SOLAR THERMAL ENERGY TECHNOLOGIES

An Overview of the Technology and a Description of Some Activities in the DoD

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June, 2002
Albuquerque, NM

Presentation Outline

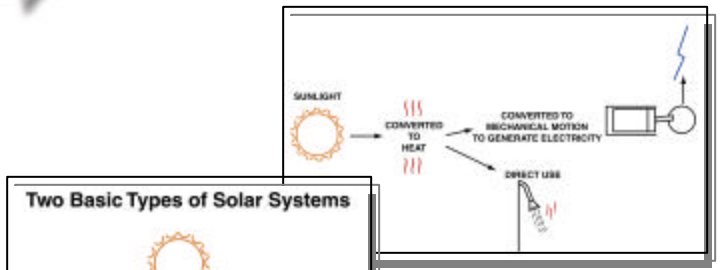
1. Brief overview of Sandia National Labs
2. Part I - Overview of the solar thermal technologies
3. Part II - A review of some interesting R&D efforts
4. Part III - A review of applications within DOD
5. Summary

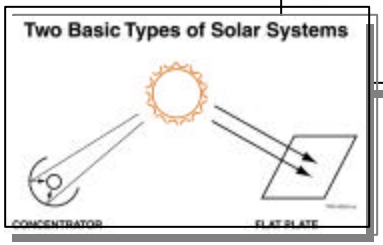
A Little Background on Sandia

- Largest DOE National Lab, 8000 staff, $1.4B
- Multi-program lab with defense emphasis
- Work in renewable energy for 25 years — longer than any other lab
- DOD RE team contains seven people, with nearly 200 years of collective experience
- Sandia is a DOE FEMP team laboratory with service to DOD as one of the priorities

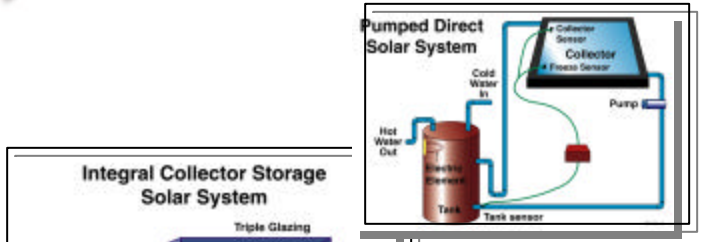
PART I
OVERVIEW OF SOLAR THERMAL TECHNOLOGIES

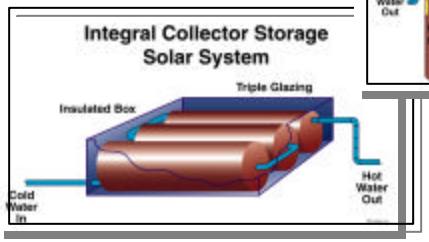
Fundamental Concepts of Solar Thermal Technology



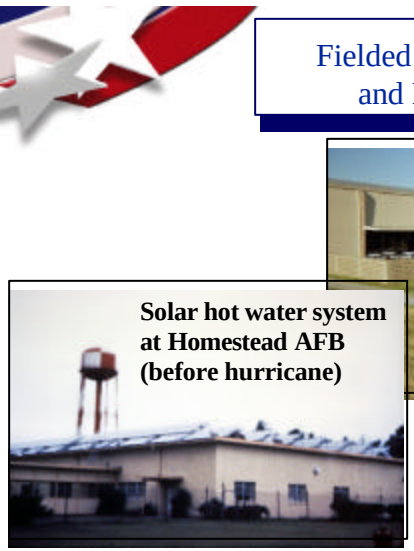


Two of the Most Popular Types of Solar Water Heaters





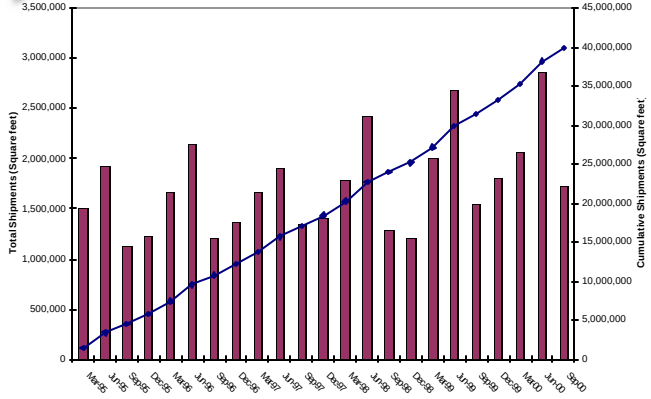
Fielded Solar Hot Water and Pool Systems



Solar hot water system at Homestead AFB (before hurricane)

Solar pool system at Ft. Huachuca

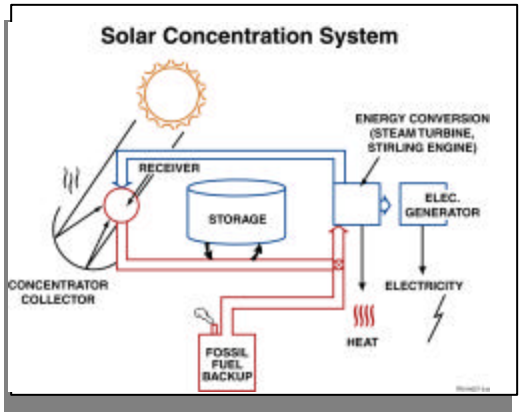
Shipments of US-Manufactured Unglazed Collectors by Quarter



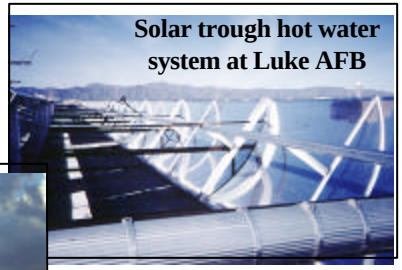
Solar Hot Water and Solar Pool Cost Break-Even Points

- Solar hot water systems begin to compete with natural gas at a cost of about $7/MMBTU; with electricity at about $0.03/kWH
- Solar pool systems begin to compete with natural gas at a cost of about $4/MMBTU

Fundamental concepts of Concentrating Solar Power (CSP)



Concentrating Solar Systems



Solar trough hot water system at Luke AFB

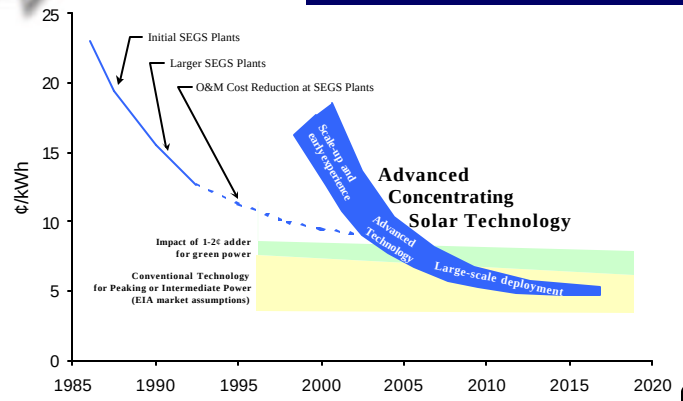
Dish/Stirling system at Ft. Huachuca

Solar Trough Electric Generating Plant in California

SEGS Trough Power Plant

Trough Collectors

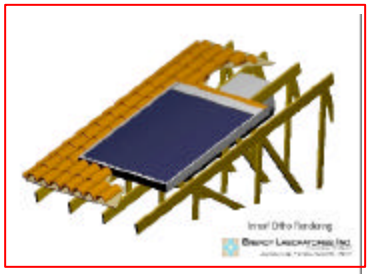
Levelized Energy Costs



PART II
SOME SOLAR THERMAL R&D PROJECTS AT SANDIA

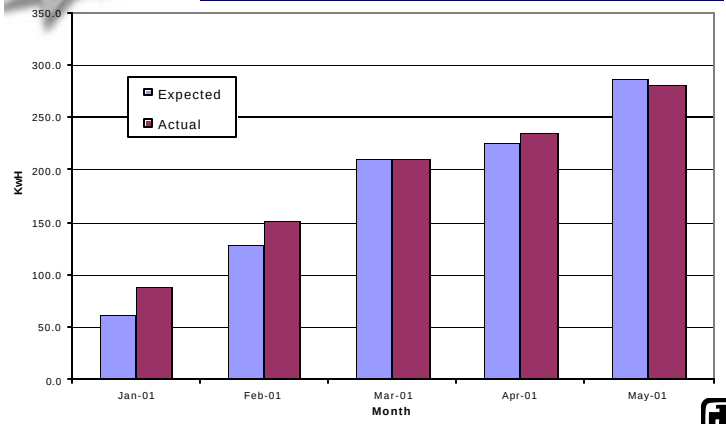
A New Solar Hot Water Heating Technology Development

- Cooperative Research and development with SRP, a major Arizona utility, to develop, a unique solar water heating system for new homes
- All passive design, all stainless steel construction integrates into roof, tank under collector, resembles skylight
- Cost goal of $1500 to homeowner is about 1/2 cost of traditional systems
- Field testing in Phoenix and Ft. Huachuca



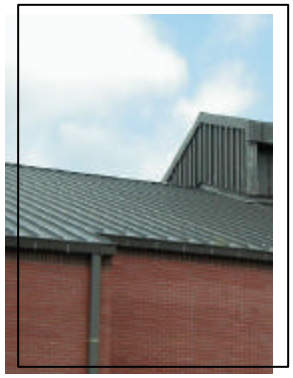
RITH Installation in Phoenix

RITH Performance

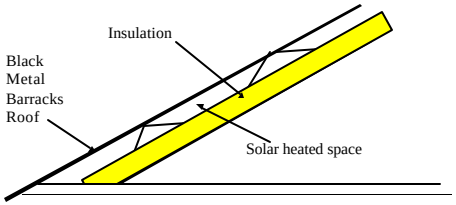


Solar Attic Hot Water Project at Ft. Huachuca

Experimental project to scavenge heat from attic to heat water

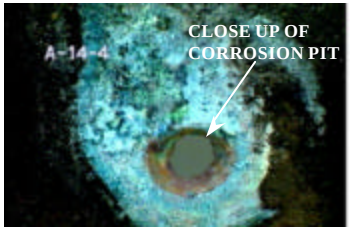


STANDARD CORPS of ENGINEER BARRACKS ROOF



Copper Corrosion in Solar Hot Water Systems is a Continuing Problem

Corrosion analysis has provided an understanding of the risks of refurbishing solar thermal systems



We understand more about the corrosion process and know more about how to prevent it. But there is still a long way to go

Sandia Designed Low-Cost BTU Meter for Solar Thermal Applications

- Sandia designed BTU meter allows solar hot water systems to be monitored easily and cost effectively.
- The meter can be installed without cutting any pipes and is fully portable
- Under test in various DOD facilities; available to all

Sandia designed non-invasive BTU Meter

- Low cost; works with fixed and variable flow systems.

Simplified Analysis Tool for DOD

SIMPLIFIED ANALYSIS FOR SOLAR HOT WATER SYSTEMS IN DOD

Prepared by: Dave Menicucci, Sandia National Labs, a DOE/FEMP Laboratory

Input Descriptions:

	User Inputs:		Suggested Default Values
Solar cost:	$50.00	per sq. ft.	$50; $45 large system; $75 small system
Average Daily Solar Radiation	6.5	kWh/sq. met/day	Location dependent : Phoenix=6.5, Boston=4.6
Solar conversion efficiency	50	%	50%
Typical solar size:	4000	sq. ft.	Application dependent: residential = 80 sq ft
Annual O&M cost	$0.10	per sq. ft.	$0.10
Boiler efficiency:	60	%	65%; 80% for commercial, 50% for residental
Cost of displaced energy:	$8.00	Per MMBTU	$8.00
System life for economic analysis:	25	years	25
Discount rate for economic analysis	5	%	5%

Analysis:

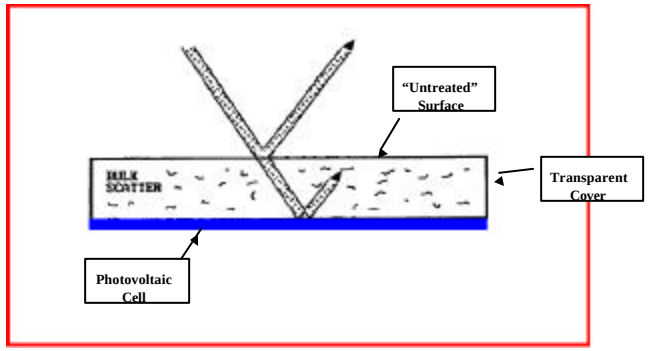
	Computed Values	
Annual solar production (energy saved):	1503.2	MMBTU
Value of solar energy production:	$20,042.88	
Annual cost of O&M	$400.00	
Net annual energy savings:	$19,642.88	
Solar system cost:	$200,000.00	
Simple payback	10.2	years
Saving to Investment Ratio	1.4	

APPLYING MOBILE POWER CENTER

3.4Kw Mobile Photovoltaic Array, part of the Mobile Power Center created for USMC and tested at 29 Palms (was damaged by tornado)

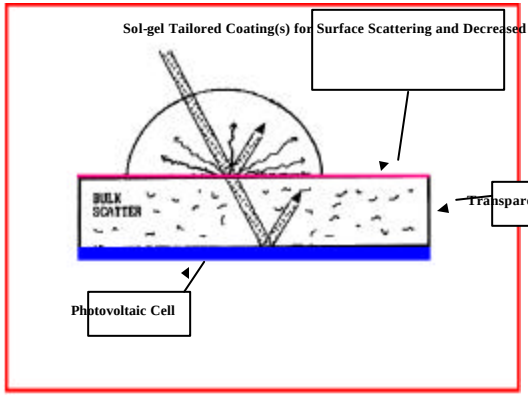
SURFACE GLINT INCREASES LOCATIONAL SIGNATURE

Glint caused by: High Specular Reflectance at Surface



REDUCED SURFACE GLINT USING SOL-GEL TAILORED COATINGS

Reduce Glint by: Increasing Surface Scatter and Decreasing Specular Reflectance



PART III
SOLAR APPLICATIONS WITH DOD

How Sandia Helps DOD to Apply Renewable Energy Technologies

- Direct technical assistance on projects for all branches of military
- Project management — complete oversight of renewable energy projects for USMC and Pentagon
- Consulting and training for military personnel
- Applied Research & Development and Test & Evaluation
- Special projects for DOD Tri-Service Renewable Energy Committee (TREC)
- Support provided by DOE/FEMP and DOD/TREC

What Makes a Good Potential Renewable Energy Project on a Base?

- Good resource (i.e., solar, wind, geothermal, etc)
- Applicable loads (e.g., loads that match solar production profiles)
- Competing fuel costs that are high or could be high in the near term.
- Applicable infrastructure on the military facility and above
  - Command interest in renewables
  - Facilities personnel buy-in; willingness to invest
  - Enthusiastic on-site champion (an energy manager)
  - HQ support

Sandia Has Identified Potential DOD Renewable Applications

- DOD wants to know what potential renewable projects exist on their facilities
- MIPR from DOD/TREC to Sandia
  - Agreed to list of sites to visit, format of database, etc
- Began to develop the database in summer of 1998
- Have surveyed 29 bases so far, over 55 potential projects identified
- Currently preparing 1391s for selected projects
- Sandia developing appropriate projects for ESPC

List of Potential DOD Renewable Projects/Sample of Complete List

NAME OF FACILITY	PROJECT DESCRIPTION	POSSIBLE NEXT STEPS	CURRENT STATUS	CHANCE OF SUCCESS (See Note)
MCB/29 Palms (USMC)	Refurbish six solar water heating systems on barracks	Refurbish one system as a pilot; others to be refurbished by ESPC or USMC	Pilot project for one system proposed to DOE FEMP	80%
MCB/29 Palms (USMC)	Install new solar system to heat training tank	Study economic potential of installing of solar system to heat tank	Unknown	50%
MCB/29 Palms (USMC)	Install PV systems in remote firing ranges to augment diesel generators	Obtain more info with detailed field survey; Study economic potential of PV in range; develop proposal	Unknown	75%
MCB/29 Palms (USMC)	Install ground source heat pump(s) for heating/cooling space in buildings	Study soil conditions to determine feasibility of ground sourcing heat pumps; study economics, develop prop	Unknown	70%
MLB/Barstow (USMC)	Salvage 3-6 existing solar panels from pool; use them to heat water for gym	Assess gym loads, check out panel quality (corrosion analysis), study economics, develop proposal	Unknown	70%
MLB/Barstow (USMC)	Install PV lighting system at remote fire training facility	Refine economic analysis, develop proposal for funding the project	Unknown	85%
MCB/Quantico (USMC)	Refurbish solar collector system in bld 3255	Verify loads in bld, verify collector condition, refine economics, develop proposal for funding	Unknown	70%
MCB/Quantico (USMC)	Install PV in remote areas: small power, composting toilets, cathodic protection	Obtain more info with detailed field survey; Study economics; develop proposal	Unknown	90%
MCB/Quantico (USMC)	Install <u>repn</u> ground source heat pumps for space conditioning	Identify med/large buildings that will undergo retrofit and study economics; develop proposal	Unknown	95%
MCAS/Cherry Point (USMC)	Install solar hot water systems to displace electric or LP gas heaters	Identify specific building with LP gas/electric water heating; refine economics, develop proposal (ESPC?)	Unknown	90%
MCAS/Cherry Point (USMC)	Install solar hot water systems to displace electric hot water system in housing	Investigate economics of installation in Slocum Village where roof pitches are optimal for solar; refine economics and develop proposal (ESPC?)	Unknown	90%
MCB/Camp Lejeune (USMC)	Refurbish nine solar hot water systems on barracks	Refurbish one system as a pilot; others to be refurbished by ESPC or USMC	Pilot project for one system proposed to DOE FEMP	90%
MCB/Camp Lejeune (USMC)	Install solar hot water systems to displace electric hot water system in housing	Investigate economics of installation in homes where roof pitches are optimal for solar; refine economics and develop proposal	Unknown	90%
NAF/El Centro (USN)	Install unglazed solar system for heating two outdoor pools	Confirm 9 month operation of pool and current gas usage; refine economics; develop proposal	Unknown	60%
NAF/El Centro (USN)	Install ground source heat pumps in small buildings	Identify suitable building (espec. one to be refurbished) for heat pump; refine economics, develop proposal for pilot project for facility (to justify future ESPC effort)	Unknown	80%

17 New Solar Hot Water Systems at Camp Wilson (MCB 29 Palms)

Solar Thermal System Refurbishment - Often a Cost-Effective Proposition

- Many non-operating solar thermal systems exist
- Many of these systems can be put back into service
- There are pitfalls—Sandia's four-step process can mitigate the risk:
  1) Visual inspection by trained professionals
  2) Fill system with water, pressurize, check for leaks, test for corrosion
  3) Develop a refurbishment plan and budget
  4) Implement the plan (write SOW, hire contractor, make repairs, and monitor performance)
- Sandia has written a refurbishment manual for USMC; FEMP publication

Solar Refurbishment Projects at Camp Pendleton and 29 Palms

29 Palms Solar Hot Water Refurbishment

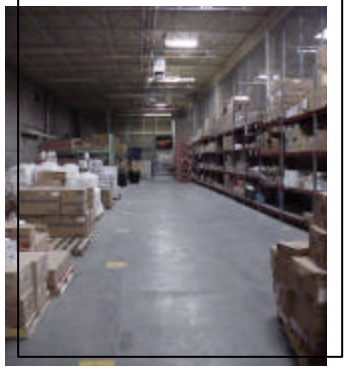
Camp Pendleton Solar Pool Refurbishment

Daylighting Technology: a Cost-Effective Lighting Method

- Commercially-available technology
- Cost competitive at or above about $0.05/kWh
- Proven in military applications, especially Ft. Huachuca and MCAS Yuma
- Easily bundled with conventional ESPC and DSM projects
- Typically, facilities are concerned about leaks from the many roof penetrations, but this has not proven to be a problem

MCAS Yuma Warehouse Daylighting Project

Daylighting With Lights



Daylighting Without Lights

Summary of Displaced Annual Energy Resulting From FEMP/TREC DOD Projects

	MWh	Value[1]
Planned Activities Completed FY01	913	$119,000
Planned Activities In Progress FY01	6,651	$865,000
Unsolicited Activities in Progress FY01	8,718	$1,100,000
Unsolicited Activities Estimated in FY02	26,400	$3,400,000
TOTAL	42,682	$5,484,000

Notes:

[1]Displaced electricity cost of about $0.13/kWh

Funding is a Limitation for Renewable Projects within DOD

Traditional Sources:

- **SERDP** — Gone
- **ECIP** — Zeroed for FY00, some $ available FY01, FY02?
- **MILCON** — Available, but projects must be large and very cost-effective; 2-4 yr. process; limited funds need congressional approval; some solar projects may qualify

Possible New Sources:

- **ESPC** — Project bundling is the key to make this successful
- **POLLUTION PREVENTION (P2)** — Naval Environmental Leadership Program in San Diego is funding renewables projects
- **SAVINGS REINVESTMENT** — Performed at base level; energy savings from fossil energy programs reinvested in renewable technologies

ESCOs Hold Much Promise for Major Funding but are Difficult to Bring to Fruition

Here are some of the issues:

- ESCOs want a high return on their investment, typically 0.5-3 year payback on projects
- ESCOs are unfamiliar with renewables projects and tend to dismiss them without proper analysis
- Renewable projects can be bundled with conventional ones to produce a favorable combination (Ft. Huachaca is proof that it can be done)
- Payoff to DOD is large if ESPC is developed for renewables because capital expense to the government is minimized; Sandia is developing opportunities

Summary

- Solar technology is improving its performance, reducing its cost, and can compete in specific applications
- R&D is producing some new technologies that have potential for widespread application
- DOD offers new and unique opportunities for renewable technologies --FEMP and TREC are helping to identify and implement these applications