Environmental benefits from water efficient taps

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Summary

Case study: tap aerators	install water-efficient equipment (tap aerators) and assess the user's behaviour and the impact on the entire urban water cycle
National energy grid mix	characterize the energy sources (clean and non-clean energy)
CO_2 emissions per kWh	estimate the specific CO_2 emissions in the energy production
Energy required per m^3	estimate the energy consumption in the urban water cycle
Water consumption pattern	quantify the water consumption and water-end use pattern
Water, energy and CO_2 savings	link the observed water reductions with the corresponding energy and carbon emissions savings

comparative analysis between the annual and the monthly scale approaches

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Case study

Location
University of Aveiro
Department of Civil Engineering **(DECivil)**

Motivation
- Previously studied
- High occupancy
- Great potential for water saving

Community (≈ 300 users)
- Students
- Researchers
- Professors
- Administrative
- Lab workers

Water consumption points
- Laboratory
- Toilets

Case study

Baseline situation (self closing push tap)

- Q = 6.7 l/min
- t = 6.1 s

Water-efficient appliances installed

tap aerators (flow reducers)

A	B	C	D
4.7 l/min	3.9 l/min	3.4 l/min	2.0 l/min

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Case study

The water consumption reduction was on average 46% smaller than the discharge reduction achievable with the tap aerator alone.

Aerators performance

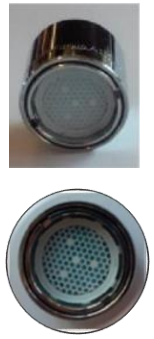
and the impact of user preferences:

Aerator A (aerated flow)

reduction of
discharge: 30%
consumption: 15%

Aerator B (spray flow)

reduction of
discharge: 42%
consumption: 17%



Aerator C (aerated flow)

reduction of
discharge: 49%
consumption: 27%

Aerator D (spray flow)

reduction of
discharge: 70%
consumption: 49%

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National energy grid mix

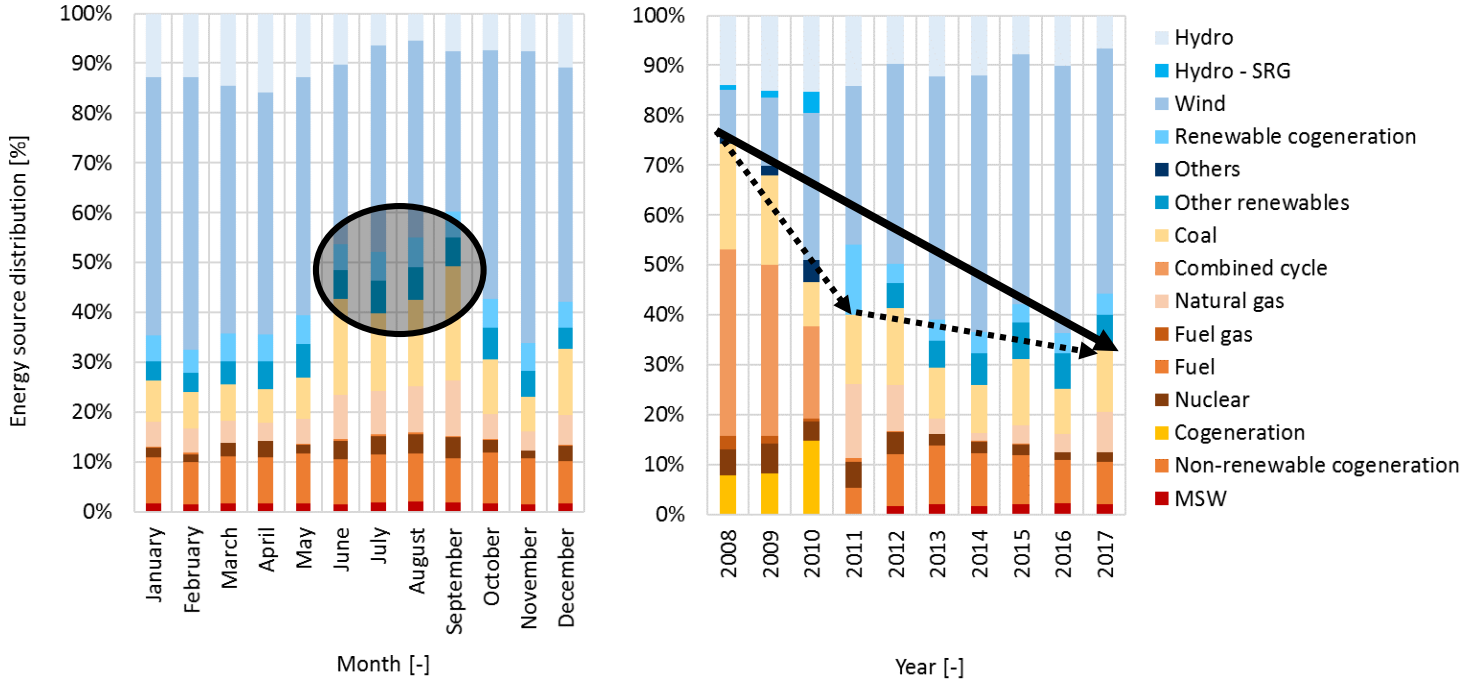
Provider / Data source
EDP – Energias de Portugal

Traditional energy sources

Clean energy
- water
- wind
- sun

CO_2, SO_2, NO_X and radioactive waste free

Non-clean energy
- burning fossil fuels (coal and natural gas)
- cogeneration



Distribution of EDP energy sources at a monthly (left) and annual (right) time scales

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National energy grid mix

power increase investments

2011 2012 2013 2014 2015 2016 2017 … 2020

246 MW
Picote II

191 MW
Bemposta II

256 MW
Alqueva II

151 MW
Baixo Sabor

118 MW
Daivões

780 MW
Venda Nova III

263 MW
Foz-Tua

223 MW
Salamonde II

82 MW
Ribeiradio/Ermida

Source: EDP *https://a-nossa-energia.edp.pt/centros_produtores/empreendimento.php?item_id=83&cp_type=he*

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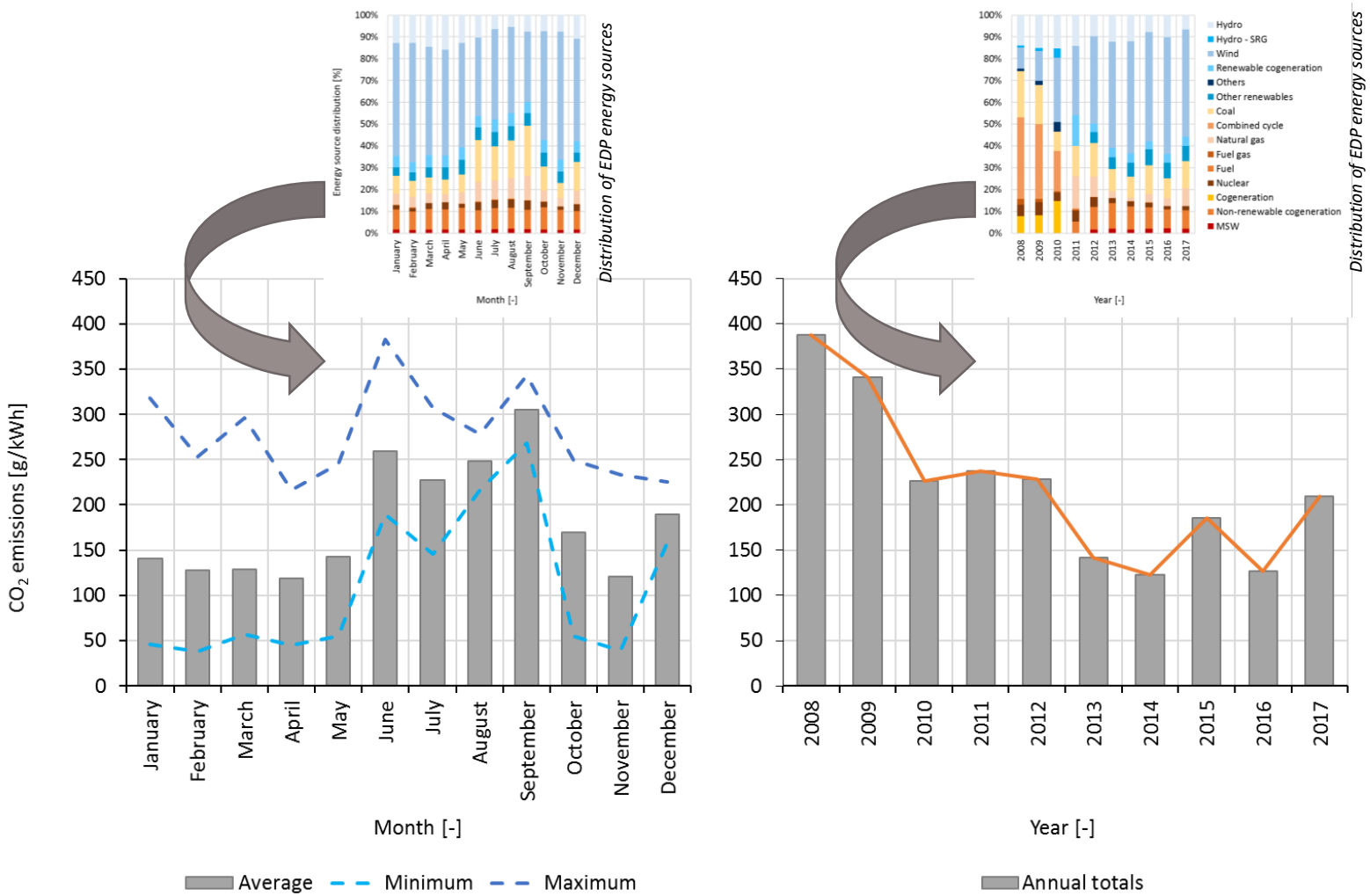
CO_2 emissions per kWh



Specific CO_2 emissions due to electricity production at EDP at a monthly (left) and annual (right) time scales

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Energy required per m³

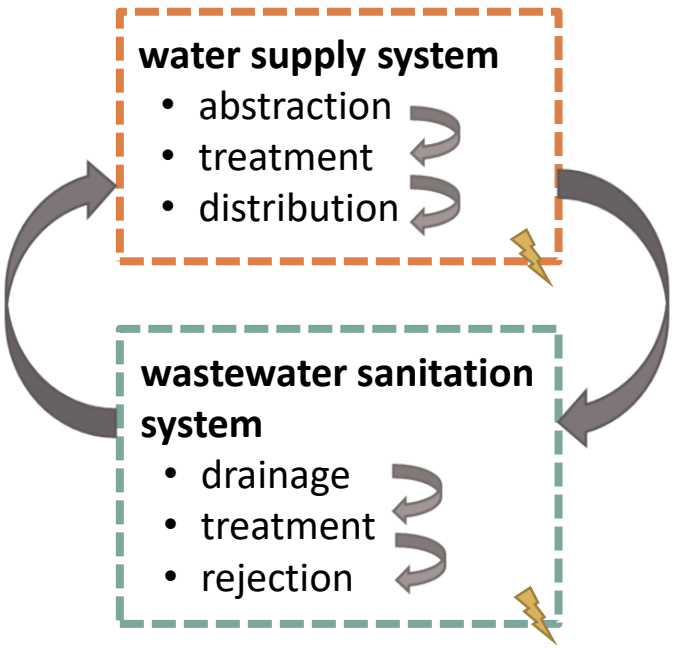
Provider

AdRA - Águas da Região de Aveiro

Data source

ERSAR – Entidade Reguladora dos Serviços de Águas e Resíduos

Urban water cycle



Energy-for-water ratio

- same ratio during the whole year (lack of monthly information);
- considers all the energy-consuming stages of the urban water cycle required to supply 1m³ of water at the building.

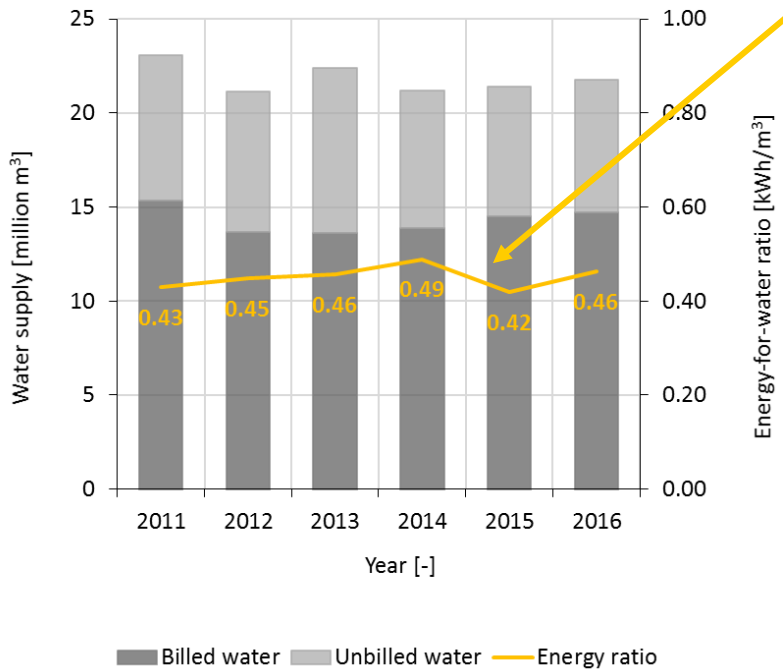
network affluence coefficient

$$\text{ratio (kWh/m}^3) = \frac{\text{energy required}}{\text{total volume of water}} + 0.8\,\frac{\text{energy required}}{\text{total volume of effluent}}$$

including billed and unbilled volumes

Energy required per m³

$$\text{ratio (kWh/m}^3) = \frac{\textbf{energy required}}{\textbf{total volume of water}} + 0.8\ \frac{\textbf{energy required}}{\textbf{total volume of effluent}}$$



Annual water supply and energy consumption ratio at AdRA

Fluctuation factors

- consumers habits reflecting sometimes the economic situation;
- the existence of network leakages and the repair and maintenance actions that are being taken to resolve them;
- the affluence of undue flows in periods of intensive precipitation;
- the need to resort to underground abstraction in dry years.

***Note**: unbilled water includes illegal abstractions, losses and leakages*

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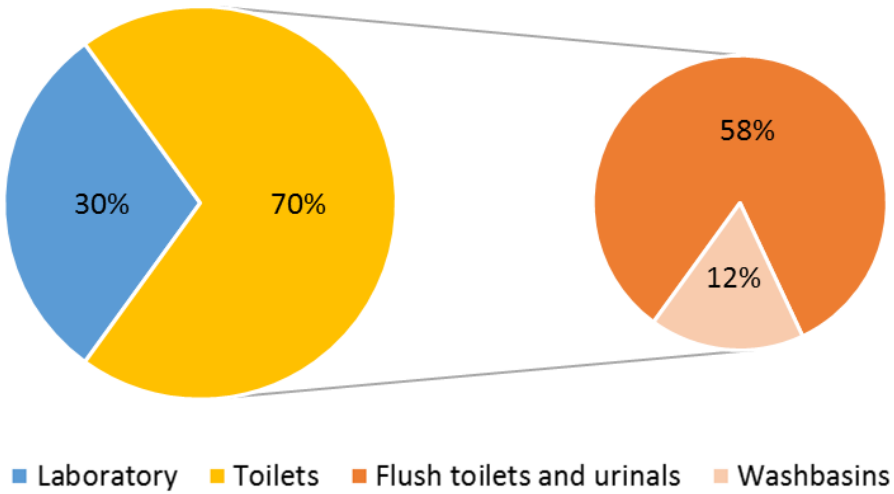
Water consumption pattern

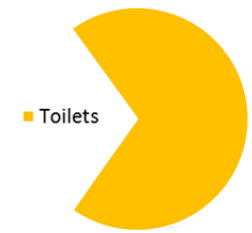
Data collection

- since the middle of 2010;
- measurements through a totalizer water meter;
- records at an hourly rate by telemetry;
- in presence of missing records, certain assumptions had to be taken.

The water consumption pattern was evaluated at a monthly timescale, that is the highest time resolution available for the remaining data used.



Distribution of water consumption points in DECivil building



- 6 main toilets
- 70% of the building's water consumption

- 14 washbasins
- 12% of the building's water consumption

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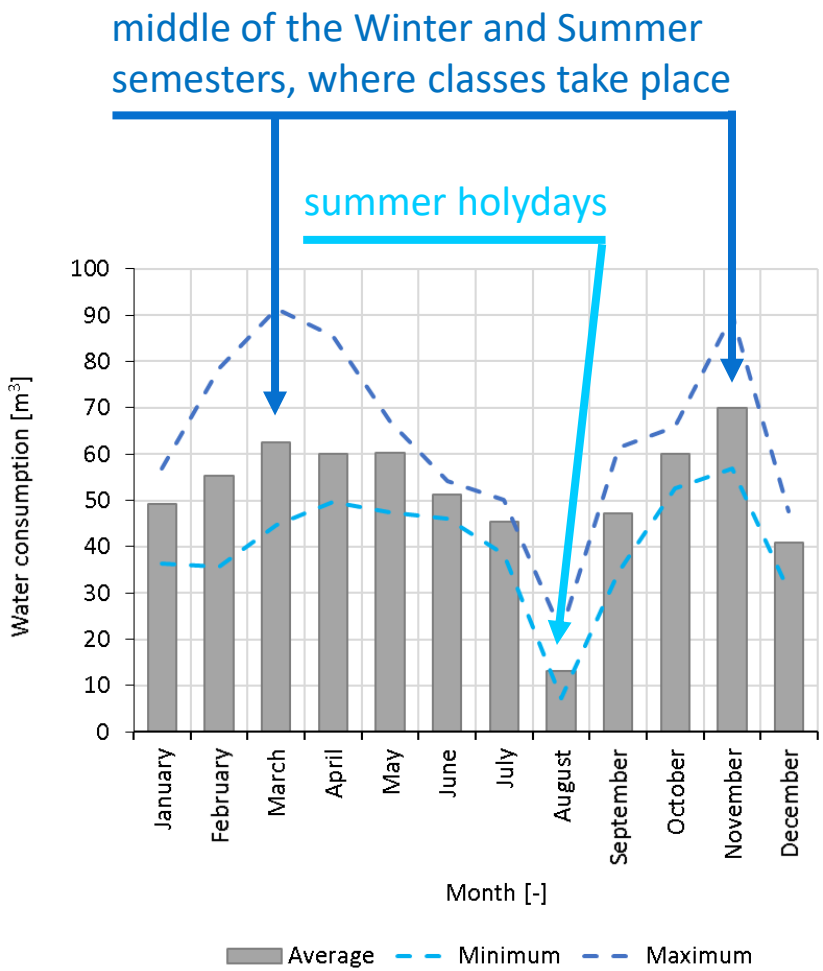
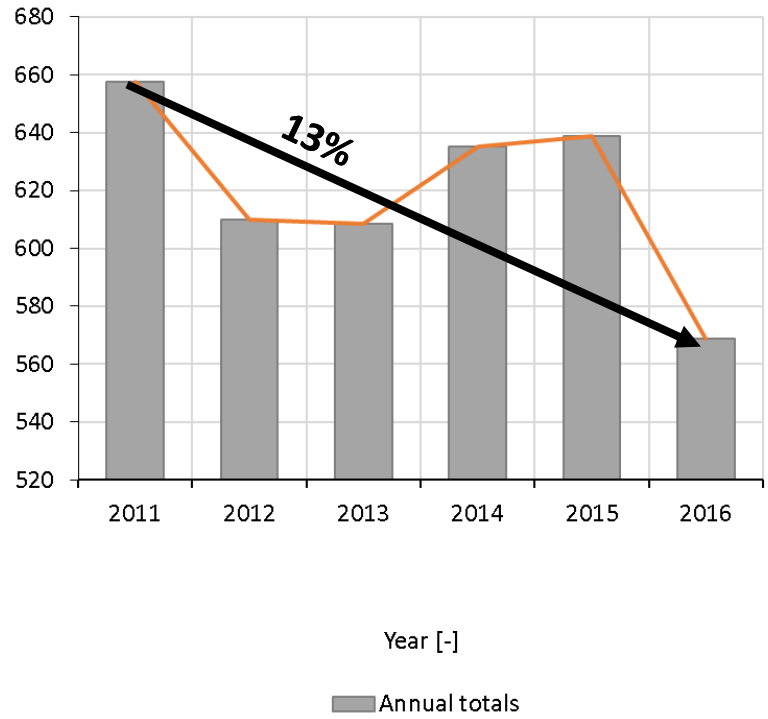
Water consumption pattern



Water consumption records

- maximum values: 91.49 m³ in March 2014
  89.98 m³ in November 2016
- lowest value: 7.33 m³ in August 2013



Water consumption in the DECivil building at monthly (left) and annual (right) time scales

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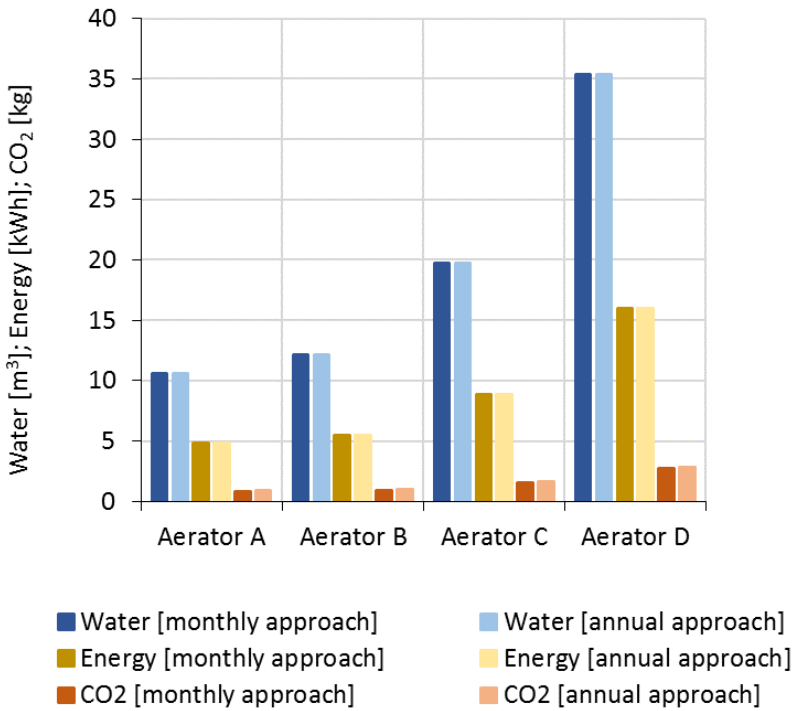
Water, energy and CO_2 savings



Potential savings for the four different types of tap aerators at monthly and annual time scales

Aerator D

Monthly analysis Vs. **Annual analysis**

- 35 m^3 water
- 16 kWh energy
- 2.7 kg CO_2

- 35 m^3 water
- 16 kWh energy
- 2.8 kg CO_2

Monthly and annual time scale approaches:

- equal water and energy savings
- similar annual CO_2 emissions: difference of 5%

The energy mix varies from month to month, resulting in a variation on the CO_2 emissions throughout the year.

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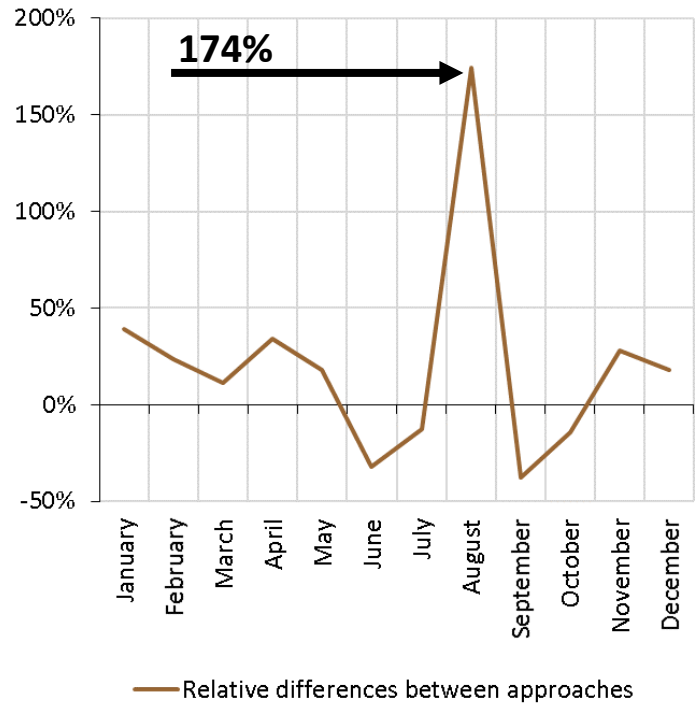
Water, energy and CO_2 savings



Relative differences of CO_2 emissions between the annual and monthly approaches

$$\frac{\text{Month } CO_2 \text{ emissions estimate with the } \textbf{yearly} \text{ approach} - \text{Month } CO_2 \text{ emissions estimate with the } \textbf{monthly} \text{ approach}}{\text{Month } CO_2 \text{ emissions estimate with the } \textbf{monthly} \text{ approach}}$$

- Analysing the results month-by-month are observed relative differences of CO_2 emissions estimates in each month of up to 174%.
- This disparity is particularly visible in buildings affected by seasonal consumption variation, like schools and touristic buildings, since carbon emissions are also season related.

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Final remarks

I. Estimation of water, energy and CO_2 savings from retrofit devices

Aerator D
The most efficient

savings of around 50% on:

- water
- energy
- carbon emissions

Savings ratios:

- 0.45 kWh/m^3
- 76 g.CO_2/m^3

II. Comparison between the annual and the monthly time scale approaches

The results are time scale dependent: the annual analysis can conduct to either overestimated / underestimated results of the carbon emissions.

(particularly for buildings affected by seasonal water consumption variation such as schools and hotels)

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Thank you for your attention!

Scientific Research and Technological Development Project

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