Design Challenges of a Geomembrane Lined and Covered Hot Water Thermal Storage

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FLEXIBLE GEOMEMBRANE LINERS & COVERS

GEOANZ #1 ADVANCES IN GEOSYNTHETICS
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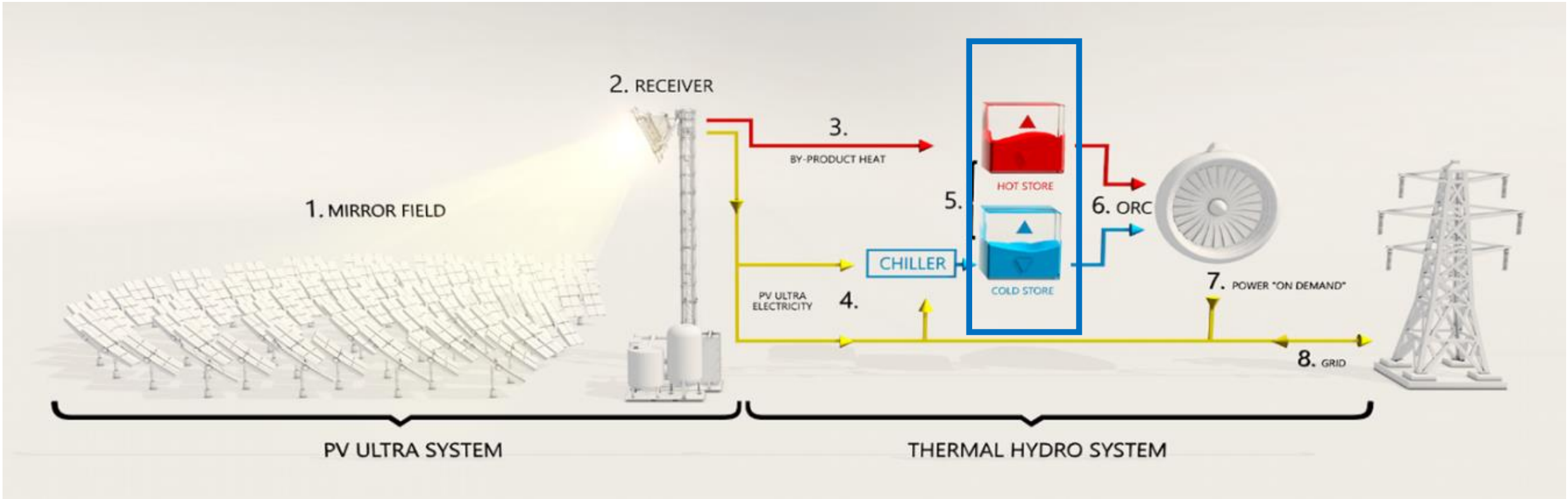
The project

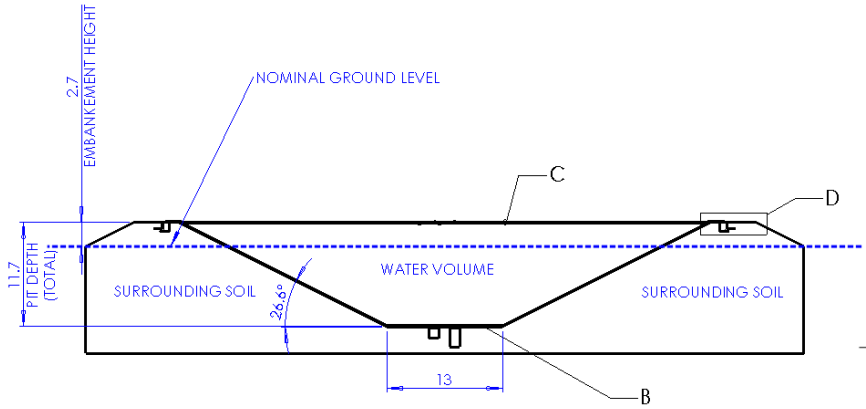
- The Carwarp Power Plant (RPPC) project will add 4MW of solar and 3MW / 50MWh (17 hours) storage
- Innovative technologies
  - PV Ultra
  - Thermal Hydro
- Disrupt the economics of solar-plus-storage
- Dispatchable renewable energy

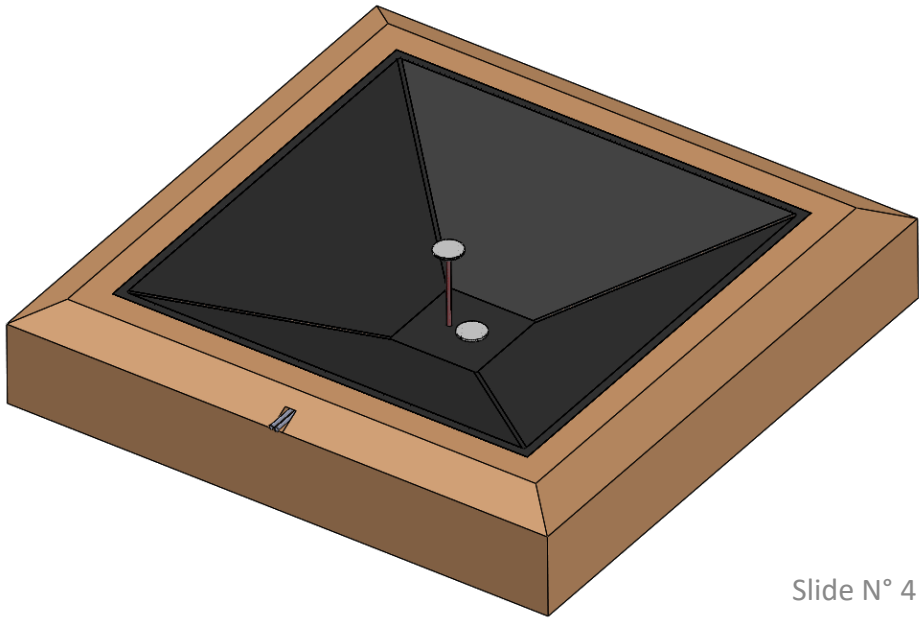
The thermal potential energy is stored in pits (transformed from solar) and it can be used at any time in an Organic Rankine Cycle (ORC) Engine (the Power Generator).



The Concept

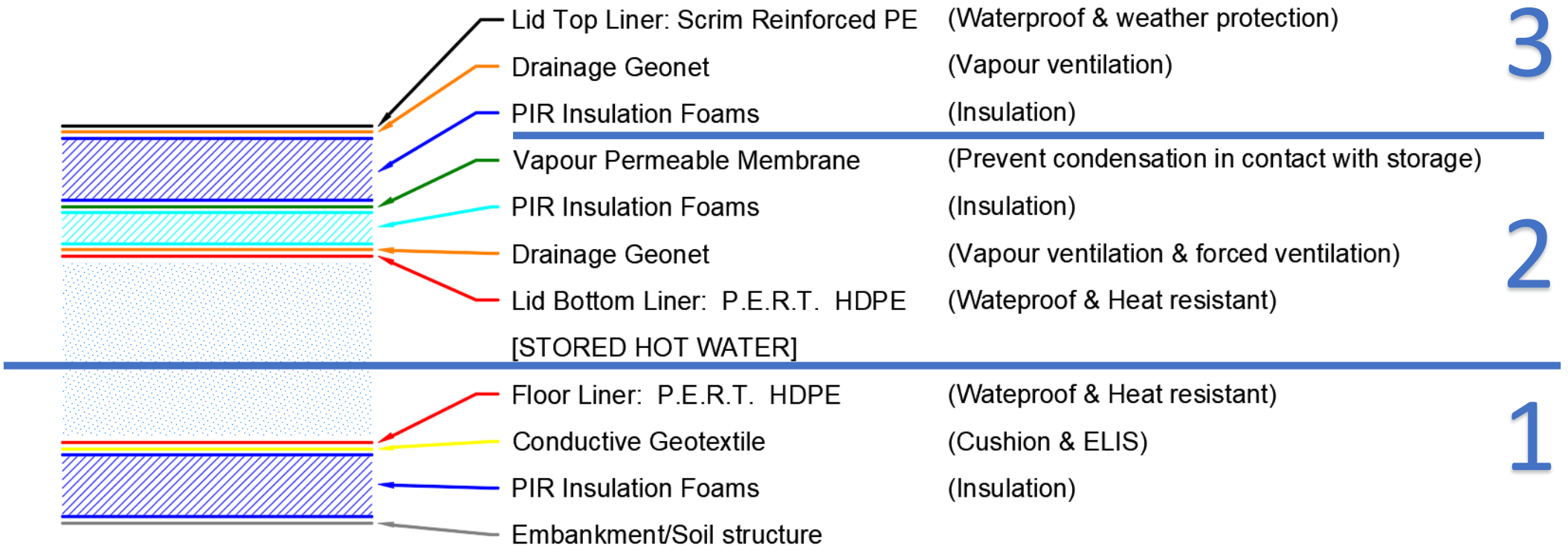
- Two <u>thermal</u> storages
  - Hot Pit: Temperature range between 70°C – 90°C.
  - Cold Pit: Temperature range between 0°C – 15°C.
- Geomembrane lined Earthen Bank Storages, 17 ML each
- Floating covers to seal storages
- High levels of thermal insulation
- Strict level control of covers – diffuser clearance
- Rain water management
- Spillway design





Thermal insulation

Is a complex multilayer system, comprised mostly of geosynthetic layers.



Geosynthetics material selection

- 85°C ± 10°C with a design life of 25+ years
- HDPE - limited around 60°C
- High Temperature Geomembranes
  - P.E.R.T resins, Polyethylene Raised Temperature
  - Domestic plastic pipes
  - Several geomembrane products available
- Bi-modal resins
  - Produced in two reactors, in series with partial polymerization in the first
  - Allows control over amorphous and crystalline regions
  - Broader MWD and beneficial properties
  - Used extensively in a number of products e.g. industrial/domestic containers
  - Able to provide high temperature performance while retaining SCR and capable of processing to geomembrane sheet

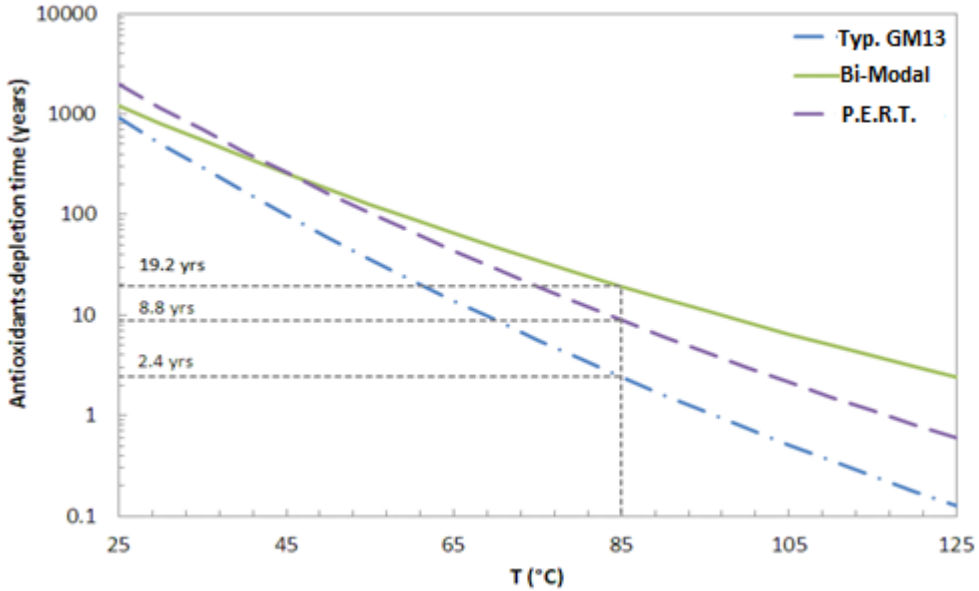
Geomembrane Characteristics

- Bi-Modal resin
  - High density and
  - High stress crack resistance
- Strong additive package
  - Accelerated air ageing
  - UV Resistance

Combination of resin and additive

- Upper temperature limit extended to > 100 deg C

Test Parameters	GM13	Project Material
Oven Aging Duration (days)	90	365
Air Temperature (deg C)	85	110
HP-OIT Retention (%)	80	90

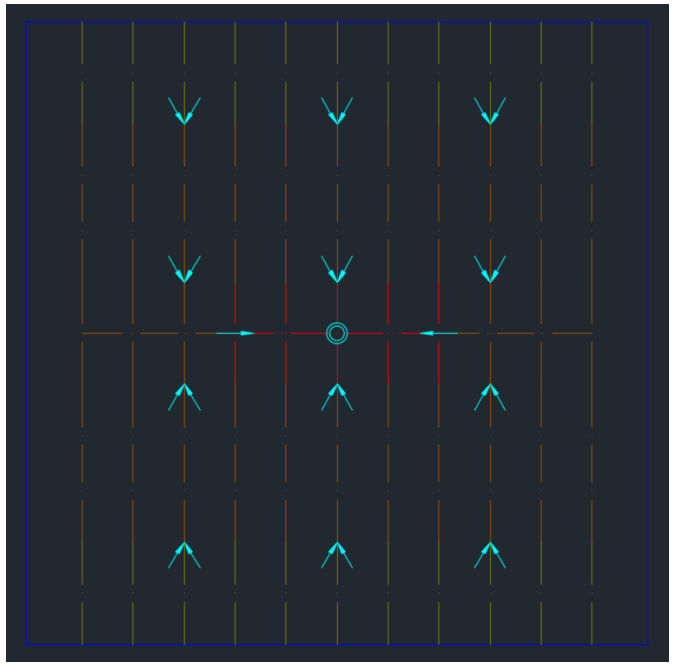


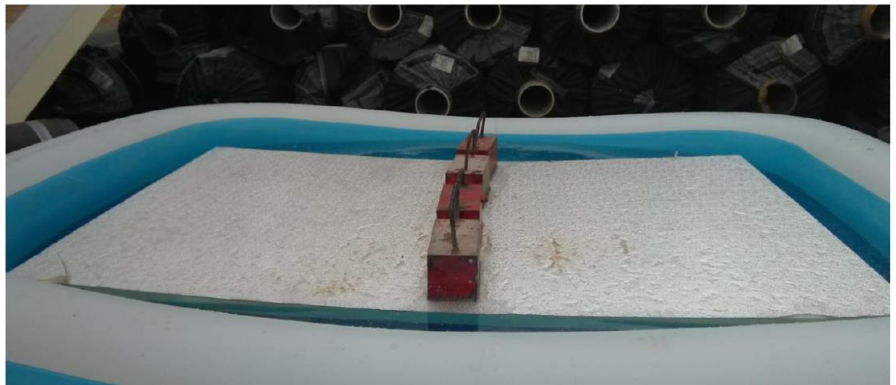
ASTM	Properties	Unit	Typ. GM13	HeatGard HD60
D5199	Thickness	[mm]	1.5	1.5
D792	Density	[g/cc]	0.940	0.962
D6693	Yield Strength	[kN/m]	22	27
D6693	Yield Elongation	[%]	12	12
D6693	Break Strength	[kN/m]	40	40
D6693	Break Elongation	[%]	700	600
D1004	Tear Resistance	[N]	187	200
D4833	Puncture Resistance	[N]	480	534
D5397	Stress Crack Resistance	[hs]	500	1000
D6370	Carbon Black Content	[%]	2.0-3.0	2.0-3.0
D5721	Oven Aging (HP-OIT)	[% ret.]	80 [@85°C]	90 [@ 110°C]
D7238/5885	UV Resistance	[% ret.]	50	90

Wind uplift ballasting & Drainage

Top exposed layer

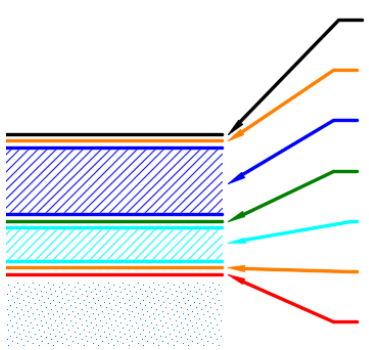
- The unique design
  - Insulation
  - Fixed diffuser height/clearance required
  - Also resist wind uplift at all times to maintain
- Unconventional solution
  - ballast tubes with mass & layout to provide ballasting
  - and also generating drain channel slopes
- Rain water collected at a central feature
- Mathematical modelling - variable water pressure from cover deformation
- Physical scale-modelling, calibration (similitude, dimensional homogeneity and errors considerations) and analysis
- Scrim reinforced Polyethylene cover material to achieve a flat surface consistent with low water flow path gradients





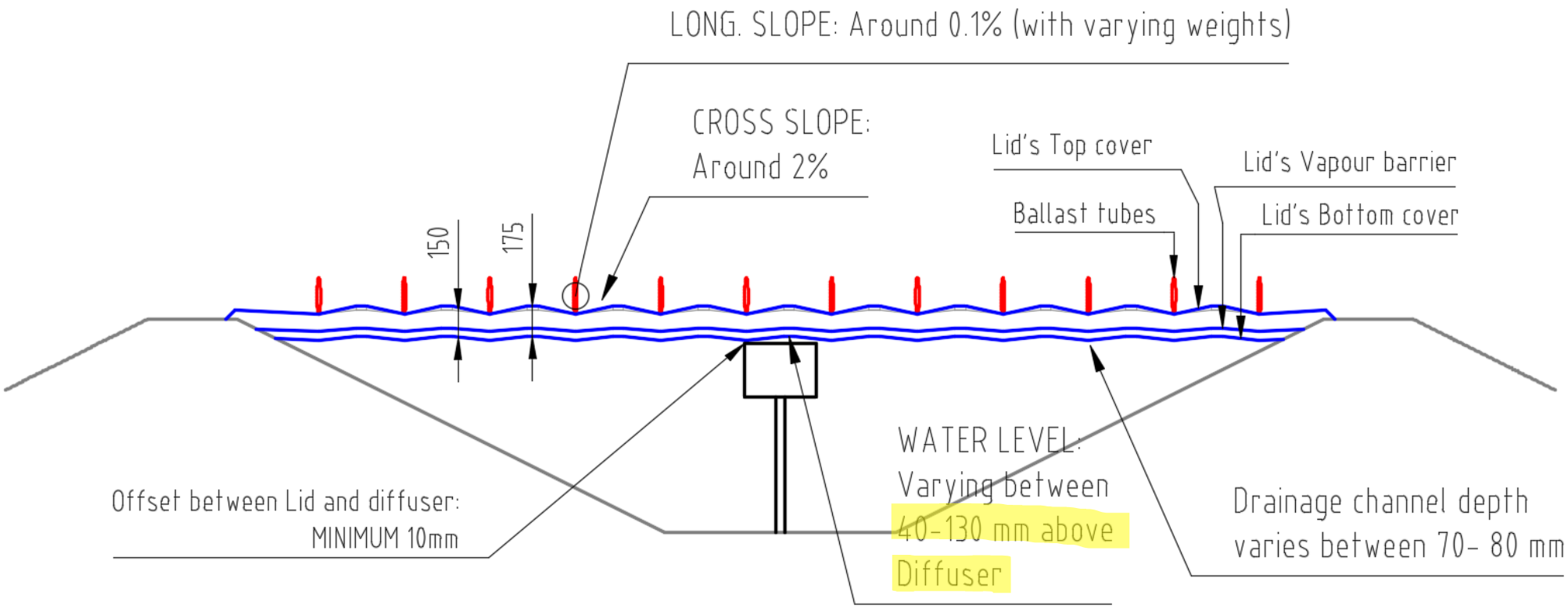
Cover Internal Water Management

- Diffusion through the cover geomembrane due to high water temperatures (90 deg C)
- Condensate management system required
- Cover incorporated a collection and drainage system
  - Vapour barrier incorporated in cover defining the top surface of the drainage system
  - Cover ballasting system designed to provide hydraulic gradients to manage surface water and internal water drainage
  - Drainage GCD to provide flow path
  - Internal sumps and micro-pumps for extraction
  - Air vents to provide passive air flow in drainage layer
- Additional ventilation layer incorporated above the drainage layer
- Design catered for forced ventalation



Lid Top Liner: Scrim Reinforced PE	(Waterproof & weather protection)
Drainage Geonet	(Vapour ventilation)
PIR Insulation Foams	(Insulation)
Vapour Permeable Membrane	(Prevent condensation in contact with storage)
PIR Insulation Foams	(Insulation)
Drainage Geonet	(Vapour ventilation & forced ventilation)
Lid Bottom Liner: P.E.R.T. HDPE	(Wateproof & Heat resistant)

Wind uplift ballasting & Drainage



Ballasting & Drainage – Water Pumps

Rain Water

- Conventional cover solutions not feasible due to the drainage design
- A Puddle Sucker Pump was specified to manage the designed low gradients and depths for the drainage system

Internal Condensate

- High temperature
- Self priming
- Low voltage micro pump was selected

Construction

- Lining system
  - Conventional construction
  - Quality Control included electrical integrity survey

- Cover System
  - Installation base layer over full storage
  - Installation further 6 layers over base layer
  - Specific safety measures for working on water
  - Tension and wrinkle management important for eater drainage systems to function

Conclusions

This emerging and competitive technology is proposing a very efficient system for the generation and storage of renewable energy.

Geosynthetics are key elements for the implementation of this system, in particular, the thermal energy storage component.

High engineering capability, extensive experience and knowledge of geosynthetics are key elements for a successful implementation of this technology.

Thanks for your attention!

Questions please!