Flow Loop

Analysis Report on Flow Loop's Circular Shower

Date: August 9, 2023

Table of Contents

Prepared by NIRAS A/S in collaboration with Flow Loop ApS

Emil Pøckel Hemmingsen (EHEM)	Claus Wessel Andersen (CWA)
Engineer	Project Manager
EHEM@NIRAS.DK	CWA@NIRAS.DK

1. Introduction

This report contains analyses of Flow Loop's showers when installed in new buildings, renovations hotels, and when implemented nationwide in Denmark.

The calculation studies of Flow Loop's circular shower aim to investigate the impact of water and energy savings, and the potential consequences for affected building parts when implementing the system. The report will review four analysis scenarios:

1. New construction case from Hillerød
2. Renovation case from Copenhagen
3. Hotel case from Comwell Hotel, Holte
4. Derived effects nationwide in Denmark

Each scenario will be presented and elaborated on in Section 2, *Descriptions and Calculations*, where a brief description of the context is given, followed by a review of the calculations.

The same basic assumptions have been used to ensure a realistic approach to assessing the effect of Flow Loop's circular shower (LOOP) in the investigated scenarios. The only variation is the specific parameters of the building, such as water and energy consumption, number of housing units, heated floor area, and number of people. In other words, the principles used in energy frame calculations have been adhered to in order to ensure a comparable analysis.

1.1 Units

The calculations are based on the water and energy savings of the Flow Loop shower and include the total consumption of cold and hot domestic water and the derived effects on the building's energy frame, which affects energy consumption and the CO_2 emitted. Finally, the financial savings are calculated.

The calculations are based on a residential unit and include the total consumption for the entire building. The results cover the following topics as shown in the table, Fig 01. Units, as well as the possibility to scale down the amount of water pipes and hot water tanks, based on the reduced cold and hot water consumption.

Fig 01. Units.

Water consumption (m^3/year)	**Energy (kWh per year)**	**Energy frame (kWh/m^2 per year)**
Finances (DKK/year)	**CO_2 (kg CO_2 per year)**	**Energy label (G-A2020)**

1.2 Prerequisites for Water, Construction and Economy

The background figures for the calculations are based on standard values, average figures for Denmark, and realistic assumptions for each individual analysis scenario. The common assumptions are described in this section, and any variations or specific assumptions are described under each scenario and related results.

The water consumption is assumed according to Flow Loop's own savings calculation, that the following standard conditions for a shower are 8 minutes with a water flow of 12 liters per minute. This water consumption is calculated by Flow Loop at 100% utilization of the system, and results in a saving of 81.8%. Water consumption per shower is thus 96 liters for a normal shower and 17.5 liters for the LOOP shower. (1)

Fig. 02. Distribution of Water Consumption

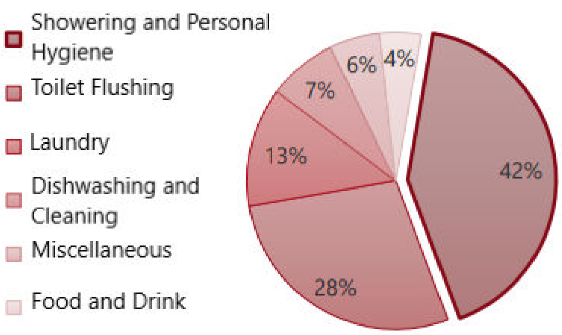
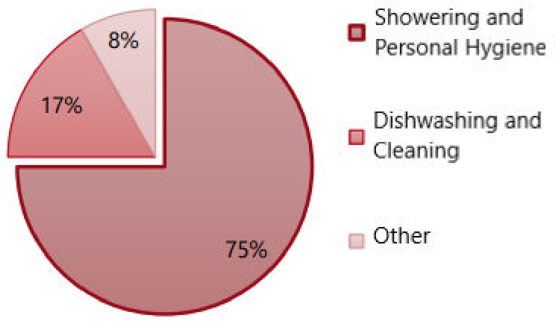


Fig. 03. Distribution of Hot Domestic Water



Water distribution and domestic hot water. The water distribution of total water consumption is based on different sources and gives a realistic baseline. The distribution between cold and hot domestic water is assumed to be 50% cold and 50% hot, based on data from an analysis report on a household's water supply. (2) Water consumption and hot water distribution are divided into the following categories: 1. Showering and Personal Hygiene, 2. Toilet Flushing, 3. Laundry, 4. Dishwashing and Cleaning, 5. Miscellaneous and 6. Food and Drink. These categories are distributed according to the graphs based on data from the Danish Water and Wastewater Association, Brunata, and the analysis report on domestic water supply. (3) An extract of the figures is used for intermediate calculations: 42% (Fig. 02) of the water consumption is attributed to bathing and personal hygiene, which is assumed to make up 75% (Fig. 03) of the hot domestic water. The quantity of domestic hot water is assumed to be 250 liters per year per m^2 for new construction when calculating the energy frame in Be18. (4) However, the baseline for domestic hot water varies according to the total water consumption, as both cold and hot domestic water must be calculated for the final savings.

Building data and the energy frame, as well as the current context from which the calculations are made, must contain the relevant figures. In addition to the water consumption, ratios must also be extracted for the consumption per housing unit and the entire building. The energy frame describes the building's energy consumption and is prepared on the basis of building data. It is normally calculated for new construction, but if the exact energy consumption and heated floor areas are available, an assumption can be made and used to calculate the energy savings. The CO_2 savings can be calculated by multiplying the energy consumption by the emission factor for district heating 2023 of 0.105 kg CO_2 per kWh. (5) Next, an approximation of the energy label can also be estimated. (6)

The economy can be calculated when all water and energy savings have been calculated. For water consumption, the price from the associated waterworks is used [7], and in the case of district heating or natural gas, the price from the local supply to the building is used for the calculations. [8]

1.3 Conclusion

The conclusion is based on the three sub-results (cases) that are for a newly built block of apartments, an older block of apartments, and a hotel. For each of the three cases, a before and after scenario has been calculated, respectively without and with Flow Loops recirculating shower, which provides water and energy savings. The percentage savings for the various parameters are indicated in the table (Table 01), and specific numerical values for the analyzed buildings are presented in the calculations in their respective sections.

Table 01.

Flow Loop in liters per shower has a water saving of: **82%**	Flow Loop in kWh per shower has an energy saving of: **69%**
Total water consumption in m^3/year has a saving of: **31%**	Energy in kWh/m^2 per year has a saving of: **10 - 23%**
Parts of the piping system and hot water tank dimension have a possible downscaling of: **-1 dim.**	CO_2 in kg/CO_2 per year has a saving of: **9 - 22%**
The price for water and energy in DKK has a saving of: **16 - 37%**	The energy label in classes has an improvement of: **+1 class**

The results are an approximation for parameters due to the reduced water and energy consumption if the Flow Loop system recirculates 100% of the time. This should be considered, and it should be noted that the background figures are based on standard values, average figures, and realistic assumptions in the context. The final result can incorporate a quantile in relation to the actual time during which the Flow Loop shower recirculates, and a potential downscaling of the piping system and the amount of hot water tanks must be considered. This potential downscaling only affects certain parts of the piping system, and it is assumed that it is possible to downscale one dimension. The downscaling of the piping system and the amount of hot water tanks must be calculated on the basis of the specific context. The downscaling of the piping system and the amount of hot water tanks will provide additional financial savings, which are not estimated in this report. If recirculating showers are installed in a project with several residential units with shared domestic water installations, the domestic hot water flow in the system is reduced, i.e., peak flow on a daily basis is significantly reduced to the extent that the recirculation option is used. This means that the need for large capacity in a hot water tank is reduced and that pipe sizes in the main system can be reduced, thus the water velocity in the pipes is maintained, and thus the risk of biofilm, etc. is reduced. For the hot water tank, this can mean that it can potentially become too small to handle the hot circulation water volume. Whereby measures must either be taken to reduce the amount of circulating water by increasing the insulation of the installation, or alternative solutions than a central hot water tank should be considered. Such measures could be decentralized production of domestic hot water in decentralized exchangers, either based on district heating, heat pumps, or perhaps in some scenarios, based on clean electricity in the future. So that only cold domestic water is circulated in the property. In this way, a system can be built that is less vulnerable to whether the individual apartment uses the recirculation function optimally or not, and thereby whether the domestic water system is too large or too small for the task at a given time. What is the optimal solution and choice of the service water system (central or decentralized) depends on the specific context, the location, the design of the building, etc.

2. Descriptions and Calculations

2.1 Description of Flow Loop's Circular Shower

Flow Loop's circular shower has two modes that the user can switch between by pressing a button:

- Regular mode – no savings – no light around the button
- Circulation mode – achievement of high water and energy savings – green light around the button

When the shower is in circulation mode, water is sucked up from the floor. In circulation mode, the water treatment goes as follows:

1. Coarse filtration
2. Micro-filtration
3. Mixing the recirculated water with hot water to compensate for the temperature loss
4. UV treatment of the water to deactivate bacteria and viruses in the water
5. The water comes out through either the hand or hand head shower, depending on the bather's choice

When the shower recirculates, 10-11 l/min is sucked up from the floor and goes through the above water treatment. In section 3 above, 1-2 l/min is added to compensate for the temperature loss. This is how water and energy savings are achieved.

Picture 1: Control panel

Picture 2: Suction inlet by floor (point drain)

Picture 3: Suction inlet by floor (uni-drain)

Picture 4: Flow Loop is available in many colors

2.2 New Construction Case from Hillerød

The building is an apartment building in Hillerød from 2023, which is taken from NIRAS' project library. The following information is provided, and the calculations are only based on data from one residential block in the entire construction.

1. The residential block consists of 110 apartments
2. Heated floor area: 8,933 m^2
3. Assumption: One residential unit is 81 m^2 and is populated by 1.7 persons
4. Heat supply: District heating, with contribution from solar cells
5. Price: Water 75.8 DKK/m^3 and district heating 0.72 DKK/kWh

The total water consumption for the construction is stated as 4,467 m^3 and 14 m^3 per residential unit. This has been adjusted according to the standard figure for hot water consumption in new construction, which is calculated as 250 liters per year per m^2.

Before the installation of the Flow Loop shower, the building's energy frame according to Be18 is calculated at 29 kWh/m^2 per year. Flow Loop's circular shower reduces the total hot water consumption by 52% to 119 liters per year per m^2 and the energy frame calculation by 23% to 22 kWh/m^2 per year. This results in improving the building's energy frame, which can now be classified as within the low energy frame. When the energy frame value is changed, the energy label can be recalculated and possibly improved.

The larger the apartments, the more people will typically live in them. Flow Loop's shower will therefore have the shortest payback time in the largest apartments.

Per residential unit	Before	After	Profit		
Water consumption	41	28	**12**	31%	m^3 per year
Energy	2,314	1,787	**528**	23%	kWh per year
Emitted CO_2	247	192	**55**	22%	kg CO_2 per year
Total price - water and energy	4,757	3,431	**1,326**	28%	DKK per year

Total for building	Before	After	Profit		
Water consumption	4,467	3,098	**1,368**	31%	m^3 per year
Energy	254,591	196,526	**58,065**	23%	kWh per year
Emitted CO_2	27,179	21,082	**6,097**	22%	kg CO_2 per year
Total price – water and energy	523,317	377,443	**145,874**	28%	DKK

Assumption of energy	Before	After	Profit		
Energy frame	29	22	**7**	23%	kWh/m^2 per year
Energy label	A2015	A2020	**+1**		Class

2.3 Renovation Case from Copenhagen

The building is a larger apartment building in Copenhagen from 1936 that Flow Loop has selected as a renovation case. The following information has been provided:

1. The apartment building consists of 683 apartments
2. Heated floor area: 60,601 m^2
3. Average size of a residential unit: 89 m^2, with an average population of 1.8 persons
4. Heat supply: District heating, with contribution from electricity
5. Price: Water 48.1 DKK/m^3, district heating 0.70 DKK/kWh and electricity 1.50 DKK/kWh

The total water consumption for the construction is stated at 50,087 m^3, which corresponds to 73 m^3 per residential unit. These figures are calculated based on the average water consumption of a Danish citizen and the hot water consumption is 413 liters per year per m^2. Before the installation of the Flow Loop shower, the building's energy frame was estimated at 116 kWh/m^2 per year based on consumption data. It is assessed as realistic in relation to the building's specified energy rating of C. [(9)] With Flow Loop's circular shower, hot water consumption is reduced by 52% to 197 liters per year per m^2 and the energy frame by 10% to 105 kWh/m^2 per year. This results in an improvement of the building's energy frame. It should be noted that the energy label is not improved, as the next category, B, has a limit value from 70.0 to 52.5 kWh/m^2 per year.

The larger the apartments, the more people will typically live in them. Flow Loop's shower will therefore have the shortest payback time in the largest apartments.

Per residential unit	Before	After	Profit		
Water consumption	73	51	**22**	31%	m^3 per year
Energy	10,302	9,349	**953**	10%	kWh per year
Emitted CO_2	1,086	986	**100**	9%	kg CO_2 per year
Total price – water and energy	10,868	9,107	**1,761**	16%	DKK per year

Total for building	Before	After	Profit		
Water consumption	50,087	34,742	**15,345**	31%	m^3 per year
Energy	7,036,495	6,385,368	**651,127**	10%	kWh per year
Emitted CO_2	741,862	673,494	**68,368**	9%	kg CO_2 per year
Total price - water and energy	7,422,680	6,220,242	**1,202,439**	16%	DKK per year

Assumption of energy	Before	After	Profit		
Energy frame	116	105	**11**	10%	kWh/m^2 per year
Energy label	C	C	**-**		Class

2.4 Hotel Case from Comwell Hotel, Holte

The hotel building was built in 1968 and has been selected due to the collaboration between Comwell Hotel, Holte and Flow Loop. The following information has been provided:

1. The hotel has 112 hotel rooms
2. Heated floor area: The rooms make up: 2,297 m^2 (*Total for the hotel: 8,803 m^2*)
3. Assumption: A hotel room is on average 22 m^2 and is occupied by 1-2 people
4. Heat supply: Natural gas, with contribution from electricity
5. Data on the hotel's annual consumption for 2019 (electricity, water, and natural gas)
6. Price: Water 35.0 DKK/m^3, natural gas 11.0 DKK/m^3 and electricity 1.50 DKK/kWh

The occupancy rate is not considered according to the specific number of people, as the starting point is the water savings and the total water consumption for the hotel, which was 7,450 m^3 in 2019, which corresponds to 72 m^3 per hotel room, based on annual water consumption. Before the installation of the Flow Loop shower, the energy frame for the building was estimated at 191 kWh/m^2 per year, based on the hotel's annual consumption of electricity and natural gas, which resulted in energy label E. After the installation of Flow Loop's recirculating shower, the energy frame is reduced by 23% to 146 kWh/m^2 per year. This results in an improvement of the building's energy frame. When the energy frame value is changed, the energy label can be recalculated and possibly improved to an energy label D.

Per hotel room	Before	After	Profit		
Water consumption	67	46	**20**	31%	m^3 per year
Energy	3,915	3,050	**865**	22%	kWh per year
Emitted CO_2	540	421	**119**	22%	kg CO_2 per year
Price – water and natural gas	6,879	4,360	**2,519**	37%	DKK per year

Total for building	Before	After	Profit		
Water consumption	7,450	5,168	**2,282**	31%	m^3 per year
Energy	438,475	341,625	**96,850**	22%	kWh per year
Emitted CO_2	60,510	47,144	**13,365**	22%	kg CO_2 per year
Price – water and natural gas	770,447	488,331	**282,116**	37%	DKK per year

Assumption of energy	Before	After	Profit		
Energy frame	191	149	**42**	22%	kWh/m^2 per year
Energy label	E	D	**+1**		Class

2.5 Derived Effects on a National Level in Denmark

To get a theoretical assessment of the impact of the Flow Loop system on a national level in Denmark, we assume that all Danish citizens take a shower with a Flow Loop device and the recirculation is activated. The following information is provided:

1. Population group aged 18-75: 4,187,600
2. Time spent in the shower per week: 37 minutes
3. Water savings: 82%
4. Energy savings: 69%
5. Time period: 2023-2030

Based on the population group aged 18-75 of 4,187,600 [(10)] and based on a survey of shower habits carried out by the Danish Energy Agency, where the average shower time is 37 minutes per week [(11)], the corresponding consumption and savings for water, kWh, and kg CO_2 with a normal shower and the Flow Loop system are calculated. An average daily number of showers of 0.6 is assumed based on Flow Loop's own standard calculation assumptions. This is multiplied by the population group and gives the following annual savings of water consumption, energy, and reduced CO_2 as indicated in table 02, at 100% implementation.

Table 02.

Unit	Traditional shower	Flow Loop	Savings
Water: m^3/year	89,088,199	16,197,854	72,890,345
Energy: kWh/year	2,800,771,623 (2.8 tWh)	869,715,892 (0.8 tWh)	1,931,055,731 (1.9 tWh)
CO_2 2023: tCO_2	294,081	91,320	202,761

Water Savings

Denmark's groundwater resource is under increasing pressure. This is due to several factors, e.g., the closure of water drill holes because of pollution and climate change. If all Danish homes had recirculating showers, Danish water consumption could be reduced by approx. 73 million m^3 per year. Danish households used 249 million m^3 of water in 2020. [(12)] Recirculating showers will be able to help reduce household water consumption by 29%.

The water savings will reduce the pressure on our groundwater resources considerably and leave more water for other sources of consumption. In addition, the reduced water discharge from households will reduce the pressure on the sewage system, which is already under pressure from more extreme rainfall.

Water savings is a sensible focus area within construction, as it is an aspect that is often overlooked. Water is a valuable resource that will always be needed, and the need will increase in the future, in connection with the use of water for Power-to-X projects. [(13)]

Energy Savings

The transition to a fossil-free energy sector makes energy savings more important than ever. Full implementation of recirculating showers in all Danish homes will save 1.9 tWh annually. Danish households' energy consumption in 2022 was 69 tWh. (14) The energy saved for heating water for showers and bathing corresponds to 2.8% of household energy consumption. In addition, there will be uncalculated energy savings for the extraction and treatment of less drinking water, wastewater treatment, etc.

Reduced CO_2-emission

The reduced CO_2 emission corresponds directly to the government's goal for 2030 to reduce greenhouse gas emissions by 70% compared to the emissions in 1990. (15) The emission must be reduced to 15 million tCO_2 based on collected emission data from 1990-2021. (16)

With 100% implementation from 2023, the overall calculated reduction for recirculating showers will contribute to an annual reduction compared to a standard shower, as indicated in Table 03. To calculate the reduction in CO_2 emissions from recirculating showers, the energy consumption is multiplied by the projected emission factor for district heating for the year in question, which describes the emission of kg CO_2/kWh for operating energy when heating domestic hot water.

Table 03.

Emission factors for operating energy for district heating: kgCO_2/kWh		Flow Loop reduced CO_2: tCO_2/year
2023	0.105	202,761
2024	0.097	186,540
2025	0.088	169,547
2026	0.085	163,174
2027	0.081	156,802
2028	0.078	150,429
2029	0.075	144,057
2030	0.071	137,684

3. Appendix

(1) Engineering Savings Calculations - Water and Energy, Flow Loop Aps, 2023. (18-04-2023)

(2) Varmt brugsvand: Måling af forbrug og varmetab fra cirkulationsledninger, 2009.
Availabilty: https://build.dk/Assets/Varmt-Brugsvand/sbi-2009-10-pdf.pdf (05-06-2023)

(3) Vandforbrug i hjemmet, Brunata, 2023. (08-06-2023)
Availabilty: https://brunata.dk/losninger/vandregnskab/vandforbrug-i-hjemmet/
Så meget el, vand og varme bruger en gennemsnitsfamilie, Bolius, 2023. (08-06-2023)
Availabilty: https://www.bolius.dk/saa-meget-el-vand-og-varme-bruger-en-gennemsnitsfamilie-279

(4) Be18. Beregningsprogram til beregning af bygningers energibehov. BUILD, 2023.

(5) Opdaterede emissionsfaktorer for el og fjernvarme, COWI. (2020).

(6) Energimærkning af boliger, Energistyrelsen, 2023. (14-06-2023)
Availability: https://old.sparenergi.dk/forbruger/boligen/energimaerkning-boliger/huse

(7) Vandpris på Danmarkskort, Danva, 2023. (20-06-2023)
Availability: https://www.danva.dk/viden/bm/om-benchmarking/vandpris-paa-danmarkskort/

(8) Fjernvarmepriser, Hillerød Forsyning, 2023. (22-06-2023)
Availability: https://hfors.dk/selvbetjening/priser-takster-2023
Fjernvarmepriser, Frederiksberg Forsyning, 2023. (22-06-2023)
Availability: https://www.frb-forsyning.dk/forside/varme/priser
Naturgaspriser, Rudersdal Kommune, Evida, 2022. (22-06-2023)
Availability: https://evida.dk/nyheder/aendringer/

(9) Energimærkningsnummer 311685564, Falkoner Alle 80 2000 Frederiksberg, 2023. (26-062-023)
Availability: https://old.sparenergi.dk/demo/addresses/map.

(10) Befolkningstal, Danmarks statistik, 2023. (28-06-2023)
Availability: https://www.dst.dk/da/Statistik/emner/borgere/befolkning/befolkningstal
Befolknings pyramide 18-75, Danmarks statistik, 2023 (28-06-2023)
Availability: http://extranet.dst.dk/pyramide/pyramide.htm#!a=18,75&v=2

(11) Hver uge bruger vi 34 minutter under bruseren, Energistyrelsen, 2022. (28-06-2023)
Availability: https://ens.dk/presse/hver-uge-bruger-vi-34-minutter-under-bruseren-spar-penge-ved-forkorte-badet

(12) Husholdningerne brugte en del mere vand i 2020, Danmark statistik, 2021 (03-07-2023)
Availability: https://www.dst.dk/da/Statistik/nyheder-analyser-publ/nyt/NytHtml?cid=34752

(13) Vand til Power-to-X, Dansk Industri, 2022. (03-07-2023)
Availability: https://www.danskindustri.dk/medlemsforeninger/vand/nyhedsarkiv/2022/vand-til-power-to-x/

(14) Energi- og emissionsregnskaber, Danmarks Statistik, 2022. (03-07-2023)
Availability: https://www.dst.dk/da/Statistik/emner/miljoe-og-energi/groent-nationalregnskab/energi-og-emissionsregnskaber

(15) Klima, udledning af drivhusgasser, Danmarks statistik, 2021. (04-07-2023)
Availability: https://www.dst.dk/da/Statistik/temaer/klima

(16) Greenhouse Gas Emissions from Energy Data Explorer, International Energy Agency, 2023 (04-07-2023)
Availability: https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer
Country Fact Sheet, Denmark, Emissions Database for Global Atmospheric Research, 2023. (04-07-2023)
Availability: https://edgar.jrc.ec.europa.eu/country_profile/DNK