TUE Energy Center EIRES
Aquathermal energy: energy from water

SEEEP, 23 August 2022

EIRES

- Opening 31 August 2020 by state secretary Van Veldhoven
- Signing of MoU with VDL
- Bringing together TU/e research aimed at systems for energy conversion and storage
- Development of icon systems together with the high-tech manufacturing industry

EIRES EINDHOVEN INSTITUTE FOR RENEWABLE ENERGY SYSTEMS TU/e

DRIVING THE ENERGY REVOLUTION

Systems for Sustainable Heat

- Chairs: Silvia Gaastra-Nedea and Henk Huinink
- Focus on development of new materials and systems for heat storage and transport
- Icon project heat battery
- Partners:

TNO innovation for life

CALDIC

EVONIK Leading Beyond Chemistry

Fontys

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TRUDO

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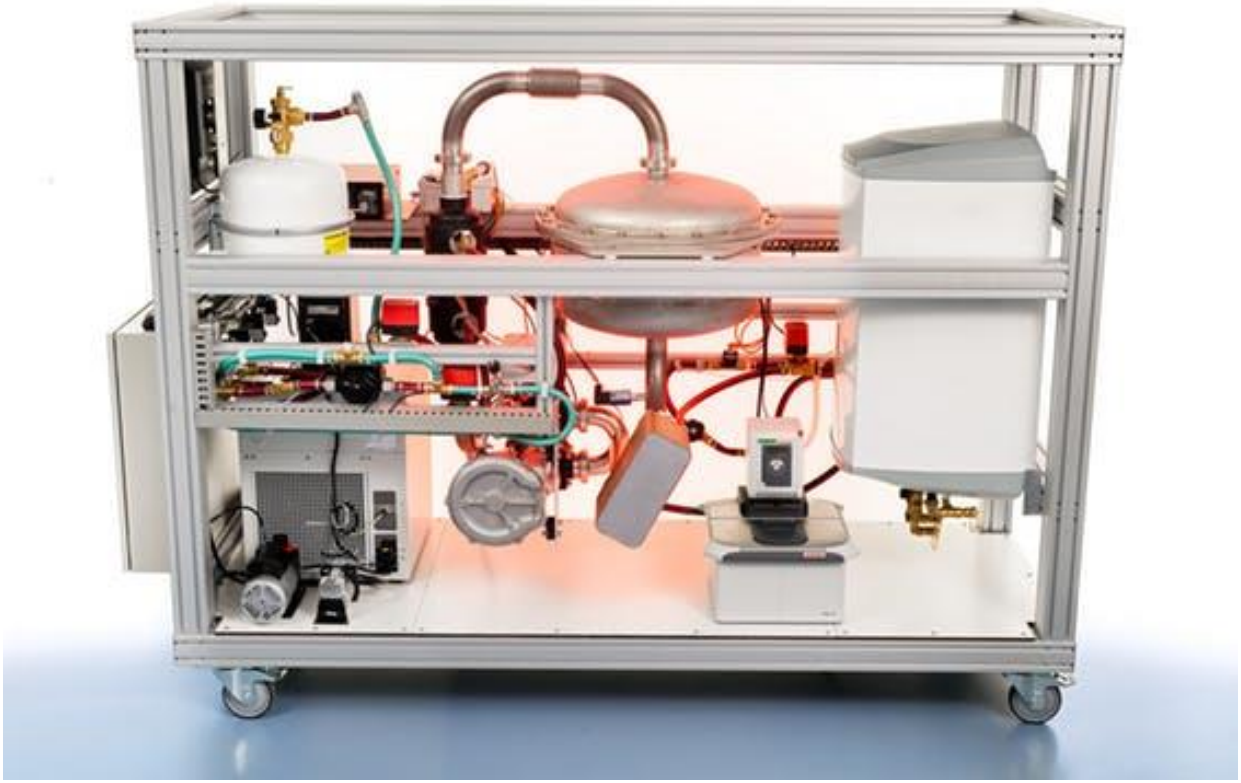
Icon project: heat battery

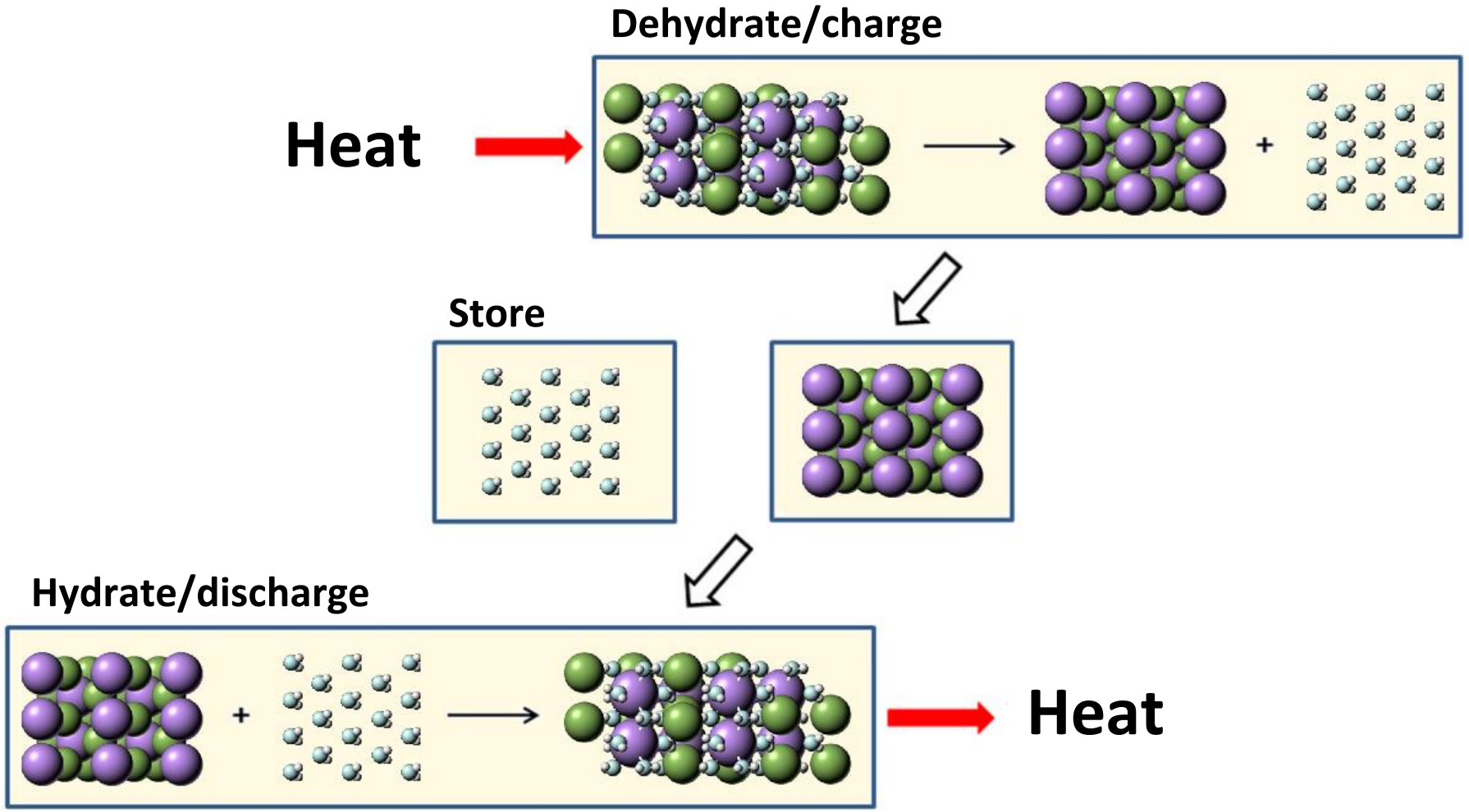
www.cellsius.com



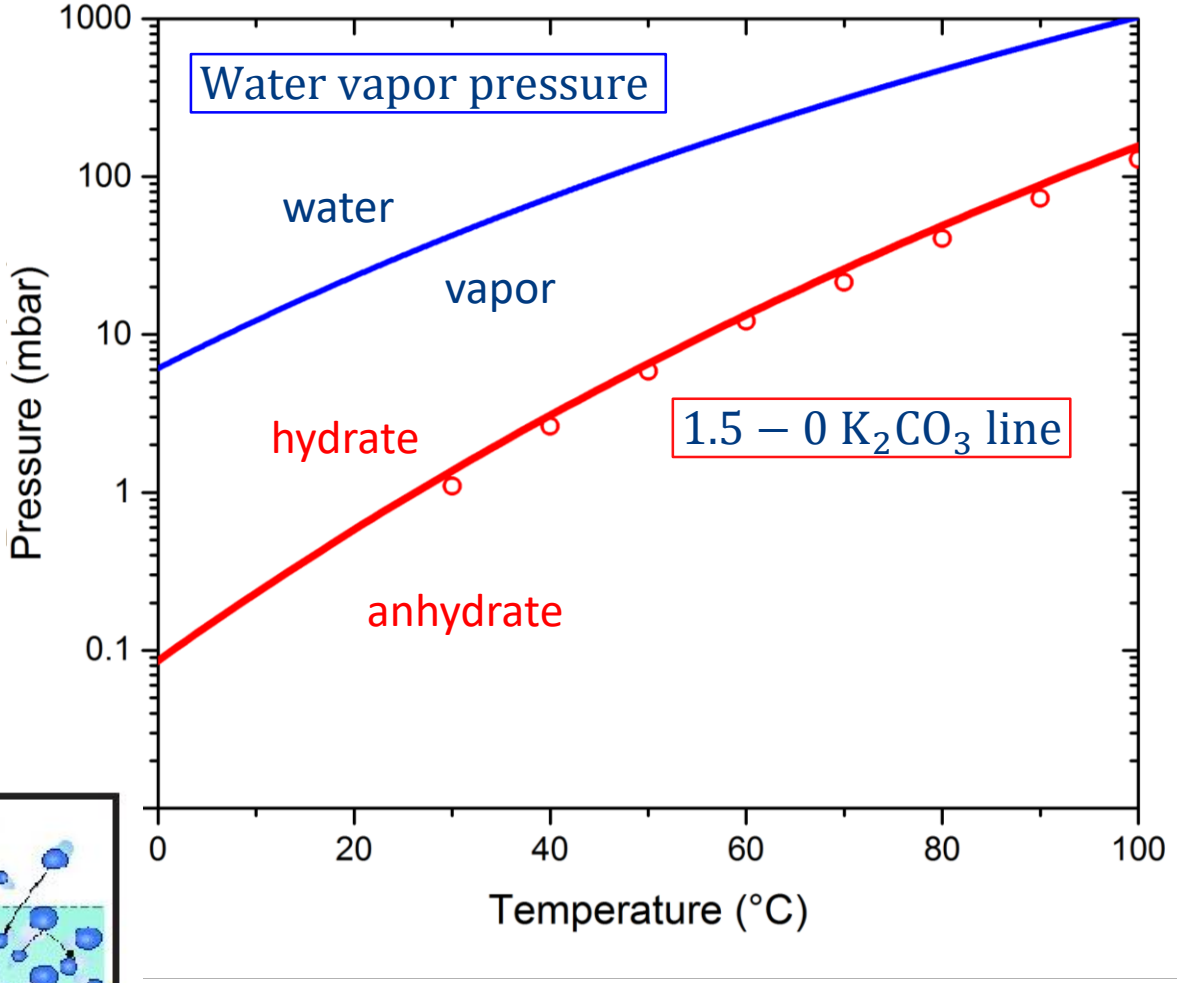
Transport industrial waste heat to residential buildings without pipeline losses

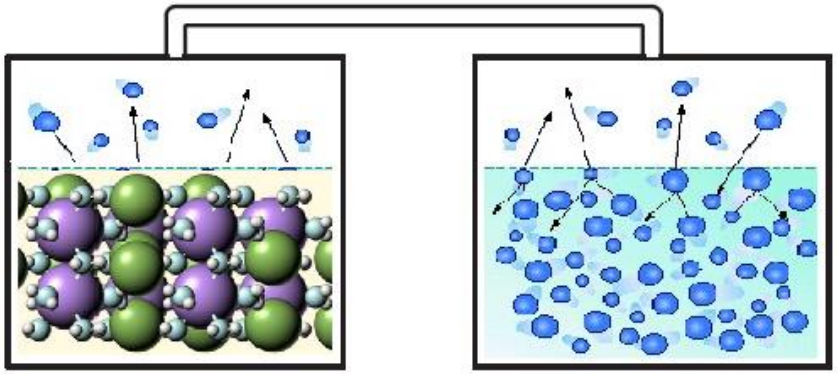
Thermochemical heat storage: Salt Hydrates (potassium carbonate)

$$\mathbf{K_2CO_3 \cdot 1.5\ H_2O} + \boldsymbol{Heat} \leftrightarrows \mathbf{K_2CO_3} + \mathbf{1.5\ H_2O}$$



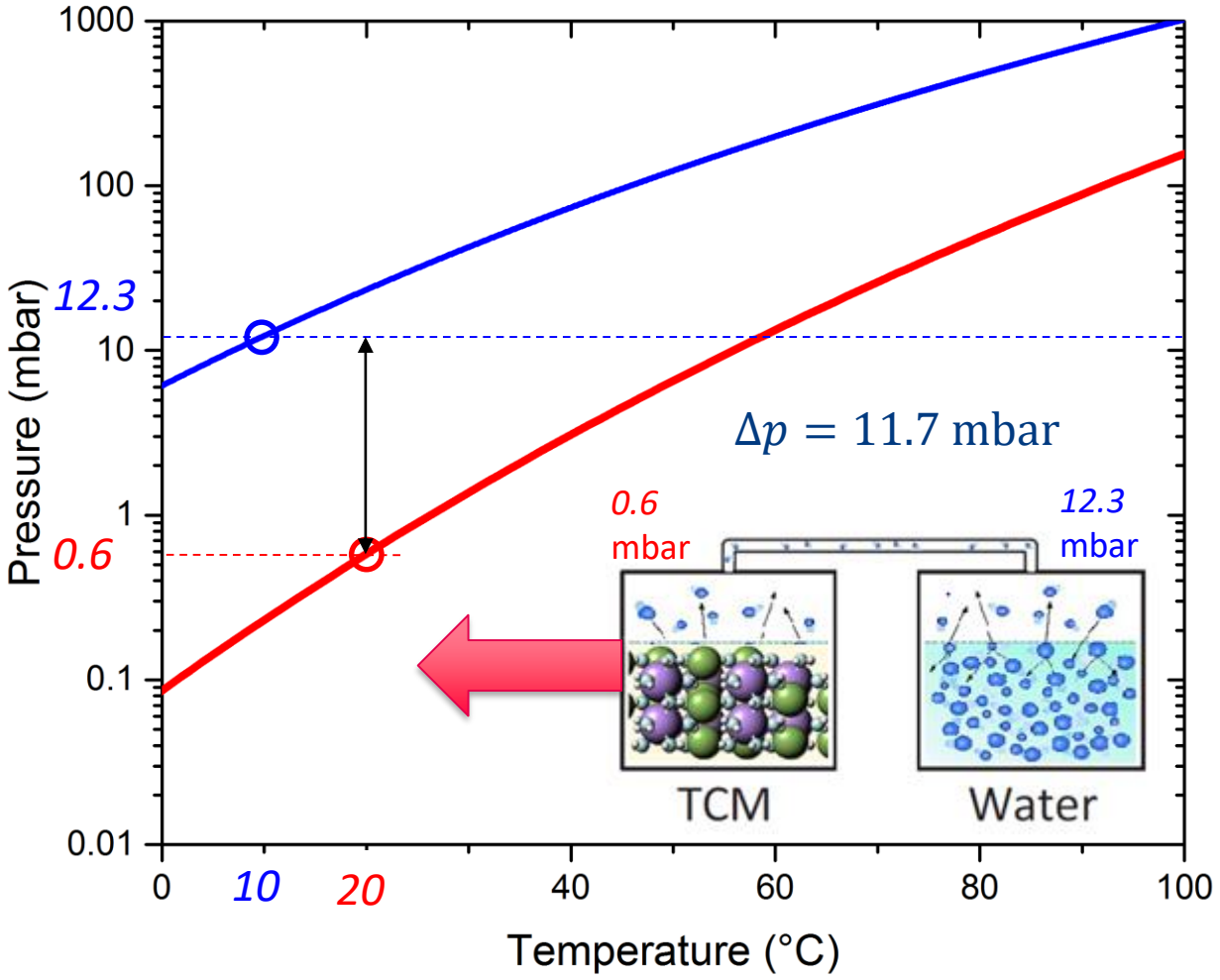
Equilibrium pressure lines



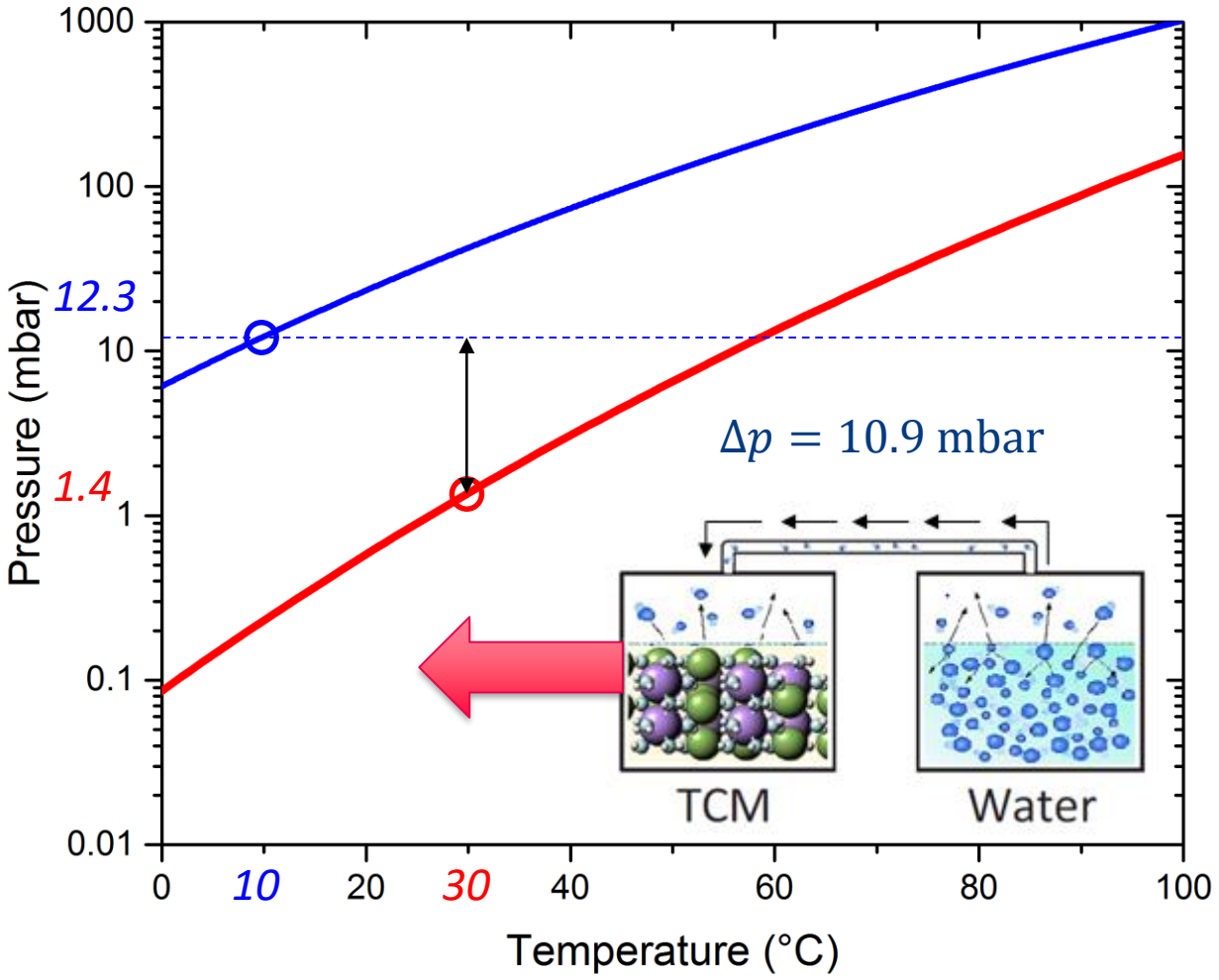


TCM Water

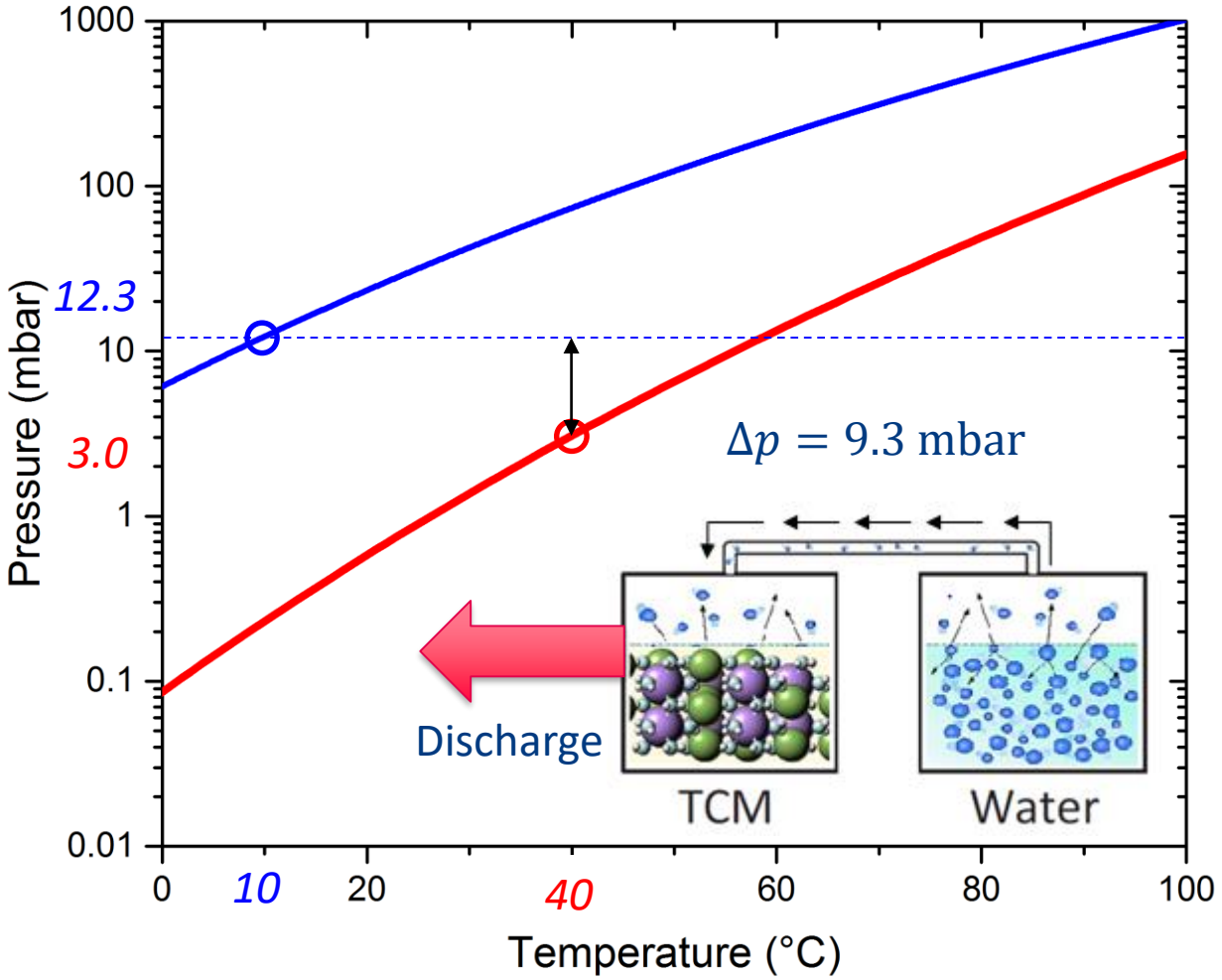
Hydration mechanism:



Hydration mechanism:



Hydration mechanism:



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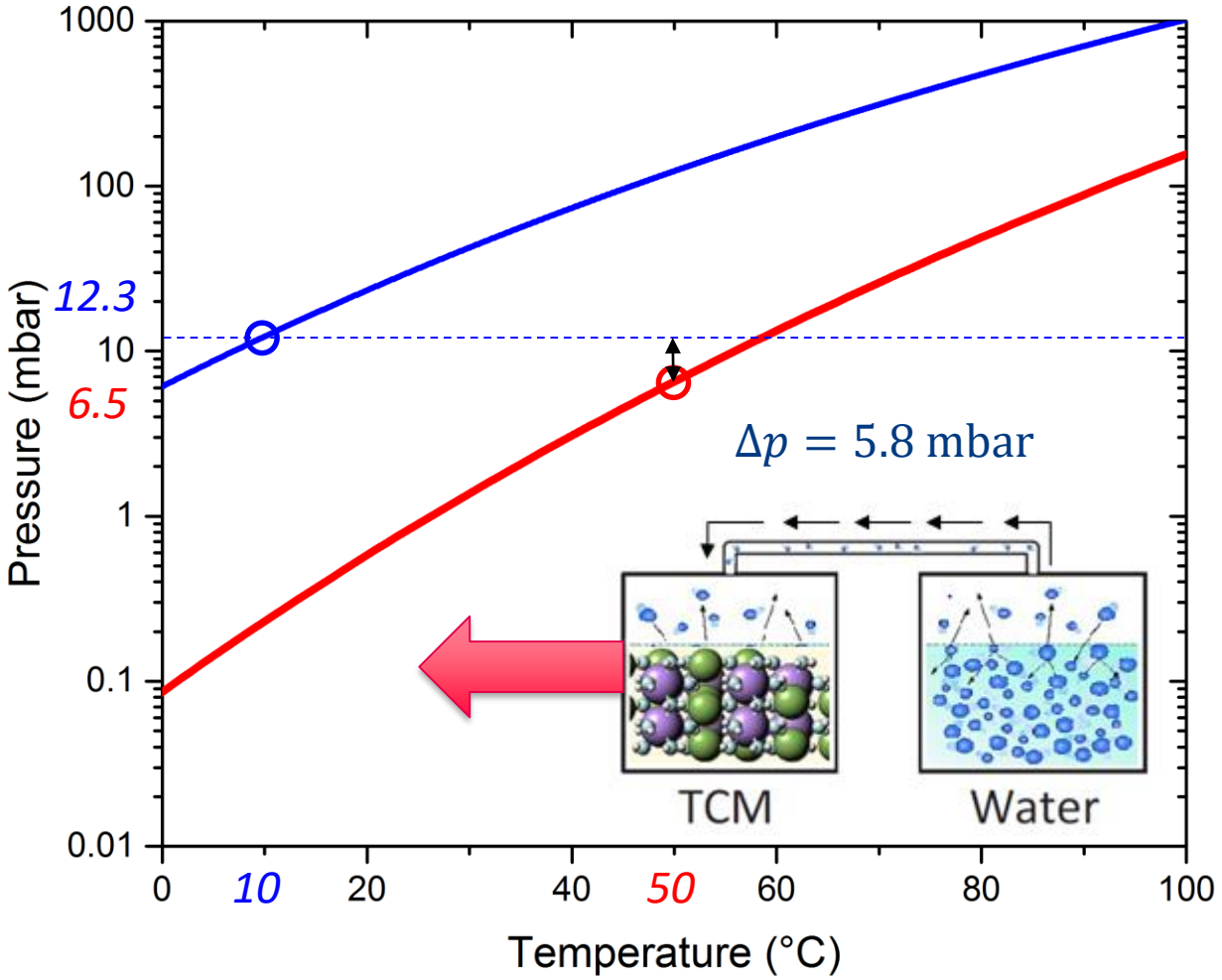
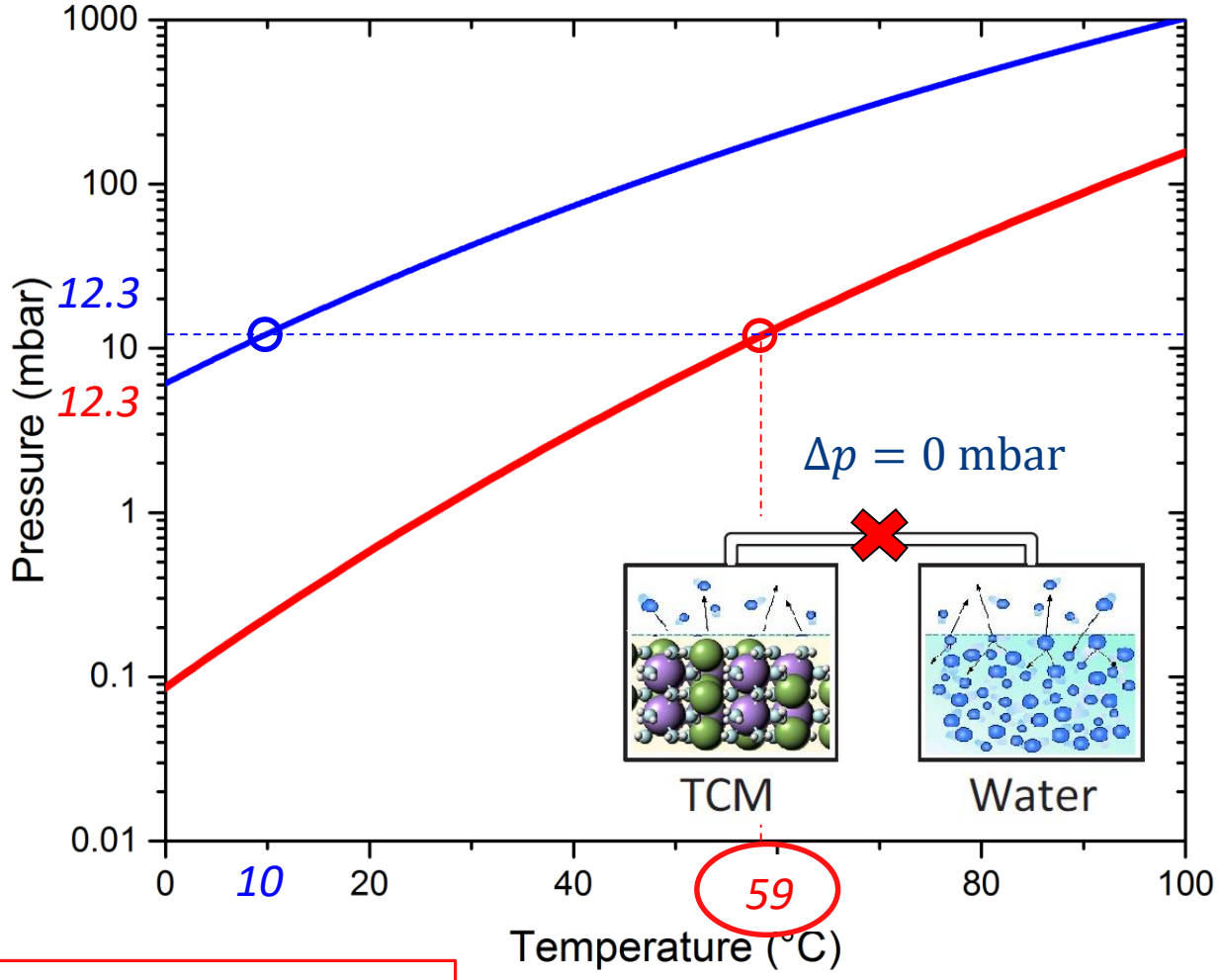


Hydration mechanism:



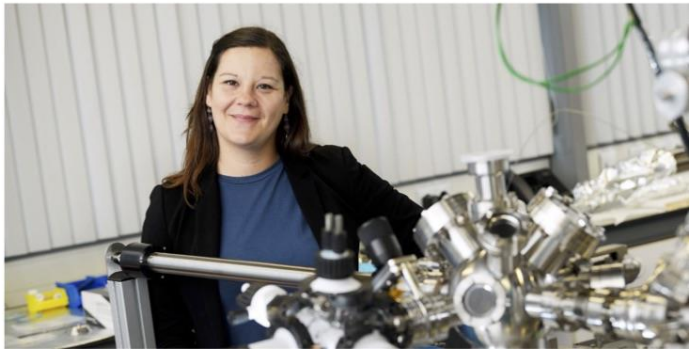
$T_{hydration}$ @ 10°C *water*

Heat storage materials

material	type	density (kg/m^3)	Energy density (kJ/kg)	energy density (MJ/m^3)	energy density (kWh/m^3)	Temperature
Water	SHM	1000	250	250	65	$\Delta T = 60\ ^0C$
Concrete	SHM	2400	10	24	7	$\Delta T = 12\ ^0C$
Water/ice	PCM	1000	330	330	92	$0\ ^0C$
Sodiumacetate in water	PCM	1300	175	228	63	$52\ ^0C$ (onderkoeling)
Paraffines and salt hydrates	PCM	540-765	149-260	80-200	22-56	$7\text{-}85\ ^0C$
Sunamp PCM 58	PCM		229	148	41	$58\ ^0C$
Sugar alcohols	PCM	1200	200-300	240-360	67-100	$70\text{-}180\ ^0C$
Zeolite	sorption			360	100	$< 100\ ^0C$
$MgCl_2 – CaCl_2$	TCM	1569-1710		490-1250	136-347	$< 100\ ^0C$
SaltX	TCM	(1600)	1450	(2300)	(640)	$500\ ^0C$
gasoline	chemical				10,000	combustion

Chemistry for Sustainable Energy Systems

- Chairs: Marta Costa Figueiredo and Adriana Creatore
- Focus on materials and structures to improve the performance of (electro)catalysts
- Icon project Dutch Electrolyzer
- Partners:



Systems Integration

- Chairs Lisanne Havinga and Guus Pemen
- Focus on modeling the production, conversion, and storage of renewable energy
- Icon project Deep Digit (tbc)
- Partners:

WOONinc.
EINDHOVEN
alliander
ENEXIS
ENERGIE IN GOEDE BANEN
Q box
TRUDO
ennatuurlijk
Energiedak
TU Delft
VoltaSolar
CONICO VALVE TECHNOLOGY
De Beijer RTB B.V.
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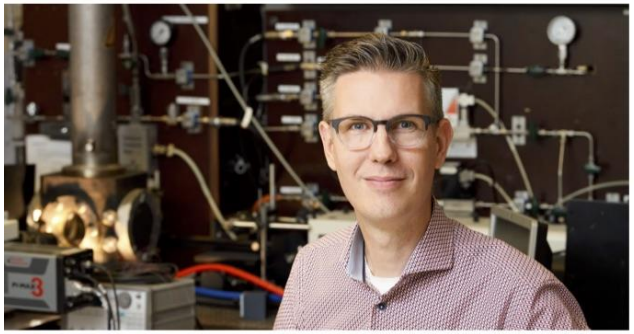


Engineering for Sustainable Energy Systems

- Chairs Niels Deen and John van der Schaaf
- Focus on the design and testing of technical solutions for sustainable energy storage and conversion
- Icon project metal fuels
- Partners:

metalot

FLOWID

uniper

nyrstar

TEAM SOLID

Provincie Noord-Brabant

Shell

HEATING & COOLING: 50% OF EU28 TOTAL FINAL ENERGY DEMAND

Europe consumes **half of its energy** for heating and cooling purposes.

Most of this thermal energy is used in buildings and industry.

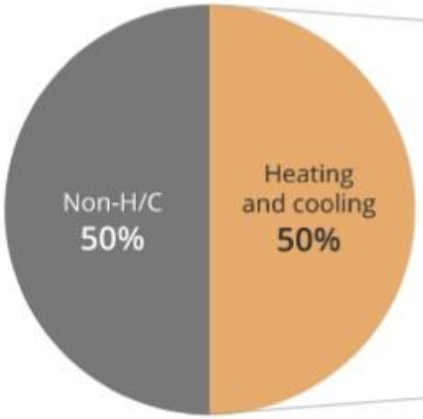


Figure 1:
Total final energy in 2015 (EU28)

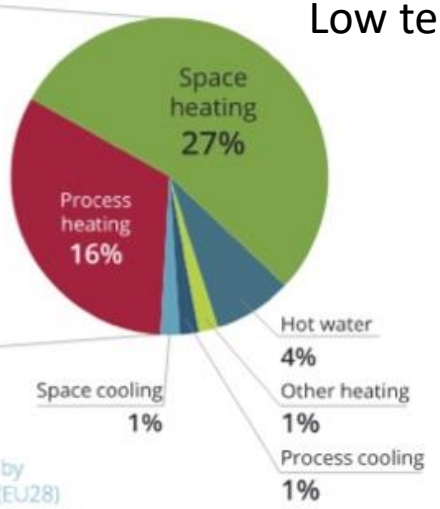


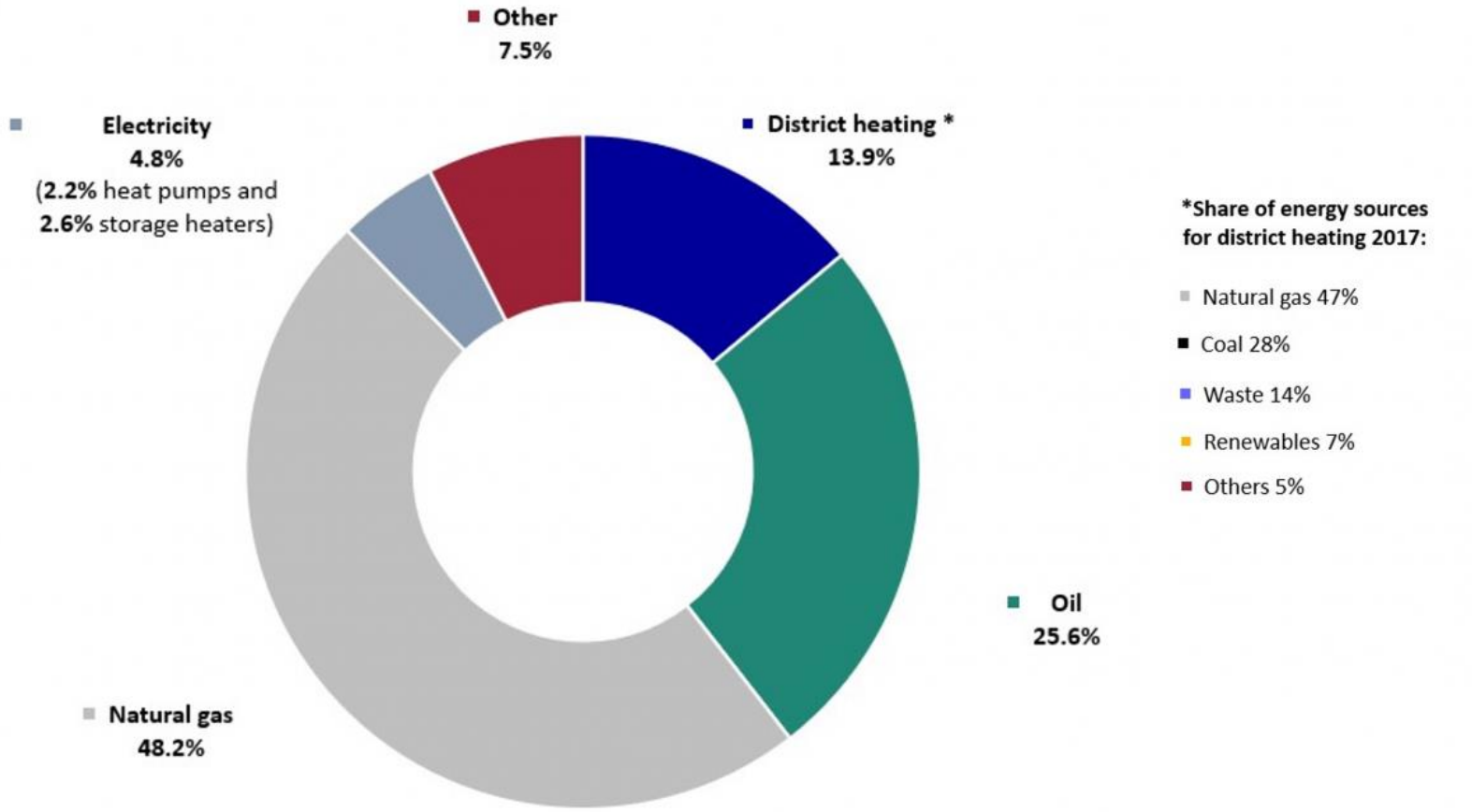
Figure 2:
H&C final energy by end-use in 2015 (EU28)

Low temperature

Sources of heating in German homes, 2019.

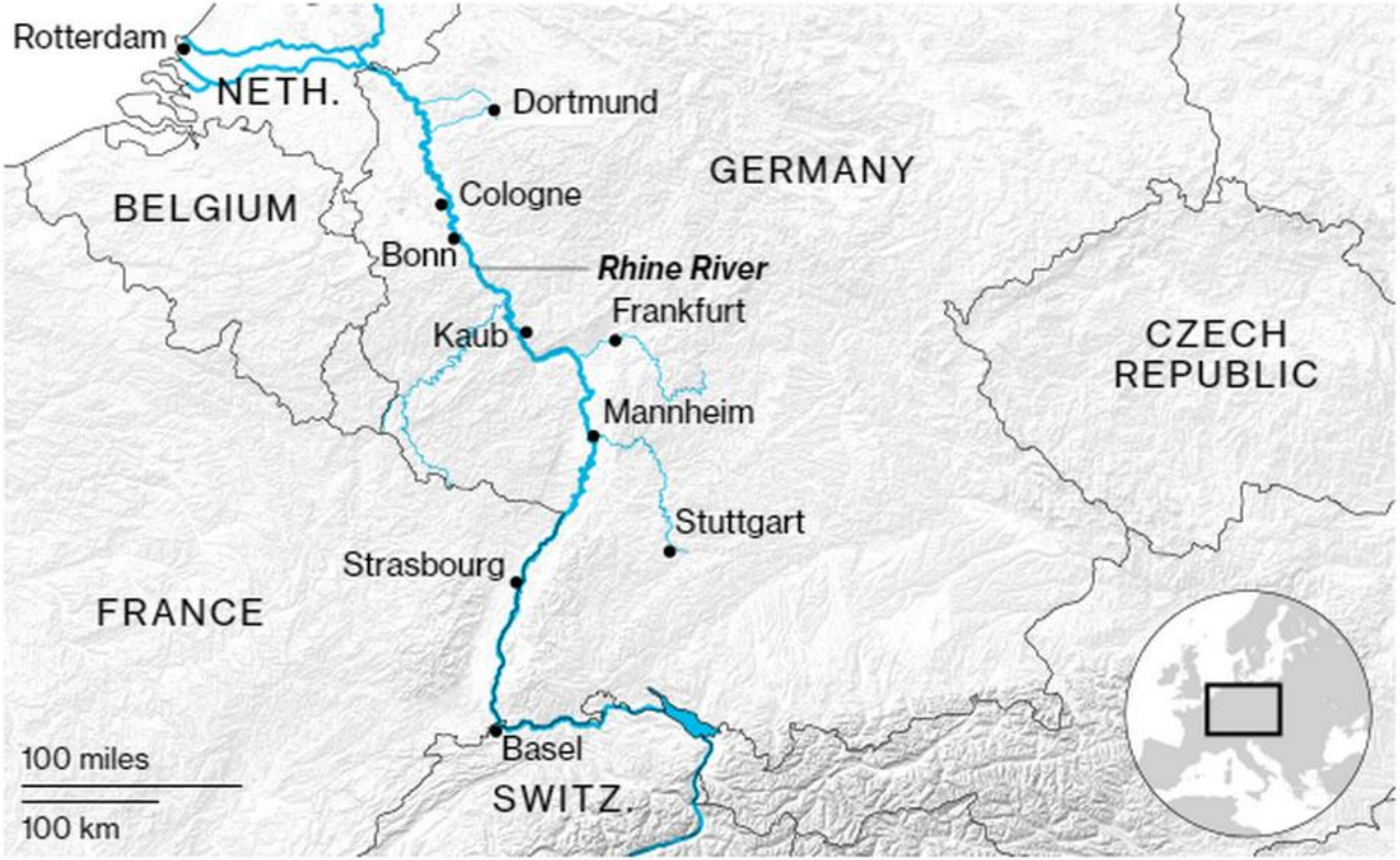
Data: BDEW, 2019/Destatis, 2018.

CLEAN ENERGY WIRE



Economic Lifeline

The Rhine links German and Swiss industry with Rotterdam, Europe's biggest port



Sources: CORINE Land Cover, Natural Earth

Photo: Boorsma BV

River Rhine: 2200 m3/s = 2.2 million kg water per second, velocity 2.2 m/s

‘Collse watermolen’, painted by Van Gogh

Kinetic energy:
4,4 MW (200 keer less than 1 traditional power plant)

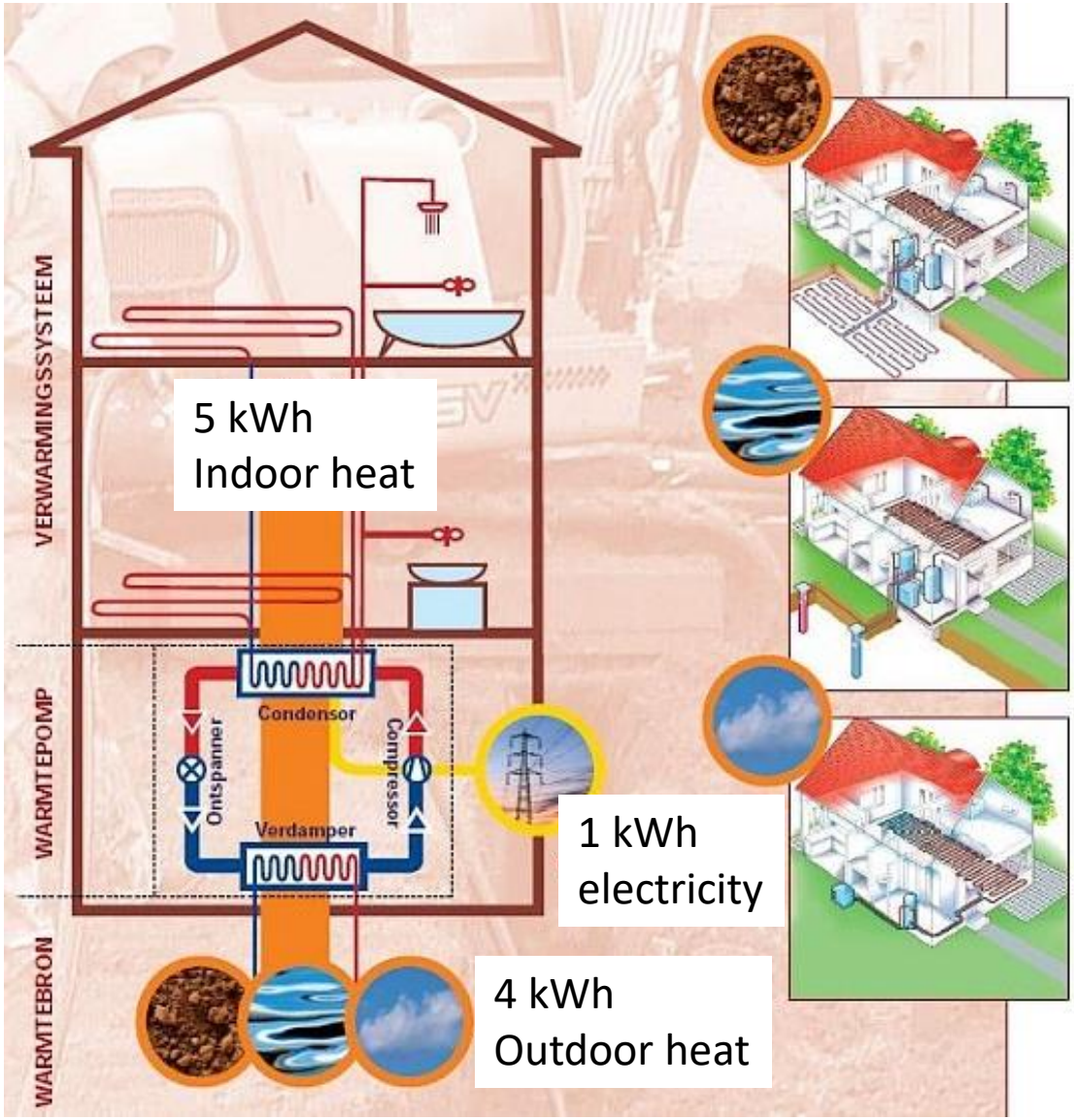
Waterkrachtcentrale Maurik. Photo Hendrik Heuvelrug

Potential energy with 4 m height difference:
88 MW (10 times less than 1 traditional power plant)

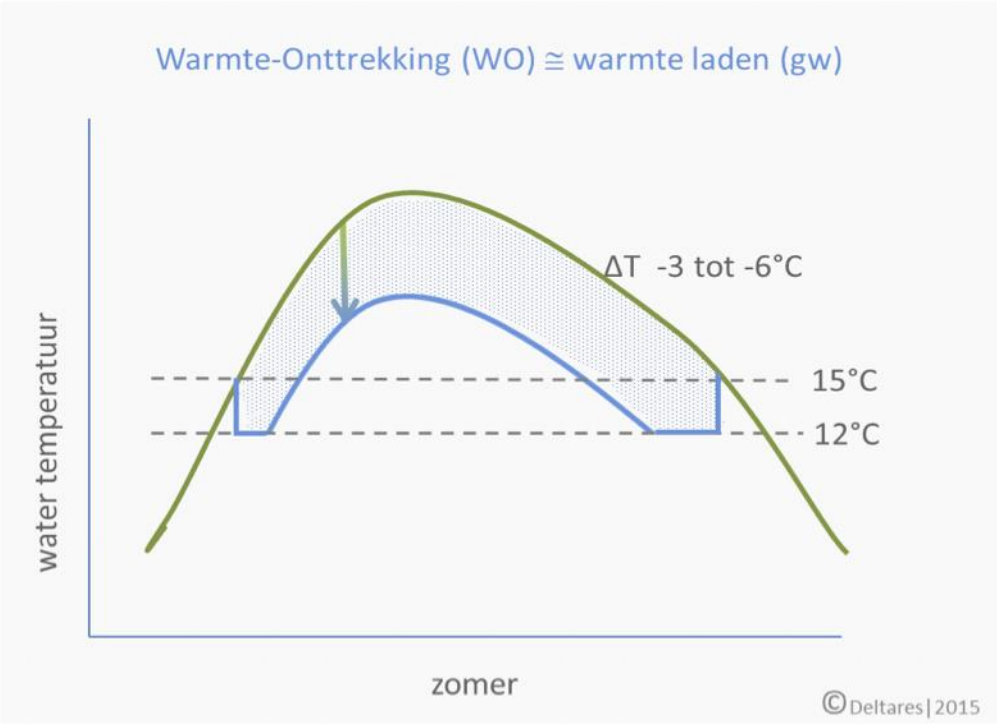
Photo: Boorsma BV

Cool down 1 degree: 9,2 GW (10 times more than 1 traditional power plant)

Heat pump with COP 5: efficiency = 500 %



Heat-extraction regulations

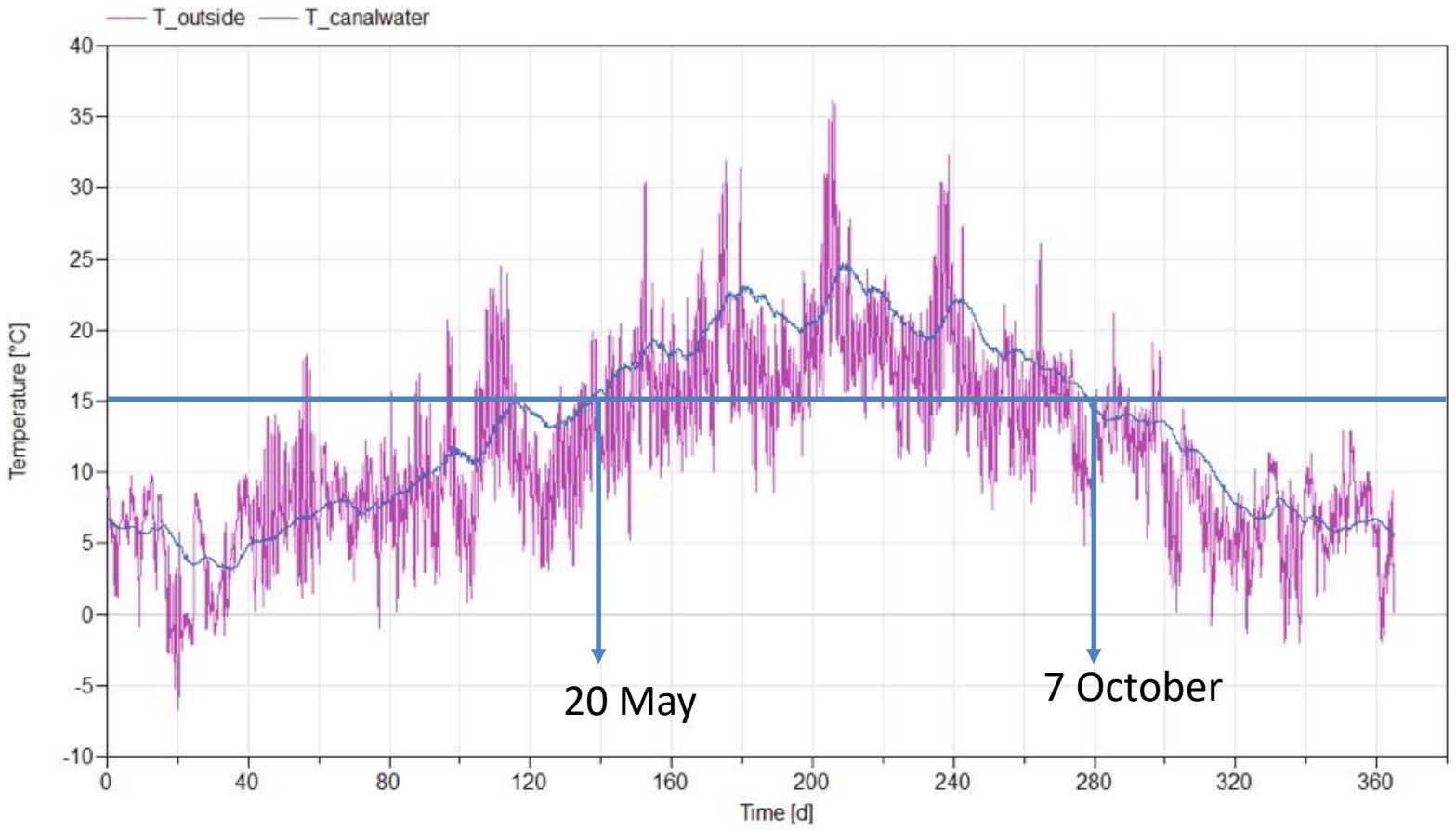


Only above 15 ^{0}C water temperature

Water temperature not cooled down below 12 ^{0}C

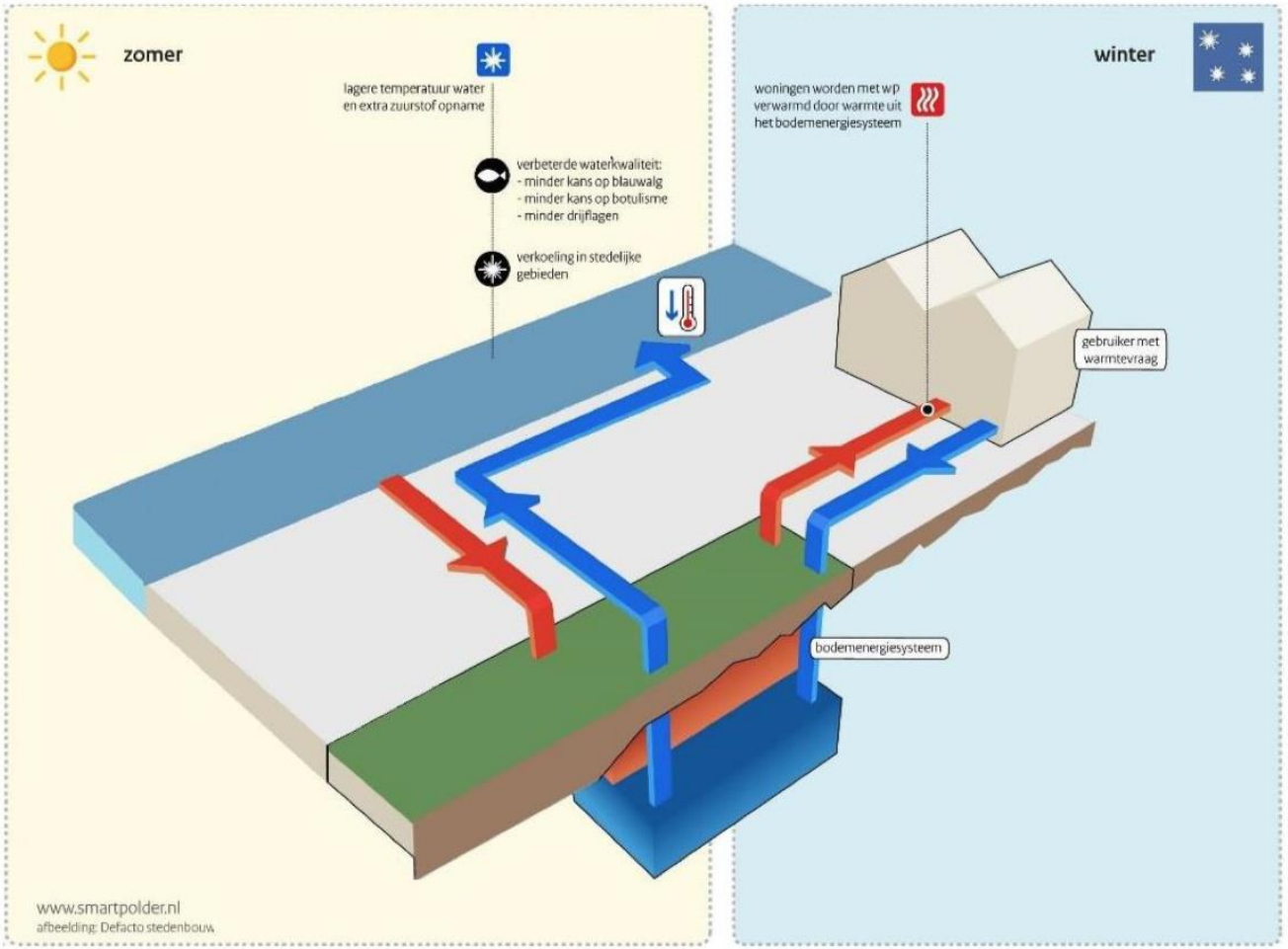
ΔT water max 6 ^{0}C

air- and water temperatures 2019



Storing heat for winter (ATES system)

Figuur 2 - Schematische weergave van TEO

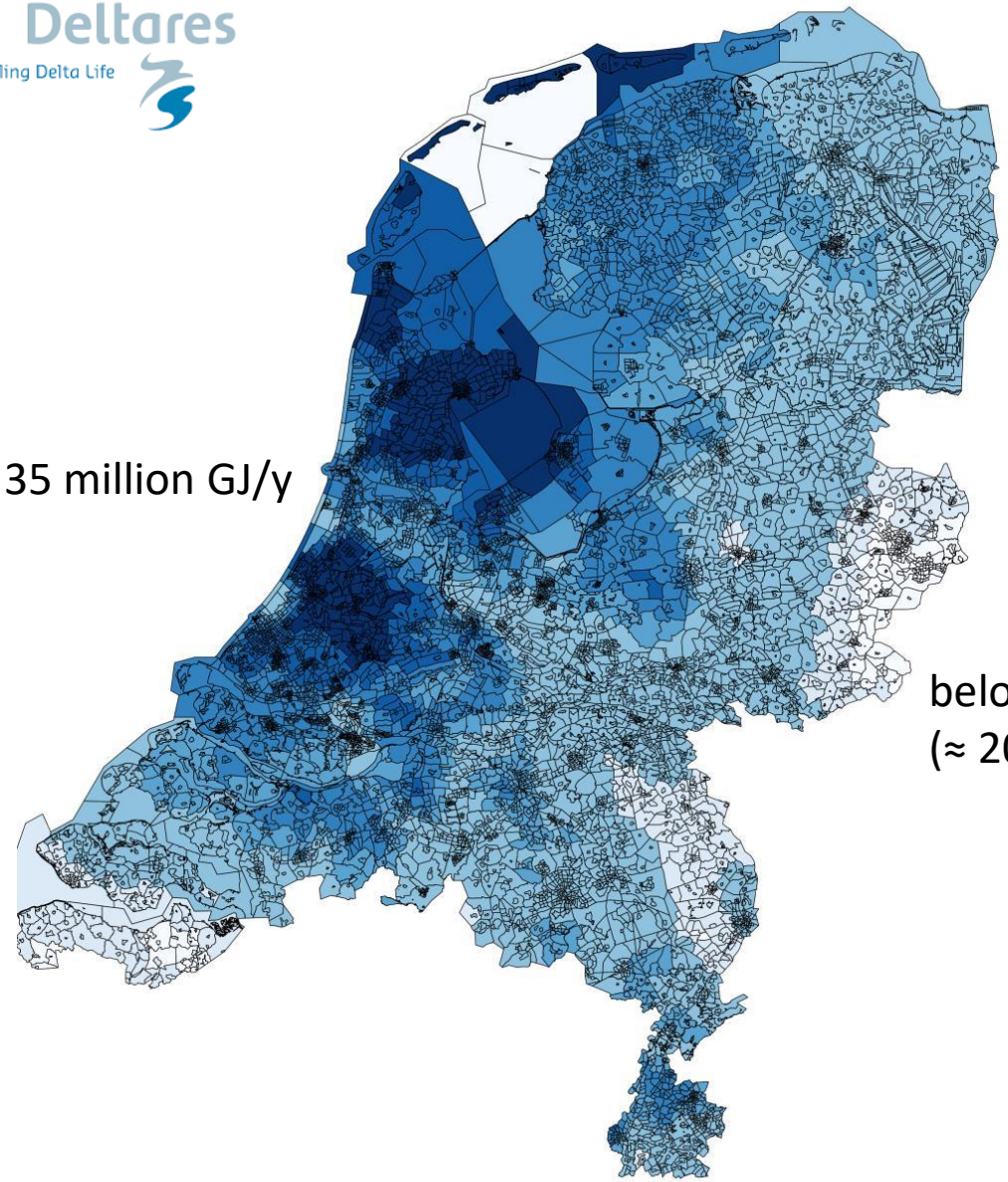


Bron: (IF Technology, 2017).

ATES potential

Deltares
Enabling Delta Life

more than 35 million GJ/y

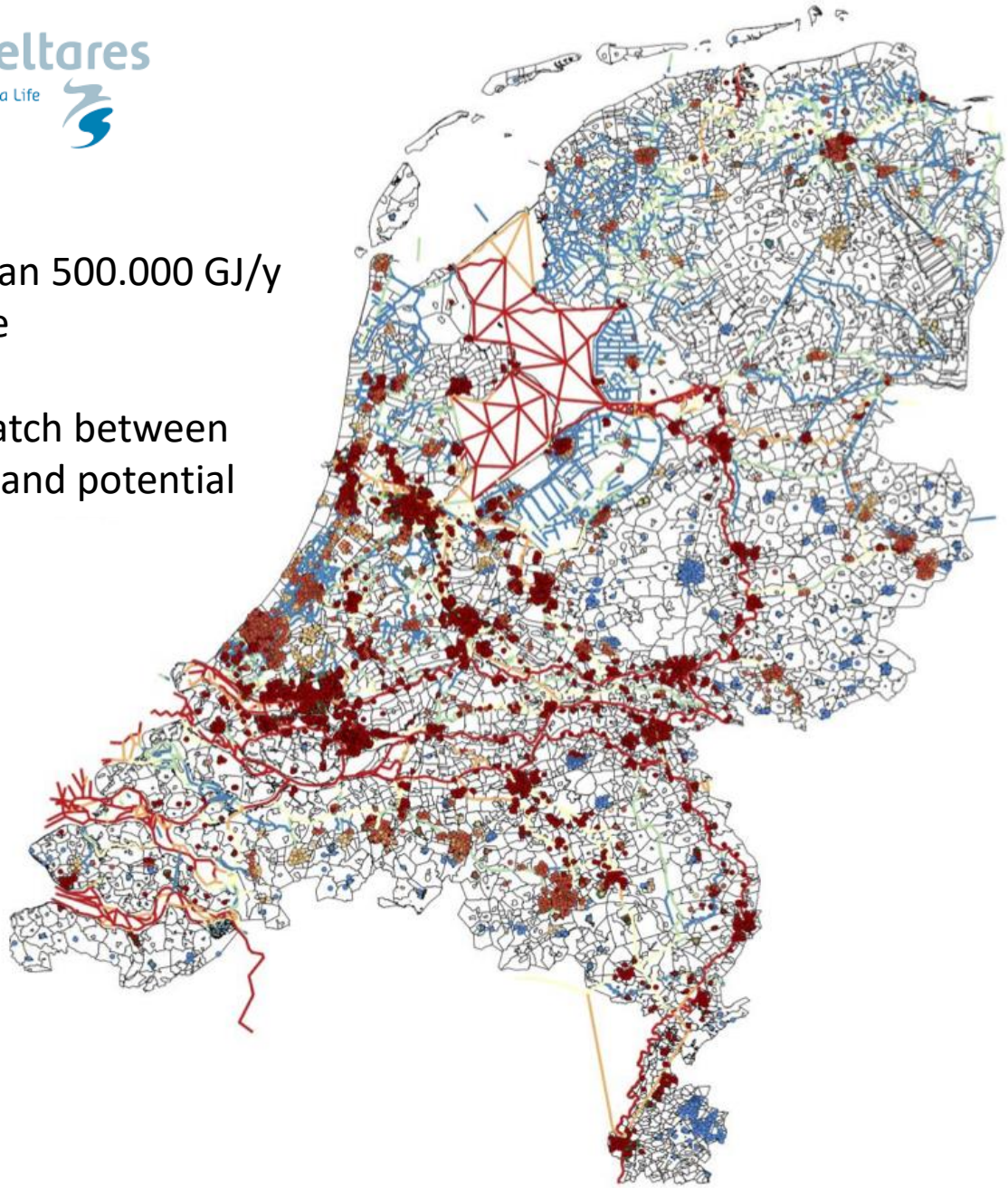


below 1 million GJ/y
(≈ 20.000 houses)

Deltares
Enabling Delta Life

--- : more than 500.000 GJ/y available

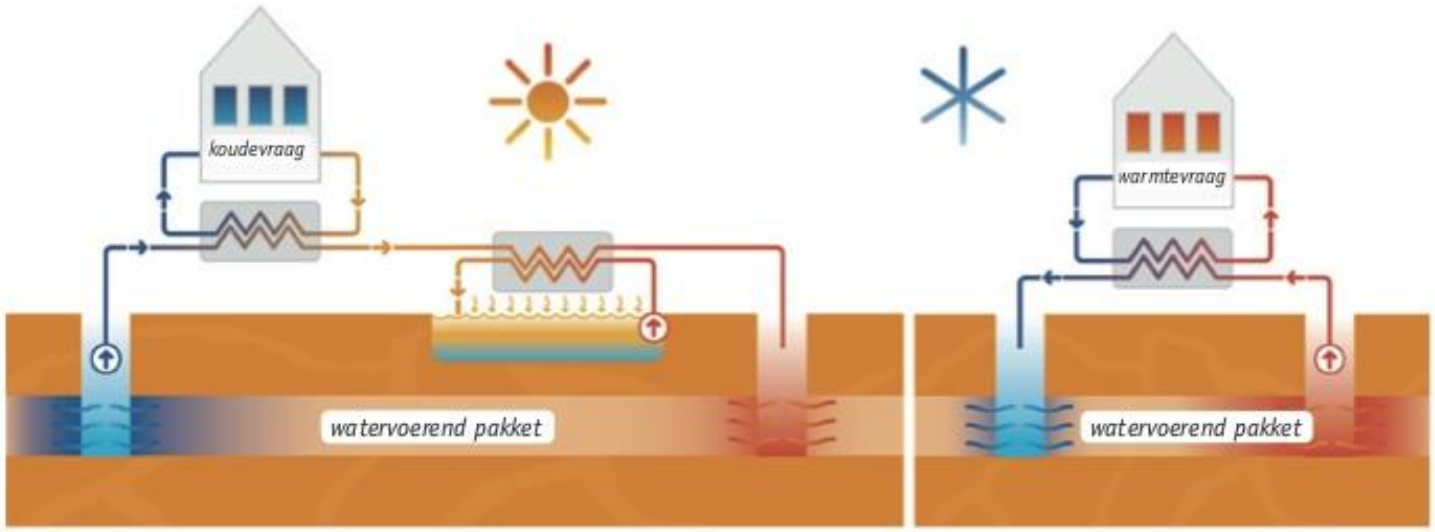
● : 100% match between demand and potential



Balancing ATES : resupplying the soil with aquathermal energy

Summer: heat soil;
Cool house

Winter: cool soil;
heat house



Importance of aquathermal solutions

Tabel 4 - Potentieel TEO voor de gebouwde omgeving

	Warmtevraag woningen en utiliteit	Geschikt voor warmtenetten	TEO mogelijk per buurt	TEO mogelijk gezamelijk	% van totaal	% van geschikt voor warmtenetten
	[PJ]	[PJ]	[PJ]	[PJ]		
Huidig	498,8	333,7	267,1	199,8	40,1%	59,9%
In 2050	349,2	233,6	189,2	151,5	43,4%	64,8%

Source: CE Delft

Pilot project ‘de Zweth’ near Delft

TU Delft

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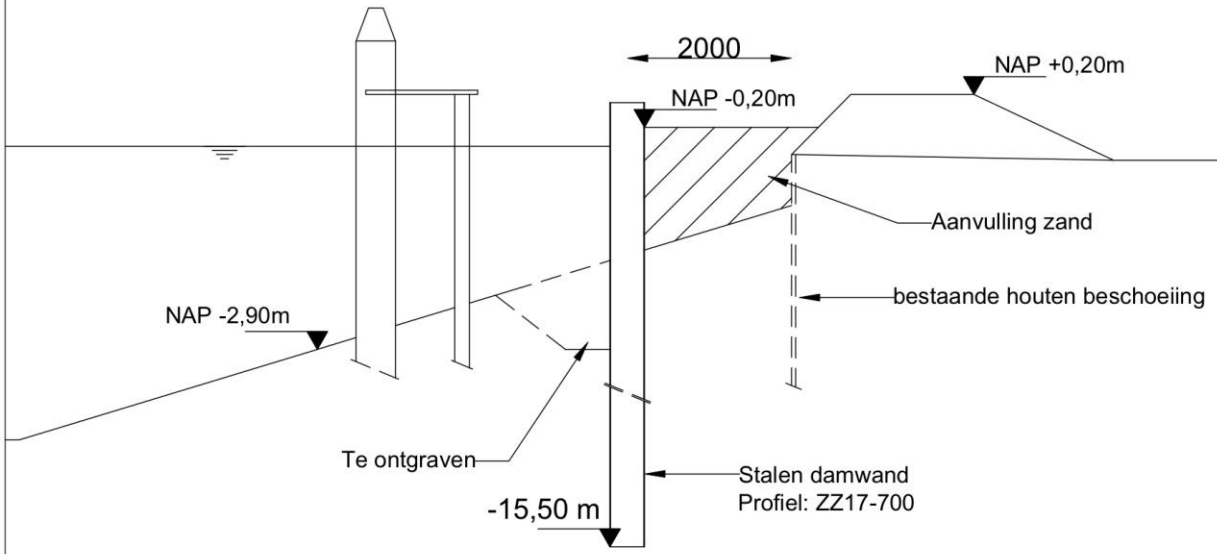
duurzaam Opgewekt energiesystemen

Energy quay ‘de Zweth’ near Delft



0 2,5M

B				
A				
Nr.	Datum:	Wijziging:	Getekend	Controle

Opdrachtgever: RVO
Project: RVO SBIR proef energie damwand
Onderdeel: Dwarsdoorsnede
Projectnr.: 19498
Tekeningnr.: 3

CRUX
Pedro de Medinalaan 3c
1086 XK Amsterdam
T: +31 (0)20 4943070
E: info@cruxbv.nl
I: www.cruxbv.nl

Tekenaar: Roo
Adviseur: Jon
Status: Def
Schaal: 1:50
Datum: 4-02-2020
Formaat: A3
Afdeling: Geo
Bladnr.: 1

Pilot project quay walls Amsterdam

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TU Delft

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Pilot project Theme Park ‘De Efteling’

Efteling
WERELD VOL WONDEREN

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Enabling Delta Life

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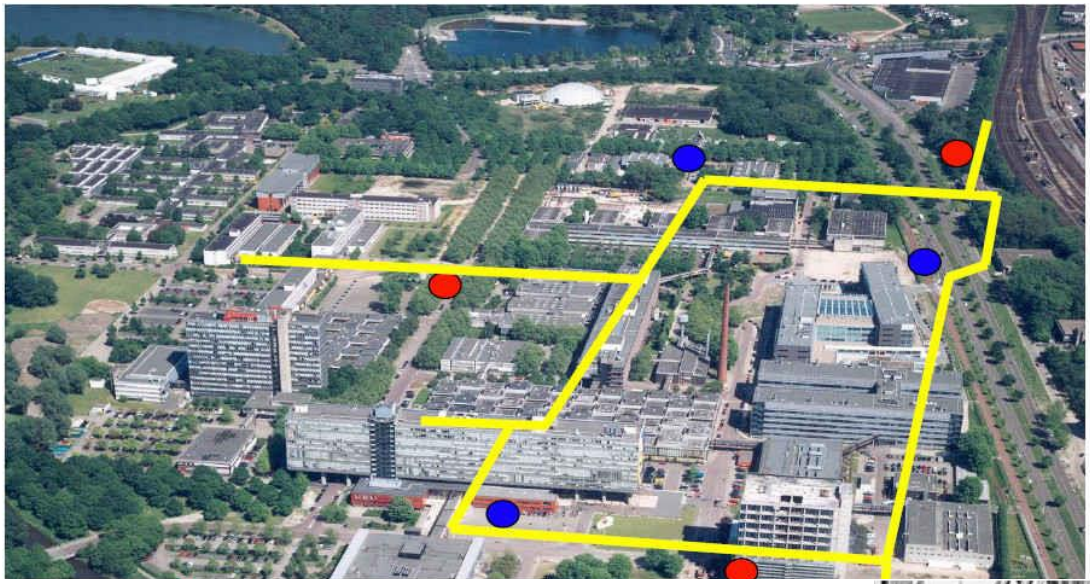
Aquifer Thermal Energy Storage at TU/e

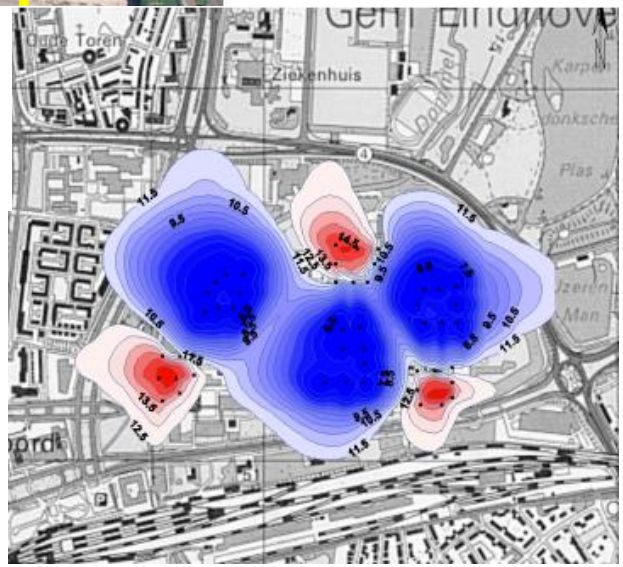
The heat under your feat is used in the largest ATES system in Europe



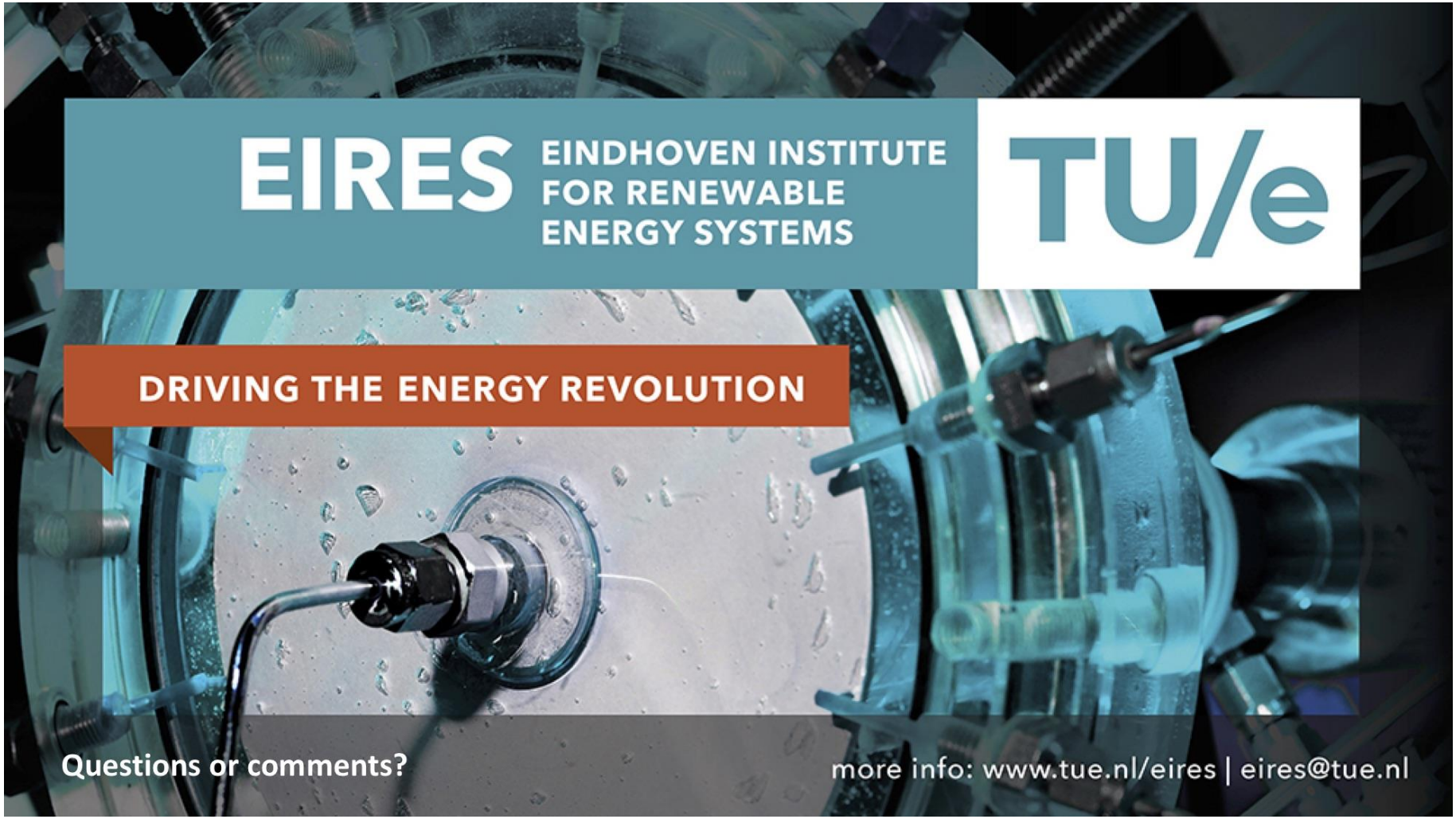
Specs of ATES TU/e

- 32 wells (16 cold, 16 warm)
- Total flowrate: 2,000 m³/h (125 m³/h per well)
- Well screens at 25-80 m below surface level
- 15 GWh heating per year (1,700,000 m³)
- 13,5 GWh cooling per year (1,500,000 m³)
- Infiltration temp warm wells: 15-22 °C
- Infiltration temp cold well's: 4-8 °C

- **Result: 59 % primary energy savings**



‘Swettehus’ city of Leeuwarden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