A JOINT WESTERN AND EASTERN CULTURE PROCEDURE FOR COST-ESTIMATING GEOTHERMAL HEAT PUMP SYSTEMS

William S. Fleming, ASHRAE Fellow and President, Jacwill Services, Inc.

Professor Li Xiuguo, Deputy Director, Chinese Academy of Science

Mr. Li Yuanpu, Manager, Geothermal Heat Pump Center
Beijing JIKE Energy New Technology Development Company

ABSTRACT

Pacific Rim nations (*The Eastern Culture*) have become a major market development area by aggressive European or North American (*The Western Culture*) community persons, businesses, and countries. Demand savings (kW), energy savings (kWh) and environmental quality are primary concerns within both cultures.

From the late 1980s to today the American author[1] has been successful in obtaining cooperative agreements, design, and export of Geothermal Heat Pump (GHP) systems to the Peoples Republic of China (PRC). The first Chinese author[2] was successful for project initiation, management, negotiation and overall approval of a Joint China Ministry of Science and Technology (MOST) and US Department of Energy (DOE) project during 1998 to 2001 for a variety of commercial office buildings within the PRC. The second Chinese Author[3] was successful for China commercial market development and is the Manager of the Beijing JIKE Energy New Technology Development Co.

The Beijing JIKE Energy New Technology Development Company (JIKE) received a grant from The United States Trade and Development Agency (TDA) for development of GHP projects within the People's Republic of China (PRC)[4]. During 2002 to 2004, the project planned for, designed, installed, operated, and maintained GHP systems and building structures, carefully chosen for their suitability. Each project was to be a showcase for increased use of GHP technology in the PRC.

The authors of this paper truthfully believe that GHP technology and service is beneficial to Western and Eastern culture's government, business and all their people. The authors also believe there is a need for information on:

1. Items to understand,
2. Factors to consider, and
3. How to properly estimate GHP systems for commercial buildings throughout the world.

The purpose of this paper is to provide information and procedures for the items discussed above. This information should be invaluable for work in both countries and other areas of the world. This paper will provide economic, technical, social and business information from manufacturers, professional

1 The author's direct contact for assistance in design, transfer of goods and construction in the 1980's was with the Shanghai Minhang United Development Co., Ltd. (SMUDC) of Shanghai, The Peoples Republic of China. During the 1996 to 1999 period the direct contact was with the co-author of this paper and the U.S. Department of Energy. During the 2001 to 2004 period the direct contact was with the co-author of this paper and the U.S. Trade and Development Agency.
2 The author's direct contact for project initiation, purchase of goods, design and construction during 1996 to present was with the Chinese Academy of Science, the co-author of this paper, and PRC building owners, managers, engineers in northern, central and southern provinces of that country.
3 Mr. Li Yuanpu, Manager of Geothermal Heat Pump Center, Beijing JiKe Energy New Technology Development Co. No. 25, Qinghua East Road, Haidian District. Beijing 100083, China.
4 Mr. William S. Fleming of Jacwill Services, Inc. was the U.S. person and firm selected by Beijing Jike and the U.S. Trade and Development Agency.

organizations, professional experience, sites and actual GHP projects within the Peoples Republic of China and North America.

Key Words: ***US and PRC Government, Energy and Economic Effectiveness, People, Technical and Market Development, Commercial Buildings, Cost Estimating within International Markets***

1 INTRODUCTION

The United States of America (U.S.) and People's Republic of China (China) cooperation in developing and promoting geothermal heat pump (GHP) technology is included in an agreement on energy efficiency and renewable energy. This agreement is jointly signed by the U.S. Department of Energy and the State Science and Technology Commission of the PRC (now, the Ministry of Science and Technology).

During the 1999 to 2000 period, the PRC purchased U.S. GHP equipment to construct, operate, and maintain three GHP demonstration sites. From 2001 to 2004, the PRC purchased U.S. GHP equipment to construct, operate, and maintain four GHP promotional sites. All seven China demonstration/promotional sites were located to provide proper technical, economic, climatic information and market applicability. There were to be equivalent sites in northern, central and southern China climatic areas.

1.1 Issues of Cost-Estimating GHP Systems Within East and West Cultures

Proper implementation of beneficial HVAC systems must ensure equipment, building construction, and operation is based on needs and expectations of the building owner, building designer, building tenants and the host country's people. The authors recommend there be a combination planning team. Subject team must have both western and eastern culture technical, financial and marketing oriented persons. When considering a manufacturer's proposed price, import cost, transportation cost, training, education and market acceptance, members of a planning team should consider a series of seven (7) issues.

1. *Understanding a Country, the Government and its People* - It is important that technical design and cost-estimating efforts be structured to address unique needs of other countries and cultures. The driving force of the PRC may be government acceptance, affordability and pride of the demonstration project. There must be flexibility in design and an understanding of government and citizen desires. This will include cost reduction, customer comfort, product quality, capability to produce or fabricate, and ease of maintenance.
2. *Personal Contact Between People* - During all phases of a building's cost estimate, design, construction and operation, a personal and professional relationship must be developed between individuals, community groups, government and business staff.
3. *Program Flexibility* - Success of a GHP project may be dependent on capability of the importing culture to move the technology within its own country's markets. Appropriate business, industry, government and professional leaders within an importing culture will provide a facilitating role at several points:

    - Opportunity Identification
    - Technology Identification and Project Design
    - Purchasing and Procurement
    - Financing
    - Start-Up and Training
    - Other

4. *Financial Incentives* - During a project's estimating and initial phases of negotiation, financial incentives should be provided in a manner that reduces cost, allows technology exchange and

encourages economic benefit at the project site. Financial incentives should also provide business or service within the specific urban or province area of a project.

5. *Combined Commercial and Multi-Family Programs* - The motivating factors driving project decisions in the commercial sector may be profoundly different from those in the multi-family (or domestic) sector. Additional issue identification, people, planning, demonstration and implementation must be provided that has direct appeal to both market sectors.
6. *People's Involvement* - It is important that local government, business and labor be involved in all stages of project initiation, cost estimating and construction. People can be enthusiastic to a technology if they are involved during implementation of the marketing program.
7. *Patience and Persistence* - Time between the project concept, initial cost estimates, questions, revised cost estimates, eastern culture labor and construction time, shipping, education and training (as a separate item – not in product cost), on-site time, initial system start-up, commissioning, warranty enforcement, and market implementation can be lengthy – and very costly. Western professionals must maintain patience and persistence if *joint western and eastern culture* benefits are expected over the long-term.

1.1.1 A Joint Project Plan—Cost-Estimating GHP Systems within East and West Cultures

To meet a primary objective of *joint* western and eastern culture GHP system development within a commercial building industry, service professionals and manufactures must consider plans that include *in-country* fabrication of GHP system support materials (piping, pumps, electric control, ductwork, air handling, etc.).

Western culture technical and business professionals must understand the following items. First, energy saving is a basic policy of China. Second, coal is the dominant energy resource of China and environmental protection has become a basic policy of China. In the past five (5) years, burning of coal directly for heat in PRC urban areas has dropped substantially. Third, the ratio of electricity price to income in China is higher than some other countries, so electricity-saving products are welcome. And fourth, western culture technical and business professionals must understand that China is vast in territory; and natural conditions, human customs and economic strength of each region can be very different.

The following is a series of items that should be discussed by project participants during a GHP project planning process. Because the items affect GHP and its technically competitive HVAC systems cost, each item must be considered when reviewing an initial cost estimate.

1. The technology will provide an HVAC system with a capability to heat and cool simultaneously.
2. The technology will provide control that is superior to that of unitary and central HVAC systems.
3. The technology will be installed with a one- to three-year payback or less.
4. If a comparable system is considered, GHP system cost can be lower in initial cost.
5. The technology will reduce a buildings operating cost. This can allow for business expansion; increased R&D, capital improvement, employee benefits; and greater profit margins.
6. The technology can provide external environmental benefits because of electric plant emission reduction and not cause environmental problems at the building site.

Prior to cost-estimating a specific project the following items must be considered, discussed and agreed upon by western and eastern culture planners:

1. Will initial design and cost estimates be provided to in-country professionals for final design?
2. What is the person time/cost and calendar time for final design and specifications?
3. What is the person time/cost and calendar time for financing, construction, and commissioning?

4. What is the person time/cost and calendar time for training of local engineers, technicians, service personnel, and operators at the project site?
5. What is the person time/cost and calendar time for a site's ongoing operation and maintenance?
6. What is the person time/cost and calendar time for warranty agreements?
7. Finally, what is the person time/cost and calendar time to prepare an initial cost estimate(s), have review(s), negotiate, and provide a last and final cost estimate?

When considering project cost, a western project manager

- *must remember that utilization of eastern culture people is a top priority.* A project must provide rewards to the local economy and people. There must be initial training and follow-on education/training during a project. The training cost must be included as a line item within a project cost estimate. It must not be hidden in a products cost or professional service fee.
- *must act in an equivalent but not dominant role.* Westerners must be trained to understand the eastern country's culture, procedures, and attitudes. Otherwise, staff that is foreign to a country could delay or hinder completion of the proposed project.
- *must consider project location within the eastern country.* Location could affect initial market revenue, burden of debt, cost sharing, revenue flow to project participants, ability to obtain funding sources, and communication.
- *must understand that the western and eastern country's information flow will be critical to project success.* A project cost estimate must have adequate margin to allow a revisit/evaluation of each activity and proper reaction to that activity. Only with proper re-visit, reaction to the project's activities and achievement of well-defined objectives can one ensure that GHP project(s):
  - are accepted,
  - continue to provide pride,
  - maintain electric resource efficiency,
  - allow continued ease of maintenance, and
  - maintain consumer satisfaction.

1.1.2 Establishing Project Information To Cost-Estimate GHP Systems within East and West Cultures

Owning and operating cost information for the GHP system should be part of the investment plan for an entire facility. This information can be used for selecting design options and preparing annual budgets for a GHP system and its host commercial building.

If a project is not within one's own country, the economics of a GHP system are difficult to assess. This is because of the complexities surrounding a country or owner's management of money and the inherent difficulty of predicting future building construction, operating and maintenance expenses. A country's tax structures, time value of money, import duties and transportation cost to (and in) a country can also affect the final cost estimate. Proper cost estimates demand an intelligent analysis of the financial objectives and requirements of a building owner. Owning and operating cost information must be provided by well known and respected computer programs. Such programs must allow access to ones input data, simulation procedures, and climatic information. The technical and economic evaluation output must have an ability to be easily converted to local languages and hold up to very hard investigation(s) by owner, government and interested people.

Certain tangible and intangible costs must also be considered when assessing owning and operating costs within both eastern and western countries. Local codes may require highly skilled or certified operators for specific types of equipment. This could be a significant cost over the life of the system. Similarly, intangible items such as aesthetics, acoustics (particularly in China), comfort, safety, security,

flexibility, and environmental impact (particularly in China) may be important to a particular building or facility.

A thorough understanding of the GHP system's installation costs and accessory requirements must be established by the western design professional or manufacturer. Detailed lists of materials, controls, space and structural requirements, services, installations labor, other must be prepared to increase accuracy in a preliminary cost estimate. A reasonable estimate of GHP system component costs may be derived from another installations cost records (of comparable design) or from quotations submitted by manufacturers and contractors. Cost adjustment may be required for materials purchased within the eastern country, cost of labor in that county and comparative hours required during construction. This information may be gathered from the eastern country partner and documented within final bid documents. Table 1 is a checklist for information that may be required to calculate initial cost of a GHP and competitive HVAC systems.

Table 1. Initial Cost Check List

1. Energy and fuel service costs	15. Alarms and indicator system
2. Heat-producing equipment auxiliaries	16. Building construction and alteration
3. Refrigeration equipment – compressors, chillers, or absorption units	17. Mechanical and electric space
4. Refrigeration equipment auxiliaries – cooling towers, condensers, well water supplies	18. Chimneys and flues
5. Heat distribution equipment - pumps, reducing valves, piping, piping insulation, etc.	19. Building insulation
6. Terminal units or devices	20. Solar radiation controls
7. Cooling distribution equipment: pumps piping, piping insulation, condensate drains, etc.	21. Acoustical and vibration treatment
8. Terminal units, mixing boxes, diffusers, grilles, etc.	22. Distribution shafts, machinery foundations, furring
9. Air treatment and distribution equipment: air heaters, humidifiers, dehumidifiers, filters, etc.	23. Exterior ground or water heat transfer loops or wells
10. Fans, ducts, duct insulation, dampers, etc.	24. Water pumps from exterior to interior of GHP system
11. Exhaust and return systems	25. Exterior to interior water to water heat exchanger
12. System and controls automation	26. Hybrid GHP system heat rejection device
13. Terminal or zone controls	27. Thermal grout for bore holes
14. System program control	28. Other

1.1.3 Comparative Initial Costs - For Cost-Estimating GHP Systems within East and West Cultures

Table 2 provides a comparison of initial costs for the GHP system and other heating and air-conditioning systems marketed in western and eastern cultures such as the PRC. It is important to note that all items listed in this table are based on United States construction costs in the year 2001. This includes United States labor rates, transportation of goods, other. A proper adjustment should be made when considering heating and air-conditioning systems in markets of other countries (see construction costs of China's demonstration projects in this paper).

Table 2. Relative Installed Costs of Commercial Systems at 200 Tons[5]

	USA[6]			China[7]		
Type of System	**$/m²**	**$/ft² [8]**	**$/Ton**	**$/m²**	**$/ft² [9]**	**$/ton**
Package terminal air conditioner (PTAC)	103	$9.48	$3,792	N/A	N/A	N/A
Unitary variable air volume (VAV)	109	10.04	3,960	84	7.80	3,150
WLHP[10]- Well heat exchanger	109	10.04	3,960	63	5.80	2,350
WLHP-cooling tower and boiler	109	10.04	3,960	65	6.00	2,400
WLHP-water pond loop	126	11.61	4,734	66	6.13	2,450
2-Pipe fan coil (chilled water)	133	12.25	4,900	71	6.50	2,600
GHP – horizontal earth loop	133	12.25	4,900	71	6.50	2,600
2-Pipe VAV (chilled water)	136	12.54	5,018	92	8.75	3,500
GHP-hybrid[11]	136	12.54	5,018	91	8.50	3,400
GHP – vertical earth loop	145	13.38	5,352	111	10.25	4,100
4-Pipe fan coil (chilled water)	157	14.5	5,800	117	10.75	4,300

1.1.4 Comparative Evaluation and Case Studies For Cost-Estimating GHP Systems within East and West Cultures

To provide information that will allow initial cost comparison in both western and eastern cultures this paper will provide a brief summary of commercial/institutional buildings recently completed in the PRC. It is recommended that the reader review recent case studies from the Geothermal Heat Pump Consortium (GHPC) or the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)[12,13,14].

There are a variety of commercial office building sizes represented in the cases presented. The installations were all in new buildings. Three were under design and construction during late 1999 and 2000. Two were under design and construction during late 2004 and early 2005[15].

Table 3A presents data for the three U.S. and China demonstration projects of late 1999 and 2000. Tables 3B to 3C illustrates China HVAC system building, owner, location, total HVAC cost, GHP unitary equipment cost and cost per ton of installed heat pump capacity. The GHP unitary equipment cost is only for equipment and shipping from U.S. to China. The total HVAC system cost in Table 3C includes all

5 One-Ton of Air-Conditioning is equal to 12000 BTUH or 3.516 kWh
6 Gathered by USA author from various public and private sources
7 Gathered by China author for various public and private sources
8 Assume 400 Square Foot (37.2 Square Meters) per ton (12000 BTUH)
9 Assume 400 Square Foot (37.2 Square Meters) per ton (12000 BTUH)
10 WLHP is the symbol for Water Loop Heat Pump
11 Hybrid systems contain Geothermal Heat Pump (GHP) earth or water loops together with supplemental cooling towers and boilers
12 The case study report is *"Analysis of Existing Geothermal Heat Pump Installation Data Sets"*, Final Report, by D. Cane, A. Morrison, C. Ireland, Caneta Research, Inc., Mississauga, ON; K. Mayo, The Cadmus Group, Inc., Waltham, MA; and William S. Fleming, Jacwill Services, Inc., Cazenovia, NY. The report was sponsored by the Geothermal Heat Pump Consortium, Inc. (Under United States Department of Energy Contract DE-F607-951D13347)
13 Information from ASHRAE may be obtained from ASHRAE Publications, 1791 Tullie Circle, NE Atlanta, GA 30329-2305 USA. Telephone 404–636–8400; Fax 404–321-5478 The Internet address in Http://www.ASHRAE.org
14 The Case Study report is Copyright © 1997 Geothermal Heat Pump Consortium, Inc., 701 Pennsylvania Ave., NW, Washington, DC 20004. Telephone (202) 508-5500, Fax (202) 508-5222 or toll free: 1-888-ALL-4-GEO. The Internet: http://www. Geothermal Heat Pump .org The E-mail: info§ghpc.org GHPC #RP-026
15 The American Author provided an initial PRC project in 1986-87. It is not included due to age of the project for comparison to current U.S. and PRC projects. Design, construction, and operation of the 1987 Shanghai PRC project provided an excellent working relationship with Shanghai Minhang United Development Co. Ltd. (SMUDC) the North American author and the North American GHP manufacturer. The PRC contract required that a 50 Hz unit be successfully laboratory tested. During laboratory testing and arranging for transport the GHP system design was completed. The manufacturer provided assistance throughout the project. Project cost for GHP equipment, and all design services, ground loop piping, control, other15 was approximately 155,000 USD or 1192 $/Ton, 4 $/ Sq- Ft, 43 $/ Sq-Meter.

internal and external piping, fittings, unitary equipment, duct work, control, electrical, plumbing, other materials. Total HVAC cost also includes professional design and labor during construction. The Geothermal loop cost is contained in total HVAC cost and includes all well construction, trenching, piping, pumps and associated labor to install.

Table 3A. The China GHP Demonstration Project		
Project Name	**Address**	**Dimensions**
Guangzhou Branch of the Chinese People's Liberation Army Defense Academy (**Guangzhou Project**)	Zengcheng District, Guangzhou city, Guangdong Province, China	50,000 square meter, to be built in stages
Administration Building in Yuquan Development Zone of Hangzhou **(Hangzhou Project)**	Yuquan development zone, Hangzhou city, Zhejiang province, China	19,000 square meters
Beijing Concordia Plaza **(Beijing Project)**[16]	Sanyuan Bridge, Chaoyang District, Beijing, China	89,000 square meters

Table 3B. The China GHP Demonstration Project				
PROJECT NAME	**Budget**		**North American Partner**	**Construction Period**
	Total HVAC	**GHP Equipment Cost**		
Guangzhou	17,000,000RMB ($2,048,192 USD)	US $800,000	The Environmental Group, Inc.	11/99 to 7/01
Hangout	8,000,000RMB ($963,855 USD)	US $300,000	The Trane Company	12/99 to 5/01
Beijing	23,000,000RMB ($2,770,184 USD)	US $1,000,000	The Trane Company	11/99 to 3/01

Table 3C. The China GHP Demonstration Project				
PROJECT NAME	Budget		Budget	
	Total HVAC USD/Sq-Ft	GHP Equipment USD/Sq-Ft	Total HVAC **USD/SQ-M**	GHP Equipment USD/Sq-M
Guangzhou Project	3.76	1.48	41	16
Hanghou Project	4.67	1.72	50.73	15.8
Beijing Project	2.86	1.03	31.12	11.2

1.1.5 The Beijing Concordia Plaza — A Large 1999–2001 Project

The Concordia Plaza is a 33-story luxury apartment building located in the downtown commercial center of Beijing. It is home to more than 300 families. The Concordia Plaza project used more than 500 GHPs at a total cost of $860,000. All heat pumps were manufactured in the United States and shipped to China. The Department of Energy's Dan Reicher, Assistant Secretary for Energy Efficiency and Renewable Energy, noted success of the project and stated "We strongly believe that energy-efficient and renewable technologies are central to sustainable development and should be an important element of energy policy and implementation for all countries."[17]

[16] The authors have provided more detailed discussion and pictures of this item later in the paper

17 Some written information obtained from the GeoExchange national Information Resource Center Newsletter Volume 7, Issue 2. March/April 2000



The Beijing Concordia

1.1.6 The Beijing June 1st Kindergarten— A Large 2002–2004 Project

This school is located near Yuquan Mountain of Haidian District. It is a key kindergarten in the city and has 1,200 registered children. The school was constructed in the 1950's. Although the school has been transformed many times, its heating system still uses coal-burning boilers, which cause serious air pollution in the school and surrounding district during winter.

There are seven buildings in the Beijing June 1 Kindergarten school. The total construction area is 11,974[18] m^2- 12,134.2 m^2. The Beijing June 1 kindergarten occupies 80,000 m^2 of land area. The US Ground-Air GHP project was started in August 2003 and completed before Nov. 15.2004.

Total investment cost for this initial project is approximately 4,576,000 RMB. During year 1 the GHP system is estimated to be 44% lower in operating cost than a Variable Refrigerant Volume (VRV) air-conditioning and gas-burning boiler, 53% lower than a direct-fired gas absorption system, and 24% lower than a water-water heat pump system. When compared with the often-used electrical direct expansion air conditioning and gas-burning boiler system, the Beijing June 1 Kindergarten operational cost saving rate is 30%.

18 The total of 11,974 m^2 is the area that was calculated within the load and energy computer simulation program. This program was used by the Feasibility Study Team to arrive at technical and economic values provided in this paper.



Beijing June 1 School Complex



GHP System in Operation

Beijing June 1 Kindergarten School



Details of Earth Loop



One School Kindergarten Building

1.1.7 The DiDu Hot Springs Resort —A Small 2002-2004 Project

The DiDu Resort Village is a successful project that will provide GHP observation, understanding and performance information to many citizens in southern China, Hong Kong and Macao. The authors visited the resort during 2002. During the winter and spring of 2003 JIKE designed, purchased and installed the closed-loop GHP system into an adjoining lake. In August 2003 the authors commissioned the system and visited the resort for opening ceremonies. The project is located near Enping City of Guangdong Province. The building's floor area is 2,950 m^2. The first floor contains an office, infirmary, changing room and interior space. The second floor includes a changing room and bathroom. The floor area for heating and cooling is 1,406 m^2



DiDu Resort



Laying Loop Piping

Energy Evaluation for Small Project - DiDu Hot Springs Resort[19]

Investment Considerations		**Building Area 3,390 M^2**	**U.S. Equipment Costs 30,000 USD**
Comparative Economic Evaluation and Operational Data		**Traditional Central Air Conditioning System (Estimate)**	**GHP System (Actual Data)**
Cooling	Operation days	240	240
	Electric kWh for cooling	169,344	82,944
Heating	Operation days	120	120
	Electric kWh for Heating	120,960	55,296
Cooling cost - RMB		203,212	99,532
Heating cost -RMB		243,855	66,355
Annual operating cost (RMB)		447,067	165,887
Annual saving operating cost (RMB)			281,180
Saving rate			63%

1.2 Past, Current, and Future Results For Cost-Estimating GHP Systems within East and West Cultures

During years 1999 to 2004 the United States Trade and Development Agency (TDA), the United States Department of Energy (DOE), and the China Ministry of Science and Technology (MOST) were key parties for the success of GHP technical and market development within China. The TDA Grant assisted JIKE and Jacwill during the process of selecting GHP promotional projects, recommending GHP technologies, ensuring equipment procurement and providing technical services.

In the early years of 1999 – 2002, China and the United States began the cooperation and promotion of U.S. Ground-Air GHP Technology in China. During that period, MOST designated Beijing JIKE as the executive unit for projects. After that, as illustrated in Table 4, Section 1, Beijing JIKE constructed 13 large-, medium- and small-sized U.S. Ground-Air GHP Systems in south, middle and northern areas of China. All are successful. Each project's heating, ventilation and air-conditioning (HVAC[20]) equipment is in accordance with Chinese national standards. The projects also considered (or installed) equipment to

19 This energy evaluation was provided during late 2002. Results from August of 2003 to February 2004 indicate the savings are within 2% of those in the above table.

20 Throughout this document HVAC will be the means to express the term Heating, Ventilating and Air Conditioning.

improve indoor air quality, provide ventilation and exhaust air, provide humidification, and provide a minus oxygen hydrogen generating device. Cost savings of GHP systems for these 13 projects are more than 50%, and owners and occupants of the buildings are quite satisfied. The largest of these initial projects is the Jiaheliyuan International Apartment Building (Beijing Concordia Plaza), with 88,000 m² of floor area and 32 floors. Its GHP system has attracted great attention in China and worldwide.

After Beijing JIKE signed a grant agreement on GHP technology with the United States Trade and Development Agency (TDA) in 2002, technical and market activities of Beijing JIKE concentrated on large buildings and entire districts. This is illustrated in Table 4 (Section 1 & 2) during years 2002–2005.

During 1999–2001[21], the purchase value of GHP equipment was $2,640,300[22]. U.S. GHP equipment was purchased from U.S. companies such as Trane, Florida Heat Pump, Mammoth, McQuay and Climate Master. During 2002–2003, the GHP promotional program caused GHP equipment to be purchased at a value of $1,895,300. During 2004, the GHP promotional program caused United States GHP equipment to be purchased at a value of $600,000. During 2004-2005, values (which are signed at time of this paper) will be $1,050,000. During late 2004& early 2005, an additional value of $ 2.350.000 is expected. Beijing JIKE believes that in the year 2005 total value of GHP purchases could be higher. The 1999-2001 value of U.S. Exports can be linked to the United States Department of Energy. The 2002-2004 values of U.S. exports can be linked to the United States Trade and Development Agency (TDA) grant agreement and Chinese plans to establish a GHP promotional project. The total past, current and near term future value of GHP units purchased within China and exported by the United States is provided in Table 4-Section 2.

1.2.1 Purchase and U.S. Exports of U.S. GHP Equipment —1999 to 2005

Table 4 –Section 1. Projects Completed And Equipment Exported During Years 1999¬2001

Serial no.	Years	Region	The name of GHP projects	Category of the building	Area (m^2)	Cost ($)
1	1999	Beijing	Jiaheliyuan International Apartment (Beijing Concordia Plaza)	Superior Apartment of 32 floors	88,000	860,000
2	1999	Ningbo	Clothing Industry City	Plant of Clothing Production	38,380	520,000
3	1999	Beijing	Taihe Temporary Office	3 Floors office	450	7,000
4	1999	Guangzhou	Zengcheng College in Guangzhou	School	18,000	310,000
5	1999	Zhenzhou	Laboratory - Agricultural college in Zhenzhou	Office	70	3,000
6	1999	Beijing	Diminutive Residential Building	Resident building	105	3,000
7	2000	Beijing	Clothing Shopping Centre near Zoo	Marketplace	15,000	290,000
8	2000	Beijing	Diminutive Residential Building	Resident Building	120	3,000
9	2000	Beijing	Small Office of Kebei Company	Office	240	6,000
10	2001	Beijing	Staff Dormitory at Wangjing District	Residence	41,000	390,000
11	2001	Beijing	Office of JIKE Company	Office	170	4,000
12	2001	Huhehaote	New energy Base	Research Building	1,000	30,000
13	2001	Beijing	Macao Satellite Television	Superior Office	10,000	214,000

21 See Table 4 – Section 1
22 Values with the item $ are USD

Table 4 –Section 1. Projects Completed And Equipment Exported During Years 1999¬2001						
Serial no.	**Years**	**Region**	**The name of GHP projects**	**Category of the building**	**Area (m^2)**	**Cost ($)**
			Carton Station	of 2 Floors		
14[23]	2002	Beijing	Science and Fortune Building	Office	66,000	940,000
15	2002	Neimenggu	Science and Technology Building	High-rise Building	10,100	210,000
16	2002	Beijing	Moon Bay villa	Superior Apartment	500	10,000
17	2002	Beijing	101 Base of Shanghai Railway	Dormitory	679	14,000
18	2002	Beijing	Adult Education Center of Haidian District	School	2000	41,000
19	2002	Beijing	Xinfadi Water and Electricity Station	Small Office	200	6,000
20	2003	Beijing	Yujing Park Club	Amusement Facility	9,000	170,000
21	2003	Chengdu	Chengdu Hotel	Hotel	12,000	230,000
22	2003	Guangdong	Vacation Village, Enping City	Vacation Villas	3,390	30,000
23	2003	Shenzhen	Shenzhen Hotel	Hotel	8,000	160,000
24	2003	Wuhu	Railway Apartment in Wuhu	Apartment	1,800	20,000
25	2003	Beijing	Kindergarten of Beijing (initial term)	Small School Buildings	5,700	64,300
Total this section of table					**331.904**	**$4,535,300**

Table 4, Section 2. Projects Completed During Year 2004						
Serial no.	**Years**	**Region**	**The name of GHP projects**	**Category of the building**	**Area (m^2)**	**Cost ($)**
1	2004	Beijing	Kindergarten of Beijing (second term)	Small School Buildings	11,671	230,000
2	2004	Beijing	High School and Elementary School at Haidian District	School	26,000	370,000
Subtotal						**$600,000**
Total – This Section of Table						**$5,135,300**
Projects Under Consideration, Construction or In Design Process in Late 2004/Early 2005						
3	2004-2005	Beijing	The Jingshiyuan Residential District (Generals Garden) - initial term	High Rise Apartment	38,680	440,000
4	2004-2005	Shanghai	Railway Bureau Project	Office	47,000	610,000
5	2004-2005	Binzhou	Office and Residential Buildings (By and Energy Service Company)	High Rise and Medium Buildings	60,000	1,300,000[24]
3 Total this section of table						**$2,350,000**
4 Total of Table 1, sections 1 and 2						**$7,485,300**

23 This item and all those remaining are a direct result of the United States Trade and Development Agency grant and resultant technical or market assistance.

24 This is an estimate (first) made at the writing of this paper

2 CONCLUSION—COST-ESTIMATING GHP SYSTEMS WITHIN EAST AND WEST CULTURES

There is a 15-20% annual growth rate in the Peoples Republic of China (PRC) space conditioning and refrigeration market (for homes, office buildings, hotels, supermarkets, railroad cars and Lorries); a predicted power shortage in the 21st century; and the Montreal Protocol. These are challenges facing the PRC's heating and air-conditioning industry over the next few years[25].

In the present energy structure of China, coal makes up over 76% of the energy consumption. Coal constitutes the chief source of atmospheric pollution in China. It is believed geothermal heating and air conditioning technologies (that have been proven as a solution within the North America) may reduce environmental pollution and be cost beneficial within urban and rural communities[26] of the PRC.

As a result of the aforementioned factors the co-author's of this paper and other professionals within the western and eastern culture's government, business, and professional organizations believe the following action and benefits will occur as a result of the joint U.S. and China GHP activity.

- Energy & Demand Savings in Buildings
- Education in China Business/Industry
- Purchase of Effective HVAC Systems
- Market Acceptance
- Marketing Approaches that Benefit All
- Procedural Approaches that Benefit All
- Benefit to Common Environmental Goals
- Fulfillment of Common Energy Goals
- Achievement of Common Objectives
- Increased Use of Renewable Resources

To achieve common objectives of the eastern and western cultures and to satisfactorily continue with GHP work that has been accomplished and illustrated within this paper, both owning and operating cost information for the GHP and comparative heating and air conditioning systems (as constructed in the eastern countries) should be included in the design of a facility.

When either western or eastern culture professionals consider the economic values of a properly engineered GHP system, all must agree there will be many difficulties during cost estimating and proper assessments. Difficulties may not only include variation in labor and in-country equipment costs, but also complexities surrounding the technology, financial evaluation procedures, environmental values and benefits of a GHP system's renewable energy for existing and future generations.

When considering a GHP system and providing cost estimates, all cultures must understand that HVAC system benefits are not limited to either the cheapest or the most expensive system. Instead, HVAC system benefits include all technical, financial, and social objectives and requirements of an owner, designer and country that consider proper energy and environmental values.

25 Heat pumps take off in China, The Chinese Market; by Joe Bourna, IEA, 1998.
26 The Earth as a Renewable and Thermal Storage Resource for Heating and Air-Conditioning Systems, An Action Plan; by William S. Fleming, 1997.

As previously discussed and provided in cost estimates by co-authors of this paper, all tangible costs and/or benefits must be considered when assessing owning and operating costs of a GHP system. Such tangible costs and/or benefits could have a significant value over the life of the system.

And finally, but of equal importance, intangible items such as aesthetics, acoustics, comfort, safety, security, flexibility, energy savings and environmental impact may be of equal or greater importance for a particular building, facility, province or country – and to its government and people.