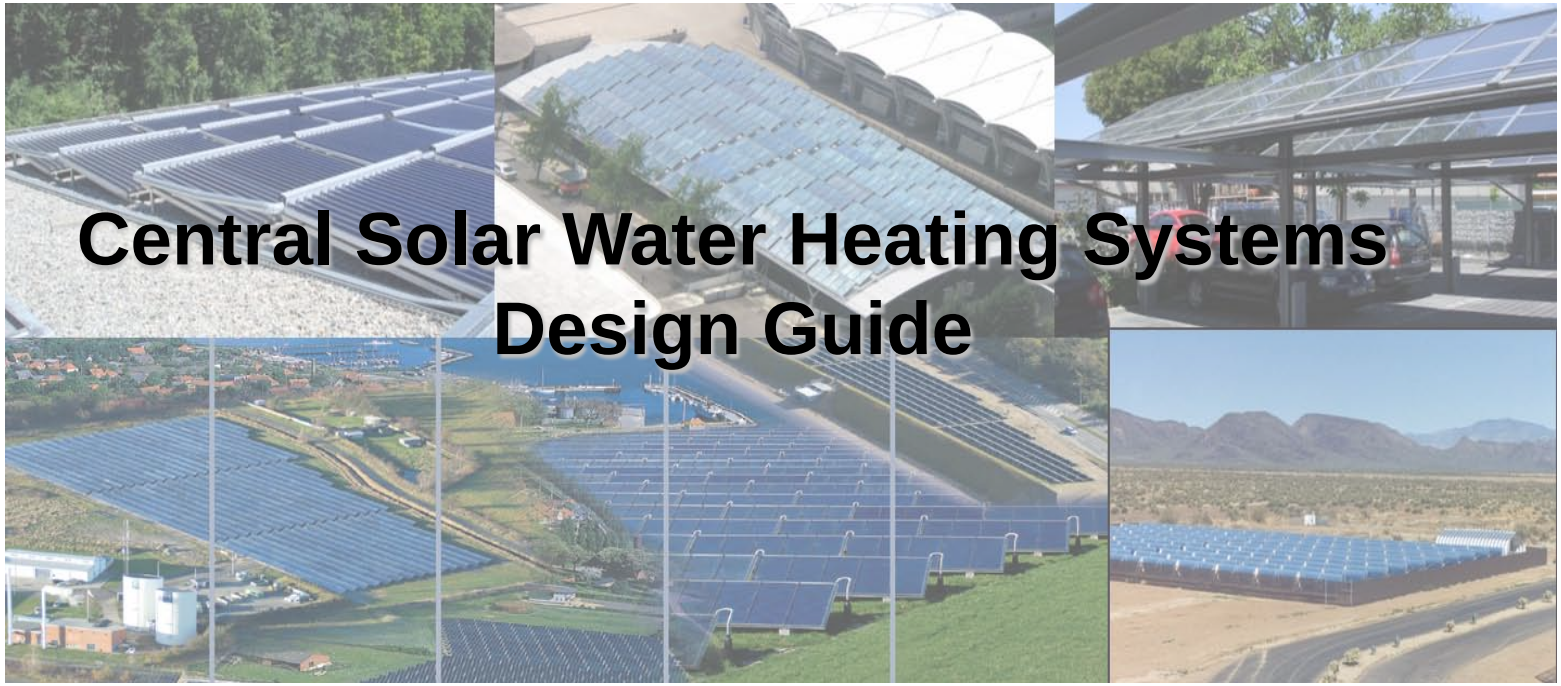

Central Solar Water Heating Systems Design Guide

7th Annual Workshop

"Energy Efficient Technologies for Government Buildings"

Las Vegas, NV

28 January 2011

Session Outline

- **Alexander Zhivov, ERDC** - Introduction, Guide scope and purpose
- **Alfred Woody, VEA** - Design Guide approach/structure
- **Andy Walker, NREL** - Solar irradiation in the USA, utility rates and SHW systems cost effectiveness and maps
- **Gerhard Stryi-Hipp, ISE** - Flat plate collectors, heat transfer fluids, freeze protection, stagnation
- **Rolph Meissner, Paradigma** - Evacuated tube collectors and their application to large scale systems
- **Franz Mauthner, AEE** - Solar supported district heating network with direct interconnection; central SHW system elements and specifics
- **Ole Pilgaard, ARCON/Hellidyne** - Large scale systems case studies from Denmark
- **Harald Blazek, SOLID** - Large scale systems case studies from Austria
- **Stephan Richter, GEF** - Integration of Solar Hot Water generation in district systems, analysis of different options for Army installations
- **Dieter Neth, Senergy** - Solar Water systems applications for Army installations, payback calculation-results
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Objective

- Develop design specs and guidelines for solar water heating systems for the Army and other government agencies' building clusters with significant usage of DHW (e.g., barracks, dining facilities, CDC, hospitals, Gyms) operating in combination with central heating systems to meet EISA 2007 SEC. 523 requirement: "if lifecycle cost-effective, as compared to other reasonably available technologies, not less than 30 percent of the hot water demand for each new Federal building or Federal building undergoing a major renovation be met through the installation and use of solar hot water heaters.''
- This guide is not intended for single residential buildings or clusters with the solar filed area less than 2000 ft^2

System Scale









Sponsors

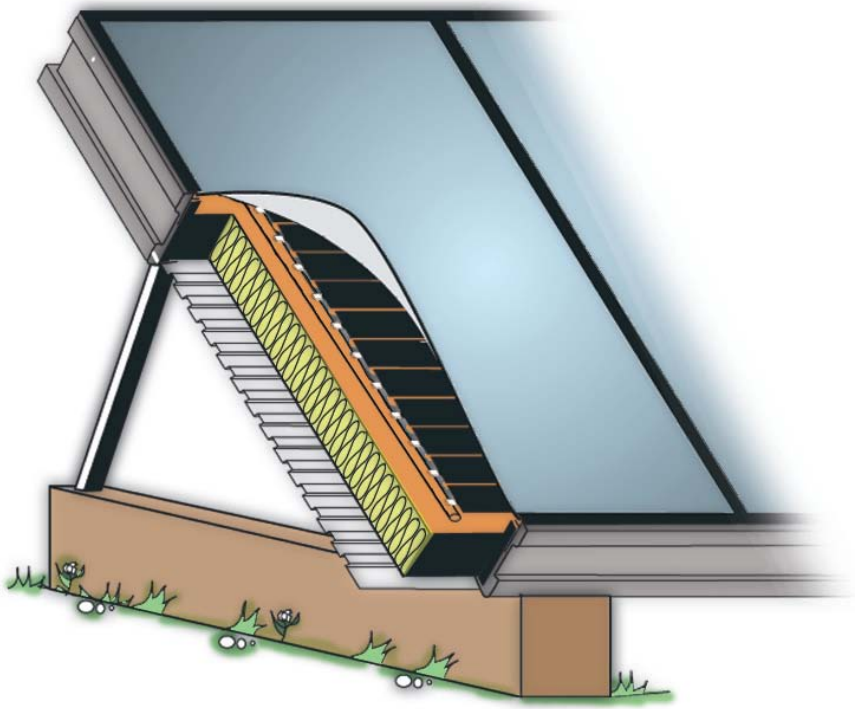
- Installations Management Command, HQ
- US Army Corps of Engineers, HQ
- US Department of Energy, FEMP

Guide Outline

- Solar Energy
- Solar Hot Water Collector Ssystem
- DID Installation Solar Hot Water Applications
- Design Considerations
- Appendix A: Solar Hot Water Case Studies (FPC-16, ETC-12, HTC-2)
- Appendix B: Examples of design options (Fort Bliss / Fort Bragg)
- Appendix C: Market Price Scenario Europe – Climate related Economic Comparisons of Solar Systems
- Appendix D: Sample SRCC Rating Page

Large Plate Collectors - Designed for larges and midsized system

- 13,5 m^2 (~140 ft^2) gross area (12,5 m^2 /~130 ft^2/ absorber area)
- High performance collector
  - Antireflective glass
  - High solar transmittance glass
  - 75 mm back side insulation
  - 30 mm side insulation
  - FEP foil
  - Selective cu/al absorber
- HT-U version without foil



Evacuated Tube Collectors

- Evacuated tubes form a hermetically sealed space that is vacuum insulated. The outer surface of the inner tube is coated with a highly efficient, environmentally friendly absorber coating. The inner tube becomes hot while the outer enclosing tube remains cold.
- Compound Parabolic Concentrator concentrates direct and diffuse sunlight onto the absorber from almost all directions and increases the efficiency of the tube collector.

European Large Scale Solar Water Heating Systems

- 15 large scale plants for district heating approx. 100.000m^2

Rang	Name	Country	Size	Built by	Year
1	Marstal	Denmark	18.300	ARCON	1996/02
2	Kungälv	Sweden	10.000	ARCON	2000
3	Gram	Denmark	10.000	ARCON	2009
4	Broager	Denmark	10.000	ARCON	2009
5	Brædstrup	Denmark	8.000	ARCON	2007
6	Strandby	Denmark	8.000	ARCON	2008
8	Nykvarn	Sweden	7.500	Scan solar	1984
7	Tørring	Denmark	7.300	SUNMARK	2009
9	Sønderborg	Denmark	6.000	SUNMARK	2008
10	Solar Graz	Austria	5.600	SOLID	2006

History of Solar District Heating

- Started in the mid 80'ties in Denmark and Sweden
- First demonstration projects with subsidy
- Sweden and especially Denmark have extensive use of district heating
- In Denmark many local networks (+500)
- 60 % of all houses are connected to district heating

Location	Year	Size
Nykvern (S)	1984	7.500 m^2
Saltum (DK)	1988	1.000 m^2
Ingelstad (S)	1988	1.000 m^2
Flakenberg (S)	1989	5.500 m^2

Saltum District heating, 1988

Falkenberg, 1989

Demonstration and testing in the 90's

- Still mainly Denmark and Sweden
- Other markets are starting up (Germany)

Location	Year	Size
Nykvern (S)	1990	3.500 m^2
Tibberupvænget (DK)	1990	1.025 m^2
Otterupgaard(DK)	1994	560 m^2
Højslev skole (DK)	1994	375 m^2
Marstal (DK)	1996	8.000 m^2
Wiggenhausen (D)	1996	2.400 m^2
Ærøskøbing(DK)	1998	2.000 m^2
Ry (DK)	1999	3.000 m^2

Marstal Fjernvarme, 1996

Ry Fjernvarme, 1999

Large Scale Systems in the new Century

- Large scale systems
- Market picks up in Denmark
- Still subsidy based demonstration projects
- Developing into a prooven and recognized technology for district heating
- More countries start up demonstration projects

Location	Year	Size
Kungälv (S)	2000	10.000 m^2
Norby Samsø (DK)	2001	2.500 m^2
Necklarsulm (D)	2001	1.100 m^2
Rise (DK)	2001	3.600 m^2
Marstal (DK)	2002	10.000 m^2
Graz (AT)	2002	1.400 m^2
Ulsted (DK)	2006	5.000 m^2
Graz (AT)	2006	5.600 m^2
Calgary (CN)	2007	2.300 m^2
Brædstrup (DK)	2007	8.000 m^2

Standard Solar Thermal Systems Combined with District Heating Technology in Denmark

- District heating – Beyond testing
- Solar has become a recognized technology for district heating
- Working on commercial terms with-put subsidy in Denmark

Location	Year	Size
Hillerød (DK)	2008	3.000 m^2
Strandby (DK)	2008	8.000 m^2
Sønderborg (DK)	2008/9	6.000 m^2
Tørring (DK)	2009	7.500 m^2
Gram (DK)	2009	10.000m^2
Broager (DK)	2009	10.000m^2
Andritz (AT)	2009	3.800 m^2
Ærøskøbing (DK)	2009	2.200 m^2

Strandby, 2008

Hillerød, 2008

Outlook for 2010 Record Year for Large Scale Solar

- Denmark is booming
- Systems are becoming larger
- Other markets are coming
- Industry is maturing
- New storage technologies are being tested to increase solar fraction
- Next step is Solar fraction of 40% to 50%

Location	Size
Dronninglund (DK)	35.000 m^2
Marstal (DK)	18.000 m^2
Ringkøbing (DK)	15.000 m^2
Jægerspris (DK)	10.000 m^2
Oksbøl (DK)	10.000 m^2
Brædstrup (DK)	8.000 m^2
Almera (NL)	7.000 m^2
Tistrup (DK)	5.500 m^2
Hejnsvig (DK)	3.000 m^2

Why to combine SHW with district heating ?

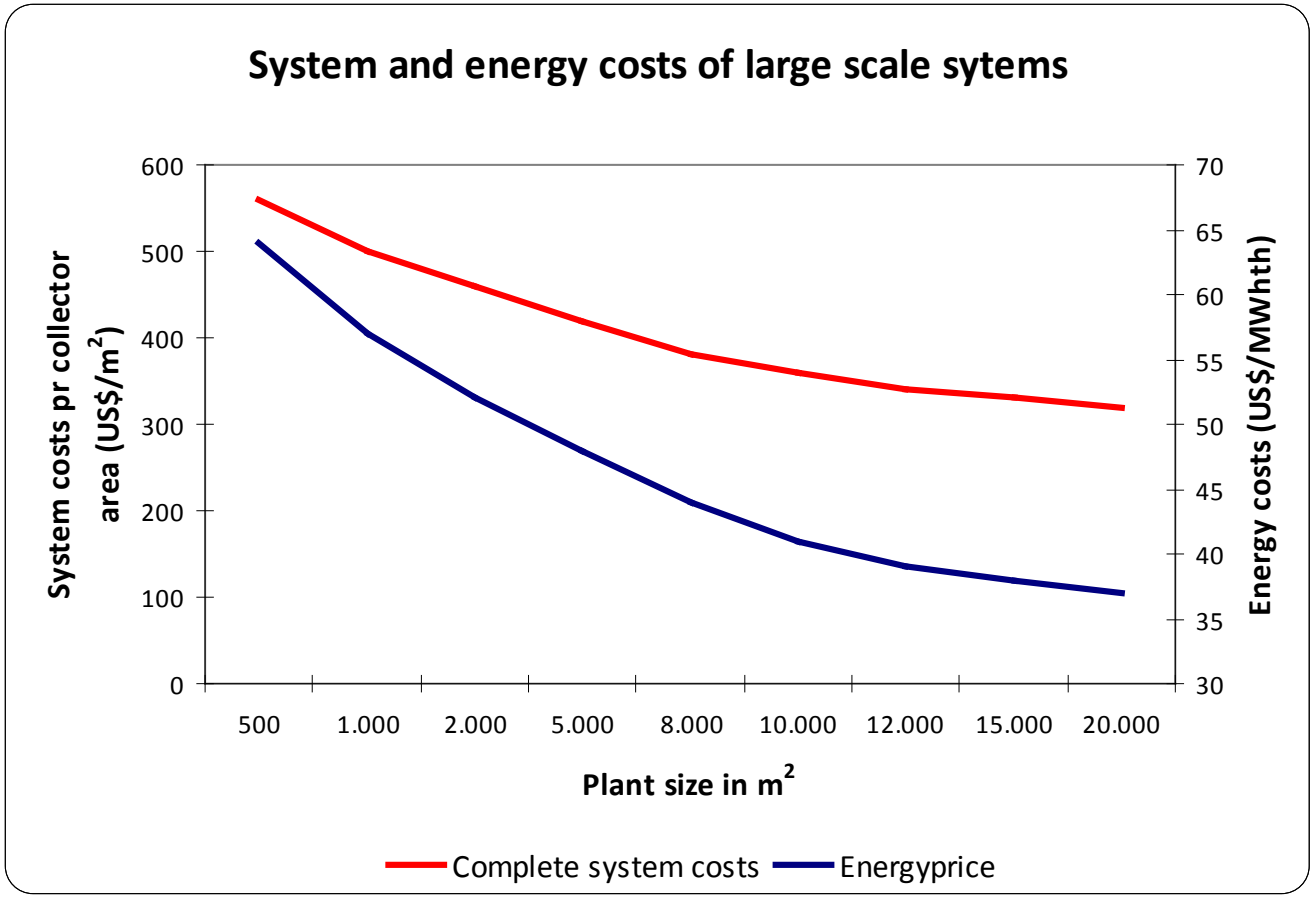
- Most cost effective application of Solar Thermal Energy
- Investment of 25% to 50% of one family house systems
- High annually yield possible (> 500 kWh/m^2 annually)
- Low fixed energy costs (down to approx. 25 EUR/MWh)
- Proven technology (+20 years in operation)
- Easy to implement
- Easy to operate
- Minimal maintenance

- Solution which can bring large CO_2 reduction

Key Factors of a Successful System

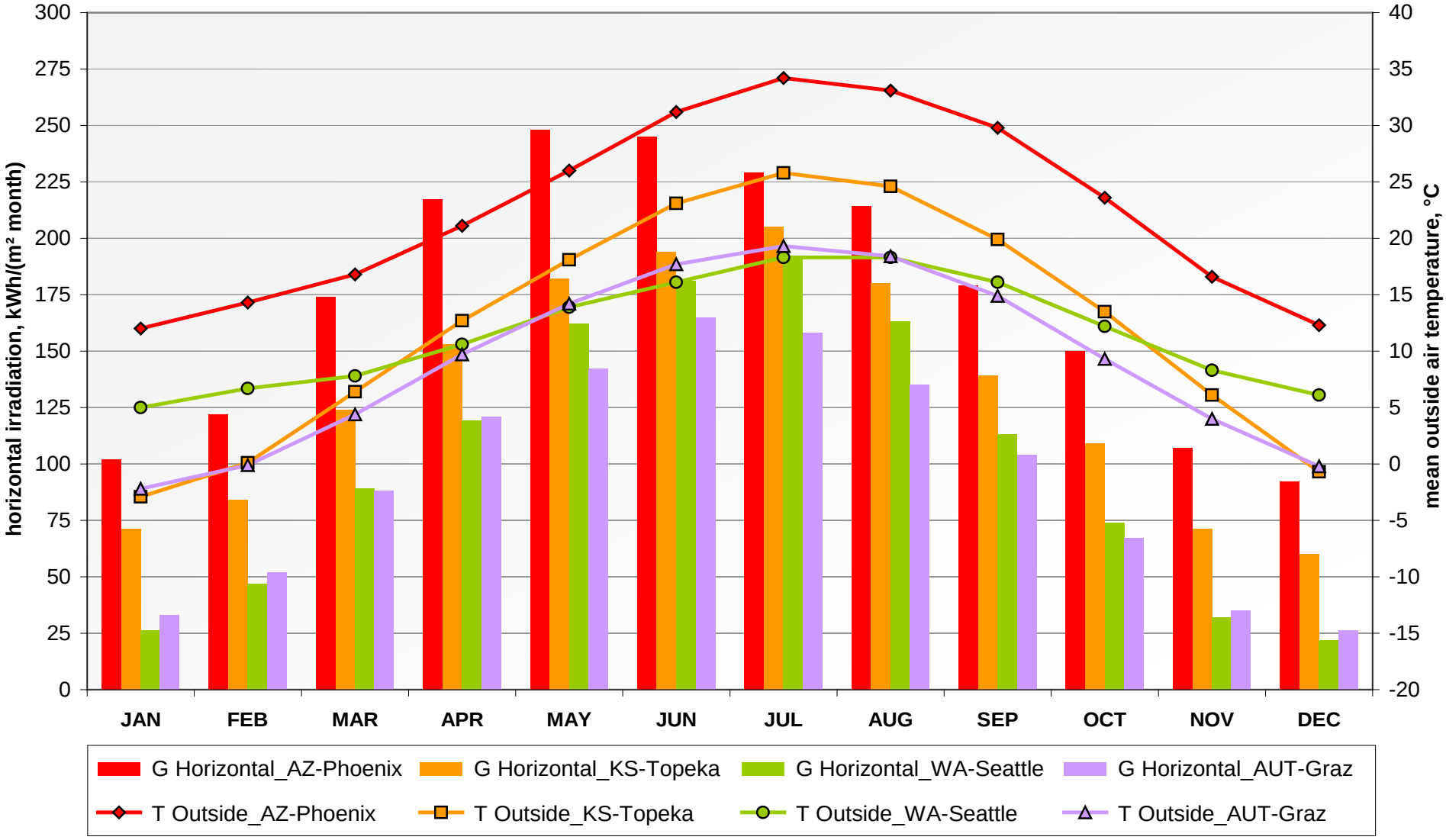
- Experienced advisor/planner or Turn-key supplier
- Experienced suppliers
- High performance collectors designed for large scale systems
- Low return temperature in district heating grid (30^{o}C to 40^{o}C is normal in Denmark)
- Optimized control system

System cost and energy Price for Large Scale Solar District Heating

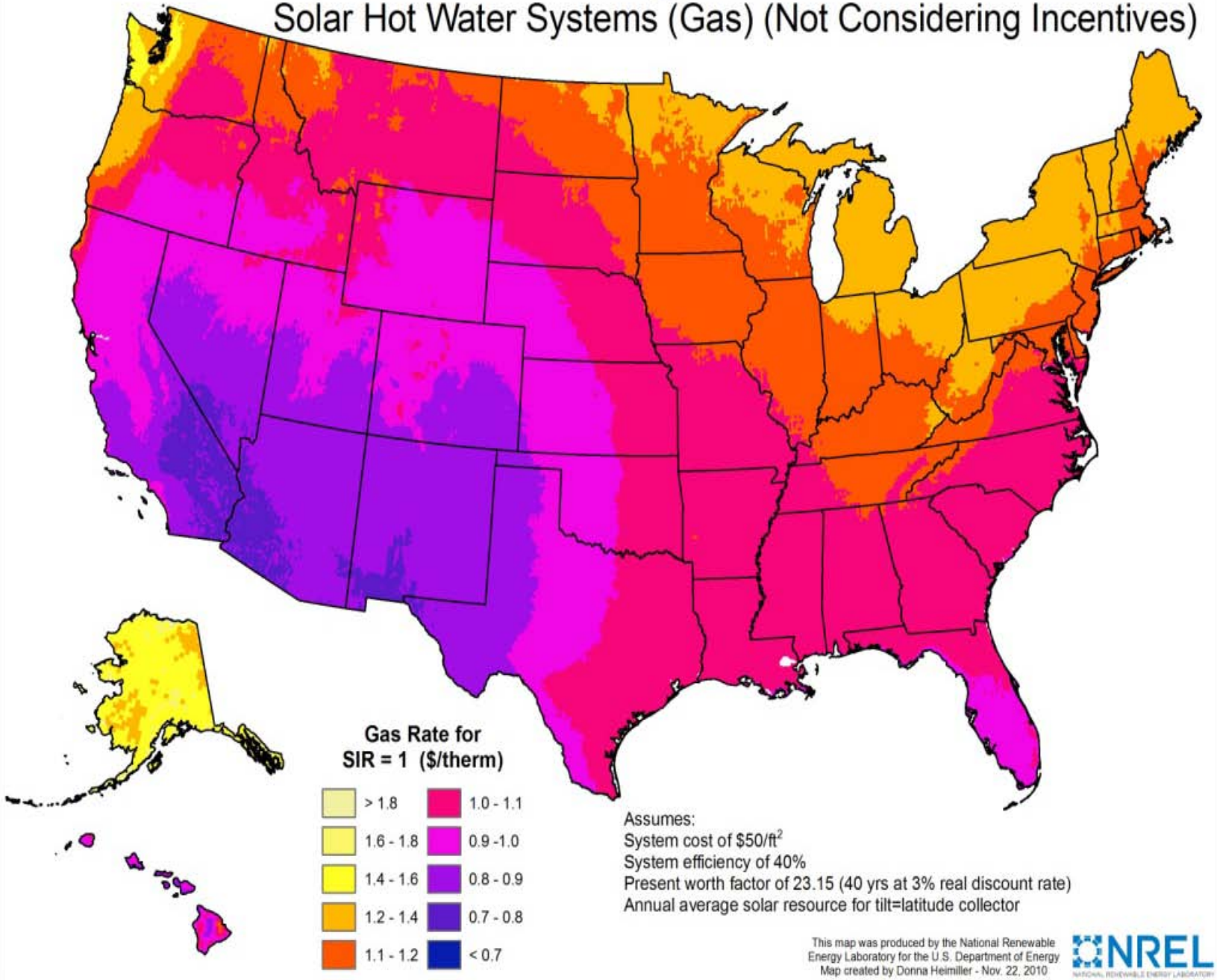


Energy price based on 3% interest rate and 500 kWh/m^2 annually
All prices are excluding subsidy / grants

Monthly climate data for different locations in the United States and in Graz, Austria



Gas Rate for Savings-to-Investment Ratio = 1 for Solar Hot Water Systems (Gas) (Not Considering Incentives)



Assumes:
System cost of $50/ft^2
System efficiency of 40%
Present worth factor of 23.15 (40 yrs at 3% real discount rate)
Annual average solar resource for tilt=latitude collector

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy
Map created by Donna Heimiller - Nov. 22, 2010

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