

# Harvesting-energy FROM THE SUN

#### PTES the next generation of storing energy

Heat storage and monitoring results October 28<sup>th</sup> 2020 Morten Vang Bobach - mvb@aalborgcsp.com



Features of Aalborg CSP PTES technology

- The lifetime of the PTES is at least 25 years.
- The efficiency of the PTES is at least 90 %.
- The PTES is capable of storing heat up to maximum 90 °C.
- Reliability: Service and maintenance can be carried out without interfering with normal operation. This gives an availability factor of 100 %.
- Charging and discharging power is minimum 90 MW but can be customized.
- Once installed and operating the PTES requires a minimum of operational resources.
- At least 90 % of the components of the PTES are recyclable.
- The maximum yearly required amount of make-up water is 1,5‰ of the total volume of the PTES.







#### **Patented solution**

Patent 1- Diffusion open top cover construction to avoid water accumulation inside insulation material

Patent 2- Top cover surfaced is build in sections, each with own drain system for surface water

Size of PTES is easy scalable due to section design

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### Draining of water and venting of air

The wedge shaped gravel layer on top of the top cover creates a slope pointing towards the centre of each section.

The water from the surface will run to the pump wells in each section

Under the surface, air bubbles will raise to the air vents, placed on the highest points on the section borders



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#### Build up of layers in lid

The top cover design consist of 11 layers of specialized materials

All materials has been tested and approved for 25 years lifetime at the relevant temperature profile





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#### The technology and functionality of PTES

Time plan for Marstal project

Installation of floating liner started September 2019

Installation of insulation during winter (December-Februar)

Operation of PTES April 2020 (as planned)

| 1  | â | Opgavetil | Opgavenavn                                    | Varighed        | Startdato   | Slutdato      | Foregående  | ber<br>Marka arba a | novemi<br>novemi | xer de          | cember           | januar           | februar               | marts                 | n naha naha naha |
|--|---|-----------|---|-----------------|-------------|---------------|---|---------------------|------------------|-----------------|------------------|------------------|-----------------------|-----------------------|------------------|
| 1  |   | -         | Activities                                    | 115 dage        | ma 21-10-19 | fr 27-03-20   | opdate:   |                     |                  | 1-110-1123-1102 | - 1202-1216-1263 | 1200-1200-0113   | -0 82-0 87-0 85-0410- | 0.17-0.294-0.202-0.50 |                  |
| 2  | 1 | -         | Welding of top liner                          | 14 dage         | ma 21-10-19 | to 07-11-19   | 18  | 1                   | 1                |                 |                  |                  |                       |                       |                  |
| 3  | 1 | -         | Installing of bottom geo net                  | 4 dage          | fr 08-11-19 | on 13-11-19   | 2;19  | 1                   | - 2              | h               |                  |                  |                       |                       |                  |
| 4  | 1 | -         | Test of transport solution on liner           | 3 dage          | to 14-11-19 | ma 18-11-19   | 3   | 1                   |                  | <b>*</b>        |                  |                  |                       |                       |                  |
| 5  | 1 | -         | On site audit with Lloyd's                    | 4 dage          | ti 19-11-19 | fr 22-11-19   | 4   |                     |                  |                 |                  |                  |                       |                       |                  |
| 6  | 1 | -         | Test, secure layers during storm              | 5 dage          | ti 19-11-19 | ma 25-11-19   | 4   | 1                   |                  | <b>*</b>        |                  |                  |                       |                       |                  |
| 7  | 1 | -         | Installing PE insulation                      | 15 dage         | ti 26-11-19 | ma 16-12-19   | 21;6  | 1                   |                  |                 | -                |                  |                       |                       |                  |
| 8  | 1 | -         | Installing bump wels onto liner               | 4 dage          | ti 17-12-19 | fr 20-12-19   | 24;7  | 1                   |                  |                 | - 1 <b>2</b>     |                  |                       |                       |                  |
| 9  | 1 | -         | Installing tubes for drain water              | 5 dage          | ma 06-01-20 | fr 10-01-20   | 25;8  | 1                   |                  |                 |                  | - <b>*</b>       |                       |                       |                  |
| 10   | 1 | -         | Installing Pumps, cables, power and sencors   | 5 dage          | ma 20-01-20 | fr 24-01-20   | 9;26  | 1                   |                  |                 |                  |                  | *                     |                       |                  |
| 11   | 1 | -         | Installing XPS, geonet, roof-mem., cassetts,, | 30 dage         | ma 13-01-20 | fr 21-02-20   | 9;22;23;27;28;29;   |                     |                  |                 |                  | 1                |                       | <b>_</b> 1            |                  |
| 12   | 1 | -         | Installing rails for ballast thickness        | 5 dage          | ma 24-02-20 | fr 28-02-20   | 11;32   | 1                   |                  |                 |                  |                  |                       | <b>1</b>              |                  |
| 13   | 1 | -         | Installing gravel ballast                     | 15 dage         | ma 02-03-20 | fr 20-03-20   | 12;31   | 1                   |                  |                 |                  |                  |                       |                       |                  |
| 14   | 1 | -         | Locking of liner in ancher trenches           | 5 dage          | ma 23-03-20 | fr 27-03-20   | 13  | 1                   |                  |                 |                  |                  |                       |                       | *                |
| 15   | 1 | -         |   |                 |             |               |   | 1                   |                  |                 |                  |                  |                       |                       |                  |
| 16   | 1 | -         |   |                 |             |               |   | 1                   |                  |                 |                  |                  |                       |                       |                  |
| 17   | 1 | -4        | Deliveries                                    | 65 dage         | ma 21-10-19 | 9 ma 20-01-20 | •   |                     |                  |                 |                  |                  | -                     |                       |                  |
| 18   | ] | *         | Floating liner                                | 0 dage          | ma 21-10-19 | ) ma 21-10-19 | 1   | 2                   | 1-10             |                 |                  |                  |                       |                       |                  |
| 19   | 1 | *         | Geonet (bottom layer)                         | 0 dage          | ti 05-11-19 | ti 05-11-19   |   |                     | .09              | 5-11            |                  |                  |                       |                       |                  |
| 20   | 1 | *         | PE isolering HD                               | 0 dage          | ti 05-11-19 | ti 05-11-19   |   |                     | 0                | 5-11            |                  |                  |                       |                       |                  |
| 21   |   | *         | PE isolering LD                               | 0 dage          | fr 13-11-19 | fr 13-11-19   |   |                     |                  |                 |                  |                  |                       |                       |                  |
| 22   |   | *         | XPS insulation                                | 0 dage          | to 09-01-20 | to 09-01-20   |   |                     |                  |                 |                  | ● 09             | 01                    |                       |                  |
| 23   |   | *         | Plastic nails for XPS plates                  | 0 dage          | on 11-12-19 | on 11-12-19   |   |                     |                  |                 | 11-12            |                  |                       |                       |                  |
| 24   |   | *         | Pump wels                                     | 0 dage          | ti 10-12-19 | ti 10-12-19   |   |                     |                  |                 | 10-12            |                  |                       |                       |                  |
| 25   |   | *         | Tubing for pump wels                          | 0 dage          | ma 06-01-20 | ) ma 06-01-20 | l internet in the second se |                     |                  |                 |                  | 06-0             | 01                    |                       |                  |
| 26   |   | *         | Pumps incl cabels                             | 0 dage          | ma 20-01-20 | ) ma 20-01-20 | l internet in the second se |                     |                  |                 |                  |                  | 20-01                 |                       |                  |
| 27   |   | *         | Geonet (top layer)                            | 0 dage          | fr 13-12-19 | fr 13-12-19   |   |                     |                  |                 | 13-12            |                  |                       |                       |                  |
| 28   |   | *         | Roof membrane                                 | 0 dage          | to 09-01-20 | to 09-01-20   |   |                     |                  |                 |                  | <b>•</b> 99      | -01                   |                       |                  |
| 29   |   | *         | Protective løyer (textile)                    | 0 dage          | to 12-12-19 | to 12-12-19   |   |                     |                  |                 | 12-12            |                  |                       |                       |                  |
| 30   |   | *         | Cassettes                                     | 0 dage          | to 09-01-20 | to 09-01-20   |   |                     |                  |                 |                  | <del>ф </del> рэ | -01                   |                       |                  |
| 31   |   | *         | Gravel ballast                                | 0 dage          | ma 21-10-19 | ) ma 21-10-19 |   | 2                   | 1-10             |                 |                  |                  |                       | -+                    |                  |
| 32   |   | *         | Rails for gravel ballast                      | 0 dage          | ma 20-01-20 | ma 20-01-20   |   |                     |                  |                 |                  |                  | 20-01                 |                       |                  |
|  |   |           | Ордине  | Projektoversig  | 4 P         |               | Manuel opgave   |                     |                  | Kun start       | E                |                  | Deadline              | •                     |                  |
| Projekt: Marstal tidsplan<br>Dato: fr 13-12-19 |   |           | an Opdeling                                   | Inaktiv opgave  |             |               | Kun verighed  |                     |                  | Kun slutdeto    | 3                |                  | Fremdrift             |                       |                  |
|  |   |           | Milepel •                                     | Inaktiv milepa  | 4 O         |               | Manuel oversigtsopt   | aftning             |                  | Elsterne opgaw  | r 👘              |                  | Manuel status         |                       |                  |
|  |   |           | Hovedopgave                                   | Inaktiv oversig | ¢ 1'        |               | Manuel oversigt   |                     |                  | Elstern milepæl | •                |                  |                       |                       |                  |



#### Validation of technology

Connections between rolls of liner material are connected via double weld seams.

Weld seams are 100 % tested by static pressure







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#### Validation of technology

Water vapour diffusion through 2.5 mm HDPE-liner: 3 to 5 g/m<sup>2</sup>/day @ 90°C

Development and validation of inverted roof solution: Bunch Bygningsfysik and test facility at Arcon-Sunmark







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Water vapour permeability as a function of temperature for a typical HDPE liner [3]

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#### Validation of technology





Author: MIC

Revision:



#### Validation of technology



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#### **Measurements from Marstal**





#### **Measurements from Marstal**



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#### **Measurements from Marstal**





#### **Measurements from Marstal**

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|--|----------|
| N X Q Q Image: Comparison of the |          |
| 📕 HT.1.1 Målepunkt 1 varmemåler 1 - (W/m²) 📕 HT.2.1 Målepunkt 2 varmemåler 1 - (W/m²) 📕 HT.3.1 Målepunkt 3 varmemåler 1 - (W/m²) 📕 HT.4.1 Målepunkt 4 varmemåler 1 - (W/m²)  |          |
|  |          |
| 16   |          |
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## THANK YOU FOR YOUR ATTENTION

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