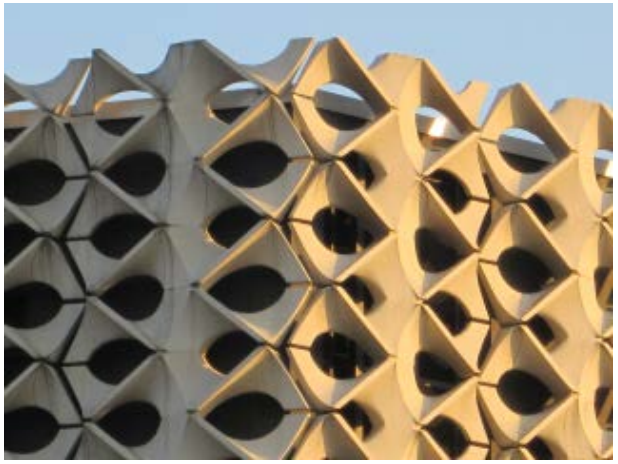
Short introduction of our interests // Thermal energy storages



Dr.-Ing. habil. Thorsten Urbaneck

Chemnitz University of Technology
Department of Mechanical Engineering
Chair for Technical Thermodynamics
Chemnitz (Saxony)
Germany

12. April 2013, Stellenbosch (South Africa)

Organization

- Chair of Technical Thermodynamics
  - Basic training in study of Mechanical Engineering (Bc.)
  - Master: Systems for Sustainable Energy Supply (M. sc.)
- My group: Thermal Energy Storage
- Field/Application
  - Systems for heating and cooling supply
    - Solar thermal
    - Cogeneration/Trigeneration
    - LowEx Concept etc.
  - Storages with water (tanks) or gravel-water (man made pits)
    - Large-scale
    - Temperature: cold (5 °C) up to hot (ca. 200 °C)
    - In the most cases short-term (also long-term)
  - Optimization
    - Systems (with TRNSYS-Simulation)
    - Storage construction
      - ➢ especially Charging and Discharging devices
      - ➢ experimental investigation of material
    - Operation (over long-term monitoring)

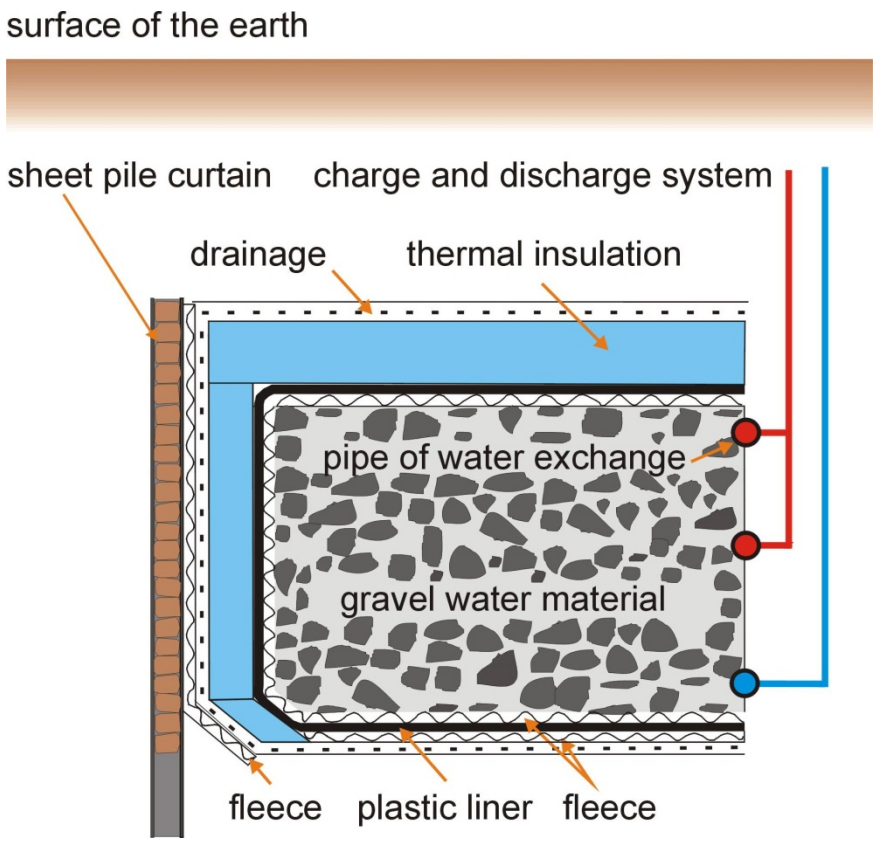
Solar assisted district heating plants with seasonal storages (1996-2003)

- Research and demonstration program Solarthermie 2000, Subtask 3 (1993-2003) in Germany ➲ Central solar heating plants with seasonal storage (CHSPSS)
- Follow-up: Solarthermie 2000 plus (2004-2009) ➲ Federal Ministry for Environment, Nature Conversation, and Nuclear Safety, Project Management Organisation Jülich
  - General objectives
    - Technology development and demonstration
    - High substitution of fossil fuel ➲ high solar fraction = 30 ... 50 %
      ➲ inclusion of space heating ➲ seasonal storage
    - Cost reduction
  - 8 pilot plants (2004) ➲ one system in Chemnitz “solarisPark” ➲ my task
- Main emphasis: seasonal storage ➲ in Germany 4 basis concept's and combinations
  - Hot-Water-Storage
  - Gravel-Water-Storage
  - Borehole-Storage
  - Aquifer-Storage

	Stuttgart	Chemnitz	Augsburg	Steinfurt
construction	1985	1996	1997	1999
volume in m^3	1000	8000	6000	1500
charge and discharge	direct und indirect	direct	indirect	indirect

Gravel water storage - Design

- Basic facts
  - 8000 m³ gravel water filling = 5333 m³ water equivalent
  - 58 m x 20 m x 7 m
  - 3,5 m under the surface of earth
  - (0 °C) … 85 °C
  - charge and discharge: direct water exchange, 3 pipes in 3 levels, thermal stratification
- Materials
  - gravel 16 / 32 (mm), washed
  - 2,5 mm PE-HD liner (polyethylene with high density), temperature < 85 °C, protective fleece
  - heat insulation: on the top 24 cm and on the side walls 12 cm (XPS, Dow Chemical, STYROFOAM, FLOORMATE 500)
  - drainage on storage surface: sand, lattice
  - additional support: sheet pile curtain



Construction of the storage

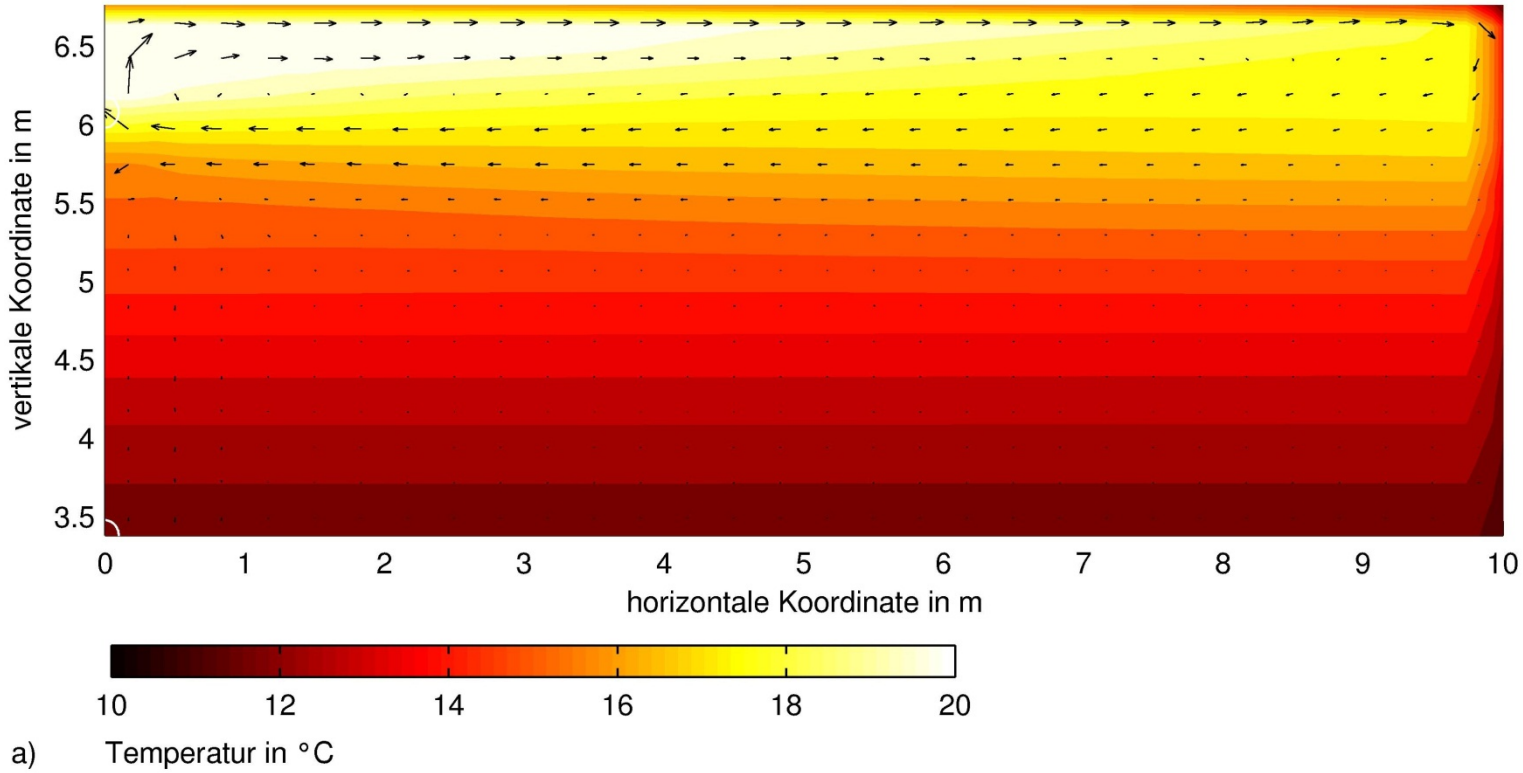
8000 m³ pit for the Gravel-Water-Store in Chemnitz (1996) // The pit

8000 m³ pit for the Gravel-Water-Store in Chemnitz (1996) // Gravel filling

Solar district heating in Chemnitz (2000) // 540 m² evacuated tube pipe collectors

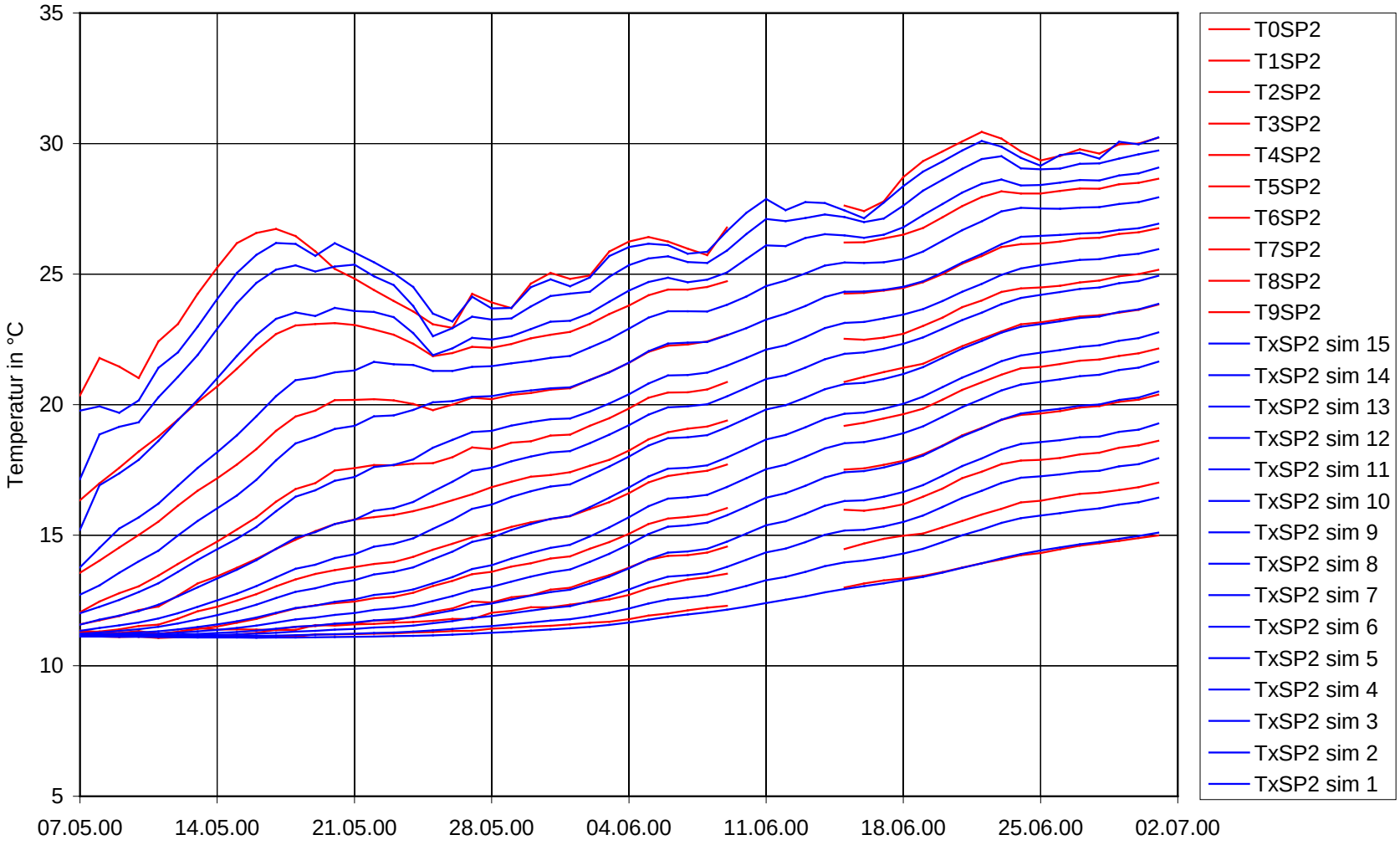
Simulation of thermal behaviour with CFD (1998-2003)

- Use of CFX 4.4 with User Fortran ➲ Storage, earth, surface
- Mass- and heat transfer with a 2 Phase Model (my PhD work in 2004)
  - Validation and experimental investigation of gravel-water
  - Evaluation of real storage behavior ➲ internal flow, stratification, losses etc.



Typical vortex during the charging phase in the upper part of storage, temperature and flow field

Measured (red) and calculated (blue) vertical distribution of storage temperature



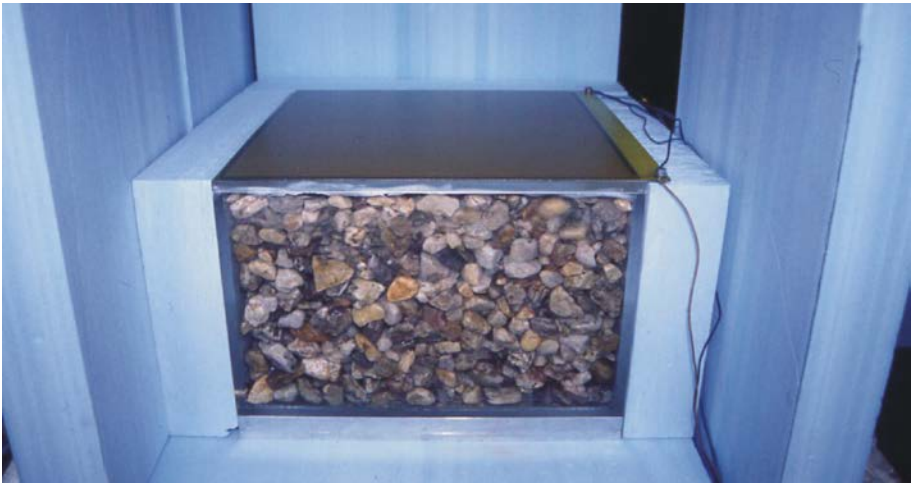
Investigation of gravel water filling

- Gravel particle and filling
  - ➲ owe experimental examinations
    - filling porosity = 0.4
    - mean particle diameter = 22.3 mm
    - mean gravel density = 2629 kg/m³
    - effective thermal conductivity = 2.49 W/(mK)
      - ➲ high spreading ➲ material analysis of gravel (petrology)
      - ➲ high portions of quartz and quartzite = 85 %-Vol. (particularity in Saxony)
    - literature ➲ specific heat capacity of gravel = 0.79 kJ/(kgK)
    - volumetric heat capacity = 2.904 MJ/(m³K)

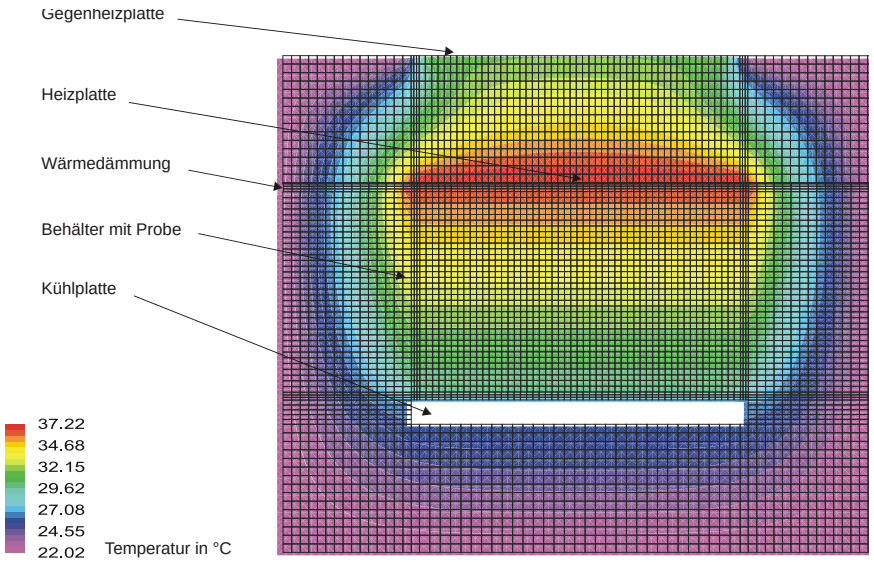
16 / 32 mm gravel

Investigation of gravel water filling

- Effective heat conductivity ➲ prime importance
  - Long-term storage
  - 2 Phase model ➲ displacement on liquid phase
- Experiment ➲ heating and cooling plate and guard heating
  - Effective heat transfer ➲ vertical direction
  - CFD
    - Validation of model
    - Checkup of many parameters



Test rig for effective heat conduction



Recalculating with CFX, 3D, temperature

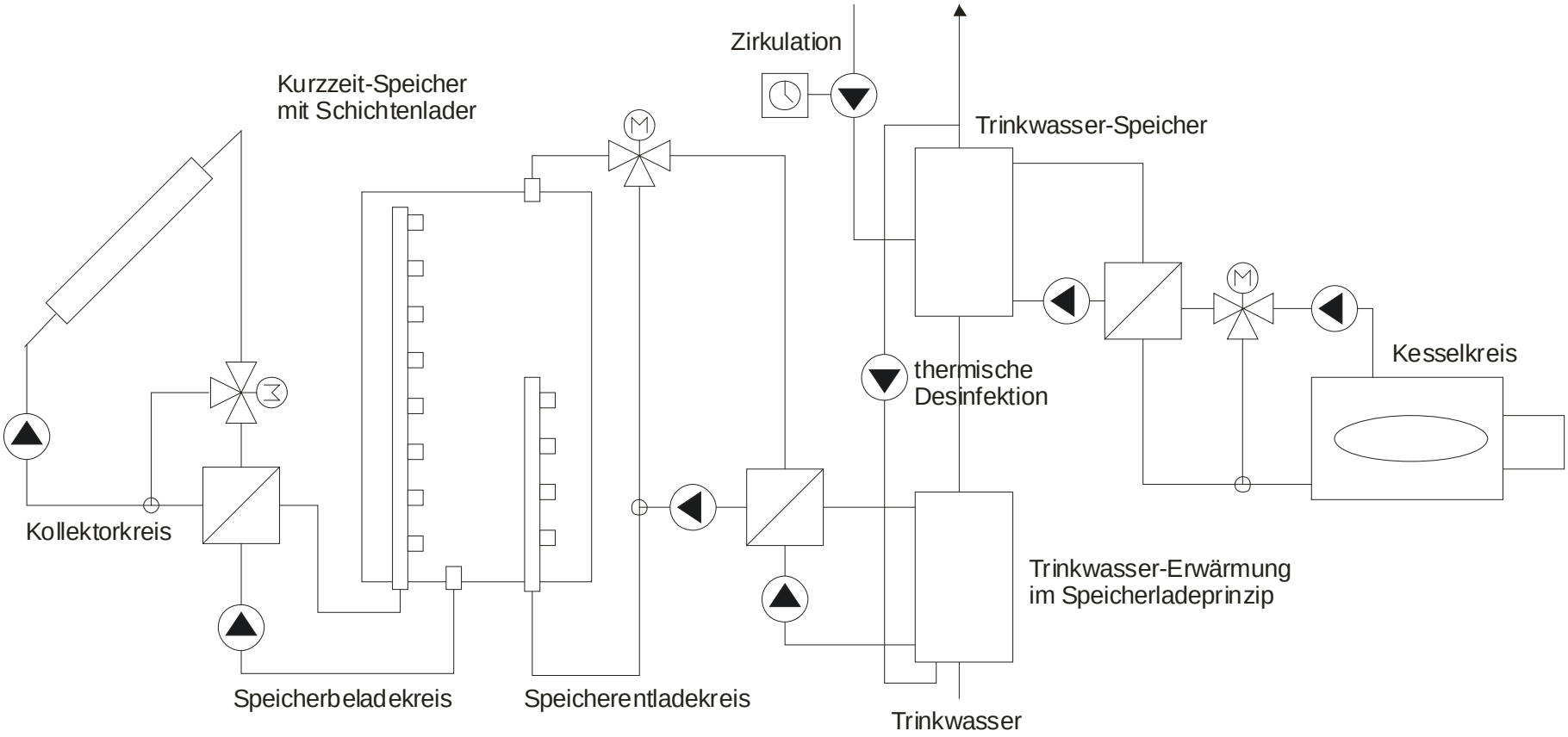
Solarthermie 2000, Subtask 2 (1993-2003)

- www.solarthermie2000.de
  - Schirmer, Göring, Freitag et al.
- Federal Ministry for Environment, Nature Conversation, and Nuclear Safety
- Project Management Organization Jülich
- Solar thermal systems for tap water heating → pre heating systems → subtask 2
  - Design with consideration of budget → „tight calculate“
    - Solar fraction: 20 ... 30 %
    - High system harvest: 450 ... 600 kWh/(m²a) → high system efficiency: 40 ... 53 %
    - Cost of solar heat: 0,12 ... 0,16 €/kWh
      - with design
      - with tax
      - without subsidies
    - Cost of system ca. 580 €/m²

Student hostel in Leipzig

Public bath in Chemnitz

Solar thermal systems for tap water heating



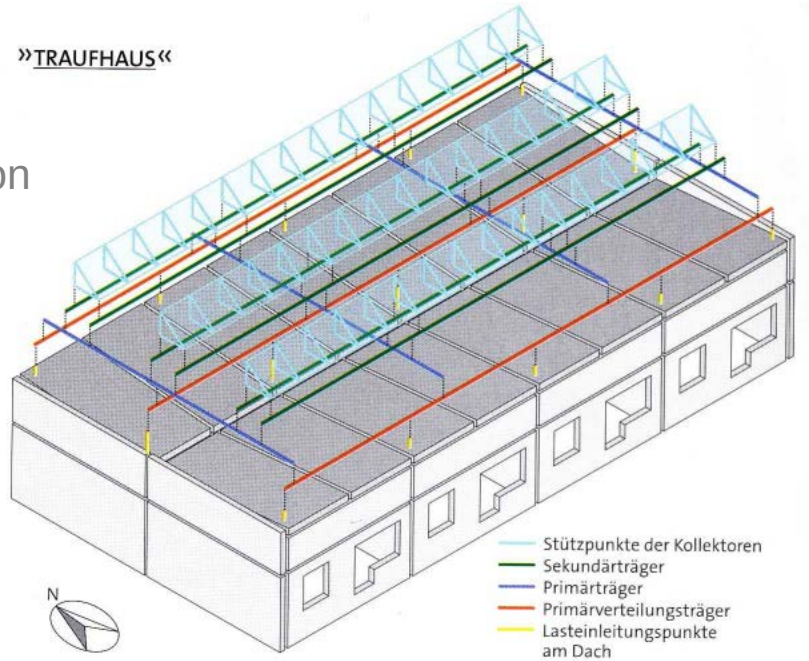
State of pre heating systems in Saxony (up to 2004)

- Nursing home in Hilbersdorf 108 m²
- Technical college in Zschopau 122 m²
- Retirement home in Leipzig 294 m²
- Students' hostel in Leipzig 198 m²
- Students' hostel in Zwickau 158 m²
- Large-scale garage of cleansing department in Dresden 151 m²
- Public baths in Chemnitz 288 m²
- Sheltered workshop in Leipzig 100 m²
- Administrative district hospital Kirchberg 180 m²
- Students' hostel in Chemnitz 100 m² ** ➲
- Dwelling house in Glauchau 114 m²
- Public baths in Pirna 105 m²

Technical college in Zschopau (Saxony) 122 m²

Installation of (solar thermal) large-scale fields on (flat) roofs (1999-2001)

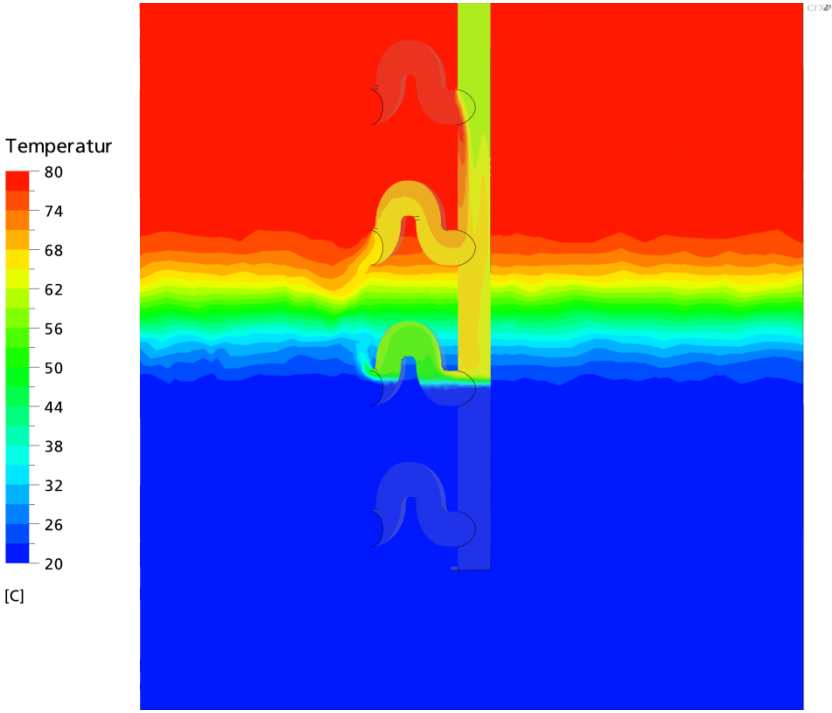
- www.solarthermie2000.de
- Federal Ministry for Environment, Nature Conversation, and Nuclear Safety
- Project Management Organization Jülich
  - Cooperation with E&P and Salarpraxis
- Optimization of constructions building with flat roofs (industrial building method in the former GDR)
  - Reducing of costs
  - Avoiding of problems in the field of buildung physics
  - Review of loads ➲ Wind, ice, snow, construction etc.
- Development of a catalogue with sample solutions for the sub construction



Gebäudetyp 0,8t Brandenburg Source: Schulze, Dieter: Wohnbauten in Fertigteilbauweise (Baujahre 1958 - 1990) – Übersicht – Hrsg. IEMB Institut für Erhaltung und Modernisierung von Bauwerken e.V., Fraunhofer-Informationszentrum Raum und Bau (IRB), Stuttgart, Januar 1995, IRB Verlag Stuttgart

Development and optimization of charging and discharging devices for tank and pit storages

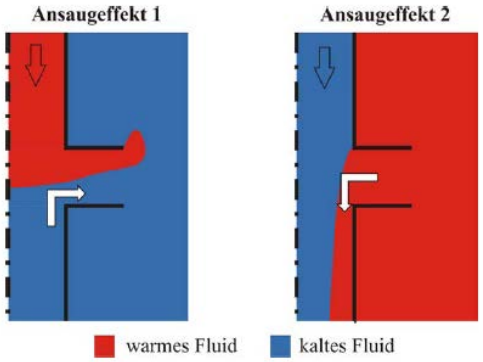
- www.solarthermie2000plus.de
- Federal Ministry for Environment, Nature Conversation, and Nuclear Safety
- Project Management Organization Jülich
  - Cooperation with Technical University of Ilmenau (Thuringia)
  - 2004-2009
- Background
  - Growing importance of solar (space) heating
  - Necessities
    - Good stratification
    - Long-therm operation
    - Low costs
- Water filled storages
  - Development with CFD
    - All information
    - No problems with similarity relation
    - No cost for charging of big storages
  - Experimental investigations



Development and analyse of a lance for stratification with CFX, Source: Lohse

Experimental investigations // Flow effects

- (independent) lances with several outlets
  - Low flow systems
  - Variable inlet temperature
- Effects
  - Inside the charging device
    - E. g. two suction effects
  - In the near of outlet
- Measurement
  - Vertical temperature distribution
  - Volume flow rate
  - Schlieren method
    - *acrylic glass



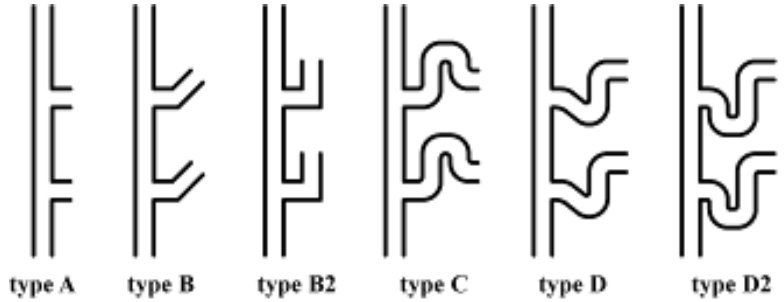
Suction effects, Source: Lohse, Göppert, Urbaneck et al.

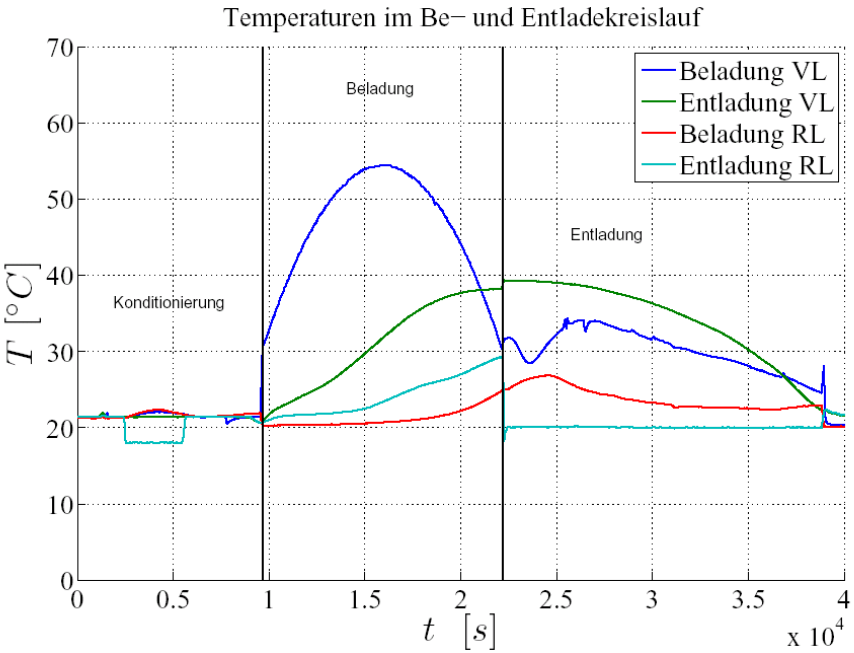
Plexi 1* – Test rig for visualization of flow

Test of charging device, Source: Kunis

Experimental investigations // Test of stratification devices for solar storages

- Full automated test system
- Defined test cycles ➲ investigation in real use

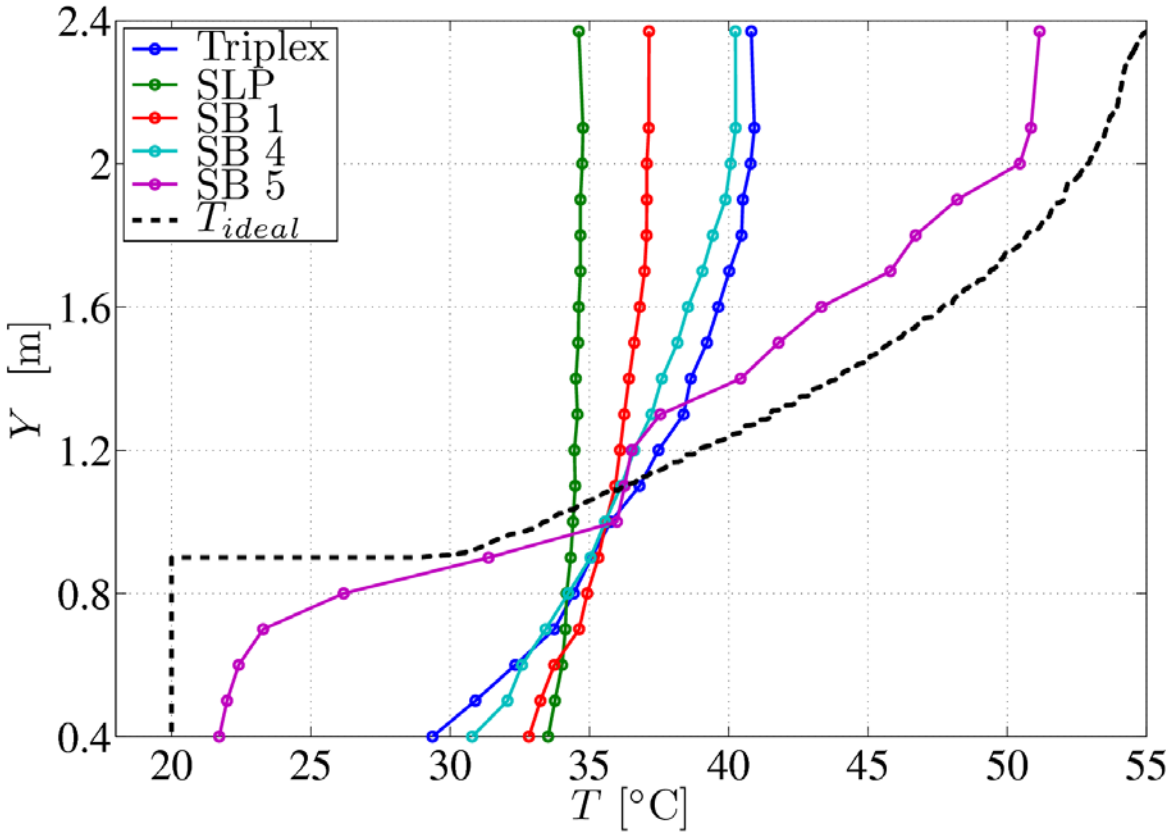




➲ Test storage with 2 m³

Experimental investigations // Test of stratification devices for solar storages

- Strong differences in the stratification quality
  - SB5 ➲ development of our group
- Several projects with industry



Development of long-term storages made of plastics

- Federal Ministry for Environment, Nature Conversation, and Nuclear Safety
- Project Management Organization Jülich
  - Cooperation with storage manufacturer *Haase*
  - Follow-up project
  - 2009

- Glass fibre reinforced plastic (GRP) as an alternative to steel
  - Sandwich construction
  - Use of plastic for the charging and discharging system
    - long-living, low-maintenance
- Higher solar fractions
  - Small district heating systems
  - Multi family houses

GRP storage in basement, Source: Haase

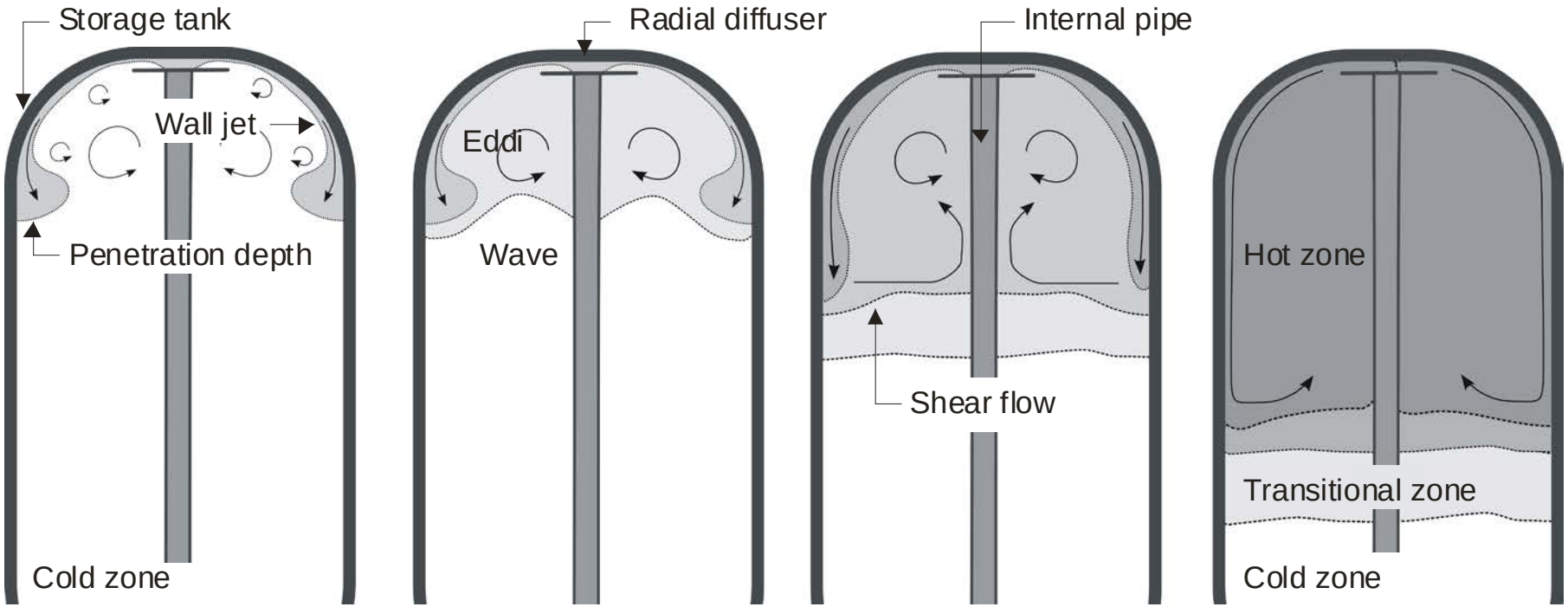
Storages in classic district heating systems // Example

- Importance of hot water storages (> 110 °C)
  - Large heat supply systems in combination with
    - Central heating plants with cogeneration (CHP)
    - Industrial systems (e. g. waste heat)
  - Often Temperatures > 120 °C
  - Pressure vessel storage
    - Tall storages ➲ High aspect ratio
    - Internal flow behavior
      - Thermal stratification
      - System efficiency

Hot water storages (6480 m³, 160 °C, 22 bar), Chemnitz, district heating with communal CHP, Schuricht et al.

Storages in classic district heating systems // CFD study (2010-2012)

- Identification of four phases
- Tall storages ➲ Different flow effects govern the operation with thermal stratification.
  - In comparison to compact storages
  - The use of Froude number is problematic.



Facilities for CFD

- CFD
  - CFX
  - Open Foam
- Hardware
  - CHIC ➲ Heterogeneous Linux Cluster
  - Parallel computing

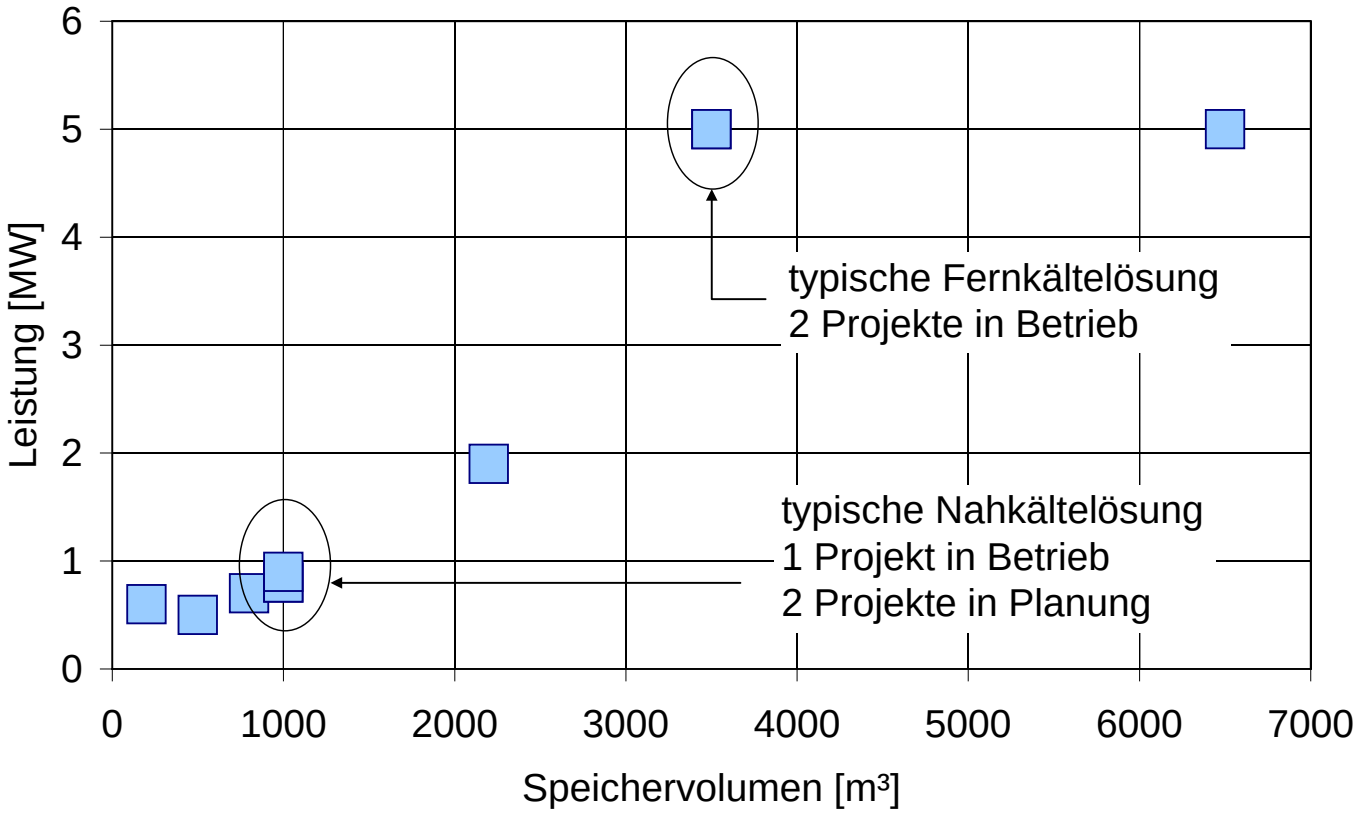
Cold water storages and district cooling // State of projects

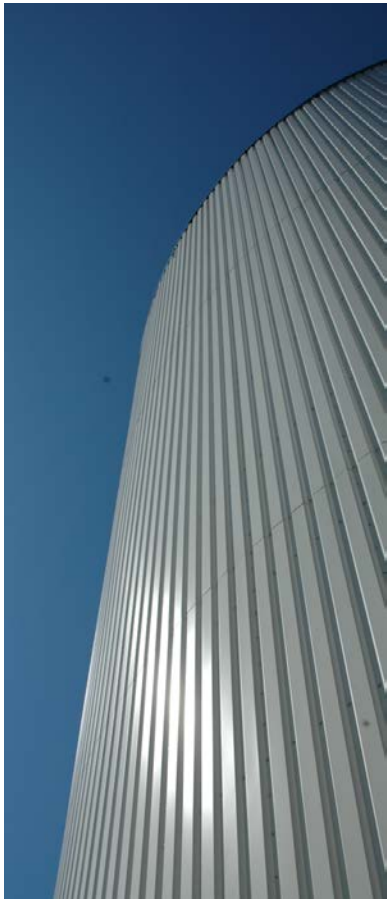
- 10 projects
  - 2 cancellations
  - 6 in operation (in 2013)
  - 2 in concept/design phase
- Combination with different chiller units
  - Relative high fraction of absorption chillers
  - High efficient vapor compression chiller unit
    - new products from 2008
- New concepts
  - Use of natural cold sources (free cooling)
    - Background: high fraction of primary energy consumption ➲ new laws for protection of environment ➲ higher requirements ➲ Renovation of building 15 % renewable cold and 50 % renewable cold for new buildings
  - LowEx (low exergy heating and cooling)
    - Cooperation with Fraunhofer ISE (Freiburg), 2011-2014
    - First cold water storage in a building (basement) in Germany
    - Use of a high efficient heat pumps (for heating and cooling in the institute)
- Use of cold water
  - Air-conditioning in each project
  - In 50 % also technological cooling

New building for R&D in Freiburg

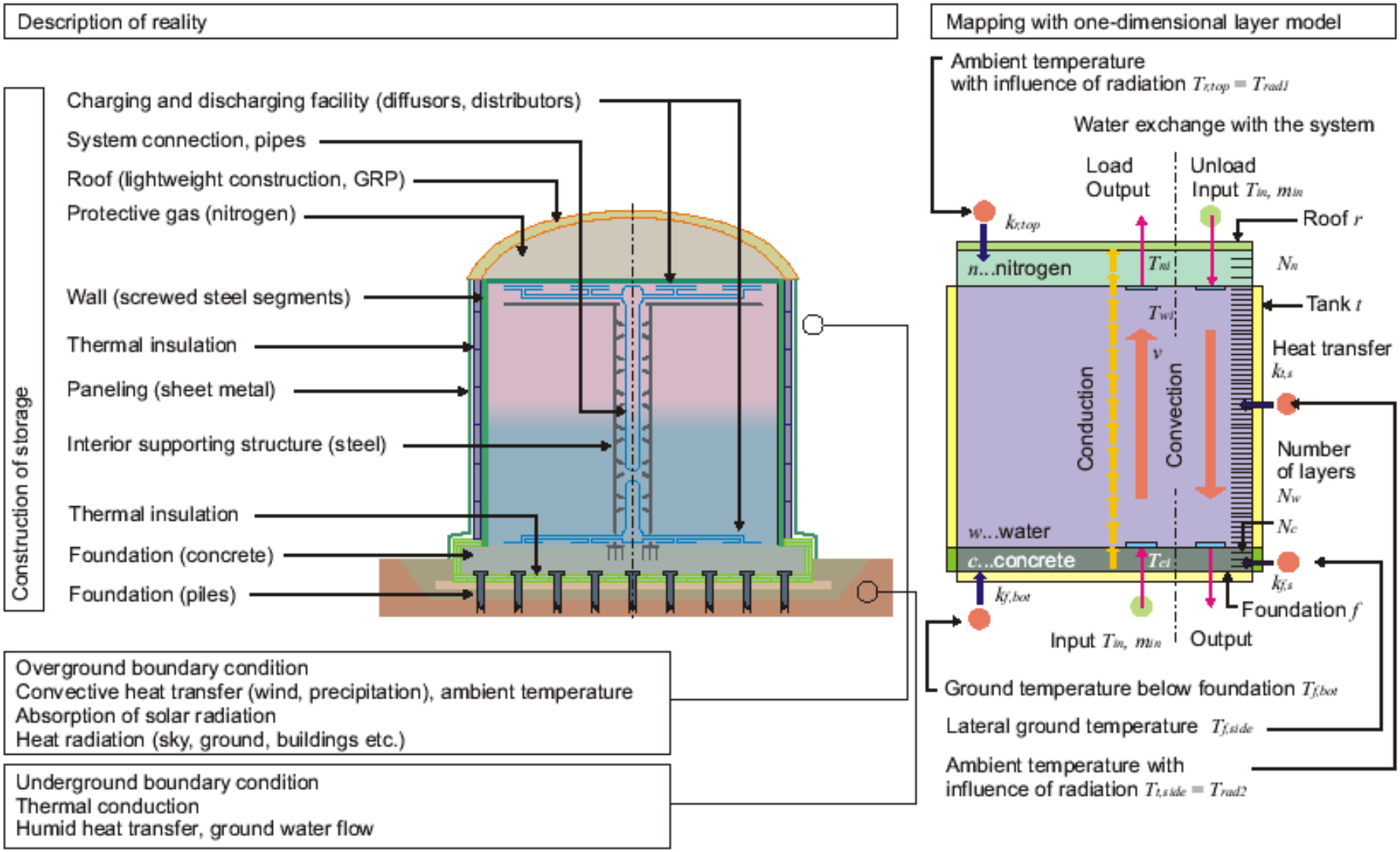
Cold water storages and district cooling // State of projects

- Distribution of storage size and capacity
- Motivation: Costs, safety (e. g. operating theatres), optimization of operation
- Our activities: Improvement of function and design methods, cost reduction, know-how transfer, monitoring



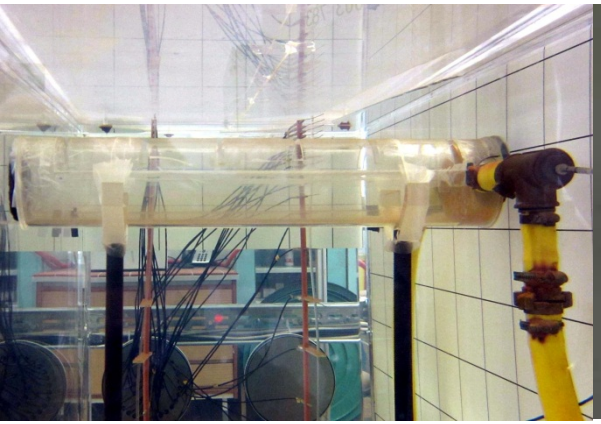


Cold water storages and district cooling // New TRNSYS model



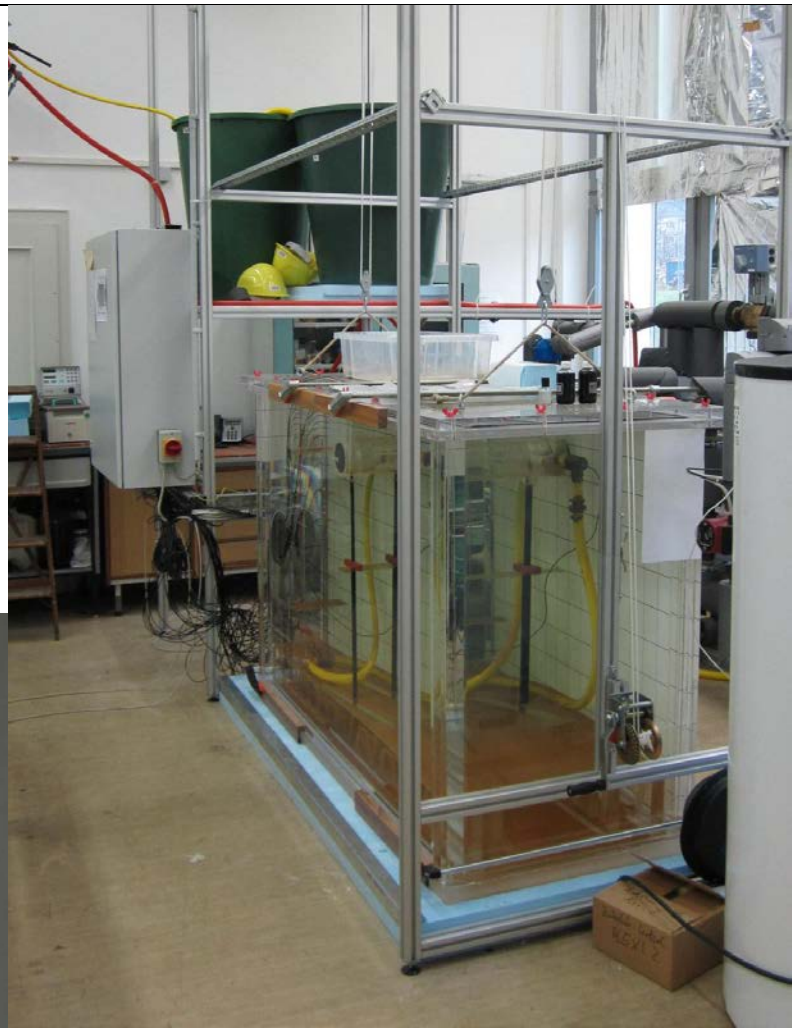
Cold water storages and district cooling // New test rig pipe diffusors and linear diffusors

- Charging and discharing devices with a fixed height
- Fully automated tests
- Test series for study of influence of parameters
  - Volume flow rate: 1.0/2.0/3.0/4.0 m³/h
  - Temperature difference: 5.0/7.5/10.0 K



Test of a slotted pipe diffusor

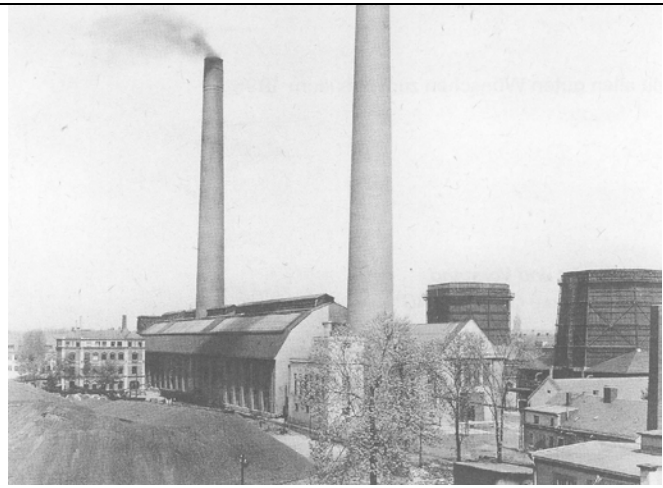
Model of a linear diffusor



Plexi 2 – Test rig for visualization of flow with schlieren method

Solar assisted district heating // General remarks Brühl project

- District heating
  - Well know technology in Germany
  - Heat supply with cogeneration
- In Chemnitz
  - Start in 1931 ➲ first action against the pollution of decentralist ovens and industry ➲ also against the bad image “Soot Chemnitz” ➲ in this time “Manchester of Saxony”
  - Brown coal ➲ Combined heat and power plant (CHP) with 3 units
  - High temperature in the supply of primary net 140 °C
  - Return temperature 60 … 70 °C
- Necessity of reconfiguration of pre-existing district heating system
  - Lower losses ➲ e. g. reduction system temperatures
  - Integration renewable energy sources etc.
- Two fields of our activities ➲ cooperation with multi utility *eins energie in sachsen* ➲ CHP and District heating net ➲ Brühl propject



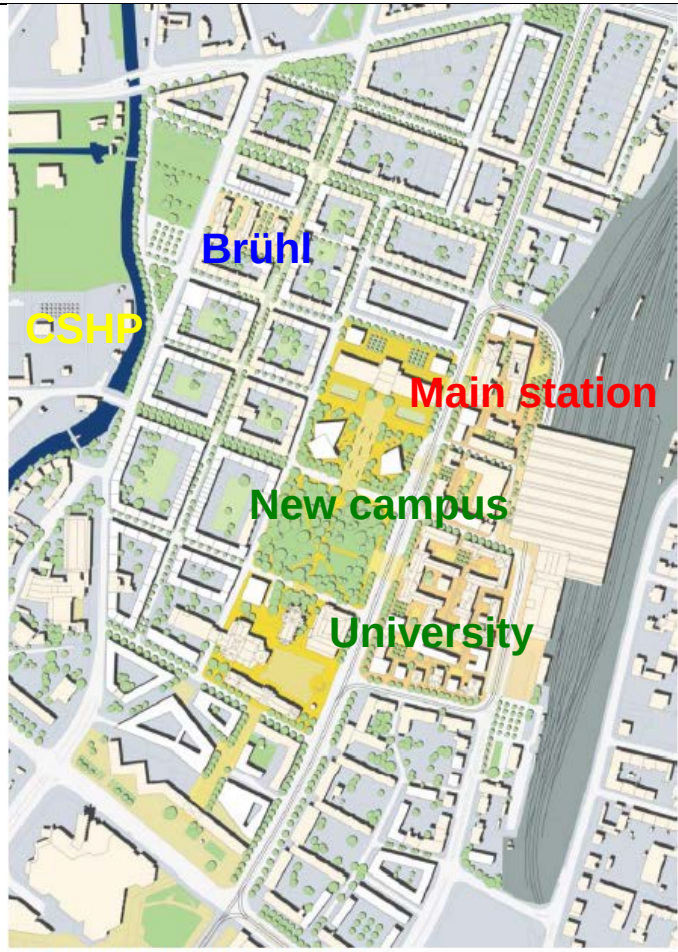
First central plant in Chemnitz

CHP North II in Chemnitz

Solar assisted district heating // Brühl project

- Complex project ➲ many aspects
  - City development ➲ e. g. traffic
  - Refitting a living area *Brühl* ➲ e. g. higher living quality
  - New campus of university in the city ➲ e. g. campus of all generations
- Our task ➲ New district heating system
  - Netzgesellschaft and eins energie in sachsen

Boulevard in the Brühl area, Source: eins

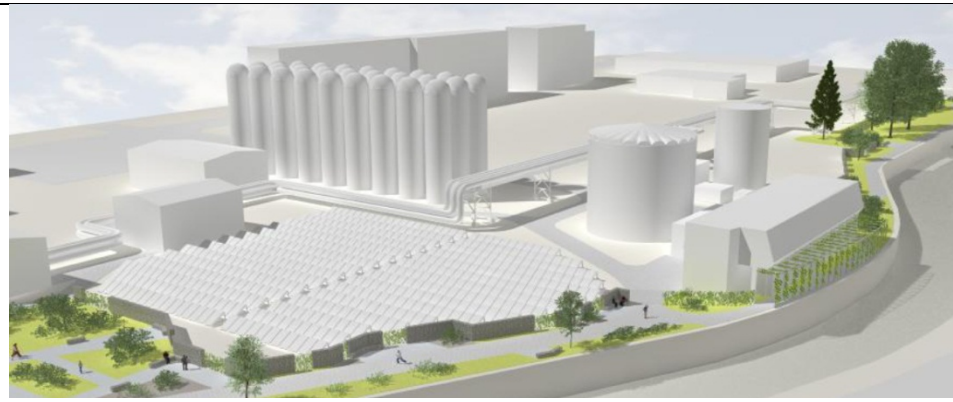


Städtebauliche Zukunftsvision

Map of area, Source: AS&P - Albert Speer & Partner GmbH: Städtebauliches Entwicklungskonzept für den Innenstadtstandort der Technischen Universität Chemnitz. Juni 2010

Solar assisted district heating // Brühl project

- Procedure (from 2011)
  - Statistic of buildings (BIV, Umweltamt)
    - Heat loads
    - Certification of buildings
  - Development of a substation for lower temperature in the net
    - Generation load profile
      - ➢ 6282 MWh/a
  - Development of central plant
    - 1800 m² collector field
      - ➢ Integration in city area
      - ➢ 11,1 % solar fraction
    - 1000 m³ water storage
      - ➢ Additional use for CHP
    - Connection to the (old) district heating net
      - ➢ Use of return water ➲ 45 %

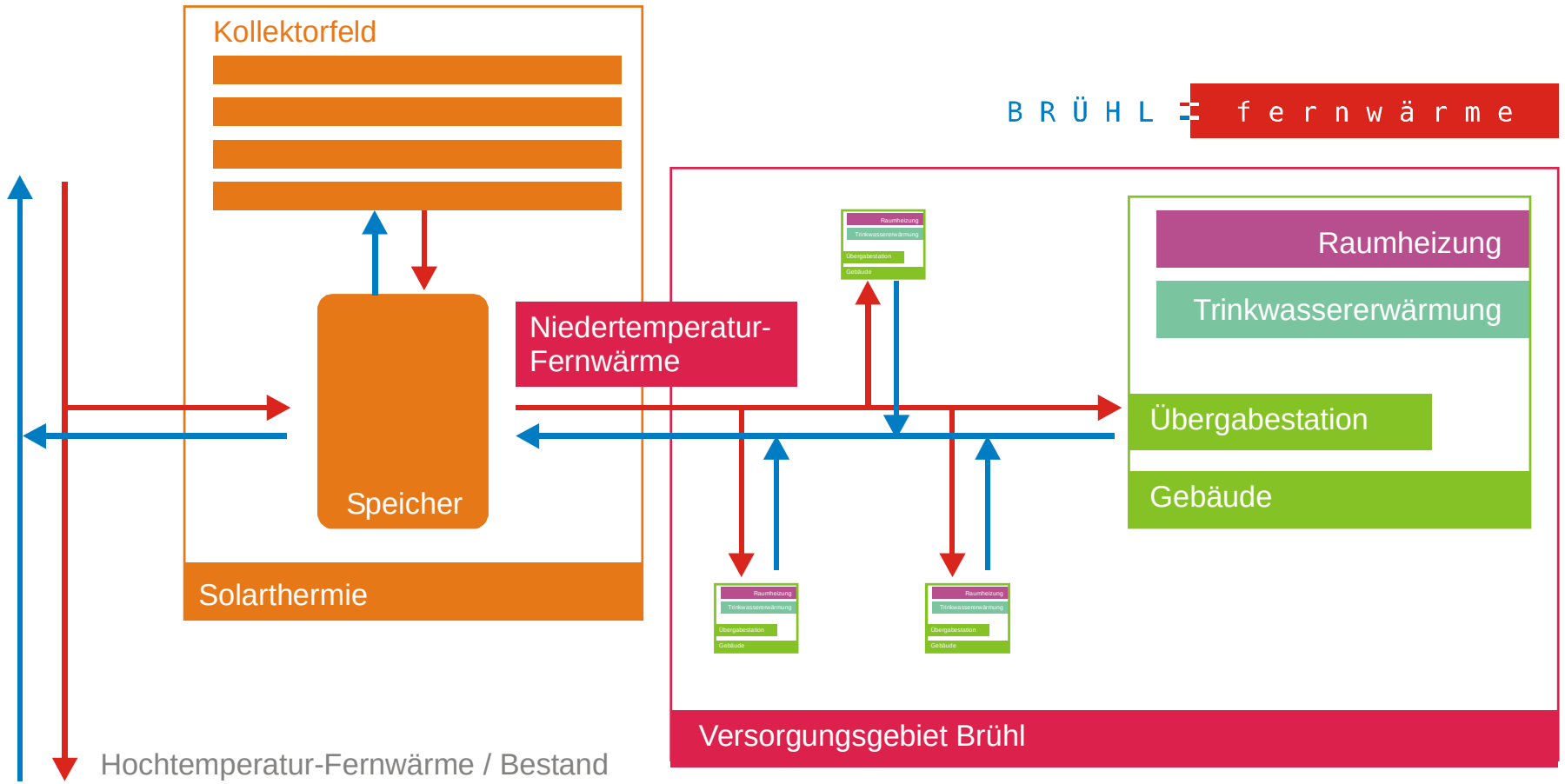


Animation of sight, Source: eins

Bird's-eye view to Brühl, Source: eins

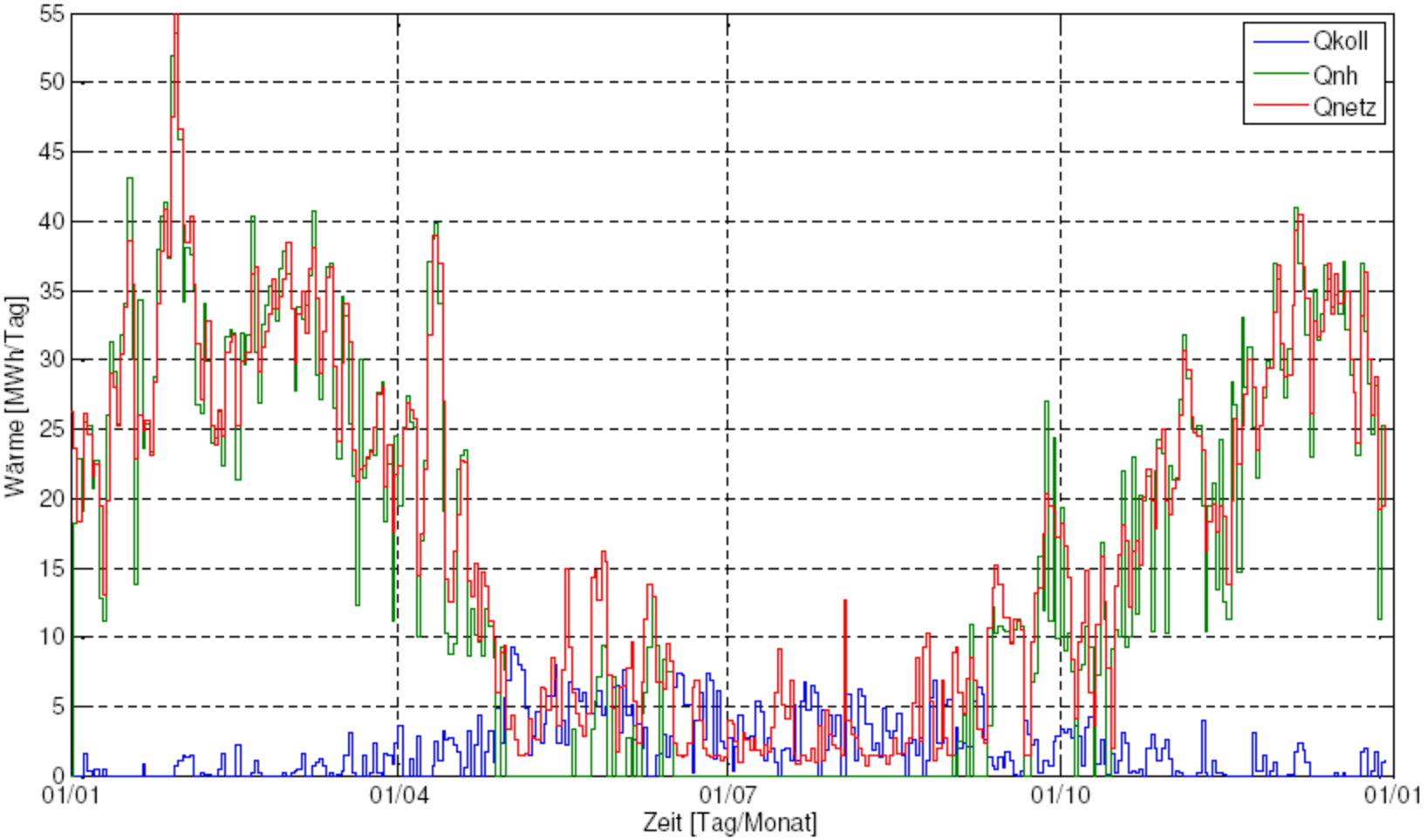
Solar assisted district heating // Brühl project

- Scheme for solar district heating
  - Isolation of Brühl area



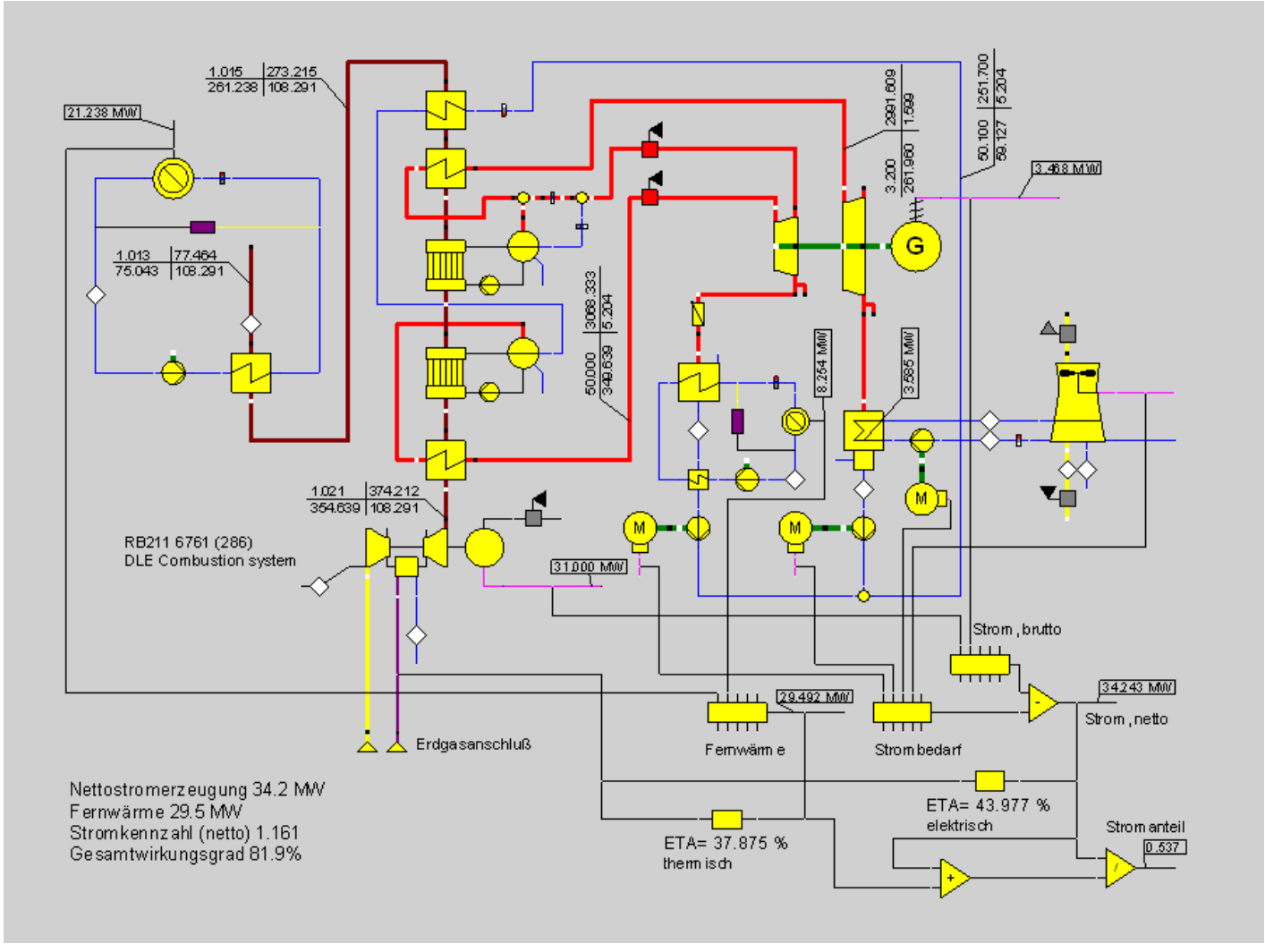
Solar assisted district heating // Brühl project

- TRNSYS simulation
  - Daily heat from collector field and the (old) district heating with CHP



CHP and district heating

- Stationary simulation ➲ EBSILON ➲ Combined power plant



- … a picture from 175th anniversary of TUC in 2011
- Good luck.

References (1)

- Solar thermal systems, monitoring
  - www.solarthermie2000.de
  - www.solarthermie2000plus.de
  - Urbaneck, T.; Schirmer, U.: Central solar heating plant with gravel water storage in Chemnitz (Germany). Terrastock 2000, 8th International Conference on Thermal Energy Storage, 2000, Stuttgart; Editors: Benner, M.; Hahne, E.; Proceedings Volume 1, S. 275-278, ISBN 3-9805274-1-7
  - Göring, J.; Urbaneck, T.; Schirmer, U. et al.: Tragkonstruktionen für Solaranlagen, Planungshandbuch. Solarpraxis-Fachverlag, 2001, Berlin, ISBN 3-934595-11-1
  - Urbaneck, T.; Schirmer, U.: Forschungsbericht – Solarthermie 2000 Teilprogramm 3 – Solar unterstützte Nahwärmeversorgung Pilotanlage Solaris Chemnitz. Technische Universität Chemnitz, Professur Technische Thermodynamik (Hrsg.), 2003, ISBN 3-00-011851-9 http://archiv.tu-chemnitz.de/pub/2006/0082
- Gravel water storage
  - Urbaneck, T.; Platzer, B.; Schirmer, U.: Advanced monitoring of gravel water storage. FUTURESTOCK 2003, 9th International Conference on Thermal Energy Storage, 2003, Warschau (Polen), Proceedings Vol.1, S. 451-458, ISBN 83-7207-435-6
  - Urbaneck, T.: Berechnung des thermischen Verhaltens von Kies-Wasser-Speichern. Diss., TU Chemnitz, Fakultät für Maschinenbau, 2004. Berichte aus der Energietechnik, Aachen, Shaker, 2004, ISBN 3-8322-2762-8
- Charing and cischaring devices for solar storages
  - Göppert, S.; Urbaneck, T.; Schirmer, T.; Lohse, R.; Platzer, B.: Be- und Entladesysteme für thermische Schichtenspeicher: Teil 1 – Überblick
  - Chemie Ingenieur Technik, 80. Jg. (2008) Heft 3 S. 287-293 - ISSN 1522-2640. http://dx.doi.org/10.1002/cite.200700162
  - Lohse, R.; Göppert, S.; Kunis, C.; Urbaneck, T.; Schirmer, U.; Platzer, B.: Be- und Entladesysteme für thermische Schichtenspeicher: Teil 2 - Untersuchungen des Beladeverhaltens. Chemie Ingenieur Technik, 80. Jg. (2008) Heft 7 S. 935-943 - ISSN 1522-2640 http://dx.doi.org/10.1002/cite.200800017
  - Göppert, S.; Lohse, R.; Urbaneck, T.; Schirmer, U.; Platzer, B.; Steinert, P.: Computations of fluid flow in stratification pipes for solar storage tanks. Effstock, 11th International Conference on Thermal Energy Storage, Stockholm (Schweden), 2009 (8 Seiten Langfassung auf CD). – ISBN 978-91-976271-3-9
  - Lohse, R.; Göppert, S.; Urbaneck, T.; Schirmer, U.; Platzer, B.: Optimization of a stratification device for thermal storage tanks. Effstock, 11th International Conference on Thermal Energy Storage, Stockholm (Schweden), 2009 (8 Seiten Langfassung auf CD). – ISBN 978-91-976271-3-9
  - Göppert, S.; Lohse, R.; Urbaneck, T.; Schirmer, U.; Platzer, P.; Steinert, P.: New computation method for stratification pipes of solar storage tanks. Solar Energy 83 (2009) S. 1578-1587, http://dx.doi.org/10.1016/j.solener.2009.05.007

References (2)

- Göppert, S.; Lohse, R.; Urbaneck, T.; Schirmer, U.; Bühl, J.; Nilius, A.; Platzer, B.: Forschungsbericht – Solarthermie2000plus – Weiterentwicklung und Optimierung von Be- und Entladeeinrichtungen für Tank- und Erdbeckenspeicher. Technische Universität Chemnitz, Fakultät für Maschinenbau (Hrsg.), Technische Universität Ilmenau, Fakultät für Maschinenbau (Hrsg.), Chemnitz, 2009, Forschungsbericht, BMU-Förderkonzept Solarthermie2000plus, Projektträger Jülich (PTJ), Förderkennzeichen 0329271A. – ISBN 978-3-9811424-0-2 http://archiv.tu-chemnitz.de/pub/2009/0102
- Lohse, R.; Göppert, S.; Urbaneck, T.; Schirmer, U.; Bühl, J.; Nilius, A.; Platzer, B.: Planungsleitfaden zur geschichteten Be- und Entladung thermischer Speicher in solarthermischen Anlagen. Chemnitz: Technische Universität Chemnitz, Fakultät für Maschinenbau, 2009. – ISBN 978-3-9811424-1-9 http://archiv.tu-chemnitz.de/pub/2009/0103/index.html
- Göppert, S.; Urbaneck, T.; Schirmer U.; Lohse, R.; Platzer, B.; Steinert, P.: Einfache Methode zur Berechnung des Ausströmverhaltens von Schichtenladern thermischer Speicher. Chemie Ingenieur Technik, 82. Jg. (2010) Heft 5 S. 681-690 - ISSN 0009-286X, http://dx.doi.org/10.1002/cite.200900145

Cold energy storages, trigenartion, district cooling, charging and discharing, monitoring

- Urbaneck, T.; Uhlig, U.; Platzer, B.; Schirmer, U.; Göschel T.; Zimmermann, D.: Machbarkeitsuntersuchung zur Stärkung der Kraft-Wärme-Kälte-Kopplung durch den Einsatz von Kältespeichern in großen Versorgungssystemen. Abschlussbericht BMWA-Forschungsvorhaben, Identifikation 0327357A, Chemnitz: Stadtwerke Chemnitz, TU Chemnitz, 2006. - ISBN 3-00-015770-0 http://archiv.tu-chemnitz.de/pub/2006/0037
- Urbaneck, T.; Schirmer, U.; Platzer, B.; Uhlig, U.; Göschel, T.; Zimmermann, D.: Optimal design of chiller units and cold water storages for district cooling. Ecostock, 10th International Conference on Thermal Energy Storage, Stockton (USA, New Jersey), Richard Stockton College of New Jersey, 2006, Tagungsband
- Urbaneck, T.; Uhlig, U.; Göschel, T.; Baumgart, G.; Fiedler, G.: Operational Experiences with a Large-Scale Cold Storage Tank – District Cooling Network in Chemnitz. EuroHeat&Power, English Edition VWEW Energieverlag Vol. 5 (2008) Heft 1 S. 28-32 – ISSN 1613-0200
- Henning H.-M.; Urbaneck, T.; Morgenstern, A.; Nunez, T.; Wiemken, E.; Thümmler, E.; Uhlig, U.: Kühlen und Klimatisieren mit Wärme - BINE Informationspaket. FIZ Fachinformationszentrum Karlsruhe (Hrsg.), BINE Informationsdienst, Berlin: Solarpraxis, 2009. - ISBN 978-3-934595-81-1
- Urbaneck, T.; Möller, H.; Kressner, T.; Platzer, B.: Kaltwasserspeicher mit radialen Diffusoren, Teil 2a: Schichtungsaufbau im Nahfeld - Grundlagen, Physik, Simulation. HLH Lüftung/Klima Heizung/Sanitär Gebäudetechnik Springer 60. Jg. (2009) Heft 6 S. 32-36. - ISSN 1436-5103
- Urbaneck, T.; Barthel, U.; Uhlig, U.; Göschel, T.: Only cold water?! - The success with the first large-scale cold water store in Germany
- Effstock, 11th International Conference on Thermal Energy Storage, Stockholm (Schweden), 2009 (8 Seiten Langfassung auf CD). – ISBN 978-91-976271-3-9

References (3)

- Urbaneck, T.; Gehrmann, J.; Lottner, V.: First large-scale Chilled Water Stores in Germany. Effstock, 11th International Conference on Thermal Energy Storage, Stockholm (Schweden), 2009 (8 Seiten Langfassung auf CD). – ISBN 978-91-976271-3-9
- Fritzsch, S.; Urbaneck, T.; Platzer, B.: TRNSYS-Model for Overground Cold Water Storages. Effstock, 11th International Conference on Thermal Energy Storage, Stockholm (Schweden), 2009 (8 Seiten Langfassung auf CD). – ISBN 978-91-976271-3-9
- Urbaneck, T.; Möller, H.; Kressner, T.; Platzer, B.: Kaltwasserspeicher mit radialen Diffusoren, Teil 2b: Schichtungsaufbau im Nahfeld – Parametervariation und Bewertung. HLH Lüftung/Klima Heizung/Sanitär Gebäudetechnik Springer 60. Jg. (2009) Heft 7-8 S. 36-41. - ISSN 1436-5103
- Held, A.; Urbaneck, T.; Platzer, B.: Untersuchung zum Ausströmverhalten aus geschlitzten Rohren. Chemie Ingenieur Technik, 82. Jg. (2010) Heft 3 S. 285-290 - ISSN 1522-2640 http://dx.doi.org/10.1002/cite.200900081
- Urbaneck, T.; Platzer, B.; Schirmer, U.; Uhlig, U.; Göschel, T.; Baumgart, G.; Fiedler, G.; Zimmermann, D.; Wittchen, F.; Schönfelder, V.: Pilotprojekt zur Optimierung von großen Versorgungssystemen auf Basis der Kraft-Wärme-Kälte-Kopplung mittels Kältespeicherung. Technische Universität Chemnitz, Fakultät für Maschinenbau (Hrsg.), Stadtwerke Chemnitz AG (Hrsg.), Chemnitz, 2010, Forschungsbericht, Projektträger Jülich (PTJ), FKZ 0327357B/C. - ISBN 3-9811424-4-6 http://archiv.tu-chemnitz.de/pub/2010/0011/index.html
- Neumann, F.; Urbaneck, T.; Platzer, B.; Uhlig, U.; Göschel, T.: Parameterbestimmung mit der charakteristischen Gleichung. ki Luft- und Kältetechnik Hüthig 46. Jg. (2010) Heft 11 S. 18-21. - ISSN 1865-5432
- Urbaneck, T.; Held, A.; Platzer, B.: Kaltwasserspeicher mit Rohrdiffusoren - Teil 3a: Grundlagen, Aufbau und Funktion. HLH Lüftung/Klima Heizung/Sanitär Gebäudetechnik Springer 61. Jg. (2010) Heft 12 S. 50-55. - ISSN 1436-5103
- Neumann, F.; Urbaneck, T.; Platzer, B.; Uhlig, U.; Göschel, T.: Vergleich von zwei baugleichen Absorptionskältemaschinen mithilfe der charakteristischen Gleichung. ki Luft- und Kältetechnik Hüthig 47. Jg. (2011) Heft 4 S. 32-35. - ISSN 1865-5432
- Urbaneck, T.; Held, A.; Platzer, B.: Kaltwasserspeicher mit Rohrdiffusoren - Teil 3b: Einfluss der Betriebs- und Geometrieparameter. HLH Lüftung/Klima Heizung/Sanitär Gebäudetechnik Springer 62. Jg. (2011) Heft 4 S. 31-37. - ISSN 1436-5103
- Urbaneck, T.: Kältespeicher – Grundlagen, Technik, Anwendung. München: Oldenbourg 2012, 479 S. - ISBN 978-3-486-70776-2
- Oppelt, T.; Urbaneck, T.; Platzer, B.: Comparison of models for calculating the heat flow through the walls of buried parallel pipes. Innostock, 12th International Conference on Thermal Energy Storage, Lleida (Spain), 2012 (9 Seiten Langfassung auf Datenträger). – ISBN 978-84-938793-4-1
- Oppelt, T.; Urbaneck, T.; Platzer, B.: Simulationsmodelle zur Berechnung von Fernkältenetzen – Übersicht zum Stand der Technik. EuroHeat&Power, VWEW Energieverlag 42. Jg. (2013) Heft 3 S. 54-57 – ISSN 0949-166X

References (4)

- Heat storage, Cogeneration
  - Urbaneck, T.; Platzer, B.: Dampf- und Heißwasserspeicher für Gasturbinen-Kraftwerke. BWK - Das Energie-Fachmagazin, Verein Deutscher Ingenieure (Hrsg.), Düsseldorf, Springer-VDI-Verlag, 63. Jg. (2011) Nr. 07/08, S. 50-54. - ISSN 1618-193X
  - Lohse, R.; Urbaneck, T.; Brämer, C.; Platzer, B.: Effects during loading of hot water storages with a high aspect ratio. EuroHeat&Power, English Edition VWEW Energieverlag Vol. 9 (2012) Heft 3 S. 42-47. – ISSN 1613-0200
  - Brämer, C.; Urbaneck, T.; Göppert, S.; Platzer, B.; Lohse, R.: Hot Water Storages – Influence of Geometry and Operation Parameters on Thermal Stratification. EuroHeat&Power, English Edition VWEW Energieverlag Vol. 9 (2012) Heft 4 S. 30-36. – ISSN 1613-0200