

A Directory of U.S. Renewable Energy Technology Vendors

-P00 ABF-514

**Biomass
Photovoltaics
Solar Thermal
Wind**



Preface

Energy is essential for economic development, and the energy needs of countries assisted by the Agency for International Development (A.I.D.) are many and varied. Renewable energy has an important role to play, for both economic and environmental reasons, but developing-country energy users do not have as ready access to information on the available options as we have in the United States.

A.I.D. began a series of publications in 1988 intended to diminish that information gap. One of that year's reports — "Renewable Energy for Agriculture and Health" — was also published in collaboration with the multi-agency Committee on Renewable Energy Commerce and Trade (CORECT). That report described the different categories of renewable energy technology that could be appropriate for important end uses, depending on site-specific conditions. This new catalog is a follow-up to help those who have decided what kind of technology to purchase, but who need to know who provides it. Additional publications are planned for 1990.

I hope that energy users find the catalog helpful. Readers are invited to submit ideas for other useful reports.

Sincerely,

Mark L. Edelman
Acting Administrator
Agency for International Development

To Directory Users

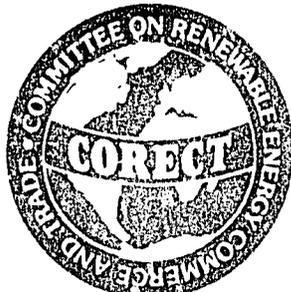
Although renewable energy makes significant contributions to satisfying energy demands in developing countries and elsewhere, it is usually quite difficult for potential end users to select commercial systems for purchase or license because of the vast array of available technologies and applications. This problem is especially difficult to solve in developing countries, where the need is great but practical information is scarce. This first edition of A Directory of U.S. Renewable Energy Technology Vendors is aimed at supplying this information and meeting this need. It focuses on selected U.S. companies that market biomass, photovoltaic, solar thermal, and wind energy equipment and turnkey systems suitable for use in developing countries. The catalog highlights commercially available products from firms that have the capability to export and support overseas sales.

The directory permits ready determination of what kinds of equipment and systems are available, provides preliminary evaluation of technical features and costs, and shows how to obtain further details on direct purchase, joint ventures, licensing agreements, and financing. Although the emphasis is on complete package systems, component and sub-system suppliers are also listed in the catalog.

This directory was published by the Biomass Energy Research Association (BERA) under the sponsorship of A.I.D. and the management of Oak Ridge National Laboratory. An intensive survey of U.S. renewable energy technology vendors was first conducted by BERA to compile information on commercially available systems and hardware in the U.S.A. The companies listed in the directory were then chosen based on information supplied by the companies and several U.S. trade associations listed on pages 70 and 71, and on criteria established by A.I.D. and BERA. It should be emphasized that a major effort was made to make the information presented herein as current as possible at the time of publication (March 1990), but that periodic revisions would be necessary to bring the listings up to date.

This catalog represents a concerted effort to supply much needed information on commercially available, U.S.-developed renewable energy systems and to encourage their export to developing countries.

Table of Contents	Page
Preface	2
To Directory Users	2
Introduction	3
Index of Vendors by Application	6
Index of Vendors by Technology	9
Alphabetical Listing of Companies	11
Financing Private Energy Projects in Developing Countries	66
Additional Information Resources	70
Conversion Factors Used in This Directory	72
Abbreviations and Symbols Used in This Directory	73
Acknowledgment	74



Introduction

Renewable energy conversion technologies have been used for more than a century for a wide variety of applications. Biomass, hydro, and wind energy conversion systems have been employed to produce mechanical shaft power, electricity, and heat. The end-use applications have ranged from small individual home lighting, cooking, and heating systems to large systems such as multi-megawatt power plants.

The U.S. industry has provided global leadership in advanced renewable energy development, resulting in lower cost and more efficient equipment with greater reliability and extended life expectancy. Advances in engineering design, manufacturing processes, and more durable and lightweight materials have been largely responsible for the emergence of the latest generation of low-cost, high-reliability, renewable energy conversion equipment.

This directory is a descriptive listing of renewable energy technologies offered for sale to developing countries by selected U.S. companies. The products, processes, systems, components, and special services such as engineering and consulting fall into four major categories — energy from biomass, photovoltaics, solar thermal radiation, and wind.

An index is provided that lists the page location for companies doing business in each of these four fields. (Several companies conduct business in more than one field.) Another index lists the page location for companies by application (such as heating water, generating electricity, etc.).

SYSTEMS PRODUCING HEAT

Several companies produce equipment to convert a variety of biomass fuels and solar insolation (sunlight) to heat for use in thermal processes.

Heat From Biomass

U.S. equipment suppliers provide technologies to convert biomass residues such as wood waste (chipped wood, bark, and sawdust), bagasse, rice hulls, cotton waste, and nut shells to heat through combustion and gasification processes. Some gasification systems can be retrofitted to existing boilers. Combustion systems often require custom-designed boilers.

Biomass can also be converted by a biochemical process called anaerobic digestion to a gaseous fuel, commonly termed biogas. Anaerobic digesters have been used in several waste-conversion applications, including swine production facilities, distilleries, sewage treatment plants, and food processing plants. The resulting gas is a mixture of carbon dioxide and methane, that can be used as a fossil fuel substitute in boilers, and for water heating, drying processes, and cooking.

Solar Heating

Solar collectors convert sunlight to heat via a heat exchange medium (water, inert gas, or air) for use in ther-

mal processes. This can be used for low grade requirements (hot water), or if concentrating/tracking systems are used, steam can be raised to drive power generating equipment.

Solar hot water systems are commercially available to meet both domestic and commercial hot water demands. The water is heated and collected in a storage tank sized to meet hot water requirements during some specific time period. During periods of prolonged low insolation, a supplemental heating system may be employed. This system can be comprised of a conventional water heater, or a biomass system may be used to provide the heat necessary to operate heat exchangers for domestic supplies of hot water.

Domestic space heating can also be provided by solar thermal collectors that generally use air to transport the heat directly from the collector or indirectly from a storage system. Large systems are also available to provide institutional space heating and cooling.

ELECTRIC POWER AND COGENERATION SYSTEMS

U.S. industry has developed several renewable energy technologies for generation of electricity. These use wind power, photovoltaics, solar thermal energy, and biomass-fueled steam power to run turbines or steam engines that drive generators. Availability of renewable sources of energy and the particulars of end-use requirements will dictate which of these systems is suitable.

Wind Generator Systems

Coastal areas and mountain passes often have sufficient wind resources that enable economic use of wind energy conversion systems. Generally, with wind speeds exceeding 4 to 5 m/s (8.9 to 11.2 mph), and with infrastructure to transmit the power to load centers, wind resources can be a very valuable generation alternative in an integrated utility.

California, with an installed capacity of 1,437 MW of wind turbines in 1987, is the world's leader in generating electricity from wind. Most of these installations use modern U.S. equipment developed during the 1980s. Average installation costs have fallen about two thirds since 1981 to \$800 to \$1200 per kW for intermediate-size systems. Sturdy, proven wind turbines now combine new materials and technologies that operate 80 to 98 percent of the time the wind is blowing. Average capacities have increased from 49 kW in 1981 to 111 kW in 1987; newer models have capacities of 150 to 750 kW. Greater power output has been achieved principally by increasing rotor diameter. On larger models, this now exceeds 15.2 m (50 ft). Turbines can be tailored for specific locations and power uses. They can be small enough for individual farms, homes, or villages, or large enough for utility customers. Clusters of wind turbines, known as wind farms, can expand operations further.

Photovoltaic Systems

Wherever there is adequate insolation, it is possible to convert solar energy with photovoltaic (PV) cells to produce direct current electricity. This can readily be inverted to alternating current if necessary. The United States leads in photovoltaic technology development and commercialization. Tens of thousands of U.S.-manufactured photovoltaic systems are in use throughout the world, providing electricity for operation of communications systems, refrigerators, medical clinics, lights, irrigation and potable water systems, utility company central power stations, residential buildings, and isolated commercial enterprises. Consumer and industrial products powered by photovoltaic systems are also available. These include items such as battery chargers, flashlights, cathodic protection systems, lighted signs, and many others.

Average flat-plate PV module costs have dropped from \$100 per peak watt in 1972 to under \$5 today. ("Peak" refers to power output under maximum solar radiation conditions.)

Several forms of silicon are used today in conventional solar cells — single crystal, polycrystalline, and amorphous types. Single crystal and polycrystalline cells are more costly than amorphous cells, but have higher conversion efficiencies. In addition to cells, there are mounting assemblies, inverters, converters, regulators, batteries, motors, pumps, refrigerators, lights, and communications equipment that have been specially designed for PV applications to maximize efficiency and optimize compactness. Thus, purchase of a U.S. PV system results in the best components available anywhere. For example, motors that are 90 percent efficient and deep-discharge batteries that furnish adequate current even when 70 to 80 percent discharged are levels of U.S. performance that are unmatched. Reliability of PV systems to deliver electrical current during sunlight hours exceeds 90 percent. Systems are made to last 20 years or more.

A few companies also offer a complete system of production equipment to make PV cells and assemble them into modules and panels.

Solar Thermal Electric Power Generation

Solar collectors that concentrate insolation by means of parabolic troughs and direct the sun's rays to a smaller heat exchanger target can produce temperatures over 1093°C (2000°F). This temperature will satisfy the needs of most thermodynamically efficient electric power conversion systems. The parabolic trough is a line-focus concentrator with reflective material to focus the sunlight on an axis along the length of the trough. Along this axis, a heat exchanger tube absorbs the radiant energy, through which a working fluid is circulated to transfer the heat absorbed to a boiler, generating steam for an electric turbine generator. To maximize efficiency, the parabolic trough is rotated on its axis to track the sun.

To date, the largest solar installations of any kind are private commercial electric power plants using parabolic trough technology. Five such plants installed in Southern California have a total collector area of 743,000 m² (8 million ft²) and an electrical capacity of 130 MW.

Other solar thermal concentrator technologies include: central receiver stations in which heliostats (flat mirrors that track the sun on two axes) reflect insolation to a tower-mounted receiver, and parabolic dish systems that also track the sun along two axes, reflecting sunlight to a small focal point in front of it to achieve very high solar concentrations. Dish-mounted Stirling engines are a leading option for dish-electric systems.

In high insolation areas where conventional energy is expensive, solar thermal electric power generation systems are economically practical and very competitive. The systems do not require commercial fuel as do conventional alternatives which must cope with the unknown future costs of fossil fuels. Vendors are able to provide specific cost comparisons for any particular option under consideration. In general, capital costs for solar thermal, parabolic trough installations fall in the range \$3,500 to \$4,100/kW (1986 dollars), and should decline to \$1,500 to \$3,000/kW by 1995.

Biomass-Fueled Steam Power Plants

Industrial type, biomass-fueled boilers cited in the section on Systems for Producing Heat Energy can be operated to produce steam for generation of electricity. A number of companies provide turnkey installations that produce from 50 kW to 25 MW of electric power. Industrial cogeneration systems with capacities up to 50 MW are also available and can sometimes be retrofitted to existing boilers. A wide range of biomass fuels can be used, but for the larger capacity system, wood is generally the preferred fuel.

Biomass-Fueled Engine Generator Sets

Single steam engines which drive a generator, as contrasted to banks of steam turbines, are also available to run on biofuels of many types. These engines are commonly used in developing countries to generate electricity needed by rural industries and/or adjacent villages. Capacities range from 10 to 80 kW. Duplex models can increase capacity to 200 kW. Stirling-type, external heat engines are also available which operate on biomass and can generate up to 3.5 kW.

Cogeneration

Whether electricity is made by steam turbines, steam engine-generator sets, Stirling engines, or solar thermal concentrators that power steam turbines, it is always possible to practice cogeneration, namely, the capture of waste heat and its use for industrial process heat, for drying, and for heating space and water. The economic feasibility of a cogeneration project, however, is determined by the market needs of the salable energy products.

SYSTEMS PRODUCING MECHANICAL POWER

For years, mechanical power has traditionally been produced by biomass-fueled steam engines and water-pumping windmills. These systems are still provided by U.S. companies. Recent developments in U.S. technology have added biomass-fueled Stirling cycle heat engines and electric pumping systems powered by photovoltaics.

Biomass-Fueled Steam Engines

Low speed (300-600 rpm) steam engines are available which have power outputs ranging from 3.8 to 225 kW (5 to 300 HP) at full load. Inlet steam pressure can be varied from 690 to 2,400 kPa (100 to 350 psig). Exhaust steam can often be used for moderate temperature applications, such as heating water or drying crops.

Biomass-Fueled Stirling Cycle Heat Engines

Suitable biomass fuels, such as wood, wood pellets, sawdust, rice husks, rice straw, cotton wastes, peanut shells, weeds, and hay can be burned externally to heat a Stirling cycle engine to provide mechanical power for water pumping, grain milling, and the like. A 3.8 kW (5-HP) engine rated at 650 rpm is commercially available.

Water-Pumping Wind Mills

Wind mills have a long history of supplying energy for grinding grain and pumping water. U.S. industry can supply windmills coupled to reciprocating cylinder pumps to pump water from wells. The unit is placed directly over the well and operates a wooden or steel pump rod. Complete wind mills, excluding towers, cost from \$1,160 for a 1.8-m (6-ft) model to \$4,370 for a 4.3-m (14-ft) model. Tower prices range from \$864 to \$2,268. Pumping capacities vary from 492 to 1,740 L/h (130 to 460 gal/h).

Photovoltaic Pumping Systems

Photovoltaic power systems are available to operate a variety of pumping systems. Photovoltaic powered submersible systems have been designed to utilize either direct or alternating current induction motors. Low-head pumping technology for stationary and portable applications is also available from a wide variety of suppliers.

SYSTEMS PRODUCING ETHANOL TRANSPORTATION FUEL

U.S. industry has developed large plants for production of ethanol from biomass by fermentation. The latest proven technology is available from firms that provide complete know-how, engineering designs, and assistance to procure the chemical process equipment needed.

AUXILIARY EQUIPMENT

Specialized equipment has been developed in the United States for harvesting biomass (feller bunchers, wood chippers, and the like), for loading and unloading, for transportation, for storage, and for feeding to furnaces. Balance-of-component auxiliary products for all technologies are available to build complete installations. Some

examples of the latter are batteries, support structures, gaskets, electric converters, transformer controls, instruments, and regulators.

CONSULTING, ENGINEERING, AND SUPPORT SERVICES

The U.S. renewable energy industry provides a wide range of special assistance services. Consulting and engineering firms can provide assistance in selection, design, and installation of systems or equipment, as well as operator training. Some firms offer other services that are needed by an end user who does not yet have the sophisticated know-how to go it alone. Some companies that market renewable energy technology also offer assistance in the use of their products, processes, and systems.

Index of Vendors by Application

I. SYSTEMS PRODUCING HEAT

A. SOLAR THERMAL

1. COLLECTORS FOR HEATING WATER FOR

- a. Domestic Uses
 - American Energy Technologies, Inc.
 - Efficient Homes, Inc.
 - Energy Depot
 - Fafco, Inc.
 - Gull Industries
 - Heliodyne, Inc.
 - Radco Products, Inc.
 - Ramada Energy Systems Limited
(unbreakable polycarbonate glazing)
 - Solartherm, Inc.
 - Solar Development, Inc.
 - Solar Electric Engineering, Inc.
 - Sun Earth, Inc.
 - U.S. Solar Corporation
 - Virginia Solar Components, Inc.
 - b. Commercial & Institutional Uses
 - American Energy Technologies, Inc.
 - Efficient Homes, Inc.
 - Energy Depot
 - Entech, Inc. (Fresnel lens concentrators)
 - Gull Industries
 - Heliodyne, Inc.
 - Solar Electric Engineering, Inc.
 - U.S. Solar Corporation
 - Virginia Solar Components, Inc.
 - c. Industrial Processes
 - American Energy Technologies, Inc.
 - Entech, Inc. (Fresnel lens concentrators)
 - Heliodyne, Inc.
 - Solar Development, Inc.
 - Solar Electric Engineering, Inc.
 - Solar Power Engineering Company (molten salt
central receiver)
 - Virginia Solar Components, Inc.
 - d. Swimming Pools
 - American Energy Technologies, Inc.
 - Efficient Homes, Inc.
 - Energy Depot
 - Fafco, Inc.
 - Gull Industries
 - Radco Products, Inc.
 - Solar Electric Engineering, Inc.
 - Sun Earth, Inc.
 - Virginia Solar Components, Inc.
 - e. Steam/Power (for Electricity, Industrial Uses)
 - Industrial Solar Technology
 - Power Kinetics, Inc.
- #### 2. COLLECTORS FOR HEATING WATER OR AIR
- a. Space Heat (Comfort, Drying)
 - Energy Depot
 - Solar Development, Inc. (water)
 - Sun Earth, Inc. (water)
 - Solartherm, Inc. (air)
 - U.S. Solar Corporation. (water and air)
 - Virginia Solar Components, Inc. (air)
 - b. Cooking Food
 - Burns-Milwaukee, Inc.
 - Solartherm, Inc.

3. CONCENTRATOR SYSTEMS

- Babcock & Wilcox Company (central receiver)
- Industrial Solar Technology (parabolic trough)
- Power Kinetics, Inc. (point focusing parabolic
receivers)

4. COMMERCIAL COOLING

- Heliodyne, Inc.

5. SPECIAL SERVICES

- DSET-Laboratories, Inc. (tests, evaluations)

6. BALANCE OF SYSTEM COMPONENTS AND AIDS

- Hedland Flow Meters (flow meters)
- Heliotrope General (controllers)
- Independent Energy Inc. (temp. controller)
- Pawling Corporation (gaskets, moldings,
extrusions)
- Solarmetrics, Inc. (temperature controls for water
or air systems)

B. BIOMASS COMBUSTION

1. FURNACES AND BOILERS FOR

- a. Hot Water
 - Dumont Stoker Corporation
 - Eshland Enterprises, Inc.
 - G&S Mill, Inc., (The)
- b. Distilled Water
 - Trofe Incineration, Inc.
- c. Space Heat (Comfort, Drying)
 - Combustion Systems Associates, Inc. (steam
engine with exhaust heat uses)
 - Dumont Stoker Corporation
 - Eshland Enterprises, Inc.
 - G&S Mill, Inc., (The)
 - Nordic Stove Company (domestic)
 - Olathe Manufacturing, Inc.
 - PRM Energy Systems, Inc.
 - Sukup Manufacturing Company (heat exchanger
for clean hot air)
 - Tryco Manufacturing Company, Inc.
 - Waste Conversion Systems, Inc. (drying, food
processing lumber kilns, rice processing)
- d. Steam/Power (For Electricity or Industrial Uses)
 - Babcock & Wilcox Company
 - Basic Environmental Engineering
 - Combustion Systems Associates, Inc. (steam
engines with exhaust heat uses)
 - Dumont Stoker Corporation (industrial)
 - Energy Products of Idaho
 - Eshland Enterprises, Inc. (commercial and
industrial)
 - G&S Mill, Inc. (The)
 - Hadson Power Systems Group
 - Olathe Manufacturing, Inc.
 - PRM Energy Systems, Inc.
 - Skinner Engine Company
 - Thermo Electron Corporation
 - Trofe Incineration, Inc.
 - Tryco Manufacturing Company, Inc.
 - Waste Conversion Systems, Inc.

- e. Cooling/Refrigeration
Waste Conversion Systems, Inc. (making ice)
- f. Balance of System Components and Aids
L. D. Industries, Inc. (silos, conveyors, live bottoms, elevators)
Morbark Industries, Inc. (harvesters, chippers)
Nicholson Manufacturing Company (debarkers, chippers, loaders, etc.)
Olathe Manufacturing, Inc. (chippers, dryer-feeders, live bottoms)
Phelps Industries, Inc. (dump trucks, live bottom hoppers)
SPM Group, Inc. (shredders, densifiers, dryers)

2. GASIFIER SYSTEMS

- Dumont Stoker Corporation (with cogeneration)
- Energy Products of Idaho
- Eshland Enterprises, Inc.
- Olathe Manufacturing, Inc.
- Tryco Manufacturing Company, Inc.

C. ANAEROBIC DIGESTION (BIOGAS FUEL GENERATION)
Biotechnical Processes, Inc. (Bacardi Corporation)

II. SYSTEMS PRODUCING ELECTRICITY

NOTE: ALSO SEE "STEAM/POWER" UNDER "BIOMASS COMBUSTION, FURNACES & BOILERS"

A. COGENERATION

1. Using Biomass Fuels

- Dumont Stoker Corporation
- Basic Environmental Engineering
- Hadson Power Systems Group
- PRM Energy Systems, Inc.
- Thermo Electron Corporation
- Trofe Incineration, Inc.
- Waste Conversion Systems, Inc.

2. Using Solar Thermal

- Industrial Solar Technology

B. WIND

1. Generators (electricity)

- Bergey Windpower Company, Inc.
(also ice-making, desalination)
- Flowind Corporation
- Northern Power Systems
- Southwest Windpower
- U.S. Windpower, Inc.
- World Power Technologies, Inc.

2. Balance of System Components and Aids

- Bergey Windpower Company, Inc. (tilt-up tower)
- Controlex, Inc. (instruments, controllers)
- Gougeon Brothers, Inc. (turbine blades)
- NRG Systems, Inc. (instruments, towers for)
- Northern Power Systems
- R. Lynette & Associates, Inc. (consulting)
- Second Wind, Inc. (data collection and monitoring)
- Southwest Windpower (all components for independent power)
- Springhouse Energy Systems (analysis, siting, design)
- U.S. Windpower, Inc. (computerized controls, site analysis, etc.)
- World Power Technologies, Inc. (utility interconnect system, towers, inverters, batteries, etc.)

C. PHOTOVOLTAIC SYSTEMS

1. Complete Systems (village/local power, lighting, etc.)

- Chronar Corporation
- Energy Depot
- Entech, Inc. (Fresnel lens concentrators)
- Flowlight Solar Power (home systems)
- Integrated Power Corporation (also hybrid with diesel, wind or thermoelectric)
- Northern Power Systems
- Photocomm, Inc. (assembled from other vendors' components)
- Photron, Inc. (photogenset system from other vendors' components; also PV-diesel hybrid cogeneration)
- Solar Electric Engineering, Inc.
- Solar Electric Systems, Inc.
- Solar Engineering, Inc. (includes PV-diesel hybrid)
- Solar Power Engineering Company (concentrating with tracker)
- Solar SignAge, Inc. (lighting)
- Solar Tek (safety lights for barricades, airports, coastal zones)
- Solarex Corporation
- Solec International, Inc. (packaged lighting)
- SunAmp Power Company, Inc. (from other vendors' components)

2. Cells-Modules — Panels

- Arco Solar, Inc.
- Chronar Corporation
- Energy Depot
- Entech, Inc. (Fresnel lens concentrators)
- Heliodyne, Inc. (for solar thermal systems)
- Integrated Power Corporation (new module technology)
- Photocomm, Inc.
- Solar Engineering, Inc.
- Solarex Corporation
- Solartherm, Inc.
- Solec International, Inc.
- SunAmp Power Company, Inc. (from other vendors)

3. Water Pumping Systems

- Arco Solar, Inc.
- A. Y. McDonald Manufacturing Company
- Chronar Corporation
- Dinh Company, Inc.
- Flowlight Solar Power
- Photocomm, Inc. (uses other vendors' components)
- Solar Electric Engineering, Inc.
- Solar Electric Systems, Inc.
- Solar Engineering, Inc.
- Solar SignAge, Inc.
- Sun Amp Power Company, Inc.

4. Refrigeration/Cooling Systems

- Arco Solar, Inc.
- Dinh Company, Inc.
- Photocomm, Inc.
- Photron, Inc.
- Solar Electric Engineering, Inc.
- Solar Electric Systems, Inc.
- Solar Engineering, Inc.
- Solar SignAge, Inc.
- Solartherm, Inc.

5. Other Solar Powered Consumer and Industrial Products

Arco Solar, Inc. (telecommunications, cathodic protection)
Chronar Corporation
Integrated Power Corporation (telecommunications, cathodic protection)
Photocomm, Inc. (telemetry)
Photron, Inc. (computer operation)
Solar Electric Engineering, Inc. (flashlights, battery charger)
Solar Electric Systems, Inc. (computer interface, security systems)
Solar Engineering, Inc. (telecommunications, battery charging)
Solar SignAge, Inc. (lighted signs, security systems)
Solartherm, Inc. (electric vehicle, fans, lights)
SunAmp Power Company, Inc. (cathodic protection)

6. Production Equipment and/or Systems

Chronar Corporation
Glasstech Solar, Inc.
Spire Corporation

7. Balance of Systems Components and Aids

Abacus Controls, Inc. (sunverter)
Arco Solar, Inc.
Chronar Corporation (lights, chargers, etc.)
Energy Depot (controls)
Exide Corporation (batteries)
Heliotrope General (transformer, inverter, battery charge controller, temperature controls, etc.)
Omniion Power Engineering Corporation (power conversion and controls)
Photocomm, Inc. (various controls)
Photron, Inc. (complete components)
Solar Electric Engineering, Inc. (inverters, controllers, etc.)
Solar Engineering, Inc. (support structures, batteries, controls)
Solar SignAge, Inc. (solar generators, controllers, etc.)
Solarex Corporation (regulators, controllers, mounting hardware)
Solartherm, Inc. (solar generators)
Solec International, Inc.
SunAmp Power Company, Inc. (batteries, inverters, converters, regulators, controls, structures, etc.)
Sun Selector (charge controllers, current booster, utility interface, ampere hour meter, battery charge and voltage regulators)
Surrette America (batteries)
Thin-Lite Corporation (fluorescent lights, electronic inverter, ballasts)
Trojan Battery Company (batteries)
Vanner, Inc. (inverters, battery isolators and equalizers, etc.)

III. SYSTEMS PRODUCING MECHANICAL POWER

A. WATER PUMPING

1. Windmills

Bergey Windpower Company, Inc.
Dempster Industries, Inc.
Heller-Aller Company, Inc. (The)

2. Photovoltaic Systems

Arco Solar, Inc.

A. Y. McDonald Manufacturing Company

Chronar Corporation
Dinh Company, Inc.
Flcwright Solar Power
Photocomm Inc.
Solar Electric Engineering, Inc.
Solar Electric Systems, Inc.
Solar Engineering, Inc.
Solar SignAge, Inc.
SunAmp Power Company, Inc.

3. Heat Engines (Externally Fueled)

Stirling Technology, Inc.

B. STEAM ENGINES

Combustion Systems Associates, Inc. (also exhaust heat uses)
Skinner Engine Company (also run generators)

C. HEAT ENGINES (Externally Fueled)

Stirling Technology, Inc.

IV. SYSTEMS PRODUCING ETHANOL TRANSPORTATION FUEL

A. PRODUCTION PLANTS FOR ETHANOL

Aaron Equipment Company (used reconditioned process equipment)

B. SUPPORT SERVICES FOR ETHANOL PRODUCTION

Hunter/Reynolds, Smith and Hills, A-E-P, Inc. (consulting and design services for ethanol fermentation)
Raphael Katzen, Associates International, Inc. (complete design, engineering, installation and training for fermentation and/or distillation systems)

V. AUXILIARY EQUIPMENT FOR

A. HARVESTING

Morbark Industries, Inc. (wood harvesting and chipping)
Nicholson Manufacturing Company (wood chippers)

B. STORAGE OF BIOMASS

L. D. Industries, Inc. (silos)

C. HANDLING OF BIOMASS (Also see Harvesting above)

Aaron Equipment Company (thicken sewage sludge)
L. D. Industries, Inc. (reclaimers for handling)
Phelps Industries, Inc. (dump trucks, live bottom hoppers)

D. STORAGE OF ELECTRICITY

Exide Corporation (batteries)
Surrette America (batteries)
Trojan Battery Company (batteries)

VI. CONSULTING, ENGINEERING & SUPPORT SERVICES

HDR Engineering, inc. (for IB and IC technologies)
Hunter/Reynolds, Smith and Hills, A-E-P, Inc. (for IA, IB, IC, IIA, IIB, IIC, IIIA, IVA technologies)
Raphael Katzen, Associates International, Inc. (for IVA technologies)
Dinh Company, Inc. (for IIC technologies)
Controlex, Inc. (for IIB and IIA1 technologies)
NRG Systems, Inc. (for IIB and IIIA1 technologies)
R. Lynette & Associates, Inc. (for IA, IIB, IIC, IIIA1 technologies)
Second Wind, Inc. (for IIB and IIIA1 technologies)

Index of Vendors by Technology

Companies Offering Biomass Energy Technology

Aaron Equipment Company
Babcock and Wilcox Company (Solar Thermal included)
Biotechnical Processes, Inc. (Bacardi Corporation)
Basic Environmental Engineering
Combustion Systems Associates, Inc.
Dumont Stoker Corporation
Energy Products of Idaho
Eshland Enterprises, Inc.
G&S Mill, Inc. (The)
Hadson Power Systems Group
HDR Engineering, Inc.
Hunter/Reynolds, Smith and Hills, A-E-P Inc.
Katzen, Raphael, Associates International, Inc.
L. D. Industries, Inc.
Morbark Industries, Inc.
Nicholson Manufacturing Company
Nordic Stove Company
Olathe Manufacturing, Inc.
Phelps Industries, Inc.
PRM Energy Systems, Inc.
Skinner Engine Company
SPM Group, Inc.
Stirling Technology, Inc.
Sukup Manufacturing Company
Thermo Electron Corporation/Energy System Division
Trofe Incineration, Inc.
Tryco Manufacturing Company, Inc.
Waste Conversion Systems, Inc.

Companies Offering Photovoltaic Energy Technology

A. Y. McDonald Manufacturing Company
Abacus Controls, Inc.
Arco Solar, Inc.
Chronar Corporation
Dinh Company, Inc.
Energy Depot (Solar Thermal included)
Entech, Inc. (Solar Thermal included)
Exide Corporation
Flowlight Solar Power
Glasstech Solar, Inc.
Heliodyne, Inc. (See Solar Thermal listing)
Heliotrope General (Solar Thermal included)
Integrated Power Corporation
Northern Power Systems (See Wind Energy)
Omnion Power Engineering Corporation
Photocomm, Inc.
Photron, Inc.
Solar Electric Engineering, Inc. (Solar Thermal included)

Solar Electric Systems, Inc.
Solar Engineering, Inc.
Solar Power Engineering Company (Solar Thermal included)
Solar SignAge, Inc.
Solar Tek
Solarex Corporation
Solartherm, Inc. (Solar Thermal included)
Solec International, Inc.
Spire Corporation
SunAmp Power Company, Inc.
Sun Selector
Surrette America
Thin-Lite Corporation
Trojan Battery Company
Vanner, Inc.

Companies Offering Solar Thermal Energy Technology

American Energy Technologies, Inc.
Babcock and Wilcox Company (See Biomass Energy listing)
Burns-Milwaukee, Inc.
DSET Laboratories, Inc.
Efficient Homes, Inc.
Energy Depot (See Photovoltaics listing)
Entech, Inc. (See Photovoltaics listing)
Fafco, Inc.
Gull Industries
Hedland Flow Meters
Heliodyne, Inc. (Photovoltaics included)
Heliotrope General (See Photovoltaics listing)
Independent Energy, Inc.
Industrial Solar Technology
Pawling Corporation
Power Kinetics, Inc.
Radco Products, Inc.
Ramada Energy Systems Limited
Solar Development, Inc.
Solar Electric Engineering, Inc. (See Photovoltaics listing)
Solar Power Engineering Co. (See Photovoltaics listing)
Solarmetrics, Inc.
Sun Earth, Inc.
U.S. Solar Corporation
Virginia Solar Components, Inc.

Companies Offering Wind Energy Technology

Bergey Windpower Company, Inc.
Controlex, Inc.
Dempster Industries, Inc.
Flowind Corporation
Gougeon Brothers, Inc.
Heller-Aller Company, Inc., The
Northern Power Systems (Photovoltaics included)
NRG Systems, Inc.
R. Lynette & Associates, Inc.
Second Wind, Inc.
Southwest Windpower
Springhouse Energy Systems
U.S. Windpower, Inc.
World Power Technologies, Inc.

Alphabetical Listing of Companies

A. Y. McDonald Mfg. Co.

4800 Chavenelle Road
Dubuque, Iowa 52001
Telephone: 319-583-7311
Telex: 43-9020 AYMCD DUQU
Fax: 319-583-0720

Chief Executive Officer: Mr. R. D. McDonald
International Sales Manager: Mr. John Eckel

Equipment or Systems Characteristics

A. Y. McDonald Manufacturing Company, (AYMC), offers 2 types of PV water pumping systems. One is coupled directly to the PV panel to pump water into storage facilities while the sun shines; the other is powered by storage batteries, recharged during sun-light periods, to assure on-demand pumping at any time. The latter can also power lights and other appliances and may include a DC-to-AC converter to supply appropriate AC electricity. Pre-engineered, packaged systems are available from stock for 30-day delivery. Both 12- and 24-volt DC pumps are available for use on shallow wells, lakes, streams, cisterns, etc. In addition, 300-, 500-, 900-, and 1300-W pumps are available for the foregoing applications and for wells up to 18.3 m (60 feet deep). Further, 4 brushless, DC, submersible pumps with capacities up to 37,900 L/day (10,000 gal/day) and depth settings up to 122 m (400 ft) are available. Warranties are for 1 to 2 years. Maintenance requires washing of the solar panels.

Applications are for remote village water supply, livestock watering, drip or trickle irrigation, remote home water supply, low-pressure sprinkler irrigation, etc. Engineering and design services are offered.

Experience and Operations

AYMC is an old, well established pump company that was formed in 1856. After 70 years of experience in the production of electric pumps, AYMC began testing DC, solar-powered centrifugal pumping systems in 1977. The feasibility of such packaged systems was proven in the 1980s, and AYMC has offered commercially available systems directly or through many solar equipment distributors for the past 2 years. AYMC has provided solar pumps and systems to many countries through several non-profit agencies; e.g., Africare, Care, Catholic Relief, UNICEF, and VITA. Commercial ventures have been completed in Guyana, Indonesia, Australia, Bolivia, Sudan, Canada, and Mexico. Other installations are in Haiti, Saudi Arabia, Oman, Guam, Djibouti, Mali, and many Central and South American and Caribbean countries. A solar pumping demonstration system is in operation at the University of California, Davis, California, to compare AC and DC pumping side-by-side using a 3-kW PV panel with 4 pumps.

Aaron Equipment Company

Box 80, 735 E. Green St.
Bensenville, Illinois 60106
Telephone: 312-350-2200
Telex: 28-9454
Fax: 312-595-3993

Chief Executive Officer: Mr. Jerrold Cohen
International Sales Managers: Mr. Kenneth B. Kyte, Mr. Alan Cohen

Equipment or Systems Characteristics

The Aaron Equipment Company, (AEC), offers complete, used, ethanol plants with reconditioned components. Re-erection and start-up service can be provided. Twelve plants, ranging in size from 50,000 to 11,000,000 L/mth (13,200 to 291,000 gal/mth), are available for immediate shipment. Feedstock can be fruit, molasses, corn, milo, and other grains. AEC also offers reconditioned "as new" centrifuges to separate or thicken sludge in sewage plants. In addition, a large selection of surplus process equipment, as described in a catalog, can be provided.

Experience and Operations

AEC has been operating since 1948 as a private organization. Annual business is in excess of \$1 million. Overseas sales in the last 5 years include deliveries to Turkey, Hong Kong, India, Haiti, Brazil, and Mexico. Service agreements and system installations can be provided, and warranties are negotiable.



Abacus Controls, Inc.

80 Readington Road
P.O. Box 893
Somerville, New Jersey 08876
Telephone: 201-526-6010
Telex: None
Fax: 201-526-6866

Chief Executive Officer: Mr. George O'Sullivan
Office Manager: Ms. Deborah Shea
*International Sales: XPORT — The Port Authority Trading Co.**

Equipment or Systems Characteristics

Abacus Controls, Incorporated, (ACI), supplies PV DC/AC inverter systems called a "Sunverter." This unit is capable of being interconnected to the electric grid, supplying nominal 240-volts AC, 50 or 60 Hz, 4-kW single-phase power; 8-kW systems are also available. Warranties are for 1 year. Solar array simulators (11 kW and 75 kW) are available for PV research.

Experience and Operations

ACI was established in 1974 and grosses in excess of \$1 million annually. It has overseas representatives in Italy at L. P. Instruments, Via Paolo Pallia, 5, 20139 Milano, Italy, Telex 315085.

The Sunverter has been installed for operation in Zurich, Switzerland, for the U.S. Postal Service in Puerto Rico, and for water pumping for an irrigation system in Egypt. The latter 2 installations were performed by ACI as subcontractor to Solarex. Locally, a 4-kW Sunverter system is installed in Hillsborough, New Jersey for the Public Service Electric and Gas — BEST facility.

* Address: One World Trading Center 63 East, New York, New York 10048, Telephone: 212-466-4204, Telex: 427346, Fax: 212-432-0297.



abacus controls, inc.

American Energy Technologies, Inc.

P.O. Box 1865
Green Cove Springs, Florida 32043
Telephone: 904-284-0552
Telex: 362644 AET UP
Fax: 904-284-0006

Chief Executive Officer: Mr. Steven K. Gorman

Equipment or Systems Characteristics

American Energy Technologies, Incorporated, (AET), provides packaged system designs and components for residential, commercial, and industrial applications. Sizes range from single-panel, active or passive, residential systems to multi-thousand gallon water heaters and/or preheaters. Generic system types include thermosiphon, open-loop drain-back and closed-loop batch heaters. Besides various sizes of standard solar collection panels, AET also offers many sizes of black chrome absorber plates.

Experience and Operations

AET was established in 1987 and grosses in excess of \$1 million annually. AET manufactures products in Jamaica, Antigua, and Granada, in addition to the United States. Additionally, AET has representation in over 20 countries through its manufacturer's representatives.



AMERICAN ENERGY TECHNOLOGIES, INC.

P. O. Box 1865
Green Cove Springs, FL 32043-1865

Arco Solar, Inc.

4650 Adhor Lane
Camarillo, California 93010
Telephone: 805-482-6800
Telex: 6716260
Fax: 805-388-6395

President: Dr. Charles F. Gay
International Sales Manager: Mr. Tom Dyer

Equipment or Systems Characteristics

Arco Solar, Incorporated, (ASI), manufactures a wide variety of PV modules. Models M-55, -65, and -75 are constructed with single-crystal PV cells which produce 53, 42, and 47 W, respectively. These have 10-year warranties. Models M-25 and -86 are also single-crystal type cells which produce 22 and 9.5 W. These have 5-year warranties. Model M-85, either 12 volt or 24 volt, is made of thin-film type PV cells which produce 10.8 W. These have a 1-year warranty. MAF-10, -20, and -35 are Coast Guard electronic units having 10-, 20-, and 35-W power outputs. Photovoltaic powered applications for these systems are water pumping, DC lighting, telecommunications (including rural education), vaccine refrigeration, cathodic protection, and power for primary health care centers.

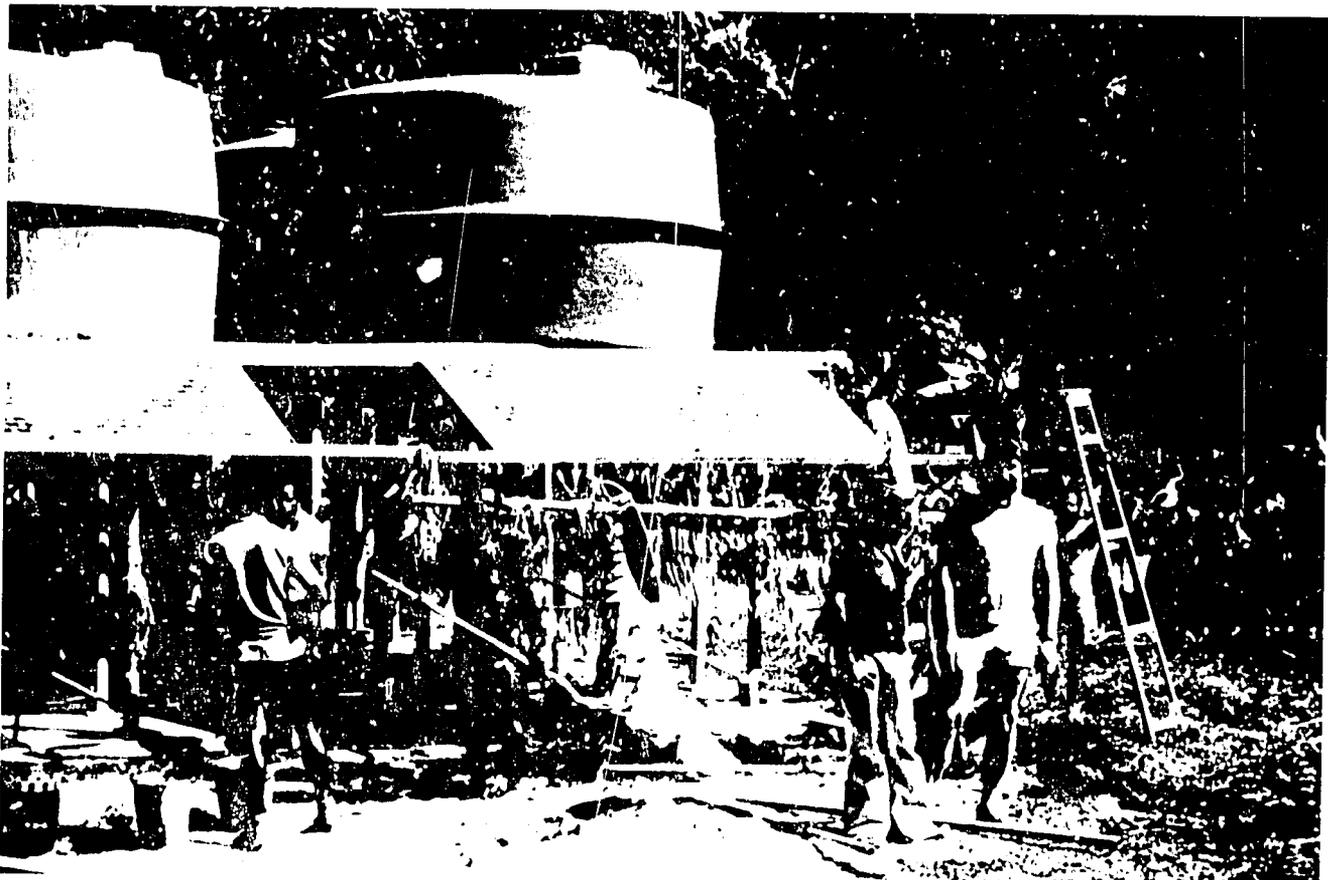
Single-crystal cells, suitable for developing countries in particular, are 26.1 m² (4.05 in.²) and produce 2.4-3.0 amperes. Balance-of-system components are adjustable angle "A" frame standard support structures and single pole mounts.

Experience and Operations

ASI was formed in 1978 and grosses about \$30 million annually. ASI carries out manufacturing in the United States, Japan, and Germany. ASI provides service agreements through a local distribution network and makes installations. Engineering and design services are also offered.

A typical large installation of PV panels is the SMUD generating station in Sacramento, California, a 2-MW system in which DC power is converted to AC.

ARCO Solar, Inc.



This 420-W, PV-powered, water-pumping system in Papua, New Guinea delivers 5580 L (1500 gal) of water per hour in bright sunlight and 3410 L (900 gal) per hour in overcast. The installation provides 5000 people in the area with a convenient water source. (Courtesy Arco-Solar, Inc.)

Babcock & Wilcox Company

20 South Van Buren Avenue
Barberton, Ohio 44203
Telephone: 216-753-4511
Telex: 98-6406 BANDW BARB
Fax: 216-860-1886

Chief Executive Officer: Mr. R. E. Howson
International Sales Manager: Mr. S. W. Borsani

Equipment or Systems Characteristics

Babcock & Wilcox Company's, (BWC), turnkey operations will provide field-erected boilers with multi-fuel capability to handle either mass burning or prepared refuse-derived fuel combustion, wood, or agricultural wastes such as bagasse. Energy output can vary from 27,200 to 272,000 kg/h (60,000 to 600,000 lb/h) steam flow. This equipment is designed for minimum maintenance. It has membrane construction and can provide steam, either saturated or under pressures up to 13,790 kPa (2,000 psi), with corresponding temperatures up to 538°C (1000°F). Full engineering and installation services are provided. Mass-burn or refuse-derived fuel Stirling power boilers are also available which have an input of 1,100 t/day (1,000 tons/day) and which produce steam, variable from saturated to 443°C (830°F) at 6,210 kPa (900 psi). BWC recently introduced small-size municipal solid waste boilers of modular design, ranging in size from 110 to 276 t/day (100 to 250 tons/day). Equipment generally carries a one year warranty.

BWC has also developed solar central receiver technology, including design and manufacture of receivers and steam generators. Concepts developed use various working fluids such as sodium, water, molten salt, and solid particles. Systems have been designed for desalination, production of fuels and chemicals, and detoxification of hazardous wastes.

Experience and Operations

BWC has a long history of multi-million-dollar-per-year operations and was acquired by McDermott International, Inc. in 1978. Chief production operations are in the U.S.A., but products are also manufactured in Indonesia and The People's Republic of China. BWC has international representatives, complete with telephone, telex, and telefax numbers, in the following countries: Argentina, Brazil, China, France, Hong Kong, India, Indonesia, Italy, Japan, Korea, Kuwait, Mexico, Spain, Taiwan, Thailand, Turkey, and Venezuela. Contact BWC's Ohio office for names and addresses.

Recent installations are 6 refuse-derived fuel Stirling power boilers for the City of Columbus, Ohio. These consume 3,310 t/day (3,000 tons/day). Three units which handle 1,230 t/day (1,120 tons/day) were also installed for Nashville Thermai Transfer Co. in Nashville, Tennessee. McDermott International's annual report for the year ending March 31, 1988, cites a \$72 million contract with Wheelabrator Environmental Services to supply 6 mass-burn waste-to-energy boilers for various Wheelabrator projects. It also reports erection of 2 BWC-built refuse-derived fuel boilers at West Palm Beach, Florida as part of a \$170 million joint venture begun in 1987. Two paper companies — the Gaylord Container Company and the Weyerhaeuser Paper Company — have recently awarded the company turnkey fabrication and erection contracts worth \$38

million and more than \$100 million, respectively. Hammermill Paper Company is already operating a BWC wood- or gas-fired boiler which produces 181,400 kg/h (400,000 lb/h) of steam at 10,300 kPa (1,500 psi) and 485°C (905°F). It burns 551,000 t/yr (500,000 tons/yr) of woodwaste.

Babcock & Wilcox

a McDermott company



This 61.3-MW power plant is fueled with 1800 t/d (2000 ton/d) of municipal solid waste. It was built by Palm Beach Energy Associates, a joint venture of the Babcock & Wilcox Company and Bechtel Civil, Inc. for the Solid Waste Authority of Palm Beach County, Florida. (Courtesy Babcock & Wilcox Company)

Basic Environmental Engineering, Inc.

21 W. 161 Hill Street
Glen Ellyn, Illinois 60137
Telephone: 312-469-5340
Telex: 5101000115 BASIC UD
Fax: 312-469-3167

Chief Executive Officer: Mr. John N. Basic, Sr.,
President

Equipment or Systems Characteristics

Basic Environmental Engineering, Incorporated, (BEE), offers a unique waste-to-energy incineration system which burns a wider range of materials than other systems without sorting, shredding, or other pre-processing. It burns anything from low-Btu, high-moisture materials (such as pathological wastes) to high-Btu, low-moisture wastes (such as whole rubber tires). It is suitable for burning municipal solid waste or biomass such as corn cobs or large pieces of wood (e.g., pallets). There are 3 materials handling devices, 3 combustion stages, and 3 zones of heat transfer for recovery of thermal energy during ecologically sound destruction of hazardous materials.

An electro-mechanical ram with a refractory face charges fuel into a waterwall membrane furnace equipped with a pulsed hearth. This hearth is a suspended brick furnace floor with a step configuration on 2 parallel sides. Preheated combustion air is directed downward through jets positioned along the vertical faces of the steps to make possible a controlled rate of combustion. The pulsing floor shuffles the burning waste, in its whole form, forward through the system approximately every 60 to 90 seconds, thereby shifting the diminishing amount of unburned waste towards the lower center or trough-like area. The height and pitch of the furnace floor and the rate of shuffling are determined according to the fuel to be burned.

Steam is generated by the waterwall heat exchanger. Residues are finally directed through a two-stage, double-wall, refractory-lined, 6-ft-diameter reburn tunnel where tars and chars are burned with introduction of natural gas (up to 5% of rated heat input) for complete destruction and additional heat recovery. Finally, ashes enter a recovery zone. Ash collection can be wet or dry.

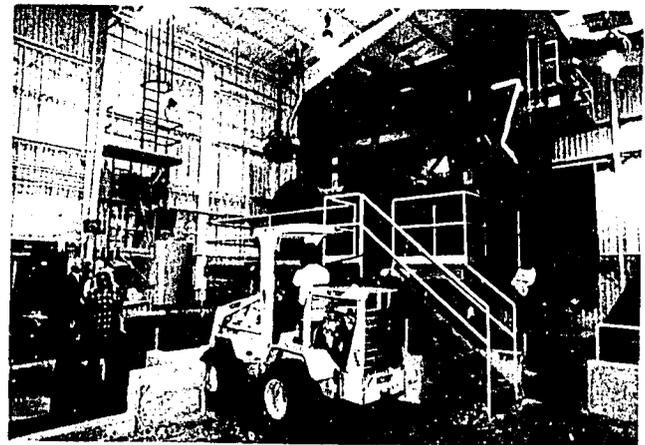
Low emissions are possible from municipal waste combustion — less than 30 ppm carbon monoxide, less than 30 ppm hydrocarbons, and less than 35 ppm oxides of nitrogen. Energy cogeneration is possible. After 17 to 30 days of operation, the system must be shut down for 3 days for cleaning.

Experience and Operations

BEE was founded shortly after the U.S. Clean Air Act of 1970 was enacted in order to offer clean-burning incinerators. This level of business is in excess of \$7 million annually. BEE has won 3 consecutive annual awards from *Pollution Engineering* magazine for

product design and industrial applications. BEE equipment is widely used from the arctic circle in Alaska to Texas. BEE will assess feasibility of on-site incineration with their standard or custom-designed units at no obligation.

BASIC ENVIRONMENTAL ENGINEERING INC.



Hot flue gases from this 25,300-MJ/h (24 million Btu/h) wood chip combustion unit are used to dry municipal sewage sludge into fertilizer pellets in Florida. (Courtesy Basic Environmental Engineering, Inc.)

Bergey Windpower Company, Inc.

2001 Priestley Avenue
Norman, Oklahoma 73069
Telephone: 405-364-4212
Telex: 5106010989 BERGEY WP UQ
Fax: None

Chief Executive Officer: Mr. Michael Bergey

Equipment or Systems Characteristics

Bergey Windpower Company, Incorporated, (BWCI), manufactures small wind turbines for rural electrification, water pumping, ice making, and desalination. Available configurations include wind only, wind/diesel, and hybrid systems (i.e., wind/PV). Designs are simple and no scheduled maintenance is necessary. Direct-drive, permanent magnet alternators are used. Examples are:

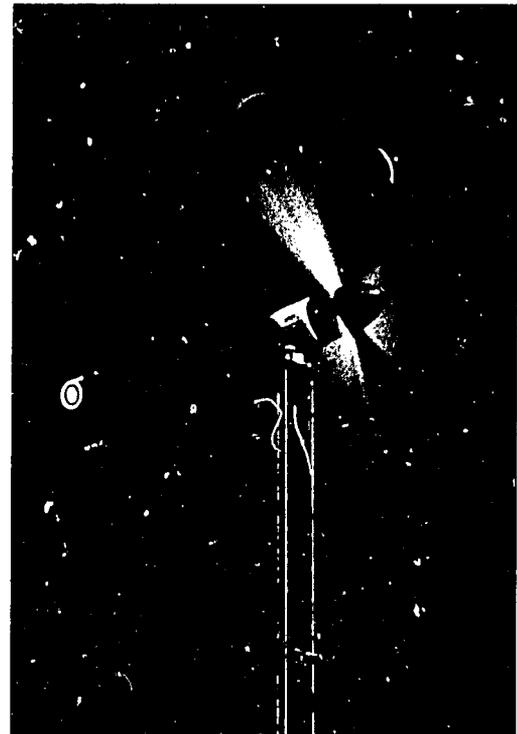
- Either 1.5-kW or 10-kW remote power systems capable of serving villages, health clinics, telecommunications, desalination, etc. Both systems are rated to wind speeds up to 54 m/s (120 mph) with cut-in wind speeds of 3.6 and 3.5 m/s (8.1 and 7.8 mph) respectively. Output at average wind speed of 4.5 m/s (10 mph) is 1,600 kWh/yr for the 1.5-kW system and 11,000 kWh/yr for the 10-kW system. No turbine maintenance is required, but inspections are required every 2 years for the 1.5-kW system and annually for the 10-kW system. Warranty for each system is 2 years.
- Either 1.5-kW or 10-kW remote, water-pumping and lifting system for water supply to villages, irrigation, aquaculture, watering livestock, salt production, etc. The turbine is directly connected to a submersible pump without use of batteries or power-conditioning equipment. This arrangement gives twice the output of a mechanical wind pump and also has capacity to generate electricity. Cut-in wind speed is 3.2 m/s (7.2 mph). Output at average wind speed of 4.5 m/s (10 mph) is 19 m³/day (119 gal/day) at 35 m (115 ft) heads for the 1.5-kW system and 124 m³/day (780 gal/day) at 35 m (115 ft) heads for the 10-kW system. Inspections are required every 2 years for the 1.5-kW system and annually for the 10-kW system.
- A tilt-up tower that can be lowered or raised with a winch or vehicle crane or gin-poles are required for erection or repair. Guy wires are used. The tower is available in kit form or as plans for local fabrication. Height varies from 15 to 30 m (50 to 100 ft). Other tower types, including guyed lattice, self-supporting lattice, and tapered-tube-type towers, are available in heights from 12 to 46 m (40 to 150 ft).

BWCI also sells wind turbines from other manufacturers, both U.S. and foreign. BWCI can thus supply remote turbines from 50 W to 40 kW and utility or diesel-electric interconnected turbines from 4 kW to 30kW. BWCI can provide equipment, installation, training, and design services for projects anywhere in the world. BWCI's patented wind turbine designs are also available for local manufacturing under license.

Experience and Operations

BWCI was established in 1977 and grosses between \$500,000 and \$1 million annually. Performance and reliability have been proven by 24 million operating hours on 900 BWCI turbines in 30 countries including India, Spain, Tunisia, Oman, Egypt, Morocco, Japan, China, Honduras, and Antigua. BWCI has a contract-manufacturing operation in Mexico and has licensed production in

India. BWCI has overseas representatives in 12 locations: 1) Northumberland, United Kingdom, 2) Groningen, The Netherlands, 3) Tunis, Tunisia, 4) Cairo, Egypt, 5) Abidjan, Ivory Coast, West Africa, 6) Bhopal, India, 7) Kelmiscott, Australia, 8) Wanganui, New Zealand, 9) Buenos Aires, Argentina, 10) Belize City, Belize, Central America, 11) St. Michael, Barbados, West Indies, and 12) Coyoacan, Mexico. Contact Export Department at BWCI headquarters in Norman, Oklahoma, U.S.A. for addresses, telephone numbers, and contact persons at these locations. Potential customers are invited to visit the research facilities and factory at Norman. A list of notable customers worldwide is available.



Small wind turbines are especially useful in remote, isolated locations where maintenance is difficult to provide. (Courtesy Bergey Windpower Company, Inc.)

Biotechnical Processes, Inc.

Bacardi Corporation
GPO 26368
Jacksonville, Florida 32218
Telephone: 904-757-1290
Telex: 56-505
Fax: 904-751-1397

Chief Executive Officer: Dr. George H. Dorion

Equipment or Systems Characteristics

Biotechnical Processes, Incorporated, (BPI), a wholly owned subsidiary of Bacardi Corporation, (BC), offers an "anaerobic filter" digestion system for treatment of agroindustrial wastewaters. This system was developed at BC to treat the stillage which remains after the rum distillation process. The system was operated on a 11.36-m³ (3,000-gal) pilot plant before being scaled up to a 13,250-m³ (3,500,000-gal) digester. The tank is 36.6 m (120 ft) in diameter and 12.8 m (42 ft) high. It is filled with 9,910 m³ (350,000 ft³) of plastic packing consisting of alternating flat and corrugated sheets. This provides about 1.21 km² (300 ac) of surface on which the operating bacteria become attached and immobilized. Stillage is fed in at the top. Eight 3.73-kW (5.0-HP) pumps draw the liquor effluent from 8 ports at the bottom and recirculate it back to the top of the tank. The digester treats 1,510 m³ (400,000 gal) of stillage/day producing therefrom 42,500 m³ (1,500,000 ft³) of biogas. The gas contains 50 to 60 percent methane. The biogas is used as a boiler fuel. The system removes 85 percent of the BOD and 70 percent of the COD present in the stillage. For some wastewaters, 95 percent BOD removal can be achieved. The system can be adapted to treat a wide variety of wastewaters, such as winery wastes, brewery wastes, pharmaceutical fermentation wastes, spent grain liquors, cheese whey, food packaging wastes, meat packing wastes, corn product wastes, paper mill wastes, and chemical wastes.

Experience and Operations

BC has been in existence for many years. The firm built the full-scale digester plant in 1981-82 and has operated it successfully ever since. A plant using this system has been operated successfully at the Miles Laboratories pharmaceutical facilities in Indiana; it has consistently exceeded guaranteed BOD and COD removal rates. BC has granted Larson International, Inc. (44 Saginaw Drive, Rochester, New York 14723) an exclusive license to utilize this technology in India. Larson has built an initial plant in India to process 225,000 L/day (59,400 gal/day) of wastewater from an industrial process that makes ethanol from sugarcane molasses. Larson is to make installations in India at 3 other larger ethanol plants. BC seeks additional opportunities to apply this anaerobic digestion system to meet the energy needs of agroindustrial plants in developing countries.



BIOTECHNICAL PROCESSES, INC.

Burns-Milwaukee, Inc.

4010 West Douglas Avenue
Milwaukee, Wisconsin 53209
Telephone: 414-438-1234
Telex: None
Fax: None

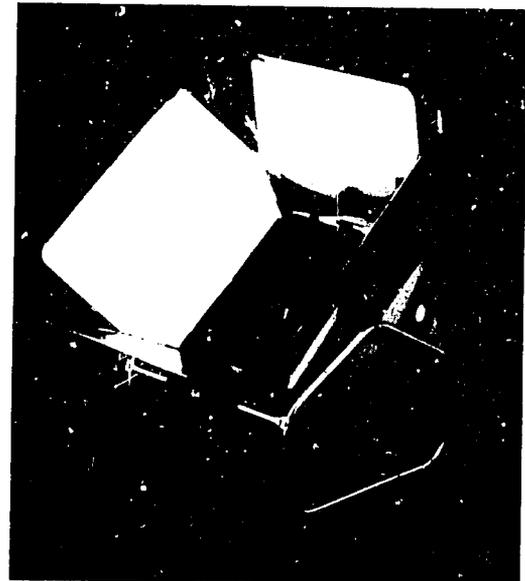
Chief Executive Officer: Mr. Thomas J. Burns

Equipment or Systems Characteristics

Burns-Milwaukee, Incorporated, (BMI), has developed the SUN OVEN, a solar oven capable of cooking vegetables, rice, meats, and breads. The oven can also boil water for sterilization purposes, and is constructed with a rugged chrome-steel stand, a seamless aluminum inner chamber, high-technology insulation, and silicone rubber seals. The door is made with specially tempered glass, the exterior is ABS polymer, and the reflectors are made of spectral finish aluminum. The equipment is totally adjustable; a levelator keeps food level at all times. The oven weighs 35 pounds. Outside dimensions are 483 cm long by 483 cm wide by 406 cm high (19 in. by 19 in. by 16 in.).

Experience and Operations

BMI was formed in 1985; gross receipts approach \$500,000 annually. BMI's solar ovens are in use in the following countries: Bolivia, Chad, Djibouti, Dominican Republic, Guatemala, Haiti, Honduras, Kenya, Mexico, Nicaragua, Peru, Somalia, Swaziland, and Tanzania. BMI is exploring interest in licensing or joint venture operations in countries of usage. BMI will set up a small assembly plant with necessary tooling, and hire and train local people to perform the manufacturing under the engineering leadership of a home office expert.



Solar ovens can be used to cook a wide range of foodstuffs or to supply boiling water. The units are portable and easy to maintain. (Courtesy Burns-Milwaukee Company, Inc.)

Chronar Corporation

P.O. Box 177
Princeton, New Jersey 08540
Telephone: 609-799-8800
800-CHRONAR
Telex: 843394
Fax: 609-799-8843

*Chief Executive Officer: Mr. Zoltan Kiss
International Sales Managers: Ms. Janice Mahon and
Mr. William M. Beecher**

Equipment or Systems Characteristics

Chronar Corporation, (CC), is a leading manufacturer of amorphous silicon, thin-film, PV modules. The modules offered are 3.5-, 6-, and 12-W amorphous silicon panels made with glass-to-glass encapsulation.

CC is also a leading supplier of turnkey solar manufacturing facilities and equipment necessary to produce amorphous silicon thin films, including deposition systems, scribing systems, testing equipment, etc. CC offers patented technology and technology updates for joint ventures, R&D collaboration, engineering and design services, system installation, service agreements, and financing.

CC also offers PV-powered consumer and industrial products and electric utility generating stations. Applications for CC's PV panels are water pumping systems, lighting systems, navigation aids, remote radar stations, forest service lookout stations, village electrification, battery chargers, clocks, security systems, electrified fence chargers, gate openers, etc. The PV cells have 5-year warranties.

Experience and Operations

CC was established in 1975 and through the first 6 months of 1988, had sales of \$19.5 million. The corporation's specific area of

expertise is in low-cost manufacturing. Manufacturing operations are carried out in 2 U.S. locations, England, France, and China. A plant is also under construction in Yugoslavia. The foregoing are 1-MW factories. A fully automated, 10-MW production facility has also recently been developed. This new facility will be located in Northern California and is being developed in partnership with Pacific Gas & Electric Enterprises, Bechtel National, and the National Pension Fund of the Sheet Metal Workers. Over 1000 Chronar PV systems have been set up in over 40 countries since 1980.

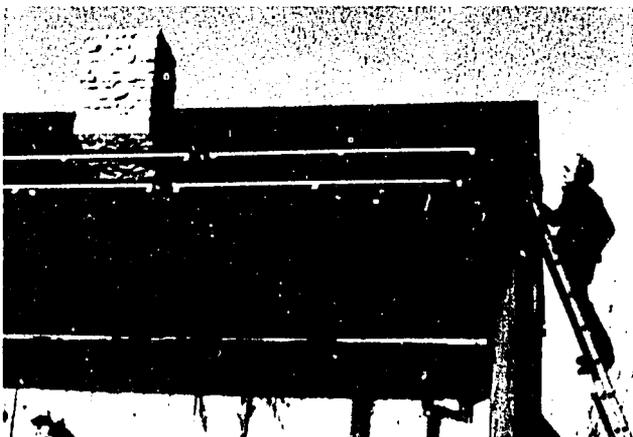
CC consists of 5 divisions. The Technology Division combines research and development, field services, and turnkey facility marketing. The Panel Division sells panels and modules to third parties. The Equipment Division installs, upgrades, and maintains the PV production equipment. The Industrial Division designs, manufactures, and markets PV products to the commercial, industrial, and agricultural sectors. The Consumer Products Division (Sunergy) manufactures and markets PV consumer products.

Over the past decade, CC has reduced the cost of PV panels to the point where remote applications can be made at cost-competitive prices. The newest facility to be completed in 1989 is expected to provide a breakthrough in solar module costs. Over the next decade, PVs should offer alternative energy with modularity and without environmental hazard.

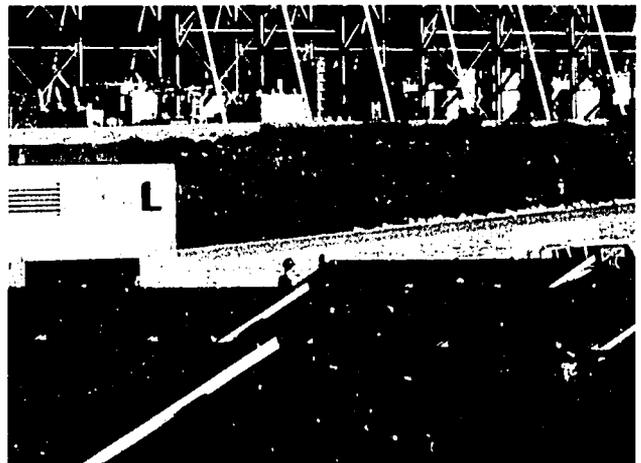
A model installation is the 75-kW amorphous silicon power station with inverter for the Alabama Power Company at Varnons, Alabama.

* Address: 195 Clarksville Rd., Lawrenceville, New Jersey 08648.

CHRONAR



Photovoltaic modules can be mounted on home roofs as a captive source of power. (Courtesy Chronar Corporation)



Arrays of PV modules can be assembled for the larger power applications. (Courtesy Chronar Corporation)

Combustion Systems Associates, Inc.

P.O. Box 749
Mill Valley, California 94941
Telephone: 415-381-6716
Telex: 5106007051
Fax: 415-381-9667

Chief Executive Officer: Mr. R. W. Winskill
International Sales Manager: Mr. H. O. Ebson

Equipment or Systems Characteristics

Combustion Systems Associates, Incorporated, (COMSAI), offers 13.4- and 26.9-MJ/h (5- and 10-HP) steam engines and a 53.7-MJ/h (20-HP) unit made up of 2 26.9 MJ/h (10-HP) engines mounted on the same base. These engines are based on modernized versions of traditional small steam engines. The 13.4-MJ/h (5-HP) model is a single cylinder, two-stroke engine; exhaust heat may be recovered with an air heat exchanger for use in drying materials or with a water condenser to produce hot water. The 26.9-MJ/h (10-HP) model is a compound, two-cylinder, four-stroke engine with a water-cooled condenser. Exhaust heat is suitable for drying rice or other materials at moderate temperatures.

Experience and Operations

COMSAI was established in 1985 by executives from the Ray Burner Company of San Francisco. While at Ray Burner, these executives installed a 53.7-MJ/h (20-HP) Skinner steam engine in Fiji to energize a 15-kW village power system. Customers are offered the new COMSAI engines together with engineering designs and specifications for a boiler system using, to the maximum extent possible, equipment manufactured in developing countries.

COMSAI

Controlex, Inc.

Francestown Turnpike
New Boston, New Hampshire 03070
Telephone: 603-487-5512
Telex: 174094 FNB PETERBORO
Fax: None

Chief Executive Officer: Mr. Richard Katzenberg
International Sales Manager: Ms. Patricia Butler

Services Offered

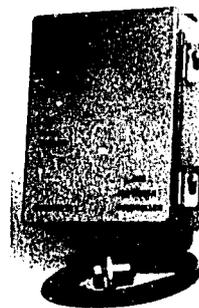
Controlex, Incorporated, (CI), specializes in environmental data collection in harsh surroundings where AC power is unavailable. CI builds instruments and systems for computer-aided data collection and analysis and uses these, for example, in wind resource assessment and monitoring to optimize energy output. Similar services are offered for assessing PV and solar-thermal resources as alternative energy options.

Special equipment includes: a wind data accumulator which calculates average wind speed, wind energy conversion system recording equipment, a wind speed pulse rate initiator, a wind speed/direction compiler with advanced logging and data retrieval capability, and a wind and solar energy resource surveyor designed to assess wind and solar energy potential at any location to select the optimum mix of these energy resources. An integrating pyranometer is also available to measure radiant solar energy falling on a particular location over time, expressed as Btu/ft², useful for siting solar-thermal and PV installations.

Experience and Operations

CI, formerly Natural Power, Inc., was established in 1972 and grosses under \$500,000 annually.

controlex



Wind and solar energy resource assessment can be carried out with a wide range of instruments to optimize the design and installation of power-generating equipment. (Courtesy Controlex, Inc.)

Dempster Industries, Inc.

P.O. Box 848
Beatrice, Nebraska 68310
Telephone: 402-223-4026
Telex: 701447 DEMPSTER UD
Fax: None

Chief Executive Officer: Mr. Don Clark
Export Sales Manager: Ms. Joyce Ehmke
Contact Person: Mr. Dean Kilgore

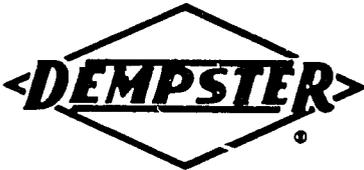
Equipment or Systems Characteristics

Dempster Industries, Incorporated, (DII), manufactures 5 sizes of water-pumping windmills coupled to reciprocating cylinder pumps. Models use galvanized steel fan wheels ranging in diameter from 1.83 to 4.27 m (6 to 14 ft). Gears run in an oil bath which is changed annually. The windmill is set up directly over the well or water source. A wooden or steel pump rod is connected to the pump. Pumping rates are influenced by windspeed, pumping elevation, diameter of mill, cylinder sizes, and length of pumping stroke. Water is pumped into a ground level or elevated storage tank. Windmill speed is controlled by an internal expanding brake or manually by a pull-out rod. A regulator is also available which removes the mill from the wind when the tank is full and turns it back into the wind when the level drops below 12.7 cm (5 in.). Windmills carry a 1-year warranty.

DII also provides 6 models of steel towers. Four with heights of 6.7 to 11.9 m (22 to 39 ft) are suitable for mills with diameters up to 3.0 m (10 ft). Towers 9.1 or 12.2 m (30 or 40 ft) high are suitable for mills 3.7 and 4.3 m (12 and 14 ft) in diameter. DII will calculate size of windmill required if given necessary information.

Experience and Operations

DII has manufactured water-pumping windmills for 110 years. DII equipment was used widely in rural America prior to the rural electrification of the 1930s. DII mills are installed in Somalia, Morocco, and Spain. DII does not provide overseas installation or service. Customers may order replacement parts.



Dinh Company, Inc.

P.O. Box 999
Alachua, Florida 32615
Telephone: 904-462-3464
Telex: None
Fax: None

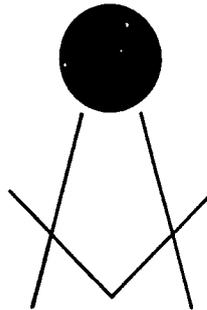
Chief Executive Officer: Mr. Khanh Dinh

Equipment or Systems Characteristics

Dinh Company, Incorporated, (DCI), provides consultation on PV projects, custom builds equipment, and assists with their installation. DCI has two models of stand-alone, shallow well, PV water pumps designed to provide 7 days of reserve capacity. Systems are designed for a 5-10 year life span and carry a 1-year warranty. A more technical pumping system is also offered which has east-west tracking and uses a 2:1 reflector and a permanent magnet DC motor. Warranty is for 1 year. Three low-head irrigation pumps are also offered with PV tracking design, 2:1 reflectors, and a high efficiency, high volume pump up to 60,600 L/day (16,000 gal/day). These carry a 10-year warranty. A custom-designed solar refrigeration system has also been provided for preservation of food and medical supplies. Generally various size Solarex cells are used which carry 10-year limited warranties.

Experience and Operations

DCI was established in 1983. The volume of business is under \$500,000 annually. DCI has engaged in a joint venture with Churion Canada, sold water pumps to the United Nations for Chile, and transferred technology to India. DCI offers patented technology, engineering and design services, and system installation, and provides manuals in English, Spanish, and French. A special DCI installation is the solar air-conditioning system consisting of a 1.6-kW PV array on trackers at the University of Miami, Coral Gables, Florida. This provides 19.0 MJ/h (18,000 Btu/h) of air conditioning.



DSET Laboratories, Inc.

Box 1850, Black Canyon Stage I
Phoenix, Arizona 85027
Telephone: 602-465-7356
Telex: 910-950-4681 DSET PHX
Fax: 602-465-9409

*Chief Executive Officer: Mr. Joseph S. Robbins, Jr.
International Sales Manager: Mr. William J. Putman*

Equipment or Systems Characteristics

DSET Laboratories, Incorporated, (DLI), has tested solar devices for many years and has developed a wide array of services, facilities, and technology for testing and evaluating solar collectors and solar systems. Available test facilities include: 1) Solar water collector and system test loops; 2) Solar air collector test loops; 3) Solar irradiance simulators; and 4) Dual-axis, sun-tracking test mounts. All facilities are designed to meet ASHRAE and ISO standards. DLI services have been made available worldwide for the past few years. Clients are also trained and assisted in setting up their own testing and certification programs. This enables clients to screen out unreliable and poor-performance solar systems. This service is especially suitable for government agencies charged with regulating or funding solar projects and the manufacture of solar equipment.

Experience and Operations

DLI was established in 1949 and grosses in excess of \$2 million annually. DLI's Solar Division has performed more than 3,000 individual collector tests and has tested more than 50 domestic hot water systems. Two projects have recently been completed in foreign countries. Equipment was specified, set up, and calibrated, personnel were trained, and a solar testing laboratory was commissioned for the Jamaican Bureau of Standards in Kingston, Jamaica. This was sponsored by the U.S. Agency for International Development. Also, a large solar simulator and solar collector test standard was designed, constructed, and installed for the King Abdulaziz City for Science and Technology in Riyadh, Saudi Arabia. The test equipment includes a large solar simulator, portable solar collector and solar systems test loop, solar calorimeter, and solar-optical evaluation system. This project was sponsored by the joint U.S.-Saudi SOLERAS program. Both of these installations are for testing solar collectors and solar systems to evaluate performance relative to ASHRAE standards.



DSET
LABORATORIES, INC.

Dumont Stoker Corporation

Mainstreet, Box 149
Monmouth, Maine 04259
Telephone: 207-933-4811
Telex: None
Fax: 207-933-2649

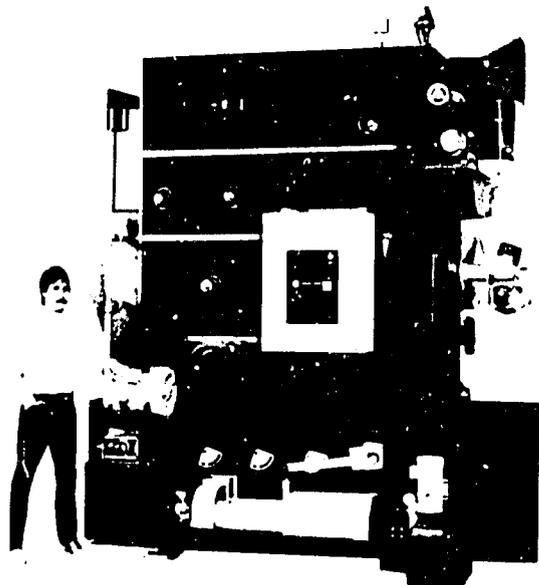
*Chief Executive Officer: Mr. John Dumont
International Sales Manager: Mr. Evert Ostermann*

Equipment or Systems Characteristics

The Dumont Stoker Corporation, (DSC), provides wood-fired residential and industrial boilers in the 294 to 1,960-kW (30 to 200-HP) range and recently developed for sale a downdraft gasifier producing 35 kW/h of electric energy and 45 kW/h of cogenerated heat. This gasifier uses wood chips and is reported to be reliable for continuous operation with only simple cleaning required. Engineering and installation services are offered; warranty is for a period of 1 year.

Company Experience and Operations

DSC was formed in 1974. Business grosses less than \$500,000 annually. DSC is a division of Dumont Management Corporation. The downdraft gasifier is installed in-house at the Monmouth plant.



The pictured boiler has multi-fuel capability and can burn biomass, wood chips, pellets, coal, and oil thereby offering lowest cost operation with changing fuel prices. (Courtesy Dumont Stoker Corporation)

Efficient Homes, Inc.

321 SW 83 Avenue
North Lauderdale, Florida 33068
Telephone: 305-722-3708
Telex: None
Fax: None

Chief Executive Officer: Mr. Stephen S. Hoag, President

Equipment or Systems Characteristics

Efficient Homes, Incorporated, (EHI), deals primarily with residential heating systems for hot water and pools. Since improper sizing and installation downgrades performance of even excellent equipment, EHI's expertise is offered to see a project through until it works as promised. A solar collector especially suited for developing nations is the thermal siphon collector which collects hot water for domestic or commercial use without the use of pumps or electricity. One such system has a collector area of 4.65 m² (50 ft²) and a storage volume of 303 to 450 L (80 to 120 gal). Collectors have a warranty for 10 years. Engineering and design, service agreements, and system installations are offered. Financing can be arranged.

Experience and Operations

EHI was established in 1983. Gross receipts for business operations are about \$200,000 annually. EHI has installed over 1,500 systems to date.



Energy Depot

61 Paul Drive
San Rafael, California 94403
Telephone: 415-499-1333
Telex: None
Fax: 415-499-1306

*Chief Executive Officer: Mr. Ancosh Mizany
International Sales Manager: Mr. Tom Noubari*

Equipment or Systems Characteristics

Energy Depot, (ED), a division of Solar Depot, Incorporated, will design PV systems for village power, water pumping, lighting, refrigeration or telecommunication system, supply all components therefor and, if desired, install turnkey installations. These systems can be stand-alone or backed up by generators. Seven Solarex crystalline PV modules ranging in size from 5 to 60 peak watts and two amorphous modules with 1.75- and 5-peak watt capacities are available. Exide, GNB, and Technacell batteries, and SCI controls are other components used. Warranties are for 5-10 years. Service agreements are offered.

ED also offers small residential and large commercial solar water heaters. The heaters are glass-glazed, copper absorber units with an aluminum frame. A low-temperature type is designed for heating swimming pools, and 2 medium temperature types are for hot water and/or space heating. Hot water storage tanks, circulating pumps, and differential temperature controls are also offered. Passive hot water units requiring no forced circulation are also available.

Experience and Operations

ED was established in 1979. It markets over 100 thousand peak watts of PV modules annually in the United States. ED also sells 1,860 to 4,650 m² (20,000 to 50,000 ft²) of medium-temperature and 13,900 m² (150,000 ft²) of low-temperature solar thermal collectors annually and grosses from \$1.5 million to \$3.5 million per year.

Energy Products of Idaho

4006 Industrial Avenue
Coeur D'Alene, Idaho 83814
Telephone: 208-765-1611
Telex: 910-240-5708
Fax: 208-765-0503

Chief Executive Officer: Mr. Norman Sowards
International Sales Manager: Mr. Michael L. Murphy

Equipment or Systems Characteristics

Energy Products of Idaho, (EPI), supplies, constructs, and starts up and operates fluidized-bed combustion units which are designed to handle any of a wide range of high-moisture fuels, including 20-60 percent moisture wood, 8 percent moisture wood pellets, sunflower hulls, olive pits, chicken litter, cow manure, prunings, refuse-derived fuel, shredded rubber tires, agricultural and garden residues, rice hulls, bagasse, and anthracite and lignite coals. Systems can generate saturated steam for process applications or superheated steam for power generation. Sizes are available to generate from 6,800 to 136,000 kg/h (15,000 to 300,000 lb/h) of steam. Equipment carries a 1-year warranty.

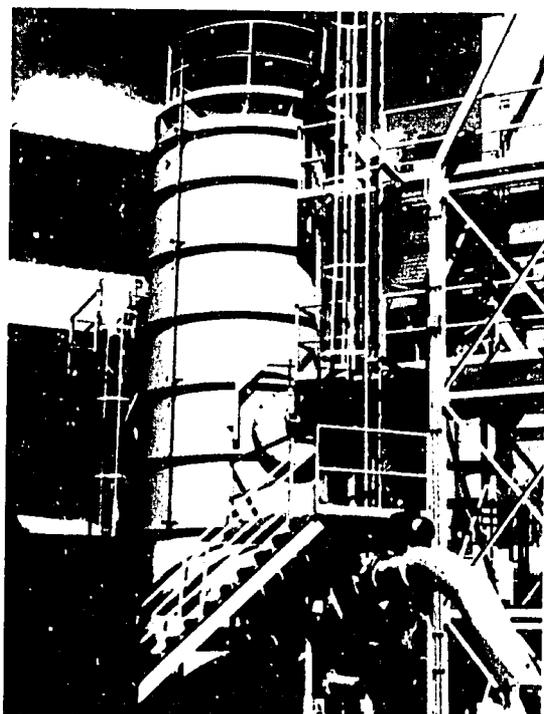
Commercial wood gasification plants have also been installed. Other activities include the construction of larger size power generation facilities.

Experience and Operations

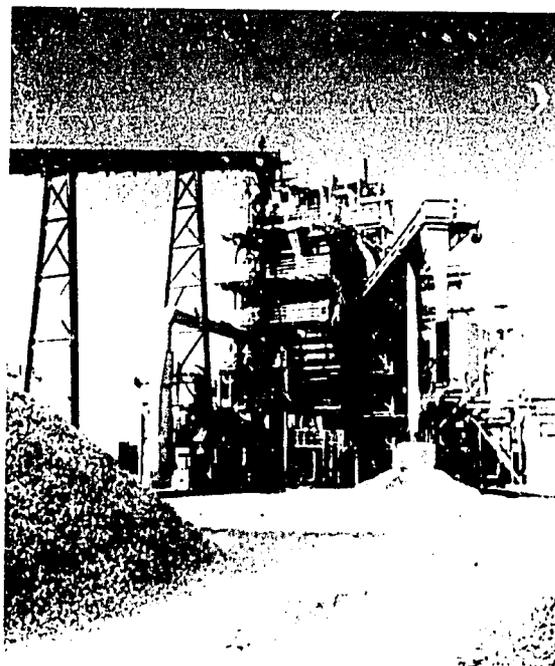
EPI was established in 1973 and carries on business in excess of \$15 million annually. During the last 15 years, EPI has installed 45 wood-waste burning units in the United States, 7 in Canada, 6 in Japan, and one in Israel. Three commercial wood gasification facilities have been installed in North America. The firm can custom-design fluidized-bed combustion or gasification units for any particular application. Larger power generation facilities installed by the company include a 22-MW plant at Chinese Camp in California that burns wood and municipal wastes. This station is the first fluidized-bed application to use deNO_x for NO_x control. Under construction are 12-MW and 25-MW generating facilities burning wheat straw, barley straw, cotton stalks, almond tree pruned corn stalks. A large 50-MW facility under construction will burn refuse-derived fuel, corn, and wood waste.

EPI is a wholly subsidiary of JWP, Inc., a New York based holding company with 1988 sales of nearly \$1 billion. Acquired by JWP on June 9, 1988, EPI now has the financial and technical capabilities to offer equity placement and turnkey facilities.

EPI
Energy Products of Idaho®



Located in Oregon, this 105,000-MJ/h (100-million Btu/h), fluidized-bed, wood-waste gasifier produces a low-Btu gas having a heating value of 59.6 MJ/m³ (160 Btu/ft³). The gas is fired directly in a steam boiler that drives a 6-MW turbine generator. (Courtesy Energy Products of Idaho)



Placed in service in 1988, this agrivaste-fired, fluidized-bed, 12.5-MW power plant is located in California. (Courtesy Energy Products of Idaho)

Entech, Inc.

P.O. Box 612246
DFW Airport, Texas 75261
Telephone: 214-456-0900
Telex: 265350 ENTECH UR
Fax: 214-456-0904

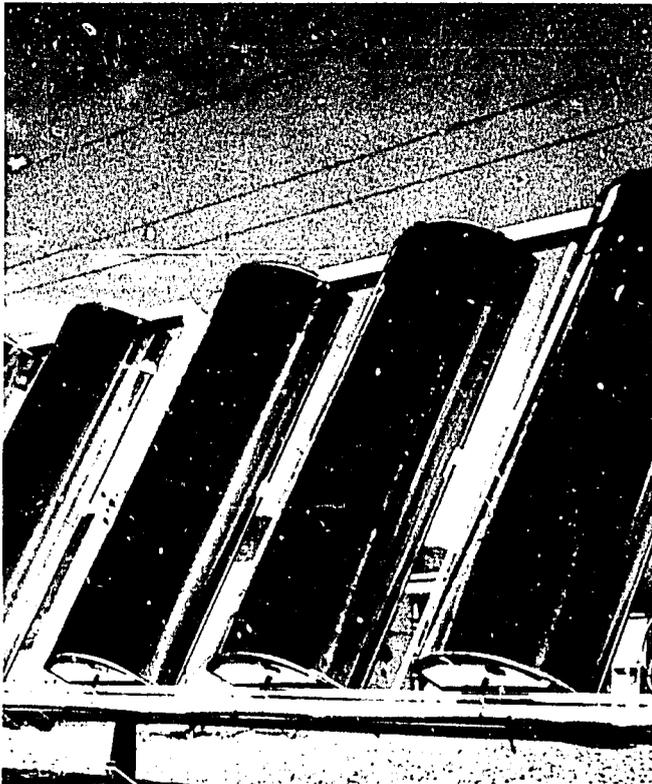
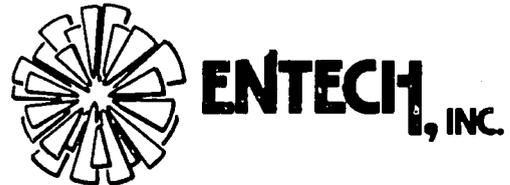
*Chief Executive Officer: Dr. Walter J. Hesse, President
International Sales Manager: Dr. Robert R. Walters,
Vice President, Marketing*

Equipment or Systems Characteristics

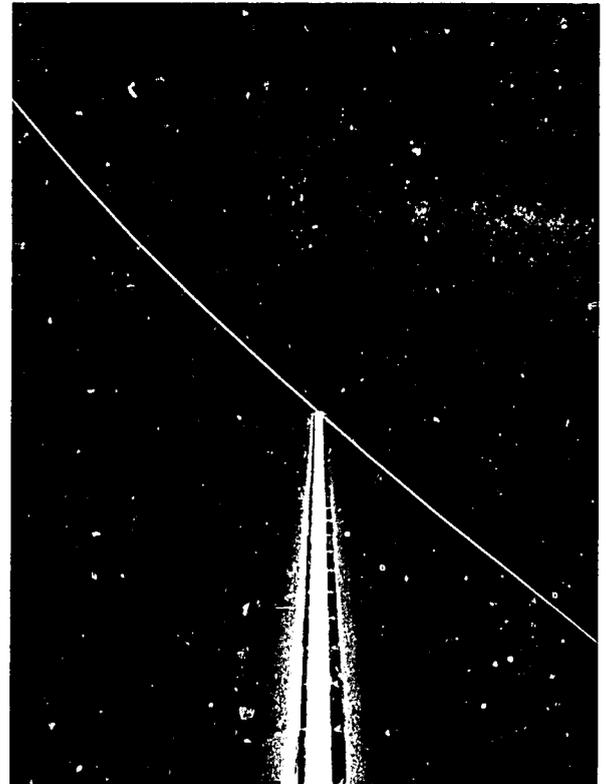
Entech, Incorporated, (EI), designs, fabricates, and installs linear and point-focusing, concentrating, solar collectors. Durable polyacrylate Fresnel lenses are used which are ultraviolet-light resistant and have a life expectancy of 20 years. An electronically controlled, 2-directional tracking system continuously adjusts the collectors to obtain maximum solar radiation. The collectors concentrate the sun's rays 22 times. Most of the collectors are used with PV cells to produce electricity; however, a combination of electricity and heat, or heat only, can be produced. Modular units range in capacity from 1.5 kW to multi-megawatts.

Experience and Operations

EI was formed in 1983 by former employees of E-Systems who purchased a majority interest in the solar division of that firm. E-Systems is a defense contractor for the U.S. government which built concentrating collectors for Texas Tech University, Jet Propulsion Laboratory, Sandia National Laboratories, and the U.S. Department of Energy. Since its formation, EI has completed 9 contracts for concentrating solar collectors for the Department of Energy and Sandia Laboratories. Also, a total of 6 contracts have been won by EI for both space and terrestrial applications. EI also built a system for the Tennessee Valley Authority and is participating in a U.S. Department of Energy demonstration project which will provide 300 kW of electric power for an industrial plant in Texas. EI also won a bid to build a 24-MW concentrator-PV power plant in phases over 5 years at an Indian reservation in southeastern California. Financing can be arranged. EI is interested in licensing agreements to produce concentrating collector systems using EI technology.



This 10-kW installation is an array of Fresnel lens-PV cell modules at Sandia National Laboratories. (Courtesy Entech, Inc.)



The Fresnel lens collector above focuses the sun's rays on a PV cell string. (Courtesy Entech, Inc.)

Eshland Enterprises, Inc.

120 E. Grant Street
P.O. Box 8A
Greencastle, Pennsylvania 17225
Telephone: 717-597-3196
Telex: None
Fax: 717-597-5344

Chief Executive Officer: Mr. Roger Eshleman, President

Equipment or Systems Characteristics

Eshland Enterprises, Incorporated, (EEI), manufactures the Wood Gun line of residential, commercial, and industrial gasification boilers capable of burning wood, wood by-products, and other biomass fuel. Efficiency is rated at 84 percent. The patented simple design has a minimum of moving parts and uses standard electro-magnetic control devices readily available worldwide. Weekly cleaning of the refractory combustion chamber is required. Optional automatic fuel delivery systems are available to handle various types of particulate fuels from fine sawdust to coarse wood chips. Thirteen models are available in sizes from 105 to 3,480 MJ/h (100,000 to 3,300,000 Btu/h) with either steam or hydraulic controls. Boilers carry a 5-year warranty.

Experience and Operations

EEI was established in 1978 and now conducts business in excess of \$1 million annually. EEI sells about 300 gasification combustion boilers per year. Examples of installations are: a 1,480-MJ/h (1,400,000-Btu/h) Wood Gun gasification steam boiler for Lafferty & Co., Inc. in Lemoyne, Pennsylvania; a 211-MJ/h (200,000-Btu/h) automatic wood waste combustion boiler to heat the 743-m² (8,000-ft²) wood products manufacturing plant of Elias Woodworking & Manufacturing Co. of Winkler, Manitoba, Canada; a 264-MJ/h (250,000-Btu/h) automatic system to burn corn (maize) cobs to heat the home, swimming pool, and agricultural building of John Wammes, Clinton, Ontario, Canada.

The owner/officers of EEI have a total of 8 years experience in promanagement in developing countries. The president is conversant in the French language. The company maintains an office in Canada: Wilhelm Combustion, R.R. 4, Stratford, Ontario, Canada N5A 6S5, telephone 519-271-4860.



ESHLAND

Exide Corporation

645 Penn Street
Reading, Pennsylvania 19601
Telephone: 215-378-0324
Telex: None
Fax: None

Chief Executive Officer: Mr. Arthur Hawkins

Equipment or Systems Characteristics

Exide Corporation, (EC), offers a specialized line of batteries for all solar PV applications.

Experience and Operations

EC was established in 1888 and has annual revenues in excess of \$1 million. EC maintains offices in Argentina, Chile, Ecuador, Egypt, Hong Kong, Israel, Peru, Saudi Arabia, Taiwan, and Thailand.

Fafco, Inc.

235 Constitution Drive
Menlo Park, California 94025
Telephone: 415-321-3650
Telex: 348-406
Fax: 415-321-3975

Chief Executive Officer: Mr. F. Ford

Equipment or Systems Characteristics

Fafco, Incorporated, (FI), is a large manufacturer which specializes in solar pool heating and integral solar collector storage systems for domestic hot water. FI's technology is covered by 17 issued patents.

Experience and Operations

FI was established in 1972 and grosses approximately \$10 million annually. FI has installed worldwide more than 70,000 solar systems with a total capacity of 1500 MW equivalent.

FAFCO

Flowind Corporation

21249 72nd Avenue South
Kent, Washington 98032
Telephone: 206-872-7080
Telex: None
Fax: None

Chief Executive Officer: Dr. Irwin E. Vas, President

Equipment or Systems Characteristics

Flowind Corporation, (FC), manufactures 150-kW and 250-kW vertical axis wind turbines. The 250-kW model has an 18.9-m (62-ft) diameter rotor. Critical components are located at ground level with easy access for maintenance. Three independent braking systems controlled by a microprocessor will safely shut the wind turbine down in high winds. FC is developing larger capacity machines (450 kW).

Experience and Operations

By 1985, FC had installed over 300 large units in windmill farms in the Western United States. FC has provided equipment for wind projects in the Caribbean area, funded by the U.S. Agency for International Development through the Caribbean Development Bank. Negotiations are in progress to install FC units in India, China, Spain, Israel, and Taiwan. FC will sell machines without responsibility for installation or service or will provide turnkey installation supervised by FC employees. Training of maintenance employees can be provided.

Flowlight Solar Power

P.O. Box 548
Santa Cruz, New Mexico 87567
Telephone: 505-753-9699
Telex: None
Fax: None

Chief Executive Officer: Mr. Windy Dankoff

Equipment or Systems Characteristics

Flowlight Solar Power, (FSP), offers a specially designed PV "Solar Slowpump" for high lift from shallow water sources at low flow rates of 32 to 820 L/h (8.5 to 217 gal/h) at lifts as high as 130 m (427 ft). Twenty-one models are available, so that a pump can be exactly matched to each application. These pumps may be directly powered by PV or via an intermediate battery. A faster booster pump is also available in 12 and 24 volt models for supplying water under pressure for domestic use. These operate with PV-charged batteries.

Experience and Operations

FSP was formed originally in 1977 as Windlight Workshop to provide wind-powered electric systems. As PV prices began to drop in 1980, the company switched to solar-electric systems and began supplying PV home systems throughout the United States. Many hundreds of systems have been sold. In 1982, FSP began selling PV water well pumping systems and designed the Slowpump to fill

special needs. Now, hundreds of Slowpumps are in use worldwide to supply domestic, irrigation, and livestock water. The volume of business approaches \$500,000 annually.

Specifications are available in metric and English units. Manuals are available translated into Spanish.



The G&S Mill, Inc.

75 Otis Street
Northborough, Massachusetts 01532
Telephone: 508-393-9266
Telex: 178717
Fax: None

Chief Executive Officer: Mr. Paul Kalenian
Marketing Director: Ms. Cathy Kalenian

Equipment or Systems Characteristics

The G&S Mill, Incorporated, (G&S), provides small to medium size industrial waste-to-energy systems, including boiler retrofits and stokers, for production of hot air, hot water, or steam. Various sizes of cylindrical fire boxes of boilerplate steel are used. Hot air furnace systems range in output from 316 to 3,690 MJ/h (300,000 to 3,500,000 Btu/h). Boiler systems range in output from 1,050 to 10,500 MJ/h (1,000,000 to 10,000,000 Btu/h). The systems can burn rice husks, coconut shells, coffee beans, nut shells, and lumber waste having up to 55 percent moisture. Heat can be used for grain drying, copra drying, coffee roasting, lumber kilns, etc. All models can be fed either manually or automatically by stoker. Both components or turnkey installations are available. One-year warranties are provided. These systems are very efficient and have very low emissions. Periodic ash and heat exchanger clean-out is required.

Experience and Operations

G&S was established in 1976 and grosses in excess of \$1 million annually. Its waste-to-energy systems are widely used by industries throughout North and Central America. G&S is willing to sell its manufacturing know-how and is seeking companies that will manufacture and market its equipment in selected areas of the world.



Glasstech Solar, Inc.

12441 West 49th Street
Wheat Ridge, Colorado 80033
Telephone: 303-425-6600
Telex: 5106014227
Fax: 303-425-0172

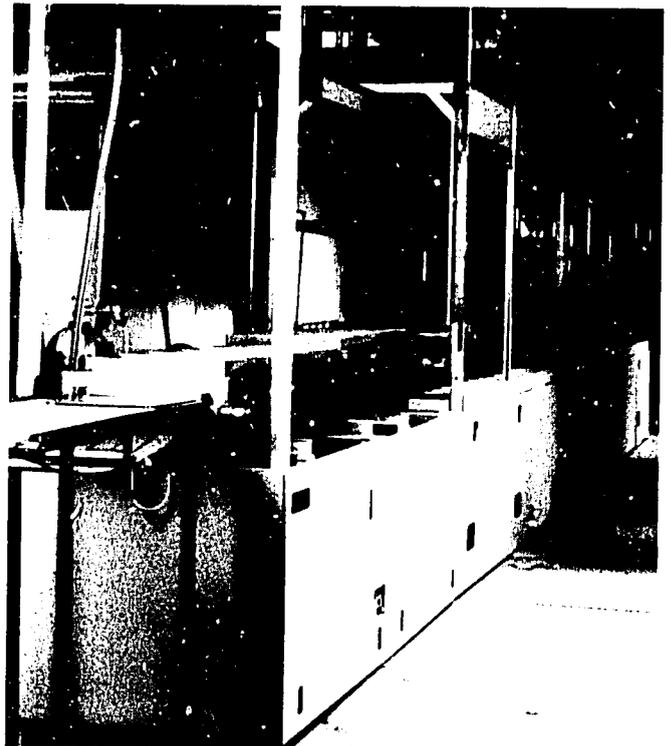
Chief Executive Officer: Dr. Arun Madan
International Sales Manager: Mr. Marc Landry

Equipment or Systems Characteristics

Glasstech Solar, Incorporated, (GSI), manufactures plasma-enhanced, chemical vapor deposition equipment designed specifically for amorphous silicon and dielectric depositions, such as SiN_x, SiO_xN_y, etc. Applications include solar cells, thin-film transistors, and imaging devices. GSI offers a variety of equipment from ultra-high-vacuum single and multi-chamber systems to large area module production systems and turnkey, completely automated, thin-film PV production plants, using GSI's patented "Glass In-Panel Out" methods. Annual production capability ranges from several hundred kilowatts to multi-megawatts. GSI can provide on-line sputtering equipment for a variety of applications, including custom-engineered systems.

Experience and Operations

GSI began operations in 1985 and grosses in excess of \$1 million annually. Overseas projects include a 500-kW (total capacity of 1.5 MW) thin-film pilot PV production plant for Bharat Heavy Electricals, Ltd., in India and a 1-MW (total capacity of 3 MW) thin-film PV production plant for Central Glass Company of Japan. GSI has also supplied single and multichamber chemical vapor deposition systems to numerous customers including the Jet Propulsion Laboratory, United Nations Industrial Development Organization, ENA (Italy), NPL (India), UNAM (Mexico), and Lawrence Berkeley Laboratory (California).



The above "state-of-the-art" continuous in-line thin-film plasma deposition system is used for the manufacture of amorphous silicon PV systems. (Courtesy Glasstech Solar Inc.)

Gougeon Brothers, Inc.

P.O. Box X908
100 Patterson Avenue
Bay City, Michigan 48707
Telephone: 517-684-7286
Telex: None
Fax: 517-684-1374

Chief Executive Officer: Mr. Meade Gougeon
General Manager: Mr. Robert Monroe

Equipment or Systems Characteristics

Gougeon Brothers, Incorporated, (GBI), designs and manufactures wood-epoxy composite wind turbine rotor blades. Wood-epoxy blades tend to be lighter and stiffer than comparable fiberglass-reinforced plastic blades and employ a proven bonded-stud root-retention technology. On-going federal and GBI material test programs on adhesives, wood-epoxy laminates, and load take-off technology have resulted in a large database that gives the blade designer maximum flexibility in tailoring the blade design to machine requirements.

Experience and Operations

Since 1979, GBI has delivered over 4,500 blades ranging in size from 6.4 m (21 ft) to 20 m (65.5 ft).

Customers from the wind energy industry include Westinghouse Electric Corporation; Enertech; ESI, Inc.; General Electric Corporation; U.S. Department of Energy; National Aeronautics and Space Administration; AeroTurbine Corporation; and Northern Power Systems. GBI continues to serve individual and windfarm owners in the refurbishing or replacement of damaged blades.



Gougeon Brothers built the 43.3-m (142-ft) rotor on this 600-kW Westinghouse wind turbine located on the island of Oahu, Hawaii. (Courtesy Gougeon Brothers, Inc.)

Gull Industries

2127 South 1st Street
San Jose, California 95112
Telephone: 408-293-3523
800-621-0854 Ext. 318

Telex: None
Fax: None

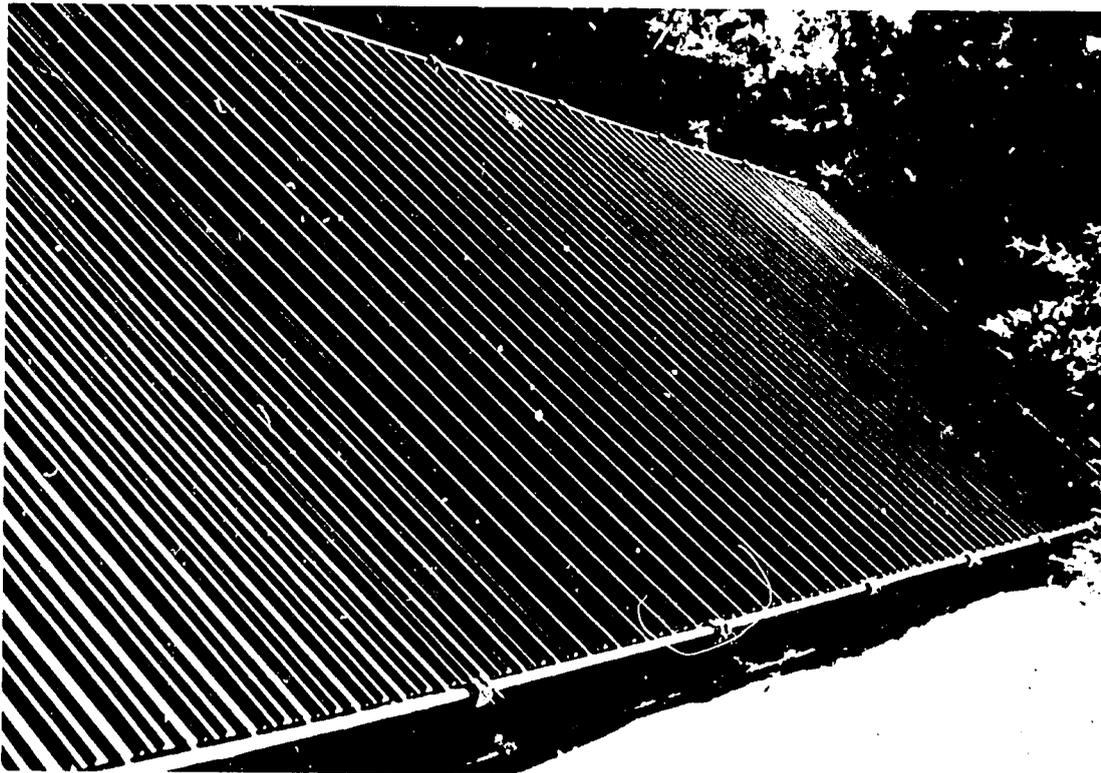
President: Mr. Michael D. Kennedy

Equipment or Systems Characteristics

Gull Industries, (GI), offers complete turnkey assistance in licensing, manufacturing, marketing, and installing flat-plate collectors for heating water for domestic use and for swimming pools. Service training can also be provided. Product can be shipped in kit form with video and blue print assembly instructions. Several sizes of flat-plate collectors are provided — some with an acrylic cover in a box for wind protection, and some in a glazed box. Closed-loop systems are also offered which use glycol heat exchangers for freeze protection or recirculation to avoid freezing. Panel-connecting hardware and panel-mounting hardware components are also offered. GI offers training overseas. A simple do-it-yourself installation is a 3.0-m² (32-ft²) collector with 151 L (40 gal) of storage requiring no soldering, and freeze valve replacement every 2 years. This system carries a 5-year warranty on the collector and a 1-year warranty on component parts. The system in a glazed box has the control module prewired and pre-plumbed. This system carries a 10-year warranty on the collector and 1-year warranty on components.

Experience and Operations

GI was formed in 1977 and grosses about \$600,000 annually. Large installations are for example: 84 collectors, each 1.22 m by 3.05 m (4 ft by 10 ft) in area in glazed boxes, using a differential solar control and recirculation to protect against freezing, to heat hot water for the Meadows Apartments in Sunnyvale, California; and 274 collectors, each 1.22 m by 3.5 m (4 ft by 10 ft) in area in glazed boxes, arranged into 7 separate systems, to heat hot water for a 7,570-L (2,000-gal) storage system for Willow Bend Apartments in Sunnyvale, California. The latter system is interconnected to an existing back-up boiler.



This array of solar collectors was installed in 1978 to supply hot water for a residential pool. (Courtesy Gull Industries)

Hadson Power Systems Group

16845 Van Karman Avenue
Irvine, California 92714
Telephone: 714-863-7000
Telex: 692356
Fax: 714-250-4866

*Chief Executive Officer: Mr. James P. Kelly
International Sales Manager: Mr. Scott Noll*

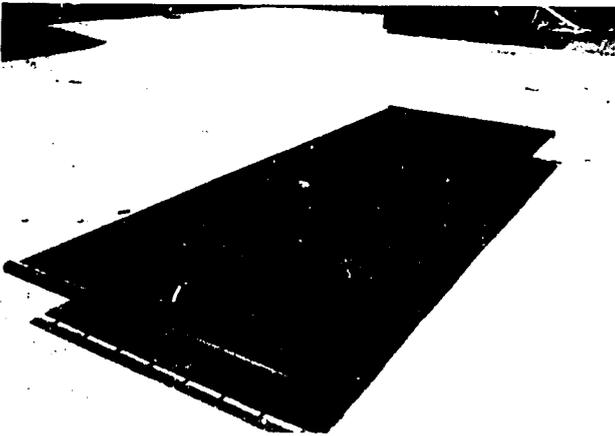
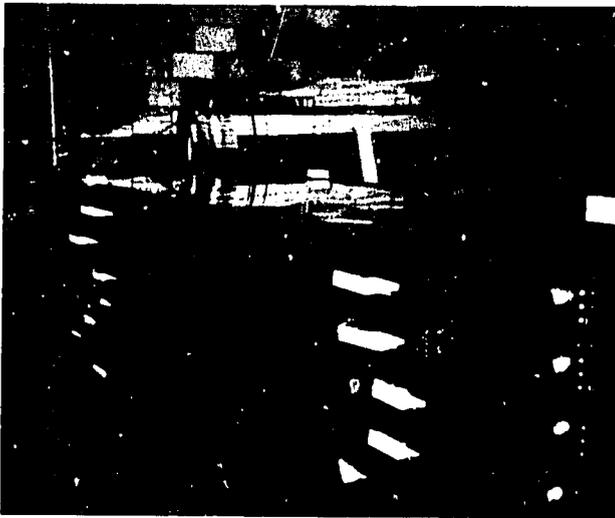
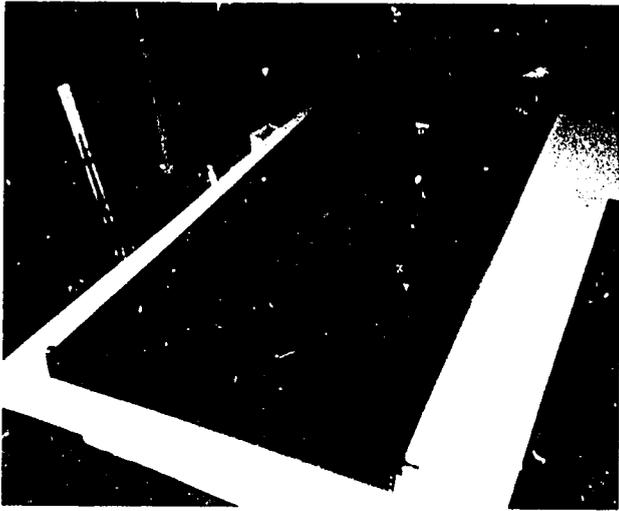
Equipment or Systems Characteristics

Hadson Power Systems Group, (HPSG), through its Ultrasystems subsidiaries, provides totally integrated power plant services; i.e., planning, development, financing, design, engineering, construction, operations, and ownership participation of wood-fired, small power and cogeneration systems. This includes initial feasibility studies, environmental analyses and compliance, fuel availability studies, and financial assistance. Fuel comes from proven in-forest harvesting and handling techniques, agricultural wastes, residues from lumber mills and other forest product industries, and urban wastes. The fuel is burned in conventional grate or fluidized-bed boilers to produce high-pressure steam for turbine generators.

Experience and Operations

HPSG has provided complete development, design, construction, and operations for 3 grate-fired units (11.4 MW each) and 4 fluidized-bed units in the 27-MW range. One other 27.9-MW, wood-fired, fluidized-bed unit is under construction. All sell power directly to the local utility, and all are partially owned by an Ultrasystems subsidiary.

HPSG is expected to have revenues of approximately \$150 million in 1988.



Flat-plate solar collectors are easy to install and have a long service life in hot water applications. (Courtesy Gull Industries)

HDR Engineering, Inc.

8404 Indian Hills Drive
Omaha, Nebraska 68114-4049
Telephone: 402-399-1000
Telex: None
Fax: 402-399-1238

Chief Executive Officer: Mr. Milton L. Smith, P.E.
International Sales Manager: Mr. Frank A. Borchart,
Executive Vice President

Services Offered

Among other services offered, HDR Engineering, Incorporated, (HDRE), provides planning, engineering, and broad technical support for utilization of solid waste, wood waste, and digester gas for production of energy. Expertise includes fluidized-bed combustion, cogeneration, utilization of alternative fuels, retrofitting, power plant rehabilitation, and transmission-distribution of electricity.

Experience and Operations

HDRE, established in 1985 and grossing in excess of \$1 million annually, is the engineering branch of HDR, Inc., one of the largest engineering and architectural design and management firms in the United States. Representing 50 design and scientific disciplines, the parent firm has projects in every state of the United States and in 30 foreign countries. Clients have included municipalities, utilities, and industries.

Hedland Flow Meters

P.O. Box 1405
Racine, Wisconsin 53404
Telephone: 414-639-6770
Telex: 26-0169
Fax: None

Chief Executive Officer: Mr. J. Erskine, Jr.
International Sales Manager: Mr. T. G. Nelson

Equipment or Systems Characteristics

Hedland Flow Meters, (HFM), provides 22 models of rugged, low-cost, direct-reading, in-line flow meters for solar hot water collectors or other installations. Temperatures are rated to 82°C (180°F) maximum and 1.72 MPa (250 psig) with a 3:1 safety factor. A ribbed piston-type unit is also available for monitoring in-line liquids containing suspended particulates up to 400 µm in size.

Experience and Operations

HFM was formed in 1971 and grosses in excess of \$1 million annually.

HEDLAND

Heliodyne, Inc.

4910 Seaport Ave.
Richmond, California 94804
Telephone: 415-237-9614
Telex: 287316 HOM
Fax: 415-524-9577

Chief Executive Officer: Mr. Jurg H. Bieri
International Sales Manager: Mr. Christel D. Bieri

Equipment or Systems Characteristics

Heliodyne, Incorporated, (HI), manufactures state-of-the-art solar collectors. This includes easy mounting hardware for all roofs. HI also offers patented heat transfer systems. Services include mechanical engineering consulting and complete system design for any application feasible with liquid flat-plate collectors, both for heating and for cooling. A variety of HI liquid flat-plate collectors features an all copper absorber with 360° wrap-around fin around the riser tube, which may be 1.27 cm (½ in.) or larger in diameter. Both black chrome surfaces over nickel or black paint are provided. A compression-fitted glazing strip with seamless EPDM gasket is used for the most extreme climates. The collectors have a strong bronze anodized aluminum frame and single, water-white tempered glass cover. Applications are for single-family, commercial, multi-residential, or process hot water supplies. Packaged systems for all climates (freezing, mild freezing or non-freezing) are available which are easy to install. One model has its own PV power supply. Another model is used for residential or commercial cooling with absorption chilling. All collectors are warranted for 5 years; components carry warranties for 1 to 5 years. Another system available from HI is a heat transfer unit complete with pumps, controls, valves, sensors, and expansion tank for mounting external to a storage tank. Other components are plumbing unions, collector-mounting hardware for varied tilt mounting, tanks, pumps, controls, sensors, valves, expansion vessels, collector fluids, heat exchangers, and PV panels. Patented technology is available for joint ventures. Sale of product or technology or manufacturing under license can be arranged.

Experience and Operations

HI was established in 1976; sales fluctuate around \$1 million annually. It has shipped \$40,000 of solar collector systems to Jeddah, Saudi Arabia for water heating. HI has installed 3,089 m² (33,248 ft²) of collectors with heat transfer systems for heating water for dormitories, laundries, and food service at the University of California, Davis. These are liquid flat-plate collectors with closed-loop glycol and drain-back heat exchanger systems because of poor water quality and freezing conditions. A similar 2,687-m² (28,920-ft²) system is installed at the University of California, Santa Barbara. This, however, has closed-loop glycol, external-tank heat exchangers because of hard water.



HELIODYNE
SENSIBLE TECHNOLOGY®

Heliotrope General

3733 Kenora Drive
Spring Valley, California 92077
Telephone: 619-460-3930
Telex: None
Fax: None

Chief Executive Officer: Mr. Sam Dawson
International Sales Manager: Mr. Mark Albert

Equipment or Systems Characteristics

Heliotrope General, (HG), offers a new, solid-state, phase-shift, 2 transformer, 2300-W inverter on which a patent application has been filed. This converts 12/24 volt DC to 115/220 volt AC electricity. The system has selectable automatic, fault-reset, and failure analysis lights. All products carry a 10-year limited warranty. HG offers 10, 20, 60, 120 ampere PV battery charge controllers and a variety of inverters from 1,000 to 10,000 W.

HG also manufactures a variety of controls. These include a number of models which are temperature differential controllers for hot water or air systems with programmable features, solar pool controls, set point aquastat controls with front-panel temperature selection from a single sensed temperature input, drain-down controls for domestic hot water systems (available also with PV panel for pump, control, and valve), temperature monitors (stand alone, 4 position digital with memory), valves for drain down or combined air vent and vacuum breaker.

Experience and Operations

HG was established in 1974 and conducts business approaching \$2 million annually. Complete engineering and manufacturing facilities include computer aided design, full-sheet metal shop, burn-in room, inspection area, and warehousing. An example of an HG installation is the 5-kW inverter in a 100 percent solar, 465-m² (5,000-ft²) medical manufacturing and business building in Tallahassee, Florida.



HELIOTROPE GENERAL

The Heller-Aller Company, Inc.

Perry and Oakwood Streets
Napoleon, Ohio 43545
Telephone: 419-592-1856
Telex: None
Fax: None

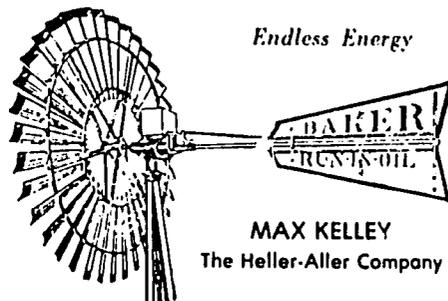
Chief Executive Officer: Mr. Max Kelley, President

Equipment or Systems Characteristics

The Heller-Aller Company, Incorporated, (HAC), manufactures "Baker" type gear-backed windmills with multiblade four-wheels having diameters that vary from 1.5 to 3.7 m (5 to 12 ft). Pumping capacities range from 378 to over 3,790 L/h (100 to over 1,000 gal/h). Four-wheels rotate on ball bearings; power is transferred to the vertical pumping shaft by gears running in a pool of oil. The windmill vanes are automatically self governing to take the windmill out of gear when the wind reaches excessive velocity. HAC also makes "Fiasa" windmills with four-wheels varying in diameter from 1.8 to 4.9 m (6 to 16 ft). The wheels rotate in babbitt-type bearings which have been used extensively in the U.S.A. for many years. HAC provides 12 models of galvanized steel towers from 4.6 to 18.3 m (15 to 60 ft) in height. HAC also offers a wide range of iron and brass cylinder pumps suitable for use with their windmills. Models fit well casings with diameters of 7.6, 8.9, and 11.4 cm (3, 3.5, and 4.5 in.). HAC can provide turnkey installations in developing countries using American contract technicians.

Experience and Operations

HAC has manufactured water pumping windmills since 1886. These were widely used in rural America prior to the rural electrification program of the 1930s. One hundred machines were sold to Nigeria in the early 1970s. Twenty-three were recently installed in Honduras by Volunteers for Technical Assistance.



**Hunter/Reynolds, Smith and Hills,
Architects-Engineers-Planners, Inc.**

6737 Southpoint Drive S.
(P.O. Box 4850)
Jacksonville, Florida 32216(32201)
Telephone: 904-739-2000
Telex: 810-827-4230
Fax: 904-731-1673

*Chief Executive Officer: Mr. Leerie T. Jenkins, Jr.
Technical Contact Person: Dr. Carlos S. Warren*

Services Offered

Hunter/Reynolds, Smith and Hills, Architects-Engineers-Planners, Incorporated, (HRS&H), offers environmental, consulting, remediation, and reclamation services. The firm also has expertise in architecture, engineering, and planning, and provides professional services around the world. Through its Energy and Environmental Technologies division, HRS&H provides consulting and design services in renewable energy projects, including ethanol fermentation, biogasification, solar energy, and wind energy. HRS&H specifically offers technical and economic analysis, system evaluation, and engineering design services for wood fuel systems, including conversion of fossil fuel fired boilers to wood fuel systems, for power generation as well as cogeneration. HRS&H also offers feasibility studies for wood gasification systems.

HRS&H also plans solid waste management systems and designs industrial and municipal wastewater treatment plants. The firm is currently investigating thermochemical gasification of municipal solid waste.

Experience and Operations

In 1988, HRS&H was acquired by Hunter Environmental Services, Inc., Southport, Connecticut, a firm that offers complete environmental services. HRS&H was established in 1941 and grosses around \$100 million annually. Examples of total design services include a 50-MW industrial cogeneration plant burning wood and coal in combination, refurbishment of 2 existing 13,600-kg/h (30,000-lb./h) wood-fired boilers for the State of Florida, detailed preliminary design for retro-fitting Tallahassee, Florida's existing 30-MW power plant to burn wood, a new 10-MW wood-fired plant for New England Alternate Fuels, 2 wood gasification plants for Louisiana Pacific, 2 ethanol plants, and the electrical, instrumentation, and control systems for a wood gasification plant in Quincy, Florida. HRS&H is involved in further development and optimization of a process to biogasify municipal solid waste.

HRS&H provides renewable energy consulting to the National Academy of Sciences and has provided complete design services for 2 modular metropolitan solid waste generators at 2 military installations.

RS&H

Architects ■ Engineers ■ Planners
A Hunter Company

Independent Energy, Inc.

42 Ladd Street
E. Greenwich, Rhode Island 02812
Telephone: 401-884-6990
Telex: None
Fax: None

*Chief Executive Officer: Mr. Donald Johnson
International Sales Manager: Mr. Fred Bootz*

Equipment or Systems Characteristics

Independent Energy, Incorporated, (IEI), manufactures high-quality, low-cost electronic temperature controls for solar-thermal, air conditioning, refrigeration, industrial, agricultural, and other applications. IEI provides several differential temperature controls as well as set-point temperature controls. The product line also includes temperature alarms, timers, monitors, and displays.

Experience and Operations

IEI was established in 1975 and grosses in excess of \$3 million annually.

INDEPENDENT  ENERGY INC.

Industrial Solar Technology

5775 West 52nd Street
Denver, Colorado 80212
Telephone: 303-431-8348
Telex: None
Fax: None

Chief Executive Officer: Mr. Randall C. Gee
International Sales Manager: Mr. E. Kenneth May,
General Partner

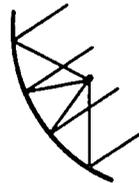
Equipment or Systems Characteristics

Industrial Solar Technology, (IST), manufactures a new generation of large-scale, highly efficient, low-cost, parabolic trough, solar collectors using 3M Corporation's reflective film. The concentrators are very rigid and weigh 5.2 kg/m^2 (1.3 lb/ft^2) of aperture area. Each collector module measures 6.1 m (20 ft) long by 2.3 m (7.55 ft) across and weighs 73 kg (161 lb). A single electric motor drives a multi-row tracking system consisting of 418 m^2 ($4,500 \text{ ft}^2$) of collector area. The Honeywell Fluxline control system manufactured by IST under an exclusive license regulates operations. The receiver features a highly selective absorber surface surrounded by an anti-reflective Pyrex glass tube. Collectors can deliver temperatures up to 316 C (600 F) to meet heating, cooling, and power generation applications. IST offers total turnkey system capability. For overseas customers, licensing arrangements are available to establish complete manufacturing operations. Capital requirements are low. Most materials needed are available locally, and fabrication requires largely unskilled labor.

The parabolic reflector systems vary in size from 223 m^2 ($2,400 \text{ ft}^2$) to $200,000 \text{ m}^2$ ($2.15 \text{ million ft}^2$). System efficiency is 60 to 70 percent depending on operating temperature. Reflectors must be washed about 6 times per year. Collectors and components are warranted for 1 year.

Experience and Operations

IST was established in 1983. Operations approach \$500,000 annually. IST has installed $1,060 \text{ m}^2$ ($11,400 \text{ ft}^2$) of collectors. An example of an IST parabolic-trough collector installation is at Adams County Detention Facility, Brighton, Colorado. It features 557 m^2 ($6,000 \text{ ft}^2$) of collectors arranged in 10 parallel rows and a 55-kW electric generator. The system operates in the cogeneration mode and provides both electricity and hot water. The system operates completely unattended and is run by a Honeywell Fluxline control system which monitors the sun, wind, fluid flow, and temperature. A 1.1-kW pump circulates ethylene glycol-water anti-freeze solution through the collectors. Operation is designed for 1,030 kPa (150 psi) and 177 C (350 F). Peak system output is 1,320 MJ/h (1.25 million Btu/h). Hot fluid flowing from the collector field vapora refrigerant that is expanded through a Rankine cycle turbine which drives an induction generator that delivers up to 55 kW of electricity to the jail. Heat extracted from the turbine condenser is routed to a 18.9-m^3 (5,000-gal) storage tank to supply domestic hot water to the jail. Hot water is used in the kitchen, laundry, and showers. Both heat and electricity are sold to the jail at a cost less than the cost of equivalent natural gas and power supplied by the local utility. The solar system provides up to 85 percent of the hot water needs and about 20 percent of the demand for electricity. IST has provided tracking and system controls for a parabolic trough solar collector system generating medium-pressure steam for the Indian Institute of Science at Bangalore, India.



Both electricity and hot water are supplied to a detention center in Colorado through this parabolic system. The system operates completely unattended. (Courtesy Industrial Solar Technology)

Integrated Power Corporation

7524 Standish Place
Rockville, Maryland 20855
Telephone: 301-204-9133
Telex: 79-7799
Fax: 301-294-0809

Chief Executive Officer: Mr. Ken F. Gerken
International Sales Manager: Mr. Lee S. Gordon

Equipment or Systems Characteristics

Integrated Power Corporation, (IPC), designs and manufactures commercial PV and PV-hybrid power systems suitable for installation in remote, harsh environments where reliable power is critical. Such applications include telecommunications, village power, oil/gas instrumentation, railroad track circuits, cathodic protection of pipelines, and military uses. Hybrid systems are PV-backed or teamed up with diesel, wind, or thermoelectric systems.

Experience and Operations

IPC was established in 1983 and is owned 43 percent by Westinghouse Electric Corporation, which is developing a major new PV module technology. Through this business relationship, IPC will provide state-of-the-art technology and market its products and services worldwide via the Westinghouse International field sales organization.

A unique installation is the 24.8-kW PV power installation that provides electricity to 135 inhabitants of Coconut Island in the Torres Strait off the northern coast of Australia. This installation uses a PV-diesel-hybrid system; the PV modules are supplied by Westinghouse Advanced Energy Systems Division and ARCO Solar. In another project, IPC is supplying a network of 24 PV cathodic protection (anti-corrosion) systems for the Arabian American Oil Company's 650-km (404-mile) pipeline from eastern Saudi Arabia to western Saudi Arabia at the Red Sea.



L. D. Industries, Inc.

601 E. Main Street
Myerstown, Pennsylvania 17067
Telephone: 717-866-2164
Telex: None
Fax: 717-866-7667

Chief Executive Officer: Mr. Richard L. Weaver,
President

Equipment or Systems Characteristics

L. D. Industries, Incorporated, (LDI), designs and manufactures material handling systems, especially for the wood industry. Concrete storage silos have been a specialty, using patented reclaimers to remove material from silos ranging in diameter from 3.66 to 24.4 m (12 to 80 ft). Conveyors, live bottoms, and elevators are also provided as needed. Equipment is heavy duty and designed for rugged service.

Experience and Operations

LDI has been operating for over 25 years and now has revenue of \$1 to 2 million per year. A commercial installation, for example, consists of 2 concrete storage silos, each 13.7 m (45 ft) in diameter and 25.9 m (85 ft) high, which hold whole tree chips that are removed by means of a reclaimer to fire a 16-MW power plant. This system is located in Bethlehem, New Hampshire at the Pine-tree Power plant. International sales have been to Canada out of the Myerstown office.



Located off the coast of Australia, this 24.8-kW hybrid PV system with diesel power back-up supplies enough grid power for the island's population of 135. (Courtesy Integrated Power Corporation)

Morbark Industries, Inc.

Telephone: 517-866-2381
South Winn Road, Box 1000
Winn, Michigan 48896
Telephone: 517-866-2381
Telex: 386488 (Morbark, Winn)
Fax: 517-866-2330

Chief Executive Officer: Mr. Norval Morey
*International Sales Manager: Mr. Mike Revord**

Equipment or Systems Characteristics

Morbark Industries, Incorporated, (MII), produces a wide range of equipment for cutting, felling and handling trees, converting them to wood chips, and handling and delivering the chips. The large Chiparvestors (mobile wood chippers) can handle trees up to 0.76 m (30 in.) in diameter. Medium-size units to handle 0.56- to 0.69-m (22- to 27-in.) diameter trees can produce 544 t (600 tons) of chips in 8 hours. A model for small diameter trees can produce 90.7 t (100 tons) of chips in 8 hours. The Feller-Bunchers (mobile units to cut trees) can cut up to 450 small trees per hour. Other products are grapple-skidders, hydraulic truck dumpers, and a variety of equipment to convey, screen, and reclaim wood chips.

In 1986, MII acquired manufacturing and marketing rights to a patented biomass gasification-combustion system suitable for converting oil- and gas-fired boilers to burn wood chips. At present, these units can produce up to 21,100 MJ/h (20,000,000 Btu/h); larger systems are being designed using the same principle. Fuel storage and feeding units are included.

Experience and Operations

MII was established in 1960 and now grosses in excess of \$1 million annually. Its products are widely used in the United States and they have also been sold in Eastern Europe, Africa, South America, and Asia. Equipment and service is supplied to customers in Asia through a Morbark manufacturing subsidiary in New Zealand and a Morbark parts and service organization in Australia. Contract facilities have been established in Hungary and Ghana to provide parts and service. Similar facilities are planned for Brazil and/or Chile. Initial inquiries should be directed to the home office.

* Address: KIC International, 4109 Fruit Valley Road, Vancouver, Washington 98660-1290, Telephone: 206-696-0561, Telex: 4742023, Fax: 206-696-3132.



This 19,000-MJ/h (20,000,000-Btu/h), three-stage, updraft gasification-combustion system converts biomass and combustible garbage or a combination of both to heat for a hot water boiler. (Courtesy Morbark Industries, Inc.)



The Waste Recycler from Morbark Industries, Inc. is designed to convert stumps, brush, old timbers, remodeling waste or building scraps into wood chips and mulch. The Waste Recycler will chip material up to 2.4 m (8.0 ft) in diameter. (Courtesy Morbark Industries, Inc.)

Nicholson Manufacturing Company

3670 East Marginal Way South
Seattle, Washington 98134
Telephone: 206-682-2752
Telex: 32-0004
Fax: 206-623-7952

Chief Executive Officer: Mr. William Iverson

Equipment or Systems Characteristics

Nicholson Manufacturing Company, (NMC), is a firm that designs, develops, and manufactures log debarkers, chippers (both portable and mill types), log loaders, chip screens, log feeders, and cutoff saws. It also does custom engineering and manufacturing.

Experience and Operations

NMC was formed in 1948 and currently does worldwide business grossing about \$9 million annually. NMC has sales offices in 6 different states of the United States, 3 offices in Canada and one in each of the following countries: Argentina, Austria, Australia, Belgium, Brazil, Chile, Denmark, England, Finland, Italy, Japan, New Zealand, Norway, Poland, Spain, and U.S.S.R.

NMC has recently installed a triboard mill in New Zealand. Special NMC systems in use are a timber miller which is a specialized, towable chipper used to chip solid wood found in peat bogs, and a woodfuel processor, which is a fixed or portable, high capacity, wood fuel chipping system that handles both solid wood and brush, yielding high quality fuel wood chips.



Nordic Stove Company

4201 North 26th Street
Omaha, Nebraska 68111
Telephone: 402-451-2575
Telex: None
Fax: None

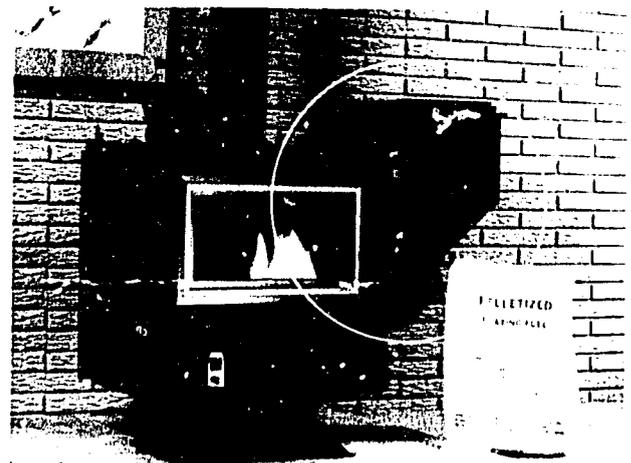
Chief Executive Officer: Mr. Gerald Stahmer

Equipment or Systems Characteristics

Nordic Stove Company, (NSC), offers the "Elite-M," a free-standing, heat stove which burns various fuels such as wood pellets, waste corn and/or coal that is automatically fed to the burner from a hopper. Output can be varied from 12.6 to 52.7 MJ/h (12,000 to 50,000 Btu/h). Service agreements can be arranged. NSC also offers an "EasiBurn" retrofit kit to convert a wood stove to burn pellets.

Experience and Operations

NSC was formed in the late 1930s. The firm sells about 1900 units per year and grosses between \$1 million and \$2 million annually.



This multi-fuel stove burns pelletized wood or sugar beet pulp, seed and nut hulls, straw, cotton gin residues, logs, or coal. The hopper system permits automatic heating operations when using pelletized fuels. (Courtesy Nordic Stove Company)

Northern Power Systems

One North Wind Road
Moretown, Vermont 05660
Telephone: 802-496-2955
Telex: 957034
Fax: 802-496-2953

Chief Executive Officer: Mr. Ted Bartholf
Marketing Manager: Mr. George Barlowe
International Sales Manager: Mr. Andrew Perkins

Equipment and Systems Characteristics

Northern Power Systems, (NPS), designs, manufactures, and installs MicroGrid™ independent, wind-powered and hybrid power systems for a wide variety of applications. These systems include electrical controllers and high reliability wind turbines for a wide range of applications. Telecommunications, navigational aids, off-shore platforms, cathodic protection, grid-connected independent power, village electrification, and water pumping are some of the applications that have utilized NPS power systems, which are typically configured to the customer's specifications. Most projects involve both engineering and design in addition to standard products manufactured by others. Custom structural or electrical components are often fabricated in NPS' shops.

Currently, wind turbine systems are available in 1-kW, 3-kW, and 12-kW sizes (Models HR1, HR3, and MR12). The corresponding horizontal axis rotors have diameters of 3 m (10 ft), 5 m (16.4 ft), and 9 m (29.25 ft). Each has a design life of 25 years. Controllers supplied by NPS are the SC-350 series and the SC-374. The SC-350 series units are dual voltage sensitive relays with independent adjustable high and low setpoints, and have 2 adjustable control outputs which can be used for PV regulation, backup power source control, high and/or low voltage load shedding, or alarms. Complete voltage and current metering is included, and models are available to effectively control 50-W to multi-kW systems. The SC-374 uses battery charge instead of system voltage to make control decisions for telecommunications power systems, uninterruptible power systems, and other battery-based systems of 200 W to 50 kW capacity where reliability is critical.

Experience and Operations

Established in 1974, NPS has annual gross sales over \$1,000,000. Since 1974, NPS has installed power systems for commercial customers in 20 countries on every continent. In the United States alone, 200 3-kW, 20 12-kW, and 15 100-kW wind turbine machines have been installed. Recently, NPS was awarded a contract by AT&T World Services, Inc., to provide the design, equipment supply, and installation of 14 standalone, PV-diesel hybrid power systems for installation at remote locations in Bolivia. The systems consist of PV arrays with peak outputs between 1 kW and 6 kW coupled with battery banks and auxiliary diesel generators. System logic is provided by NPS' SC series of system controllers. NPS has also designed and installed PV only, and wind-PV-diesel hybrid standalone power systems for off-shore platforms of the U.S. Navy's Tactical Aircrew Combat Training Systems. Five platforms have power requirements ranging from 310 to 375 W, powered by 2.5-kW SOLAREX PV arrays; 3 platforms have power requirements of 2.8 to 3.6 kW and are powered by 2 12-kW wind energy conversion systems, a 5-kW PV array, and a 25-kW auxiliary diesel generator. NPS supplied the wind turbine generators and controllers, and SOLAREX supplied the PV arrays.

NPS' installation and project management team have provided turnkey systems in locations around the world including Alaska, Antarctica, Morocco, Norway, Oman, and Pakistan. These services include site preparation, commissioning and testing, training, and service and maintenance. SPS also offers patented technology for joint ventures.

NRG Systems, Inc.

1955 Church Hill Road
Charlotte, Vermont 05445
Telephone: 802-425-3468
Telex: 650-313-6421 MCIUW
Fax: 802-425-3712

Chief Executive Officer: Mr. David Blittersdorf
International Sales Manager: Mr. Lawrence Mott

Equipment or Systems Characteristics

NRG Systems, Incorporated, (NRG), designs and manufactures wind measuring instrumentation, sensors and tower systems. NRG also has expertise in wind resource assessment around the world and in field installations and recovery of data from wind instruments. Instruments provided are: the Wind Challenger, a wind speed computer for remote operation (power density, peak gust readings, average windspeed over times of occurrence); the Wind Totalizer, an instrument which displays total wind run and present wind speed; the NRG Logger No. 9000, a serial real-time wind data logger; the Wind Hawk which continuously computes and displays 8 different functions and may also indicate wind direction. NRG also provides the Tall Tower for mounting instruments. This has a tilt-up design and may vary from 10 to 40 m (33 to 131 ft) in height. NRG is now the exclusive distributor for the widely used No. 40 maximum anemometer.

Experience and Operations

NRG was formed in 1981 and grosses between \$500,000 and \$1 million annually. It sells about 200 wind measuring instruments, 600 wind direction sensors and 150 instrument towers annually. It has supplied 20 NRG Loggers to Greece, towers and Loggers to an Australian utility and to India, and assorted instruments to New Zealand, Norway, Denmark, England, Chile, Spain, Canada, Netherland Antilles, and Egypt.

Olathe Manufacturing, Inc.

100 Industrial Parkway
Industrial Airport, Kansas 66031
Telephone: 913-782-4396
Telex: None
Fax: 912-829-2825

Chief Executive Officer: Mr. Steve Rogers, President

Equipment or Systems Characteristics

Olathe Manufacturing, Incorporated, (OMI), is a manufacturer of small, wood-chip gasifier systems, including gasifiers, feeders, dryers, and chippers. The systems, known as the Buck Rogers Wood-Chip Gasifier Systems, produce up to 5,270 MJ/h (5,000,000 Btu/h). New installations are given a 1-year warranty.

Fuel handling equipment, namely, live bottom feeders, dryer-feeder combinations, harvesting equipment, and the Olathe 986 and 864 wood and wood debris chippers, can be supplied separately.

Experience and Operations

OMI was established in 1972 and now grosses in excess of \$1 million annually. An example of the OMI gasifier, which can be inspected in operation, is the 5,270-MJ/h (5,000,000-Btu/h) installation at Kansas State University. It includes a wood-chip gasifier feeder and dryer.

OLATHE MANUFACTURING, INC.



Omnion Power Engineering Corporation

188 Highway ES
Mukwonago, Wisconsin 53149
Telephone: 414-363-4088
Telex: None
Fax: None

Chief Executive Officer: Mr. Hans Meyer

Equipment or Systems Characteristics

Omnion Power Engineering Corporation, (OPEC), designs and manufactures power conversion equipment and system controls for utility-interconnected, PV, battery load leveling, and fuel cell, wind, hydro, and other advanced energy sources. The Series 2000 product line accommodates input voltages up to 300 volts DC and produces a 120/240 volt AC, 50 or 60 Hz, single-phase output. Other input and output voltages can be provided as well. This system is simple, rugged, and economical, but has a low power factor (0.8 at rated voltage) and high current harmonic content (15 to 20 percent at rated output). The Series 2200 overcomes these power quality limitations and achieves higher performance. This system is available in 2- and 4-kW models and will soon include 8- and 12-kW models. The Series 3000 is a 3-phase product available in 6- and 12-pulse configurations built to order. The Series 3200 system is a 3-phase extension of the Series 2200 and will be available in approximately one year.

Experience and Operations

OPEC was established in 1970 and grosses between \$500,000 and \$1 million annually. OPEC has produced in excess of 2000 systems since shipping the first models in 1975. Capacities range from 1 kW to 1 MW. Installations abroad have been, for example, a 2.3-kW Series 2200 power conversion system for a PV project in Switzerland, and 3 4-kW Series 2000 systems for a PV installation in Israel. In the United States, examples of installations are 4 2-kW Series 2200 PV power conversion units for Arizona Public Service, Tempe, Arizona, and a 60-kW Series 3000 PV power conversion system for an office complex in San Diego, California.

OMNION POWER
ENGINEERING
CORPORATION

Pawling Corporation

157 Charles Colman Blvd.
Pawling, New York 12564
Telephone: 914-855-1000
Telex: 646720
Fax: 914-855-1937

*Chief Executive Officer: Mr. Roger W. Smith
International Sales Manager: Mr. Stephen J. Smith*

Equipment or Systems Characteristics

Pawling Corporation, (PC), does custom molding and extruding of the specialized materials necessary for solar applications. Examples are: silicone glazing gaskets for high temperatures needed for high efficiency panels, EPDM glazing gaskets for high temperatures used on medium range collectors, and EPDM or silicone grommets and header seals for all temperature conditions. PC offers engineering and design services.

Experience and Operations

PC was established in 1946 and grosses in excess of \$1 million annually. PC has had 12 years of experience in working with and field testing products in solar applications.



Phelps Industries, Inc.

P.O. Box 1093
Little Rock, Arkansas 72203
Telephone: 501-375-1141
Telex: None
Fax: 501-375-6568

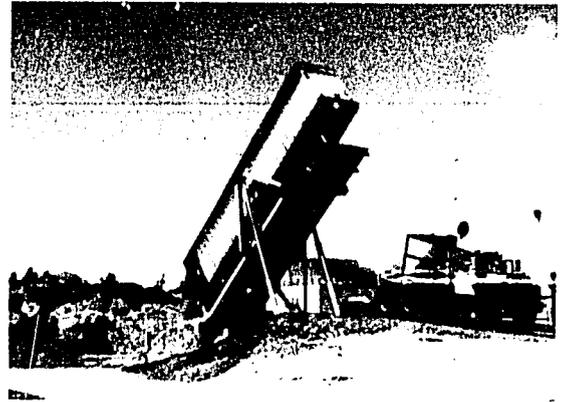
Chief Executive Officer: Mr. Ivo Phelps
International Sales Manager: Mr. Charles Peterson

Equipment or Systems Characteristics

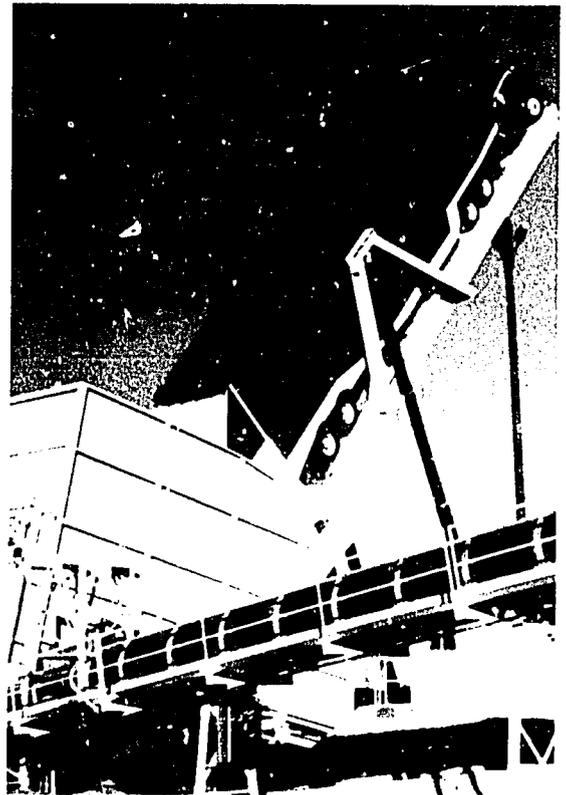
Phelps Industries, Incorporated, (PII), manufactures hydraulic truck dumpers, hydraulic cylinders, and live-bottom receiving hoppers for handling bulk materials. One of PII's truck dumpers has a 19.8-m (65-ft), 63-degree tilt and a 68-t (75-ton) capacity and employs an extended arm for use with an above-grade mounted hopper. One of the hopper systems has a 136-m³ (4,800-ft³) capacity with an above-grade, live-floor hopper having 6 strands of drag chain, a single-speed drive, and an adjustable-height gate for varying the amount of material taken out of the hopper. This works well on wood chips, bark, and other biomass fuels.

Experience and Operations

PII was established in 1923 and now grosses in excess of \$1 million annually.



This 12-m (40-ft) standard pivot trailer dumper is used for dumping product to the ground. (Courtesy Phelps Industries, Inc.)



Hydraulic 21-m (70-ft) truck dumpers dump into live-floor receiving hoppers. The hoppers have a 113-m³ (4000-ft³) capacity and use a six-chain drag system to convey wood chips. (Courtesy Phelps Industries, Inc.)

Photocomm, Inc.

7735 E. Redfield Road
Scottsdale, Arizona 85260
Telephone: 602-948-8003
Telex: 823165
Fax: 602-483-6431

Chief Executive Officer: Mr. Bob Kauffman
International Sales Manager: Mr. Lee W. Tanner

Equipment or Systems Characteristics

Photocomm, Incorporated, (PI), is a large systems house distributor of a wide range of PV products. Whereas many firms concentrate on module and component sales, PI supplies complete, ready-to-install systems worldwide. Other vendors' components are selected for use in these systems. Applications are: the Basic Cabin System of 94 W (0.4 kWh/day average) for electricity generation and storage for small residential lighting and small 12-volt DC appliances with 10-year warranty (1 year on battery); the Intermediate Home Power System of 282 W (1.5 kWh/day average) of electricity generation with 10-year warranty on modules and supports, 2-year warranty on controls and batteries; and the Pump System No. 1 for low-flow-rate medium-head water pumping complete with solar power generator. This delivers 3.79-7.57 L/min (1-2 gal/min) of water with heads up to 200 ft. Warranty is for 10 years on power generator, 1 year on pump. Balance-of-system components offered are: a 5-ampere regulator/controller for small 1-2 panel solar systems; 10-, 20-, and 30-ampere regulator/controllers, ranging from use for small-to-medium size battery charging and load control up to full system control for up to 10 panels or as a sub-array control; water pump controller in 60-, 90-, and 180-ampere configurations to maximize pump output volume. Custom, large-capacity control units (Centrix Series) are available also.

Experience and Operations

PI was formed in 1981 and grosses in excess of \$6 million annually. PI has installed 22 systems of either 200 W, 240 W or 280 W capacity for lighting and refrigeration in the U.S. Trust Territories of the South Pacific. PI has also installed 52 systems (22 kW total) in Zaire for lighting systems for residences and medical dispensaries of Project Isros of the Methodist Church. Another 44 systems (360 W) were installed in Morocco for Ford Aerospace. Village power of 440 W was installed for Walden International in Mexico. Eight telemetry systems were installed for Willoglen, Ltd. Canada. In the United States, a full system of merit consists of solar modules, control regulators, etc. for the Onyx Peak Telecommunication Power System, San Bernardino County, California. This provides 7.1 kW of power generation and storage for a telecommunication repeater.



PHOTOCOMM INC.
PHOTOVOLTAIC SYSTEMS

Photron, Inc.

77 West Commercial Street
Willits, California 95490
Telephone: 707-459-3211
Telex: None
Fax: 707-459-2165

Chief Executive Officer: Mr. Laurence Jennings
International Sales Manager: Mr. Keith Rutledge

Equipment or Systems Characteristics

Photron, Incorporated, (PI), specializes in design and integration of electrical systems and manufactures a complete line of PV and genset balance-of-system components, such as PV mounting structures, charge controllers, AC/DC switch gear, AC/DC load distribution transfer switches, batteries, battery chargers, generator controls, power monitoring systems, and prefabricated power systems for remote stand-alone operations.

PI also offers complete "Photogenset" packaged electrical power systems containing an ARCO Solar PV array, an Onan generator, a Photron battery charger, a Photron battery bank, and a Trace inverter which produces 12, 24, or 48 volt DC and 120/240 volt AC power ranging from 40 to 23,000 W in size. "Gencharger" packaged systems are available which provide all of the above without a PV array; "Solectric" packaged systems omit only the generator from the above. Warranties on PV modules are for 10 years, and on batteries and controllers, 5 to 10 years.

Experience and Operations

PI was established in 1983 and has sold about 2000 PV or PV/genset systems. Examples of installations abroad are a Photogenset system for a remote resort in the British Virgin Islands and another for an ice plant in Cairo, Egypt. Stand-alone PV lighting was installed for a residence in the Marshall Islands, and a PV lighting, refrigeration, and computer operation was installed for the World Health Organization in Africa. In the United States, a system of merit is the Photocogenset at Caples Lake, California. This is a PV-diesel cogeneration hybrid system with a capacity of 30 kW PV and 125 kW of cogeneration. Both electricity and thermal energy are produced. This system was given a National Energy Award by the U.S. Department of Energy and a State Energy Award by the California Energy Commission for innovative energy technology advancement.

PI has developed a system design software package called SYSTEM-SPEC. The software runs on IBM operating systems, and is supplied on floppy disks for use with standard personal computers.

PI maintains an office in Canada, P.O. Box 136, Colinton, Alberta, T06 0R0, Attention: Mr. Ron LaPlace, Telephone: 403-675-2586, Fax: 403-675-2634.



POWER SYSTEMS

Power Kinetics, Inc.

415 River Street, 4th Floor
Troy, New York 12180-2822
Telephone: 518-271-7743
Telex: 6007222
Fax: 518-271-0782

Chief Executive Officer: Mr. Robert J. Rogers, President

Equipment or Systems Characteristics

Power Kinetics, Incorporated, (PKI), does engineering for special solar applications which require high flux, solar densities. Receivers are designed which direct highly concentrated sunlight to focal points of PKI's special parabolic concentrator, termed the "Square Dish." The systems are closed loop and free of contaminants. Applications are, for example:

- A 40-kW, grid-connected, solar-thermal electric power module, which uses: 300 m² (3,230 ft²) of collector area for a Square Dish with water management system; one 4-cylinder reciprocating steam engine; and a 50-kW, 3-phase, 6-pole alternator.
- An 80-kW, standalone, solar-thermal power module, which uses: a 600 m² (6,460 ft²) collector (2 Square Dishes) with water management; 2 4-cylinder, reciprocating steam engines; a 90-kW, 3-phase, 6-pole alternator; a 60-kW, DC generator and motor; a AC-DC rectifier, a battery bank, and a 4-cylinder diesel generator.
- A 240-kW, grid-connected, solar-thermal power module, which uses: 1,800 m² (19,400 ft²) of collector (6 Square Dishes) with water management system; 2 6-cylinder reciprocating steam engines; a 250-kW, 3-phase, 6-pole, 480-volt alternator.
- Industrial steam generation using a 300-m² (3,230-ft²) collector with sealed glass reflectors, a steel or aluminum structure, a 2-point polar axis mount, and a high-pressure receiver.

Other applications include chemical reactions at the focal point of the receiver by using photochemical and/or thermochemical processing. The "open architecture" of the Square Dish permits its adaptation to most commercial requirements, as well as laboratory testing. For each of the foregoing, systems collectors are warranted for 3 years, auxiliary components and parts for 1 year.

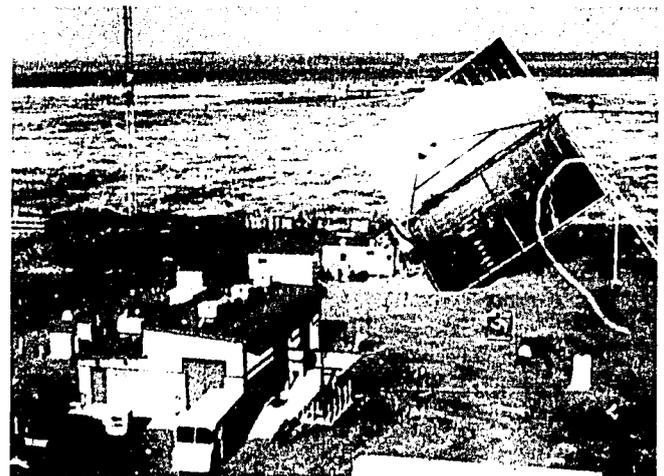
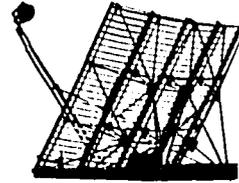
The specific products supplied by PKI are:

- Point-focusing solar collectors (termed Square Dish) or licenses to manufacture them. The Square Dish uses sealed, laminated glass mirrors, is polar axis mounted, and tracks on 2 axes. Maximum thermal output is 280 kW. For saturated steam, it normally operates at 288°C (550°F) under 6,550 kPa (950 psi) with a flow of 318 to 408 kg/h (700 to 900 lb/h). Annual sun-to-electrical efficiency is rated 12.5 percent, or 18 percent peak when paired with PKI's steam engines.
- Four-cylinder, single-acting, reciprocating steam engines (with lubricating system).
- Fossil boilers with superheater and economizer (termed Hybrid Oil Boiler) or licenses to manufacture them. This is an oil-fired burner with vertical passage through 3 spiral tube bundles. The economizer tube bundle is in the flue; the superheater with separate burner is below the boiler tubes. This boiler can also be modified to accommodate biomass fuels. Full specifications for these 3 products are available from PKI.

Experience and Operations

PKI was established in 1979 and grosses \$1 million annually. PKI manufactures products in Australia as well as in the United States. PKI participated in the joint USA/Saudia Arabia SOLERAS project at Yanbu, Saudi Arabia, by using Square Dishes with Syltherm oil heat transfer fluid for a seawater desalination process.

Power Kinetics, Inc.



Power Kinetics, Inc. 300-m² (3293-ft²) Square Dish under test in New Mexico consists of 392 hermetically sealed glass mirrors, each measuring 63.5 cm by 122 cm (25 in. by 48 in.). (Courtesy Power Kinetics, Inc.)

PRM Energy Systems, Inc.

Box 855
Stuttgart, Arkansas 72160
Telephone: 501-673-2546
Telex: 536-038
Fax: 501-673-2564

Chief Executive Officer: Mr. Ron Bailey
International Sales Manager: Mr. James Chua,*

Equipment or Systems Characteristics

PRM Energy Systems, Incorporated, (PRM), markets a gasification/combustion system which burns rice husks and other agricultural residues such as peanut shells, straw, cottonseed hulls, and wood wastes, including barks, chips, and sawdust, to produce process steam, process heat, and electric power. Systems with turbine generator range from 200 kW to 10 MW in electric capacity. The patented technology can be implemented quickly in remote areas to provide energy for industry or villages.

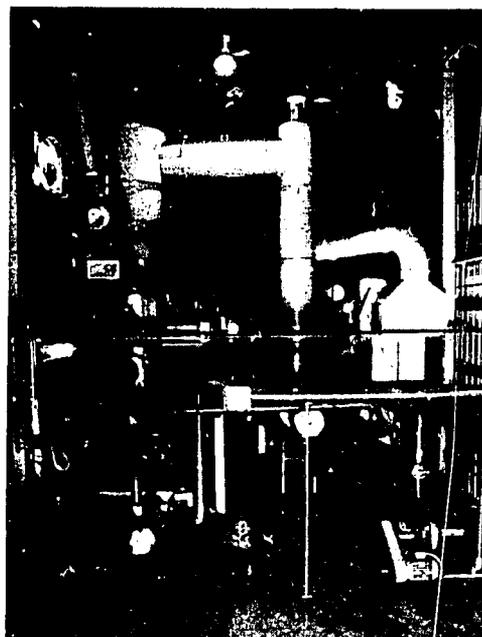
Two PRM reactors at the PRM Rice Mill in Arkansas burn rice husks. One unit burns 4,000 lb/h producing a clean hot gas stream at 1204°C (2200°F) to fire a close-coupled boiler which produces 6,800 kg/h (15,000 lb/h) of process steam. The boiler exhaust is clean and is utilized for rice drying. The second reactor burns 2,270 kg/h (5,000 lb/h) to produce heat for rice drying. The patented King-Chastain energy reactor is a cylindrical steel shell that has a reduced diameter in its upper portion and is lined with a high temperature castable refractory. The combustion takes place on a fixed bed that is mechanically agitated or fluidized. A two-stage combustion control prevents the ash from slagging and enables thermal cracking of tars and hydrocarbons. Ash is removed by water cooled discharge screws and conveyed to a packaging system. The packaged ash is sold as an absorbent and as an insulating topping for steel mills.

Experience and Operations

PRM, established in 1984, was formerly a subsidiary of Producers Rice Mills, Inc., which operates one of the world's largest rice processing complexes; it handles 1.06 million m³ (30 million bu) annually. This PRM mill has used the rice husk-to-energy system described above since 1982 with large savings in fuel costs and substantial income from sale of ash. Based on such proven performance, the recently formed PRM firm already grosses over \$3 million annually and manufactures its systems in Malaysia, the Philippines, Singapore, Indonesia, India, and Australia.

The Malaysian Padi Board has installed 3 PRM energy systems. Each unit burns rice husks to provide heat for drying and production of 400 kW of electricity. Another PRM system in Australia burns rice husks to provide heat for drying.

* Address: PRM Energy Systems (S) PTE, Ltd., 1 Scotts Road, 25-10 Shaw Centre, Singapore 0922, Telephone: 65-737-7988
Fax: 65-737-7948.



PRM Energy Systems, Inc. rice husk-fired reactors firing a boiler and rice dryers at a large U.S. rice mill. Fuel savings and ash sales amount to \$2 million annually. (Courtesy PRM Energy Systems, Inc.)



One of three PRM Energy Systems, Inc. rice husk-fired padi drying plants in Malaysia in which clean direct heat from rice husks is applied to two 27-t/h (30-ton/h) continuous flow dryers. The PRM systems replace fuel oil by burning renewable agri wastes. (Courtesy PRM Energy Systems, Inc.)

R. Lynette & Associates, Inc.

15042 NE 40th Street, Suite 206
Redmond, Washington 98052
Telephone: 206-885-0206
Telex: None
Fax: 206-881-8468

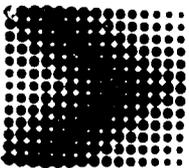
Chief Executive Officer: Mr. Robert Lynette
International Sales Manager: Mr. Dan Seligman

Services Offered

R. Lynette & Associates, Incorporated, (RLA), is a specialized consulting company that provides a range of engineering and financial services to the international renewable energy industry, particularly in the field of wind power. RLA also assists developers in the United States and abroad in project planning and design configurations of wind power, PV, and solar thermal energy systems.

Experience and Operations

RLA was established in 1979 and grosses in excess of \$2 million annually. RLA monitors the performance and reliability of the California wind turbines for the U.S. Department of Energy and the Electric Power Research Institute.



R. LYNETTE & ASSOCIATES

Radco Products, Inc.

2877 Industrial Parkway
Santa Maria, California 93455
Telephone: 805-928-1881
Telex: 658340 or 295298 Intertel SNC
Fax: 805-928-5587

Chief Executive Officer: Mr. George O. Radford

Equipment or Systems Characteristics

Radco Products, Incorporated, (Radco), manufactures and sells a complete line of medium temperature, metallic, solar collectors used primarily to generate residential hot water or to heat swimming pools. Standard sizes of collectors range from 1.5 m² to 4.5 m² (16.1 ft² to 48.4 ft²). Mounting racks, mounting hardware, frames, boxes, and absorbers are supplied. For countries that have manufacturing facilities, Radco can provide component parts which can be partially fabricated and assembled on site. Prefabricated absorbers can be supplied to countries that choose to make collector boxes locally. Radco will also provide expertise and machinery to enable assembly of custom-size absorber components (header manifold and tube and fin sections).

Radco's high performance collectors have an absorber plate with either a non-selective paint surface or a selective black chrome surface. The latter produces higher temperatures and retains more heat than the former. Fins are either fusion-solder bonded to the

waterways or have a wrap-around structure. The higher temperature models use EPDM gaskets and R-10 insulation with the addition of fiberglass blankets to resist high temperatures due to stagnation. Radco also provides engineering and design services.

Experience and Operations

Radco was formed in 1925 and grosses in excess of \$1 million annually. Sales average 6,500 collectors and 24,500 m² (264,000 ft²) annually. Radco is a principal supplier to the Arab Organization for Industrialization, Helwan, Egypt. Radco recently supplied 2,000 m² (21,500 ft²) of absorber plates for a 1,000-unit, residential, hot water installation for the Helwan area. The customer constructed the collectors using local materials for the collector boxes.



Ramada Energy Systems Limited

1421 S. McClintock Drive
Tempe, Arizona 85281
Telephone: 602-829-0009
Telex: None
Fax: None

Chief Executive Officer: Mr. Richard Bingmann
International Sales Manager: Mr. Vincent J. Marziani

Equipment or Systems Characteristics

Ramada Energy Systems Limited, (RES), manufactures a low-cost, medium-temperature, unbreakable solar collector which is unique in that it uses polycarbonate glazing technology. Direct purchase, joint venture, and technology transfer are offered to developing country prospects. Engineering and design services are also offered. The basic collector is 0.6 m by 3.0 m (2 ft by 10 ft) with twin-wall polycarbonate glazing, and a copper absorber plate. Extensive use of polymers for support structure and other parts is employed. The collector is modular and can be grouped into various arrays. Panels can also be manufactured to any length desired, allowing designs of arrays for special situations. Modules are equipped with a recirculation pump, controller, and sensor, and may have a closed-loop drainback system for positive freeze protection. The most common application is for providing domestic hot water. Collectors have a 5-year warranty and components, 1 year.

Experience and Operations

RES was established in 1980 and grosses in excess of \$1 million annually. Some 17,000 systems have thus far been installed. A typical installation is that of 100 systems for domestic hot water for Bowen Homes — The Islands, Chandler, Arizona.



Raphael Katzen Associates International, Inc.

7162 Reading Road, Suite 1200
Cincinnati, Ohio 45237
Telephone: 513-351-7500
Telex: 810-461-2930 KATZENASSOC UD
Fax: 513-351-0810

*Chief Executive Officer: Dr. Raphael Katzen
International Sales Managers: Mr. Bipin S. Shroff, Mr.
Philip W. Madson*

Services Offered

Raphael Katzen Associates International, Incorporated, (RKAI), provides consulting engineering and technical management services related to production of ethanol. These services include research and development evaluations, process development, technical and economic studies, design of new plants, improvement of existing installations, training of client staff for new operations, and assistance with technical problems.

Experience and Operations

Established in 1953 as an extension of predecessor Raphael Katzen Associates, RKAI conducts business in excess of \$1 million annually. Since construction of Dr. Katzen's wood hydrolysis plant for the Defense Plant Corporation in 1945 and the motor fuel grade ethanol plant for the Arechabala Sugar Company in 1947, the Katzen firms have supplied commercially proven, efficient ethanol technology, including fermentation, distillation, and dehydration. The latest major project is the South Point Ethanol plant built in South Point, Ohio. RKAI has completed 41 successful alcohol projects in the Western Hemisphere, ranging in capacity from 7.6 to 227 million L/yr (2 to 60 million gal/yr). These span a wide range of feedstocks (such as molasses and grains) and all production grades of ethanol. RKAI is organized to provide services worldwide. It is represented in Switzerland to serve the European Economic Community and Western Europe, by Geo Resources Conservation S.A., CH-6900 Lugano-Paradiso, Via F. Zorzi 41, Switzerland; Dr. Francesco Salimbeni, President, Telephone: (91) 542472. Telex: 841299 GRC CH. Fax: 011 41 (91) 549571.

RKAI also serves a wide variety of other industries besides ethanol, e.g., agriculture, chemicals, pulp, sugar, cryogenics, and electronics.

RKAI

Second Wind, Inc.

880 Lombard Street
San Francisco, California 94133
Telephone: 415-885-4447
Telex: 650-294-5660
Fax: None

*Chief Executive Officer: Mr. Walter Sass
International Sales Manager: Mr. Dan Mayhew,
General Manager**

Equipment or Systems Characteristics

Second Wind, Incorporated, (SWI), markets wind data and wind turbine monitoring equipment. SWI designs and manufactures its equipment for analysis and operation of wind-driven power plants. The products offered include:

- The AL-2000 series data loggers which measure and record wind speed and direction information for assessing wind as an energy source. Data are stored on solid-state memory chips that interface directly with a microcomputer. Field installation and maintenance require no special training or education.
- The Communicating Turbine Monitor which monitors generators and facilitates operations by a centralized computer that handles up to 255 wind turbines. Software is available for remote contact with the operation site.

Experience and Operations

SWI was formed in 1980 and grosses between \$500,000 and \$1 million annually. The Communicating Turbine Monitor system currently monitors 16 different types of turbines among 10 locations worldwide. There are over 600 AL-2000 series data loggers in use worldwide. They have been installed in many developing countries, including Barbados, Brazil, Chile, Egypt, Honduras, India, Kuwait, Mexico, Morocco, Panama, Thailand, and Tunisia as well as in many developed countries.

* Address: Second Wind, Inc., 7 Davis Square, Suite 9, Somerville, Massachusetts 02144, Telephone: 617-776-8520, Telex: 650-294-5660, Fax: 617-776-0391.

SECOND WIND



Wind speed and direction can be monitored and recorded with this instrument to assess specific locations as wind energy sources. (Courtesy Second Wind, Inc.)

Skinner Engine Company

P.O. Box 1149
Erie, Pennsylvania 16512
Telephone: 814-454-7103
Telex: 91-4481
Fax: 814-454-7108

Chief Executive Officer: Mr. Gerald A. Ryan
President: Mr. Robert M. Sok
Contact Person: Mr. Frederick A. Prah, III

Equipment or Systems Characteristics

While Skinner Engine Company, (SEC), will still build traditional vertical steam engines — 7 models to 833 MJ/h (310 brake HP), to 2,410 kPa (350 psi) inlet steam pressure, 345 kPa (50 psi) through full condensing exhaust for customers who desire them, the company is developing a new series of significantly smaller, less expensive engines — to 2,148 MJ/h (800 brake HP), to 4,140 kPa (600 psi). The old series is of slow speed, piston valve, predominantly single cylinder (some duplexes available) design. The new series is of medium speed (1,200 to 1,800 rpm), poppet valve, multi-cylinder (2 to 16) design.

Generating sets are available: the old series with belt or gear box speed increasers, the new series with direct drive. Steam can be generated by burning wood, rice hulls, bagasse, coconut husks, or other biomass in either manually or automatically loaded furnaces. SEC is also preparing to make available the complete system including boiler and combustion/furnace components.

Experience and Operations

SEC has been building steam engines since 1868; many 50-year old (or older) units are still in operation. It has a line of steam turbines up to 8,060 MJ/h (3,000 brake HP) and Unaflo engines up to 16,100 MJ/h (6,000 brake HP). Skinner systems presently provide electric power at many sites around the world. Typical applications are in processing mills, rural industries, and adjacent villages. In Fiji, coconut processing facilities use SEC systems for 15 kW and 70 kW electric power generation. SEC can arrange for turnkey installations or component parts, with engineering by local firms or U.S. groups.

Solar Development, Inc.

3630 Reese Avenue
Riviera Beach, Florida 33404
Telephone: 407-842-8935
Telex: None
Fax: None

Chief Executive Officer: Mr. Donald J. Kazimir
International Sales Manager: Mr. Donald J. Kazimir

Equipment or Systems Characteristics

Solar Development, Incorporated, (SDI), manufactures a full line of flat-plate solar collectors for use in domestic hot water, space-heating, and industrial process-heat applications. Systems are sized with the aid of a computer.

SDI's unique freeze protection system was patented and sold to Rheem Manufacturing Company. SDI offers the Pacemaker, Sunstar, and Sunraker models for various applications. The Pacemaker has a thermally operated valve which provides freeze protection without the need for electric power. Sunstar is a closed-loop, residential, solar water heater for use in northern climates; it utilizes a heat exchanger that does not deteriorate. The Sunraker is a residential solar water heater with a long-lasting DC pump driven by a PV panel. Each comes in a variety of sizes from 2.97 m² to 7.43 m² (32 ft² to 80 ft²). Warranties on the solar panel are for 10 years, and on other components, 5 years. These have been given the highest rating by the Florida Solar Energy Center. Hot water tanks, ranging in size from 246 to 454 L (65 to 120 gal), are available and are equipped with a 4,500-W, back-up heating element. Differential controllers, circulating pumps, and timers are also provided.

Experience and Operations

SDI was established in 1974. Gross receipts approach \$500,000 annually. About 69,700 m² (750,000 ft²) of SDI collectors have been installed. An installation of merit is the SD6A solar collector array of 109 m² (1,171 ft²) for space heating at The Tennessee Valley Authority, Gilbertsville, Kentucky. This system is one of the highest rated in America; the collectors are warranted for 10 years. System design and with engineering services are available to all customers.

SDI



The 1.2 m by 3.0 m (4 ft by 10 ft) solar collector mounted on the roof of this home in Florida supplies a 303-L (80-gal) hot water tank. (Courtesy Solar Development, Inc.)

Solar Electric Engineering, Inc.

175 Cascade Court
Rohnert Park, California 94928
Telephone: 707-586-1987
Telex: None
Fax: 707-586-0690

Chief Executive Officer: Mr. Gary Starr
International Sales Manager: Mr. Rod Catalano
Intercontinental Solar

Equipment or Systems Characteristics

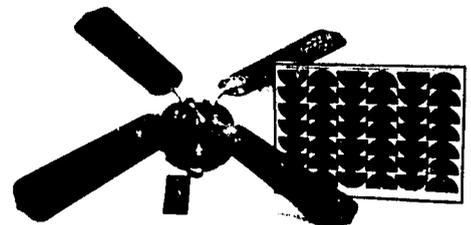
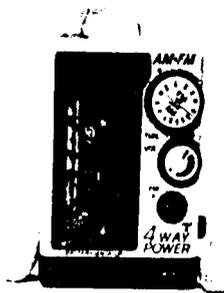
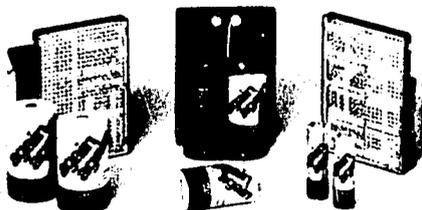
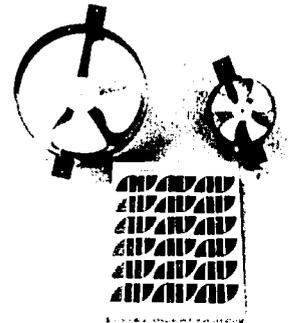
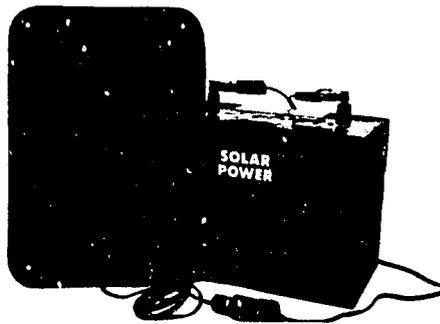
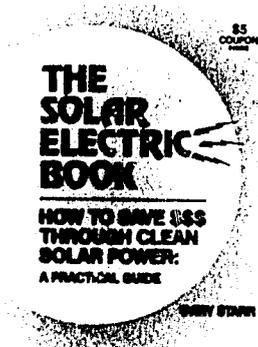
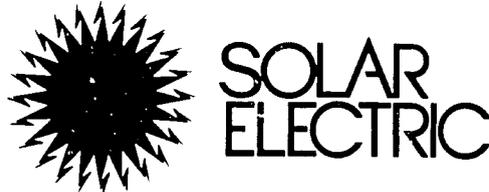
Solar Electric Engineering, Incorporated, (SEEI), is a manufacturer and distributor of solar-electric consumer products and complete power systems ranging from solar-powered flashlights to solar water pumps, solar fans, solar refrigerators or complete solar-powered homes and villages. The solar water pump can pump water from 30.5-m (100-ft) depths to a 122-m (400-ft) height above grade. Warranty is for 5 years. A basic solar cabin system provides 23 W/h. It includes panel, battery, and charge controller, and provides basic power for lighting, radio, and television. Warranty is for 5 years. Solar-powered battery chargers are available for any size portable batteries for flashlights, radios, lanterns, cameras, etc. Any size module ranging in size from 1.6 volts and 70 milliamperes, to 15 volts and 20 amperes can be custom made. Thin films or crystalline cells can be used. SEEI supplies over 100 compo-

nents and subsystems, including inverters, charge controllers, and stationary or tracking racks. Engineering and design services, patented technology for joint ventures, system installation, service agreements, and financing are available. Instructional books and videos are also available.

SEEI has designed many solar hot water systems ranging from small, low-cost, do-it-yourself systems to large commercial swimming pools and industrial hot water systems.

Experience and Operations

SEEI was established in 1976 and grosses in excess of \$1 million annually. Production is carried out in the United States. An office abroad is maintained at Intercontinental Solar, Attention Mr. D. LaRogue, Sodhia Amtipolis, 2740 Rote De St. Barnard, 06220 Val-lavris, France, Telephone-93-653232, Telex-470900, Fax-93-654142.



Photovoltaic conversion of solar energy to electric power permits the manufacture of many solar powered consumer products such as battery chargers, fans, and radios. (Courtesy Solar Electric Engineering, Inc.)

Solar Electric Systems, Inc.

2700 Espanola NE
Albuquerque, New Mexico 87110
Telephone: 505-888-1370
Telex: None
Fax: 505-884-8077

Chief Executive Officer: Mr. Paul Verchinski
President: Mr. Stefan Verchinski
International Sales Manager: Mr. Pierre Gebarra
Central American Sales Representatives: Mr. Ricardo
Alfredo Belloso, Mr. Humberto Prieto**

Equipment or Systems Characteristics

Solar Electric Systems, Incorporated, (SES), provides materials and systems, specification writing and proposals, project management and installation, and operations and maintenance handbooks. Training is available. Applications are for governmental agencies and private groups and include communications (telephone, telemetry for satellites), village or hospital power micro-utility systems, water systems for poor-producing household wells and low-head, gravity-drip irrigation systems, and home power lighting and refrigeration. SES has the ability to provide foreign language translators to define problems and communicate (a Fax letter is requested for 48-hour notice of language need and conference calls).

Examples of systems include the following:

- A 630-W, 12-volt DC system for an 74.3-m² (800-ft²) home with options for lights, appliances and refrigerator.
- A solar pack system which provides charging and battery power for laptop computers such as the Apple IIC. This is a typical system purchased by the Peace Corps in Katmandu, Nepal. Warranty is for 1 year.
- Basic DC modules constructed from single crystals or flexible thin films on stainless steel, sealed batteries, regulator, rack, and 2 fluorescent lights with spare bulbs and ballasts. The largest module of the single-crystal type is 90 W, that for the thin film, 7 W. Warranties are for 1 year.
- A portable PV generator for water purification via microfiltration. Size varies from 1 to 9 L/min (0.26 to 0.37 gal/min) for household use to 5 to 90 L/min (1.32 to 23.8 gal/min) for industrial applications. Affiliated products include solar stills and site-built solar ovens. Instructions are available in Spanish and will soon also be available in Arabic.

Experience and Operations

Established in 1982, SES approaches gross sales of \$500,000 annually. It maintains Central American contacts in Sonsonate, El Salvador and Puebla, Mexico. It has provided design work for installations ranging from a 100-kW, micro-utility to an 8-kW radio station in the Dominican Republic. Many unique water-irrigation systems have been field tested such as the Los Ojos Rancho in Santo Rosa, New Mexico, where a 2-kW, tracking-PV system powers 2 DC submersible pumps directly for 1,000 head of cattle.

* Address: Central American Representatives: 7a Av. Norte No. 4-1, Sonsonate, El Salvador C.A., Telephone: (011)(503)513613;

Mariner Comunicaciones, Retorno Pitagoras Num. 24 1-C, Col. Valle de Sol, P. O. Box J-19, Ciudad de Puebla, Puebla, Mexico, Telephone: 350962.



Solar Engineering, Inc.

1210 Homann Drive SE
Lacey, Washington 98503
Telephone: 206-438-2110
Telex: 288860 SES UR
Fax: None

Chief Executive Officer: Mr. Timothy Ball
International Sales Manager: Mr. Chris Holz

Equipment or Systems Characteristics

Solar Engineering, Incorporated, (SEI), manufactures, distributes, and engineers stand-alone PV power systems for applications including water pumping, telecommunications, refrigeration, village power, battery charging, lighting, and hybrid PV/diesel systems. The product line includes PV modules, support structures, batteries, controls, metering, generators, water pumps, refrigerators, lights, appliances, and packaged systems for common applications. SEI provides professional engineering services, including drawings, manuals, training, trouble shooting, technical assistance, and installation of systems. Training in stand-alone PV is available at SEI facilities or in the host country using a complete handbook on PV applications, written in part by SEI. In assembling its systems, SEI uses components from a wide variety of well-known manufacturers.

Experience and Operations

SEI was established in 1981 and grosses between \$500,000 and \$1 million annually. It has installed many systems abroad. Water pumping systems, for example, have been installed in Antigua, West Indies; 3 locations in Roatan Island, Honduras; Marrakech, and Taroudannt, Morocco; Tern Island, French Frigate Shoals, Central Pacific. Telecommunications, monitoring, and alarm systems have been installed in at least a dozen U.S. locations for branches of the U.S. government (National Forest, Coast Guard, Army, Federal Aviation, Bonneville Power, National Oceanic and Atmospheric Administration), some states, and power utilities.

 **Solar Engineering**

Solar Power Engineering Company

P.O. Box 91
Morrison, Colorado 80465
Telephone: 303-697-8144
Telex: None
Fax: 303-781-7568

Chief Executive Officer: Mr. H. C. Wroton

Equipment or Systems Characteristics

Solar Power Engineering Company, (SPECO), does design and development work on solar-thermal systems and PV systems. SPECO can design, develop, and deliver components such as heliostats or a molten salt receiver or complete systems such as the concentrating PV system at Riyadh in Saudi Arabia which was developed by SPECO's predecessor, Martin Marietta Solar Energy Systems. SPECO continues the solar power technology work and developments of Martin Marietta Corporation under an exclusive license agreement. Most SPECO personnel have direct experience in solar projects accomplished by Martin Marietta.

SPECO offers engineering and design services on all aspects of concentrating PV systems. Capabilities include the following: overall plant sizing, layout, design, and performance analysis; design, fabrication, installation, and checkout of concentrating PV modules and trackers; design, specification, and installation of balance-of-system components; and control system analysis and design for the total plant.

SPECO also offers engineering and design services on all aspects of solar-thermal, central-receiver systems with emphasis on heliostats, molten salt receivers, and thermal storage systems, and control systems. Capabilities include the following: overall plant sizing, layout, design, and performance analysis; heliostat design, fabrication, installation, and checkout; design, analysis, and specification of molten salt receivers and thermal storage systems; specification and analysis of components for molten salt systems (valves, pumps, piping, instrumentation); control system analysis and design for the total plant with emphasis on the heliostat field and molten salt receiver and thermal storage system; and system and component testing.

Experience and Operations

SPECO has performed solar power engineering and development work under contract to the U.S. Department of Energy (as a subcontractor to Arizona Public Service Co.), Sandia National Laboratories, the Solar Energy Research Institute, and the Electric Power Research Institute (as a subcontractor to Bechtel National, Inc.). Work under these contracts included designing and building of the world's largest heliostat, performing conceptual design studies of advanced concepts for molten salt central receivers, participating in the on-going study of a solar central receiver for a utility, and developing heliostat-aiming strategies for both cavity and external receivers. SPECO is presently developing an advanced tracker for high-concentration PV modules.

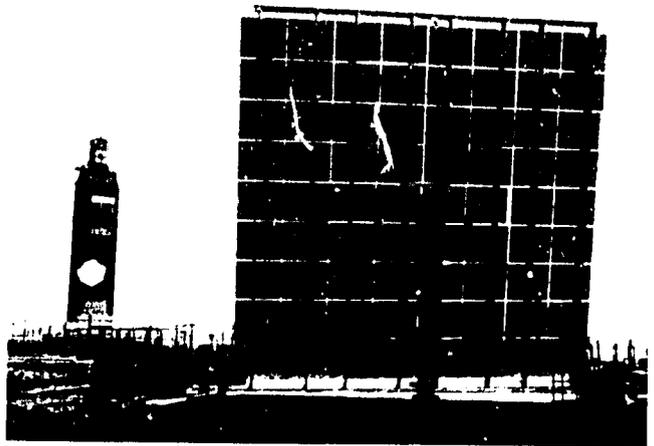
Martin Marietta Solar Energy Systems, the predecessor to SPECO, designed, built, and installed complete concentrating PV systems at Riyadh in Saudi Arabia and Sky Harbor Airport in Phoenix, Arizona. Martin Marietta subsequently developed a second-generation, concentrating, PV tracker under contract to Sandia National Laboratories, and worked on the design of a high-concentration PV system using a heliostat-type tracker. In the

solar-thermal area, Martin Marietta Solar Energy Systems designed, built, and installed the heliostat fields at Sandia-Albuquerque, New Mexico, and Almeria, Spain, and a molten salt receiver and thermal storage system for testing at Sandia-Albuquerque.

SPECO was organized in 1984 to continue the work done by Martin Marietta during 1974 to 1984. At present, SPECO's operations gross less than \$500,000 annually.



SOLAR POWER ENGINEERING COMPANY, INC.



SPECO's 200-m² (2150-ft²) heliostat at Sandia National Laboratory test facility in New Mexico. (Courtesy Solar Power Engineering Company)

Solar SignAge, Inc.

9806 Mula Road
Stafford, Texas 77477
Telephone: 713-933-1578
Telex: None
Fax: 713-933-0100

Chief Executive Officer: Mr. William Paul Cantrell
International Sales Manager: Mr. Kevin L. Conlin

Equipment or Systems Characteristics

Solar SignAge, Incorporated, (SSA), has developed and manufactures a broad line of solar products, including architectural quality solar sign systems, completely self-contained industrial solar generators, solar lights, solar powered security systems, solar billboard lighting systems, an expandable line of solar timers and controllers, a standard line of battery enclosures for solar or other applications, and solar powered water pumping systems for agricultural and export markets. SSA's SUN PAK generators range in size from 5 to 318 watts; warranty is for 5 years. Freedom Series sign systems come in 12 different sizes; warranty is for 2 years. Generally, SUN PAK and Freedom signs are custom-manufactured for each application. The automatic system controller offered includes a PV shunt regulator with temperature compensation circuit breaker, a 16-hour timer, high and low voltage disconnect, photo-eye, light-emitting diode indicators, and temperature sensors to provide complete control over solar power system lights or other loads.

SSA offers engineering and design services, patented technology for joint ventures, system installation, and service agreements.

Experience and Operations

SSA was established in 1986 and grosses over \$500,000 annually. SSA maintains an office in Belgium: Professional Geophysics, Inc. Belgielei 78, 2018 Antwerpen, Belgium, Attention: Mr. Joseph M. Putcuyps, Telephone: 323-230-9859, Fax: 323-225-2712.

SSA has supplied its solar powered SUN PAK generators for aircraft telecommunications and tower lighting systems in Panama and Honduras for crop dusting applications. SSA is presently supplying complete solar powered lighting systems and radio equipment for 9 health clinics and 2 hospitals in Liberia.

Solar Tek

4310 Wiley Post Road
Aircraft Hanger 4310-206
Addison Airport
Addison, Texas 75244
Telephone: 214-235-8537
Telex: 251621 DISINT
Fax: 214-701-8744

Chief Executive Officer: Mr. James Robert Seidel
International Sales Manager: Mr. Richard Thorburn Walling

Equipment or Systems Characteristics

Solar Tek, (ST), provides solar-light systems for special uses such as barricade safety lights and identification lights for wind socks at airports. The "solar light" is an 18- or 35-W, low-pressure, sodium light with a 7-year light filament and a 5-year battery. Warranty is for 1 year. This system is claimed to be extremely durable. Regulators for 111 and 222 W are also offered. ST also sells and installs solar-powered cellular communication systems, and can design any solar power system utilizing AutoCad Version Dos9 for installation worldwide.

Experience and Operations

ST was formed in 1986 and grosses less than \$500,000 annually. ST is providing 750 units for 34.6 km (21.5 miles) of solar lights in the Texas coastal zone. A national seashore project for 210 km (125 miles) is in progress.

Solarex Corporation

1335 Piccard Drive
Rockville, Maryland 20850
Telephone: 301-948-0202
Telex: 64-358
Fax: 301-948-7148

Chief Executive Officer: Mr. John Corsi
International Sales Manager: Mr. John Cebrowski

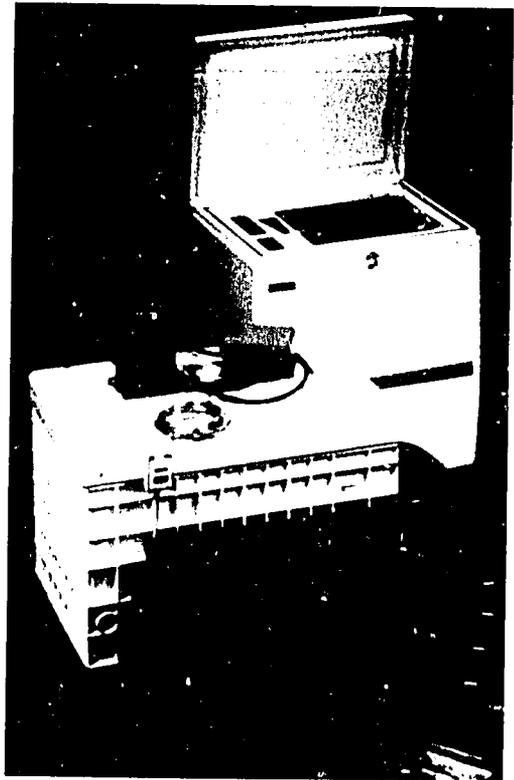
Equipment or Systems Characteristics

Solarex Corporation, (SLX), provides premium, semicrystalline PV modules as well as the amorphous silicon type modules. It offers a very diverse product line of 20 different modules as well as products such as MSX-Lite modules, which are unglazed and have no frame, specially designed marine modules, and a complete line of regulators, controllers, and mounting hardware. SC will design and install complete turnkey power systems anywhere in the world. All products are covered with a minimum power guarantee and large modules carry a guarantee for 10 years.

Experience and Operations

SLX was established in 1973 and is a wholly owned subsidiary of Amoco Corporation. SC grosses in excess of \$20 million annually. Production operations are in the United States, Australia, and Hong Kong. Overseas offices: Solarex Electric Ltd., 18th Floor, Sincere Insurance Building, 4 Hennessy Road, Hong Kong, Telephone-852-5-285717, Telex-780-61254, Fax-852-5-279704; Solarex Pty Ltd., 78 Biloela St., Villawood P.O. Box 204, Chester Hill 2163, NSW Australia, Telephone-61-2-727-4455, Telex-790-21975, Fax-61-2-727-7447; Solarex S.r.L., Centro Direzionale Colleoni, Palazzo Cassiopea 2, 20041 Agrate Broanza, Milan, Italy, Telephone-39-39-636251, Telex-843-326423, Fax-39-39-636256.

With thousands of systems installed, SC is an experienced PV systems companies. To illustrate versatility, tele-communications have been installed for Belize, Thailand, Columbia, Italy, and Panama, telephone repeaters for Columbia, on-shore beacons for Hong Kong Electric, tower lighting for South Yemen, navigational aids for the Hellenic Navy and the Canadian Coast Guard, medical systems for remote health clinics for Kenya, Zimbabwe, Ecuador and Guyana, cathodic protection for Saudi Arabia, and PV systems for the Puerto Rico post office.



This PV-powered refrigeration system is available in 180 or 225 W and includes the PV modules, batteries, controller, and instrument package. (Courtesy Solarex Corporation)



Villagers in Oman enjoy television programs broadcast by the Ministry of Information on a PV-powered television receiver. (Courtesy Solarex Corporation)

Solarmetrics, Inc.

250 Commercial Street
Manchester, New Hampshire 03101
Telephone: 603-668-3216
Telex: None
Fax: None

*Chief Executive Officer: Mr. R. Leinsing
International Sales Manager: Mr. Earl Farley*

Equipment or Systems Characteristics

Solarmetrics, Incorporated, (SI), manufactures temperature controls for use with solar panels. SI offers 2 models for automatic solar pool or spa control. These measure temperature differentials between the collector and the pool and divert pool water to the collector when heat is available. This unit includes a digital display of temperature. Another model for domestic water heating measures temperature differentials between the collector and the bottom of the storage tank to control hot water input. A third temperature sensor is at the top of the storage tank to regulate maximum temperature as desired between 49°C and 93°C (120°F and 200°F). The unit displays 3 temperatures. It includes freeze protection, draindown valve operation, factory adjusted hysteresis set-points, interfacing with secondary heating systems, and automatic shutoff for sensor fault, power failure, etc. This unit is also applicable to air systems. SI offers patented technology for joint ventures, engineering and design services, system installation, and service agreements.

Experience and Operations

SI was established in 1980 and grosses between \$500,000 and \$1 million annually. It has installed some 8,000 systems.

Solartherm, Inc.

1315 Apple Avenue
Silver Spring, Maryland 20910
Telephone: 301-587-8686
Telex: None
Fax: None

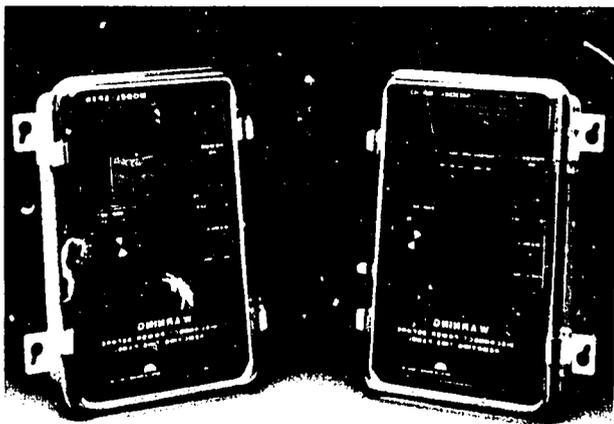
*Chief Executive Officer: Dr. Carl Schleicher, President
International Sales Manager: Mr. Roger Little*

Equipment or Systems Characteristics

Solartherm, Incorporated, (SI), furnishes a wide variety of PV components and systems for a variety of needs. This includes products such as solar-cells, electric panels, solar-powered generators, and solar-cell power panels for electric vehicles. Solar-thermal products are offered for heating water and air, and a solar "cooker" is also supplied. SI is also a distributor for a PV-battery-powered refrigerator. SI also offers a variety of consumer products — a solar ceiling fan powered by a solar panel from another vendor, and a solar-electric, attic exhaust fan to cool a house. An ARCO PV, 12-volt DC, power panel and battery system is used for solar-powered fluorescent light systems offered by SI. These have uses in marine and recreational vehicle lighting.

Experience and Operations

SI was established in 1977 and grosses under \$500,000 annually. Markets have generally been in the United States, although PV systems have been installed in India and Singapore.



Temperature controller for solar panels. (Courtesy Solarmetrics, Inc.)

Solec International, Inc.

12533 Chadron Avenue
Hawthorne, California 90250
Telephone: 213-970-0065
Telex: 910-325-6215 SOLEC HWTH
Fax: 213-970-1065

*Chief Executive Officer: Mr. Ishaq Shahryar, President
International Sales Manager: Mr. Quadrat Delawari*

Equipment or Systems Characteristics

Solec International, Incorporated, (SII), manufactures a wide range of solar modules and packaged systems and PV cells 10.2 cm (4 in.) round or square. SII also supplies components such as voltage regulators, array frames, and batteries. SII will design and install complete customized systems in addition to their packaged lighting and water-pumping systems. Lumisol Lighting is offered for security and area lighting in 18-, 35-, or 55-W, low-pressure systems suitable for all-night, stand-alone operation. Bus-shelter lighting systems (50 W) are also available for self-contained, all-night operation. A billboard lighting system, using metal halide lamps, is available with a capacity of 250 W. While the complete packaged systems carry a 1-year warranty, the solar modules have a 10-year warranty. Maintenance-free, PV-power systems are also supplied for communications, water pumping, instrumentation, etc.

Experience and Operations

SII was established in 1976. A privately owned business, SII is reported to be the third largest manufacturer in the United States. SII products are available through agencies and distributors both domestically and internationally. SII's manufacturing capacity is 1 MW per year; it produces thousands of cells for modules each day. SI has licensed its technology in Italy and France, and to Kurimoto, Ltd. of Japan.

Southwest Windpower

Route 8, Box 51 L.R.B.
P.O. Box 22178
Flagstaff, Arizona 86002
Telephone: 602-526-8017
Telex: None
Fax: None

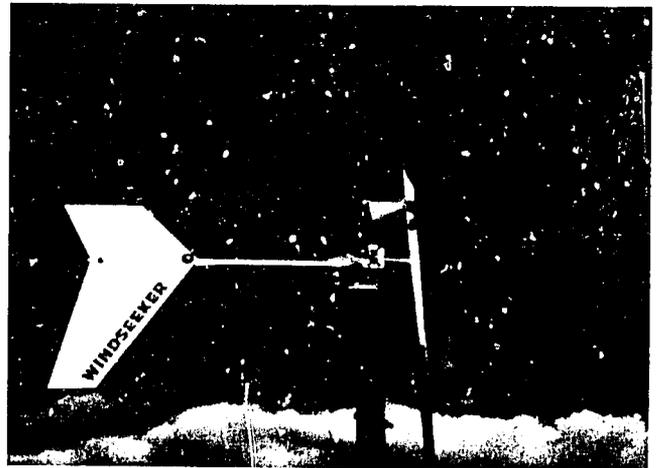
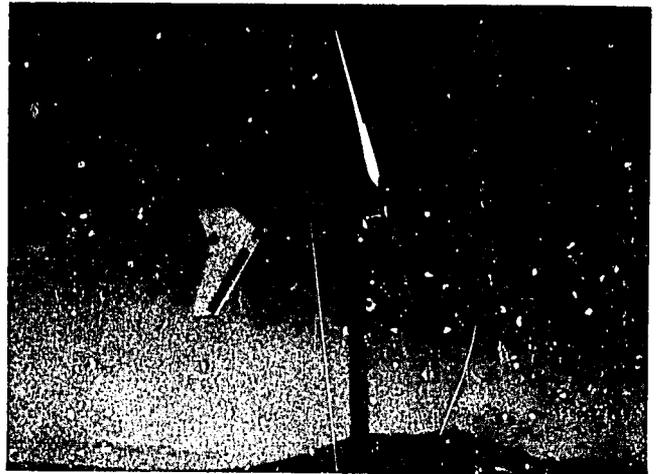
Chief Executive Officers: Mr. Andrew Kruse, Partner, Mr. David Calley, Partner
International Sales Manager: Mr. Andrew Kruse

Equipment or Systems Characteristics

Southwest Windpower, (SW), developed and manufactures the Windseeker II, a small, maintenance-free, wind generator for use in independent and remote power systems. This is designed for independent home wind or hybrid systems, especially in combination with PV panels. The 12-volt design has a maximum power output of 300 W, the 24-volt machine, 400 W. Minimum wind speeds are 3.6 and 4.0 m/s (8 and 9 mph), respectively. Rotor diameter is 1.52 m (60 in.). Output voltage for the 12-volt machine is set at 14.8 volts, for the 24-volt model at 29.5 volts. It has a cast aluminum frame, stainless steel hardware, sealed slip-rings, and a built-in regulator. The weight is 9.1 kg (20 lb). The Windseeker uses a 12-pole, 3-phase alternator modified for high output and efficiency at low RPM. Warranty on the Windseeker II is for 2 years. By arrangements with wholesale distributors, SW has also made available a full line of components to complete, expand, or specialize an independent power system, including solar panels, inverters, batteries and 12- or 24-volt DC appliances. Guyed tower kits are also available in 7.6-, 13.7-, 19.8-, and 30.5-m (25-, 45-, 65-, and 100-ft) heights.

Experience and Operations

SW was established in 1981 and grosses under \$500,000 annually. Sales of the Windseeker II began in 1987 after several years of development. A little over 100 of these wind turbines have been sold for various applications. Contracts are being developed for projects in India and Central America. International representatives are: Photocomm, Inc., Telephone: 602-948-8003; Interisland Solar, (Southern Pacific), Telephone: 808-947-5733; International Marketing, (India), Telephone: 714-862-3676; Natural Power Systems, (England), Telephone: 011-441-688-5572; and Mr. Lynn Hurlbert for South America, Telephone: 602-230-0827.



The Windseeker II is designed for use in small independent or hybrid power systems, especially in combination with PV panels. (Courtesy Southwest Windpower)



**SOUTHWEST
WINDPOWER**

Spire Corporation

Patriots Park
Bedford, Massachusetts 01730
Telephone: 617-275-6000
Telex: 961072
Fax: 617-275-7470

Chief Executive Officer: Mr. Roger Little

Equipment or Systems Characteristics

Spire Corporation, (SC), manufactures PV-production equipment and turnkey production lines. SC provides technology transfer and performs research and development on high efficiency cells for concentration and terrestrial applications. System packages offered are a 1-MW/yr module-production line, a 1-MW/yr cell-manufacturing line, and a 1-MW/yr wafer-production line. Also supplied are a sun simulator, laminator, cell tester, array tester, etc. SC offers patented technology for joint ventures and engineering and design services.

Experience and Operations

SC was established in 1969 and grosses in excess of \$20 million annually. It has installed production lines and equipment in Algeria, Saudi Arabia, India, China, and Europe.



Mock-up of Spire's 1-MW per year PV module production line. (Courtesy Spire Corporation)

SPM Group, Inc.

1601 W. 23rd Street
Suite 200
Lawrence, Kansas 66046
Telephone: 913-841-7764
Telex: None
Fax: 913-749-7222

Chairman: Mr. Konrad Ruckstuhl

Equipment or Systems Characteristics

SPM Group, Incorporated, (SPM), offers many waste recovery systems for generation of energy while reducing environmental pollution. A cuber has been developed to make densified, refuse-derived fuel cubes from the light fraction separated from other components in municipal solid waste (MSW). Other burnable components, such as wood, may be ground by shredder or hammermill to uniform size to be burned as flakes or processed into pellets or briquettes suitable as boiler fuels. SPM also offers a briquettor for compacting a wide range of materials, including wood waste, bagasse, peat, rice straw, the light fraction of MSW, and bitumen. SPM has developed suspension dryers for drying bagasse from 50 to 14 percent water. Wood waste and sewage sludge can also be dried by this system which uses flue gases as a heat source. SPM will often use equipment from other manufacturers, seeking out the best for the job to be done.

Experience and Operations

SPM operations began in the early 1940s in Switzerland. In 1977, SPM was formed in the U.S. as a subsidiary of the Swiss group. In 1978, SPM acquired exclusive rights to 11 waste processing technologies from the former Swiss parent company. In 1980, SPM became a publicly-held U.S. company.

In 1984, SPM built a refuse-derived fuel plant in Richmond, Virginia, which produces cubes of fuel. This plant was then sold to CAG Consortium. In 1985, SPM formed a joint venture to build a wood waste shredding plant in Brooklyn, New York, using wood building debris and broken pellets as feedstock. The product is sold to Proctor & Gamble on Staten Island, New York, for generation of steam and power.

In 1987, SPM was contacted by Maust Fiber Fuels, Inc. of Preston, Minnesota, who had serious problems with a briquettor supplied by a competitor. SPM supplied one of their largest briquettors as a replacement. This transaction led to a joint venture with Maust & Sons, Inc., to build a recycling/composting plant for Fillmore County and to a large waste tire shredding plant. Both plants were built in Preston, Minnesota. The operation of these plants in Preston has made it possible to market various plants for recycling, composting, RDF fuel production, and waste tire processing, which are presently under construction.

Springhouse Energy Systems

Room 412, Washington Trust Building
Washington, Pennsylvania 15301
Telephone: 412-225-8685
Telex: None
Fax: None

*Chief Executive Officer: Mr. William T. Hopwood,
President*

Services Offered

Springhouse Energy Systems, (SES), offers a computerized data reduction service for analysis and reduction of customer-supplied data, and data tapes and computer chips containing wind speed information for assistance in siting, designing, and operating wind turbines. Services have been principally in the Northeast United States where various terrains have complex wind flow patterns.

Experience and Operations

SES was established in 1980 and grosses less than \$500,000 annually.



Stirling Technology, Inc.

P.O. Box 2633
Athens, Ohio 45701
Telephone: 614-594-2277
Telex: 241196 SUNPOWER AHEN
Fax: None

Chief Executive Officer: Mr. Bruce J. Chagnot
Contact Person: Mr. Craig Kinzelman, Vice President

Equipment or Systems Characteristics

Stirling Technology, Incorporated, (STI), offers biomass-fueled, external combustion, Stirling cycle heat engines (the ST-5) rated at 13.4 MJ/h (5 HP) at 650 rpm. Suitable fuels include wood, wood pellets, sawdust, rice husks, peanut shells, and coffee hulls. The engine is supplied with either a wood burner or a cyclone burner for small-particle fuels. Several options are available for recovering waste heat using water from the engine's cooling loop. Uses for the engine include water-pumping, grain milling, and a variety of cogeneration (the production of heat and electricity) and food processing applications.

Experience and Operations

STI was founded in 1983 to introduce a simple, low power, biomass-fueled, Stirling cycle heat engine to the alternative energy market. The founders have over 25 years of engineering and marketing experience in Stirling engine business, beginning with work at Sunpower, Inc., also of Athens, Ohio. Early engine prototype work leading to the ST-5 design was originated under U.S. A.I.D. funding for an engine to provide shaft power for small rice mills and rural operations in Bangladesh. The Bangladesh project led to the formation of STI.

The ST-5 engine is being manufactured in India under a joint venture licensing arrangement. Except in India, all sales are through the Athens, Ohio office. STI is interested in developing both marketing and manufacturing arrangements with firms in appropriate countries.



Stirling Technology's 5-HP, Model ST-5 engine is set up to operate a water pump for irrigation in Pune, India. The fuel is rice husk. (Courtesy Stirling Technology, Inc.)

Sukup Manufacturing Company

Sukup Parkway, P.O. Box 677
Sheffield, Iowa 50475
Telephone: 515-892-4222
Telex: 62025126
Fax: 515-892-4629

*Chief Executive Officer: Mr. Eugene G. Sukup, President
"Biomaster" Sales. Mr. Robert E. Sanders, Product
Director*

Equipment or Systems Characteristics

Sukup Manufacturing Company, (SMC), produces a "Biomaster" heat exchanger furnace which has completely automatic operation with optional types of fuel-feeding systems. It is capable of burning wood chips, husklage, corn cobs, rice hulls, sunflower seed hulls, and other biomass materials which can be augered. Because it is a heat exchanger system, only heated clean air enters the bin or building being heated. Applications vary from commercial to industrial to agricultural uses. Capacity is 3,690 MJ (3.5 million Btu). The automatic feeding system solves operational problems. A high-temperature thermocouple continuously monitors furnace temperature and regulates it by controlling the fuel feed rate. The combustion chamber is guaranteed for 5 years.

Experience and Operations

SfMC was established in 1963. SMC's heat exchanger furnace has been installed in several locations throughout the world. An example is the Biomaster unit installed for the Eno Seed Farms in Sheffield, Iowa. This unit is used to dry seed corn. Export companies with overseas offices have helped to market such units abroad.



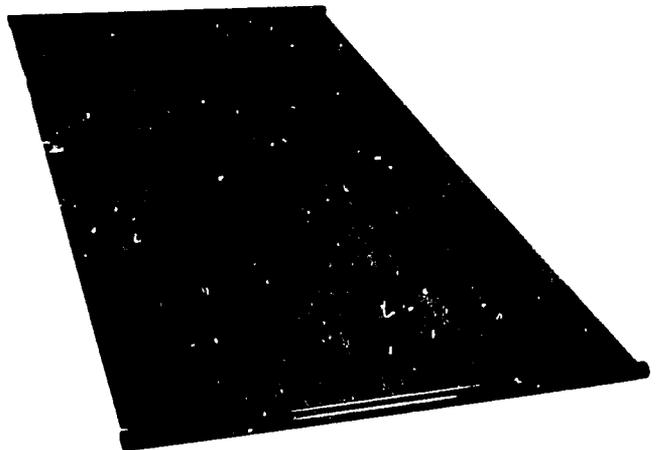
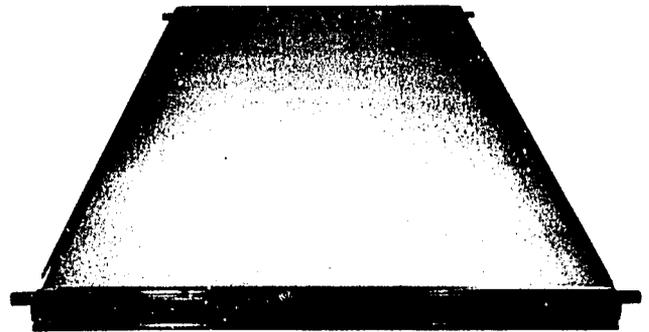
extruded aluminum frame and comes in an insulated box covered with low-iron, water-white, tempered glass.

- A medium-temperature solar collector for use in space heating and domestic hot water. This collector has an all copper absorber and a black chrome, selective coating on the absorber. It comes in a fully insulated box, with extruded aluminum frame.

All collectors are warranted for 10 years.

Experience and Operations

SEI was formed in 1978 and grosses in excess of \$1.5 million annually. An installation of merit is that of the 177 solar collector panels 1.2 m by 3.0 m (4 ft. by 10 ft) each having a black chrome, selective coating for domestic hot water at the Sunrise Apartments in Sacramento, California.



Glazed and unglazed solar collectors are manufactured by SunEarth, Inc. (Courtesy SunEarth, Inc.)

SunEarth, Inc.

4315 Santa Ana Street
Ontario, California 91761
Telephone: 714-984-8737
Telex: None
Fax: 714-988-0477

Chief Executive Officer and International Sales Manager: Mr. Arthur J. Brooks

Equipment or Systems Characteristics

SunEarth, Incorporated, (SEI), manufactures solar collectors which provide the contractor with design freedom, easy installation, and excellent performance. Three types are offered:

- A low-temperature, unglazed, swimming pool heating system with all copper waterways, having high thermal conductivity and invulnerability to ultraviolet degradation.
- A medium-temperature collector for pool or spa heating and domestic hot water heating. This collector uses all copper waterways and selective paint on the absorber. It has an

Sun Selector

P.O. Box 1545
512 37th Street
Parkersburg, West Virginia 26101
Telephone: 304-485-7150
Telex: None
Fax: 304-485-6303

Chief Executive Officer: Mr. Robert J. Bobier
*International Sales Manager: Mr. Joseph Varghese**

Equipment or Systems Characteristics

Sun Selector, (SS), manufactures ultra-high efficiency, PV charge-control devices of all sizes as well as complete system interfaces for multiple power sources and load control. SS charge controllers use a patented process that eliminates fragile, wasteful, blocking diodes, and up to 97 percent of battery gassing normally produced by controllers that utilize "two step" or "trickle" charging. SS also makes a linear current booster for PV-motorized applications such as pumping water, ventilation, grinding grain, etc. This is offered as a stand-alone product or can be fitted inside the junction box of a PV module. Custom units are made for various PV makers. SS also offers a utility interface for PV systems used in homes to allow use of PV with the utility or generator in the back-up mode. SS makes many other custom or standard balance-of-system components. One such item is the digital ampere-hour meter, which measures current rate continuously and accumulates the total current flow, integrated over time, and displays the result as amp-hours.

Experience and Operations

Bobier Electronics, Inc., owner of SS, was established in 1957 and grosses between \$500,000 to \$1 million. Over 2,000 SS balance-of-system components such as charge controllers and power conditioning devices have been installed in the U.S.A. and hundreds have been successfully installed worldwide. Negotiations are underway for manufacturing SS products outside the U.S.A.

* Address: 1376 Sussex TPK, Mt. Freedom, New Jersey 07970,
Telephone: 201-895-4035, Fax: 201-472-0845



SunAmp Power Company, Inc.

P.O. Box 6346B
Scottsdale, Arizona 85261
Telephone: 602-951-0699
Telex: 823191 PV RES UF
Fax: 602-945-5434 ATT SUN

Chief Executive Officer: Mr. Wayne Anderson
International Sales Manager: Mr. Lane S. Garrett, P.E.
Production Manager & Design Specialist: Mr. Russ Campbell

Equipment or Systems Characteristics

SunAmp Power Company, Incorporated, (SAPI), manufactures and assembles components of various suppliers into a wide variety of PV systems that can be classified as follows (arranged alphabetically): 1) Appliances and Lighting, 2) Batteries, 3) Cathodic Protection, 4) Home Electric Systems, 5) Inverters, Converters, and Uninterruptible Power Supplies, 6) Junction Boxes, 7) PV Modules, 8) Power Production, 9) Regulators and Controls, 10) Recreational Vehicle and Marine Power, 11) Structures, and 12) Water Pumping. SAPI is a complete PV system supplier with full engineering design and dealer back-up services. Complete training courses are offered. Field support is available and license agreements can be negotiated. Home electric kits range in size from 30 W to 4 kW peak. Water-pumping kits vary in size from 3.79 to 7,570 L/min (1 to 2,000 gal/min). Street light systems vary from 4 to 480 watts in capacity. SAPI manufactures a complete line of controls and regulators and has patented several products.

Experience and Operations

SAPI was established in 1986 and has revenues between \$500,000 and \$1 million annually. However, the firm has a staff that has been working in photovoltaics since 1975 and numerous engineering associates are available for work as needed. Examples of installations abroad include timers and controls in Saudi Arabia and Gabon, a DC/AC lighting system in Nigeria, a home electric PV power system with wind back-up in Bermuda, PV communications systems at 58 sites in Ecuador, multiple water-pumping systems in Mexico, Central America, and Africa, home electric and computer power systems in the Philippines and the Solomon Islands, communications and water-pumping systems in Canada, and PV-powered tape recorders in numerous locations around the world.



SunAmp Power Company

Surette America

P.O. Box 249
Tilton, New Hampshire 03276
Telephone: 603-286-8974
Telex: None
Fax: None

Chief Executive Officer: Mr. B. A. Migell
*International Sales Manager: Mr. D. E. Wellen**

Equipment or Systems Characteristics

Surette America, (SA), manufactures deep cycling, heavy duty, lead-acid storage batteries for wind, solar and uninterrupted power supply systems. SA also makes stand-by batteries for the U.S. Navy. SA will help customers in sizing or determining capacity of the battery bank required for various applications at no charge.

Experience and Operations

SA is a division of Atlantic Battery Company and was established in 1929. SA grosses in excess of \$1 million annually.

* Address: 80 Elm Street, P.O. Box 172, Watertown, Massachusetts 02172, Telephone: 617-924-2858

Thermo Electron Corporation

Energy Systems Division
101A First Avenue
Waltham, MA 02254-9047
Telephone: 617-622-1500
Telex: 92-3411
Fax: 617-890-6839

Chief Executive Officer: Mr. George Hatsopolus
Energy Systems Division President: Mr. Jerry P. Davis
International Sales Vice President: Mr. Lazaros J. Lazaridis

Equipment or Systems Characteristics

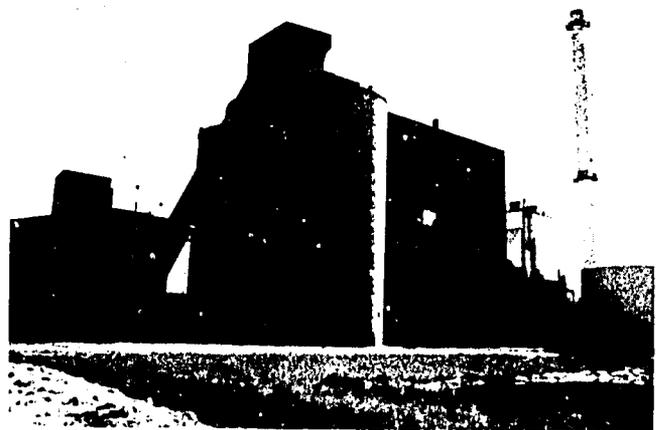
The Energy Systems Division of Thermo Electron Corporation, (ESD/TEC), serves as contractor, designer, developer, and supplier of turnkey energy systems. These systems generate electric power and/or process steam and operate as independent power or cogeneration plants. Biomass-fueled systems use sawmill residues, whole-tree chips, and various wood or agricultural wastes, such as orchard/vineyard prunings, shells and pits, rice hulls, bagasse, and rice straw. A circulating, fluidized-bed boiler has been used in some installations.

Experience and Operations

The Corporation has been in business since 1956 and sales are now close to a half billion dollars per year. ESD's cumulative capacity of installed systems is 150 MW. The ESD of TEC can provide design, engineering, financing, construction, and operation services for cogeneration and independent power plants, and through third party ownership and leasing arrangements, can minimize capital outlay by the host facility energy user. In addition to using in-house and U.S.-based capabilities, the company's project management team as required may cross international as well as interdisciplinary boundaries, through selection of suitable locally manufactured equipment, and local subcontractors and component suppliers. The company's professional staff can handle all phases of a project from feasibility analysis to plant commissioning on a turnkey basis, and guarantee budget and performance.

Latest renewable energy projects include 3 16-MW, wood-to-energy facilities, and 3 28-MW plants of which one is fueled by wood/agricultural wastes, and the others by agricultural wastes. All plants are located in the United States. The 16-MW plants are at Hemphill Power and Light Co. in Springfield, New Hampshire, the Gorbell/Thermo Electron Co. in Athens, Maine, and the Whitefield Power and Light Co. at Whitefield, New Hampshire. The 28-MW plants are at Mendota Biomass Power, Ltd. in Mendota, the Woodland Power Plant in Woodland, and the Delano Power Plant in Delano, all in California.

 **Thermo Electron**
Energy Systems



16-MW wood-fueled power plant showing silos for wood fuel and storage, enough to sustain plant's operation for up to 3 days. (Courtesy Thermo Electron Corporation)

Thin-Lite Corporation

530 Constitution Avenue
Camarillo, California 93010
Telephone: 805-987-5021
Telex: 662203 RECSPEC CAMA
Fax: 805-388-C921

Chief Executive Officer: Mr. D. David Szymanek

Equipment or Systems Characteristics

Thin-Lite Corporation, (TLC), manufactures 12-volt DC, fluorescent light fixtures (over 60 models) and low-voltage, low-pressure sodium lights (3 models) for use in conjunction with alternative sources of energy (photovoltaics, wind generators). A majority of the 12-volt DC, fluorescent light fixtures are U.L. listed and CSA certified. Wattages range from single 6-W (0.5 amperes) to dual 40-W (5.8 amperes) fixtures. The fluorescent lights offer high light output at low amperage. TLC manufactures its own high-frequency, electronic inverter ballasts. These are available separately for retrofitting.

Experience and Operations

TLC was formed in 1970 and grosses in excess of \$5 million annually. TLC works through distributors who handle projects. Products are exported to some 35 different countries in Europe, Africa, Central and South America, and the South Pacific. Overseas offices are: GG Trade Coordination, Case Postale 248, CH-1920 Martigny 1, Switzerland, contact Mr. Gabor Gyabiro, Telephone-02612 85 27, Telex-473833 PFMV CH; and also Arco Solar (Northeast) Europe, P.O. Box 109, N-4791 Lillesand, Norway, contact Mr. Jan B. Moe, Telephone-47 4170677, Fax-47 4172416, Telex-21256 JANB N.

Thin-Lite

Trofe Incineration, Inc.

Trofe Industrial Park
Mt. Laurel, New Jersey 08054
Telephone: 609-235-3030
Telex: None
Fax: 609-722-5969

Chief Executive Officer: Mr. Joseph E. Trofe
Vice President: Mr. Joseph J. Lisa, Jr.

Equipment or Systems Characteristics

Trofe Incineration, Incorporated, (TII), designs, constructs, markets, installs, and services patented "Roc-A-Jet" incineration equipment for waste disposal at 816° to 1649°C (1500° to 3000°F). Two systems are offered — one for solids and one for liquids. Special features are an afterburner with a multistage air pollution control train and a recycled process water filtration system. Five models are available; inputs vary from 45 to 227 t/day (50 to 250 tons/day) of waste materials. Based on waste having a calorific value of 11,620 kJ/kg (5,000 Btu/lb) the output of these 5 models ranges from 26,400 to 132,000 MJ/h (25 to 125 million Btu/h). Product steam has been used to generate electricity and to make pot-

able water from sea water. Non-hazardous ceramics can be made from the treated ash residue. Warranty is for 3 years. Refractory replacement is recommended at 5-year intervals. The Roc-A-Jet system has a minimal number of moving parts. It uses equipment of standard sizes; replacement parts can be purchased from many suppliers. TII maintains a teaching staff to train client students at its New Jersey plant.

Experience and Operations

TII was established in 1977 and has operations which gross in excess of \$1 million annually. Some 158,000 MJ/h (150 million Btu/h) of capacity is sold annually; 3 105,000-MJ/h (100 million-Btu/h) units are now on order. A Roc-A-Jet installation may be inspected at the Mt. Laurel facility of TII.

TROFE INCINERATION, INC.

Trojan Battery Company

12380 Clark Street
Santa Fe Springs, California 90670
Telephone: 213-946-8381
Telex: None
Fax: 213-941-6038

Chief Executive Officer: Mr. Richard Godber
International Sales Manager: Mr. Richard C. Bower

Equipment or Systems Characteristics

Trojan Battery Company, (TBC), designs, manufactures, and markets a complete line of high quality, deep cycle batteries. All commercial and industrial sizes, both 6 and 12 volt, are available.

Experience and Operations

TBC was established in 1925 and grosses in excess of \$1 million annually. TBC maintains an office in Industries Murrell, S.A., Av De Los Paraisos 68 CD, Cranja Guadalajara, JAL C.P. 45010, Attention: Mr. Jaime Sanchez Montealvo.

Tryco Manufacturing Company, Inc.

P.O. Box 1277
Southside Drive
Decatur, Illinois 62525
Telephone: 217-428-0901
Telex: ITT 4971743
Fax: 217-428-4451

Chief Executive Officer: Mr. R. B. West

Equipment or Systems Characteristics

Tryco Manufacturing Company, Incorporated, (TMC), supplies a completely automatic biomass "Bioflamm" gasifier system made to retrofit and replace oil or gas burners on existing heat exchangers or boilers. The gasifier separates gasification and combustion, allowing higher temperatures where gas is burned in the boiler and lower temperatures where gasification occurs. Twelve sizes, from 126 up to 6,320 MJ/h (120,000 up to 6 million Btu/h), are offered. The system can be idled at 5 percent of rated output and automatically returns to full capacity in seconds. The system burns combustible biomass material containing up to 60 percent moisture. Hot combustion gases are used to pre-dry the fuel. An induced draft fan is used; efficiency of combustion is 95 percent. An automatic auger reduces labor and permits thermostatic temperature control. Ashes are automatically removed to a sealed bin. A multi-cyclone, particulate collector cleans flue gas emissions. The system can heat a kiln or a building or produce steam for power and cogeneration of electricity. The system is electronically controlled and can be operated automatically for weeks, depending on the size of fuel bin. Engineering and installation services are provided, as needed.

Experience and Operations

TMC was established in 1947 to manufacture agricultural equipment. Bioflamm is a new product introduced a few years ago.



- Flat-plate air collector, consisting of a copper plate with black chrome finish. Sizes are 1.22 m by 1.98 m to 1.22 m by 3.96 m (4 ft by 6-½ ft to 4 ft by 13 ft).
- Thermosiphon free-flow collector units, consisting of a stainless steel tank with 151 to 303 L (40 to 80 gal) of storage and the types of flat-plate liquid collectors cited above. The tank is above the collector and no pumps or controls are required.
- A batch heater, consisting of a 151-L (40-gal) vertical standing solar water heater with aluminum reflector which provides the heat.

Collectors are warranted for 10 years, and components are warranted for 1 to 5 years. USS also provides controllers, pumps, hot water tanks, and drain back reservoirs. Engineering and design services are offered.

Experience and Operations

USS was established in 1977 and grosses between \$500,000 and \$1 million annually. USS provided 175 thermosiphon systems for hot water to the Ralph De Chabert Housing Project, St. Croix, U.S. Virgin Islands. A partial listing of other installations includes 16 housing projects, 8 community government complexes, 6 educational institutions, 7 motels and hotels, 3 firms, and 2 hospitals. USS maintains a number of offices abroad: Sistemas Solares, Apartado Aero 1980, Medellin-Columbia, South America, Contact: Mr. Robert Nicolait, Telephone: 02-45732 and 02-44329, Telex: 131 Nicolait B2; also Rocket Boiler Industrial Co., Ltd., P.O. Box 5881, Seoul, Korea, Contact: Mr. B. H. Lee, Telex: 78724868; also RF1, 27 Al Zahraa St., Off Mousadak St., Dokki, Gizza, Egypt, Contact: Mr. Raouf Fahmy, Telephone: 202-3600672, Telex: 927-93575, Fax: 202-718685; also Solergy Inc., P.O. Box 37, St. Johns, US Virgin Islands, 00830, Contact: Bill Spalding, Telephone: 809-776-7064.



U.S. Solar Corporation

P.O. Drawer K
Hampton, Florida 32044
Telephone: 904-468-1517
Telex: 887242
Fax: None

Chief Executive Officer: Mr. Irwin A. Blocker

Equipment or Systems Characteristics

U.S. Solar Corporation, (USS), manufactures a complete line of flat-plate collectors, both water and air, for residential, commercial, and industrial use. USS has facilities to provide complete systems and engineering capabilities to design such systems. The following product lines are offered:

- Flat-plate liquid collector, consisting of aluminum or copper plate, with copper tube either painted or black chrome. Sizes vary from 0.91 m by 1.83 m to 1.22 m by 3.96 m (3 ft by 6 ft to 4 ft by 13 ft). Mounting hardware is included.

U.S. Windpower, Inc.

500 Sansome Street, Suite 600
San Francisco, California 94111
Telephone: 415-398-3825
Telex: None
Fax: 415-391-7740

Chief Executive Officer: Mr. Gerald R. Alderson
*International Sales Manager: Mr. Earl Davis**

Equipment or Systems Characteristics

U.S. Windpower, Incorporated, (USWI), is a vertically integrated company that carries out all phases of wind-powered electric generating plants. USWI designs, manufactures, constructs, finances, operates, and maintains wind plants. USWI analyzes wind resources, uses aerodynamic designs, and monitors operations with computerized controls. The database has enabled designs to be perfected while achieving maximum output and minimizing maintenance.

USWI offers a grid-connected, 100-kW wind generator with 17.1-m (56-ft) rotor diameter. It has a free-turning yaw bearing to align with changing direction of wind. It operates at a cut-in speed of 5.4 m/s (12 mph) and a cut-out speed of 19.7 m/s (44 mph). It has 3 variable pitch blades, remote computer control, and a tripod tower.

Experience and Operations

USWI was established in 1974 and grosses in excess of \$80 million in sales annually. Headquarters are in San Francisco; R&D is conducted in Burlington, Massachusetts; and manufacturing, field operations, and maintenance are carried out in Livermore, California. USWI has developed 24 wind farms with cumulative capacity of 323 MW. On the average, USWI installs/constructs 60 MW/yr. USWI operates wind farms for third parties and for its own account and sells electricity to interconnecting utilities. Through December 1987, these farms have produced over 1.5 billion kWh. In 1987, over 475 million kWh were produced in California (28 percent of the state's wind-generated electricity). In Altamont Pass, California, USWI has installed 3,400 grid-connected, wind turbines, which represents 22% of all wind capacity installed in California.

* Address: 6952 Preston Avenue, Livermore, California 94550,
Telephone: 415-455-6720, Telex: 650-202-0019-MCI,
Fax: 415-443-3995.

U.S. WINDPOWER

Vanner, Inc.

745 Harrison Drive
Columbus, Ohio 43204
Telephone: 614-272-6263
Telex: None
Fax: 614-272-0085

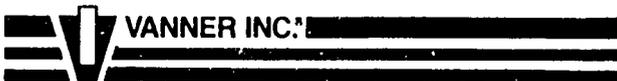
Chief Executive Officer: Mr. Simon Russell
International Sales Manager: Mr. Harold M. Craig

Equipment or Systems Characteristics

Vanner, Incorporated, (VI), designs and manufactures electronic controls to regulate electrical energy. Products are DC and AC power inverters from 150 W to 5,000 W (12 volt and 24 volt), battery isolators (to 250 amperes), electronic automatic throttle controls, and battery equalizers (10, 20, 50, and 100 amperes) that control the charging of battery banks for extended life.

Experience and Operations

VI was established in 1977 and grosses in excess of \$1 million annually. VI maintains an office at Universal Technologies S.P.R.L., Rue Claude Debussy 22 BTE 1, B-1070 Bruxelles, Belgium. Contact Mr. Thierry Godefride, Telex-25125 UNITEC B.



Typical applications for the Sunwater are to supply domestic hot water and to heat asphalt and a farrowing house during pig breeding. The Southwall system with 4.64 m² (50 ft²) of collector will yield 42.2 MJ/day (40,000 Btu/day) and heat 130 m³ (1,400 ft³) of residence. It is wall mounted and can be PV powered.

Experience and Operations

VSC was established in 1974 and grosses under \$500,000 annually. VSC has installed 6,000 systems to date. An installation of merit is the Templeton Sunpower system at Lynchburg, Virginia for heating asphalt. The size of the system is 189 m³ (50,000 gal).



Virginia Solar Components, Inc.

Highway 29 South
Rustburg, Virginia 24588
Telephone: 804-821-9523
800-532-0132

Telex: None
Fax: None

Chief Executive Officer: Mr. Bob Savage

Equipment or Systems Characteristics

Virginia Solar Components, Incorporated, (VSC), manufactures absorber plates and customized size collectors in quantity. Three different products are offered:

- "Sunwater" liquid-cooled, flat-plate, copper waterways, and copper absorber, 1.22 m by 2.13 m (4 ft by 7 ft) collector. Plate wraps around tube and is solder bonded. Collector is supported by aluminum frame and enclosed with tempered glass.
- Solar pool heater of flat-plate aluminum bonded to copper waterways. This collector is 1.22 m by 2.44 m (4 ft by 8 ft), has an aluminum frame and acrylic glazing.
- Southwall, a 1.22 m by 2.13 m (4 ft by 7 ft) air-cooled, flat-plate aluminum absorber with 15.2-cm (6-in.) duct ports. It has an aluminum frame and a tempered glass enclosure. Collectors are warranted for 5 years, components 1 year. VSC offers engineering, design, and installation services and service agreements.



Sunwater heating system installed on a hog breeding house. (Courtesy Virginia Solar Components, Inc.)

Waste Conversion Systems, Inc.

7315 S. Revere Parkway
Suite 601
Englewood, Colorado 80112
Telephone: 303-790-8300
Telex: 910-250-3547
Fax: 303-792-3708

Chief Executive Officer: Mr. Stan Abrams

Equipment or Systems Characteristics

Waste Conversion Systems, Incorporated (WCS), manufactures burner-boiler systems (known as "Thermal Burner") which have multi-fuel burners that can accept a wide variety of waste products, such as refuse-derived fuel from municipal solid wastes, wood chips, rice hulls, and rubber, or practically any other carbonaceous materials. The system has few moving parts, the components can be easily repaired, the operations are simple in either the manual or automatic mode, and remote monitoring is possible. The systems range in size from 1,560 to 15,200 kg/h (3,450 to 33,500 lb/h). Steam pressures range from 103 to 1,875 kPa (15 to 600 psi) and superheat to 399°C (750°F). The systems are used to power total package systems to provide process steam and electric power. Applications are drying, food processing, refrigeration, ice making, water pumping, lumber kilns, rice mills, etc.

Turnkey systems ranging in size from 100 to 5000 kW are provided. WCS designs, engineers, constructs, and provides start up for projects to fit specific needs of clients worldwide. Financing can be arranged. Supervision and training are also provided. Large capacity, field-erected systems have two-stage combustors with capacities from 269 to 2,690 MJ/h (100 to 1,000 HP). These units are retrofittable to both existing and new Scotch Marine and water tube boilers that are now fired by gas or oil.

Experience and Operations

WCS was formed in 1986 and grosses in excess of \$1 million annually. Its offices abroad are in Seoul, (Mr. S. E. Kim, Keun Yang Enterprises Co. Ltd., 4th Floor, Ko-Chon Bldg., #94-121, Young Deun Po Ku, Seoul, Korea 150, Fax: 82-2-678-1841) and in Manila (Mr. Medardo C. Tan Cardoso, PTC International Trading and Development Corp., 112 State Condominium, Makati, Metro Manila, Philippines, Fax: 63-2-521-7225).

A typical installation is the Thermal Burner with computerized control system at Western Dry Kiln, Inc., Tacoma, Washington; it provides 403 MJ/h (150 HP) of process steam.



World Power Technologies, Inc.

19 North Lake Avenue
Duluth, Minnesota 55802
Telephone: 218-722-1492
Telex: None
Fax: 218-727-6888

President: Dr. Elliott Bayly
International Sales Manager: Ms. Patricia DeLano

Equipment or Systems Characteristics

World Power Technologies, Incorporated, (WPT), manufactures rugged, direct-drive, permanent magnet, wind-powered generators for homes, small businesses, and remote locations. WPT offers 2 models of 1- and 5-kW systems suitable for battery charging, electric heating, and direct motor-drive systems that operate a 200 to 250 volt AC, 50 to 60 Hz, standard, 3-phase induction motor for water pumping, irrigation, aeration, and other low-starting-torque motor loads. No utility or batteries are needed. The wind generator may be placed where the wind is and the pump where the water is. A WPT motor-drive water pump will deliver 2 to 4 times as much water as a multi-bladed windmill. A low-wind booster and high-wind-speed options are available. Warranty is for 1 year.

WPT also has a 5-kW utility interconnect system with electronics for fully automatic, unattended operation. WPT also offers self-supporting, guyed, hinged, fold-up, 12.2 to 30.5-m (40 to 100-ft) high towers in kit form, batteries, battery chargers, stand-alone inverters, 12-volt converters, low voltage lamps for battery lighting systems, and low voltage accessories.

Experience and Operations

WPT was formed in 1989 and grosses under \$500,000 annually. WPT has acquired the technology of the former WhirlWind Power Company, which had over 500 installations worldwide.



Financing Private Energy Projects in Developing Countries

Many types of renewable energy systems can be evaluated for commercial use in developing countries. These systems can be grouped into those that produce thermal energy as heat, hot water, or steam for direct use; those that produce electric or mechanical power; and those that produce liquid or gaseous fuels. The energy or fuel products produced by the system can often be used to meet on-site captive needs or be marketed to other energy consumers such as an industrial plant or utility. The financial and economic competitiveness of specific renewable energy system applications depend on the technology chosen, the energy resources used, and the quantity and rate of energy or fuel production, all of which affect the capital and operating costs of the system. The ultimate economic feasibility of the project is determined by these costs, which in turn have major effects on the financing arrangements that can be developed to fund the project. After development of a business plan in which these costs factors are detailed, it is usually necessary to present the plan to potential sources of financing. This section of the directory presents a brief summary of the factors involved in developing financing and of the funding arrangements and sources suggested for consideration by project developers.

Business Plan and Financing Mechanisms

To obtain financial support for a renewable energy project, it is necessary to assure potential investors that the project is financially viable, will be completed, and that the loans will be repaid. The business plan presented to potential lenders should contain information on the technical and economic feasibility of the proposed project, capital and operating costs, the availability of external sources of materials, labor, and energy needed to operate the project, management resources and capabilities, markets for and marketing of the products, government permits and approvals needed, project milestones and completion schedules, equipment and performance guarantees, insurance, and contingency plans. Sufficient data should be presented in the business plan on each of these parameters as well as others that may be required because of local custom or law to support the request for financing.

Prior to developing the business plan, the project developer should identify potential investors. This will depend in part upon the type of project under consideration. In general, there are two types of renewable energy projects. One is called a captive energy project in which the energy products are partially or completely used to fuel operations on site. A portion of the products may be sold to other private, commercial or industrial markets. The other type of project is often called a utility-interactive project in which a power distribution utility is the primary purchaser of the energy products — either electricity or intermediate fuels — for conversion to power. The amount of usable energy products from captive energy projects is usually less than that of utility-interactive projects. However, essentially all renewable energy projects are small-to-medium size in terms of energy production relative to, for example, coal-based electric power plants or a substitute natural gas

manufacturing plant operating on naphtha feedstock. As a result of these relative size differences, the capital requirements for most renewable energy projects range from, for example, thousands of dollars for a single wind turbine or a small wood gasifier to several million dollars in the case of a fuel ethanol plant. Much larger capital requirements can of course occur for systems that consist of banks of several units or for integrated multi-process plants.

The modest capital needs for a renewable energy project facilitate several different financing arrangements. The developers of the project can sometimes make arrangements for financing the project with the equipment or process supplier or through direct loans with local lending agencies. The basic funding mechanisms that can be considered by the project developer include joint ventures, leasing, debt-for-equity trades, third party financing, and build-own-and-transfer (BOT) or build-own-and-operate (BOO) agreements.

In a joint venture arrangement, two or more parties jointly develop, own, and/or operate the project. There is broad flexibility in establishing joint ventures in terms of structuring the roles, risks, and returns for each party. Leasing involves the ownership of the equipment or facility by a party other than the project developer such as the equipment suppliers or a leasing company. The project developer pays leasing fees to the equipment owner and can often acquire ownership of the equipment at the end of the lease term for a nominal fee. Third party financing involves raising capital from private investors, and debt-for-equity trades involve the swapping of debt for an equity position by the investor.

In a BOT arrangement, project ownership is transferred after a prescribed period of time, usually to a utility, which then assumes responsibility for operations. All debt and equity service obligations are completed at the time of transfer. In a BOO arrangement, the project developer is responsible for financing, construction, and operation of the facility, and for the sale of the energy products. The project developer bears the highest risk with this arrangement, but has the advantage of making most of the decisions that affect the success of the project.

Sources of Financing

Many different sources of funds can be used to finance a renewable energy project. Commercial banks, institutional investors, venture capitalists, and corporations are the principal sources of private capital. Multilateral development banks are also engaged in financing renewable energy projects, especially in developing countries. However, as a result of the Third World debt crisis, commercial banks are less willing to lend in many poorer and more debt-burdened countries. Multilateral banks have been increasingly called upon to try to fill this gap. The U.S. Government, like many governments, provides various export risk insurance benefits for U.S. companies that invest or sell overseas.

An outline of the types of financial support that the project developer should consider from the private sector is illustrated in Fig. 1. It is clear that there is a broad spectrum of potential funding sources that can be solicited for financial support. The most directly available sources in a developing country are the local institutions. Several U.S. suppliers of renewable energy equipment, as noted in the directory listings, are also interested in developing financing arrangements with users of their equipment and technologies.

	<i>Equity Investment</i>	<i>Debt Investment</i>	<i>Debt/Equity Swaps</i>	<i>Project Co-Financing</i>	<i>Equipment Financing</i>
Commercial Banks		●	●	●	●
Institutional Investors	●	●		●	
Venture Capitalists	●			●	
Individual Investors	●			●	
Equipment Suppliers	●			●	●

Figure 1. PRIVATE SECTOR LENDERS

The international development banks and export credit agencies of various nations will often be the most attractive sources of financing. Their attractiveness resides in three debt-servicing characteristics — fixed interest rates, lower-than-market rates, and long repayment periods. The types of support that can be obtained from the major multilateral banks are illustrated in Fig. 2. The World Bank, through the International Bank for Reconstruction and Development (IBRD), has financed renewable energy projects, most often as components within larger projects. For example, the World Bank has financed biogas plants in Yugoslavia and biomass facilities in Guyana and Portugal. Direct project loans have been provided to IBRD member-developing-country governments or government-guaranteed organizations up to 100 percent of project cost, ranging from \$1 million to \$100 million with 5 to 30 year repayment periods at near-commercial interest rates. The World Bank's Multilateral Investment Guarantee Agency (MIGA) awards risk loan guarantees and technical assistance to corporations based in or largely owned by people from member countries. Loan guarantees have been provided up to 90 percent of the loan value for projects \$1 million to \$50 million in size, over repayment periods of 3 to 15 years. Similarly, the World Bank's International Finance Corporation (IFC), which is the largest source of direct project financing in developing countries, has provided loans of \$1 million to \$20 million up to 100 percent of project cost with repayment periods of 7 to 12 years at commercial market interest rates, and will assume equity positions on selected projects.

	<i>Feasibility Studies</i>	<i>Equity Investment</i>	<i>Debt Investment</i>	<i>Investment Co-Financing</i>	<i>Loan Guarantees</i>	<i>Lease Guarantees</i>	<i>Political Risk Insurance</i>	<i>Technical and Training Assistance</i>
World Bank (IBRD)	●		●	●				●
International Finance Corporation (IFC)	●	●	●	●				●
Multilateral Investment Guarantee Agency (MIGA)					●	●	●	●
African, Asian, or Inter-American Development Banks	●	●	●	●	●			●

Figure 2. MULTILATERAL DEVELOPMENT BANKS

The African, Asian, and Latin American development banks have likewise promoted the economic and social development of member countries in the banks' respective regions. Successful loan applicants are member-developing-country-government or government-guaranteed organizations. Loans of \$1 million to \$30 million up to 100 percent of project cost have been provided with repayment periods of 5 to 30 years at near commercial market interest rates.

It should be emphasized that many of these lending sources also provide co-financing arrangements with other bilateral or multilateral developing organizations or commercial banks, as well as financial support for feasibility studies, technical assistance, and training.

The U.S. Government export assistance programs available are summarized in Fig. 3. The U.S. Export-Import Bank (Eximbank) has the prime responsibility of facilitating the financing of exported U.S. goods and services through loans, loan guarantees, and risk insurance. In general, Eximbank can loan up to 85 percent of the value of the exports at the lowest interest rates allowed by the Organization for Economic Cooperation and Development. The U.S. Overseas Private Investment Corporation (OPIC) provides U.S. private sector investment in developing countries through financing and insurance programs. Small-to-

medium size U.S. businesses have been provided with loans of \$250,000 to \$6 million at repayment terms of 6 to 12 years at commercial rates. OPIC has also provided loan guarantees up to 100 percent of the loan value for projects ranging in size from \$1 million to \$50 million with repayment terms of 5 to 12 years. OPIC will underwrite risk insurance for up to 90 percent of the investment for projects in the \$100,000 to \$100 million range for U.S. businesses that have more than 50 percent U.S. ownership or foreign businesses with at least 95 percent U.S. interest.

The U.S. Trade and Development Program (TDP) finances project planning in potential U.S. export market developing countries, while the U.S. Agency for International Development (A.I.D.) assists private U.S. companies in export sales and investment in A.I.D.-supported developing countries. A.I.D.'s support is focused on feasibility studies, financial assistance for U.S. or local developing-country companies in developing countries, and pilot project funding.

Addresses for and communications information on key lending agencies and banks are shown in Table 1.

	<i>Feasibility Studies</i>	<i>Debt Investment</i>	<i>Investment Co-Financing</i>	<i>Export Equipment Financing</i>	<i>Loan Guarantees</i>	<i>Lease Guarantees</i>	<i>Political Risk Insurance</i>	<i>Technical and Training Assistance</i>
U.S. Export-Import Bank				●	●	●	●	
U.S. Overseas Private Investment Corporation		●	●		●	●	●	●
U.S. Agency for International Development	●	●	●					●
U.S. Trade and Development Program	●							●

Figure 3. U.S. GOVERNMENT EXPORT ASSISTANCE PROGRAMS

**Table 1. INTERNATIONAL MULTILATERAL AND BILATERAL
FINANCIAL INSTITUTIONS**

African Development Bank
01 B.P. No. 1387
Abidjan 01, Ivory Coast
Telephone: 225-32-07-11
Telex: 969-3263, 3282, 3498, 3717

Asian Development Bank
2330 Roxas Boulevard
Metropolitan Manila, Philippines
Postal Address:
P. O. Box 789
Manila, Philippines 2800
Telephone: 834-4444
63-2-711-3851
(International Calls)
Telex: 23103 ADB PH
63587 ADB PN
40571 ADB PM
Fax: 632-741-7961

Export-Import Bank of the
United States (EXIMBANK)
811 Vermont Avenue, N.W.
Washington, DC 20571, U.S.A.
Telephone: 202-566-8990
Telex: 89461
Fax: 202-566-7524

Inter-American Development Bank
1300 New York Avenue, N.W.
Energy Division
Washington, D.C. 20577, U.S.A.
Telephone: 202-623-1963
Telex: 440-1241DB
Fax: 202-623-3096

International Finance Corporation
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.
Telephone: 202-477-1234
Telex: ITT 440098
RCA 248423k
WU 64145
Fax: 202-477-6391

Multilateral Investment Guarantee
Agency (MIGA)
1818 H Street, N.W.
Suite P4001
Washington, DC 20433, U.S.A.
Telephone: 202-477-1234
Telex: RCA 248423 WORLDBK
WUI 64145 WORLDBANK
Fax: 202-334-0265

U.S. Agency for International
Development (U.S. A.I.D.)
Office of Energy
Washington, D. C. 20523, U.S.A.
Telephone: 703-875-4203
Telex: 892703
Fax: 703-875-4053

U.S. Overseas Private Investment
Corporation (OPIC)
1615 M Street, N.W.
Washington, D.C. 20527, U.S.A.
Telephone: 202-457-7010
(1-800-424-6742
outside D.C. in U.S.A.)
Telex: 440227 OPIC UI

U.S. Trade and Development
Program (U.S. TDP)
Agency for International Development
Room 309, SA-16
Washington, D.C. 20523, U.S.A.
Telephone: 703-875-4357
Telex: 64154 (892703 in U.S.A.)
Fax: 703-875-4009

World Bank
1818 H Street, N.W.
Washington, D. C. 20433, U.S.A.
Energy Development Division
Telephone: 202-473-3266
Telex: RCA 248423 WORLDBK
WUI 64145 WORLDBANK
Fax: 202-477-6391

Additional Information Resources

Additional information on renewable energy can be obtained from several U.S. organizations.

Biomass

Biomass Energy Research Association
1825 K Street, N.W., Suite 503
Washington, D.C. 20006
Telephone: 202-785-2856
312-567-3783
Telex: 25-6189
Fax: 312-567-5209

Information Resources, Inc. (Alcohol Fuels)
499 South Capitol Street, S.W., Suite 406
Washington, D.C. 20003
Telephone: 202-554-0614
Telex: 314383
Fax: 202-554-0613

National Wood Energy Association
1730 North Lynn Street, Suite 610
Arlington, Virginia 22209
Telephone: 703-624-6104
Telex: None
Fax: 703-527-2833

Renewable Fuels Association (Alcohol Fuels)
201 Massachusetts Avenue, N.W., Suite C-4
Washington, D.C. 20002
Telephone: 202-543-3802
Telex: None
Fax: 202-543-6925

Photovoltaics

PV Energy Systems, Inc.
P.O. Box 290
Casanova, Virginia 22017
Telephone: 703-788-9626
Telex: None
Fax: 703-347-5103

Solar Thermal

American Solar Energy Society
2400 Central Avenue, B-1
Boulder, Colorado 80301
Telephone: 303-443-3130
Telex: None
Fax: 303-443-3212

National Association of Home Builders
National Research Center
400 Prince George Boulevard
Upper Marlboro, Maryland 20772
Telephone: 301-249-4000
Telex: None
Fax: 301-249-3096

Passive Solar Industries Council
1090 Vermont Avenue, N.W.
Washington, D.C. 20005
Telephone: 202-371-0357
Telex: None
Fax: 202-682-0168

Solar Energy Industries Association
1730 North Lynn Street, Suite 610
Arlington, Virginia 22209
Telephone: 703-524-6100
Telex: None
Fax: 703-527-2833

Wind

American Wind Energy Association
1730 North Lynn Street, Suite 610
Arlington, Virginia 22209
Telephone: 703-273-8334
802-649-2112
Telex: None
Fax: 703-527-2833

Export Regulations

United States Export Council for
Renewable Energy
P.O. Box 10095
Arlington, Virginia 22210-9998
Telephone: 703-524-6105
Telex: None
Fax: 703-527-2833

Conversion Factors Used in This Directory

	Multiply	By	To Obtain
Length	Inches (in.)	2.540	Centimeters (cm)
	Inches (in.)	0.0254	Meters (m)
	Feet (ft)	0.3048	Meters (m)
	Miles (miles)	1.6093	Kilometers (km)
Area	Square Inches (in. ²)	6.452	Square Centimeters (cm ²)
	Square Feet (ft ²)	0.09290	Square Meters (m ²)
	Acres (ac)	4047	Square Meters (m ²)
	Acres (ac)	0.004047	Square Kilometers (km ²)
Volume	Gallons (gal)	3.785	Liters (L)
	Cubic Feet (ft ³)	28.32	Liters (L)
	Barrels (bbl)	159	Liters (L)
	Gallons (gal)	0.003785	Cubic Meters (m ³)
	Cubic Feet (ft ³)	0.02832	Cubic Meters (m ³)
	Barrels (bbl)	0.159	Cubic Meters (m ³)
	Bushel (bu)	0.03524	Cubic Meters (m ³)
Weight	Pounds (lb)	0.4536	Kilograms (kg)
	Short Tons (ton)	907.2	Kilograms (kg)
	Pounds (lb)	0.0004536	Tonne (t)
	Short Tons (ton)	0.9072	Tonne (t)
Pressure & Mass Per Unit Area	Pounds Per Square Inch (psi)	6.895	Kilopascal (kPa)
	Pounds Per Square Foot (lb/ft ²)	0.04788	Kilopascal (kPa)
	Pounds Per Square Inch (psi)	0.006895	Megapascal (MPa)
	Pounds Per Square Foot (lb/ft ²)	4.882	Kilograms Per Square Meter (kg/m ²)
Energy & Power	British Thermal Units (Btu)*	0.001054	Megajoules (MJ)
	British Thermal Units (Btu)	0.0002929	Kilowatt-Hours (kWh)
	Horse-Power (HP)	2.6856	Megajoules Per Hour (MJ/h)
	Horse-Power (HP)**	0.7457	Kilowatts (kW)
	Horse-Power (HP)†	9.8095	Kilowatts (kW)
Velocity	Miles Per Hour (mph)	0.447	Meters Per Second (m/s)
Heating Value	British Thermal Units Per Pound (Btu/lb)	2.324	Kilojoules Per Kilogram (kJ/kg)
	British Thermal Units Per Cubic Foot (Btu/ft ³)	0.3726	Megajoules Per Cubic Meter (MJ/m ³)

* Thermochemical value.

** Electrical.

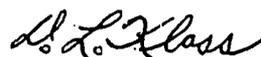
† Boiler.

Abbreviations and Symbols Used in This Directory

AC	= alternating electric current
ac	= acre
ASHRAE	= American Society of Heating, Refrigeration and Air Conditioning Engineers
bbf	= barrel
BERA	= Biomass Energy Research Association
billion	= 1,000,000,000 or 10^9
BOD	= biological oxygen demand
Btu	= British thermal unit
Btu/ft ³	= British thermal units per cubic foot
Btu/lb	= British thermal units per pound
bu	= bushel
°C	= degrees Celsius
cm	= centimeter
cm ²	= square centimeter
COD	= chemical oxygen demand
DC	= direct electric current
EPDM	= sulfur-vulcanizable terpolymer of ethylene, propylene, and a diene
°F	= degrees Fahrenheit
ft	= foot
ft ²	= square feet
ft ³	= cubic feet
gal	= gallon
HP	= horsepower
h	= hour
Hz	= Hertz
in.	= inch
in. ²	= square inches
ISO	= International Organization for Standardization
J	= joule
kg	= kilogram
kg/m ²	= kilograms per square meter
kJ/kg	= kilojoules per kilogram
km	= kilometer
km ²	= square kilometer
kW	= kilowatt
kWh	= kilowatt-hour
L	= liter
lb	= pound
lb/ft ²	= pounds per square foot
M	= 1,000,000 or 10^6
m	= meter
m ²	= square meter
m ³	= cubic meter
million	= 1,000,000 or 10^6
min	= minute
MJ/h	= megajoules per hour
MJ/m ³	= megajoules per cubic meter
mph	= miles per hour
m/s	= meters per second
mth	= month
ppm	= parts per million
PV	= photovoltaic
R-10	= insulation equivalent to uninsulated aluminum sheeting with 3 in. of glass fiber and facing.
rpm	= revolutions per minute

Acknowledgment

It is appropriate to acknowledge those who made major contributions to the publication of this directory. Dr. Paul Bente, Dr. William Klausmeier, and Mr. Carlo LaPorta were the members of the project team that conducted the survey of the renewable energy industry in the United States, in cooperation with the U.S. Export Council for Renewable Energy. Dr. Bente, in addition, wrote most of the company descriptions and indices, and Messrs. Robert Parra and Mathew E. Buresch contributed to the section on financing. Critical reviews and commentary were supplied by Dr. Dan Waddle of Oak Ridge National Laboratory, many of the trade associations listed on pages 70 and 71 of this directory, and most importantly, the company officers and staff who responded to our initial survey questionnaires. Finally, the production work was performed by Ms. Lillian Courtney, Mrs. Sheila Daniels, and Mr. Ted Patla of IGT. All of their efforts are greatly appreciated.

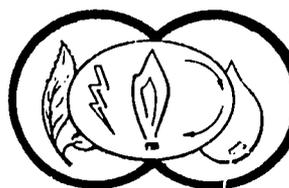


D. L. Klass
President, BERA

Produced by Biomass Energy Research Association. Graphics by Institute of Gas Technology. Front cover by Meridian Corporation.

ISBN 0-910091-74-9

Printed in U.S.A. 1990



BERA
Biomass Energy
Research Association