PRACTICAL EXPERIENCES

Of The

Pioneers of Low-Cost Parabolic Dish Concentrators

Thomas A. Damberger, Ph.D., CEM

PRACTICAL EXPERIENCES OF THE PIONEERS

Background

History provides sufficient evidence to doubt the economic success of any solar scheme. It is clear that solar energy has its place in society. Making practical use of both successes and failures provide the necessary steps to avoid the pitfalls of the past. This allows the goals for both performance and economic success of the next generation renewable energy to exceed expectations with reasonable risks.

The co-founders of OMNIUM-G have been directly involved with solar thermal technology using point-focusing parabolic dish concentrators since 1973. The principals are sole owners of patents and trade secrets created as partners in a partnership called OMNIUM-G. At OMNIUM-G in the mid 1970's, they developed, manufactured, and delivered single-collector solar powered electrical generating systems worldwide to customers in private industry, universities, government agencies, and individual consumers.

In-house development of a wide range of manufacturing technologies assured a strong proprietary knowledge base. A thorough understanding of these fabrication processes produced a level of error-free product design specifications unobtainable with manufacturing outsourcing. A staff of 40 specialists working in a 16,000 square foot manufacturing facility (plus 8,000 sq ft test area) located in Anaheim, California produced early single-collector systems at the rate of one system per month.

During this period, both the business and its customers were funded or motivated by government sponsored solar initiatives[1]. The business ceased operations in 1982 when such initiatives were no longer available, both domestically and internationally. Of course, all units have gone through the basic research for which intended and have long since been dismantled.

In the intervening period the principals have come to realize that solar energy harvesting had to be at a scale much larger than single collector systems. In 1989, the task of designing a system of practical size was started. The engineering task, including trade-off analyses and design to the piece-part level, was accomplished. A considerable amount of manufacturing engineering was also accomplished. The result is a refined design of an optimally sized on-demand solar electrical generating system, called CENICOM™ (**C**oncept for an **E**nergy-**N**eutral **I**ndustrial **COM**plex.

A thorough understanding of the refined design is based on finely tuned "lessons learned" methods validated in the mid-1970's for single-collector systems. An archive of documentation is included in Appendix A. This substantial historical experience points to the means of producing critical components that will be difficult for any competitor to match. These methods have led to a product that will endure a 30-year life. For a competing company or technology to attract market share, they will have to undergo a similar investment in manpower to equivalently compete with the extraordinary physical specifications of the process (manufacturability, transportability, reliability and maintainability). Its introduction to the market will secure its market position and dominance for years to come.

All system design engineering and component manufacture design have been done to establish the best procedures for manufacturing, testing, packaging, shipping and on-site assembly. No further inventions are required. Remaining design definition is primarily devoted to updating drawings, procedures, and material selection to current market choices, costs, and availability.

Key Individuals

Stan Zelinger – Acting CEO and General Manager

As a Co-founder of OMNIUM-G, Mr. Zelinger managed the company's worldwide business relationships and assisted in the design of the electro-mechanical solar energy power generation system. He has over thirty-five years experience using

[1] Grant money, Small Business Association loans, or consumer tax credits

computer technology for design and simulation of products. Mr. Zelinger held positions of Vice President of Marketing and Sales to General Manager. He has a BS in Electrical Engineering (with honors) from the University of Colorado and an MS in Electrical Engineering from the University of Southern California.

Sam Lazzara – Chief Technical Officer

As a Co-founder of OMNIUM-G, Mr. Lazzara designed and engineered the ***CENICOM***™ process as well as all previous configurations of OMNIUM-G's technologies. He has forty years experience in engineering research and development involving electromagnetic radiation, high-energy lasers, high-powered optical systems, high-temperature effects on materials, large lightweight precision mirrors, and Rankine cycle machines. Mr. Lazzara held the position of Senior Scientist at General Motors Hughes Electronic Corporation. He has a BS in Electrical Engineering from the University of Illinois along with graduate studies at the University of Southern California.

Bill Dampier – Chief Operating Officer

As a co-founder of OMNIUM-G, Mr. Dampier is involved in the development and construction of point-focusing parabolic concentrators, solar-thermal electric power plants, and thermal energy storage. With over thirty-seven years experience in engineering and management of large-scale projects, he managed factory operations during the development and manufacture of all Omnium-G products. Mr. Dampier held an executive position at General motors Hughes Electronics Corporation, retired after 37 years to invest full time to ***CENICOM***™. He has a BS in Electrical Engineering from the University of Florida and has extensive education and training in System Engineering and Project Management.

Thomas A. Damberger, Ph.D., CEM – President Consortium of Alternate Energies – Project Development

With over thirty-five years of experience in renewable energy, Dr. Damberger has installed many solar thermal and cogeneration systems throughout the southwest. He brought his company as a resource to project development by working with governmental agencies and Indian tribes. He holds a Ph.D., from Walden University and dual degrees in Public Administration from California State University Long Beach and San Diego State University.

Team History

The initial founders are a group of engineers and scientists with a wide variety of professional qualifications and expertise in solar energy, large-scale projects, research and development, engineering, manufacturing and logistics service. The combined strengths of this team include but are not limited to:

1. Thirty-seven years of a continuous business association in solar-thermal power generation industry
2. Management of large-scale development and production programs
3. Leaders in commercial applications of solar thermal technology using high concentration parabolic dish technology
4. Substantial proprietary knowledge in thermal storage technology, electric power generation, and water desalination systems
5. Finely tuned "lessons learned" methods in a wide range of manufacturing technologies
6. Plentiful operations and maintenance field data
7. Solid reputation in computer modeling, mathematical analysis, and large database management
8. Substantial knowledge of both corporate and product development
9. Have developed methods for producing critical components and envisions the process required
10. Quality leadership, professional advisors, and technical specialists

Appendix A–Archive of Experience & Documentation

1. Introduction

A summary of excerpts from a bibliography of formally published reports, proceedings, proposals, and research projects provide substantial historical evidence of pragmatic implementation experience by OMNIUM-G. Also included is a list of nearly two-dozen systems delivered worldwide, some of which are shown in the historical photo gallery section.

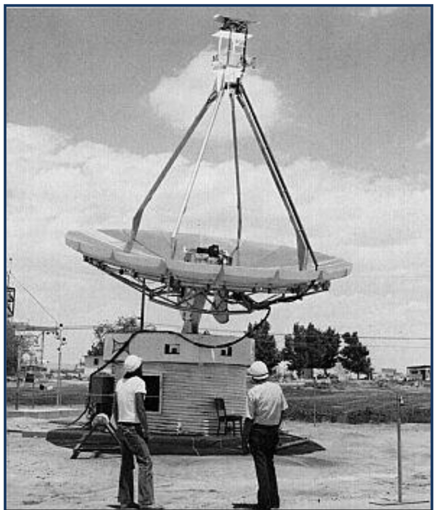
The company's principals designed, produced, delivered and installed single-collector systems world wide from 1973 to 1982. They have been directly involved with solar thermal technology using point-focusing dish concentrators since the Nation's oil embargo of 1973. In 1977, the company won the prestigious IR-100 Award for one of the Nation's most significant products of the year. Our parabolic solar collector was one of the first pieces of equipment in the U.S. Department of Energy (DOE) outdoor testing facility in Golden, Colorado. In May 1978, it provided the photo-op background of President Carter's dedication of the Solar Energy Research Institute (SERI) (now National Renewable Energy Laboratory-NREL) and establishing the first National Sun Day. The first commercial, point-focusing dish system was provided to Jet Propulsion Laboratory's (JPL) Parabolic Dish Test Site (PDTS) in 1979 for commercial evaluation, O&M experience, and acquisition of cost data. An archive of documentation is included in the following section.

Through the years, continuous improvements evolved in a most cost-effective and pragmatic implementation of solar-thermal-electric processes.

Single-collector systems were supplied to Universities to enhance their research studies, supplied to developing nations and other foreign countries to evaluate rural use and village power systems, and finally to research institutions like the Solar Energy Research Institute and The California Institute of Technology. An attempt was made to market to the private sector.

These pioneering research and development projects in high-energy processes and dozens of other remote and urban locations in eight countries around the world led to the CENICOM™ process. The engineering design and statistical performance calculations were completed for this technology showing cost-effective regional energy production, even in urban America.

The CENICOM™ process is derived from over 37 years of refinement to the effort of collecting solar energy for convenient storage and conversion of thermal energy to electrical power for delivery when needed.



Dish Under Evaluation at JPL Test Site

1. Independent Reports on OG Parabolic Dish

Beveridge, Brian "Parabolic Concentrator Designs and Concepts". Pasadena, CA: Jet Propulsion Laboratory; JPL 400-98; December 1980.

"The Solar Thermal Power Systems Project at JPL, sponsored by the U.S. Department of Energy (DOE) is assisting private industry in the development of cost-effective, modular solar power systems for both thermal and electric applications"

Pages 12-13: Photo of OMNIUM-G dish undergoing system-level testing with implementation description of concentrator reflective surface, support structure, drive mechanisms, control system, receiver, and thermal transport.

Flux Mapper

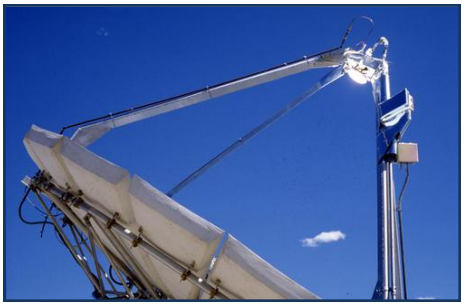
Callorimeter

<u>HTC Tracking Concentrator</u>

Zelinger, S. H. 1980. "The OMNIUM-G HTC-25 Tracking Concentrator". Proceedings of the First Semi-Annual Distributed Receiver Systems Program Review. Conference held in Lubbock, TX; 22-24 January 1980. JPL Publication 80-10.

Pages 23-24: "---Testing and evaluation of these dish power modules are performed at the JPL desert test site shown in Figure 7. Evaluation of early dish hardware is already taking place at this site. A 6-meter diameter dish module purchased commercially from the OMNIUM-G Company of Anaheim, CA has been under evaluation at the test site since early 1979---".

Pages 53-57: "---This paper deals specifically with OMNIUM-G's model HTC-25 Tracking Concentrator, the initial problems and their subsequent solutions. These solutions have guaranteed the continued success in dramatically reducing the costs of the concentrator to the extent that large field applications may now be realized economically and to a high degree of reliability---"



OG Concentrator Test Results

Patzold, J. D. 1980. "OMNIUM-G Concentrator Test Results". Proceedings of the First Semi-Annual Distributed Receiver Systems Program Review. Conference held in Lubbock, TX; 22-24 January 1980. JPL Publication 80-10.

Pages 125-131: "---conducted a performance evaluation on a commercially available point-focus solar concentrator manufactured by the OMNIUM-G Company---"

OG-7500 Production Cost Analysis.

(1) Fortgang, H. R. 1980. "Costing the OMNIUM-G System 7500". Proceedings of the First Semi-Annual Distributed Receiver Systems Program Review. Conference held in Lubbock, TX; 22-24 January 1980. JPL Publication 80-10.

Pages 139-144: "---A complete OMNIUM-G System 7500 was cost analyzed for annual production quantities ranging from 25 to 100,000 units per year. Parts and components were subjected to in-depth scrutiny to determine optimum manufacturing processes, coupled with make-or-buy decisions on materials and small parts. When production quantities increase – both labor and material costs reduce substantially. A redesign of the system that was analyzed could result in lower costs when annual production runs approach 100,000 units/year---".

(2) Blake, C A. 1980. "Cost Analysis of the OMNIUM-G System 7500 in Selected Annual Production Volumes". Report by Solar Thermal Systems Project, May 1980. Pasadena, CA: Jet Propulsion Laboratory; DOE/JPL 5105-23.

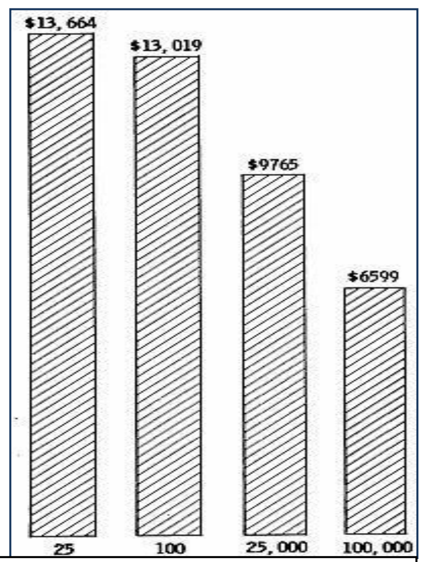
Solar Thermal Technology

(1) Solar Thermal Energy Systems. "Annual Technical Progress Report FY 1980"; Golden, CO: Solar Energy Research Institute DOE/CS/1012-2.

Pages 20: "---A costing study that ranked 1- to 10-Mwe solar power systems, including dishes, troughs, component parabolic collectors, bowls, and central receivers, was completed; the results are shown in Figure I-17. The study was a companion to studies conducted by SERI and Battelle Pacific Northwest Laboratory. The results were similar, although ranking positions differed for some systems. The JPL study concluded that point-focusing systems in general, and dish systems in particular, have the lowest levelized busbar energy costs---".

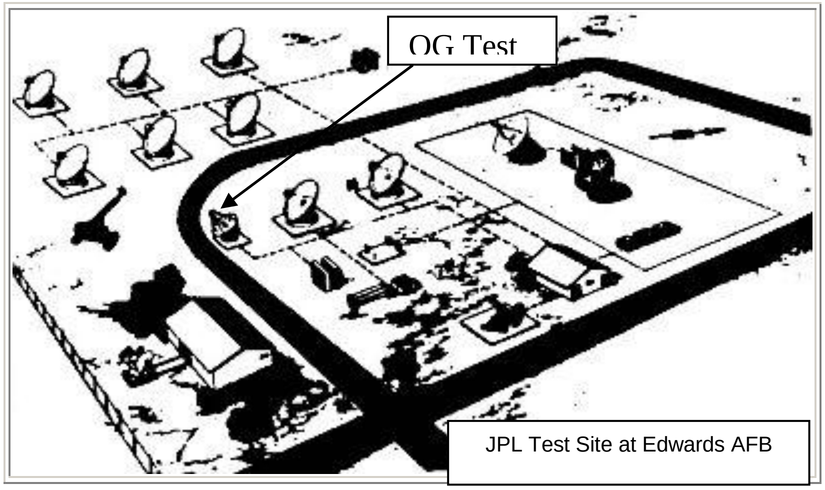
"---Test results of thermal power output by the OMNIUM-G module [3] are shown in Fig.I-18".

Page 21: "---A number of 24-hour tests were performed on the OMNIUM-G module to gather operation and maintenance data. Thermal performance was assessed by using the OMNIUM-G 20.3-cm (8-in) diameter aperture converter (receiver) as a cold water calorimeter".



Production Cost Analysis Results

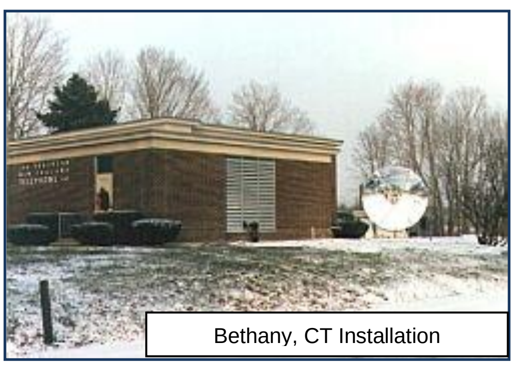
Page 22: "---The Point-Focusing Solar Test Site (PDTS) was established at Edwards Test Station in the California Mojave Desert to test point-focusing concentrator systems and related hardware for DOE". "The site occupies approximately 10 acres of the 600 acre Edwards Test Station (Fig. I-19 shows OMNIUM-G's 6-meter diameter parabolic dish)".



JPL Test Site at Edwards AFB

Page 32: "---The Southern New England Telephone Company was awarded a $44,000 grant from DOE in 1979 toward construction of a $100,000 parabolic dish system to provide power and space conditioning for a small switching station in Bethany, CT".

"---The telephone company awarded contracts to OMNIUM-G of Anaheim, CA for the dish module---". "---The installation was completed early in FY 1980, followed by system check-out and personnel training".



Bethany, CT Installation

Page 103: "---The purpose of the Advanced Component Research Facility at SERI is to provide the capability to test and develop advanced components related to point-focus solar concentrating collectors". "---In late FY 1979 and continuing through FY 1980, two 6-meter dishes (purchased commercially from OMNIUM-G Company) were converted into flexible test loops to provide the aforementioned test capability. The north dish was converted into a high-temperature thermal test loop with the ability to deliver a wide range of coolant flow rates, pressures, and temperature for testing receivers over a wide variety of operating conditions. The south dish was converted into an optical test fixture with the development of several test techniques including a real-time flux mapper, a technique for optical alignment (reverse reflection method), and the development of a cold-water calorimeter. The facility (including the OMNIUM-G dishes) is shown in Fig. 4-10 and results from the flux mapper are shown in Fig. 4-11".

(2) Jaffe, L. D. 1982. "Dish Concentrators for Solar Thermal Energy: Status and Technology Development". Report by Solar Thermal Power Systems Project, January 1982. Pasadena, CA: Jet Propulsion Laboratory; JPL Publication 81-43.

Page 8: "---Table 1 (page 8) is a summary of the characteristics of some current U.S. dish concentrator concepts; the concentrators are pictured in Figures 1 through 27 (pages 14 through 40)". Note: OMNIUM-G is the first dish concentrator to be evaluated and is pictured in Figure 1 on page 14.

Page 10-12: Optical materials for solar Concentrators. "---Metal sheet has the advantage of easy formability to doubly-curve shapes. Panels of polished aluminum sheet, generally with an anodized surface finish, have been used for dish concentrators (Figure 1 OMNIUM_G Concentrator)". "---The optical element itself can be supported in a number of ways. A mirror may be placed on a continuous structural backing of metal, cellular glass, reinforced polymeric material (Fig. 1 OMNIUM_G Concentrator), or wood". "---Dish solar concentrators most commonly use azimuth-elevation ("az-el") mounting (Figure 1 OMNIUM_G Concentrator".

Page 14: Photograph of fully operational OMNIUM-G Concentrator at the JPL Test Site undergoing performance evaluation.

OG-7500 Concentrator at Jet Propulsion Laboratory (JPL), Edwards AFB

Pages 41-49: Section III Concentrator Performance and Cost

Pages 51-54: Section IV Technology Development

Page 57: Section VI Summary

(3) Solar Thermal Technology. “Annual Technical Progress Report FY1981; Volume1: Executive Summary”. Pasadena, CA: Solar Energy Research Institute DOE/JPL-1060-53.

Page 5: “---significant progress occurred in two major areas of the parabolic dish program in FY 81. The first parabolic-dish solar total-energy plant neared completion; successful operation of the plant will provide a model for other potential industrial users”.

(4) Solar Thermal Technology. “Annual Technical Progress Report FY1981; Volume II: Technical”. Pasadena, CA: Solar Energy Research Institute DOE/JPL-1060-53.

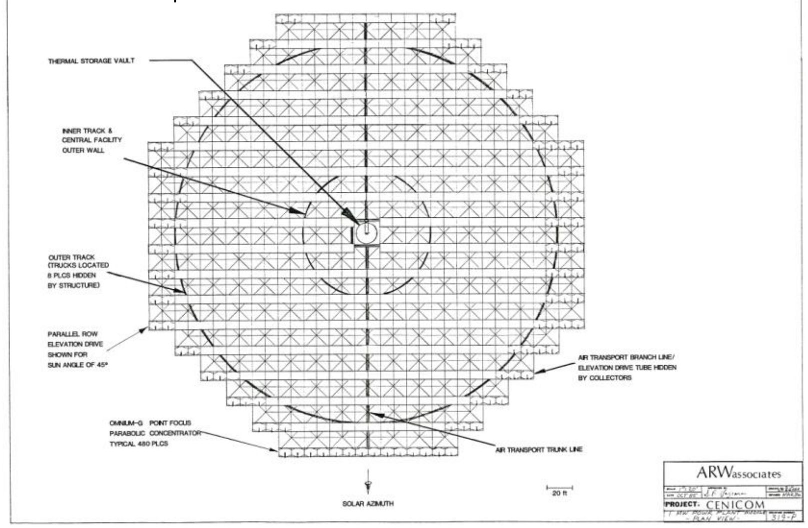
Page 3-11: “---(7) Completed flux mapping of the OMNIUM-G concentrator. Tested the OMNIUM-G steam engine using TBC-1. Mounted and aligned new concentrator petals”.

Chemehuevi Solar Electric Facility

A 30 MWe solar electric plant for the Council of Energy Resource Tribes (CERT) submitted a proposal by The Consortium of Alternate Energies in May 1986, San Diego, California.

ABSTRACT: Construction of a 30 Megawatt solar electric plant for the Chemehuevi Indian Tribe at Lake Havasu, California. This project evolved as a part of Project CENICOM™ which uses OMNIUM-G parabolic dish technology together with unique methods of assembling and controlling large numbers of collectors in a cluster. The result is a power plant featuring conversion and land use efficiency, and cost economics superior to all other available conventional forms of solar-derived electrical generation. To accomplish this, the collector cluster is supported on a common structure in such a manner that the structure---which resembles a large wheel and hub lying on its side---is rotated as one unit to follow the sun.

Top View of Standard 1 MWe Power Module



Accordingly, OMNIUM-G has set a goal of providing this technology as a major energy alternative to conventional sources. This new energy-neutral concept, when implemented, will generate more over-all revenue and job opportunities than any other total solar installation now available. Installed cost is low to begin with, but considering the plant’s several income streams---from cogeneration and creative use of space---real cost becomes dramatically less.

Solar Thermal Cogeneration Facility

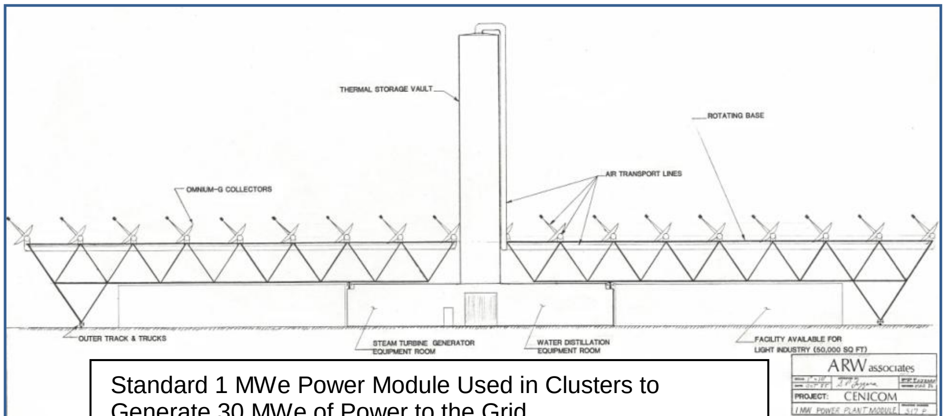
Installation of 1 MWe and higher solar electric plants at pre-selected sites in the U.S. Southwest. “Solar Thermal Cogeneration Facility”. Proposal by: The Consortium of Alternate Energies, August 1986, San Diego, California.

ABSTRACT: Solar parabolic dish concentrators have been developed to a high state of refinement by the scientists, engineers, and members of the Consortium group. Years of development, sophisticated testing, evaluation, and field experience have proven the equipment feasible, practical to construct, and economically competitive with other power sources. It is a market-ready resource with vast potential.

Accordingly, the Consortium of Alternate Energies and its proven project partner, OMNIUM-G of Anaheim, California, have set a goal of providing this technology as a major energy alternative to conventional power sources.

ABSTRACT: Utilizing proven parabolic dish concentrator equipment, grouped in 1-Megawatt or higher arrays, in areas proximate to underground water sources, local inhabitants may purify and distribute vast quantities of water for farming, culinary or livestock uses. Electricity and waste heat is also available for pumping, lighting, heating, cooling or any number of other functions needed in basic village or community development.

The systems are modular and expandable, according to need. Plant energy output may be shifted into different modes of production as conditions dictate. Around these power clusters may develop other facilities and projects. The over-all goal, and very probable outcome of this activity, is actual local self-sufficiency in water resources, food production, nutrition, and economic development.



Standard 1 MWe Power Module Used in Clusters to Generate 30 MWe of Power to the Grid.

Advanced Solar Cogeneration Systems.

Standard 1 MWe solar electric plant at Borrego Springs, CA. “Advanced Solar Cogeneration Systems”. Proposal by: The Consortium of Alternate Energies, March 1984, San Diego, California.

ABSTRACT: System design is considered a “standard plant”, well adapted for use throughout the world. It is designed to perform several functions. It will produce 1,000 kilowatts of electricity, desalinate brackish underground water, and provide residual heat for a variety of agricultural, commercial or residential uses. No by-product of the plant will go unused; even the very residue left from the water purification process will be sold as a fertilizer component.

The facility utilizes parabolic concentrator solar thermal technology, a well-proven process based on common thermal, mechanical, electronic and materials engineering principles.

African Village Development Project

Standard 1 MWe energy clusters for developing nations. “African Solar Energy-Based Village Development Project”. Proposal by: The Consortium of Alternate Energies, September 1987, San Diego, California.

2. Pragmatic Implementation Experience

Accomplishment & Breakthroughs.

Through 30 years, continuous improvements evolved in a most cost effective and pragmatic implementation of solar thermal processes. It is a long and tedious road from the scientific experiment to where all may derive benefit and share in the wealth and welfare of an idea.

Projects.

Plentiful operations and maintenance field data has been documented from the proposals, installations, and projects which include:

African village development	CAE, San Diego, CA
Solar thermal enhanced oil recovery	EXXON, Pittsburgh, PA
Parabolic dish solar thermal cogeneration	CAE, San Diego, CA
Solar power plant, 30 MWe	Chemehuevi Indian Reserve
Solar thermal power plant	Borrego Springs, CA
Solder manufacturing process	Litton, Anaheim, CA
Potato Chip Process	Laura Scuddar, Anaheim, CA

Life Cycle Considerations

30 Year Life

Superior performance of aluminum over glass collectors

Construction Techniques

Simplified light-weight and durable mirror design

Conventional off-the-shelf materials and processes

Manufacturing Processes

Standard commercial tools, materials, personnel

Refined and finely tuned “lessons learned” methods

Safety

Concern for environment, human and animal hazards in construction, implementation, and utilization—no environmental risk

Maintainability

Environmentally protected components requiring only preventative maintenance and cleaning to insure long life

Reliability

Inclement weather resistant and durable conventional utility power components with minimization of moving parts

Survivability

Innovative techniques to protect against potentially destructive high velocity wind and wind-driven particles

Cost/Effectively

Optimally sized for maximum utility of energy

Installations.

The product is designed for crating and shipping via any land, sea or air transport carrier. At any worldwide destination, the product is re-assembled on-site and installed manually using included tools and lifting devices. Installations and pictures of projects are seen hyperlinked on the following page:

3. Project Installation Links

DESCRIPTION	CUSTOMER	For More Info	DATE
Chemical Storage System	U of Houston, Texas	Houston	December 1977
Water Pumping for Greenhouse	El Marj, Libya	Libya	January 1978
Lasers & Satellite Energy Transmission	U of Washington, Seattle, WA	Washington	March 1978
President Carter Dedication	SERI, Golden, CO	Golden	May 1978
Evaluation for Industrial Processes	SERI, Golden, CO	Golden	May 1978
Evaluation for Process Heat	JPL, Edwards AFB, CA	Edwards AFB	September 1978
Evaluation for Rural Use	U of Queensland, Brisbane, Australia	Australia	November 1978
United Nations Demonstration Facility	Tangallie, Sri Lanka	Sri Lanka	December 1978
Evaluation for Village Power System	Hyderabod, India	India	December 1978
Developing Heat Engines	Martin-Marietta, Marietta, GA	Florida	February 1979
Evaluation for Island Fishing Village	Kaeya Island, Korea	Kaeya	March 1979
Power/heat for Phone Switching Building	Bethany, CT	Bethany	June 1979
Evaluate Rocket Engine Nozzle	RPL, Edwards AFB	Edwards AFB	September 1979
Power for Employee Canteen	FIAT, Brindisi, Italy	Italy	November 1979
Irrigation Pumping	TexasTech University, Lubbock, Texas	Lubbock	November 1979
Irrigation Pumping	TexasTech University, Lubbock, Texas		November 1979
Evaluation for Small Power System	JPL, Edwards AFB, CA	Edwards AFB	August 1980
Residential Heating Unit	Monument, CO	Residential	September 1980
Residential Heating Unit	Clementon, NJ	Residential	October 1980
Evaluation for Industrial Process Heat	Anaheim, CA	Residential	December 1980
Pizza Oven Furnace Unit	Elgin, IL	Residential	February 1981
Process for Chemical Company	C.Itoh, Kawasaki, Japan	Japan	March 1981
Manufacturing Facility	Anaheim, CA	Anaheim	June 1974
Component Manufacturing	Anaheim, CA	Anaheim	June 1974