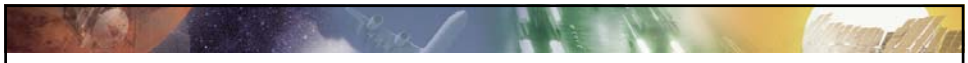
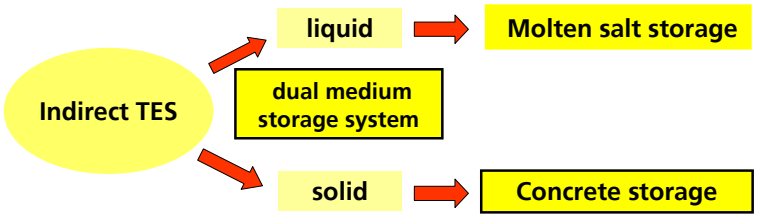
Concrete Storage Developement for Parabolic Trough Power Plants

Doerte Laing, German Aerospace Center (DLR)

Parabolic Trough Technology Workshop, March 08, 2007, Golden CO, USA



Concrete Storage
Motivation



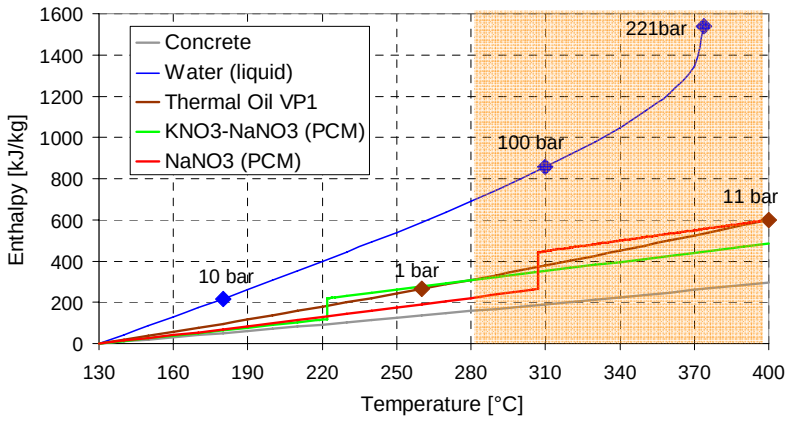
- Economic and reliable TES
- Cost target < 20 € / kWh TES capacity
- Modular and scalable design
- Flexible to large no. of sites and construction materials

Solid Media Sensible Heat Storage
Road Map

Phase 1: **11/2001 – 12/2003**
SCIENTIFIC PROJECT
⇨ feasibility demonstration, on-sun tests at PSA
⇨ contractor DLR, sub-contractor SIEMPELKAMP
⇨ project funded by BMU

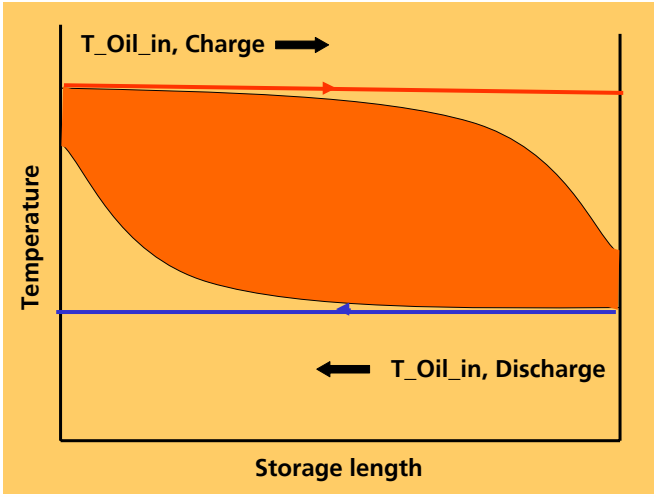
Phase 2: **03/2004 – 12/2006**
JOINT INDUSTRIAL/SCIENTIFIC RESEARCH PROJECT
⇨ pre-commercial design
⇨ contractors DLR, ZUEBLIN, FLAGSOL
⇨ project funded by BMU

Thermal Energy Storage
Motivation



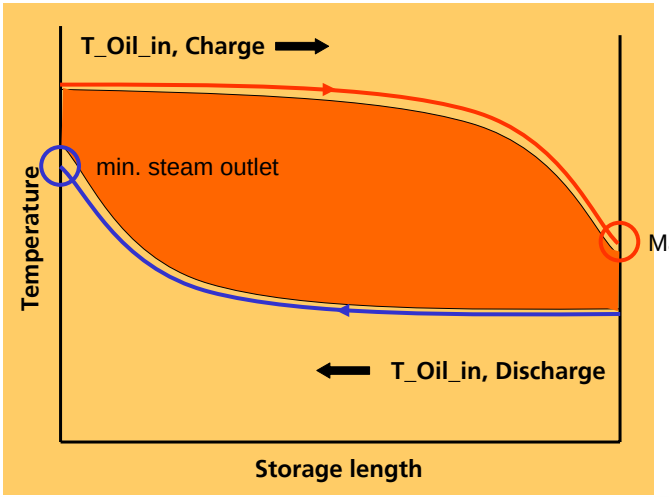
Solid Media Concrete Storage

Characteristic behavior of dual media solid TES

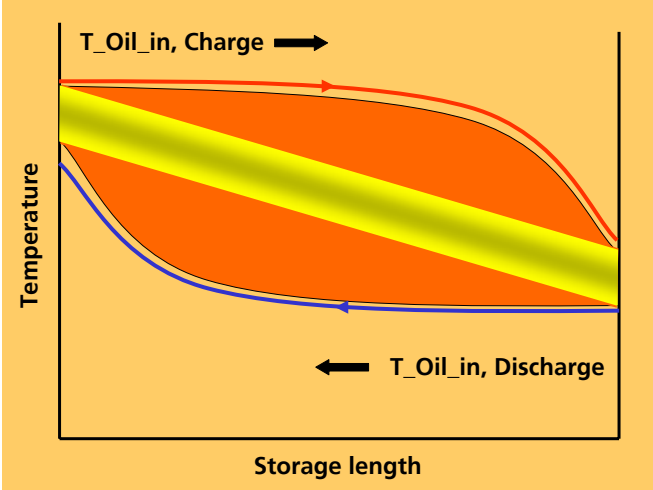


Solid Media Concrete Storage

Characteristic behavior of dual media solid TES

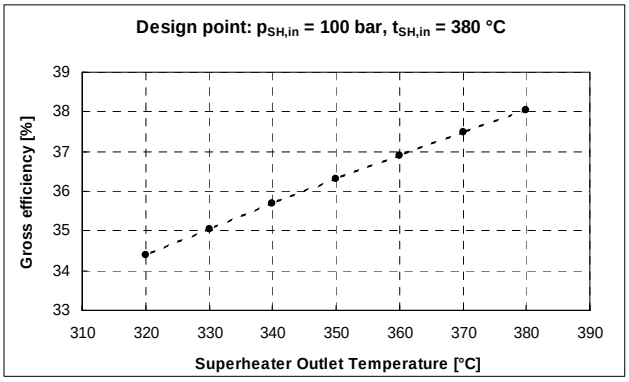


Solid Media Concrete Storage
Characteristic behavior of dual media solid TES



Important issues:
- **internal heat transfer**
- **heat conductivity of solid media**

Characteristic behavior of dual media solid TES
Consequences



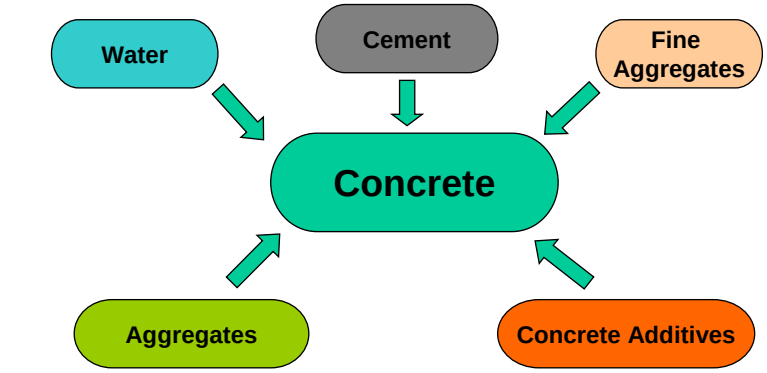
- No technical constraints against temperature decrease at the hot end
- Decrease is limited by economic aspects
- Storage integration is a specific issue of indirect TES systems

Concrete Storage Material Development
Requirements on concrete storage material

- High heat capacity
- High heat conductivity
- Thermal endurance and long term stability
- Thermal expansion similar to tube register
- Good handling
- Low costs
- Availability of components

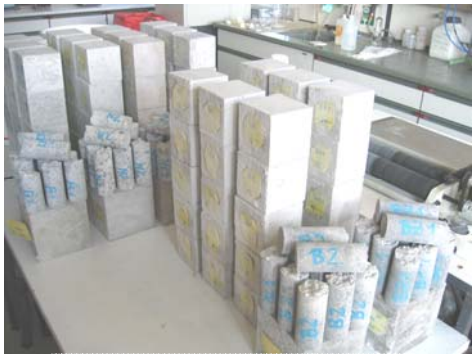
Development of concrete storage material

classical „ternary system“ → **modern „five material system“**



Adaptation to specific requirements is possible!

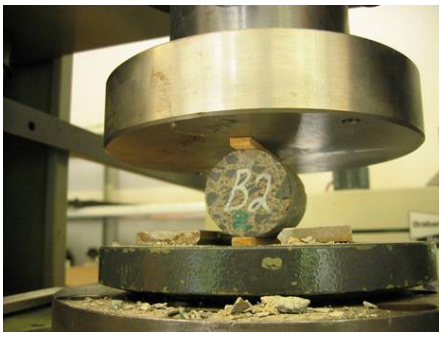
Development of concrete storage material
Testing of concrete modifications

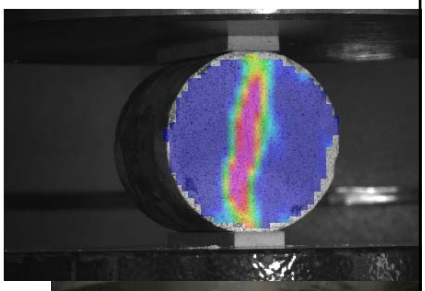


Investigated major aggregates:

N2	-	Sand / Gravel
NZ 2	-	Sand / Gravel + Scale
B1, B2	-	Basalt
BZ 1	-	Basalt + Scale

Development of concrete storage material
Investigation of material strength

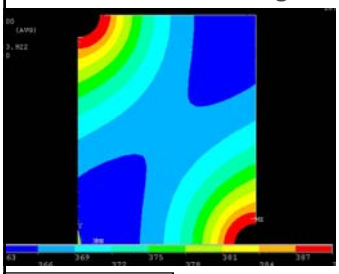




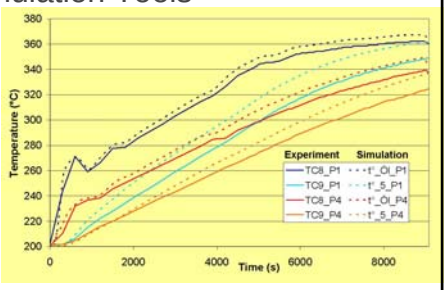
- Tensile and compressive strength are in expected range of common concrete
- 30-40% decrease of tensile strength after long term cycling
- No decrease of compressive strength after long term cycling

Solid Media Concrete Storage

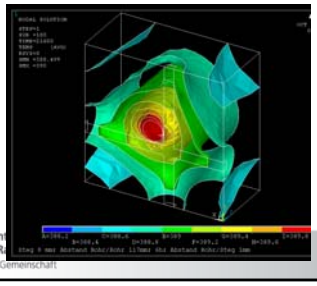
Thermal Engineering and Simulation Tools

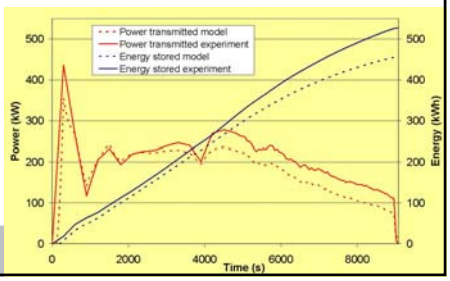


Simulation tools for storage design



Introduction of heat transfer structures

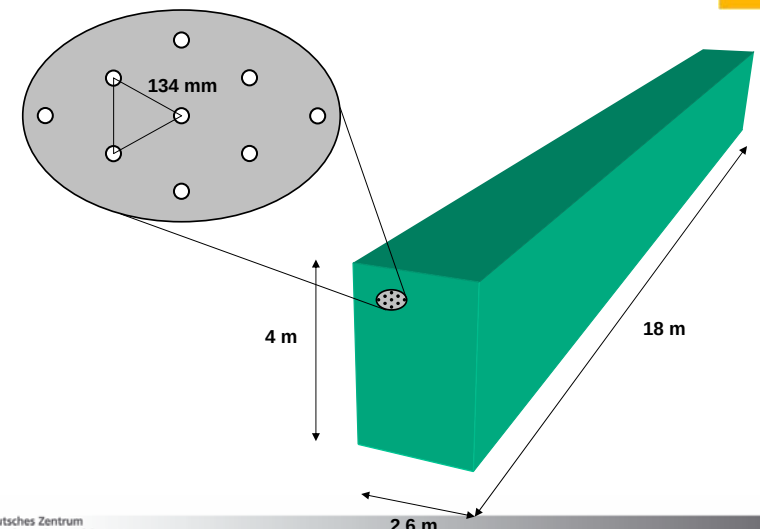




Storage Design for Andasol-Konfiguration

Basic Storage Module

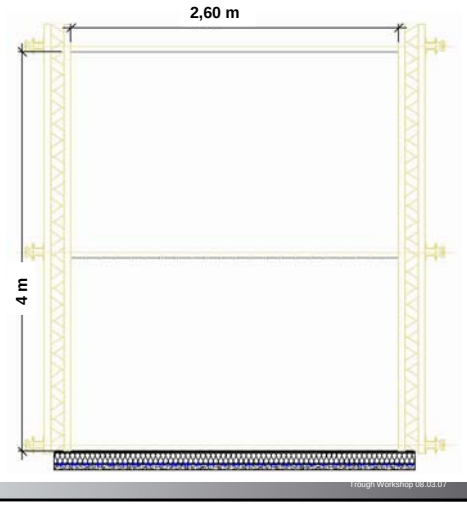
ZÜBLIN



Storage Design for Andasol-Configuration
Construction of storage module

ZÜBLIN

1. Foundation slab
2. Insulation
3. Gliding plane
4. Framework



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Storage Design for Andasol-Configuration
Construction of storage module

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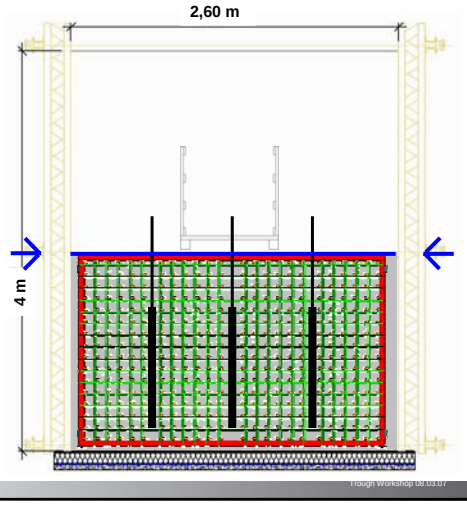
5. Tube register (1. Element)
6. Working platform
7. Formwork tie
8. Pouring and compaction
9. Remove working platform



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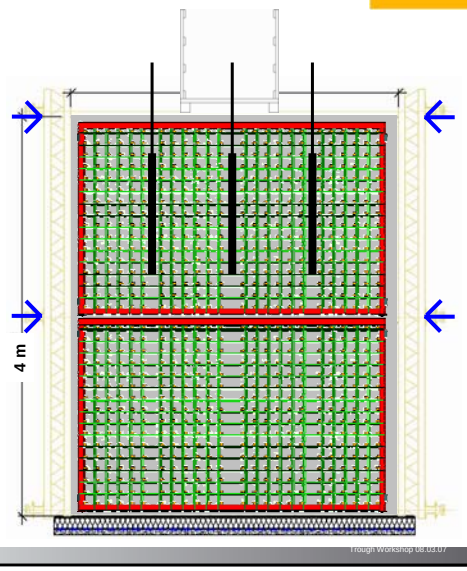
Storage Design for Andasol-Configuration
Construction of storage module

ZÜBLIN

10. Tube register (2. Element)
11. Working platform
12. Formwork tie
13. Pouring and compaction
14. Remove working platform



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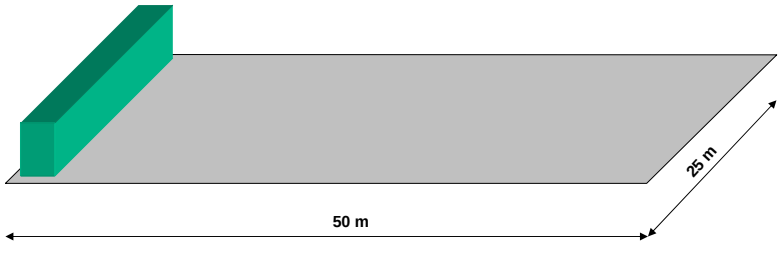
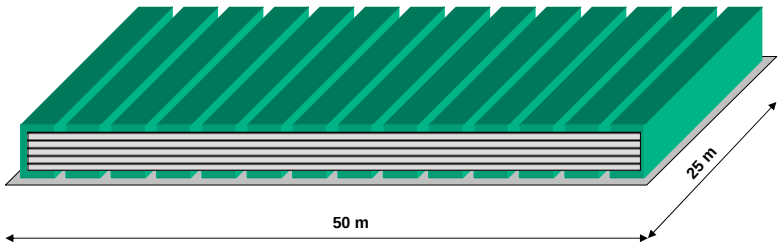
Storage Design for Andasol-Konfiguration
Storage Package

ZÜBLIN



Storage Design for Andasol-Konfiguration
Storage Package



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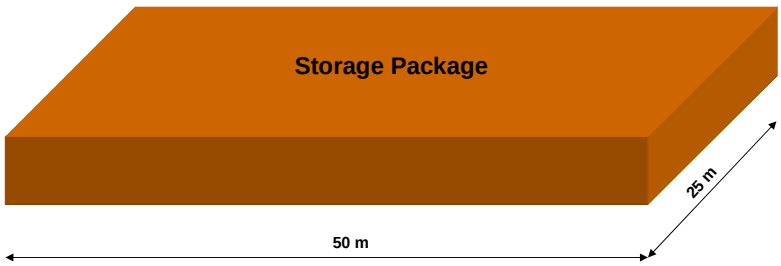
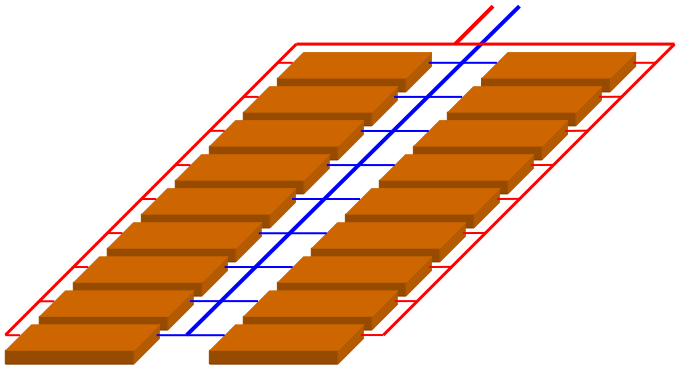
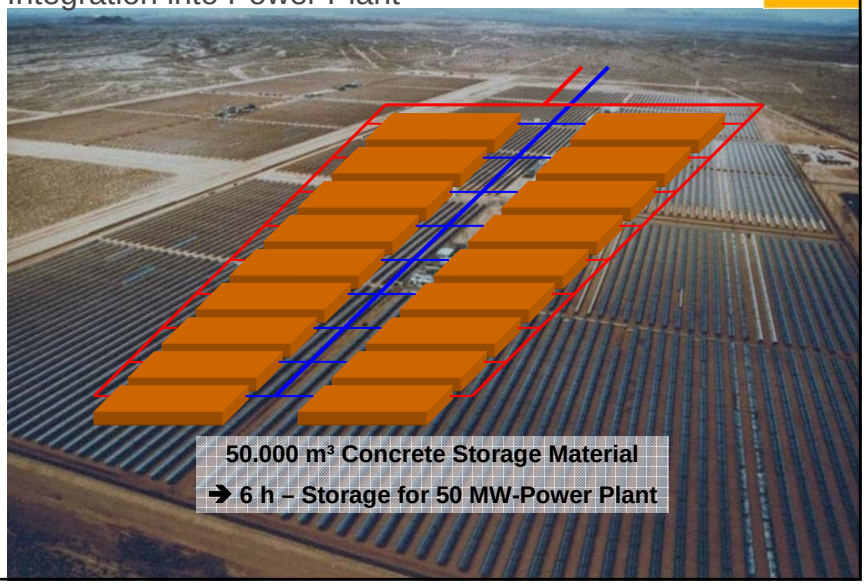


Storage Design for Andasol-Konfiguration
Storage Design - Piping



Storage Design for Andasol-Konfiguration
Integration into Power Plant



Storage Design for Andasol-Konfiguration
Integration into Power Plant

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DLR

Concrete Storage Testmodul
100 kW Testloop near DLR Stuttgart

- Storage volume 20 m³ (1,7 m x 1,24 m x 9 m)
- Storage capacity 400 kWh (for dT = 40 K)
- 100 kW Testloop with Sylltherm 800 for heating and cooling

Concrete Storage Test Module
Construction tube register

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Concrete Storage Test Module
Mounting of thermocouples

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Concrete Storage Test Module

Formwork and pouring of concrete

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Concrete Storage Test Module

Housing of test loop

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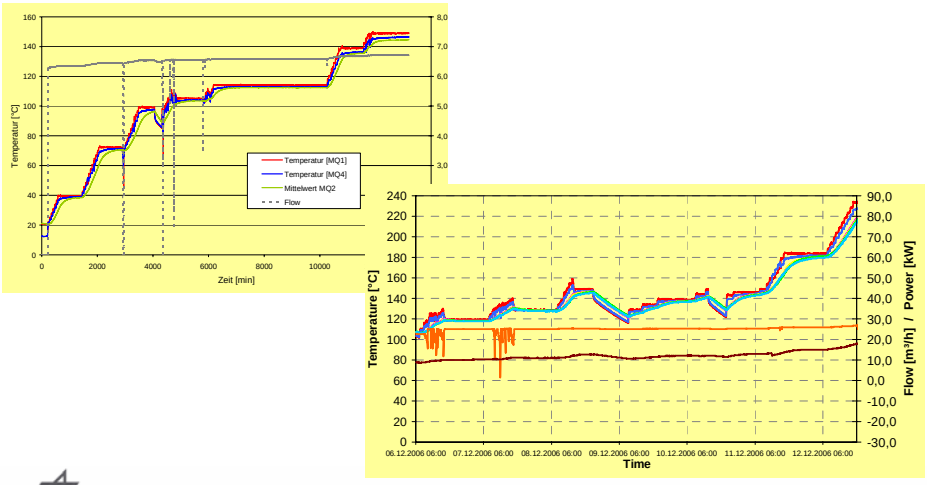
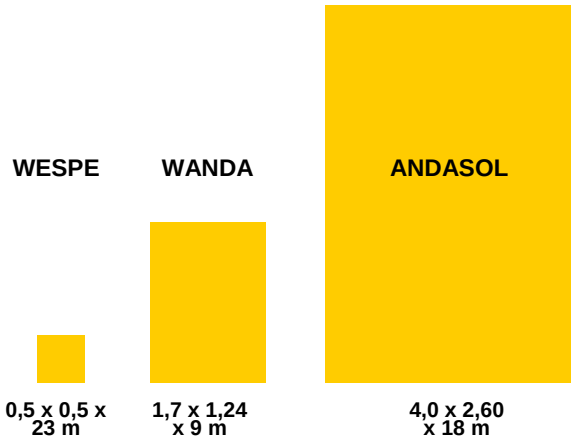
Concrete Storage Test Module
Start-up



Storage Design for Andasol-Konfiguration
Basic Storage Module – Cross section



ZÜBLIN

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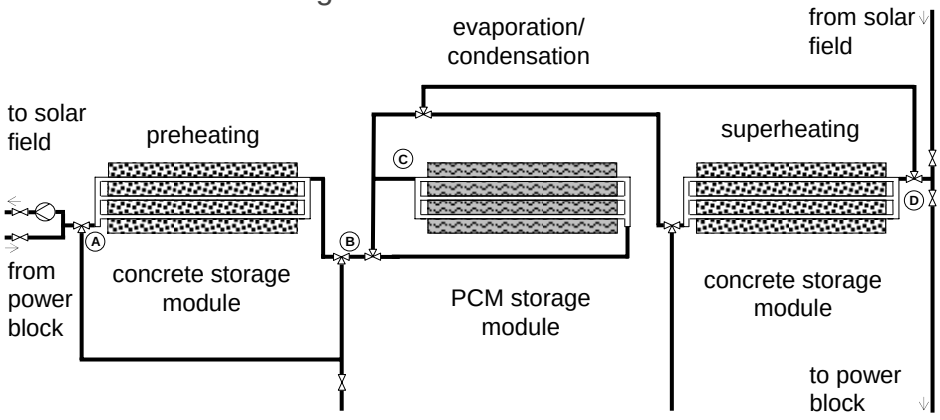
Phase 3: **2007 – 2008**
Re-design and verification of improved design, up-scaling

Phase 4: **> 2009**
Pilot storage – commercial supplier

Outlook
Concrete Storage for Direct Steam Generation



A feed water inlet / outlet
B liquid water
C saturated steam
D live steam inlet / outlet

Conclusions

- Energy storage is a key issue
  - for efficient energy utilization
  - to reduce fossil fuels consumption and CO2 emissions
  - for increased heat and power generation with RES
  - to balance unequal supply und demand profiles
- Concrete storage technology seems to be a cost effective option for solar power plants
- Continuous research and development effort is needed to bring this technology to commercial stage