Heat and Cold Energy Demands of Buildings

Module 2.3
Domestic hot water demand

SHaKE – Sharing Heat and Knowledge on Energy Communities
Erasmus+ KA220-HED Cooperation Partnerships in HE
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SHaKE
Sharing Knowledge on Energy Communities

1. Introduction

What are the expectation for the domestic hot water (DHW) production?

Comfort

The DHW needs must be always fulfilled in terms of:

- Instantaneous flow rate
- Temperature < 60°C
- Volume per day

Health

Prevent the proliferation of legionella (a deadly bacterium) which can spread where:

- The water temperature is between 20°C and 55°C
- The water is stagnant

1. Introduction

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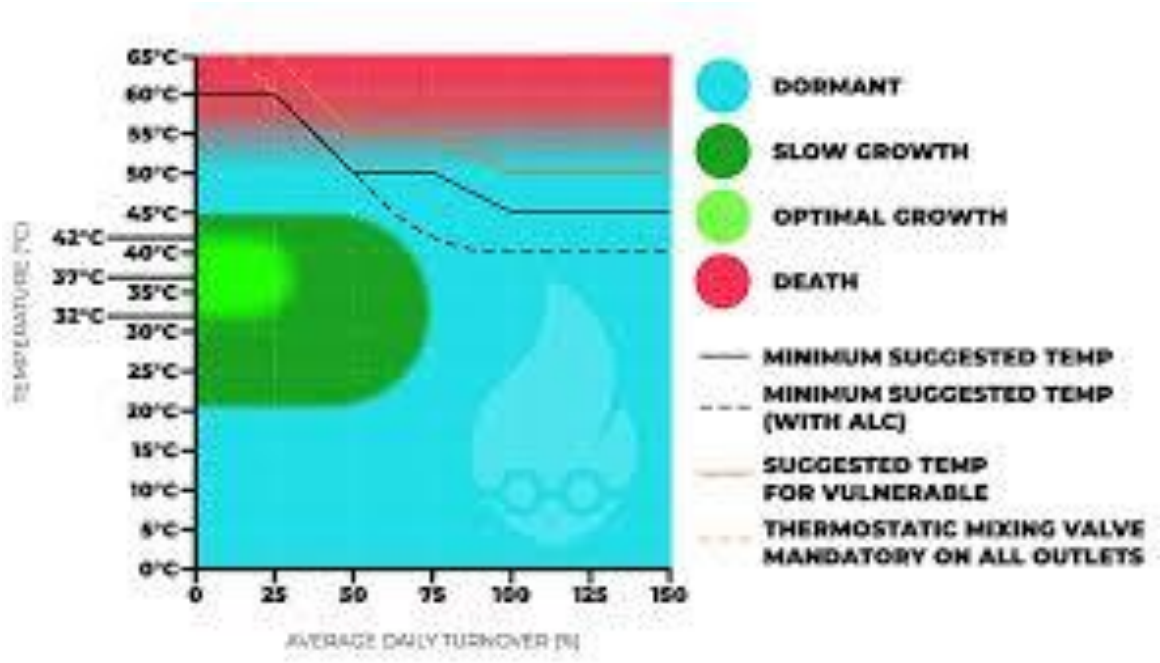
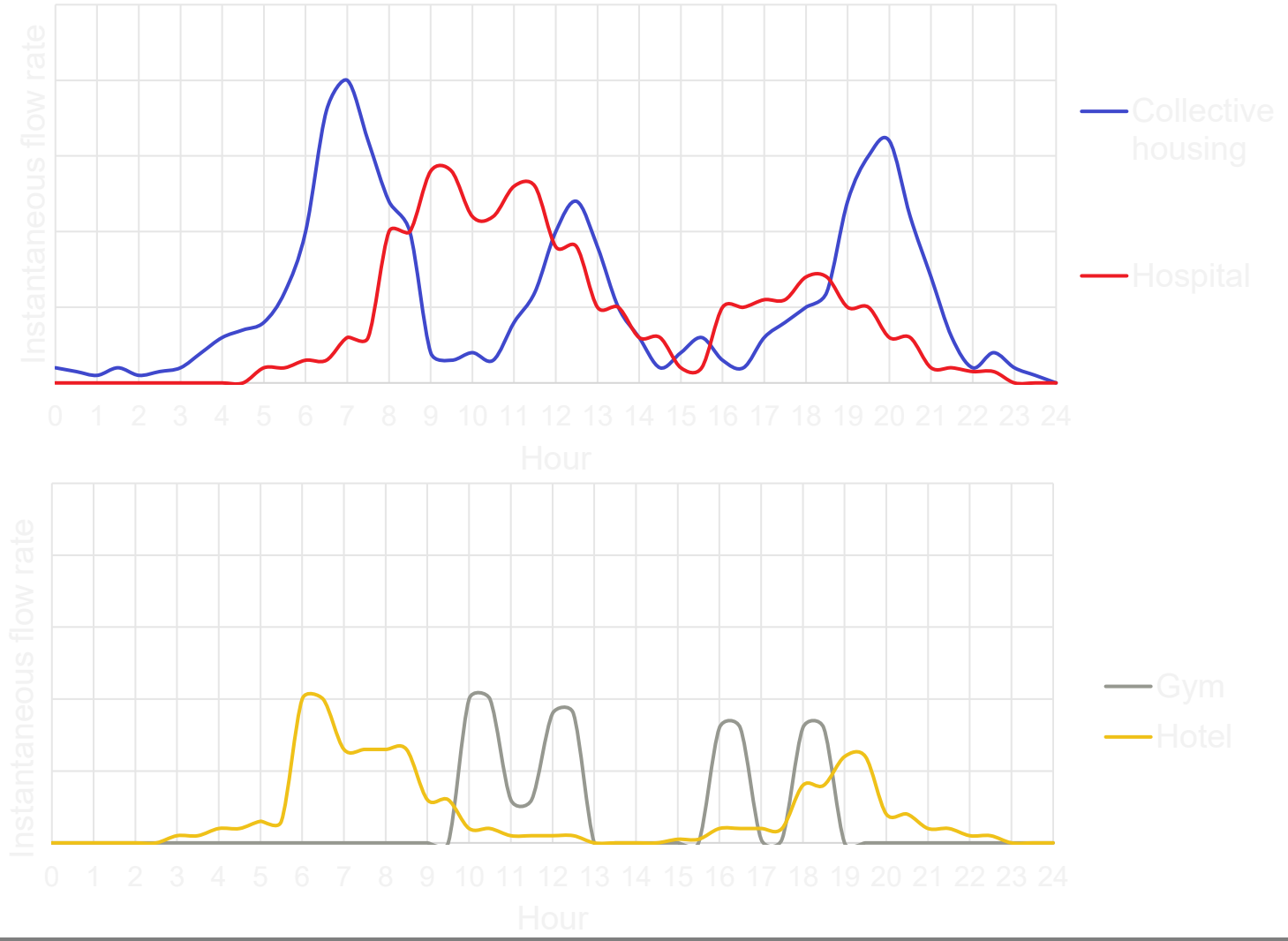


1. Introduction



What can be observed on this:

The consumed DHW volume is time dependent

The daily DHW volume consumed depends on the type of buildings

The maximum flow rate is time dependent and depends on the type of buildings

[Baeckeroot & Cadorcet,2011]

1. Introduction

The domestic hot water consumption depends on

Type of equipment


Sink


Shower

and if connected to DHW


Dishwasher


Washer

Type of buildings


Housing → Number of dwellings


Hotel → Number of rooms

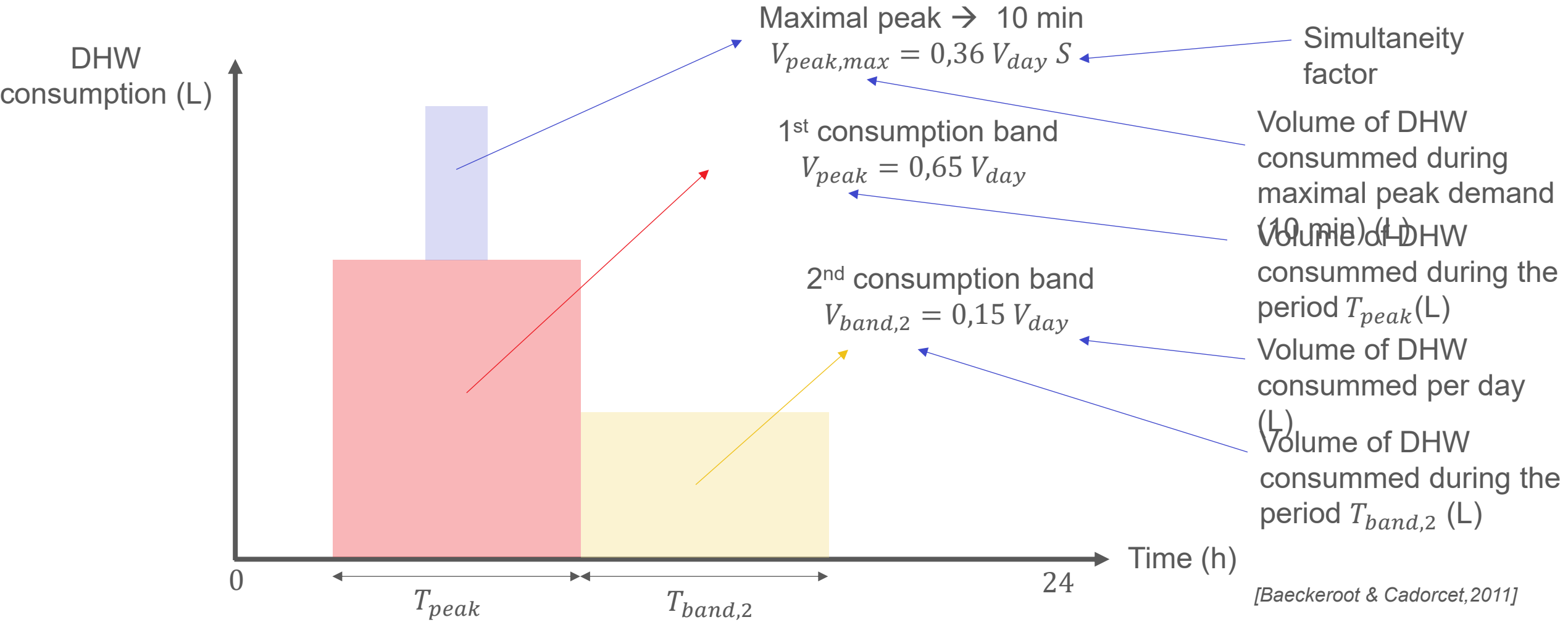

Office → Number of employees


Hospital/retirement home → Number of beds

Number of equipment (Module)

How to determine a building's DHW consumption ?

2. DHW consumption pattern



[Baeckeroot & Cadorcet,2011]

3. DHW water demands

DHW daily volume consumption (m^3)

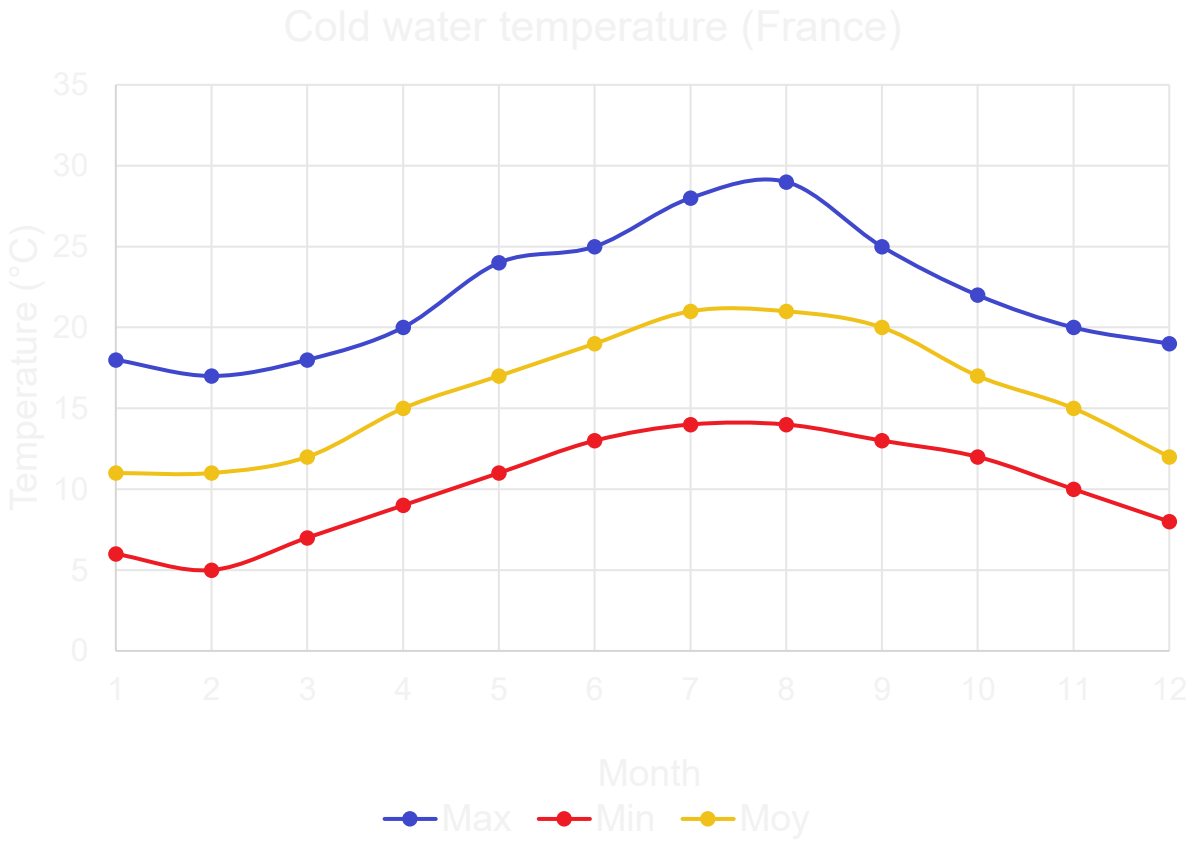
DHW temperature (55-60°C)

$$E_{DHW} = V_{day}\ Cp\ (T_{DHW} - T_{cw})$$

Daily DHW consumption (kWh)

Water specific heat ($kWh/m^3.K$)

Cold water temperature (°C)



3. DHW water demands

[Baeckeroot & Cadorcet,2011]

$$\dot{Q}_{DHW} = Cp\,(T_{DHW} - T_{cw})\,\frac{V - Ca}{\Delta t_{ref}}$$

Instantaneous DHW power (W)

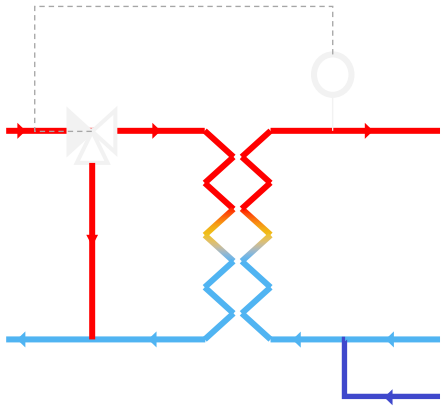
Drawing reference time (h)

Minimal DHW needs, V (m^3) during Δt_{ref}

Volume capacity of the stockage (m^3)

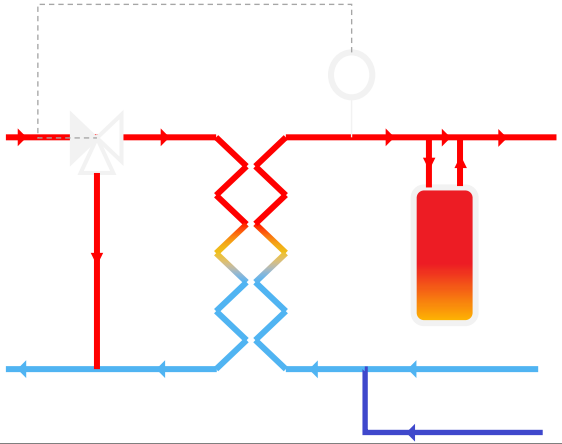
- Instantaneous

No storage tank
$Ca = 0\ m^3$



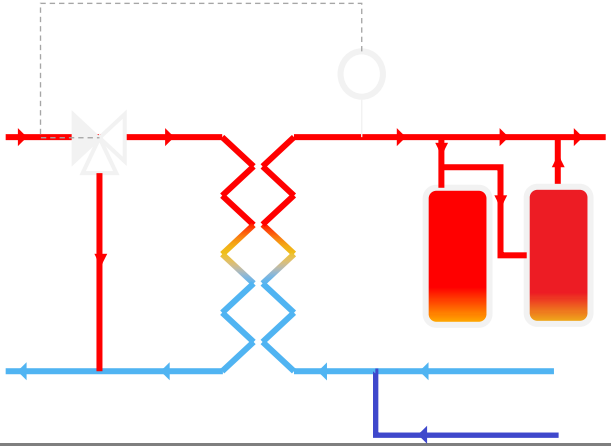
- Semi-instantaneous

Storage tank to cover the peak
$Ca = V_{peak,max}$, $\Delta t_{ref} = 10min$



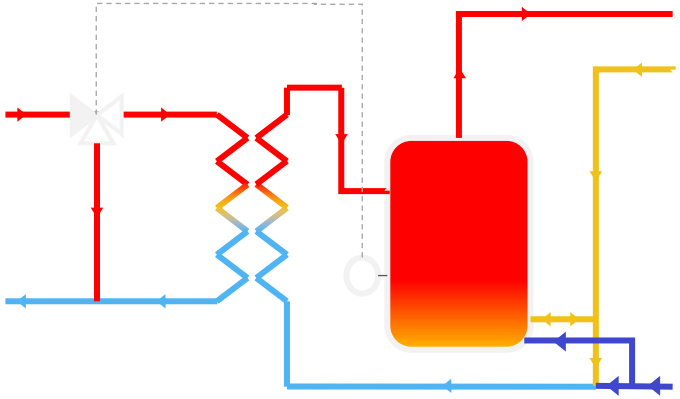
- Semi-accumulation

Storage tank to cover the period
$\Delta t_{ref} = T_{peak}$, $Ca = V_{peak}$



- Accumulation

Storage tank to cover the daily consumption $Ca = V_{day}$



4. DHW volume consumption

$$V_{day} = \sum V_m * N$$

Drawing point	Unit	Daily consumption (L)	Instantaneous flow rate (L/min)
Individual sink	1 Hot water tap	40	6
Collective sink	1 Hot water tap	120-240	3-6
Bathtub	1 Bathtub	120	20
Individual shower	1 Shower	80	15
Collective shower	1 Shower	300	10
Kitchen sink	1 Hot water tap	60	12
Dishwasher	1 meal	4	10 (per device)
Washer	1 Washer	200-340	25

[Baeckeroot & Cadorcet,2011]

4. DHW volume consumption

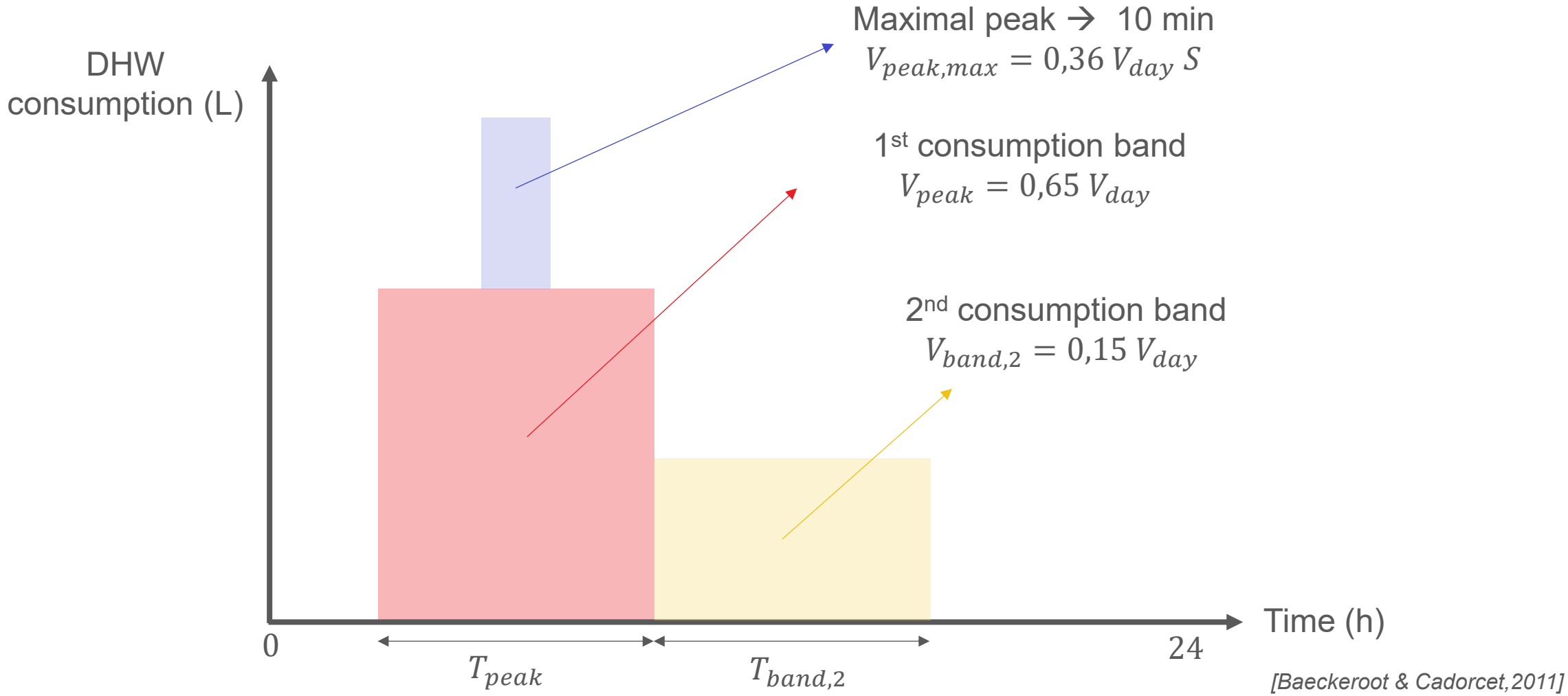
$$V_{day} = \sum V_m * N$$

A module is, for the DHW consumption, a set of drawing points likely to be used regularly by a group of identifiable people. For example:

Type of buildings	Module	Example	
Residential buildings	1 Dwelling	1 room flat 3 room flat	1 Shower + 1 kitchen sink 1 Bathtub + 1 kitchen sink + 1 individual sink
Hotels	1 Room	Hotel * Hotel ***	1 Shower 1 Bathtub
Office	10 employees		1 collective sink
Hospital	1 bed		

[Baeckeroot & Cadorcet,2011]

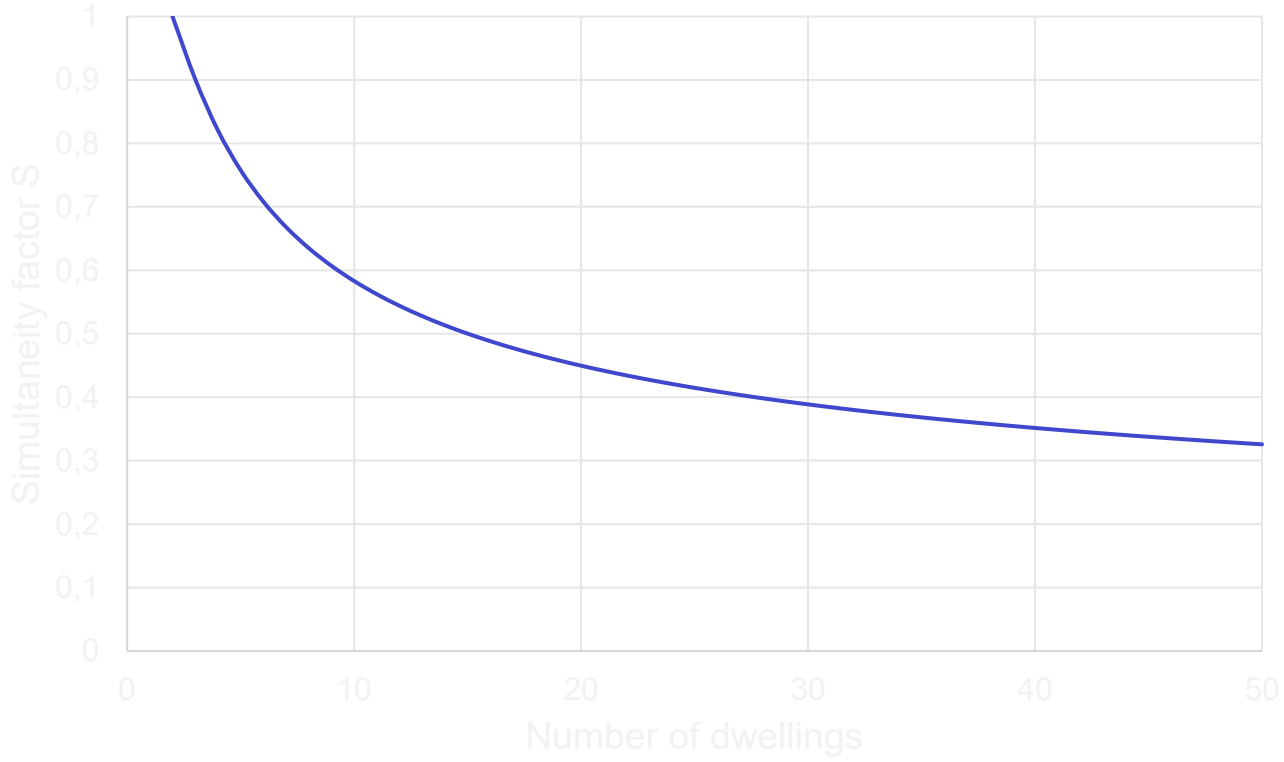
4. DHW volume consumption



[Baeckeroot & Cadorcet,2011]

4. DHW volume consumption

Usually in a building, the water draws do not occur at the same time. To not overestimate the DHW consumption a simultaneity factor must be taken into account



Residential buildings

$$S = \frac{1}{(N-1)^{0,3*i}}$$

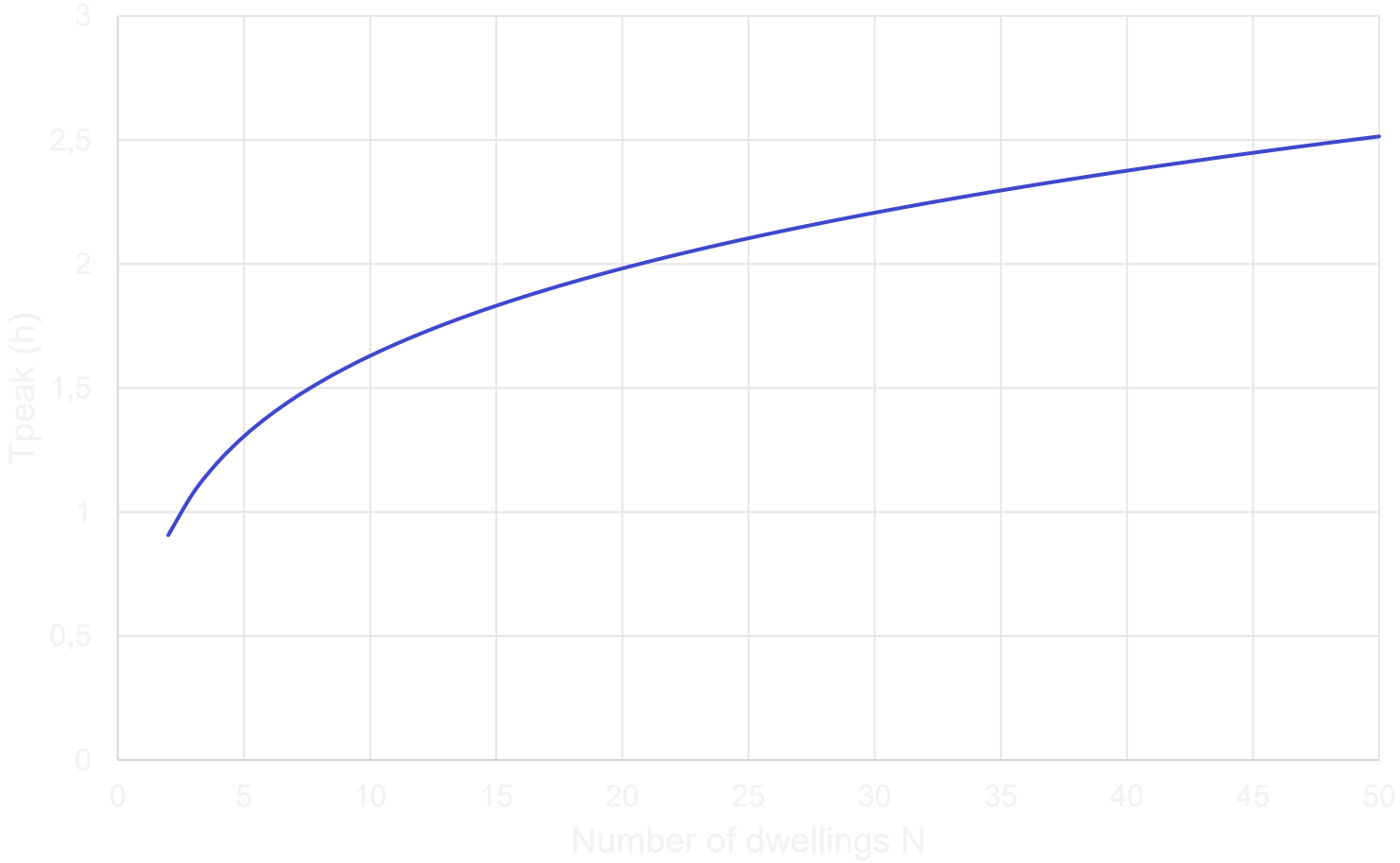
Hotel, Office, Hospital, …

$$S = \frac{1}{(N-1)^{0,2*i}}$$

With $i = \frac{N-1}{N+1}$

[Baeckeroot & Cadorcet,2011]

4. DHW volume consumption



Residential buildings

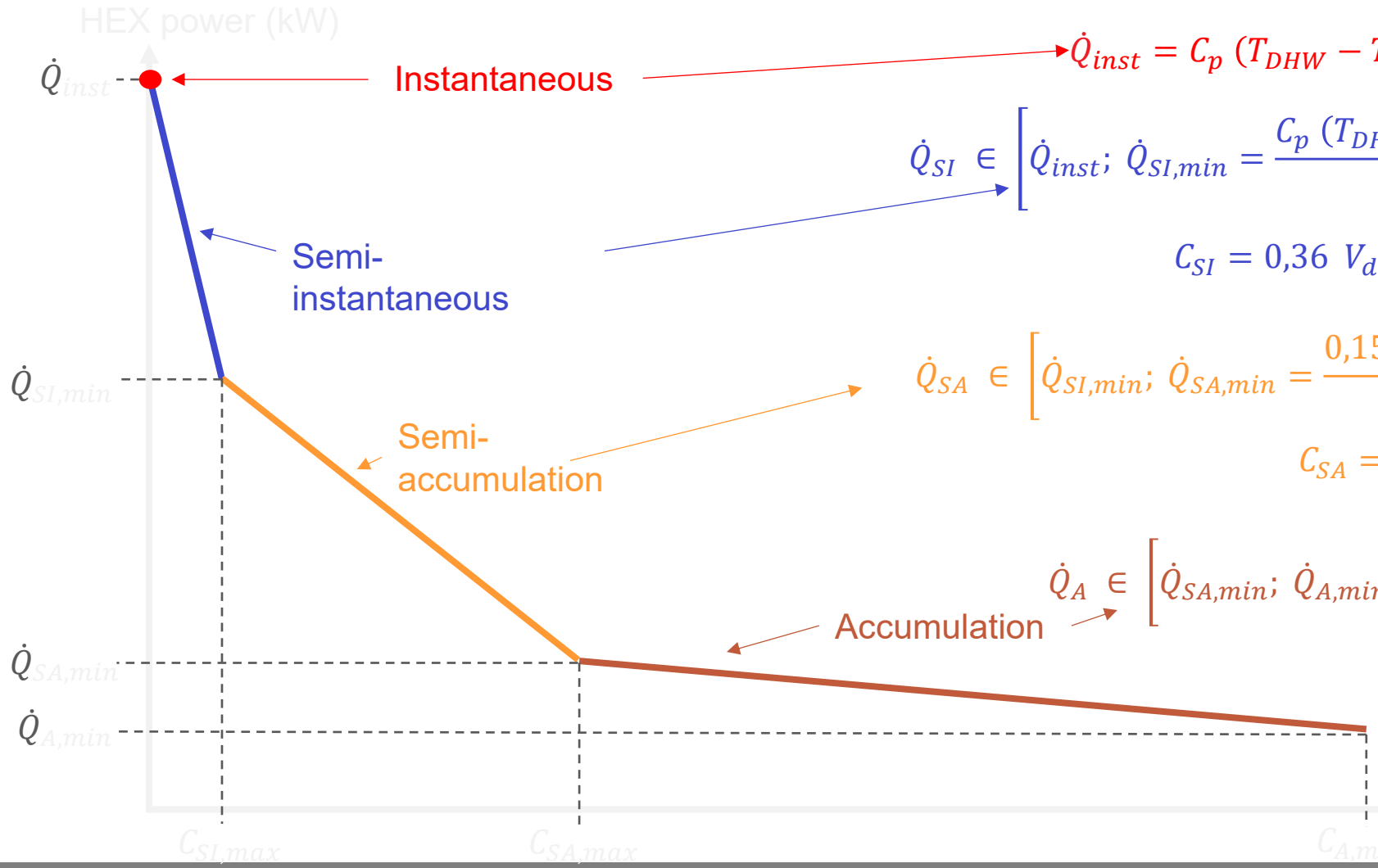
$$T_{peak} = \frac{N^{0,889}}{(N+1)^{0,65}}$$

Hotel, Office, Hospital, …

$$T_{peak} = \frac{N^{0,878}}{(N+1)^{0,7}}$$

[Baeckeroot & Cadorcet,2011]

4. Heating power vs tank capacity



$$\dot{Q}_{inst} = C_p\,(T_{DHW} - T_{CW})\,V_{day} \times 0{,}36 \times 6 \times S$$

$$\dot{Q}_{SI} \in \left[\dot{Q}_{inst};\ \dot{Q}_{SI,min} = \frac{C_p\,(T_{DHW} - T_{CW})\,V_{day}\,(0{,}65 - (0{,}36\,S))}{T_{peak} - 0{,}166}\right]$$

$$C_{SI} = 0{,}36\ V_{day}\,S\ - \frac{\dot{Q}_{SI}}{6\,C_p\,(T_{DHW} - T_{CW})}$$

$$\dot{Q}_{SA} \in \left[\dot{Q}_{SI,min};\ \dot{Q}_{SA,min} = \frac{0{,}15\,C_p(T_{DHW} - T_{CW})V_{day}}{T_{peak}} + recircu\right]$$

$$C_{SA} = 0{,}65\ V_{day}\ - \frac{\dot{Q}_{SA}\ T_{peak}}{C_p\,(T_{DHW} - T_{CW})}$$

$$\dot{Q}_A \in \left[\dot{Q}_{SA,min};\ \dot{Q}_{A,min} = \frac{C_p(T_{DHW} - T_{CW})V_{day}}{24} + recircu\right]$$

$$C_A \in \left[0{,}5\,V_{day}\,;V_{day}\right]$$

[Baeckeroot & Cadorcet,2011]

Bibliography

- Mode de calcul des installations d’eau chaude sanitaire, G. Baeckeroot & J-M. Cadoret, EDIPA, 2011

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Thank you!

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https://www.shakeproject-dhc.eu/

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