.

Single	Only one of the available options must be selected by putting “1” in the relevant cell. The score for this parameter will be given by multiplying the correspondent maximum contribution by the percentage given to the selected option. For example, if the water network shows evidence of water losses (criterion W1.1.1), one must only select the option “evidence of water losses”.
Multiple	One or more options may be selected, as applicable, by placing “1” in the respective cell(s). In this case, the total is equal to the sum of all the options existing in the validation. For example, if the household/building has alternative water sources from various sources (e.g. use of collected rainwater and reuse of treated greywater) all options must be selected.
%	It is mandatory to specify the percentage of devices, areas, equipment, etc., within the entire household or building that correspond to each option. The total must sum to 100%. For example, if half the garden area is watered with sprinklers, 20% has a drip irrigation system and the rest is watered with a hose, “50%”, “20%” and “30%” must be entered in the corresponding options.
Multiple %	It is mandatory to specify the percentage of fixtures, equipment, etc., within the entire household or building that corresponds to each option. In this case, the total percentage across different options may be higher or lower than 100%. The % calculation must be performed by dividing a quantity (number of devices, area, equipment, etc.) that fits the option under evaluation in the matrix, by the total quantity (number of devices, area, equipment, etc.) that is verified for the entire household/building. It applies to functionalities of fixtures and equipment. For example, if the building has 3 shower systems, all with aerators, 1 with two-position flow faucet and 2 with thermostatic mixer tap, “100%”, “33,3%” and “66,6%” should be placed in the respective options.

Table 5: Type of answers existent on the evaluation matrix. Adapted from CRS’s methodology 11

3.2 Application of the WEN methodology

The WEN methodology follows seven main steps which are presented in Figure 6 and detailed below.

Figure 7: Phases of the application of the WEN Methodology for the Mediterranean basin.

3.3 Building selection

The WEN Methodology for the Mediterranean basin is applicable to residential, small service (including public administration) and small commercial buildings in their different life-cycle phases: design, new construction, operation, and rehabilitation. Both individual dwellings and buildings may be accessed.

Note that the methodology is not adequate to be applied on high energy consumption buildings such as industrial or big commercial buildings.

3.4 Type of data to collect

The data collected to fill in the methodology's Excel file should always be based on documental proofs. These include not only technical documentation or tags, energy labels and/or proofs of purchase of the several fixtures, equipment and systems related with water use existent in the building, but also the buildings' plans and technical projects with information concerning the buildings' water supply and distribution networks (including irrigation and swimming pool networks when existent), and licences/ projects of alternative water sources (e.g. rainwater catchment systems or grey water reuse systems). These data should always be complemented with *in situ* measurements in case of constructed buildings.

The type of data to collect to fill out the evaluation matrix "baseline scenario" worksheet consists in:

1) One-year monthly data of water consumption (m^3) and energy consumption (kWh) of the building, if possible, separated by the different water uses:

- For example, water consumption related to outdoor uses, to irrigation, etc.;
- For example, energy consumption of the domestic hot water systems, of the circulation pumps, etc.;
- If there are no water and/or energy consumption data per type of use, at least provide the total monthly values for the whole building.

2) Characterisation of all existent equipment related to the use of water (elevation and circulation pumps, taps and showers, hot water production systems, irrigation system, dishwashers, monitoring systems, etc). Collect existent technical documentation, energy label, characteristics tag or proof of purchase. Note that it is usual that not all equipment data is available.

The data referred to in points 1 and 2 above should be uploaded to the worksheet "baseline scenario".

Concerning the Climate Adaptation dimension, documental research for the existence of local and/ or regional adaptation plans (or equivalent), that encompass climate hazards that may affect water supply and distribution on the building's area, namely heat waves, coastal and pluvial floods, and droughts, is required. Direct contact with local or regional authorities, local water supply utilities and meteorological/geophysical institutes may be necessary. Data concerning climate hazards and risks is also available at international and global scale (e.g. [12], but local and regional data sources should be privileged.

Note that it is still possible to apply the methodology even if not all the information on fixtures, equipment and systems' models, energy efficiency, etc, is available.

3.5 In situ technical visit

In case of a constructed building, an *in situ* technical visit should always be performed. This visit should include, at least:

- Measurements of water flow in taps and showers;
- Measurement of the volume of water wasted at the fixture located at the farthest point from the hot water production system until the temperature reaches 37ºC (criterion N6.2.1);
- Measurements of static pressure and head loss (theme N4.1);
- Verification and photographic documentation of water use fixtures, equipment and systems, including of technical tags or energy labels to complement the documental proofs previously collected;
- Verification and photographic documentation of potential water losses (e.g. dripping or rusted pipes) and/or water-related equipment mal-functioning.
- For these ends, it is recommended the use of the following equipment (see Figure 13):
- Photographic camera or mobile phone to take pictures;
- Flow meter or standard volume and chronograph/ mobile phone for water flow measurements;
- Waterproof thermometer and chronographer/mobile phone (criterion N6.2.1 measurement);
- Pressure meter up to 6 Bar, analogic or digital, (theme N4.1 measurements);
- Metric tape.

Note that it may not be possible to perform all above measurements, but it will be still possible to apply the methodology.

Figure 8: Suggested instruments to use at the *in situ* technical visits.

Within the scope of this methodology, it is recommended that all measurements are performed in a non-intrusive manner, not damaging any fixtures or equipment, and that the water spent to perform the measurements is, whenever possible, collected and reused.

3.6 Upload the data on the WEN methodology Excel Workbook for the current situation

After the collection of the documental proofs and of the *in situ* data, the Excel file should be filled out for the building's current situation. Firstly, all data concerning water and energy consumption, and technical data of the fixtures and water-related equipment/systems should be introduced into the "baseline scenario" worksheet.
Secondly, columns J and AB of the three checklists' worksheets should be completed, respectively, with the answers to the different criterion according to the type of answer required, and with notes concerning the justification for the corresponding answer.

Note that in the "Checklist Water Efficiency" and "Checklist Water-Energy Nexus", in case any area, theme or criteria is non-applicable, it should be zero-scored in the matrix. The way to do this is to introduce a zero on column B of the checklists, next to the corresponding area/theme/criterion. In these cases, it is not necessary to fill in the corresponding column J. Only the areas, themes or criteria that may be zero-scored, have the green box on column B. An example is presented in Figure 9.

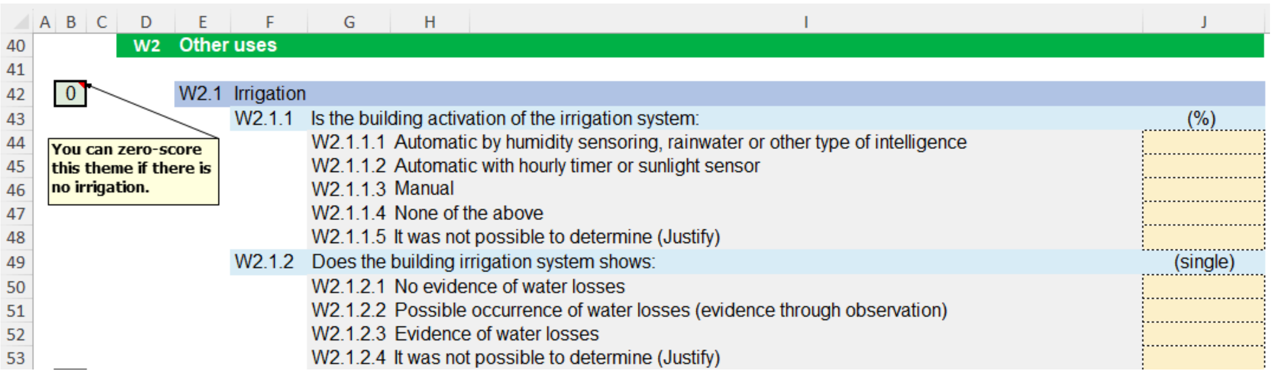


Figure 9: Zero-score of the theme "W2.1 Irrigation" on the Water Efficiency checklist.

Please make sure that in case these criteria, themes or areas are applicable, there is a "1" on the corresponding box in column B.

As the checklist is filled, partial scores and classifications for each dimension are automatically updated on a Figure on top of each worksheet (see Figure 10).

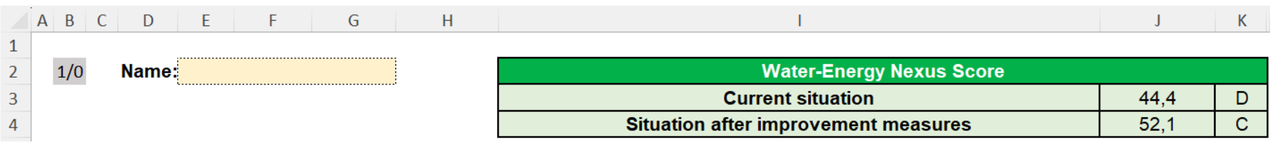


Figure 10: Zero-score of the theme "W2.1 Irrigation" on the Water Efficiency checklist.

3.7 Selection of the improvement measures

After filling the Excel file with the current situation, a maximum of two to three infrastructural improvement measures per dimension should be identified. The selection should be adjusted to the buildings' reality and context (e.g. available funds and interventions already predicted). A wide selection of improvement measures, both infrastructural and behavioural are presented in section 4. Once these measures are selected columns X and AD, for all three checklists, should be filled with the answers to the different criterion according to the type of answer required, including now the improvement measures proposed, and with notes concerning the observations about these measures.

The worksheet "summary of results" presents the comparison of the partial and global scores and classifications for the current situation and for the situation after the implementation of the improvement measures. The predicted increase in global and partial scores in % is also automatically calculated in line 7 (see Figure 11).

Summary of Results

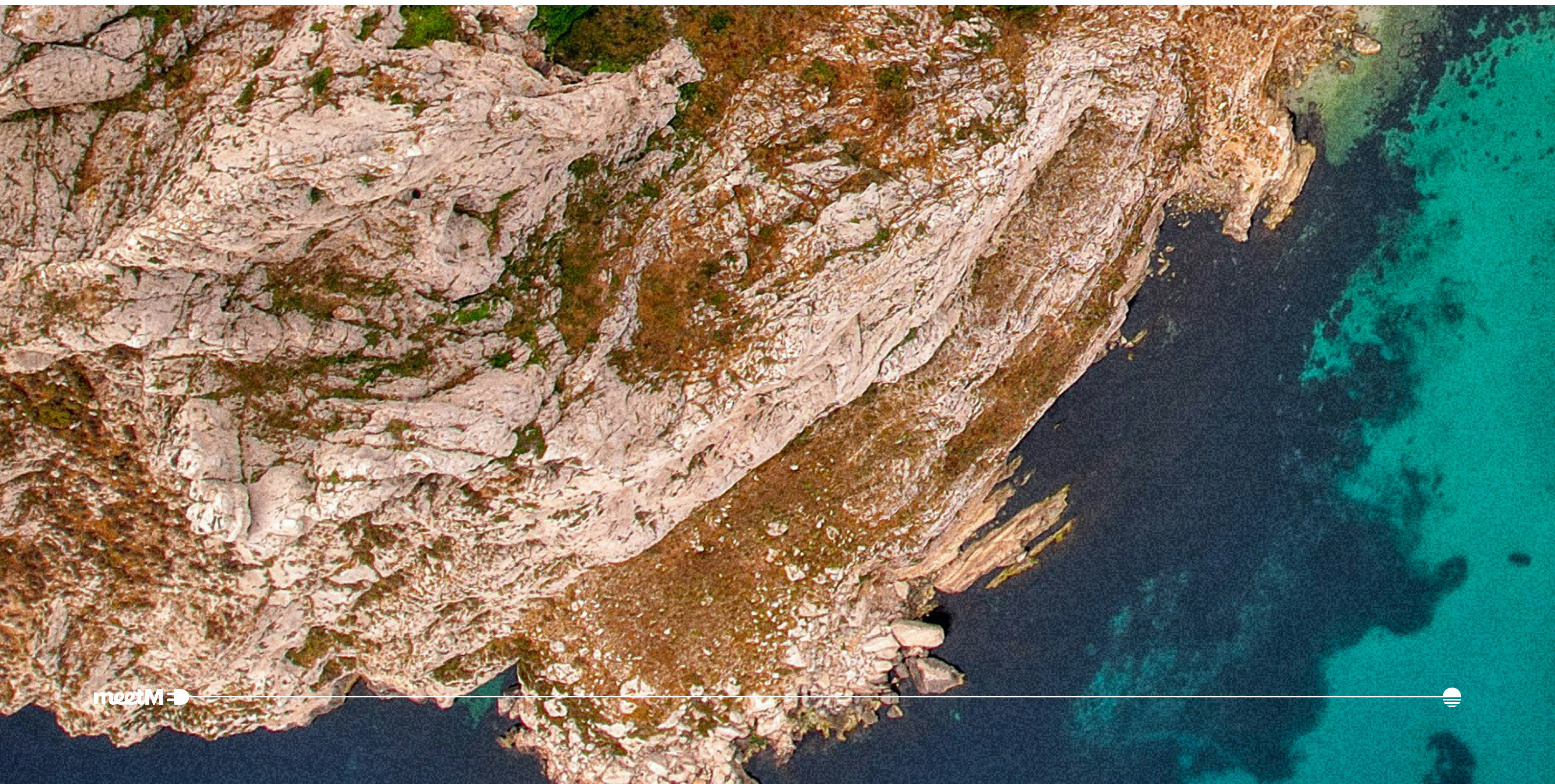
	Score (%)			
	Water Efficiency Score	Water-Energy Nexus Score	Climate Adaptation Score	Global Score
Current Situation	28,8	44,4	69,5	47,3
After Improvement Measures	59,8	52,1	69,5	60,4
Increase in score	31,0	7,7	0,0	13,1

	Score (hydric class)			
	Water Efficiency Score	Water-Energy Nexus Score	Climate Adaptation Score	Global Score
Current Situation	F	E	F	C
After Improvement Measures	B	C	B	B

Checklist Water-Energy Nexus | Checklist Climate Adaptation | Summary of Results

Figure 11: Example of a "Summary of Results" Figures for a case study.

The higher the difference between the scores in the current situation and in the situation after the implementation of the improvement measures, the higher the increase of the building's efficiency regarding each dimension. To determine which is the set of measures that leads to a higher increase of efficiency of the building its advisable to evaluate different sets of improvement measures.



3.8. Definition of the monitoring plan and strategy

After the definition of the set of improvement measures to implement in the building, it should be defined, for each solution, the monitoring strategy for its implementation, the KPIs to evaluate and the estimated benefits (including the economic ones). For the KPIs, the estimated reduction in absolute value or percentage of water and/or energy consumption/costs in relation to the baseline should be indicated. Table 6 presents examples of monitoring strategies, KPIs and expected benefits for the most common improvement measures.

Note that these should be adjusted to each specific situation and improvement measure.

	Examples
Monitoring Strategies	• Regular monitoring of energy and water consumptions • Regular monitoring of water pressure and water flow • Monthly tracking of energy and water bills • Regular maintenance checks to ensure optimal performance of equipment/systems • Conduction of user satisfaction surveys • Etc.
KPIs	• Reduction in electricity consumption (kWh/month) • Reduction in electricity bills (% cost savings/month) • Reduction in water consumption (m^3/month) • Reduction in water bills (% cost savings/month) • Reduction in carbon emissions (kg CO_2/month) • User's comfort improvement • Increase in garden's health and productivity • Etc.
Benefits	• Reduction in electricity consumption and correspondent costs savings • Reduction in water consumption and correspondent costs savings • Reduction in CO_2 eq. emissions • Less reliance on public water networks/ best water fit-for-purpose balance • Less reliance on public energy networks • Improvement in water pressure and flow rates • User's comfort improvement • Increase in garden's health and productivity • Reduction of vulnerability to floods/droughts/heat waves • Etc.

Table 6: Examples of monitoring strategies, monitoring indicators and benefits for most common improvement measures.

Note that it may be necessary to acquire specific measurement instruments to monitor energy, water consumption, flow rate and water pressure.

3.9. Implementation results

A minimum of three months of regular monitoring is recommended to evaluate the results of the implemented improvement measures. Baseline water and energy consumptions that were registered for the current situation should be compared with the values obtained during the monitoring period. Previously estimated reductions in water and energy consumptions and bills, either in absolute values or in percentage, and in other defined KPIs, should be calculated to confirm the efficacy and effectiveness of the implemented measures.

The goal of assessing the water-energy nexus performance of a building is to establish a baseline and identify measures that can support the overall improvement of the building in the different dimensions. In a broad perspective these measures can be classified as infrastructural, equipment related or behavioural. Section 4.1 details the most relevant and cost-effective infrastructural/equipment-related improvement measures on the scope of water efficiency, water-energy nexus efficiency and climate response for residential and commercial/small service buildings. If there are differences between the recommended measures regarding their application in residential or in commercial/small service buildings, that is referred below. Section 4.2 details the most relevant and effective behavioural measures that can be adopted by adults and by children.

4

Most common WEN improvement measures

4. Most common WEN improvement measures

The goal of assessing the water-energy nexus performance of a building is to establish a baseline and identify measures that can support the overall improvement of the building in the different dimensions. In a broad perspective these measures can be classified as infrastructural, equipment related or behavioural. Section 4.1 details the most relevant and cost-effective infrastructural/equipment-related improvement measures on the scope of water efficiency, water-energy nexus efficiency and climate response for residential and commercial/small service buildings. If there are differences between the recommended measures regarding their application in residential or in commercial/small service buildings, that is referred below. Section 4.2 details the most relevant and effective behavioural measures that can be adopted by adults and by children.

4.1 Infrastructural measures

4.1.1 Water efficiency dimension

Installation of local and decentralized licensed rainwater harvesting systems and/or greywater reuse systems

Rainwater harvesting systems are systems that collect, store, filter, distribute and allow for the use of rainwater for non-drinking purposes. They are typically composed by 1) a catchment area to collect rainwater (e.g. rooftop), 2) conveyance system composed by gutters and downspouts, to direct the harvested rainwater to the storage tanks (usually by the action of gravity), 3) pre-storage filtration, 4) storage in tanks, 5) filtration, 6) distribution on dedicated pipe systems for use. It includes, when needed, water pump systems and respective energy sources for the filtration/distribution of the water. Greywater reuse systems are systems that collect, treat, distribute, and allow for the reuse of untreated domestic wastewater that did not contact with "black water", for non-drinking purposes. It is usually composed by wastewater from toilet sinks, showers and washing machines.

A greywater system is typically composed of equipment that allow for the following stages: 1) coarse filtration to eliminate suspended solids, 2) collection of the untreated grey water in a tank, 3) treatment and disinfection, 4) storage in suitable tanks, 5) referral on dedicated pipe systems for reuse. It includes, when needed, water pump systems and respective energy sources for the treatment/distribution of the water.

Water from rainwater harvesting a greywater reuse is only suitable for non-potable uses such as toilet flushing, laundry machines, irrigation, cleaning of garages and outdoor spaces, cooling towers, firefighting, and water fountains or similar. Water distribution networks/equipment should be independent from potable water networks/equipment to avoid cross-contamination. The systems design and sizing, installation, operation, and maintenance should follow local legislation/regulations.

✅ Themes/Criteria it improves

W1.2 – Alternative water sources
C3.3- Water fit for purpose

Installation of efficient and automated irrigation systems

An irrigation system is composed by pipes, valves and junctions that direct water from the water supply networks to the irrigation emitters (drippers, sprinklers, etc), and protection components (pressure regulators, filters, etc). It may also include an activation system programmed to activate and regulate irrigation, as well as sensors that feed it with on-site information.

Every time the outdoor space characteristics (size of the plot, location, sunlight and wind exposure, type of soil, etc), the water and energy supply characteristics (water and energy meters' capacity, etc), and the plant's characteristics (type of plants and water needs, dense or sparce plantation, etc) justify the implementation of an irrigation system, water-efficient irrigation systems such as dripping or micro-sprinkler systems should be privileged to the detriment of macro-sprinklers and sprayers systems.

An outdoor area can be divided into sections according to the characteristics mentioned above and the irrigation devices that will be installed. One area may have different sections with diverse types of irrigation devices/emitters. Each section should have a separate valve to control the water supply to facilitate the system's maintenance.
The design of irrigation systems should be made by experts, follow local regulations and standards and be adequate to the outdoor space characteristics. Design includes determining the type of materials, components, and irrigation devices to use, the spacing between them, flowrates, and activation details.

Drip irrigation is a low-flow watering method using tubes that run on or underneath the soil. The water is released close to the roots of the plant. Direct delivery and the slow application rate prevent over spraying and runoff, making it the most water-efficient irrigation method. For the same irrigated area, a dripping irrigation system spends one litre of water per hour, while a macro-sprinkler 300L/hour.
Prioritize, as well, in detriment of manual activation systems, automatic activation systems coupled with soil moisture or rainwater sensors. These provide adequate irrigation to the soils and plants real water needs and reduce water losses per evaporation. As a second option, choose an activation irrigation system with an hourly timer or a system coupled to a sunlight sensor.

✅Themes/Criteria it improves

W2.1 – Irrigation

Introduce in gardens mulch, native plants and/or plants with low water needs

Privilege gardens with native plants or plants with lower water needs that may reduce/cancel irrigation needs. Privilege the use of mulch in gardens. Mulch is a protective covering of the soil composed of sawdust, compost, or paper, which is spread on the ground to reduce evaporation, maintain soil temperature and prevent erosion, amongst other benefits. Plants with high water requirements, such as turf and lawns, should be avoided.

✅ Themes/Criteria it improves

W2.1 – Irrigation
C3.2.1 – Planted areas

Swimming pool treatment systems

Privilege biological swimming pools or classical pools with automatic water treatment systems. Biological pools use aquatic plants and micro-organisms instead of filters and chemical products to treat the water. Usually, in biological pools no introduction of fresh water is necessary to restore water levels.

Automatic water treatment and filtration systems in classical pools, instead of manual systems, minimise needs to introduce water to restore the pool's water levels.

✅ Themes/Criteria it improves

W2.2- Swimming pools

Installation of pool covers

The installation of pool covers when the pool is not in use, reduces water losses per natural evaporation. For example, the use of a cover on a ten-by-five exterior swimming pool may reduce losses of water per evaporation by 1.500 litres per week.

✅ Themes/Criteria it improves

W2.2- Swimming pools

Gutter with compensation tank

Pools with gutters with compensation tanks facilitate the water circulation and filtration, as well as minimise water losses due to the movement of bathers, thus reducing the need to introduce more water to maintain the swimming pool's water levels.

✅ Themes/Criteria it improves

Introduction of flow restrictors with aerators on showers

Introduce flow restrictors in showerheads that limit the water flow to maximum 7L/min.

Flow restrictors (flow regulators or flow controllers) are simple and cheap devices that can easily be installed inside a showerhead, reducing and regulating the water flow.

They allow water to run at a constant rate and allow showers to run optimally, preventing damage caused by excess flow. A flow of 7L/min for showering is a value that allows water savings while it guarantees the user's comfort.

✅ Themes/Criteria it improves

W3.1- Showers

Replace old and broken showers

Replace old (> 5 years old) and broken showers by new ones with flow restrictors that limit the water flow to maximum 7L/min. Privilege showers with the following functionalities:

- For residential buildings choose thermostatic showers or showers with the eco-stop function. Thermostatic showers are a type of mixer showers that feature a thermostatic valve which maintains a pre-set constant water temperature (previously defined by the user), by automatically and immediately adjusting cold and hot water supply quantities. They limit the unnecessary use of water by remaining shut while the hot water does not arrive in the beginning of the shower, and by shutting down during the shower if hot or cold supply fails. By limiting the unnecessary production of hot water, they also save energy. Furthermore, they prevent scalding and chilling showers, maintaining user's comfort. Eco-stop showers are showers with a stop button on the showerhead that allows the user to turn off the water when not in use. The water in the shower will stay at the same temperature, meaning that it is not necessary to wait for it to heat up again when turning the button back on, saving both water and energy;
- For commercial/public buildings choose timed flow shower systems or shower systems with fixed flow positions. Timed flow shower systems are showers designed to switch off after a set running time to prevent water waste and deter misuse. They are activated by a push button. By pushing it, the water flows for a set of time, while the button works its way back to the original position. Shower systems with fixed flow positions are the ones with pre-defined positions where water flows at constant and pre-defined flow values. Shower systems with fixed positions or timed flow systems are ideal to prevent water waste in public and high-traffic facilities.
- A flow of 7L/min for showering is a value that allows water savings while it guarantees the user's comfort.

✅ Themes/Criteria it improves

W3.1- Showers

Regulate maximum discharge volumes

Regulate toilet flushers maximum discharge volumes to 3L and 6L of external cistern toilets by installing water displacement devices (“save-a-flush” bags) in the cistern. These cut the amount of water used for each flush.

✅ Themes/Criteria it improves

W3.2- Toilet flushers

Replace simple toilet flushing mechanisms by double discharge systems

Introduce double discharge toilet flushing mechanisms with maximum discharge volumes of 3L and 6L. For example, replacing all single flushing toilets per double discharge ones on a residential building, may save up to 63.000L/year for a family of 4 (value for Portugal, after AQUA+).

✅ Themes/Criteria it improves

W3.2- Toilet flushers

Uninstall bidets if unused

Consider uninstalling bidets if unused, especially on commercial/public buildings.

This aims to reduce water endpoints, therefore reducing the risk of water losses.

✅ Themes/Criteria it improves

W1.1.1- Water losses
W3.5- Bidet taps

Replace old dishwashers and laundry machines by more water and energy efficient ones

The water specific consumption of the dishwasher, according with the European labelling rules should be 0,60 litres per cycle and serving or below. The water specific consumption of the laundry machine according to the European labelling rules should be 4,5 litres per cycle and kg or below.

As reference, both appliances should be less than 8 years old (proxy efficiency) due to the lack of standardised labelling in the south Mediterranean countries.

✅ Themes/Criteria it improves

W4.1 - Dishwasher
W4.2- Laundry machine
N5.1- Appliances

Introduce flow restrictors with aerators on taps

Introduce on the various types of taps flow restrictors that limit water flow to maximum:
- 4L/min for sink and bidet taps;
- 6L/min for kitchen or service taps.

Flow restrictors (flow regulators or flow controllers) are simple and cheap devices that can be easily installed inside a fixture, reducing and regulating the water flow. They allow water to run at a constant rate and allow fixtures to run optimally, preventing damage caused by excess flow.

The flow values indicated above, are the values that allow water savings while guaranteeing user's comfort for each type of tap/use.

✅ Themes/Criteria it improves

W3.3- Sink taps
W3.4- Kitchen taps
W3.5- Bidet taps
W3.6- Service taps

Replace old and broken taps

Introduce on the various types of taps flow restrictors that limit water flow to maximum:
- 4L/min for sink and bidet taps;
- 6L/min for kitchen or service taps.

Flow restrictors (flow regulators or flow controllers) are simple and cheap devices that can be easily installed inside a fixture, reducing and regulating the water flow. They allow water to run at a constant rate and allow fixtures to run optimally, preventing damage caused by excess flow.

The flow values indicated above, are the values that allow water savings while guaranteeing user's comfort for each type of tap/use.

Replace old (> 5 years old) and broken taps by new ones with flow restrictors that limit the water flow to maximum:
- 4L/min for sink and bidet taps;
- 6L/min for kitchen or service taps.
- Privilege taps with the following functionalities:
- For residential buildings choose thermostatic sink, bidet, and kitchen taps. Thermostatic taps are a type of mixer taps that feature a thermostatic valve which maintains a pre-set constant water temperature (previously defined by the user), by automatically and immediately adjusting cold and hot water supply quantities. They limit the unnecessary use of water by remaining shut while the hot water does not arrive in the beginning of use, and by shutting down during the shower if hot or cold supply fails. By limiting the unnecessary production of hot water, they also save energy. Furthermore, they prevent scalding and chilling, maintaining user's comfort. Eco-stop taps are taps with a stop button that allows the user to turn off the water when not using it. The water will stay at the same temperature, meaning that it is not necessary to wait for it to heat up again when turning the button back on, saving both water and energy;

- For commercial/public buildings choose sink, kitchen and service taps with fixed flow positions or timed taps. Timed flow taps are taps designed to switch off after a set running time to prevent water waste and deter misuse. They are activated by a push button or, in case of sink taps, by a motion sensor. By pushing button or by activating the sensor, the water flows for a set of time. Taps with fixed flow positions are the ones with fixed positions where water flows at constant at pre-defined flow values. Systems with fixed positions or timed flow systems are ideal to prevent water waste in public and high-traffic facilities.

Flow restrictors (flow regulators or flow controllers) are simple and cheap devices that can easily be installed inside a fixture, reducing and regulating the water flow. They allow water to run at a constant rate and allow fixtures to run optimally, preventing damage caused by excess flow. The flow values indicated above, are the values that allow water savings while guaranteeing user's comfort for each type of tap/use.

✅ Themes/Criteria it improves

W3.3- Sink taps
W3.4- Kitchen taps
W3.5- Bidet taps
W3.6- Service taps

Installation of systems for monitoring water consumption

Metering or monitoring systems that collect frequent or real-time water consumption information (flow and volume) are important to help users address their water uses more efficiently, and to detect abnormal high consumptions that may indicate water leakages. In that sense, on the scope of the methodology, monitoring systems that allow, at least, the daily water consumption registry with history logger are valued.

Systems with the possibility of cutting off remotely the supply and/or of alarming the occurrence of leaks when detecting abnormal high consumption are also privileged.

Furthermore, intelligent systems that centralise output signals from water measuring devices on home/building automation systems are recommended. The configuration/installation of these systems should be made by experts and follow local regulations and standards.

✅ Themes/Criteria it improves

W1.1- Water network losses
W5.1- Water monitoring

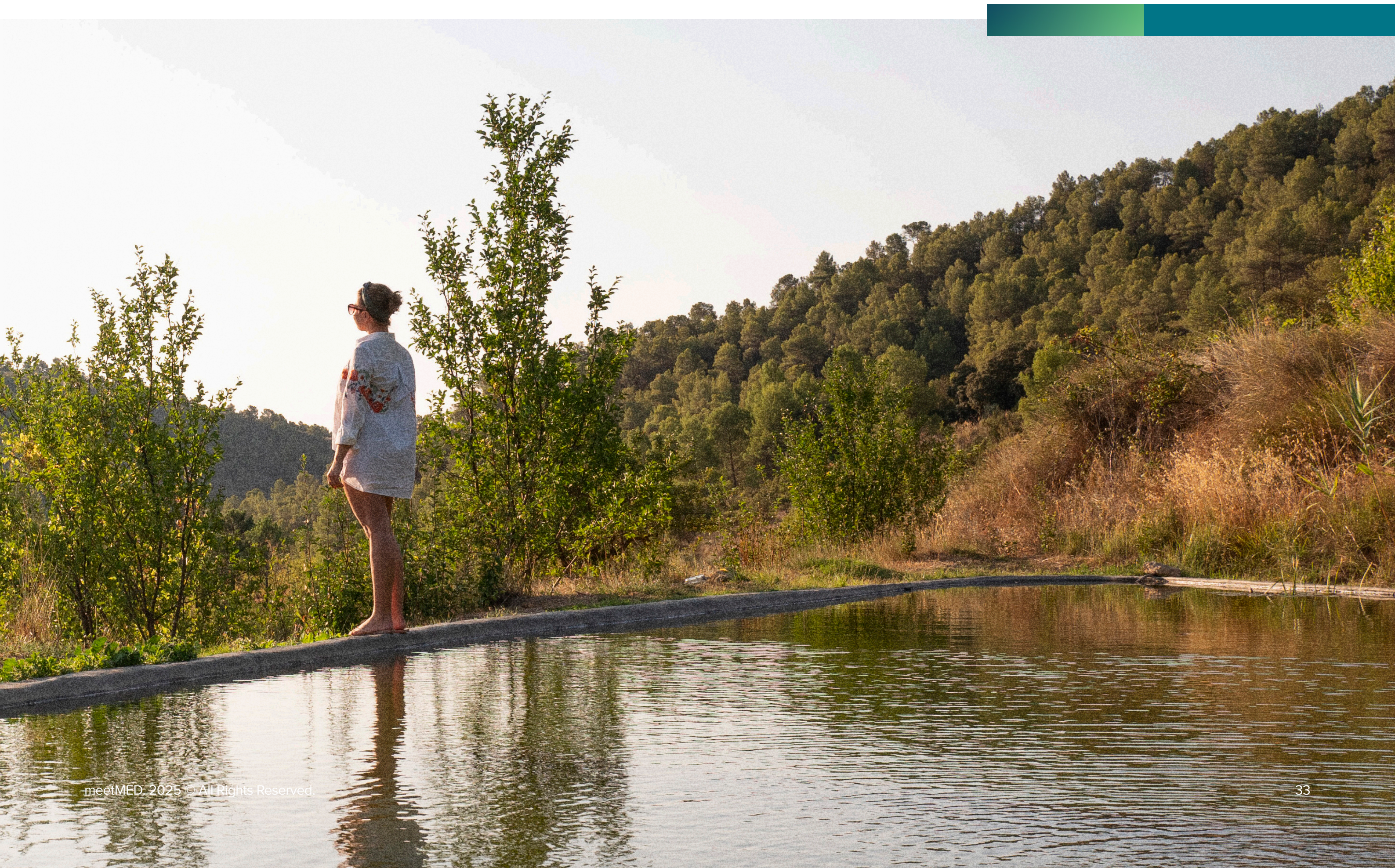
Installation of water monitoring equipment or flowmeter per type of use

It is advised the installation of flowmeters or other water monitoring equipment that allow minimal discrimination of water consumption per type of use. This discrimination should include, at least and when existent, outside uses, irrigation, swimming pools and alternative water sources/non-poFigure water. Alternatively, it is recommended the installation of leakage detectors with remote supply interruption and alarm for the occurrence of leaks.

These strategies are used to facilitate the detection of water losses. The configuration/installation of these systems should be made by experts and follow local regulations and standards.

✅ Themes/Criteria it improves

W1.1- Water network losses
W2.1- Irrigation
W2.2- Swimming pool
W5.1- Water monitoring



4.1.2 Water-Energy Nexus dimension

Privilege water distribution by gravity for end-uses

Privilege passive systems that use exclusively the action of the gravitational potential energy to the supply and distribution of water. On this scope, place water storage tanks above ground and in high places whenever possible.

For example, privilege placing in high places storage tanks of rainwater harvesting and greywater reuse systems. In this way, less energy is spent to distribute the water for the different end-uses (irrigation, cleaning of outside spaces, use in toilette flushers or laundry machines, etc).

✅ Themes/Criteria it improves

N1.2- Renewable energy (or gravity) for end uses

Privilege the use of renewable energy sources for end-uses

Privilege active systems that use *in situ* renewable energy sources for the supply and distribution of water, to the detriment of using energy from the public electric networks or from non-renewable sources such as diesel or natural gas.

On this scope, privilege local *in situ* production of renewable energies, such as solar photovoltaic, for the supply and distribution of water from rainwater harvesting and greywater reuse systems to different end-uses (irrigation, cleaning of outside spaces, use in toilette flushers or laundry machines, etc).

✅ Themes/Criteria it improves

N1.2- Renewable energy (or gravity) for end uses

Install efficient water elevation/circulation pumps for adequate and stable pressure/head loss values on the water network

Privilege installing pumps with the efficiency class IE5 according to the International Energy Efficiency Classes (IE) for electric motors defined in the European Union Regulation on electric motors and variable speed drives (EU) 2019/1781. Consider the local recommended water pressure values for residential and commercial/small service buildings.

The configuration/installation of these systems should be made by experts and follow local regulations and standards. Consider replacing pumps older than 8 years old and/or with European efficiency class lower than IE4.

✅ Themes/Criteria it improves

N4.1- Pressure/head loss

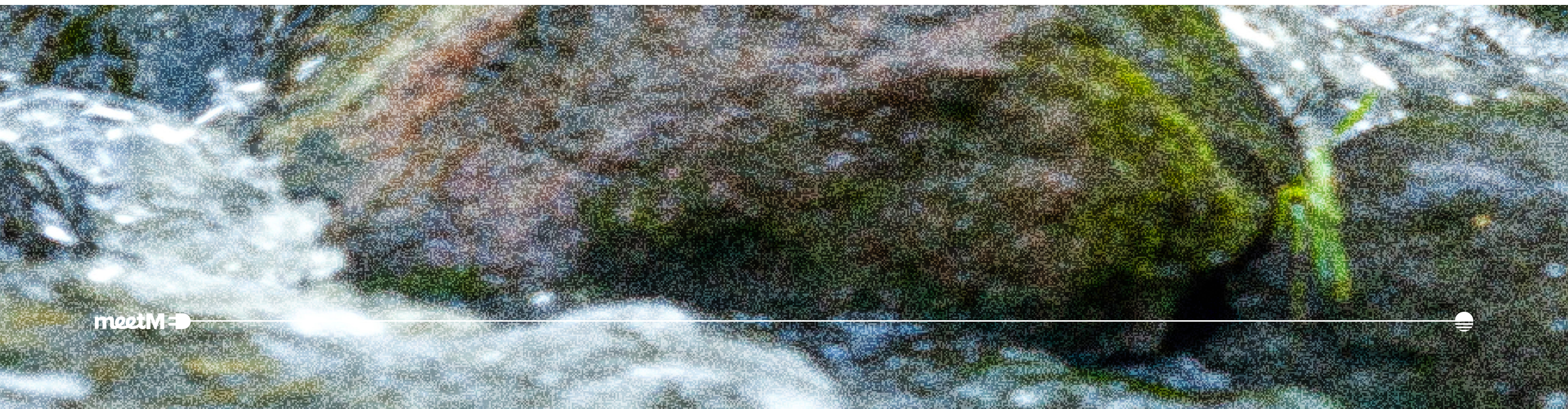
Replace old dishwashers and laundry machines by more water and energy efficient ones

The water specific consumption of the dishwasher, according with the European labelling rules should be 0,60 litres per cycle and serving or below. The water specific consumption of the laundry machine according to the European labelling rules should be 4,5 litres per cycle and kg or below.

Both appliances should be less than 5 years old (proxy efficiency) due to the lack of standardised labelling in the south Mediterranean countries.

✅ Themes/Criteria it improves

W4.1 - Dishwasher
W4.2- Laundry machine
N5.1- Appliances



The DHW network should have adequate thermal insulation in all its extension

Proper insulation around pipes limits losses by heat transfer and provide a vapor barrier against moisture, which improves the thermal efficiency of the DHW system. The average pipe diameter/insulation thickness ratio should be less than 1,8.

This measure is solely recommended when major rehabilitation occur in the building due to cost effectiveness.

✅ Themes/Criteria it improves

N6.1- Pipe insulation

Installation of other energy efficiency equipment

It is advised the installation equipment such as local hot water recirculation and return systems with automatic activation (including return monobloc systems), water heat recovery equipment (e.g. column systems, or under shower/bathtub systems), or similar. The use of these equipment reduce needs to spend more energy to heat water. For example, the installation of a hot water recirculation and return system for a family of 4 may lead to annual water savings of 34 thousand litres (value for Portugal, after AQUA+).

✅ Themes/Criteria it improves

N6.1- Pipe insulation

Installation of adequate and efficient DHW production systems

Privilege efficient DHW systems with thermostatic modulation, or at least pressure and temperature regulation. Choose DHW production systems adjusted to the household/building's real needs, avoiding unnecessary energy wasting. These systems should be less than 5 years old (proxy efficiency). Privilege renewable energy systems, such as solar thermal, biomass boilers or others.

✅ Themes/Criteria it improves

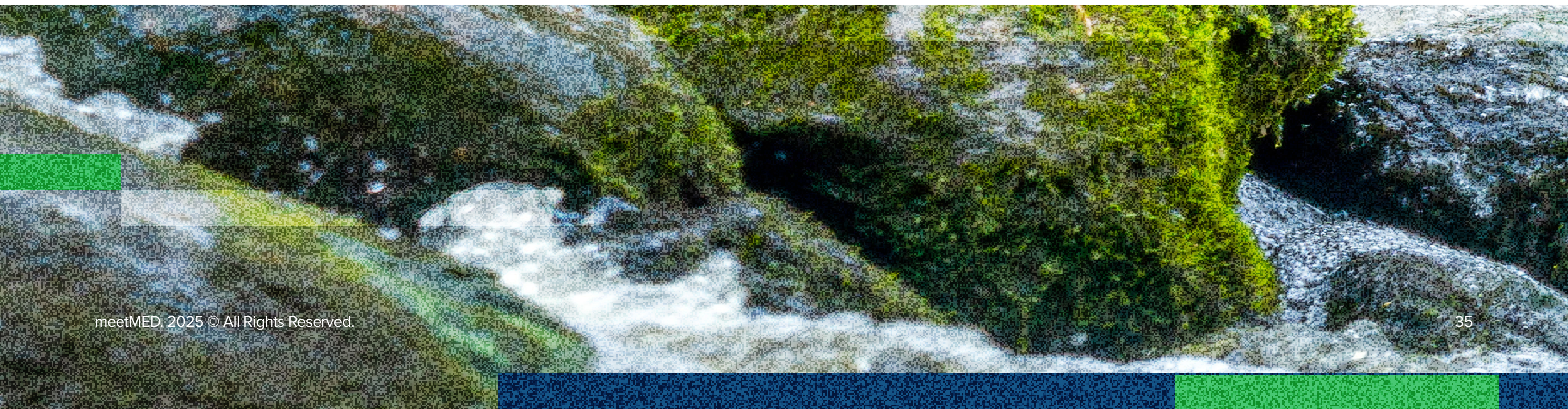
N6.2- DHW production system

Installation of energy efficient pumps

Measure valid for elevation, circulation, irrigation, abstraction, and distribution of alternative water sources pumps, as well as for water treatment, filtration, heating, and recirculation systems in swimming pools. Privilege pumps with the European efficiency class IE5. Consider replacing pumps older than 8 old and/or with European efficiency class lower than IE4.

✅ Themes/Criteria it improves

N1.1- Water distribution
N2.1- Irrigation
N3.1- Swimming pool
N3.2.1- Water heating



Installation of intelligent systems for monitoring energy consumption

Energy metering or monitoring systems that collect frequent or real-time energy consumption data are important to help users address their energy uses more efficiently, and to detect abnormal high consumptions. In that sense, on the scope of the methodology, systems that allow, at least, the daily energy consumption registry with history logger are valued.

Furthermore, intelligent systems that centralise output signals from energy measuring devices on home/building automation systems are recommended.

The configuration/installation of these systems should be made by experts and follow local regulations and standards.

✅ Themes/Criteria it improves

N7.1- Energy monitoring systems

Installation of systems for monitoring energy consumption per water use

It is advised the installation of energy monitoring equipment that allows minimal discrimination of energy consumption per type of water use. This discrimination should include, at least and when existent: outside uses, irrigation, swimming pools and alternative water sources/non-potable water.

These strategies are used to facilitate the detection of abnormal energy consumptions related to water uses and help users address their energy and water uses more efficiently.

The configuration/installation of these systems should be made by experts and follow local regulations and standards.

✅ Themes/Criteria it improves

N7.1- Energy monitoring systems

Note that, whenever hot water is being used, by saving water, the energy that was used to heat it is also being avoided. So, in this case, by using water efficient fixtures such as showers, sink, bidet and kitchen taps, fixtures with aerators and with the functionalities referred on section 4.1.1, both water and energy will be saved, within the scope of the water-energy nexus.

4.1.3 Climate adaptation dimension

Introduce in outside gardens blue infrastructure such as rain gardens

Create blue infrastructure such as rain gardens. Rain gardens are man-made depressed areas in the landscape that collect rainwater and allow it to soak into the ground. They are usually planted with grasses and flowering perennials. They reduce water irrigation needs thus helping to mitigate droughts, and help to reduce runoff, therefore helping to mitigate floods.

✅ Themes/Criteria it improves

C3.1- Climate risks mitigation
C3.2.1- Planted areas

Increase permeable areas or place permeable flooring

By increasing the outside permeable area, water soil infiltration increases, and runoff water reduces, thus mitigating floods and droughts.

✅ Themes/Criteria it improves

C3.1- Climate risks mitigation

Install green roofs or green façades

Green infrastructure such as green roofs or green façades infiltrate rainwater and help mitigating floods, by reducing and delaying stormwater's flow peaks. These infrastructures also regulate buildings' internal space temperature, thus increasing user's comfort and reducing the energy needed to cool the building, contributing also to mitigate heat waves and droughts.

✅ Themes/Criteria it improves

C3.1- Climate risks mitigation

4.2 Behavioural measures

Inspect and detect water leaks and make a general maintenance plan of the water networks, fixtures, and equipment

Make regular inspections on the water distribution networks, irrigation, alternative water sources and DHW systems, swimming pools, water use equipment and fixtures to detect leaks. Report the existence of leaks. This can save water, and the energy used to heat it.

A dripping toilet flusher may spend up to 600 litres of water per day. A tap that drips 10 drops per minute may spend up to 3.000 litres per year.

✅ Dimensions it improves

Water Efficiency   Water-Energy Nexus

Perform regular maintenance on fixtures, appliances, water use systems and equipment

Perform regular maintenance on water use fixtures, appliances, water use systems and equipment, as well as in pumps used for water supply, heating, circulation, etc, to prevent/detect leaks and guarantee effective and efficient functioning. Always follow manufacturer's maintenance recommendations.

✅ Dimensions it improves

Water Efficiency   Water-Energy Nexus

Close the taps when not in use

For example, when brushing teeth or washing hands. One person can save up to 8.760 litres per year by closing the tap for 3 minutes, twice a day, while brushing the teeth (assuming the use of an efficient sink tap with flow of 4L/min).

✅ Dimensions it improves

W3- Fixtures

Take a 5-minute shower instead of a bath

Taking a 5-minutes shower with an efficient shower of 7L/min uses around 35 litres of water. Taking a bath in a bathtub can use up to 80L. While showering, close the tap when shampooing.

✅ Dimensions it improves

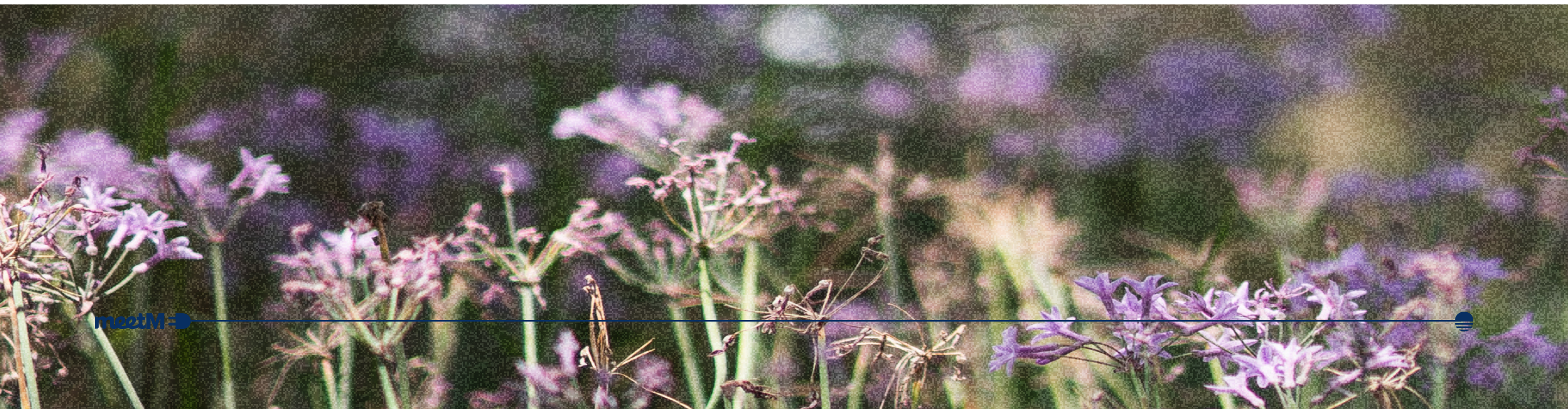
W3.1- Showers

Adjust hourly timer irrigation systems

When using an hourly timer irrigation activation system, always set the watering time to nighttime, early morning, or late afternoon to reduce losses per evaporation. Adjust, as well, the timer according to the season of the year. Consider deactivating the timer during rainy months.

✅ Dimensions it improves

N2.1- Irrigation



Store the water that runs in the shower while waiting for the hot water to arrive

Store in a bucket the water that runs in the shower while waiting for the hot water and then use it to water plants or for cleaning purposes, for example. Waiting two minutes for hot water, means storing around fourteen litres of water per shower (considering an efficient shower with a flow of 7L/min).

Considering one shower per day, in one year the savings are up to around 7.500 litres of water.

✅ Dimensions it improves

W3.1- Showers

Use a dishwasher instead of washing the dishes by hand

An efficient dishwasher uses around 7,8L per cycle (for a dishwasher with water specific consumption of 0,6/cycle/serving and serving 13) versus 60L for handwashing (using an efficient kitchen tap of flow 6L/min for 10 minutes).

✅ Dimensions it improves

W4.1- Dishwasher N5.1- Dishwasher

Always use the dishwasher and laundry machine with full load

Opting for using the dishwasher and laundry machine with full load allows saving both water and energy. The machines spend the same amount of water and energy independently if they are used empty or with full load.

✅ Dimensions it improves

W4.1- Dishwasher N5.1- Dishwasher

Use ECO programmes in the dishwasher and laundry machines when existent

Using ECO programmes saves both water and energy. ECO programmes may take longer but are programmed to spend less water and energy per cycle. Furthermore, using lower temperature programmes in laundry machines, whenever possible, saves energy, as 80% to 85% of the energy consumed by a laundry machine is used for water heating.

✅ Dimensions it improves

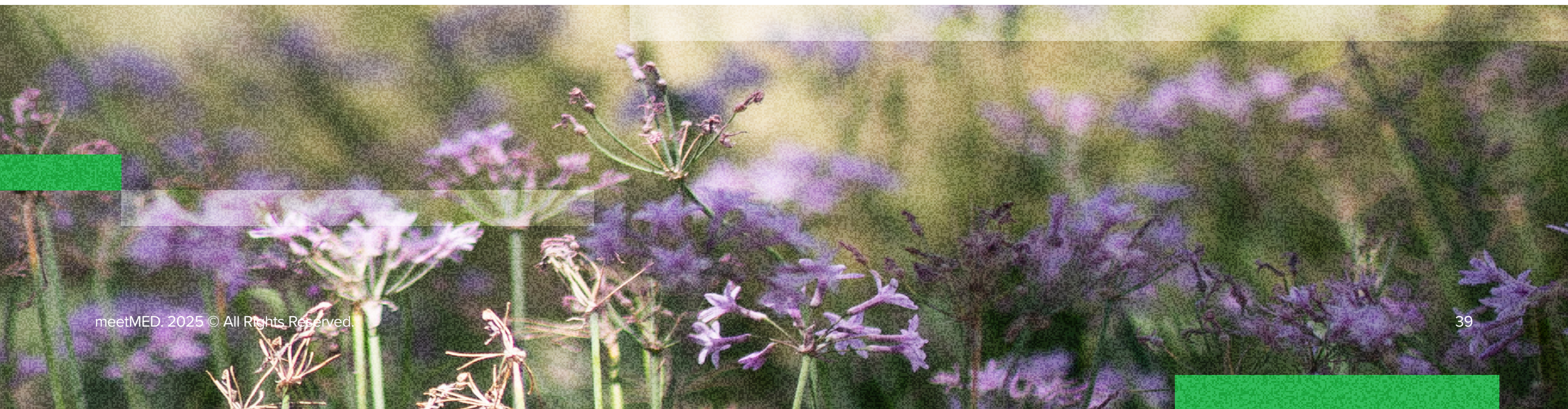
W4- Appliances N5- Appliances

Avoid the excessive use of detergents on laundry machines

Avoid the excessive use of detergents on laundry machines

✅ Dimensions it improves

W4.2- Laundry machine N5.2- Laundry machine



5

Pilot buildings

5.1 Jordan – public building

Iskan Al-Faiha'a Primary Mixed School

Building Characteristics:

- Madaba governance, southeast of Amman
- 3-floors with 30 classrooms and 11 administrative rooms, placed on a 2.930m^2 terrain hosts around 725 students

Technical characteristics

- Water is supplied by Miyahuna Water Company and stored in water tanks on the rooftop of the building
- Water is gravitationally distributed, where it is used for non-drinking purposes (toilets, cleaning, and irrigation of the outside garden)
- 85 kWp photovoltaic system that covers the school's electrical demand
- Solar Domestic Hot Water system that covers hot water needs

Baseline scenario:

- Overall water consumption: 507 m3/year
- Overall energy consumption: 107 MWh/year
- Partial energy consumption for water-related equipment: 150 kWh/year

Before Measures		After Improvement Measures
	Global Classification	
D (41%)		C (56%)
	Partial Classifications	
16%	Water Efficiency →	51%
46%	Water-Energy Nexus →	52%
63%	Climate Adaptation →	70%

Proposed Improvement Measures	Main Benefits	Monitoring Strategy
Installation of an automatically activated pressure-boosting pump	• Increased network pressure and improvement of water distribution efficiency on the 2nd and 3rd floors of the building • Better user experience and satisfaction	• Regular measurements of static pressure at various points of the water network • Conduct user satisfaction surveys
General maintenance of the water network, fixtures, and equipment	• Reduction in water leaks and correspondent cost savings • Improvement of water pressure and of flow rates	• Regular measurements of water static pressure and of water flow rates at various points of the water network • Monthly tracking of water bills
Rainwater harvesting system with total capacity storage tanks of 10m^3	• Reduction in municipal water consumption and correspondent cost savings • Better fit-for-purpose	• Measurement of the volume of harvested rainwater • Monthly monitoring of municipal water consumption • Monthly tracking of water bills
Drip irrigation system with automatic activation system and hourly timer to optimise water usage for gardening	• Reduction in water consumption and correspondent cost savings • Improvement of garden's health and productivity	• Monthly monitoring of water consumption for irrigation • Monthly tracking of water bills • Assessment of garden's health and productivity

Figure 12: Installation of the improvement measures in Iskan Al-Faiha'a Primary Mixed School

5.2 Algeria – residential building

Residential Building in Algiers

Building's Characteristics
- 5-bedroom household of a 3-floor building with a garage, a garden, and a terrace, constructed in 2012
- Located in Algiers, Algeria

Technical characteristics
- The water is supplied by the public company and stored on a water tank
- Water is gravitationally distributed, where it is used in the kitchen, bathrooms and garden
- Relevant water-use equipment: gas domestic water heater and laundry machine

Baseline scenario:
- Overall water consumption: 134 m^3/year
- Partial energy consumption for water-related equipment: 2 MWh/year

Before Measures		After Improvement Measures
	Global Classification	
E (18%)		D (31%)
	Partial Classifications	
23%	Water Efficiency →	39%
12%	Water-Energy Nexus →	20%
20%	Climate Adaptation →	34%

Proposed Improvement Measures	Main Benefits	Monitoring Strategy
• Install low-flow fixtures in kitchens and bathrooms	• Reduction in water consumption and correspondent cost savings	• Monthly tracking of water bills • Regular measurement of taps' water flow rate
• Install an energy and water efficient dishwasher and laundry machine	• Reduction in water and electricity consumption and correspondent cost savings	• Monthly tracking of water and electricity bills
• Plant drought-resistant plant species in the garden	• Reduction of potable water consumption for irrigation and correspondent cost savings	• Monthly monitoring of potable water consumption for irrigation • Monthly tracking of water bills • Assessment of garden's health and productivity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5.3 Morocco – public building

Training Centre of the Moroccan Agency for Energy Efficiency

Building's Characteristics

- 3-floors' building, constructed in 1980, with offices on the first two floors and a documentation room on the second floor
- Located in Issil, Marrakech

Technical characteristics

- Water is supplied by the RADEEMA Water Company, the autonomous water and electricity distribution company of Marrakech
- Water from a well is used for irrigation of the exterior garden
- Main water uses include ten toilets and the irrigation of the garden
- There are three types of solar photovoltaic systems that cover the functioning of the irrigation pump and the heating of Domestic Hot Water, amongst other uses

Baseline scenario:

- Overall water consumption: 3.600 m3/year
- Overall energy consumption: 19 MWh/year
- Partial energy consumption for water-related equipment (circulation pumps): 409 kWh/year

Implementation and results

Before Measures		After Improvement Measures
	Global Classification	
D (36%)		C (48%)
	Partial Classifications	
36%	Water Efficiency →	62%
23%	Water-Energy Nexus →	23%
48%	Climate Adaptation →	56%

Proposed Improvement Measures	Main Benefits	Monitoring Strategy
• Rainwater harvesting system for sanitary facilities	• Reduction in public water consumption and correspondent cost savings • Better fit-for-purpose	• Measurement of the volume of harvested rainwater • Monthly monitoring of potable water consumption • Monthly tracking of water bills
• Install water efficient devices in the toilets (double discharge flushers and low-flow taps)	• Reduction in water consumption and correspondent cost savings • Better user experience and satisfaction	• Monthly monitoring of water consumption • Monthly tracking of water bills • User feedback to assess effectiveness and satisfaction
• Climate-friendly landscaping: plant low-water need plants in green spaces	• Reduction of water consumption for irrigation and correspondent cost savings • Better fit-for-purpose	• Monthly monitoring of water consumption for irrigation • Monthly tracking of water bills • Assessment of garden's health and productivity
• Install an intelligent water monitoring and management system equipped with sensors and an alert system	• Quick detection and reduction of water leaks and correspondent cost savings • Better understanding and management of water usage	• Monthly monitoring of potable and non-potable water consumption • Monthly tracking of water bills


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5.4 Palmela – public building

Poceirão Cultural Centre

Building's Characteristics
- Single-body services building, of "theatre" typology with useful floor area of 434 mr, constructed in 2006 and renovated in 2014
- Located in Palmela, Portugal

Technical characteristics
- Water uses include 8 toilettes and one kitchen
- Relevant water-use equipment: electric domestic water heater

Baseline scenario:
- Overall water consumption: 50 m3/year
- Overall energy consumption: 7,7 MWh/year

Before Measures		After Improvement Measures
	Global Classification	
C (47%)		**B (60%)**
	Partial Classifications	
29%	Water Efficiency →	60%
44%	Water-Energy Nexus →	52%
69%	Climate Adaptation →	69%

Proposed Improvement Measures	Dimensions Improved
Replacement of the existent water meter per one with record of daily consumption data and alert system	**Water Efficiency**
Replacement of taps, showers, toilet flushing systems, and other fixtures in bathrooms and kitchens by more efficient ones with lower flow rates	**Water Efficiency**
Installation of a rainwater harvesting system on the buildings roof for irrigation and cleaning	**Water Efficiency** **Climate Adaptation**
Installation of a timer on the electrical supply circuit of the hot water heater to assure the system operates primarily using energy from the solar panels	**Water-Energy Nexus**
Improve the water supply and distribution system by identifying all consumers and carrying out renovation works on the public water network to reduce water losses	**Climate Adaptation Dimension**

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