New Generation of durable and safe Pit Thermal Energy Storage – **PTES**

Numbers, data, facts of the G quadrat Group

- Founded in August 2000
- Company shares family owned
- Turnover: approx. 35 Mio. €
- Employees: 85

- Numerous certifications and qualifications
- Various research projects and patents
- Active in boards and commitees, i.e. DIN and CEN
- Commitment and investment in sustainability

Gquadrat

Business divisions

Infrastructure

- Landfill construction
- Underground cable construction / renewables
- Tunneling
- Hydraulic engineering / renaturation

Production

- Protection systems
- Sealing systems

Industry / Agriculture

- Tank field redevelopment
- AwSV / WHG sealing
- Warehouse sealing
- Tank linings

Recreational facilities

- Swimming pool construction (private and public)
- Landscaping special products

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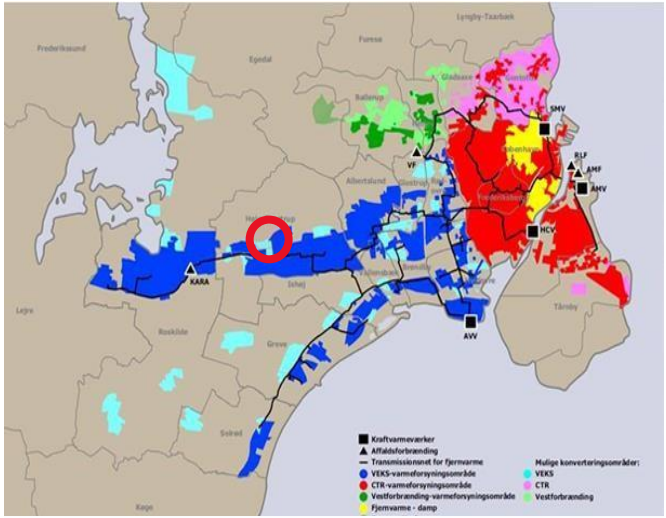
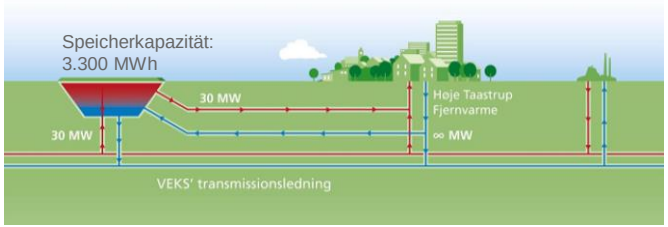
Project Report Høje Taastrup, Denmark

Gquadrat

Project description & Projectdata

- Weekly storage as part of the Copenhagen district heating network
- Ownership 50% VEKS,
  50% Høje Taastrup fjernvarme a.m.b.a
- Storage capacity: 3,300 MWh
- Charging & discharging capacity: 30 MW
- Usage to optimize heat generation
- Feed-in of cheap generation energy and
  use for expensive generation energy
- Optimizes heat and electricity production of the power plants
- Reduction of peak load production

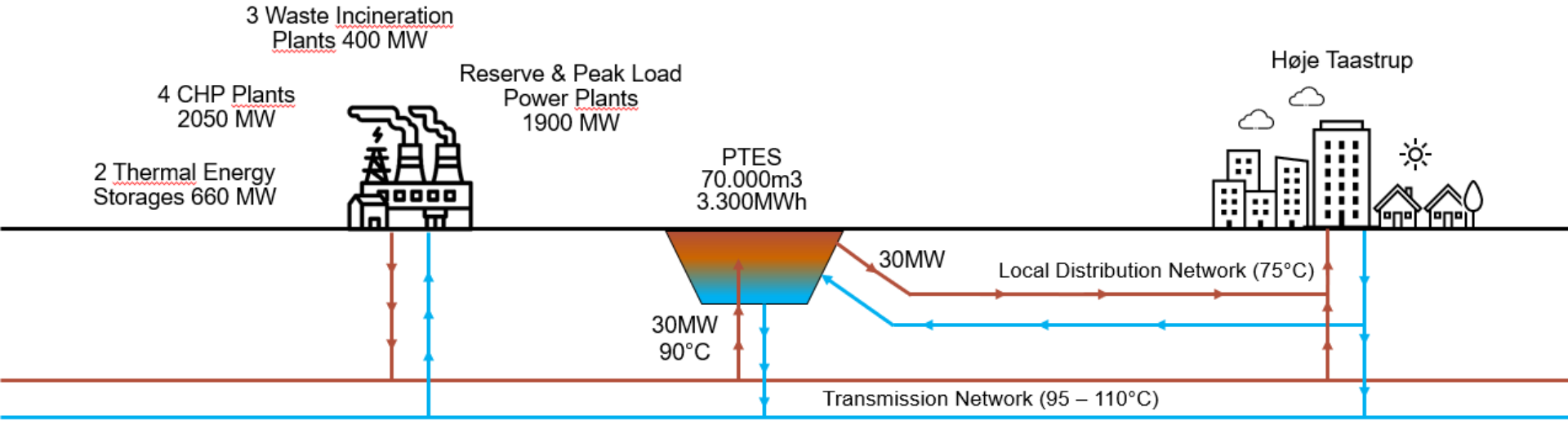




Reference: Hoje Taastrup Fjernvarme

Status: 11/2023

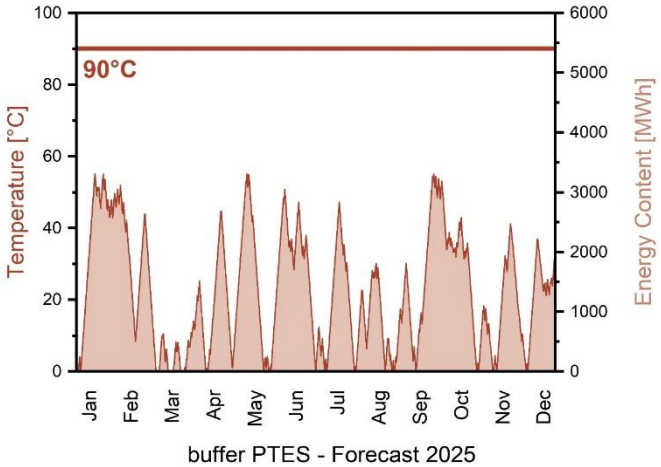
Operation Model „Høje Taastrup“



Status: 11/2023

Operation Profiles

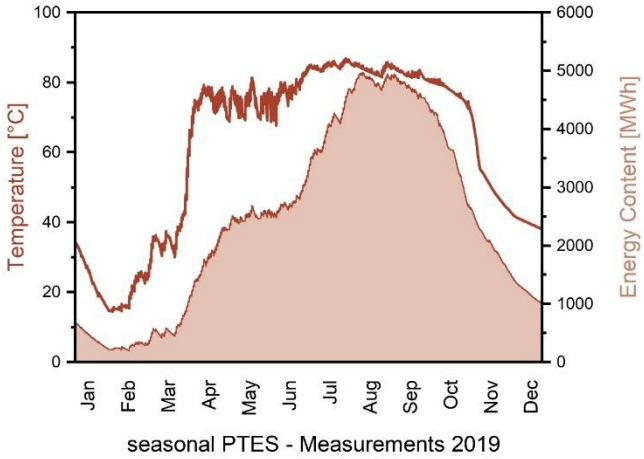
Høje Taastrup



Flexible Energy Generation / Consumption

Annual Operational System Benefits ca. 1.05M€ in 2025

Dronninglund



Summer: Energy Generation

Winter: Energy Consumption

Quelle: PlanEnergi

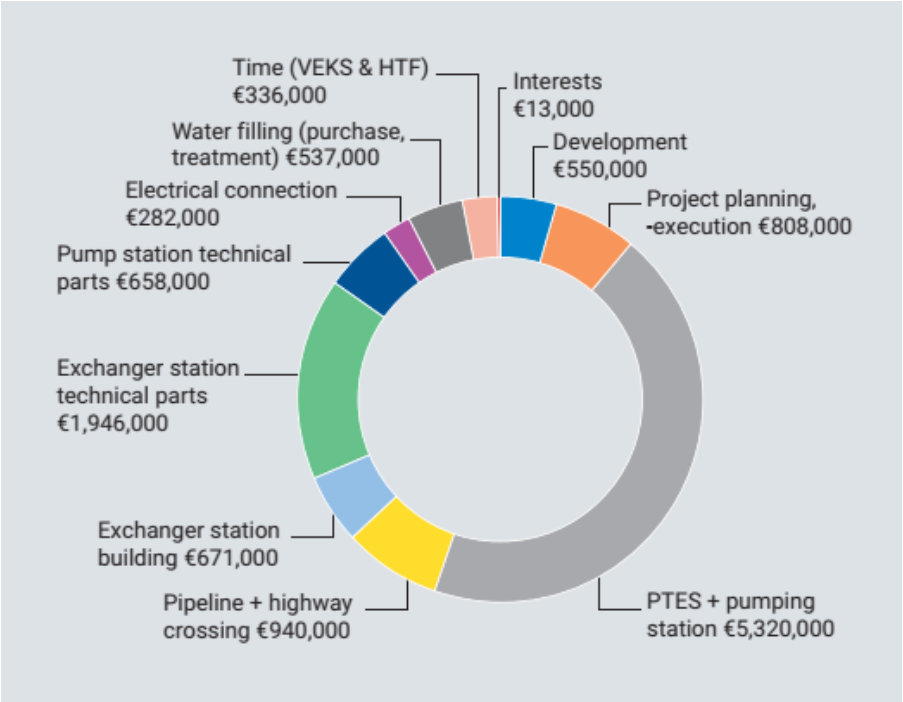
Project Costs & Invest

Total Investcosts

approx. € 12 Mio.

Thereof PTES incl. Pumping

approx. € 5.3 Mio. → approx. 76 €/m³



Source: PlanEnergi

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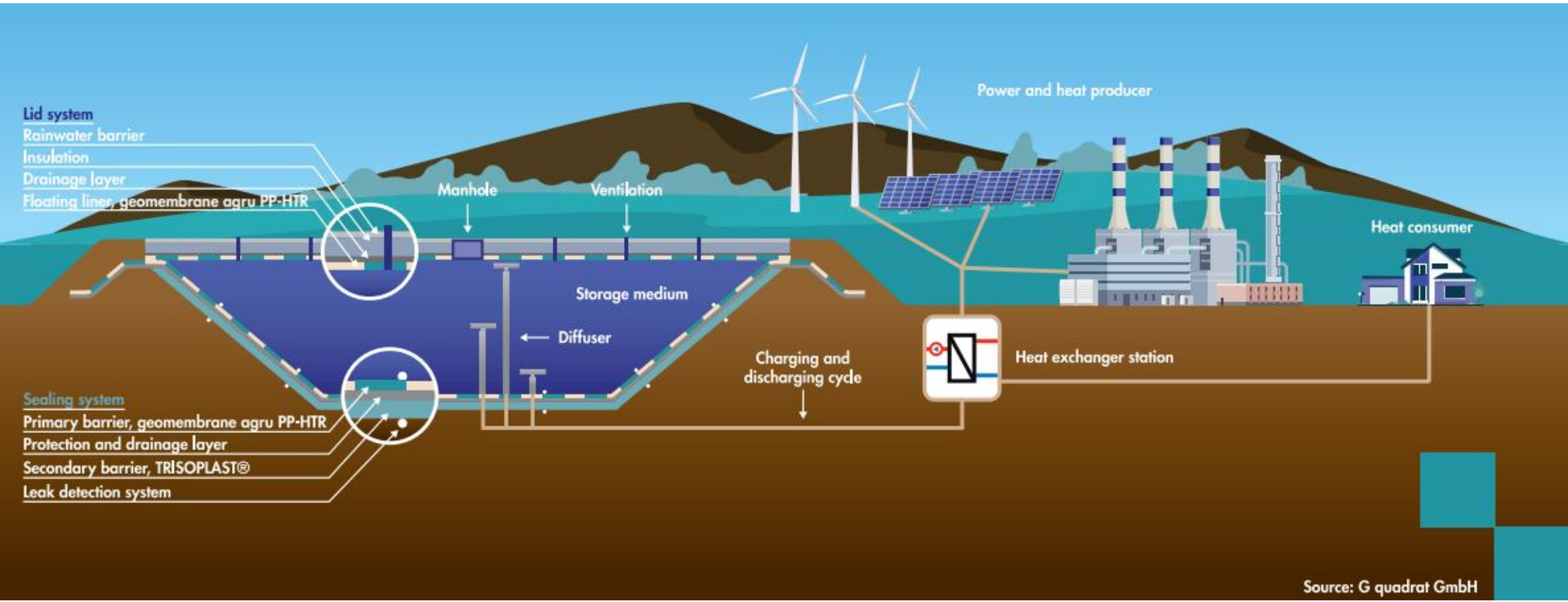
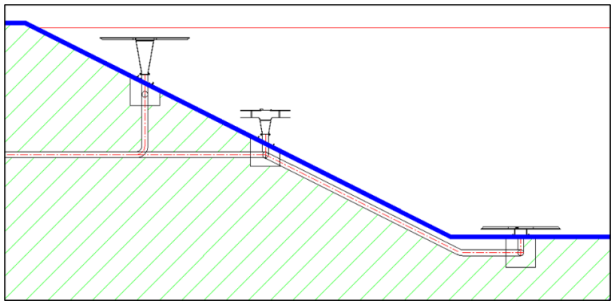
Sealing System Pit Thermal Energy Storage

Construction of PTES



Profiling basin & Pump building for heat storage



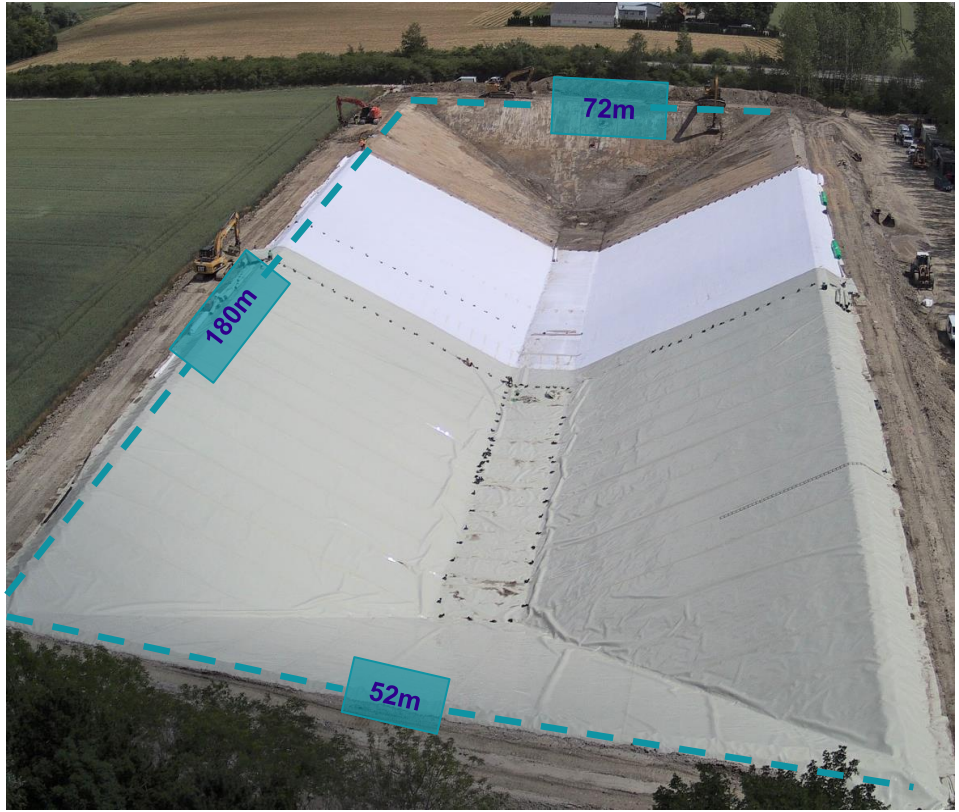
Primary sealing barrier

Polymer Sealing

- Innovative high-temperature-resistant geomembrane, made of optimized PE or PP
  - PE-HTR bzw. PP-HTR

Next generation Geomembran Agru PP-HTR

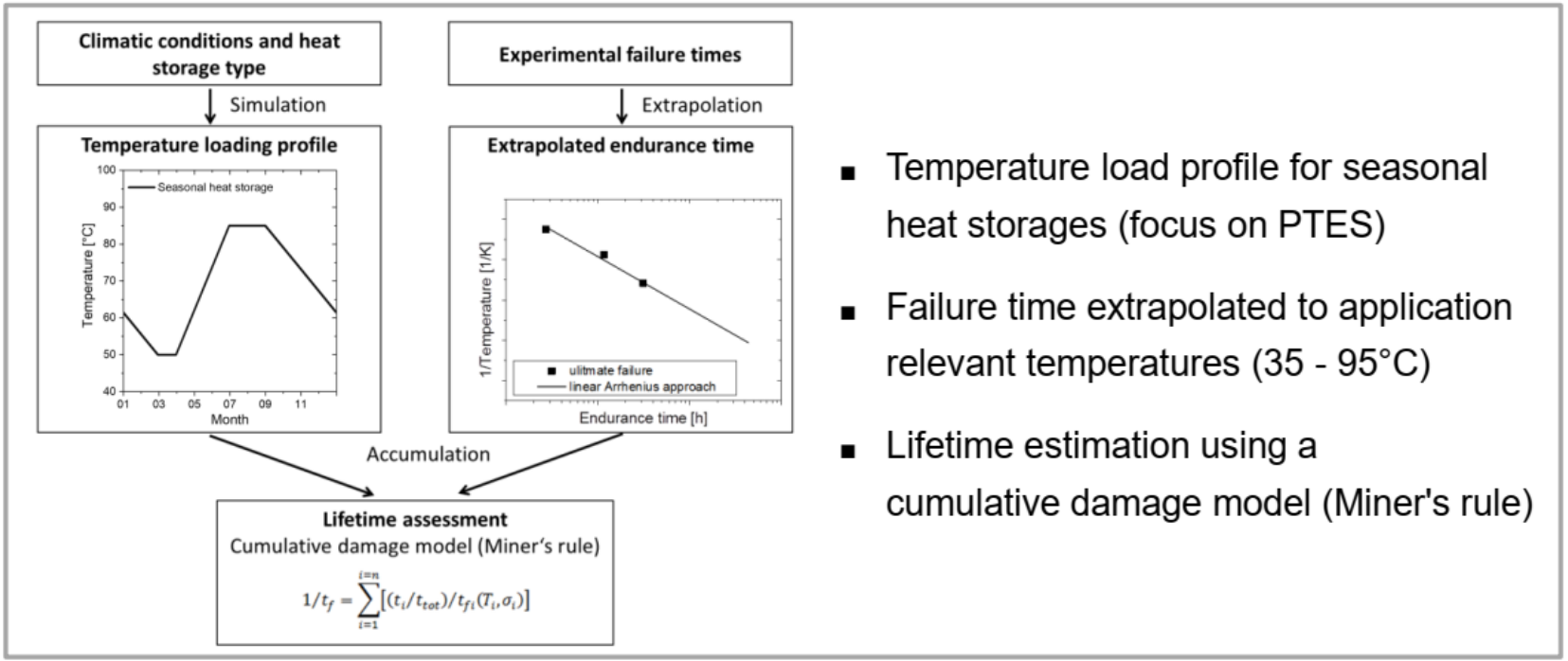
- Picture 14,000 m² agru PP-HTR 2,5 mm S/S for buffer storage Høje Taastrup
- High temperature profiles up to 95 °C and operation time > 20 years
- Longtime stability at all storage types
- Developement of hot water resistance Polypropylen (PP) application since 2008 at agru, AT



Source: DTU, Ioannis Sifnaios

Status: 05/2024

Lifetime Assessment – Methodology



- Temperature load profile for seasonal heat storages (focus on PTES)
- Failure time extrapolated to application relevant temperatures (35 - 95°C)
- Lifetime estimation using a cumulative damage model (Miner's rule)

Source: JKU, Johannes Kepler, University Linz

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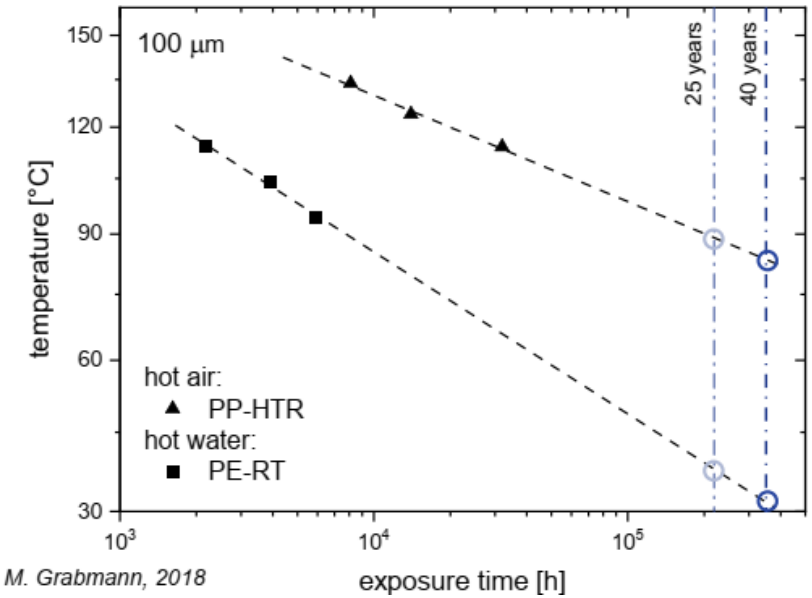
Cumulative Damage PE-RT vs. PP-HTR



Source: JKU, Johannes Kepler, University Linz

- PP has a higher melting point than PE als PE, as a result PP-HTR has in general a better performance in comparison to PE-RT
- Hot water more critical for PE-RT, Hot air more critical for PP-HTR
- HTR … **H**igh **T**emperature **R**esistance
  RT … **R**aised **T**emperatur

25 Jahre

estimated, extrapolated continuous temperature		
PE-RT	3 mm	66°C
PP-HTR	2.5 mm	92°C

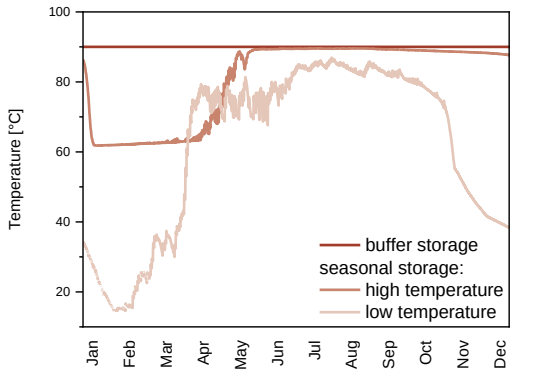
Estimated continuous temperature based on experimental data at 95, 115 and 135°C.Scattering and real ambient conditions are not taken into account.

Status: 11/2023

Exemplary Load Profiles & Estimated Lifetime

Temperature Profiles

Buffer 90 °C | **HT Sais.** 60 – 90 °C | **LT Sais.** 15 – 85 °C



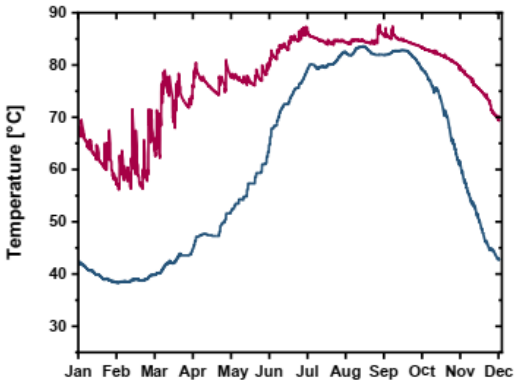
Predicted Lifetime [years]

	Buffer Storage	Seasonal Storage (HT)	Seasonal Storage (LT)
PE-HD	6.5	9	17
PP-HTR	25	31	47

Liner Thickness: 3 mm

temperature profile

40 – 85°C **55 – 90°C**



temperature	estimated lifetime [years]	
	PE-RT	PP-HTR
NT-Profile	19	49
HT-Profile	11	46

- Scatter and real environmental conditions are not taken into account.

Quelle: JKU, Johannes Kepler, University Linz

Status: 11/2023

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D = 14.5 m – 16.0 m

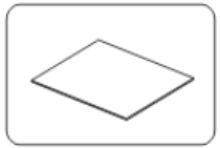
Abstract of agru Datasheet PP-HTR 2.5 mm

Smooth / Smooth
PP- HTR Liner
Hight temperature resistant

agru
The Plastics Experts.

- **Liner G / G**
  - **Calandered**
  - **PP-HTR**
  - **Light grey**

- **Smooth / Smooth**
- **Thickness: 2,5mm**
- **Width: 5.0 m & 7.0 m**
- **Code: 1R.5**



Code: 1R.5

Properties	Test Method	Unit		
Width	-	m	5,0	7,0
Thickness (average)	EN ISO 9863 – 1	mm	≥2,5	≥2,5
Thickness (single values)	EN ISO 9863 – 1	%	±10	±10
Density	EN ISO 1183 - 1	g/cm³	≥0,9	≥0,9
Melt Flow Rate (MFR 230/2,16)	EN ISO 1133	g/10 min	0,2 - 1,0	0,2 - 1,0
Dimension stability :				
(135°C/1,0h)	EN 1107 – 2	%	<3,0	<3,0
Tear resistance	EN ISO 34 – 1	N/mm	130	130
Tensile properties:				
Tensile stress at yield	EN ISO 527 – 3	N/mm²	18	18
Elongation at Yield	EN ISO 527 – 3	%	10	10
Elongation at break	EN ISO 527 – 3	%	600	600

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The PP-HTR membrane is conditionally UV stable and may be exposed to UV radiation for a maximum of 3 month.

Impact- and bending stresses at temperatures <0 °C have to be avoided.

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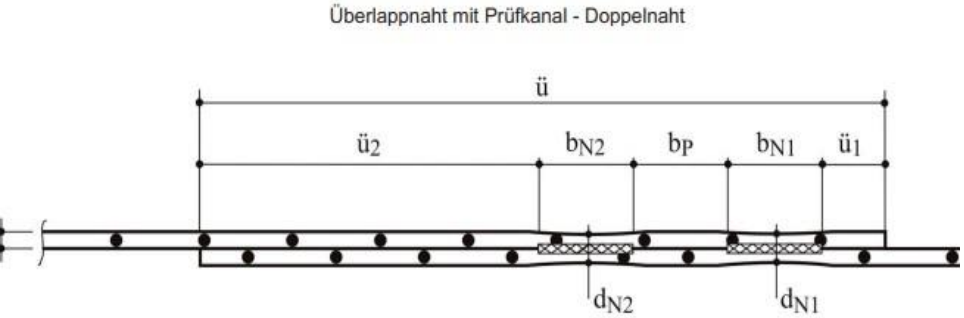
Welding qualifications & test methods

- Specialized company according to Arbeitskreis Grundwasserschutz (AK GWS)
- Welding of geomembrane according to DVS 2225
- Weld examination according to DVS 2212

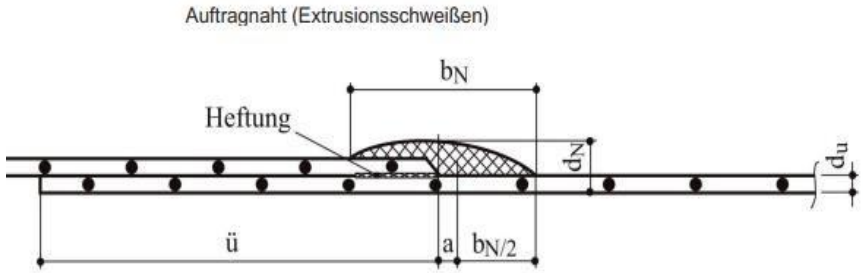
Hot wedge double weld:

- Leak test by compressed air in the test channel (b_P)



Extrusion weld :

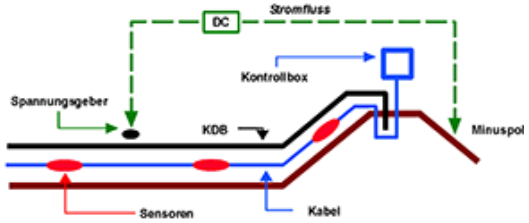
- Test by with vacuum bell



Testing of the sealing-system

Continious leak detection System (DKS/DDS)

- Permanent leak detection
- Highest Certification in the landfill sector (BAM)
- Simple and efficient installation



Source: Sensor DKS GmbH

Arc Testing Method

- Surface inspection
- On exposed geomembrane according to ASTM

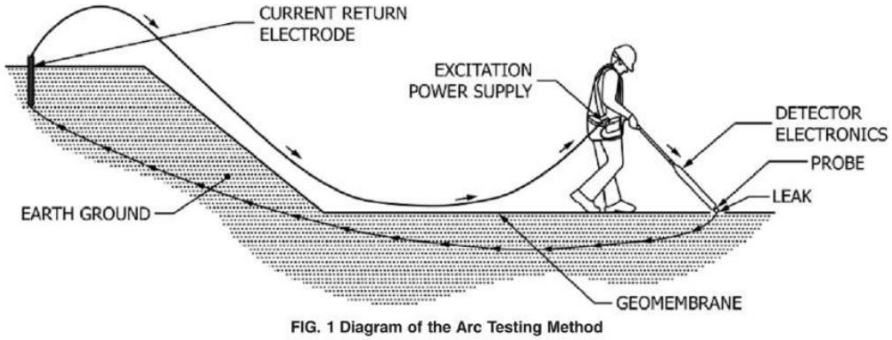
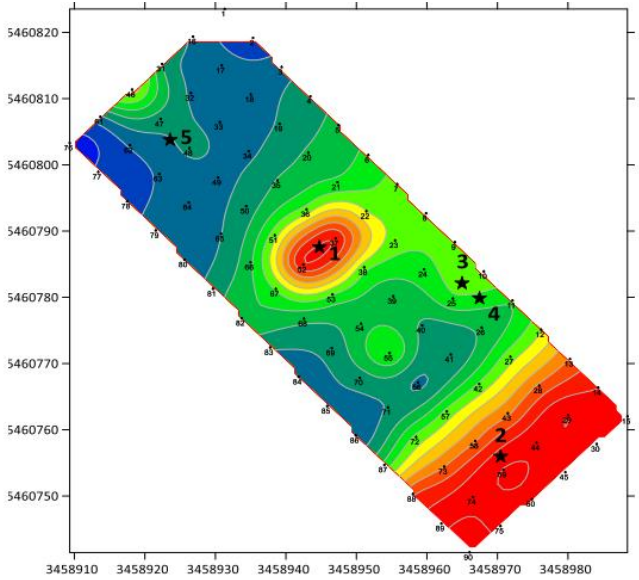


FIG. 1 Diagram of the Arc Testing Method

Source: ASTM D7953-20

Function of Leak-Detection-System



Source: Sensor DKS GmbH

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Secondary sealing barrier

TRISOPLAST®

- Patented mineral sealing material out of sand, bentonite, polymer (& water)
- High swellable bentonite, fast activators
  → Swelling & sealing
  → high watertightness
- Protection of groundwater / drinking water
- LAGA – Approval of Suitablity,
  BAW - Approval (WHG-Conformity)
- Compacted installation thickness = 8 cm
  (Substitute for 50 cm clay layer)

Floating Liner

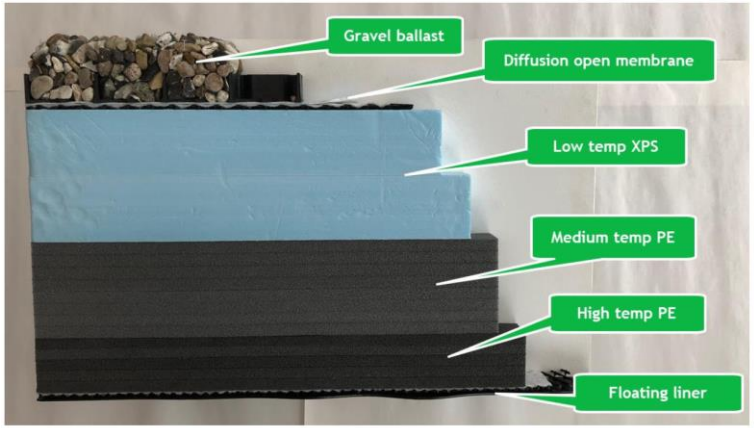
Temporary cover

- **agru HDPE** 1,0 mm S/S
  → During filling process
  → „Sacrifical liner “

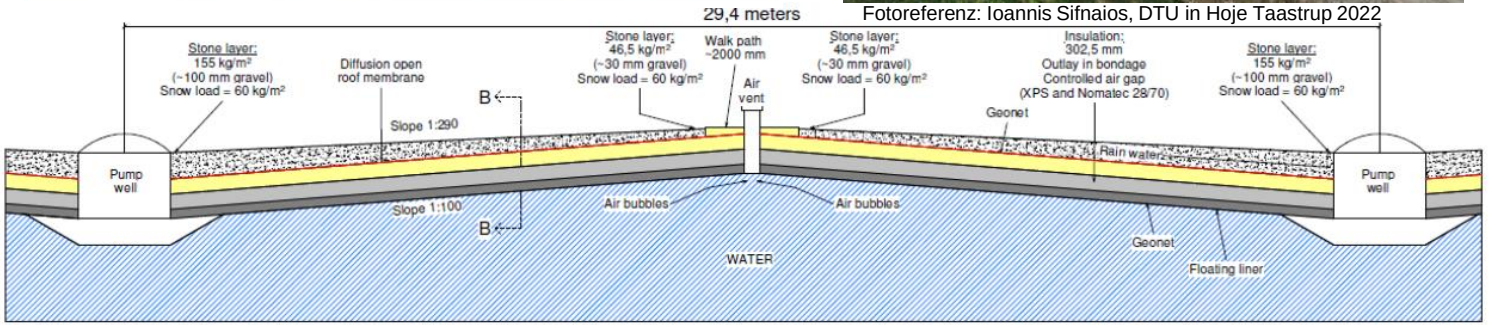
Permanent cover

- **agru PP-HTR** 2,5 mm S/S
  → Base for floating insulationsystem

Floating liner and insulation



Fotoreferenz: Ioannis Sifnaios, DTU in Hoje Taastrup 2022



Source: Aalborg CSP

Gquadrat

Thank you for your attention.

Martin Sünnwoldt
Sales Director

G quadrat GmbH
Adolf-Dembach-Straße 4a
47829 Krefeld
Germany

+49 2151 78883-44
+49 171 4173264
suennwoldt@gquadrat.de

Markus Seume
Sales Manager PTES

G quadrat GmbH
Adolf-Dembach-Straße 4a
47829 Krefeld
Germany

+49 2151 78883-43
+49 151 14634265
seume@gquadrat.de

Gquadrat