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NC113

FIELD TESTING OF AN
AUTOMATED WOOD-COMBUSTION SYSTEM
AND
DEVELOPMENT OF BUSINESS PLAN
FOR
COMMERCIALIZATION OF PRODUCTION

Grant No. DE-FG-4481R410459

FINAL REPORT FOR PERIOD ENDING
AUGUST 1, 1982

May 24, 1983

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App. C - removed, probably copyrighted

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1.0 INTRODUCTION

After a successful first Appropriate Technology (AT) Grant with a lot of laboratory testing of a prototype burner, this AT grant was awarded for field testing and preparation for commercialization. A school was selected for the field testing.

Integrated Energy Systems (IES) has contributed to this project on a cost-sharing basis and the individuals involved have made contributions in hard work and good ideas which went unaccounted.

Chris Turner at Arizona State University made, as project monitor, valuable contributions in information dissemination and with his encouragement. All the people who made contributions to the project during the last two years deserve a big "thank you".

2.0 RESULTS

The results can be best listed as follows:

- 1) A tunnel burner has been installed and tested at Hope Valley School in Durham, NC
- 2) The tests revealed many problems which did not exist while testing the prototype in laboratories. The experience led to redesign and more cautious site selection criteria.
- 3) Controls are at final stage and working reliably.
- 4) A patent application has been filed.
- 5) A business plan has been developed.
- 6) Plans exist for demonstration unit, forming a new corporation, and negotiating for licenses.

The main problems at Hope Valley arose in connection with the main, outside storage bin. Several different designs were considered in order to meet the many constraints (power line, esthetics, space, cost). Several examples are given in Figures 1, 2 and 3. Attaching the burner to the existing Kewanee boiler was no problem at all. The final design of the bin had to be altered several times after installation because of a locked auger.

The other severe problem appeared when it was difficult to find a wood chip supplier who could deliver 3 tons per delivery by means of a dump truck. Most suppliers are equipped with 20-ton tractor trailers. The fuel then was coming from Dorothea Dix and had to be hand shoveled into the bin.

Test results on the scaled-up burner (200,000 BTU/hr versus 40,000 BTU/hr of prototype) were very good. Table 1 shows results for green wood chips compared to test results with the prototype at EPA with pellets.

The controls accounted for a cold start (electric starter coil) and hot start. A thermocouple controls the two modes. A time delay relay is used on the combustion air blower in order to burn most of the fuel in the combustion chamber before shutdown. The interface with the existing boiler controls was only made difficult because more of the existing wiring was labeled.

A patent application was filed by David Rabin (Patent Attorney) of Greensboro.

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FUEL STORAGE ELEVATION

Figure 1. Dumpster Chip Storage.

Figure 3. STORAGE TANK FOR CHIPS. SCALE - 3/4" = 1 FT.

Table 1.

COMBUSTION TEST RESULTS OF THE
TUNNEL BURNER

	Wood Pellets ¹ (IES TB 11/12/82)	Green Wood Chips ² (IES TB 2/9/82)
Fuel Feed rate, lbs/hr	4.82	48.00
Burner Capacity, BTU/hr	38,560	168,000
Stack gas temp., °F	384	326
Combustion efficiency, %	85.6	82.0
O ₂ , %	10.08	13.5
CO ₂ , %	12.20	8.0
CO, ppm	175	*
NO, ppm	70	na
NO _x , ppm	72	na
MC, ppm	2.0	*
Smoke, Bacharach	7.6	na
TSP, mg/m ³	49.7	na
POMS, µg/m ³	<0.004	na

*
na
na
* } 0.15%

¹ Tests made at EPA's IERL, Research Triangle Park, NC

² Tests made at Hope Valley, Durham, NC

A business plan has been developed with some professional help from Control Data Corporation. The personnel is also involved in SBA-funded business development and was fully aware of our special needs (see Appendix A).

The economics of our final product look good against oil. It is clear that retrofit applications are the most likely to give us a good start in the market place. The economics are presented in Figure 4.

3.0 UNSOLVED PROBLEMS

Despite the claims made by a lot of the forestry professionals, wood chips for our size of burner will not be readily available. With the first units almost a fuel delivery guarantee has to be given.

There is a remaining question about further scale-up of our burner. Are we in a size range where enough fuel cost potential exists that it will be attractive for an end-user to purchase a burner (approximate cost: \$6,000)?

Sizing the burner is critical, especially for steam boilers. No matter what steam load is needed at an installation, our existing boiler with its size has to be matched by the burner capacity. Underfiring a given boiler has its definite limits (approximately 80%).

Figure 4.

FUEL COST SAVINGS FOR DIFFERENT BURNER CAPACITIES AND FULL LOAD OPERATING HOURS

4.0 CONCLUSIONS AND PROJECTIONS

This grant has given us the opportunity to get good experience with a real-life case installation of our burner. No major changes were necessary on the burner itself, but safety and control improvements were significant.

Many of the problems with the fuel handling and supply end gave us the necessary respect for these problems before we tackle the marketing of the burner.

Financially, we pretty much stayed on track time-wise and money-wise.

"HEAT HARVESTOR BURNER"
AN AUTOMATED WOOD BURNING
HEATING SYSTEM

BUSINESS PLAN

NOVEMBER 1981

This Business Plan is the property of Heat Harvester, Inc. Because it contains confidential information proprietary to Heat Harvester, Inc., no copies may be made whatsoever of the contents herein nor any part thereof, nor should the contents be disclosed to any party not previously authorized to discuss said contents by Heat Harvester, Inc. officers. This copy must be returned to Heat Harvester, Inc. upon request.

Business Plan Prepared By:

Michael Degni
Marketing/Management Specialist
Control Data Business Center
3726 Latrobe Drive
Charlotte, North Carolina 28211
Telephone - (704) 365-1420

Heat Harvester, Inc.
307 North Columbia Street
Chapel Hill, North Carolina 27514
Telephone - (919) 942-2007

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I. SUMMARY

Heat Harvester, Inc., was chartered for the purpose of developing and marketing a wood combustion system that utilizes a "Tunnel Burner."

The Product

The product, "Heat Harvester Tunnel Burner," is an improved wood combustion system that utilizes a "Tunnel Burner" for continuous automated combustion. The "Heat Harvester Tunnel Burner" has been developed in a form which makes it an appropriate replacement for gas or oil fired burners on boilers or furnaces. The "Heat Harvester Tunnel Burner" was designed to be used as an initial heating system or as a retrofit replacement for oil or gas fired burners on boilers and furnaces and was designed to provide the same level of comfort as other heat sources but at a much more favorable cost ratio per BTU of heat produced. A patent application has been filed in the United States and filing is being considered in both Canada and the European countries.

State of Development

The "Heat Harvester Tunnel Burner" has been developed to the point that prototype units have been assembled and are now being used at selected locations where controls are in effect for maintaining the system applications under actual final user conditions. Manufacturers who can produce the component parts that make up the "Heat Harvester Tunnel Burner" have been identified and tooling up is ready to begin.

The Market

The estimated annual market in North Carolina for heating systems is \$100 million in sales, with a growth rate of 10% to 15% per year into the next several years. Heat Harvester, Inc. could possibly capture 5% to 10% of this market within a five-year period. Annual sales volume could be as much as \$15 million within a five-year period in North Carolina. Equal market potentials exist in Georgia and Tennessee. The New England states and the Pacific Northwest are other potential markets which are even larger.

Production

The "Heat Harvester Tunnel Burner" system components will be produced by subcontractors who will use their machinery and custom

made dies which are authorized under specifications dictated and controlled by "Heat Harvester, Inc." Assembly and shipment to distributors will be accomplished by Heat Harvester, Inc. Other options of producing the Tunnel Burner are still being discussed.

Distribution

Wherever feasible, the company will market the "Heat Harvester Tunnel Burner" through boiler or other existing heating equipment manufacturers. "Heat Harvester, Inc." may also consider the granting of licenses for production and use under specific restricted applications.

Financing Required

Heat Harvester, Inc. estimates that it will need approximately \$100,000 to bring its product (the "Heat Harvester Tunnel Burner") to its final development stage. This \$100,000 investment will represent approximately 28% equity in the company.

II. THE COMPANY AND ITS BUSINESS

The Company

"Heat Harvester, Inc." will be a new company specifically chartered for the purpose of commercializing energy systems and components developed by small businesses. Manufacturing, assembling, or issuing licenses are operational options. The main product the company will start dealing with is an automated wood chip and pellet burner, which has proven to be very efficient and practical in small to medium size heating systems and agricultural heating and drying applications. Integrated Energy Systems, Inc. (IES), an engineering and architectural consulting firm has successfully done research and development work on the tunnel burner during 1980 and 1981. Two DOE grants have helped to turn the system into a well-tested piece of new technology.

In the longer term future, the company will promote biomass, solar, and other renewable energy technologies. Equipment necessary for fuel handling and energy distribution systems associated with the wood chip burner will be considered.

*The company will try to use, whenever possible, existing distribution and sales organizations to bring the new technologies to potential markets. A primary concern with the introduction of any new product will be ability to offer quality, reliable service and parts backup.

*The company is actively seeking a few business partners for the production phase (Phase III). These partners ideally will also provide expertise in sales and marketing.

III. THE PRODUCT

The Product

The "Heat Harvester Tunnel Burner" is an automated wood burning system. The heart of the system consists of a double wall steel tubular structure that forms a combustion chamber in which wood and other biomass waste are converted into heat. The conversion is accomplished by a distinct sequential process consisting of drying, gasifying and combusting of the fuel. The "Tunnel Burner" is a combustion chamber, specifically designed to burn solid fuels with high volatile matter content.

The "Heat Harvester Tunnel Burner" was designed for use as a primary heat source for heating systems used by the following sectors:

1. Residential
2. Institutional
3. Commercial
4. Industrial
5. Agricultural

The system was designed for use with small to medium size boilers, furnaces, kilns and dryers found in the above sectors. The "Heat Harvester Tunnel Burner" is an excellent replacement heat source option for oil and gas fired appliances.

Benefits of Product

The "Heat Harvester Tunnel Burner" provides the user with the following benefits over other solid fuel combustion systems:

1. Operating cost savings by using low cost wood.
2. High combustion efficiency.
3. Automatic regulation of heat output over wide range.
4. Less air pollution problems.
5. Can be used as a replacement in gas or oil fired system.

Patent and Product Protection

Patent applications have been filed and product protection has been established. Confidentiality agreements have been executed with all persons who have been exposed to the system.

Status of Product

The "Heat Harvester Burner" was satisfactorily tested under the Department of Energy Grant number DEFG 4480R410156. Air pollution emissions were found to be 8 to 10 times lower than wood stoves and fireplaces. When compared to oil, gas and coal burners, the particle emissions of the burner were of the same magnitude as oil and gas burners and well below coal burners. Hydrocarbon emissions from the burner were below those of oil and gas.

IV. THE MARKET

The State of North Carolina presents a very lucrative market for the sale of heating systems. Heating systems now used by the following sectors in North Carolina are:

Market Potential

<u>Sectors</u>	<u>Applications</u>		
Residential			
Institutional Commercial			
Industrial			
Agricultural	New - Retrofit - Replacement		
<hr/>			
<u>Residential</u>			
300,000 to 500,000 Furnance Systems	Yes	Yes	Yes
70,000 to 80,000 Boiler Systems	Yes	Yes	Yes
<u>Institutional - Commercial</u>			
Over 2300 Schools with one or more buildings	Yes	Yes	Yes
Over 158 Hospitals	Yes	Yes	Yes
Over 10,000 Office Buildings	Yes	Yes	Yes
<u>Industrial</u>			
At least 10,000 Manufacturing firms	Yes	Yes	Yes
<u>Agricultural</u>			
Over 90,000 Farms Using Heating systems for:			
1. Tobacco curing/over 60,000 tobacco barns	Yes	Yes	Yes
2. Greenhouse Use/over 1330 plant or foilage growers	Yes	Yes	Yes
3. Poultry Farms - About 12,000	Yes	Yes	Yes

The total annual heater replacement from all sectors approaches approximately 50,000 heater replacements each year with a 10% increase each year for new installations. There exists, assuming \$2,000 cost per replacement unit, a potential \$100 million for 1982.

TABLE III - 1

TOTAL NORTH CAROLINA MARKET FOR HEATING SYSTEMS

Potential Sales *	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>
Total Market in Million Dollars	\$100	\$110	\$121	\$133	\$146
Estimated Market for The "Heat Harvester Burner" in Million Dollars**	\$2	\$4	\$8	\$12	\$15***

(*) Assuming a 10% growth rate in new construction each year.

(**) Assuming that Heat Harvester captures 10% of the potential market in five years.

(***) This \$15 million estimate is based on capturing 10% of the market after five years of continuous operation.

Resource Base

The State of North Carolina has an abundance of wood fuel that is readily accessible and is available to the final user at a very favorable cost as compared to natural gas, oil or electric heat sources.

Competition

Competition for the "Heat Harvester Burner" will come from other combustion equipment using biomass and fossil fuels:

1. Conventional Hand-fired Combustion Systems

The bottom grate hand-fired combustion system does not function well in other than single family installations. The burning rate is not easily controlled and thus lacks good efficiency. Hand-fed systems require constant attendance and heat output is difficult to control.

2. Stoker-fed Systems

Most stoker-fed systems presently on the market are still to be considered labor intensive in that ashes accumulate at the bottom of the combustion chamber and these ashes must be manually removed. The "Heat Harvester Tunnel Burner" utilizes an automatic ash retrieval concept.

3. Suspension Burning Equipment

The wood fuel source for a suspension burning system must be in a sawdust form prior to injection into the combustion chamber. This type system is not efficient in applications where large load variations occur. The system in many cases requires a co-firing with oil or gas.

4. Pre-Chamber Burner System

Two-chamber burner systems which apply some of the same principles of the "Tunnel Burner" are available. Those systems are more expensive and lack the ease of retrofit capability of the "Heat Harvester Burner." Some others are not automated, again requiring constant attendance.

5. Gasifier Systems

Coal, wood and other biomass gasifiers are being built again after virtually disappearing from the market after World War II. The gasifier systems tend to be fairly complex.

6. Gas and Oil Fired Systems

The oil and gas fired systems offer clean, dependable heat sources. The main disadvantage to these systems are cost of operation. A burner system that uses natural gas and fuel oil costs approximately 2.6 times and 5 times more, respectively, for fuel than the same equivalent cost for waste wood used to fire the "Heat Harvester Burner." Useful life of the competing burner units is similar.

7. Electrically Heated Systems

Electrically heated systems offer a clean, dependable source of heat, however, using electricity can cost as much as 7.7 times as much as the waste wood heating source.

TABLE III - 2

COST COMPARISON FOR A BURNER SYSTEM WITH A
CAPACITY OF 250,000 BTU'S/HR.

<u>HEATING SOURCE</u>	<u>OPERATING COST/HR.</u>	<u>COST TO GENERATE 1 MILLION BTU'S</u>
Wood	\$.38	\$ 1.55
Coal	.51	2.04
Natural Gas	1.00	4.00
Fuel Oil	2.00	8.00
Electricity	3.00	12.00

CHART III - 1

HOURLY OPERATING COST FOR A BURNER SYSTEM WITH A CAPACITY OF 250,000 BTU'S/HR.

Cost/Hr.

\$3.00

3.00/hr.

\$2.00

2.00/hr.

\$1.00

1.00/hr.

.51/hr.

.38/hr.

0

WOOD

COAL

Natural
Gas

Fuel
Oil

Electricity

V. THE MARKETING PLAN

Sales Objectives

The sales projections, See Table III-1, made for the "Heat Harvester Burner" were developed after giving consideration to the anticipated market penetration rate and the internal needs of "Heat Harvester, Inc." A rapid acceptance of the "Heat Harvester Burner" is anticipated based on the following:

- A national priority to achieve a rapid decrease in the consumption of petroleum and its by products for political and economic reasons.
- A chronic need by all sectors of the economy to reduce operating expense but not reduce the level of goods and services.
- A constant pressure on all sectors of the economy to cope with the inflationary effect caused by dependence on petroleum base heating fuels.
- A desire on the part of potential users who are seeking an alternative source of heating fuel that will be readily available and stable in price.

Marketing Strategy

"Heat Harvester, Inc." will attempt to market the "Wood Chip Burner" through existing heating equipment manufacturers. Specific

examples would be use of manufacturers who make boilers and gas or oil fired burners that are used by the residential, institutional, commercial, industrial and agricultural sectors.

The burner would be offered as a selected option to users in the above sectors just as users now have the option to select natural gas, LP gas or oil burner options for their respective application. "Heat Harvesto, Inc." may in specific applications issue licenses restricted to those application areas.

Sales will be concentrated in North Carolina initially, but as acceptance of the burner grows and benefits of the system are demonstrated through its use, a national and international market could become a reality.

Applications Evaluation

Phase I in the development of the "Tunner Burner" involved all the work that was done through May, 1981, which included work accomplished under the Department of Energy Grants. Phase I ended with the development of a tested working model.

Phase II in the development of the "Tunnel Burner" is now in progress. Phase II will involve one or more installations and applications of the burner system. Monitoring these systems and owner evaluation will then become a significant part of Phase III of the marketing plan. The objectives of Phase II are:

- Establish product history through experience gained in actual applications of one or more systems.

- Obtain accurate operating cost data.
- Gain experience with field application to detect idiosyncrasies or weaknesses, if any, in the "Tunnel Burner" assembly or any of the component parts of the entire system assembly.
- Produce two or three prototypes of a well-packaged product in one or more applicable areas which generate good reaction from potential buyers and manufacturers.

Marketing Tactics

The success of the "Heat Harvester Burner" as a heating system product will depend on the simplicity, reliability, operating comfort and quality or life expectancy of the system. Phase II will generate the above data and provide the "show case" applications of the burner system that will be used as attention-gaining vehicles. During the Phase II period, the test applications will be promoted through news releases, articles in selected publications and direct contact with heater product manufacturers who would be interested in adding the wood burning "Tunnel Burner" option to their product line.

Marketing Timetable

Once the capital of \$100,000 is received, Phase II will be adequately funded and then be launched for maximum effect. Approximately nine to twelve months will be needed to accomplish Phase II of the business plan. Phase III can be started as Phase II begins to come to a conclusion.

VI. THE PRODUCTION PLAN*

Production

Production of the "Heat Harvester Burner" system can begin at this time. Either the manufacturers who can produce the component parts have to be identified and are ready, willing and able to supply these parts in sufficient quantities to meet current demands, or an established company capable of manufacturing all parts will be acquired or put under contract.

Regardless of the manner or fashion selected for manufacture of the "Tunnel Burner," modification and refinement of the "Tunnel Burner" system will be an ongoing process with the following goals in mind:

- Reduction in manufacturing costs.
- Speed up handling and assembly
- Increase in the "value added" and uniqueness of the product.
- Gain manufacturing expertise which may be applied to develop related products.

Production Time Cycle

Assembly of the component parts into the finished "Tunnel Burner" system and simple testing takes 20 hours. Assembly time should decrease as assembly personnel acquire experience with the burner system.

*The development and production of prototype for Phase II will follow the Timetable and Cash Flow schedule as show in Appendix "C".

Manufacturing Cost Savings

"Heat Harvester, Inc." will not have a need for any manufacturing facilities, as all the component parts will be produced by companies which have been identified. These companies have the production capacity estimated to be required by "Heat Harvester, Inc." during the next five years. Component manufacturers will be continuously evaluated and new manufacturers will be identified and contracted with as the need develops.

VII. THE MANAGEMENT TEAM

Below are the critical skills needed by the management team:

Marketing

- a. Market Definition
- b. Market Planning
- c. Salesmanship

Finance

- f. Financial Planning
- g. Financial Management
- h. Accounting

Manufacturing

- d. Engineering
- e. Industrial Design

Organization

- i. Negotiating Skill
- j. Office Administration
- k. Knowledge of Legal Aspects

The management team will grow in anticipation of the company's needs, using committed full-time individuals. An external team will provide needed additional services on a part-time or lease basis as long as this type of approach is efficient.

Present Staff

Werner Martin, President

Daniel R. Koenigshofer,
Secretary

Principal Skills

a. b. d. g. j.

a. b. c. d. e. g. i.

External Team

Integrated Energy Systems
Chapel Hill, N. C.

Control Data Business Ctr.
Charlotte, N. C.

David Rabin, Esq.
Greensboro, N. C.

Potential Partners

d. f. g. h. j.

a. b. c. f. g. h.

i. k.

b. c. e. g.

Perspective Team Member

"Heat Harvester, Inc." is maintaining contact with individuals who are ready to assume key roles when necessary. The decision to add a full time business or marketing manager will be deferred until the conclusion of Phase II.

Officers and Directors

Werner Martin, President

Daniel R. Koenigshofer, Secretary

The Board of Directors will be expanded to include individuals who can bring expertise in areas of finance, law, marketing, manufacturing, accounting, engineering and other areas that will promote the goals of the company.

VIII. THE FINANCIAL PLAN*

Current Financing Objectives

Management has determined now that Phase I has been completed that \$100,000 of additional venture capital is necessary for implementation of Phase II of this business plan. Proceeds will be used as follows:

- Identify two to three specific user applications.
- Purchase parts and assemble at least three prototype "Tunnel Burner Systems." (Cost \$15,000 to \$20,000)
- Supervise test installations. Set measuring equipment to monitor the systems and gather data about the systems.
- Debug the "Tunnel Burner" system and modify as may be necessary during the Phase II period.
- Upon completion and documentation of the test applications make final changes as may be necessary to the "Tunnel Burner" system.
- Promote the progress of the "Tunnel Burner" in appropriate publications and issue timely news releases.
- Develop printed literature on the "Tunnel Burner" system during this period.

*See Appendix "C" for detail breakdown of anticipated cash flow.

- Have a "turn key" quality "Tunnel Burner" system is simple to operate, is reliable and gives operating comfort comparable to oil or gas fired systems.

WERNER MARTIN

PRESIDENT

Present Position

Integrated Energy Systems, Inc.
307 North Columbia Street
Chapel Hill, North Carolina 27514

Project management: technical evaluation of new energy technologies on community and individual house levels; energy policy and planning; energy-environmental interface problem analysis and solving.

Previous Work Experience

Federal Office for Environmental Protection
Berne, Switzerland - 1976-1979

Section Head: Division of Air Quality Maintenance; energy and environmental concerns of traffic systems.

Ministry for Land-Use, Housing and City Planning
Bonn-Bad Godesberg, Fed. Rep. of Germany - 1976

Expert on UR-Study Group project
"Influence on the Settlement and Land-Use by Development in the Energy Sector."

Basler and Hofmann
Planners and Consulting Engineers
Zurich, Switzerland - 1975 - 1976

Scientific staff and project leader:
"First Energy Conservative Study for Switzerland." Federal Commission for Energy Planning, Berne

Organization for Economic Co-operation and Development (OECD), Energy-Environment Task Force, Paris, France - 1975

Consultant: Analysis and syntheses of energy environment interface subjects.

Education

University of North Carolina
Chapel Hill, North Carolina
1972 - 1975

MS-Environmental Science & Engineering,
Thesis: "Analysis of the Air Quality Management Standards of 32 Countries,"
Advisors: A.C. Stern, M. Heath, and M. M. Hofschmidt, 1975.

Federal Institute of Technology
Zurich, Switzerland

Diploma, Forest Engineer 1972, Thesis: Attempt to Characterize the Urban Air Through Biological Indicators," Th. Keller, H. Leibundgut, E. Granjean.

Languages

English, German, French

Werner Martin, President

Professional Organizations

International Solar Energy Society

Society of American Foresters

Committees/Appointments

NC Wood Energy Coordinating Group, Air Quality Committee, 1980

Leader of Working Group on Wood Energy, Swiss Energy Foundation, 1977-1979

DANIEL R. KOENIGSHOFER

SECRETARY

Present Position

Integrated Energy Systems, Inc.
307 North Columbia Street
Chapel Hill, North Carolina 27514

Principal: Project manager on solar, wind and heat pump, design and engineering, plan field data acquisition, client contact, outline and edit reports.

Previous Work Experience

U. S. Environmental Protection
Agency
Energy Strategies Branch
Durham, North Carolina

Environmental Engineer: formulate and analyze government policies on air pollution from power plants and evaluate energy conservation schemes, e.g., waste heat reuse, solid waste combustion, and material substitution (5/75 - 4/76).

Board of Commissioners
Orange County
Hillsborough, North Carolina

Co-founder Energy Conservation Task Force: conduct energy audit of all public buildings and schools; determine source and end use of all energy used in county (4/75 - 4/76).

Research Triangle Institute
Durham, North Carolina

Consultant: review and analyze natural sources of air pollution; help prepare final report presented to EPA (9/76 - 11/76)

Pollution Curbs, Inc.
St. Paul, Minnesota

Project Engineer: plan and supervise source sampling of utility and industrial boilers and industrial processes; lab analysis, cost estimate for ventilation and air pollution control systems (7/71 - 4/72).

Education

University of North Carolina
Chapel Hill, North Carolina

M.S. Degree in Environmental Science and Engineering, May 1975. THESIS: "Long Range Transport of Trace Metals in Tain Water" involving field data acquisition, instrumentation and computer modeling.

Daniel R. Koenigshofer, Secretary

University of California
Davis, CA

B.S. Degree in Physics, emphasis on
Meterology, graduated Cum Laude,
June 1971.

Languages

English, Spanish, German

Professional/Honorary Organizations

International Solar Energy Soc.
NC Solar Energy Assoc.

National Society of Professional Engineers
Professional Engineers of North America

Committees/Appointments

Research and Development Subcommittee for the NC Wood Energy Coordination Group
1980

Professional Engineer #8994 North Carolina

HEAT HARVESTOR, INC.
PRO-FORMA BALANCE SHEET

1-2-82 To 12-21-87	<u>1-1-82</u>	<u>12-31-82</u>	<u>12-31-83</u>	<u>12-31-84</u>	<u>12-31-85</u>	<u>12-31-86</u>
<u>ASSETS</u>						
Cash	\$ 98,000	458,000	1,656,000	4,454,000	8,852,000	14,450,000
Inventory	-0-	-0-	-0-	-0-	-0-	-0-
Machinery	1,999	1,999	1,999	1,999	1,000	1,999
Patent Rights	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>
TOTAL ASSETS	<u>\$ 100,000</u>	<u>460,000</u>	<u>1,658,000</u>	<u>4,456,000</u>	<u>8,854,000</u>	<u>14,452,000</u>
<u>LIABILITIES</u>						
Working Capital Loan	\$ -0-	457,000	415,000	313,000	211,000	109,000
TOTAL LIABILITIES	<u>-0-</u>	<u>457,000</u>	<u>415,000</u>	<u>313,000</u>	<u>211,000</u>	<u>109,000</u>
<u>CAPITAL</u>						
Stockholder's Equity	\$ 100,000	100,000	100,000	313,000	211,000	109,000
Retained Earnings	<u>-0-</u>	<u>(97,000)</u>	<u>1,143,000</u>	<u>4,174,000</u>	<u>8,543,000</u>	<u>14,242,000</u>
TOTAL CAPITAL	<u>100,000</u>	<u>3,000</u>	<u>1,243,000</u>	<u>4,274,000</u>	<u>8,643,000</u>	<u>14,343,000</u>
TOTAL LIABILITY AND CAPITAL	<u>\$ 100,000</u>	<u>460,000</u>	<u>1,658,000</u>	<u>4,456,000</u>	<u>8,854,000</u>	<u>14,452,000</u>

HEAT HARVESTOR, INC.
PRO-FORMA INCOME STATEMENT

12-31-82 To 12-31-86	1-01-82 To 12-31-82	1-01-83 To 12-31-83	1-01-84 To 12-31-84	1-01-85 To 12-31-85	1-01-86 To 12-31-86
<u>SALES</u> (000)	\$ 2,000	4,000	8,000	12,000	15,000
Less Cost of Goods Sold = Sales x .50	<u>1,000</u>	<u>2,000</u>	<u>4,000</u>	<u>6,000</u>	<u>7,500</u>
Gross Profit	1,000	2,000	4,000	6,000	7,500
Less:					
General & Administrative Expense	300	300	300	300	300
Assembly Expense = Sales x .20	<u>200</u>	<u>400</u>	<u>800</u>	<u>1,200</u>	<u>1,500</u>
NET PROFIT BEFORE TAXES	<u>\$ 500</u>	<u>1,300</u>	<u>2,900</u>		
<u>PRO-FORMA CASH FLOW</u>					
Beginning Balance (ooo)	\$ 98	458	1,656	4,454	8,852
Increases:					
Cash Receipts	<u>2,000</u>	<u>4,000</u>	<u>8,000</u>	<u>12,000</u>	<u>15,000</u>
Working Cash	<u>2,098</u>	<u>4,458</u>	<u>9,656</u>	<u>16,454</u>	<u>23,852</u>
Disbursements:					
Fixed Assets	98				
General & Administrative	300	300	300	300	300
Direct Materials	1,000	2,000	4,000	6,000	7,500
Direct Labor	200	400	800	1,200	1,500
Repayment of Venture Capital Loan*	<u>42</u>	<u>102</u>	<u>102</u>	<u>102</u>	<u>102</u>
Total Disbursements	<u>1,640</u>	<u>2,802</u>	<u>5,202</u>	<u>7,602</u>	<u>9,402</u>
Ending Balance	<u>458</u>	<u>1,656</u>	<u>4,454</u>	<u>8,852</u>	<u>14,450</u>

*Assuming working capital loan of \$300,000 on 7/1/82 with monthly repayment of \$8,469, beginning 8/1/82.

Work plan and Budget for Phase II: Development and Production of
Prototypes 1981/82

Tasks	Costs
1. Patent application U.S. (complete).	\$ 3,000
2. Patent application in FRG, CH, A, F, S (contacts with law firms and cost estimates done).	\$15,000
3. Installation of tunnel burner system on steam boiler at Hope Valley School. Durham, NC; field testing (1,000 hours); (project half complete).	\$31,000
4. Installation of tunnel burner on boiler/furnace on kiln at commer- cial outfit, (several prospects identified).	\$30,000
5. Design and fabrication of product prototype (300,000 BTU/hr) for school heating boiler application.	\$ 6,000
6. Design and fabrication of product prototype (300,000 BTU/hr) for commercial, agricultural warm air systems.	\$ 6,000
7. Design and fabrication of product prototype (50,000 BTU/hr) for residential hydronic heating systems.	\$ 6,000
8. Presentation of 3 product prototypes to potential producers and end-users.	\$ 9,000
9. Last changes on products.	\$ 5,000
10. Evaluation of reactions, comments interests of potential producers and end users.	\$ 1,500
11. Evaluation of production, sales, and service options.	\$ 2,000
Total	\$114,500
Reserve	17,500
Integrated Energy Systems Investment in Phase II	34,000
Needed Capital for Phase II	\$ 98,000

Milestone and Cash Flow Plan for Phase II.

Start Δ
End $\blacktriangle$

October 1981

Approximate Layout	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	5th Quarter	Reserve	Total
Capital Needed	\$28,000	\$42,000	\$19,000	\$17,000	\$ 8,500	\$17,500	\$132,000
IES Capital	18,000	16,000	-	-	-	-	34,000
Missing Capital	\$10,000	\$26,000	\$19,000	\$17,000	\$ 8,500	\$17,500	\$ 98,000

As wood becomes a more and more popular fuel again, many old wood combustion systems like cast iron stoves and dutch ovens are being revived. The old problems of wood heating, however, remain. They are: high maintenance, slow reaction time, low heat storage capabilities, and incomplete combustion. Most of the solutions for clean, efficient combustion are presently sought by gasification, liquifaction, and by rather complex technologies like fluidized bed combustion. Integrated Energy Systems (IES) has in the past few months developed a piece of equipment which is relatively simple, but incorporates new and old principles of gasification and combustion. The prototype was developed under a DOE grant and has demonstrated high efficiency, low air pollution, and very short reaction times to load changes. The most important principles incorporated in the new combustion system are outlined below:

A. Horizontal Fuel Flow

CONVENTIONAL TUNNEL BURNER

In most existing solid fuel combustion systems the fuel flow is vertical rather than horizontal. Fuel is brought into the combustion zone either from underneath or above.

The tunnel burner uses a horizontal fuel flow, allowing better stratification of the combustion process.

B. Separation of Combustion Chamber and Heat Exchanger

Because of the enormous difficulties experienced in reaching complete combustion in an environment of relatively cold boiler and furnace walls, the new system separates combustion from the heat extraction process. IES believes that by separating the two, the combustion chamber and the heat exchanger can be optimally designed. Also the tunnel burner becomes a combustion system well suited for retrofitting existing boilers, furnaces, and kilns from liquid and gaseous fuels to wood or other solid fuels.

C. Minimize Size of Combustion Chambers

The tunnel burner through its flow-through concept allows a small cross-section combustion chamber. This gives a better chance of having equally good combustion conditions throughout the whole combustion zone.

The tubular structure eliminates less controllable corners and provides an ideal environment for the flow of fuel and combustion gases.

Preheating the combustion air allows the high combustion temperatures necessary to burn wood efficiently. At the same time, stress on the metal from those high temperatures can be reduced by cooling the inside wall of the tunnel.

E. Ideal Fuel-Air Mixing

CONVENTIONAL

TUNNEL BURNER

AIR INTAKE JETS

Turbulence is a very important factor in all combustion processes. The tunnel burner utilized small air jets for bringing combustion air from above and below into the fuel bed. The pattern of the air holes and the speed of the incoming combustion air are both carefully selected in order to achieve ideal turbulence.

F. Fixed Ratios Between Fuel Characteristics and Tunnel Dimension

For a wide variety of solid fuels (wood, peat, coal, crop waste, etc.) the basic design of the tunnel can be used. Parameters characterizing fuels will, however, effect the dimensions of the tunnel.

Seeking First Applications

A. Hydronic Heating and Domestic Hot Water Systems in School, Apartment, and Office Buildings

Systems in the range of 150,000 to 400,000 BTU's/hr. output presently fired with oil or gas are good candidates for a tunnel burner system. Critical constraints for retrofits are: availability of fuel storage space and expected remaining life-time of existing boiler.

Tunnel burners could be made available for burning wood pellets within approximately 3 months. The cost for the complete system will be around \$20/thousand BTU's output capacity. Adjustment costs on site will vary from application to application. In larger boilers several individual burners of about 150,000 BTU's/hr. will be attached to the existing system.

Wherever automatic systems are necessary, the tunnel burner will have its chance.

B. Drying Processes (Tobacco, Corn, Peanuts, Minerals)

Drying installations like tobacco barns, other crop drying equipment, kilns for the drying of lumber, minerals, and even for pottery could benefit from the tunnel burner.

can move it around for various uses.

The wooden fuel in such cases can be either in the form of pellets or a hogged biomass fuel. The adaptation work to use wood chips in the tunnel burner should get underway soon.

IES has not the funds available to start working on it at the present time. But for applications in the agricultural sector, it seems important to give consideration to the biomass fuel most easily and cheaply available to the farmer.

INTEGRATED ENERGY SYSTEMS, INC. has specialized in energy design, planning and engineering since 1976. Besides air pollution studies and wood burning technology, IES is also involved in solar home design, and environmental planning. We have recently completed energy audits of over 300 schools around North Carolina, currently heating with gas or oil, where the Tunnel Burner system would have tremendous advantages to offer.

ARTIST'S VIEW OF HEAT HARVESTOR WOOD CHIP BURNER IN
COMMERCIAL OR SCHOOL APPLICATION

ARTIST'S VIEW OF HEAT HARVESTOR WOOD CHIP BURNER IN
RESIDENTIAL APPLICATION

integrated energy systems

For immediate release, 7/14/81.

For more information contact:
Werner Martin
919/942-2007

GRANT AWARDED FOR INSTALLATION OF WOOD BURNING SYSTEM

Integrated Energy Systems of Chapel Hill has been awarded a federal grant to install their automated wood burning system in two North Carolina schools. The funds come from the Department of Energy as part of a program to encourage small-scale renewable energy projects.

IES is a group of architects, engineers, and planners specializing in energy conservation and applications of alternate energy systems. Werner Martin, the inventor of the wood burning system has directed the testing and development efforts for the past year at the IES research facility and at the U.S. Environmental Protection Agency. The test results show that the burner is over 85% efficient and that the air pollution is comparable to an oil burner.

IES is currently looking for two schools who are interested in trying out the burner. The federal funds will pay for the installation and for fuel during testing. The equipment will remain at the school after the tests are complete.

A patent application has been submitted and the company hopes that the burner system will soon be commercially available. Other potential uses of the system are seen in crop drying, motels, laundries, and small industrial and commercial buildings.

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