**QUARTERLY TECHNICAL PROGRESS REPORT
TO THE U.S. DEPARTMENT OF ENERGY**

from the

ENERGY EFFICIENT INDUSTRIALIZED HOUSING RESEARCH PROGRAM

CENTER FOR HOUSING INNOVATION

UNIVERSITY OF OREGON

and the

FLORIDA SOLAR ENERGY CENTER

**A Research Institute of the
UNIVERSITY OF CENTRAL FLORIDA**

July 1 - September 30, 1990

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**QUARTERLY TECHNICAL PROGRESS REPORT
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PROJECT DESCRIPTION:

The United States housing industry is undergoing a metamorphosis from hand built to factory built products. Virtually all new housing incorporates manufactured components; indeed, an increasing percentage is totally assembled in a factory. The factory-built process offers the promise of houses that are more energy efficient, of higher quality, and less costly. To ensure that this promise can be met, the U.S. industry must begin to develop and use new technologies, new design strategies, and new industrial processes. However, the current fragmentation of the industry makes research by individual companies prohibitively expensive, and retards innovation.

This research program addresses the need to increase the energy efficiency of industrialized housing. Two research centers have responsibility for the program: the Center for Housing Innovation at the University of Oregon and the Florida Solar Energy Center, a research institute of the University of Central Florida. The two organizations provide complementary architectural, systems engineering, and industrial engineering capabilities. In 1989 we worked on these tasks: 1) the formation of a steering committee, 2) the development of a multiyear research plan, 3) analysis of the U.S. industrialized housing industry, 4) assessment of foreign technology, 5) assessment of industrial applications, 6) analysis of computerized design and evaluation tools, and 7) assessment of energy performance of baseline and advanced industrialized housing concepts.

The current research program, under the guidance of a steering committee composed of industry and government representatives, focuses on three interdependent concerns -- 1) energy, 2) industrial process, and 3) housing design. Building homes in a factory offers the opportunity to increase energy efficiency through the use of new materials and processes, and to increase the value of these homes by improving the quality of their construction. Housing design strives to ensure that these technically advanced homes are marketable and will meet the needs of the people who will live in them.

Our goal is to develop techniques to produce marketable industrialized housing that is 25% more energy efficient than the most stringent U.S. residential codes now require, and that costs less. Energy efficiency is the focus of the research, but it is viewed in the context of production and design. This approach will enable researchers to solve energy problems in such a way that they can assist industry to improve its product and compete with foreign companies, to alleviate the trade imbalance in construction products, to increase the productivity of the U.S. housing industry, and to decrease both the cost of housing and the use of fossil fuels that are expensive and damaging to the environment.

The current tasks are: Area 1 **CRITICAL REVIEW OF ENERGY EFFICIENCY IN
INDUSTRIALIZED HOUSING, HOUSING PRODUCTS, AND
PROCESSES**

- 1.1 Statistical Reviews of U.S. and Foreign Industry
- 1.2 Site Visits and Process Analysis of Manufacturing Plants
- 1.4 Computer Use and Automation

Area 2 DEVELOPMENT OF 21ST CENTURY INDUSTRIALIZED
HOUSING CONCEPTS

- 2.1 Design for Energy Efficiency
- 2.2 Energy Design Software
- 2.3 Manufacturing Process Innovation
- 2.4 Modular Language for Design and Production
- 2.6 Energy Testing of Houses, Assemblies, Products, Materials

Area 3 CATALYSTS FOR TECHNOLOGY UTILIZATION

- 3.4 Publications

Area 4 PROGRAM MANAGEMENT

- 4.1 Program Steering Committee Meeting
- 4.2 Topical Technical Committee Meetings
- 4.4 Annual Operating Plans
- 4.5 Quarterly Progress Reports
- 4.6 Annual Reports

Tasks 1.1, 1.4, and 4.3 have been completed. Tasks 1.3, 2.5, 2.7, 3.1, 3.2, 3.3, and 3.5 are inactive.

RESEARCH PROJECT ADVANCES:

Task 1.1 The National statistical analysis conducted in FY89 was refined, with the information base refined and interpolated to reflect the regional climates, markets, and production norms of the U.S. Conclusions were reviewed with the major analysts working in the field, and findings summarized in a final report which included work from FY89 and 90. This task is now completed.

Task 1.2 Significant site visits were made throughout Norway and Sweden to assess the state of the art of industrialized housing manufacturing and innovative processes. Detailed trip reports are attached.

Task 1.4 An evaluation of software currently in use for energy analysis, other design tasks, and for production was completed.

Task 2.1 A baseline design/market problem statement was created for a 21st century house, based on historical and projected data which was then coalesced into topical reports. Anticipated design and market characteristics and goals were then defined, and Design Cycle 1 begun.

Task 2.2 The research team is identifying energy related design decisions and who makes them. Development continues on hardware and software criteria and feasibility for new design tools and conceptual software.

Task 2.3 The first sub-task focuses on the development of a Generic Industrialized Housing Manufacturing Simulator. The objective of the simulator is to easily demonstrate the impact of implementing manufacturing process innovations in any industrialized housing manufacturing operation. The project team continued to make progress in the development of specifications which will be used to guide the simulator software development effort. Specific accomplishments include an extensive, ongoing literature search and a review of current manufacturing simulators. The project team also continues to make progress in the development of prototype models which are being developed as a test bed for simulator concepts. A rudimentary model of the Fleetwood operation in Lakeland, FL has been completed using the SIMFACTORY manufacturing simulator. Efforts are underway to port this model to a SIMAM simulation language platform. Work

has recently been initiated in the development of a process/equipment "innovation" data base which will serve as a key source of information for the simulator. Potential sources of information have been identified and efforts are underway to identify data fields needed.

The second sub-task focusses on a Concurrent Engineering Approach for Industrialized Housing. Research in this direction includes: Defining concepts and attributes of concurrent engineering (CE) in industrialized housing, future development of a expert system for implementing CE in industrialized housing and developing a structured approach for industrialized housing design and manufacturing.

Task 2.4 Considerable progress has been made in literature review. Innovative modular systems are being developed in Finland and Sweden. An analysis of these two innovative systems is underway by Janet McIlvanie, newly hired architect for this task. In addition, Emanuel Levy, task subcontractor has prepared a draft literature review report.

Task 2.6 Summer testing has been completed on the prototypes at FSEC. The results will be reviewed by DOW and American Ingenuity in October and the task report prepared in November/December. Infrared testing has been done at the Integri (a division of Penn Lyon homes) Plant in Leesburg, FL. This testing has resulted in measurable improvements to the energy efficiency and quality of Integri homes.

Task 3.4 Technology information distribution is facilitated through presentations and publications, as specified in a following segment of this report.

Task 4.1 A meeting was conducted by the CHI and FSEC with members of the EEIH Steering Committee during July, in Eugene, Oregon, for the purpose of reviewing EEIH research results, obtaining industry input on future research plans, and seeking ways in which to improve utilization of research findings by industry.

Task 4.2 A technical committee for Task 2.3 has been formed, and an initial meeting set for Nov. 8, 1990. Related to technical concerns, an estimate of quad savings from the EEIH project has been prepared and sent to DOE at George James' request

PAPERS & PRESENTATIONS:

Elshennawy, A.K., W.W. Swart, and S. Chandra, Application of Robotics and Automation Technologies to the Industrialized Housing Manufacture, in "Economic Aspects of Advanced Production and Manufacturing Systems," edited by H. Parsaei and A. Mital, Taylor & Francis, Ltd., 1990.

Elshennawy, A.K., C.H. Lee, W. Swart, and S. Chandra, Human Engineering Aspects in the Automation of Industrialized Housing Manufacture, 2nd International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation, Honolulu, Hawaii, August 12-16, 1990.

Elshennawy, A.K., W.W. Swart, M. Mullens, and S. Chandra, Energy Efficient, Affordable Industrialized Housing for the 21st Century, XVIII IAHS World Congress: Buildings in the Future, Rio de Janeiro, Brazil, October 8-12, 1990.

Elshennawy, A.K., M. Mullens, W.W. Swart, and S. Chandra, A Model for the Factory of the Future for Industrialized Housing, to be presented at the 5th International Conference on CAD/CAM, Robotics and Factories of the Future, December 2-5, 1990, Norfolk, Virginia.

Elshennawy, A.K., M. Mullens, W.W. Swart, and S. Chandra, A Concurrent Engineering Approach for Industrialized Housing, to be presented at Design Productivity Conference, February 3-9, 1990, Honolulu, Hawaii.

CONFERENCES/MEETINGS:

- 7/90 Preparation and debriefing meetings between CHI and FSEC personnel regarding the EEIH Steering Committee meeting in Eugene, Oregon, and the recommendations for the project arising from that meeting. (Full staff, CHI & FSEC)
- 7/90 Hosted EEIH Project Steering Committee Meeting in Eugene, Oregon. Presented status of project/research, gathered opinions on continuing direction and process of the project. (Full staff, CHI & Elshennawwy, Mullen, Swart, FSEC)
- 7/90 Presentation of project and work in progress to Oregon State University Forest Products Research Laboratory. Shared ideas and findings on wood materials research futures for the 21st Century House Project. (Brown, Berg, Kellett)
- 8/90 Proposal for research, design and technical assistance for Swedish factory crafted housing made to LanDymanics, an American/Swedish joint venture establishing a house manufacturing plan in Springfield, Oregon.

BRIEFINGS/VISITORS:

- 7/90 Briefing on project and work in progress to Stan Mendelsohn, Ball State University. Principal investigator on project to develop econtemporary housing prototypes for Indiana modular manufacturers. (Brown, Kellett)
- 8/90 Briefing on project and work in progress to Dan Market, Century Homes, Portland and Eugene/Springfield Metro Partnership. Potential participant in Lane Industrialized Housing Initiative. (Brown, Kellett)
- 8/90 Briefing on project to Vladimir Reznikoff, Zapsibinvest and Dmitriy Bekelshov, USSR Ministry of Foreign Economic Relations and Keith Wright, Bohemia Corporation. Potential Trade in manufacturing equipment, building materials and housing. (Brown, Kellett)
- 9/90 Briefing on EEIH and Energy Scheming software projects for U.S. Senator Hatfield's representative, Margo Nouse. (Brown, Kellett)
- 9/90 Briefing on project, work in progress and potential areas of future work to Steve Onisko, Bonneville Power Administration. (Brown, Kellett)

CONTACTS/TRIP LISTING:

- 6/90 Consulted with Hallahan Associates and Lane County Industrialized Housing Initiative to develop the "Report on Industrialized Housing Assessment" prepared for the Lane Council of Governments. (Brown, Kellett)
- 8/90 Site visits and analysis over a one month period of time, to industrialized housing plants and research centers in Norway and Sweden. (Brown)
- 9/90 NAHB/BSC Plant Tour, Industrialized Housing Manufacturers throughout Massachusetts, New Hampshire and Maine. (Mullens)
- 9/90 Acorn Structures, Inc., Concord, MA. Tour led by Art Milliken, Pres. (Mullens)

- 9/90 Cybernation Inc., Medford, MA. Tour led by Bob Provencher (Director), attended by (Mullens)
- 9/90 Epoch Corp., Pembroke, NH. (Mullens)
- 9/90 New England Homes, Inc., Greenland, NH. Tour led by John Carrisone, Pres. (Mullens)
- 9/90 Classic Post & Beam Homes. Visit to model home site. (Mullens)
- 9/90 Wood Structures, Biddeford, ME (Mullens)
- 9/90 Coastal Structures, Inc., Portland, ME. (Mullens)

PUBLICATIONS ACQUIRED:

Affordable Housing in Older Neighborhoods: Multiple Strategies. National Trust for Historic Preservation, October 1989.

Affordable Housing Through Energy Conservation: A Guide to Designing and Constructing Energy Efficient Homes. 3v. U.S. Department of Energy, June 1989.

Ahluwalia, Gopal and Michael Carliner. What Home Buyers Want. National Association of Home Builders of the United States, 1989.

Arockiasamy, M. and S. Lee. Computer-Aided Structural Engineering (Case) Project: State of the Art on Expert Systems Applications in Design, Construction, and Maintenance of Structures. U.S. Army Corps of Engineers, Sept 1989.

Barron, Joanne and Audrey Dougherty. Housing Markets in 2000: Prototypes of the Region's Communities. Metropolitan Council of the Twin Cities Area, n.d.

Bazjanac, V. and F. Winkelmann. Daylighting Design for the Pacific Museum of Flight: Energy Impacts. Lawrence Berkeley Laboratory, September 1988.

Blum, Sheila, Michael J. Holtz and Ralph R. Tavino. Post-Construction Activities: Passive and Hybrid Solar Low Energy Buildings: Design Information Booklet Number Eight. Architectural Energy Corporation, Aug 1989.

Bugler, Daniel et al. Assessment of the Industrialized Housing Industry and Public Policy Options. Maxwell Graduate School of Citizenship and Public Affairs, Syracuse University, June 1989.

Building Thermal Envelope Systems and Materials (BTESM) and Research Utilization/Technology Transfer Progress Report for DOE Office of Buildings and Community Systems: Monthly Progress Report. Oak Ridge National Laboratory, April 1989.

Carper, James, et al. Using Building Systems: Modular, Panelized, Log, Dome.. National Association of Home Builders of the United States, 1990.

Collier, R. Kirk, Barry M. Cohen and Ronald B. Slosberg. Desiccant Properties and Their Effects on the Performance of Desiccant Cooling Systems. Florida Solar Energy Center, 1989.

Davis, Randall C., Dick M. Royster and Thomas T. Bales. Analysis and Test of Superplastically Formed Titanium Hat-Stiffened Panels Under Compression. Langley Research Center, January 1987.

Dougherty, Audrey, Neal Cuthbert and Ana Moreno. Looking Ahead at Housing: The Effect of Changing Demographics on the Twin Cities Area Housing Market. Metropolitan Council of the Twin Cities Area, September 1988.

Evaluation Procedure for Building Energy Performance Prediction Tools, Vol. I and II. Building Energy Design Tool Development Council, July 1984.

Foreign Terminology and Trade Handbook for the Wood Products Industry. Mater Engineering, Ltd., 1989.

Griffin, Paul, ed. The Wood Book. Hatton-Brown Publishers Inc., 1990.

Heat Pump Water Heater in Multi-Family Housing Test: Final Report. United Industries, 1989.

The Housing Industry: Perspective and Prospective: 5 Working Papers. Canada Mortgage and Housing Corporation, 1989.

The Evolution of the Housing Industry in Canada, 1946-86

The Housing Industry and Change

The Housing Industry and the Economy, 1946-1986

The Housing Industry and the Production Process, 1946-86

The Housing Industry in the Future

Kahn, Edward. Electric Utility Planning & Regulation. American Council for an Energy-Efficient Economy, 1988.

Karaki, S. Colorado State University Program for Developing, Testing, Evaluating, and Optimizing Solar Heating and Cooling Systems. Solar Energy Applications Laboratory, Jan-Feb 1989.

McConnell, Donna. Evaluation of Commercially Available Lighting Design Software. Sandia National Laboratories, 1989.

Morrison, Peter A. Demographic Factors Shaping the U.S. Market for New Housing. Rand Corporation, July 1988.

Parker, G.B. et al. Lessons Learned from Monitoring Electricity Use in Multifamily Residences. Pacific Northwest Laboratory, June 1989.

Partitions with Integral Doorsets: Fifth Programme Keysan Ltd., Product Data. Property Services Agency, 1989.

Partitions with Integral Doorsets: Fifth Programme Neslo Interiors, Tarmac Construction Ltd., Product Data. Property Services Agency, 1989.

Partitions with Integral Doorsets: Fifth Programme Unilock Partitions Ltd. Ranges UT2-UT10, Firesound System Ranges UT31-UT38 Mistral System, Product Data. Property Services Agency, 1989.

Permanent Foundations Guide for Manufactured Housing. U.S. Department of Housing and Urban Development, August 1989.

Plastics used as Building or Construction Materials. Jan 75- Sept. 88.. NTIS, September 1989.
Citations from the Engineering Index Database.

Russ, Armin. Discussion of Active Solar Cooling Alternatives. Florida Solar Energy Center, 1989.

Saastamoinen, J.J. Thermal Behavior of a Heat Storage Floor Heated by an Air Flow. U.S. Dept. of Commerce, 1988.

Turk, B.H. et al. A Comparison of Indoor Air Quality in Conventional and Model Conservation Standard New Homes in the Pacific Northwest. U.S. Department of Energy, 1987.

Ventilation for Acceptable Indoor Air Quality. ASHRAE, 1989.

Yuill, G.K. Project to Continuously Monitor the Performance of the Laminar Flow Super Window-Humidity Controlled Air Inlet-Baseboard Heater Ventilation and Heating System. Canada Mortgage and Housing Corporation, November 1989.

**DOE QUARTERLY REPORT
CHECKLIST:**

ID# DE-FC03-89SF17960

**Energy Efficient Industrialized Housing
Research Program**

Forms Required Quarterly: (one copy each to each address shown)

Federal Assistance Milestone Plan	1,2,4
Federal Assistance Budget Information Form	1,3
Federal Assistance Management Summary Form	1,2,4
Federal Assistance Program/Project Status Report	1,2,4
Financial Status Report, OMB Form 269	1,2,3
Narrative Technical Progress Report	1,4,5,6

to include:

- Papers & Presentations
- Briefings/Visitors
- Contacts/Trip Listing
- Conferences/Meetings
- Research Project Advances
- Publications Acquired

includes input from:

Chandra/FSEC	
Berg	Brown
Fincher	Finrow
Kellett	McGinn
Ryan	Sekiguchi

Required Initially, then Annually: Notice of Energy RD&D Project 1,5

Required Annually: Topical Report 1,4,5
Year-to-Date Executive Summary

- Addresses:**
1. Program Manager -- Mike Lopez
 2. Contracting Officer -- Bill O'Neal
 3. Finance Division
U.S. Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, CA 94612
 4. George James, CE-421
U.S. Department of Energy
1000 Independence Ave., SW
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 5. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oakridge TN 37830
 6. Carla Kish
D & R International
962 Wayne Ave, Suite 800
Silver Spring, MD 20910

Copies of everything to Florida Solar Energy Center, EEIH Files, and to DOE contract and quarterly report book.

TRIP REPORT

TITLE: BRE wind tunnel facilities

DATE: April 3, 1990

LOCATION: Garston, Watford, England

ATTENDING: Rudy Berg

PURPOSE: To view low speed wind tunnel facilities

SUPPORTING DOCUMENTS: Photos, BRE publications, Instrument catalogs

The British Research Establishment is a unit recently elevated to Agency status within the Department of the Environment. Its test facilities at Garston are quite extensive, including geotechnical engineering, structural engineering, energy conservation, wood structures, and wind engineering. Here BRE has operated wind tunnels for 60 years, with a new one under construction which will be the most sophisticated such instrument in the world. Mr. Chris Judge, Head of Wind Engineering, showed me through the facility.

Two tunnels are the present mainstays of BRE testing. One is chiefly devoted to wind load testing, and the other to flow investigations -- the likely focus of our own work. While the general size and arrangement of both tunnels is like ours, they differ in significant ways. The general standards of permanency and precision are higher than those of our tunnel (the test sections are built of brick).

The traversing mechanism of the flow investigating tunnel (Figure __) is a heavy steel structure and maintains locating tolerances of less than 1mm. Stepping motors are computer controlled and manually operable via joystick so that a probe can maintain a constant relative position -- as a model is rotated, for example. In many cases, Judge noted, manual probe placement is still simplest because of the complex model shapes.

A feature of interest in the flow visualization tunnel is the use of airfoil shaped slats as walls of the test section (Figure __). These are meant to stabilize flows at the edge of the test section while relieving the blockage effects of the model itself, and were developed by Professor Jeff Parkinson of the University of British Columbia.

A test was underway during my visit. A shopping mall built in the 60's, typical of many such, included an open courtyard and a tower element at the north end, where it would

not shade the mall. British winter winds tend like ours to be southerly; consequently winds washing down the face of the tower scour the courtyard. Remedies usually comprise glass roofs or courtyard kiosks arranged to block these problem winds. A model of this arrangement under test is shown in Figure ____.

BRE flow visualization techniques include smoke, small helium-filled soap bubbles, ground walnut shells (of the sort used for grit blasting), or in some cases a spray of fluorescent-pigmented solvent. This mixture is sprayed onto the model and dries, leaving a colored trace which reveals surface flow patterns (Figure ____).

Two sources of probes and related equipment were mentioned: TSI Corporation of San Jose, CA (tel 408/452-0808) and Dantek, a Danish firm whose catalog I acquired. BRE's microcomputer system is PC based, linked to a network that permits researchers to engage the wind tunnels from their offices.

The new wind tunnel under construction is notable in several respects. It was designed from the inside out -- that is, the model support turntable (In fact, a pair of concentric turntables with massive anti-vibration foundations, Figure ____), the traversing mechanism (placement tolerances less than 0.1mm) and roughening element disposition (arrays of retractable aluminum blades which penetrate the floor of the tunnel, Figure ____) were designed before the tunnel itself. Also novel is the blow-down rather than draw-down fan arrangement which provides overpressure within the tunnel, making openings for roughening elements, etc., much less critical in their effect on tunnel flows.

The test section dimensions of this tunnel are 1.5m x 2.0m, about the same as ours. It will be roughly 25m long. Air speeds to about 40 mph will be possible, driven by a large standard air conditioning squirrel-cage blower unit.

In recent years political/economic pressures have encouraged BRE to engage in private consultancy more actively. This work is now quite substantial and their approach might serve as an example for us. I have copies of their promotional brochures.

TRIP REPORT

TITLE: Hooke Park College for Advanced Manufacturing in Wood

DATE: April 19, 1990

LOCATION: Beaminster, Dorset, England

ATTENDING: Rudy Berg

PURPOSE: Visit facilities, discuss research

SUPPORTING DOCUMENTS: Photos, brochures, *PA* article

"Hooke Park College opened in March 1989 to offer integrated training in Design, Product Manufacture and Enterprise Development in the context of the managed woodland. The College's objectives are:

- to generate new manufacturing businesses using indigenous timber in the production of quality products.
- to develop design and business talents, manufacturing systems and industries which benefit the natural environment.
- to co-ordinate research leading to improved ways of using timber, reducing waste and increasing value.
- to reduce pressure on the world's diminishing forests by demonstrating how improved management stimulates the growth of renewable resources."

Hooke Park College offers reasons for our interest besides these objectives. Its buildings, which reflect the aims outlined above, are innovative and architecturally interesting, and its circumstances -- responding to environmental issues and economic pressures of a changing timber resource -- are something like our own here at CHI.

The College was set up by the Parnham Trust, an entity established under the direction of British furniture maker John Makepeace to administer the Parnham House estate where he works and teaches, and which serves as a showcase of both skillful building restoration and world-class contemporary woodworking. In 1982 Makepeace was in effect "given a forest" of commercially useless small trees a few miles from Parnham. This forest now serves as campus, forestry experiment, and woodlot for the dozen full-time students who live and work for two years at Hooke Park.

Training there covers three basic areas: the first includes design, business skills, technology of materials and production, and marketing and promotion; the second covers development of new processes and product prototypes; and the third aims at

bringing promising new ideas into production, and incorporates computer integrated woodworking machinery and linked CAD/CAM operating stations. In addition Hooke Park offers short courses in related areas.

In the current start-up phase these courses are receiving economic support from national and regional governmental agencies. Understandably the prospect of creating a new set of industries based on an underused resource is appealing. The fact that this enterprise also aligns with the rising Green sentiment in Britain makes it doubly attractive.

The buildings at Hooke Park reflect the rustic/sophisticated duality of the College's approach. A large workshop/office is framed with arches made of spliced poles, roundwood purlins, and a high-tech insulated fabric skin. A second building, ultimately destined to become a dormitory, is a rather tentlike structure employing poles in tension and compression, specially detailed to permit use of green wood. Again, it uses a sophisticated fabric skin. These buildings were designed by the London firm of Ahrends Burton and Koralek, with Frei Otto as consulting architect and Buro Happold as structural and services engineer.

Equally high-tech is the joinery employed in some parts of these structures: steel fittings are glued into tapered holes in the green poles with an epoxy-sawdust mix. The environmental questions involved in the use of such toxic ingredients (as well as the plastic building skins) are glaring ones. Since these are experimental structures, however, it seems likely that subsequent refinements will have a "greener" aspect.

Certainly Hooke Park College offers an interesting experiment at several levels -- in student-developed wood products, in the innovative campus buildings, and in the pioneering approach of the College itself.

TRIP REPORT

TITLE: "The Architect, Energy and Global Responsibility," conference jointly sponsored by the Royal Institute of British Architects and the Energy Efficiency Office

DATE: January 24, 1990

LOCATION: London

ATTENDING: Rudy Berg

PURPOSE: To learn British attitudes and approaches to energy-efficient architecture, and assess current efforts

SUPPORTING DOCUMENTS: Conference program, presentation synopses, AJ editorial

Relying on the attached presentation synopses to describe the content of the conference, I'll add a few notes and observations.

The conference room was packed. Kristensen and Ferraro were impressive. In general, however, the meeting seemed like a ritual for the architectural establishment. I emerged from the conference, and from the nation as a matter of fact, with the feeling that cavity wall construction is still a mite *nouveau*, and that the proper remedy for the standard building problem -- dampness -- is the fortuitous occurrence of a second standard problem -- drafts.

Kristensen's straightforward presentation of Scandinavian buildings which achieve high energy performance, and his matter-of-factness in showing how those energy levels could be cut by two-thirds, was inspiring. With present techniques only 14% of residential heat need come from the heating system; small boilers need further development. He showed a three-story apartment building in Copenhagen retrofitted with glazing over the south facade. This provided 34% savings in heat, added 100 sq ft sunspace per unit, and cost roughly \$2000 per unit over cost of conventional facade renovation.

He also showed commercial buildings (BRF HQ building, Lyngby, Denmark, and others) with high energy performance. He described small gas fired heat/power stations used in remote locations to provide power and district heating while minimizing distribution losses.

Kristensen was asked (but did not effectively answer) how to understand the "CO2 content" of different energy end uses.

Richard Ferraro is with ECD Partnership -- certainly one of the major players in UK energy efficient architecture (ECD incidentally was Energy Conscious Design when they started in the 60's -- had to hide the "energy" word a decade later for image purposes). He showed a number of high performance projects. ECD has stood its moral ground for 30 years and now looks like it's on the front of the wave. Ferraro mentioned that the new British energy building regs match the Swedish standards of 1935.

Recent British winters, while they may be flukes, have helped persuade Brits of the greenhouse effect. Bill Bordass said air conditioning use in office buildings is doubling.

Bill Holdsworth gave a poetic slide tour of the NMB Bank HQ in Amsterdam. He must have worked on it. Claims it provides "the lowest energy consumption in the world."

Little else worthy of comment. I gathered a fat handful of leaflets re BRE energy studies and projects.

TRIP REPORT

TITLE: Workshop for Architects on the Walter Segal Self-build Method
DATE: March 30-April 2, 1990
LOCATION: Center for Alternative Technology, Machynlleth, Powys, Wales
ATTENDING: Rudy Berg
PURPOSE: Study Walter Segal method, visit CAT facilities
SUPPORTING DOCUMENTS: Photos, AJ reprint, CAT brochure, CAT conservation house details

This workshop was set up to familiarize architects with the simplified wood frame building system developed by Swiss architect Walter Segal to ease the problems faced by self-builders, particularly in Britain. In a sense this system falls inside our definitions of "industrialized" housing because it relies heavily on stock lumber and panel sizes, thus turning standard building supplies into a kit of parts for pre-cut homes. It is an open systems approach. Within modular constraints it permits designers considerable freedom, and the Segal method has been used by as a takeoff point by David Lea and others to create a rich variety of buildings.

I will not describe the system further, since its details have been published (*Architects' Journal* has a special issue on it). This workshop devoted considerable attention to refinements in the basic system to improve its energy efficiency, and here too there are close parallels with our EEIH efforts.

The attitudes of British architects attending the workshop (these tended

to comprise, as they would in the US, the "fuzzy fringe" of the profession) revealed something of typical proficiencies and attitudes about residential energy performance. Not everyone believed in vapor barriers. Several were quite sophisticated in their knowledge of energy technology and issues.

The site of the workshop, the Center for Alternative Technology, is something of a 60's dream come true. It makes its own electricity and grows most of its own food. Yet it is not a bunch of folks wearing crystals and smoking funny cigarettes. Roughly 55,000 visitors per year come to learn about solar, wind, and water power, and this place teaches them, feeds most of them, and houses those who stay overnight. Its displays

are well done, its workshops (if this is any indication) are meaty and well organized, and it has an excellent bookstore. The people at CAT probably have more daily experience in solving energy problems and living with the results than anyone else on the planet. A list of current courses is attached.

One feature of interest at CAT is their "conservation house." This very-high-performance residence is described in the attached pages.

TRIP REPORT

TITLE: British Research Establishment
Garston, England
0923 89 4040 Phone
0923 6640 10 Fax

DATE: 8/6/90

LOCATION: Garston, England

ATTENDING: G.Z. Brown, Center for Housing Innovation
BRE - Energy and Environment Group
Buildings Energy Efficiency Division
Bil Musannif - Housing
George Henderson - Statistics
Alan Penny - Computers
Foroutan Parand - Computers
Tom Lindsay - Artificial Sky

British Research Establishments is the principle organization in the United Kingdom carrying out research into building and constructions and the prevention and control of fire. There are five research groups:

- Geotechnics and Structures
- Materials
- Environment and Energy
- Fire
- Construction and Application

The Geotechnic and Environment and Energy groups are the largest research groups. BRE had a total staff of 685 with 398 researchers.

Musannif gave an overview of energy use in the United Kingdom and the research going on in the housing unit. Total energy use by sector is similar to the United States but buildings account for a larger share (approximately 40%) of total use. There has been a substantial increase in central heating throughout the U.K. since North Sea natural gas became available in the 70's. The housing group is currently emphasizing infiltration causes and cures. Electric utilities, in order to compete with gas (on a total bill basis), are requiring houses to be better insulated and contractors to do blower door testing to substantiate performance (TACH @ 50 pascals). Radiators remain popular although BRE has demonstrated well insulated houses with room heaters perform better and cost less.

Henderson reported that there is a stable housing stock of about 21 million units with 1% being demolished and 1% built new each year (210,000 units annually). BRE's primary modeling tool for simple use is BREDEM (BRE - Domestic Energy Model). It has two versions - a degree day annual production and a monthly production method. It runs on IBM compatibles and requires numerical input of about 60 values. They were interested in energy schemings graphic takeoff method and will request beta testing. Calculation time is less than 1 second for the annual and a few seconds for the monthly. BREDEM is said to be sold to architecture schools. It is also used

to determine compliance with National Building regulation conservation standards and their energy tables program. BRE has also developed BREDEM as an auditing tool. Because residential buildings are so similar in England (London) it can be used with accuracy only in inputting the 1) age of the building (determines construction, room size, window size), 2) number of stories and number of windows. When increasing accuracy is desired additional inputs are (in order of importance) floor area, window area, heating system. Multiple heating systems - especially with intermittent operations are very difficult to model accurately. Henderson's group is also beginning work on global warming issues. Since the United Kingdom's primary residential load is heating and there is little installed air conditioning, global warming is thought to reduce total energy use. Henderson is pursuing the impact of increased air conditioning penetration rates on total energy use. BRE in general is placing a great deal of emphasis on standards development related to the 1992 EEC.

Penny reported on methods they've developed for evaluating computer software. Four areas of evaluation have been developed - documentation of the theoretical basis for the model, model comparisons, sensitivity analysis and empirical testing. See "An Investigation into Analytical and Empirical Validation Techniques for Dynamic Thermal Models of Buildings". There has been and continues to be a lot of coordinated activity with other European countries in this area. They are currently moving toward more evaluation of how tools are used. Parand described four task groups - documentation, appropriate use, evaluation and reference cases, and dissemination. They seem to be coming to the realization of importance of the interface design. (The Energy and Environment Group is dominated by physicists and engineers with few architects - hence the alpha-numeric quality of its interfaces.) They are just starting a project to develop a CAD based expert system which sounds very similar to AEDOT. It is funded 50% by the European community and 50% by BRE. It is said to be completed in two years. (Seems like a serious under estimate.)

Parand also discussed the European community's work on establishing standard product transfer protocols. This will be a method describing the attributes of building products in standard electronic formats. This development supports the contentions put forth in the Smart Materials proposal developed at the University of Oregon.

Penwalden gave a brief tour of two wind tunnels. The older pull and the newer push models. They use crushed walnut shells (from the United States) as a surface visualization technique. They draw contours based on what is blown away at various wind speeds and use this information to establish the location of high velocity areas to be used as sites for hot wire anemometer readings. They do a lot of work determining ventilation rates by developing pressure coefficients for various planes on the building and then using a computer model to determine air flow rates. See "BREVENT - A Ventilations Model". This method will work well for our proposed HUD code and multi family ventilation studies. It is especially related to air flow rates through acoustical and visual privacy screens.

The new wind tunnel (currently being calibrated) utilizes a series of side baffles to allow the larger obstructions of the tunnel without adverse effects. The roughening elements are aluminum fins which are raised through the floor of the tunnel by crank, greatly reducing the time needed for new set ups. The data acquisition process is highly automated with the model automatically turning to collect data from different wind directions. They expect to be able to run the tunnel 24 hours per day without operators.

Linsey demonstrated the mirrored box artificial sky. It is about 10-12 feet square and about 7 feet, 6 inches high (inside). It is built directly on the lab floor. The jointing between the mirrors and plex diffusing panels is relatively crude. The calibration is similar to the University of Oregon sky

with problems at the horizon and corners. British Research Establishment agrees that these variations become insignificant when models are tested. British Research Establishment has developed a new toplighting formula. It is described in British Research Establishment Digest 310.

Musannif, who originally came to British Research Establishment to work on industrialized housing, said there is currently very little going on by United Kingdom manufacturers. Apparently the large builder, John Lainge, precuts all the house materials (wood) and ships them to the site ready for assembly by trained crews.

DOCUMENTS ACQUIRED:

- Building Research Establishment Annual Review 1990
- BRE Information Paper, November 1988
- BRECSU Annual Review 1989/90
- BRECSU Publications List, July 1990
- BRECSU Energy Efficiency Office brochures:
 - Energy Efficiency Demonstration Scheme - Expanded Project Profile 30b
 - Energy Efficiency Demonstration Scheme - Expanded Project Profile 59
 - Energy Efficiency Demonstration Scheme - Expanded Project Profile 223
 - Energy Efficiency Demonstration Scheme - Project Profile 280
 - Energy Efficiency Demonstration Scheme - Project Profile 324
 - Information Leaflet 6
 - Information Leaflet 16
 - Research and Development Project Profile 42
- BREDEM brochure
- BRE/SERC. "An investigation into analytical and empirical validation techniques for dynamic thermal models of buildings" December 1988
- "Energy Efficiency Best Practice Programme" - Good Practice Case Studies 6-12
- Hartless, R.P. "Brevent - A Ventilation Model"
- "HouseBuilder" - House Builder Reference Series 1-10
- Slides - wind tunnel, artificial sky

TRIP REPORT

TITLE: Norwegian Building Research Institute (Byggforsk)
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DATE: 8/9/90

LOCATION: Oslo, Norway

ATTENDING: G.Z. Brown, Center for Housing Innovation
Trond Ø. Ramstad, National Building Research Institute

The Norwegian Building Research Institute is the "official" building research establishment in Norway with facilities at Oslo, Trondheim and Narvik. Their support is 30 - 40% government grants (was 100% until the 70's) and 60-70% private contracts from the building industry. They have a staff of 155 which includes 65 researchers. Their research covers ranges from timber frame to concrete technology. These efforts can be broken into three categories:

1. Information on building practice
2. Testing materials and components
3. Consulting to the building industry on failure, structural design, etc.

The testing lab at Trondheim (which I didn't see) is supposed to be a world class facility for evaluating envelope components.

The new housing starts in Norway (4.5 million population) are about 30 to 40% stickbuilt on site, 5 to 6% modular and the rest are panelized. Panelized construction is increasing rapidly. Of the new starts 40 - 50% are single family and 50 - 60% multifamily including high rise. Multi family units typically use double wall party wall construction.

Residential heating is almost 100% electric, using radiators or warm surfaces with no forced air systems.

The 4.2 million population is stable although the total housing stock is increasing somewhat. There are currently 25,000 new starts down from 30-35,000 a few years ago. There is significant demolition of old houses in rural areas because new houses are cheaper (due to government loans) than remodeling old houses

About 98% of single family construction is timber frame, 70-85% of all housing 4-story or less is timber frame. The building code is performance based.

An example of a cooperative project called a "technology ring" is one to investigate new products/manufacturing techniques for eight panelized building companies. The project is intended to be three to five years in length (now in year two) and is 50% funded by the government (National Research Council) and 50% funded by private industry. The proposals are submitted by industry. The Research Institute's presence on the proposal lends credibility. Ramstad is the project leader because he is seen by the manufacturers to be a neutral party. The group meets (two

from each company) to discuss ongoing projects and plan. Originally projects were suggested by the Research Institute. Roof panelization techniques was selected as the first project and the Research Institute has developed a set of details (see reference documents) for roof panels that are used (or modified) by each manufacturer. They are willing to cooperate on technology because they see themselves as competing on the basis of marketing. Roofs were selected because the truss systems currently in use take too much time to enclose the building, which is a problem in Norway's climate. The roof panels are 2.4 meters (8 feet) wide (limited by transportation) and use wood members 24 inches on center. Gaskets are fixed on the panels to speed erections. The crane needs to be on the site for only one day. Wall panels are made up to 10 meters long.

The second project underway for the technology ring is the development of a method for blowing fiber glass insulation into wall panels as they lie open on the assembly line. Blowing in insulation reduces costs associated with cutting batts to length for special conditions, and stocking various size and thickness of insulation. The fiber is blown with glue which cures rapidly and can be used to glue interior and exterior sheets to the studs. The research problems are determining the fiber length, blow pressure, and glue quantity, all of which affect insulation density and there its R value. Codes require wiring to be in conduit and on the inside or outside of the insulation to reduce risk of overheating.

The third technique ring project is the development of simplified wall panel connections using the manufacturer's current panel manufacturing systems

The fourth project is the development of a light weight (wood) floor panel with good sound insulation for separating multifamily units. Apparently concrete systems are currently used.

The Institute's information service has "good practice notes" as its backbone (see sample attached). These are continuously updated. Conversations with Institute personnel as well as contractors and designers revealed that these notes formed the de facto code even though they sometimes exceeded code requirements. The Institute also produces the building construction textbook Trehus which is used in schools of architecture.

The Institute is the primary approval agency for new products and manufacturing quality control. This makes closed panels possible. This approval system may change in 1993 because the European Economic Community may say that national approval systems constitute a barrier to trade. About 60% of the panels produced are open (50 % of those are delivered with insulation) and 40% closed. The closed panels typically have conduit installed by having wiring pulled in the field. They are experimenting with installing conduit for plumbing to be pulled through in the field (video tape of system available).

The Research Institute has done extensive research on exterior wind barriers over the last couple of decades. Numerous papers have demonstrated the value of wind barriers to reduce heat loss from infiltration. There have been numerous construction details developed. After the first year, when moisture in the wood in the wall has been lost, the wind barrier has been shown not to increase moisture levels in the wall. In Norway's wind driven rainy coastal areas, there is no way to keep the rain from penetrating the exterior siding. The rain that penetrates the siding runs down the exterior face of the wind barrier which is bituminous paper, fiberboard or 9 mm gypsum board.

Wall thicknesses are typically 6 inches (1981 code) and use solid studs. Roof (8 inch) and floors (10 inch) use "I" sections with masonite or gypsum board webs.

The Research Institute has extensive testing facilities. During my visit they were testing HVAC distribution in a glass walled room that allowed for visualizing air flow. They were also testing a plastic foam basement panel system whose cores were filled with concrete.

We also discussed the Multi/Element panel system. This system uses a foam core with gypsum faces. (Brochure available) The product was designed to be continuously made with window and door openings cut on the site. The panels are non load bearing, not too good acoustically, don't contain plumbing but do have two wire chases. The product is about 15 years old.

Computer use in the building industry (as represented by the eight technology ring companies) is mostly build on CAD systems. The companies have most of their standard plans on the system which they modify to meet customer needs. A plan and four elevations are what are needed to get a building permit from the local authority. The trusses are typically calculated for each house. As panel manufacturers, they adopt the attitude that they will supply whatever the customer needs.

A tour of a suburban area northwest of Oslo revealed conventional and panelized homes under construction and recently completed. There was less variety in design than would be typically the case in the United States.

One conventionally framed house used a prefab three inch foam core panel for the basement wall which was three inches of gunite on the exterior. The same house also used an accordion fold roofing paper (no sheathing) that spanned a few rafters.

A multi family project in the same area utilized poured concrete party walls and floors with prefab wood infil. The construction was somewhat unusual but typical of this contractor who also built high rises and had lots of concrete forms available.

DOCUMENTS ACQUIRED:

- Slides - single and multi family projects
- Multi/Element A/S Sales Brochure
- Sample wall and roof details developed for the technology ring
- General brochure describing the Norwegian Building Research Institute
- Sample building detail sheets on windows, external walls, slab on grade foundations and mechanical fastening of bituminous membranes
- Listing of approved manufacturers of prefabricated systems
- Moelven Sales Brochures
- Trehus construction textbook

TRIP REPORT

TITLE: Mesterhus Norge A/L
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DATE: 8/10/90

LOCATION: Oslo, Norway

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Bent Einar Nygren - Director, Computers, Mesterdata A.S.
Tom-Olaf Wilhemsem - Project Director, Mesterhus
Reidulf Stenbakk, President, Stenbakk Co.
Åge Fjellveit, Engineer, Stenbakk Co.

Mesterhus is a company owned by approximately 300 contractors spread throughout Norway. These contractors employ about 4000 people. Contractors are organized regionally, in groups from 1 - 15, around 77 sales offices. The contractors within a given sales territory limit competition. Mesterhus is the company which represents the contractors' collective interests and supplies individual contractors with information, represents them to governmental agencies (national and local), addresses building regulations, and gives them an annually updated sales catalog. Through majority owned subsidiaries Mesterhus also supplies building materials (including subassemblies, like panels or trusses), legal contracts, and computer services. The primary advantages to individual contractors are more sophisticated sales aids, volume purchasing of materials, increased expertise dealing with government representatives and regulations and detailed drawings, specifications, material lists and costs. The largest Mesterhus contractors produce 30-40 units per year. It costs 10,000 NKr to join Mesterhus (15,000 NKr if a sales representative in an area) and there is a 5,000 NKr annual fee. All contractors own one share in Mesterhus. Mesterhus has been in business for 20 years.

The company experienced exceptional growth in the 1970's when Norwegian housing production peaked at 43,000 units. Production in 1989 was 26,200 units and is projected to be 22,000 units in 1990. Mesterhus produced 2300 units in 1989, making it one of the 2 or 3 largest companies in Norway. (Block Watne and Novel are the others). Mesterhus has 8 -9% of the market. About 80% of its production is single-family and 20% is multi-family. Mesterhus produces low and middle cost houses. The low cost housing market has been quite strong in the last few years. Because Mesterhus contractor/owners are all independent companies, their means of production varies from contractor to contractor. Most of the contractors build on the site using a small number of manufactured components. However some (25%) of the contractors produce panels such as Stenbakk. Mesterhus is working on increasing efficiency and prefab panels are seen as a way to do this.

Design ideas come primarily from sales offices and contractors although some are developed for Mesterhus by architects. House designs are developed in house by a small technical staff and by architects hired by Mesterhus.

Each design offered by Mesterhus is guaranteed to be completed. If the contractor building the house has financial difficulties, other Mesterhus contractors complete the project. Each design in the sales brochure is described with complete working drawings and a large book of specifications which describe every piece of material to be ordered. The prices in specifications books are tied to a consumer price index and are updated continuously. There are no special energy features sold as part of the Mesterhus. The building code defines the basic energy performance of the building. Norway is a net exporter of energy oil, gas, and electricity. Rich in hydropower, most houses are electrically heated.

The computer group (Mesterdata) is a wholly owned subsidiary of Mesterhus. Most of its computer services are purchased by Mesterhus. The software in use is MultiCAD (predecessor was UniCAD) which was running on an Olivetti computer with an EIZO monitor and an MS/DOS based operating system under Microsoft Windows 3.0. The program was developed by a Norwegian architect, Leif Smedbakken who now lives in Belgium. The software is currently marketed by a Belgian firm. The program is also used by other building producers although, according to the computer group at SINTEF, University of Trondheim, it is less used than AutoCAD. The software requires the plan, which is the starting drawing, to be drawn counter clockwise. Once drawn in plan (roof as well), the software will produce the building's elevations. The dimensioning is dynamic with all dimensions changing as the user changes the size of elements. There is a preference section which includes an automatic "save". The walls are built from library selections (user designed) and corners are added later. The program can calculate the area or volume of selected elements. The user can create layers for as many drawings (elec, mech, etc) that are necessary.

The cost estimating part of the program is quite strong. It is based on the Akkordtariff which is a detailed listing of all construction tasks and how much Norwegian labor will be paid to do them. For example, installing a certain type window has a specific labor cost associated with it. The costs are developed and adjusted over time by workers' and contractors' labor unions. The Akkordtariff is being revised and will be reissued next year. As new means of production (like panelizing) are developed, new tasks and their costs are added to the Akkordtariff. Cost and material estimates are very accurate.

The sales office I visited in the Tonsberg area used models and brochures as the primary sales aids. Houses under construction in the area (when available) are used as models to show customers. The sales offices are relatively modest in scale and type compared to Japanese companies. The sales office I visited was located in office space on the second floor of a building occupied by a group of building material (kitchens, etc.) suppliers.

I visited two projects under construction, both within a 1 to 2 hours drive from Oslo near the towns of Horten and Tonsberg. The project near Horten named Markagrense has 3 phases of 21, 11 and 11 units. The project was the collective effort of 4 to 6 small Mesterhus contractors and was managed by Tom-Olaf Wilhemsem who is a project manager for Mesterhus. Mesterhus was managing the project because it had greater expertise than any of the small contractors. The housing was for the low to moderate income market. Low cost mortgages were going to be available from the Norwegian Housing Bank which places restrictions on the size (max. 120 sq. meters) and other features of the house. The houses were approximately 75 sq. meters on the first floor, 35 sq. meters on the second for a total net area of 110 sq. meters. The house with land were priced at 570,000 NKr (approximately \$93,500) and the project was sold before completion. The land cost per house was estimated at 80,000 NKr and the infrastructure at 40,000 NKr. The owner arranges financing with the housing bank. All houses were electrically heated. They are required to be built with chimneys in case the owner wanted to change fuel sources. The buildings were sheathed with windbarrier asphalt impregnated paper. All windows had "trickle" vents at

their tops. Electrical conduit (plastic) was installed on the inside of the insulation. Windows were triple glazed and foam insulated around their edges. The energy code defined the maximum building performance. Car parking was required at each unit. This was different from many Norwegian and Swedish developments I saw where parking was clustered near groups of units. The houses were being constructed on site using a few industrialized components like trusses and windows.

Several owners were completing parts of their houses themselves. Using the Akkordtariff, the owners were given a reduction in price equal to the labor they supplied. The materials were supplied by Mesterhus.

The second project visited was a 21-unit multi-family Old Folks community. Near Tonsberg, the project was developed by a non-Mesterhus contractor but the timber work (everything but foundation, electrical, mechanical) was being done by Stenbakken, a Mesterhus contractor who produces open panels. The panels had windows installed and were finished on the exterior. There were 100 square meters per unit and they sold for 600,000 Nkr (\$100,000) each and had a 5,000 Nkr monthly service charge. At this project Stenbakken was experiencing major difficulties because the foundations were the wrong size. Stenbakken was upset because they usually subcontract the foundation in order to insure good quality. In this case, the developer had hired the foundation contractor himself.

I also visited Stenbakken's panel factory whose capacity is about 100 units per year. Currently they produce 50-60 single-family or multi-family units per year. The factory used jigs, cranes, automated saws and pneumatic nailers. The engineering office produced careful large scale drawings of each construction drawing.

DOCUMENTS ACQUIRED:

- Slides - Horten project
- Slides - Tonsberg project
- Mesterhus 20 ÅR 1990 Sales Brochure
- Mesterhus Low cost House Sales Brochure
- Mesterhus Chart of Comparative House Features
- Mesterbase 3 HUS Database description
- Cost and Material Estimates for House #1508
- Multi-Cad/c Sales Brochure
- Multi-Cad/c Demo
- Article on Multi-CAD/c and its Author

TRIP REPORT

TITLE: Department of Architecture and SINTEF (Foundation for Scientific and Industrial Research)
Norwegian Institute of Technology
University of Trondheim
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DATE: 8/14/90

LOCATION: Trondheim, Norway

ATTENDING: G.Z Brown, Center for Innovative Housing
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Birgit Sudbø - Computers in Architecture Department
Tore Haugen - SINTEF Computer Research
Roald Bergstrom - SINTEF Computer Research
Hans Granum - SINTEF & Architecture Prefabricated Housing
Eystein Rødahl - HVAC Engineer Department
Terje Jacobsen - SINTEF Solar Energy Research
Ida Bryn - SINTEF Expert System Atrium Design

Architecture is a department like engineering within the Norwegian Institute of Technology which is part of the University of Trondheim.

The Architecture Department has 300 students and 75 FTE faculty. Within Architecture there are five divisions: Form and Color, Building Technology, Architectural Design, Architectural History and Town and Regional Planning.

SINTEF is non profit private research institute that is closely affiliated with the Technical Institute. Many of its researchers are University faculty, SINTEF rents space from the University and the University shares laboratory facilities with SINTEF. SINTEF has 2000 research employees - about twice as many as the University. It is the largest research institute in Norway, Sweden and Denmark, with a budget of 972 million Nkr.

There are 10 FTE faculty in the Buildings and Technology division, several of whom are involved in energy research especially related to the international energy agency (IEA) Solar Heating and Cooling program.

Task XIII- Advanced Solar Low-Energy Buildings (Robert Hastings)

Task XI - Passive and Hybrid Solar Commercial Buildings (Anne Grete Hestnes)

Computers are being integrated into the architecture curriculum. Students receive a literacy course in the first year. The emphasis is on solid geometry problems using Apple Macintoshes and IBM PC's. Fourth and fifth year students are taught 2 and 3D visualization using CAD systems. The department recently purchased 15 Mac CX's. The energy programs used are SUN CODE and SER I RES.

The compute group at SINTEF (12-15 FTE) is extensively involved in visualization (see Fra ide til virkelighet) and facilities management. They collected most of the software in use in western Europe and are an excellent source of information on its use.

Hans Granum, Professor Emeritus Architecture, is internationally known for his work on prefabricated housing and has published extensively in the area. (see. Ferdighus Og Typehus, 1, Norge, 1940-1970 andv Norge) He has also had extensive experience developing energy calculation methods for codes and economic optimization of construction and energy performance.

The mechanical engineering department offers a 4-year degree in HVAC with 8 undergraduate and 4 graduate courses and continuing education courses. They currently have Ph.D. students working in Active solar for desiccant cooling and Expert systems for Passive Solar.

The mechanical engineering department recently was funded for one position, the Energy Administration for a coordinator of energy conservation research at the University of Trondheim.

The SINTEF HVAC has 30 people, with half working in the energy group (active and passive solar, district heating, IEA tasks, and building simulation) and half in the ventilation group (indoor air quality, air flow patterns in rooms, and smoke ventilation). Thirty per cent of the groups' income is from the Norwegian Research Council and 70% is from private sources, primarily oil companies. The HVAC group got started as part of the architecture group but split off as its size increased.

The HVAC group, in conjunction with Architecture, is also developing an expert system for Atrium tool design as part of the IEA Task XI Passive and Hybrid Solar Commercial Buildings. The program runs on an IBM/PC. It uses only alpha/numerics for input. It has sections for rule of thumb calculations and case studies. The case studies are shown by video disk. The Expert system shell is Crystal. The prototype is currently being rewritten and will have three sections:

1. General advice (good topologies and sources of information)
2. Case orientated with rule of thumb calculations
3. Simulation

I visited two projects in the Trondheim area; one developed by Block-Watne and the other Terge Jacobsen house which is a SINTEF experimental low energy house. In the Block-Watne project the land was purchased and developed by B-W and the lots sold to individual owners with the provision that precut homes had to be purchased from B-W. The Jacobsen house utilizes a sunspace, increased insulation, solar water heating and an exhaust air heat pump. The house is also noteworthy for its thermal zoning concept, its architectural design and its use of a non- south-facing narrow lot. (See "An Experimental Solar Dwelling with Low Energy and Power Demand".)

DOCUMENTS ACQUIRED:

Apeland, K. et al editors, Bygge I Norge
Aschehoug, Ø. "Daylight in Glazed Steels"
Aschehoug, Ø. et al Design Guidelines for Passive Low Energy Dwellings - Denmark/Norway
Aschehoug, Ø. "The Energy Impacts of New Glazing Technology at High Latitudes"
Aschehoug, Ø. Glazed Spaces - Research and Development in Norway
Bergstrom, R. Fra Ide til Virkelighet

Granum, H. & Larsen, K.E. Ferdishus Og Typehus, 1, Norge, 1940-70
Granum, H. "Wooden Houses in Norway" Wood Frame Housing '87
International Conference
Haugen, T. Facility Management
Hestnes, T. "Advanced Solar Low Energy Buildings IEA Task XIII"
Hestnes, A. "Atrium Buildings for Cold Climates"
Hestnes, A. "An Experimental Solar Dwelling with Low Energy + Power
Demand"
Hestnes, A. "The Solar Houses at Heimdal, Five Years of Experience"
Jacobsen, T. "Effekt-og Energikrktig bolig"
Jacobsen, T. Energy Savings and Thermal Climate in Passive Solar Heat
Dwellings
Nygard, B. & Haugen, T. "An Integrated - CAD - System for Economic
Optimization in Planning and Design"
SINTEF Annual Report
SINTEF "Glass Covered Streets"
SINTEF Passive + Hybrid Solar Commercial Buildings. IEA Task XI. Four
Norwegian Case Studies

TRIP REPORT

TITLE: National Swedish Institute for Building Research
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LOCATION: Gävle, Sweden

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Urban Norlen, Head Energy Conservation Division
Staffan Hygge - Noise and Productivity
David Wyon - Thermal Comfort
Benqt Eriksson - Energy Conservation

The National Swedish Institute for Building Research is under the direction of Ministry of Housing. The parliament and the ministry establish policy and the institute has an independent hand in determining what research is required to support the policy and how it should be conducted. The focus of the research is on housing with the goal of "making practice better." The distinction between applied and basic research is unimportant in terms of the institute's goals. The institute is probably unique in the world in its magnitude and focus on long term housing issues. Housing has been an important political issue in Sweden since the 1930's. Antoni feels that housing will probably decrease in importance in the (Swedish) future and environmental issues will become more important. The institute may change its focus to urban issues and become more strongly university related.

The institute has 110 researchers and although significant in size it makes a concerted effort to compliment the research being done elsewhere in Sweden. The institute emphasizes social issues and 50% of its researchers are social scientists. While the Institute conducts high quality technical research, it emphasizes the effects of that research on people's use of dwellings.

The institute is divided into 6 to 8 research departments each with 12 to 15 researchers. Eighty percent of the funding comes from the federal government and the rest from private industry. I met with two research groups: Energy Conservation and Heating and Climate.

The energy conservation group is working in three areas:

1. A large survey of the building stock
2. Simulation for policy assessment
3. Parameters for describing physical systems

The first project is a updating and augmenting of a similar survey conducted 15 years ago. The goal of the project is to determine what can be done to improve the electrical efficiency (1/3 of the houses are electrically heated) of the stock and to improve its air quality. The project is motivated by Sweden decision to discontinue the use of nuclear power. The survey is of 1200 houses. Industrial and commercial buildings are being studied at Chalmers University in Gateborg. The

survey goal is to paint a statistical picture of the buildings and how they are used by their inhabitants. Because there are budget and time constraints and the sample is large, careful consideration is being given to how the data is collected. This winter equipment is being tested for determining the interior conditions. Air changes per hour will be measured using tracer gas and a wood block(Danish) for relative humidity. There will also be a subjective evaluation of the indoor climate by the users. Metered electrical data and exterior climate data will also be collected.

The second project is the development of a simulation model using the statistical sample as a base that predicts energy use in the residential sector given a range of future conservation strategies. The conservation and alternation production strategies will be developed by asking researchers in various fields what they think the most likely future developments will be.

The development of parameters for describing physical systems was "on hold" while the survey was being developed and analyzed.

The institute has full scale testing facilities for HVAC equipment. The test environments are a series of rooms in which the temperature of the surfaces can be maintained at various temperatures. The HVAC equipment as well as the interior environment is then continuously monitored to determine their performance. The facilities include full size glass walled room for testing air distribution from HVAC equipment. A light knife (lazer) is used to visualize air movement in smoke in the room. They have also been experimenting with scaled simulation of thermal phenomenon using various fluids.

The institute also has a closed circuit type wind tunnel with a 3 meter wide, 1.5 meter high and 11 meter long test section and a maximum wind speed of 23 m/s. Recently the tunnel has been used to develop wind pressure distribution on 1 1/2 story detached to 2 story terrace houses and to show the effect of sheltering by adjacent buildings. A series of coefficients has been developed to have designs predict the effect on infiltration/ventilation based on buildings arrangement.

The institute is doing a series of studies on the effects of noise and thermal stress on human task performance. The purpose of the studies is to establish standards for building acoustical and thermal performance. The thermal work is quite extensive involving the use of subjects and manikins in environmental chambers. Of particular interest is the work on task area heating and cooling systems. While it is being investigated for office environments, it may have application in residential environments. We should be looking at the impact of various ventilation strategies for exhausting air contaminated with outgassing from appliances and computers in home offices without drawing it past the inhabitants.

DOCUMENTS ACQUIRED:

- Wiren, B.G. Effect of Surrounding Buildings on Wind Pressure Distributing and Ventilation Losses from Single Family Houses
 - Part 1 - 1 1/2 story detached
 - Part 2 - 2 Story terrace houses
- Wyon, D.P. "Human Response to Cyclic Changes in the Thermal Environment"
- Hygge, S. "The Interaction of Noise and Mild Heat on Cognitive Performance and Serial Reaction Time"
- Wyon, D.P. "Use of Thermal Manikins in Environmental Ergonomics"
- Enander, A.E. et al "Thermal Stress and Human Performance"
- Wyon, D.P. "Wind Chill Equations Predicting Whole-body Heat Loss for a Range of Typical Civilian Outdoor Clothing Ensembles"

Wyon, D.P. Publications list
Wyon, D.P. "Effects on On-Off and Proportional Integral Regulation of Air Conditioning
Wyon, D.P. et al "Thermal Manikin Prediction of Discomfort Due to Displacement
Ventilation
Hammarstin, S. et al "Passive Solar Components Testing with Identification Models"
Norlen, U. "Estimating Thermal Parameters of Outdoor Test Cells"
Norlen, U. "Identifying Energy Savings Potentials and Evaluating Energy Conservation
Programs in Sweden"
Norlen, U. "Estimation in a Complex Survey - Expenses from a survey of buildings with
regard to energy use"
Description of Conservation of Electricity in Existing Buildings Research Program
Norlen, U. Publications list

TRIP REPORT

TITLE: Insjöhus
Box 60
S - 790 30 Insjön, Sweden
0247 410 10 Phone
0247 408 10 Fax

DATE: 8/20/90

LOCATION: Insjön, Sweden

ATTENDING: G.Z. Brown, Center for Housing Innovation
Ake Arnesson, Vice President

Insjöhus was founded in 1929 and produced as many as 10,000 houses per year for the Stockholm market in the 1930's. At the end of the 1950's, Insjöhus had 27% of the Swedish market. In 1965, the company was disaggregated and in 1985, it acquired new ownership. In 1991, the company will be acquired by the Nobel group which owns companies that produce a range of building products. Last year, 85% of Insjöhus' product was exported. Its biggest customer is Japan who purchased 250-300 homes.

Insjöhus supplied the houses for the well-known Lavonia development north of Boston. The company formed to develop the site, Svenskahus, is bankrupt. Part of the problem was attributed to dishonest building inspection which resulted in the shutdown of all projects in the area. The houses were shipped in containers as large panels with horizontal siding. Arnesson felt the houses should have been redesigned for the American market to make them less expensive.

Changes required for the U.S. market were 16" on center studs rather than 24" and 24" rafter spacing rather than 48". In order for Insjöhus to ship to the U.S., the dollar would have to equal 7 to 8 Swedish crowns (Currently \$1=5.7 SKr). Shipping to the U.S. is twice as expensive as to Japan. It cost 30,000 SKr per container to ship to Boston. The Lagoninia house took 1 1/2 to 2 containers. An 80 - 90 square meter house will fit in one container. Many U.S. companies have asked Insjöhus to set up a plant. Insjöhus feels that its critical to have a trained crew and a market as well as a factory. They suggest the companies start by supplying trusses to educate crews and to develop suppliers for good quality wood.

Insjöhus started deliveries to Japan in 1985. Most houses are being built around Tokyo and Sapparo. They have built both vacation and regular houses. Panels going to Japan are shipped via the Siberian Railway involving movement by truck, boat, train, boat and truck. They are able to deliver in 7 weeks with very little breakage. The houses shipped to Japan are small panels and they are produced for inventory in Japan. The house designs are done in Japan from the parts in inventory. The Japanese have 7 houses for show in Tokyo and 4 in Sapparo. Quality is very important for the Japanese market. Manufacturing is checked by Swedish inspectors and is accepted by Japan. The building system is very similar to the one used for small panels in Sweden except there is less insulation and more earthquake protection.

Insjöhus uses the Design Data Systems CAD software on a UNISYS computer and monitor. It takes them about 10 hours to finish the drawings for a house (See DDS trip report for an explanation of the software). They have been using the software for one year. They print the drawing on a Schlumberger (French) plotter. Roof truss structural design is by a consultant.

They use a moisture program supplied by Gullfiber (an insulation manufacturer) to determine if there will be condensation in a proposed wall construction. The user chooses a climate or inputs climate variables, and creates a wall by selecting wall elements. The software calculates the R value of the wall as pieces are added and shows a temperature profile through the wall. The final output is a summary of moisture in the wall over the year.

Insjöhus also uses an R value program supplied by Gullfiber to do the average R value check required by Swedish codes. The software doesn't consider solar or mass in the building. The DDS software puts out the area required for input to the Gullfiber software.

Arnesson evaluated several pieces of software before purchasing DDS. He felt DDS was better than either the Karto system (see Karto report) or Multi CAD (see Mesterhus report) because of its 3D capability, friendlier interface and better building information. Autocad and versa CAD were more expensive and not as good.

Arnesson has developed a very sophisticated estimating and production control software based on the DAMAPS software which is an industrial engineering system. The software is about 40% standard and 60% proprietary to Insjöhus. The availability of this software probably explains Arnesson's preference for the DDS software which is weaker than MultiCAD/3 in cost estimating and Karto in production control. The software allows the user to build a very detailed description of each machine operation, labor time and material necessary to produce a given element. A database has been built and is continually updated on all Insjöhus production. As a consequence, it is possible for Arnesson to know where every piece is in production, what pieces are in each order, when they were shipped, how timely suppliers delivered, etc. Using the software one person can do what 7 used to do by hand.

Insjöhus sells the fact that it will deliver all the parts the contractor needs on time in the order needed there by saving erection time which equals cost to the contractor. Insjöhus can build designs that are prefabrication "friendly" at a 10% cost saving

DOCUMENTS ACQUIRED:

- Insjöhus standard construction and alternatives
- Finnbohus vacation house brochure
- Insjöhus house plans - 2 brochures
- Forsgrens house plans brochure
- Faluhus brochure

TRIP REPORT

TITLE: Nordisk Karto AB
Box 124
S - 123 22 Farsta, Sweden
+46 894 03 80 Phone
08 604 29 28 Fax

DATE: 8/21/90

LOCATION: Farsta, Sweden

ATTENDING: G.Z. Brown, Center for Housing Innovation
Egil Borgersen, Project Manager, Machine and Production Line Design
Benqt-Olof Englund, CAD/CAM Specialist

Karto sells fastening systems including nails, screws and glues. More than 70% of its business is to the wood products (houses, furniture, palettes, windows and doors) industry. Of that 70%, 70% is to the house building industry. It also sells hot melt and fasteners for concrete and earth. It buys most of its fasteners and nail guns from abroad. As a way to increase the sales of its fasteners, it designs production facilities and computer software for its customers. It has designed many of the production facilities used in Sweden, Norway, and Finland by housing companies. Karto also services all the machinery it designs. The service contract is a way to guarantee the producer that production will run smoothly. Karto also sells a lightweight framing system of its own design.

Karto is an excellent source of information about the Swedish Home Building Industry. They reported that 85% of Swedish homebuilding takes place in the Smaland area. The largest manufacturers, Myresjöhus and Borohus, produce more than 2000 units per year. Myresjöhus has factories in Holland and Finland. Myresjöhus ships to all of Sweden from its plant in Smaland. Most Swedish homebuilding companies originated with saw mills and as a consequence were often vertically integrated from raw material production to sales. Currently less than 20% of the companies are represented by the Swedish Timber Frame House Association.

Borgersen showed a video tape of the wall and floor production lines at Myresjöhus. These lines were designed by Borgersen and in his opinion are the most highly automated in the world. They have been in operation for 2 years. The facility is more highly automated from start to finish than the Japan factories I visited. The following points were made during the video:

- Wall panel line is an area 120m X 30m.
- The top and bottom wall plates are made continuously from 2 - 2x's and a Masonite sheet. They are cut to wall length automatically from information transferred by electronic file from the CAD drawing software to the control software. The houses are produced one at a time, therefore each panel is usually a different size. The CAD software transfer to the production machinery is typical of all the manufacturing operations on the wall line. Myresjöhus uses a Medusa CAD system on a Prime computer.
- Studs which are purchased from a supplier have wooden cords with Masonite on both sides. The cavity is filled with insulation.

- Insulation is delivered as blocks all the same width and length. The insulation is put into the attic of the factory where it is stored and handled automatically. The insulation is not touched by human hands after it is lifted to the level of the attic unloading door by a forklift.
- The insulation blocks are glued together to form a continuous mat which is cut exactly the right size for stud spaces in the order needed to build a particular panel. The first stud is placed then the insulation block then the next stud insuring perfect insulation placement. There is no waste insulation.
- Small panels are produced as a group with continuous top and bottom plates so they form one larger panel in terms of the production line. This is a solution to the problem that each station has a fixed cycle time therefore it takes as long to make a small panel as a larger one. The panels are shipped together to increase the ease of handling and are cut apart on the site. Apparently the CAD software operator decides which small panels should be grouped together.
- The exterior of the panel is applied first including siding and windows, then flipped over to apply the vapor barrier and interior hardboard. The interior board is applied over the openings and then cut out automatically. The hardboard joints are better over openings because they make the stronger joint (more nails around the openings?). The leftover hardboard is used to make top and bottom plates.
- There is no wiring or plumbing in the exterior walls. The wiring is in a channel in the floor.

- All switches are on interior walls except the front and back doors.
- Hardboard is used on the interior because gypsum board is too hard to cut with a saw. Interior joints are taped and spackled then painted.

- With the exception of the small panels, the panels are produced in the order they will be erected on the site.
- There is a 9 minute cycle time at each station.
- There are 5.3 nail guns for each worker.
- Vapor barriers are cut using a hot wire.
- The panels receive hardboard on both sides.
- The lumber for the floor cassetts comes in 3 lengths and in 3 dimensions. Therefore the line is handling 9 different joint types.
- 11m X 240mm is the maximum casset size; 6 meters is the maximum span.
- Hardboard is nailed and glued on the top surface in large sheets. Smaller (4' x 8') sheets are used on the bottom. The insulation is covered with plastic on the down side where the hardboard joints occur.
- Plumbing penetration and bathroom floor slopes are done in the factory.

Karto has developed CAD systems for truss design and house design. The following descriptions are for House CAD. The software was developed by Karto with support of the Swedish Government and support/cooperation of 20 house manufacturers. The intention was to build a basic system which could be easily modified and enhanced for each manufacturer's needs. The software is based on a Swedish CAD product called Varkon. It utilizes a Unix operating system and can run on a PC with a math co-processor (Toshiba 100 in the demo) but is often run on a mid-range machine with multiple graphic terminals. The multi-processing capabilities is seen as important so that calculations (finite analysis) can be run in the background while CAD operations are being worked on. The software is quite flexible and access to its higher level code is easy for a knowledgeable user. However, the interface is entirely alpha numeric and the mouse seems to play a minor role in the drawing mode. It takes 4 to 6 weeks to train some one to use it and 4 to 6 months before they are highly productive.

Rather than having a symbol for each wall type, the user selects a wall portion and gives it attributes. It is easy to change the attributes of all walls at the same time. One can develop attributes for a wall and then draw or vice versa. It is relatively easy to decompile the code for each building element and change it with a text editor.

After the drawing is complete in definitions of corners, etc., the software will automatically calculate the number of studs, plates, and headers and will determine how they should be fastened, what their spacing should be and what order they should be assembled in. This information is put into a file which is easily transferred to production control software. The program doesn't do any energy calculations. Karto offers help directly by modem to the software users.

DOCUMENTS ACQUIRED:

Borgersen E 1986 "Untitled" - The Development of Swedish Automation in Housing
Production Line literature
Details of floor panel construction - (Myresjöhus)
Nail plate literature
Karto company description
Karto lightweight building system
CAD system description.

TRIP REPORT

TITLE: Data Design Systems
P.O. Box 1032
Nikkelveien 10
N-4301 Sandnes, Norway
04 62 35 33 Phone
04 62 53 57 Fax

DATE: 8/22/90

LOCATION: Sandnes, Norway

ATTENDING: G.Z. Brown, Center for Housing Innovation
Erik Wold - CAD Engineer
Sverre Vagle - Managing Director

Data Design Systems was a 1984 spinoff company from one of Norway's largest housing companies, Block Watne. Work on the computer system had begun at Block Watne in 1979 directed by Vagle utilizing the Autotroll CAD (Danish) system. The system written in Fortran was modified for Block Watne's design and production system. In 1982-83 the decision was made to abandon the main frame and utilize PC's. After a search of available CAD software, they decided to write their own CAD software. The Data Design CAD System which took six person-years to develop uses an MS DOS operating system and is written in Fortran 77. The system is now in use by 50 Norwegian, 15 English and 30 Swedish housing companies and design firms utilizing industrialized housing systems. Seventy percent of the kitchen manufacturers in Norway use the system. The company claims to have 700 systems in use by a wide range of companies. The system has a 3-D CAD system and Data Base as its central element and nine modules - Arkpartner, House Partner, Kitchen Partner, Interior Partner, Terra Partner, Electro Partner, Prefab Partner, Building Partner and HVAC Partner which are purchased separately depending on the user's needs. See the attached for a brief description of each module.

For use by an industrialized housing producer the system can be seen as having three parts: sales, project documentation and manufacturing process. In the sales process, the CAD + Database + House Partner are used to create a set of preliminary drawings including perspectives, bill of materials and cost estimate. These drawings are relatively fast to create and have just enough detail to get local authority approval. According to Data Design Systems, only 20 - 50% of sales drawings get to production so it is important not to do too much work on the initial drawings. If the project goes ahead, then the 3D model created is used as input to other modules which supply detailed drawings of panel or wall construction. These modules follow simple rules of stud placement and it is the user's responsibility to optimize the design or do structural analysis. The manufacturing process part of the Data Design Systems software has not been developed beyond a rudimentary level. Although some manufacturers are developing their own software to run production processes based on output from the DDS system, Karto, the Swedish machine company, is said to be working on a manufacturing system to use input from DDS although I didn't see it when I was there. A concrete panel manufacturing company uses the system to produce full scale panel drawings which are used by crews to layout form work. The system has to be used in conjunction with the ISPM software to do cost estimates.

The first part of the software demo consisted of the CAD, Database, and House Partner modules. Project description screens require input of project name, location, etc. There is a main menu across the top of the screen with pull down menus. The user draws in the plan with a single line and the computer adds additional lines depending upon the wall type selected from the menu. Windows and doors are selected from the menu and can be inserted on the wall using the cursor or other dimension based methods. The computer will redraw the wall in several levels of detail by element, the element mix selected by the user. A wireframe perspective view of the drawn elements is available at any time. The user must go to another module for hidden line removal. The roof is automatically drawn after the user identifies a roof type and points to two corners of the roof. The program will automatically infill the gable ends of the exterior wall or the tops of the interior partitions if it is a cathedral ceiling. The program will automatically give dimensions using several user selected reference points. The program can be run using cursor keys or a mouse.

The timber frame module (Prefab Partner?) adds all the framing members, automatically dimensions them and produces a cutting list. The information is transferred from the CAD-DB with a text file. Therefore it is possible to input to this module with any program that can create this text file. The CAD-DB output text file could also be used as input to an energy program. Changes, i.e., window location done in this module, are not reflected in the CAD-DB module.

The program automatically draws all framing members which the user may add to or change. The user can create his own wall, corner, etc. types. These elements are defined in terms of their parameters so that when wall thickness, for example, is changed, the drawing automatically resizes itself and this characteristic is true of all modules of the program. Therefore it is very easily adapted to any manufacturing system. The user can also define a standard element (like a window/door in a certain size panel) and add it to the menu. The automatic dimension system is very flexible, using several reference points and various levels of details. Again, because the elements are parametrically defined, changes in them are reflected in the drawings. Sections are automatically cut and perspective drawings of all framing members can be generated.

The HVAC module doesn't calculate loads or predict annual energy use. It is used primarily to size and layout HVAC distribution systems. Elements within the system automatically resize themselves as the duct sizes are changed. The HVAC drawings can also be seen in perspective and combined with the framing drawings. Output from the HVAC can be output to other HVAC analysis programs for duct sizing and balancing. The software doesn't currently operate under Windows 3.0. Data Design Systems is waiting to see how it does in the market place before it modifies its programs to run under it.

Data Design Systems gives two 3-day training courses for new operators. The best operators are productive in as little as 3 weeks but 3 - 5 months is more typical.

A complete application is 100,000 NKr (\$16,500). An architectural office that has nothing and wants to produce complete building designs and drawings should expect to spend 200,000 to 300,000 NKr for software and hardware. Data Design Systems charges 12.5% of the selling price annually for updates and support.

S. Vagle who has been active in the industrialized housing industry for 25 years and has also worked in the U.S. had several observations to make about industrialized housing:

1. With the advent of software like Data Design Systems, architects may have the opportunity to reassert themselves in the residential (and probably commercial) market because they will be able to offer clients a low cost custom design with a detailed set of drawing and specifications and a very accurate bill of materials. The client may then use this information to shop home building companies to see who can deliver it at the lowest cost.
2. Most innovative ideas that now characterize Swedish and Norwegian industrialized housing came from the U.S. in the period after World War II and the mid 1960's. Platform framing, nail plates and operation breakthrough were cited. After that period the Scandinavian countries continued to develop these systems and the U.S. seemed to slow its pace of development and was less interesting to Scandinavian builders. The U.S. is still more advanced in its utilization of labor which specializes in certain tasks.
3. The current level of housing industrialization in Sweden (and Norway to a lesser degree) is the result of two factors. First, housing companies started as a way for sawmills to sell their products. This meant that they thought in terms of high volumes and mechanized processing of timber. Second, the development of small panel systems and the ready acceptance of housing designs based on them by Swedish consumers led manufacturers to automate the repetitive tasks in the production of panels for inventory. Given the history of the Swedish producers it was natural for them to continue to automate their production when they changed to large panel production. These factors were considered more important to the development of high level automation than the cost of Swedish labor.

DOCUMENTS ACQUIRED:

List of DDS customers in Norway, Sweden and England
DDS product literature
Diagrams of the DDS system
Output sample from ISPM software
Output of DDS House Partner
Output of Building Partner
DDS newsletter
Output of DDS Kitchen Partner
Output from Czechs Construction Company, DDS
Sample perspective drawing
Sample output from timber design module comparing 4 wall systems

TRIP REPORT

TITLE: Swedish Council for Building Research
Sankt Goransgatan 66
S-112 33 Stockholm, Sweden
+46 8 817 73 00 Phone
+46 853 74 62

DATE: 8/22/90

LOCATION: Stockholm, Sweden

ATTENDING: G.Z. Brown, Center for Housing Innovation
Inger-Siv Mattson - International Liaison Officer
Jan Sandelin - Senior Research Officer,
Dept. of Building Technology & Energy Conservation
Michael Rantil - Senior Research Officer,
Dept. of New Energy Systems
Carl Johannesson - Royal Institute of Technology

The Swedish Council for Building Research is one of several units that is funded by the Ministry of Housing and Physical Planning. The Swedish Council for Building Research's role is to plan and initiate research and to disseminate information about the research. It doesn't conduct research itself. In 1989/90, its budget was 225.7 M SKr (more or less \$49 M) in grants and 34.2 M SKr (\$6 M). Of that amount, 49% went to universities, 19% to research institutes, 18% to private enterprise, 10% to national and local authorities and 4% to others. There are four main areas of research:

1. Urban and Regional Planning
2. Housing, Architectural Design and Management
3. Building Technology and Energy Conservation
4. New Energy Systems - energy end use in buildings

The Swedish Council for Building Research has established these research priorities for 1990-1993:

1. Urban Renewal, Urban Development and Social Change
2. The Planning, Building and Management Process
3. Durability and Economic Life of Buildings
4. Climate and Environment in Settlements
5. Infrastructure and Electrically Efficient Buildings.

The Council was formed during the 1960's in response to a perceived housing crisis. Research was seen as an important way to help improve the quality of housing by providing better living conditions for Swedish citizens. Initially, much of the research was supported by a 4% tax on construction. This tax was abolished about 10 years ago and research support now comes from general funds.

International cooperation is seen as important for Sweden because it is a small country with a relatively modest total (although high on a per capita basis) budget, therefore, benefit from the research of others is an important priority. Sweden has established Building Sciences Attaches in Los Angeles, London, Tokyo, Paris, Bonn, Brussels, and Peking.

Most Swedish towns over 50,000 have district heating. This experience has led researchers in the direction of augmenting these systems with seasonally stored solar heating. There are a number of experimental projects going on at scales from the clusters of houses to universities. They expect to realize a 25% reduction in the cost of solar collectors.

Almost all of new Swedish houses use an electric exhaust air heat pump. While very efficient, the use of electricity will be a subject of debate for several years with Swedish decision to abandon nuclear power. The cost of electric energy is expected to rise 50% in the next five years.

Indoor air quality is receiving increasing emphasis. Energy conservation is seen in the context of quality assurance. Evidence of this has been the development of the "P-rating" system for prefabricated detached houses. The P-rating is intended to assure:

- a house without moisture and mold damage
- a house with a low consumption of energy
- a house with a decent indoor climate
- a house built with tested and approved building materials

The Swedish Council for Building Research has numerous experimental projects in Sweden. I visited two in the Stockholm area. Bodbetjanten which is a combination residential and office building designed to utilize the reject heat from the office to heat the residences. It also has a glazed atrium which is used as a climate buffer. SunCourt is a multi-family development which uses an atrium to capture heat which is seasonally stored in the earth below the building. There is good documentation on these projects in the publications "SunCourt - low energy multi-family housing" and "Bodbetjäten" both published by the Swedish Council for Building Research.

DOCUMENTS ACQUIRED:

Association of Industrialized Housing Builders. "Industrial House Builders"
The Federation of County Councils. "A House with a View"
Församling, F. Söderleds Church
1989 Swedish Housing
Nordic Associations of Architects. Nordic Housing 1945-1980
Some Housing Areas in Stockholm guide
SCBR brochure G3:1990
SCBR. "Combining office and Residential facilities in one building"
SCBR. "Cost-Efficiency in Custom Design - The Swedish Factory-Crafted Home"
SCBR. Energy Answers '87
SCBR. Energy in the Built Environment
SCBR. "Foreign Language Publications" - 1988 and 1989
SCBR. "Housing Research and Design in Sweden"
SCBR. "Newsletter of Swedish Building Research 1990" nos. 1 and 2
SCBR. "Research for a Better Acoustic Environment"
SCBR. "Research on the Built Environment of the Future"
SCBR. "Six Unique Houses"
SCBR. "Summary of Energy in the Built Environment"

SCBR. "Suncourt: Low Energy Multi-family Housing"
SCBR. "Synopsis of Swedish Building Research 1990" No. 2
SCBR. "Unique Results"
The Swedish Institute. "Fact Sheets on Sweden"
The Swedish Institute. "Learning to Live without Nuclear Power" Current Sweden
The Swedish Institute. Publications on Sweden
The Swedish Institute. Sweden in Brief
Vattenfall, the Swedish State Power Board. "Energy Ahead"

TRIP REPORT

TITLE: Villa and Fritidshus
Expo
Bogardsvagen
12362 Farsta (sub. of Stockholm)

DATE: 8/23/90

LOCATION: Stockholm, Sweden

ATTENDING: G.Z. Brown, Center for Housing Innovation

This is a sales park of Swedish, Norwegian and Finish houses. Approximately 60 manufacturers were represented. Houses were arranged along pedestrian streets and each house contained sales personnel and promotional literature. The housing part is owned by a developer and spaces are rented to each manufacturer. I photographed the exterior of the majority of houses.

DOCUMENTS ACQUIRED:

Sales Brochures: Rakentajan OPAS
Lapponia House
Ensokotilewti

TRIP REPORT

COMPANY: Myresjöhus AB
57485 Vetlanda

DATE: 8/24/90

LOCATION: Vetlanda, Sweden

ATTENDING: G.Z. Brown, Center for Housing Innovation
Daq Ygdevik - Manager, computers
Catharina Ekwall - International Division

Myresjöhus is the prefabricating home building company of the Myresjö group which is comprised of Myresjöfönster, window and doors, Myresjökök, kitchens and wardrobes and Combiglas, windows. The Myresjöhus group is owned by Skanska.

Myresjöhus sold 1617 units in 1989 of which 237 were for export and 1380 for the domestic market. Of those sold in Sweden, 850 (62%) were single family and 530 (38%) multi-family. Most of the export was to the United Kingdom and included motels and nursing homes, as well as single family and multi-family units. According to Myresjöhus, Sweden produced 55,000 housing units in 1988 of which 27,000 were single family and the rest were multi-family. Apparently "housing starts" in Sweden are just single family and therefore don't match "housing starts" in the U.S. which include multi-family units. Approximately 93% of the single family units in Sweden are prefabricated. Myresjöhus is one of the largest home producing companies in Sweden with a plant capacity of 2000 units annually. Between 1965 and 1989, Myresjöhus shipped 1677 units to Germany, 702 units to Holland, 59 to Switzerland, 59 to Austria, 5 to Luxembourg, 2 to Belgium, 82 to England, 65 to Iran, 56 to the Falkland Islands, 49 to France, 33 to the U.S. and 9 to Greenland. The U.S. projects are in Sharon Foxborough near Boston and Pennington New Jersey. Myresjöhus has evaluated building a factory in the U.S.

Myresjöhus has increased its sales of houses in the past 10 years even though the housing market in Sweden has declined with many smaller producers going out of business.

Myresjöhus has 32 sales offices in Sweden and three in Norway who deal directly with the homeowner/developer. They also have a house in housing expos (sales parks) in Stockholm and Goteborg. The sales offices follow sales in the land market and when a parcel changes hands, they contact them to try and sell a house. The sales office works with the customers to develop a design usually working from stock plans and gets price (and feasibility checks) from the factory. The customer price is developed by working from a base price and adding on for changes or additions. Myresjöhus has 2 two models that it discounts 40-50,000 SKr if the buyer will accept it with no changes. These are increasingly popular. The drawings that are used for local authority approval are developed by hand. The sales office helps get the local approval and the customer can sign for a bank loan at the sales office. The bank later reviews the contract and eligibility of the buyers. Only two customers have been turned down in the past year. Myresjöhus feels that a key to its sales success is its willingness to sell a house in any stage of completion from shell to turnkey. This allows the customer to supply his/her own labor and reduce an expensive part of the project-site labor. The sales office builds a model house in a nearby subdivision and uses it as a show house until a new model comes out and they sell it and build another.

The model I visited was well constructed with a high level of finish in the public rooms. There doesn't seem to be the emphasis on master bedrooms and baths that there is in the American market. The "L" shaped house, different from the usual Swedish rectangular plan, has said to be quite popular because a semi-enclosed outside private deck could be created. The costs for the model I looked at were:

(5.7 SKr = \$1.00)

Selling price	1,175,000 SKr	\$206,140.00
Sales office price	963,000 SKr	\$168,947.00
Interior and Site finishes	23,000 SKr	4,035.00
Land and Utilities hook up	144,000 SKr	\$25,263.00
Construction loan	45,000 SKr	\$7,895.00
Monthly payment	5,170 SKr	\$907.00

The cost of the house to the buyer is a function of the percent of the house cost that is eligible for low cost government loans (an example given was 70% of the house cost was eligible for a 5.5% government loan which increased at .5% annually and was renegotiated at the end of 10 years.)

I visited a quadruplex under construction in Vetlanda. It used a slab on grade foundation, wood panelized exterior bearing walls, site built interior bearing walls and a concrete (precast I think) second floor. The party wall was double with insulation. Interior finishes were gypsum board (for fire?) which is unusual in Sweden but typical of Myresjöhus' product for the United Kingdom. They have had problems with the gypboard cracking at the corners of windows and moved the studs to get better nailing. They have also used a gypsum wood fiber product (Fermacell, German) for the German market. The product is supposed to have a better resistance to cracking. Fermacell costs twice as much (material only) as gypsum board and the fiber board normally used costs 1 1/2 times as much as gypsum board. There was no electrical work visible in the exterior walls.

The heating system was going to be a under floor water system heated with an electric boiler. The electrical distribution to the interior walls will probably be in the same layer as the heating pipes.

The Myresjöhus plant covers 200,000 square meters with 84,000 square meters under roof. The production facility includes a highly automated sawmill. Myresjöhus is an example of a factory in which logs go in one end and houses come out the other. In the course of a year's production, the plant uses 400-500 square kilometers of timber, 200,000 trees, 450,000 logs, 23,000 windows, 186,000 cubed meters of insulation, 636,000 cubed meters of plywood and chipboard, 22,000 doors and 300 tons of nails. It employs 480 people, 180 in production, 150 in administration and 150 in sales.

Myresjöhus has recently changed the details of its housing construction to the 2000 model. It is this system that is used on the new highly automatic floor and panel lines (see the Karto meeting report). The wall panel assembly line is more automated than anything I saw in Japan. The wall line seemed to be operating with about six workers. There was automatic placement of insulation, studs, and window units and automatic nailing of sheathing and siding and interior finishes. This line was designed to produce the panels for 1200 houses per year (5 per day). The operations of the line are entirely computer controlled with operations based on instructions developed during the process of producing CAD drawings (see later computer section for more detail).

There are other lines which produce multi-family panels and small panels for the Norway market (small panels are produced for inventory).

The construction details of the system are quite interesting and hopefully Myresjöhus will send the construction drawings. The corners are separate elements and the wiring is run in a floor chase at the perimeter (See Karto report for some details.)

The computer group is comprised of 10 people. The company has had various levels of computerization starting in 1975. The CAD/CAM system now in use started development in 1982. The hardware currently in use is a networked system. Mainframes in the network include one HP-3000, one MicroVAX 34000, and one PRIME 4450. In addition, there are several disk-stations, printers, plotters, modems, and terminal servers.

Myresjöhus is moving in the direction of distributed systems using sun sparcs work stations for the CAD software.

The CAD software is based on Medusa, developed by computer vision in Cambridge who is now owned by prime computer. The software has been modified by Myresjöhus. The CAD/CAM system for the 2000 system has taken six person/years to develop. The CAD/CAM system has seven components.

The Medusa CAD system has been modified and new menus developed for Myresjöhus' system 2000. The close collaboration between the computer programmers and drafters was said to be critical to developing a workable system. The system currently uses two monitors, one to show the drawing and the other containing input queries. The interface was typical of CAD systems - the drawing was something that was a record of what was input not something the user could manipulate on the screen.

The CAD system operates within the rules of construction of the system 2000. For example, a limited set of roof pitches. It takes about 60 minutes to input a plan which is automatically dimensioned, the roof designed and the drawing sheet generated. When the operator has completed the CAD drawing, each element has an architectural description (location, Size) and element name that is unique to the system 2000. The CAD system transmits a file of building elements to the Mimer database (commercial product). The database completes its file on each element based on its unique name from the Registar. The files for each element are passed to the steering module which determines how the element should be built. For example, how many and at what spacing should the studs in a wall panel be? All manufacturing specification are generated at this point and are saved on a disk which is accessible by a PC at the manufacturing work station. The PC loads the file from the disk and provides instruction to the machines to perform their functions. The P.C. software system is commercially available from SAAB. The P.C. updates the disk as panels are completed and materials are used.

The CAD system is taught to operators in a 5 day course. It must take several weeks to become productive on the system.

Interestingly enough, the CAD/CAM system doesn't do cost estimating and it was not clear how connected it was to the inventory and ordering systems. The system also doesn't do energy calculations which are required for all Swedish houses. A freestanding PC program called ENORM is used for all energy calculations. Energy calculations are completed for each price quotation shipped to the United Kingdom. The calculations compare the fuel costs for traditional British construction, 120mm and 165mm of insulation (240mm is the Swedish standard). The United Kingdom houses are standard with 120mm of insulation. 165mm is an extra charge.

DOCUMENTS ACQUIRED:

Myresjöhus exports from 1965-1989
Myresjöhus sales brochure for the U.K.
"Facts about the Myresjö Group"
"Denya Husen" Myresjö House catalog

TRIP REPORT

TITLE: School of Architecture
Chalmers University of Technology
Göteborg, Sweden
31 41 08 10 Phone
+46 31 72 24 85

DATE: 8/27/90

LOCATION: Göteborg, Sweden

ATTENDING: G.Z. Brown, Center for Housing Innovation
Peter Salander, Professor
Anne Marie Wilhelmsen, Dean
Michael Edén, Lecturer

The School of Architecture at Chalmers is one of three in Sweden. The school has a staff of approximately 140. Forty of those are administrators and staff and the remainder are faculty and researchers. The school's budget is \$30,000,000 SKr's per year; 55% coming from the Swedish government and 45% coming from research contracts. Most research is funded by the Swedish Council for Building Research. The school admits 55 undergraduates per year. It also has a Ph.D. program which grants about 3 degrees per year. There are about 10 chaired positions each of which represents a "department" within the school. Planning is integrated with architecture.

The university is in the process of forming a new department, "Environmental Technology Science" which will be composed of faculty from diverse disciplines. The department will be research oriented (unlike the Center for Environmental Studies which is informal and teaching oriented) investigating the impact of technologies on the environment. Buildings and construction will have an important role in the new department.

When Salander and Eden were asked the question, "Why did energy efficient industrialized housing happen in Sweden?" they speculated that there were several factors at work.

1. The Masonite stud was developed prior to the energy crisis by the Masonite company as a means of increasing sales of their product. It may have been in response to a perception of impending wood shortages in Sweden. The stud's ability to economically allow increased insulation thickness was not considered until after the energy crisis. However the product was available when the government established new energy code requirements.
2. At the time of energy crisis, Sweden was funding research in optimum insulation thickness for renovating existing buildings. The study looked at the reduction of energy use and increased cost at increasing levels of insulation. These studies were conducted by Ingemar Höglund at Royal Institute of Technology Stockholm and Bo Adamson at Lund Institute of Technology. These studies were nearing completion in 1973 and the evidence was clear and available to the government that increased insulation was a good way to reduce energy use. There was general understanding and acceptance of the need to conserve energy.

3. Almost 40% of Swedish energy was used for heating in the early 1970's. There was a strong incentive to reduce energy use and the political climate necessary to mandate reduced use.
4. Historically, housing construction in Sweden has been used by the government to stimulate the economy. In the 1970's, the government was attempting to increase housing construction and there was considerable activity in the building industry. This level of activity apparently made it easier for the government and for manufacturers to explore innovative techniques.
5. The importance of the airtightness of the exterior envelope was established by tests in 1978. This research led to the reduction of plumbing and electricity in the outside walls and to the development of new details for wiring installation.
6. Up until 1970, the building industry was highly regulated. The legacy of this regulation made it relatively easy for the Swedish government to communicate with the housing industry. Sweden is also relatively small which made it easier for the various ministries to coordinate activities that resulted in new energy codes in 1975 and 1980.

Frame house construction was introduced to Sweden after World War II by government agencies who approved it for low cost loans. Housing in Sweden changed dramatically from 1945 to 1980 going from 2 to 3 people per room to 2 to 3 rooms per person.

Almost all housing research is funded by the federal government with little funded by private industry. In most cases, industry participates in setting the research agenda, but it is carried out by universities and research institutes with federal funds. Industry involvement has led Sweden to concentrate on insulation and heat recovery and neglect the impact of users behavior on energy use.

When asked the question why is Swedish housing so highly industrialized, the responses were less clear. Salander and Eden mentioned that:

1. Industrialized housing was cheaper than site building.
2. The only economically-sized single family housing was produced by manufacturers. The housing was based on vacation housing where industrialized housing apparently got started.
3. Site building of individual houses always resulted in problems for the owner (cost overruns, code approvals, etc.). Housing companies solved most of these problems with guaranteed prices, assistance with code approval, design help, etc.
4. The site building industry found multi-family construction to be more profitable.
5. Single family housing was unusual in Sweden and there wasn't a long history of how it should be produced.

I also reviewed Salander's facility management program which is a super card program and runs on the macintosh. The program is intended for use by universities. The user builds a data base on Excell for each room having to do with daylighting, ventilation, water, use, area, floor to floor height, etc. The Excell data base can be used to sort data using Excell's features. The data can also be displayed on bit mapped building plans that have been scanned into super card.

The display can show any of the elements in the data base in any combination. This might be an interesting way to how energy use by space in a complex building. Especially those spaces greatly influenced by use patterns over time and season.

TRIP REPORT

TITLE: "The Architect, Energy and Global Responsibility," conference jointly sponsored by the Royal Institute of British Architects and the Energy Efficiency Office

DATE: January 24, 1990

LOCATION: London

ATTENDING: Rudy Berg

PURPOSE: To learn British attitudes and approaches to energy-efficient architecture, and assess current efforts

SUPPORTING DOCUMENTS: Conference program, presentation synopses, AJ editorial

Relying on the attached presentation synopses to describe the content of the conference, I'll add a few notes and observations:

The conference room was packed. Kristensen and Ferraro were impressive. In general, however, the meeting seemed like a ritual for the architectural establishment. I emerged from the conference, and from the nation as a matter of fact, with the feeling that cavity wall construction is still a mite *nouveau*, and that the proper remedy for the standard building problem -- dampness -- is the fortuitous occurrence of a second standard problem -- drafts.

Kristensen's straightforward presentation of Scandinavian buildings which achieve high energy performance, and his matter-of-factness in showing how those energy levels could be cut by two-thirds, was inspiring. With present techniques only 14% of residential heat need come from the heating system; small boilers need further development. He showed a three-story apartment building in Copenhagen retrofitted with glazing over the south facade. This provided 34% savings in heat, added 100 sq ft sunspace per unit, and cost roughly \$2000 per unit over cost of conventional facade renovation.

He also showed commercial buildings (BRF HQ building, Lyngby, Denmark, and others) with high energy performance. He described small gas fired heat/power stations used in remote locations to provide power and district heating while minimizing distribution losses.

Kristensen was asked (but did not effectively answer) how to understand the "CO2

content" of different energy end uses.

Richard Ferraro is with ECD Partnership -- certainly one of the major players in UK energy efficient architecture (ECD incidentally was Energy Conscious Design when they started in the 60's -- had to hide the "energy" word a decade later for image purposes). He showed a number of high performance projects. ECD has stood its moral ground for 30 years and now looks like it's on the front of the wave. Ferraro mentioned that the new British energy building regs match the Swedish standards of 1935.

Recent British winters, while they may be flukes, have helped persuade Brits of the greenhouse effect. Bill Bordass said air conditioning use in office buildings is doubling.

Bill Holdsworth gave a poetic slide tour of the NMB Bank HQ in Amsterdam. He must have worked on it. Claims it provides "the lowest energy consumption in the world."

Little else worthy of comment. I gathered a fat handful of leaflets re BRE energy studies and projects.

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PROGRAMME

Chairman	Professor Peter F. Smith
9.30-10.00	Registration
10.00-10.15	Welcome by RIBA President, Max Hutchinson
10.15-10.30	Keynote address by The Secretary of State for Energy The Right Honourable John Wakeham MP.
10.30-11.15	'Energy Efficient Building Design in Scandinavia - Status and Future Perspectives.' Poul Kristensen, Ebsensen Consulting Engineers.
11.15-11.45	Coffee
11.45-12.15	'Appropriate Methods and Technologies for New Build and Refurbishment: Housing & Industrial Buildings. Richard Ferraro - Partner, <u>The ECD Partnership</u>
12.15-12.45	'Appropriate Methods and Technologies for New Build and Refurbishment': Offices. Dr. Bill Bordass, <u>William Bordass Associates</u> .
12.45-13.15	'Real Low Energy Buildings - A Life Cycle Energy Costing Approach to Energy Efficient Design'. John Connaughton, Associate, <u>Davis Langdon and Everest Consultancy Group</u> .
13.15-14.30	LUNCH AND EXHIBITION
Chairman	Bill Rogers, Director General, RIBA.
14.30-15.15	'The Building Services Engineer's View - Internal Environmental Parameters & Their Effects'. David Lush, Technical Director, <u>Ove Arup Partnership</u> .
15.15-16.00	'Energy and Environment - New Building Design and Achievement'. Bill Holdsworth, <u>Holdsworth & Associates</u>
16.00-16.45	'The Global and National Perspective'. John Chesshire, Head of Science Policy Research Unit, Energy Group, University of Sussex.
16.45-17.00	Closing remarks - Professor Peter F. Smith. followed by tea.

Energy Efficient Building Design in Scandinavia

Status and Future perspectives.

by Poul E. Kristensen B. Sc. - Esbensen Consulting Engineers.

Poul E. Kristensen worked as energy researcher and assistant professor at the Technical University of Denmark from 1977 to 1983. Since then he has been working with energy R&D at Esbensen Consulting Engineers - since 1986 as a partner. He is involved in energy research within the CEC programme, within the IEA Solar Energy R&D programme as well as within the Danish programme for solar energy and low energy housing.

Synopsis

Energy has always been relatively expensive in Scandinavia, because the major part of fossil fuel used has been imported. Consequently, energy conservation in building design has been important since the fifties.

The present building code in Denmark prescribes double glazing in windows, and the minimum insulation thickness of the exterior wall and roof is 125mm and 200mm respectively. However, the roof is often insulated with 300mm, and double glazing with low E - coating is often used, reducing the heat loss through the windows by 50% compared to normal double glazing.

In the future, energy consumption of new-built dwellings can be reduced to very low values. Present research in Denmark indicates that the overall energy consumption for heating, hot water, lighting and appliances for a terrace house could be reduced from a typical current figure of 14,000 kWh/year to 8,000 kWh/year, utilising techniques available today. A further reduction of total energy use down to 4-5,000 kWh/year is foreseen as a realistic target within the next decade.

In dwellings, energy for space heating and hot water accounts for the major part of total energy consumption. In commercial buildings, however, lighting and cooling will often account for 50-75% of the total energy use in the building.

A recent design study indicates that utilisation of natural daylight and passive solar energy can reduce the total energy consumption in an office building by 50% compared to a new-built office building of traditional design. Energy for lighting can be reduced by as much as 80%, and in addition the design can create good visual comfort and a stimulating working environment. In May 1989 the design was awarded the first prize in the CEC architectural competition "Working in the City".

One of the main recommendations of the Brundtland Report "Our Common Future" is that the use of fossil fuels in the industrialised world should be reduced by 50% during the coming 30-50 years. The examples mentioned here indicate that this goal can be realised in the building sector.

Appropriate methods and technologies for new build and refurbishment:

Housing and Industrial Buildings.

by Richard Ferraro BA, Dip.Arch. RIBA - ECD Partnership.

Richard Ferraro, BA, Dip.Arch. RIBA, is currently a partner in the ECD Partnership. He started work in low energy architectural design in 1974 and since then he has worked on a wide range of low energy building projects, including several award winning designs, in the housing and commercial sectors.

Synopsis

The presentation will illustrate some of the work of the ECD Partnership over the past decade, and places it in a current context. It will show by example that Energy Conscious Design is a reality in practice, and that architects can make a direct and major contribution to the reduction of atmospheric damage. This is achieved through proper understanding and control of their product: the architecture resulting is not only progressive, but articulate, attractive and popular.

We live in changing times. The nuclear solution remains unproven, and the thinkers of the new decade must broaden the perspective of the energy issue. ECD, for example, no longer sees the case for energy efficiency as one solely based on the equation of savings in running costs, versus the capital investment required to achieve them. This equation will and must remain high on the agenda, but additional regulation does in our view need to be put in place, specifically to reduce damage to the environment. We all know that the creation of CO2 by the consumption of fossil fuels is causing massive damage to the atmosphere which, if not substantially and quickly reduced, will shorten our tenure on the planet.

Architects are in the hot seat on this issue, and a laissez-faire approach is no longer acceptable. By way of example, four new-build public sector housing schemes by ECD will be illustrated, all with cost effective energy saving measures. Two are EEO Energy Conservation Demonstration Projects, and three have been the subject of low energy design awards. Three low energy private houses are also illustrated.

ECD is also heavily involved in low energy housing refurbishment, including two major estate refurbishment projects now on site in London's East End. Both are illustrated. One award winning low energy housing refurbishment will be illustrated, together with the results of design studies for low energy industrial buildings, undertaken under contract with ETSU (Energy Technology Support Unit).

All ECD buildings illustrated save between 20% and 40% in their energy consumption, compared to buildings built to current regulations and standards. In all cases the energy saving measures are cost-effective, in some projects the capital overcost to achieve the savings is approaching net zero. We have set the pace ahead of the Building Regulations and other professional standards. There is no room for complacency on this essential issue, either within the profession or within Government. There is still much more to do.

Appropriate Methods and Technologies For For New Build and Refurbishment : Offices

by Bill Bordass, William Bordass Associates.

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Bill Bordass is a building scientist involved in issues of energy, environment, and building deterioration. At RMJM from 1970-84 he worked first on planning projects and their environmental impact and was subsequently associate in building services and director of its energy group. He was the first chairman of the multi-professional London Energy Group. He is currently working together with the Davis, Langdon & Everest Consultancy Group on a project for BRECSU and EEO on the patterns of energy use in office buildings, including a series of case studies.

Synopsis.

Studies of energy in buildings indicate that the best and most cost-effective solutions nearly always come not from single technologies but from an integrated approach to briefing design, construction and management issues. The architect clearly has a key role in making this happen, particularly as an intelligent approach at a strategic level (eg: location, plan and section) can often lessen a building's demand upon energy-consuming services.

Building regulations concentrate predominately on heating, which is only a small part of the energy equation in the most new commercial buildings. With reasonable fabric insulation levels, and the double glazing which is now very widely used, heating often accounts for less than 25% of the energy costs in a modern office, and in some less than 10%. Lighting, air-conditioning (where installed) and equipment are often more important. Current preoccupations with information technology and shell-and-core design tend to create sealed office buildings with bland, climate-excluding facades and independently serviced interiors. Building services energy costs are often considerably higher than for their predecessors, owing to increased electrical consumption. Often office equipment heat gains are over-estimated, typically a factor of three or so, and although we will have more IT in the future, the technologies are not only becoming more powerful but more efficient. And unwanted heat gains do not always have to be countered by refrigeration energy.

So what should the architect do? The series of case studies currently in progress may begin to provide some of the answers. The paper will concentrate on some of the results, which give some insight into patterns of energy use and cost, show that energy efficiency does not restrict design freedom, and indicate potential for considerable improvement by combining the best features from a number of current exemplars. Overall, I see three important clues for future designs:

- i. Don't make things too elaborate: simple solutions often seem most effective.
- ii. There seems to be scope in the UK for what I call "mixed mode" buildings, designed to maximise "passive" design opportunities where appropriate, but which can also accommodate more sophisticated services when and where required.
- iii. People (both management and users) must be more carefully considered in the design

I am also seriously worried about the trend to modern out-of-town office "park" developments. However efficient and responsible the buildings themselves, the implications of the associated car-based transportation system on land use, energy consumption, pollution, and social and visual amenity must also be seriously addressed. Here architects also must surely have something to say.

Energy Efficiency Office

Energy and Environment - New Building Design and Achievement:

A Fresh Approach

by Bill Holdsworth MSc, MASHRAE

Bill Holdsworth has worked for over forty years in many spheres of building construction and energy engineering. Principal of his own consultancy firm, Holdsworth and Associates, he is now a Netherlands based writer, broadcaster and lecturer.

Synopsis

Construction of a building should be an extension of the land it stands on and its climatic surroundings. Land, water, air and the power of the sun are providers of natural energy. Integrating these natural providers with materials of construction that use less man-made energy in their formation, is the agenda for the future.

These factors have all been taken into account in the design of the NMB Bank in Amsterdam. Architect Tom Albert and the team of technical advisors have produced an office building which currently claims the lowest energy consumption in the world.

The building is an amalgam of organic and holistic thinking involving the use of sunlight and rainwater for heating and cooling. A gas turbine provides combined heat and power. This and other aspects of the building will be described in detail, along with examples of the use of earth heat and cooling employed in theatres and apartment buildings in Germany and Poland. These examples will illustrate some new primers for a more humanistic and natural approach to architecture, energy and global responsibility.

**The Building Services Engineer's View :
Internal Environmental Parameters and Their Effects.**

by David M Lush, Technical Director, Ove Arup Partnership.

David Lush is responsible for the electrical and mechanical work in Arup Research and Development with very wide experience in the co-ordination and interfacing between all design disciplines. He has specialised in all facets of energy conservation and utilisation relating to the effective design of buildings. This has led to the study of 'smart' and 'intelligent' buildings and an interest in the health aspects of the internal environment. He has published papers on a wide variety of topics.

Synopsis.

The obvious environmental and global disadvantages resulting from our profligate use of energy necessitate strenuous efforts to reduce overall consumption. Buildings, as the single largest energy user (50%) are obviously the major sector to address in terms of reducing energy-related environmental pollution. Architects and building services engineers collectively must collaborate from the inception of the project to reduce both the consumption and the consequential effects on the global environment.

Building services engineers are taught to choose energy efficient equipment as a fundamental part of their day-to-day operations. The parallel is not true in architectural terms despite the efforts of the RIBA in the last fifteen years to emphasise the importance of architectural design on long-term energy considerations. Developers should therefore specify energy efficient design in their brief, and, equally, the design team should impress the need on developers who overlook it.

Whilst existing inefficient buildings may take fifty to one hundred years to replace, or refurbish, all new buildings should be designed for efficiency. The architect's contribution to this can be immense, at no additional cost if there is commitment to energy efficient design. Any reduction in energy consumption in buildings improves the global environment. Apart from energy consumption and global pollution, architects and engineers need to re-examine the specified parameters for a comfortable and healthy working environment. Occupants have greater expectations, but the environmental specification has remained static.

In an economic climate where market forces are the primary mechanism, voluntary environmental and energy efficient policies will only be carried out if the resulting product remains competitive. This will severely restrict implementation of both policy areas unless there are financial inducements or statutory rules - the carrot and the stick.

Architects and building services engineers working together can produce buildings which meet the client's brief in aesthetic and functional terms, while being energy effective and 'green'. These last two elements, coupled with flexibility for changing use patterns, will virtually guarantee the client a long-term re-leasing potential which will not be true of inefficient buildings in the next century - only ten years away.

The Global and National Perspective

by John Chesshire - SPRU

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John Chesshire is an economist and Head of the Energy Programme, Science Policy Research Unit, University of Sussex. He has acted as a consultant to the EEC, IEA, UNEP, UNCTAD, ECC, NEDO, CBI and energy agencies in Canada and Sweden. He has been an adviser to the Select Committee on Energy since 1979.

Synopsis

Without doubt, the environment has become the most salient feature of current political debate. For policy makers and decision takers in many fields it represents both an enormous tripwire and a great opportunity. Global warming has now replaced the earlier issues of acid rain and CFC-induced ozone depletion at the top of the environmental agenda. However, whilst in the case of acid rain and CFCs scientists could offer politicians neat technological fixes, this is unlikely to apply to global warming should the need for urgent and concerted action be confirmed.

The two principal responses to global warming required via energy suppliers and consumers are (i) enhanced energy efficiency and (ii) energy substitution - within the fossil fuels to natural gas, and away from fossil fuels to renewable and nuclear sources. Debate will concentrate on the relative merits of the stick (prices, taxes, regulation) versus the carrot (information, grants, allowances) approaches. It is unlikely that dogma will have much contribution to make and equally unlikely that global warming will respond in any significant way to the laissez-faire interplay of free market forces. National approaches will need to be co-ordinated in an unprecedented way in the international arena.

Given that 50% of IEA area energy demand is consumed in buildings, the role of the architect and associated professions - such as building services, controls and instrumentation - will assume significant importance. How should the architect respond to the greenhouse issue? Is it sustainable given the many other issues confronting the public? Should architects forge inter-disciplinary professional alliances to become more effective? What action can be taken now without waiting for further scientific proof of the greenhouse phenomenon.

AJ

GLOBALLY RESPONSIBLE

Glass, but no greenhouse.

Last week's RIBA conference 'The Architect, Energy and Global Responsibility' showed that designers are perfectly capable of producing buildings with energy consumption well below the standards set by the Building Regulations, at little or no extra cost. We are getting there.

But as we build up our technical expertise, we need to be aware that the target is shifting, the horizon broadening, and the sense of urgency increasing. Industrialised nations like ours need to cut back hard on fuel use for there to be a hope of containing the greenhouse effect: developing countries will inevitably increase their energy consumption in the near future. About half the world's population lives in China, India and Brazil.

Energy conservation is far more cost-effective than building power stations. We cannot isolate ourselves, either as a profession or as a nation. We have to see buildings within a broader environmental picture. We have to be aware of, for example, their micro-climatic effects or the life cycle energy costs of materials from production to final disposal. The energy costs of materials can equal 10 to 15 years of fuel costs. And we need to look more widely at what is going on in other sectors so that all environmental strategies work together.

The conference was shown a telling example of how sometimes they do not. A slide showed a low-energy office building that had been located out of town: in the foreground of the picture was a large car park. In commuting to work the staff may well have been using much more energy than was being saved by the building's energy efficiencies.

For buildings, market forces are evidently imperfect. Those paying for environmental improvements, for example, are often not the direct beneficiaries. There are, however, some signs that the government is coming to terms with this problem: plans have been made for new insulation grants for low-income households, and energy secretary John Wakeham's address to the conference made no great claims for market forces. This is not to suggest that the government has modified its policies, but that it has few policies that may be open to suggestions. There are opportunities to lobby for better standards, even though the new Part L of the regulations does not come into force until April.

It is disappointing then to find the RIBA so ill-equipped for its lobbying role. Max Hutchinson opened the conference with enthusiasm, as always, and Professor Peter Smith closed it with a rousing manifesto. But these were personal statements. There is no agreed RIBA policy and it is later than the institute thinks.

It would be wrong to suggest, however, that the global environment is somebody else's problem — the RIBA, the government and the like. It is also a personal matter for every architect. We can all help by being literate in energy technology and by persuading uninformed clients to make energy and the environment a part of building briefs.

Environmental concern can stimulate good architecture as an increasing number of buildings show, like the low-energy factories featured this week (p59). There is plenty that can be done now and no reason to delay.

TRIP REPORT

TITLE: Workshop for Architects on the Walter Segal Self-build Method

DATE: March 30-April 2, 1990

LOCATION: Center for Alternative Technology, Machynlleth, Powys, Wales

ATTENDING: Rudy Berg

PURPOSE: Study Walter Segal method, visit CAT facilities

SUPPORTING DOCUMENTS: Photos, AJ reprint, CAT brochure, CAT conservation house details

This workshop was set up to familiarize architects with the simplified wood frame building system developed by Swiss architect Walter Segal to ease the problems faced by self-builders, particularly in Britain. In a sense this system falls inside our definitions of "industrialized" housing because it relies heavily on stock lumber and panel sizes, thus turning standard building supplies into a kit of parts for pre-cut homes. It is an open systems approach. Within modular constraints it permits designers considerable freedom, and the Segal method has been used by as a takeoff point by David Lea and others to create a rich variety of buildings.

I will not describe the system further, since its details have been published (*Architects' Journal* has a special issue on it). This workshop devoted considerable attention to refinements in the basic system to improve its energy efficiency, and here too there are close parallels with our EEIH efforts.

The attitudes of British architects attending the workshop (these tended to comprise, as they would in the US, the "fuzzy fringe" of the profession) revealed something of typical proficiencies and attitudes about residential energy performance. Not everyone believed in vapor barriers. Several were quite sophisticated in their knowledge of energy technology and issues.

The site of the workshop, the Center for Alternative Technology, is something of a 60's dream come true. It makes its own electricity and grows most of its own food. Yet it is not a bunch of folks wearing crystals and smoking funny cigarettes. Roughly 55,000 visitors per year come to learn about solar, wind, and water power, and this place teaches them, feeds most of them, and houses those who stay overnight. Its displays are well done, its workshops (if this is any indication) are meaty and well organized, and it has an excellent bookstore. The people at CAT probably have more daily experience in solving energy problems and living with the results than anyone else on

the planet. A list of current courses is attached.

One feature of interest at CAT is their "conservation house." This very-high-performance residence is described in the attached pages.

Typical interior: house at Yelling, Cambridgeshire, 1970 (AJ30.9.70 p772)

THE SEGAL METHOD

The type of timber-frame construction known as the 'Segal method', after its inventor who died last year at the age of 78, demonstrates some fundamental attitudes towards building. It questions assumptions about how buildings, not just houses, are designed; how buildings, and not only timber ones, are built; and how buildings, particularly houses, are related to their users. Jon Broome describes the essential features and implications of the Segal method, highlighting the principles behind each element of its design, construction and organisation. This follows the self-build sequence from planning through to finishes.

THE SEGAL METHOD

Walter Segal's approach

The essential method

1 General arrangement

The planning process

2 Modular grid

3 Layout drawings

4 Structural layout

5 Calculations

6 Framing drawings

7 Schedule of materials

8 Catalogue of elements

9 Building instructions

The building process

10 Foundations

11 Structural frame

12 Roof

13 Floors

14 External walls

15 Windows

16 Partitions

17 Ceilings

18 Stairs and other features

19 Services

The future

Conservation House

In the summer of 1975, Wales Built Homes were approached with the hope that they would take up the challenge of building a low-energy house at the Centre as a demonstration of what could be achieved with existing building technology. Wales responded enthusiastically and commissioned Peter Bond Associates to design the house. During preliminary discussion, the following decisions were made: to retain a building of fairly conventional appearance and size, so as not to prejudice marketing possibilities; to limit the budget to £20,000; to concentrate efforts on reducing energy demand rather than supplying energy. The last point ensured that the house design would be suitable for any location, initially in most cases connected to mains services, but in isolated situations (and perhaps more widely in the future) powered by ambient energy. The function of the house is partly to be a research tool and a means of gaining experience with large amounts of insulation and heat pumps, but also to stimulate interest in low energy housing among the public, building societies etc.

The design employs a high degree of insulation in the walls, roof space, and beneath the ground floor, small quadruple glazed windows, mechanical ventilation, and inner walls of fairly high thermal capacity to take maximum advantage of incidental gains without local overheating, and to smooth out the effect of diurnal temperature variations. The internal air design temperature was taken as 18°C. A heat pump is used for domestic hot water (DHW) supply, and the design also attempts to minimize cooking energy and uses low-power lighting. Rain water from the roof is collected, filtered and used for all purposes except drinking, with automatic reversion to mains water when necessary.

Cavity wall construction is used; the outer skin is brick and the inner Thermalite block. The 450mm wide cavity is filled with 'Drittherm' glassfibre which was inserted during construction with little difficulty. The outer wall is buttressed internally and tied only at the buttresses to the inner wall. It is calculated that the dewpoint will occur on the outer surface of the insulation, and since the insulation is layered in vertical plains, condensate will run downwards, together with any moisture penetration through the outer skin, to the base of the wall where drainage holes are provided to the outside. Inspection of the insulation, by removing bricks from the outer skin, has shown that even in the worst conditions only the outer centimetre or so of insulation and the surface of the brick were damp. The rest of the insulation has remained dry. The top surface of the ground slab is laid to fall towards the outer skin, discharging any condensate via the same drainage holes. A polythene vapour barrier is also provided above the ground slab insulation; this also serves the function of stopping glassfibre particles from being drawn into the building by the warm air heating system. The calculated U value for the walls is 0.075 W/m²°C.

A normal tiled pitched roof is used and, to accommodate 450mm of roof insulation without excessive building height, part of the ceilings of the upstairs rooms are angled. A polythene vapour barrier is provided beneath the roof insulation and the roof space above the

insulation is naturally ventilated. Some problems were experienced with condensation on the roofing felt. Quadruple glazing brings the window losses more or less in line with the rest of the structure. A fixed outer frame carries one sealed double-glazing unit and spaced at 200mm, an inner openable frame carries a second similar unit.

Only one entrance is provided, thus avoiding through draughts, and this is fitted with double doors. Ventilation is provided by a Greenwood Airvac whole-house ventilation system with heat recovery. Warm, stale air is extracted from areas of high humidity (the kitchen and bathroom). This air is passed through a counterflow heat exchanger where it gives up 70% of its heat to the incoming fresh air. The warmed fresh air is introduced by high level grilles into the living rooms. The air change rate is variable and approximately 0.25-0.5 the total volume of the house per hour.

The calculated specific heat loss rate for the house is 66 W/°C. The peak demand is 1.2 kW and the space heating requirements with incidental gains taken into account is only 8 kWh/day on average in December and January, and a total of about 950 kWh over the heating season. This compares with 13,000 kWh over the heating season for an equivalent-sized conventional house. The heat demands of the conservation house and a comparable house over a typical year, taking into account incidental gains, are shown in Figure 1. The house itself is shown in Figure 2.

Figure 1 Space heating energy demand

THE CONSERVATION HOUSE

Conservation House takes domestic energy saving to its practical limit.

The house uses one-fifth of the energy of a conventionally built house of the same size.

Most of the savings are due to 'superinsulation' and heat recovery, giving an annual space heating bill of £30-60.

SUPERINSULATION

The walls, floor and roof are insulated with a thick layer of mineral wool (450mm or 18"). This is 8 times the thickness required by the current Building Regulations.

The windows are quadruple glazed.

Heavyweight internal walls act as a heat store and help maintain a steady internal temperature.

HEAT RECOVERY FROM VENTILATION

Stale air is extracted from the kitchen and bathroom and used to heat incoming fresh air.

Up to 70% of the heat in the extract air can be recovered.

HEAT RECOVERY FROM WASTE WATER

Domestic water is heated by a small heat pump which uses the warm waste water as a heat source.

TECHNICAL DETAILS

Annual space heating demand 960kWh
Peak loss 1.2kW

'U' values of construction:-

Walls	0.075 W/m ² °C
Roof	0.081 W/m ² °C
Windows	1.45 W/m ² °C

TRIP REPORT

TITLE: BRE wind tunnel facilities

DATE: April 3, 1990

LOCATION: Garston, Watford, England

ATTENDING: Rudy Berg

PURPOSE: To view low speed wind tunnel facilities

SUPPORTING DOCUMENTS: Photos, BRE publications, instrument catalogs

The British Research Establishment is a unit recently elevated to Agency status within the Department of the Environment. Its test facilities at Garston are quite extensive, including geotechnical engineering, structural engineering, energy conservation, wood structures, and wind engineering. Here BRE has operated wind tunnels for 60 years, with a new one under construction which will be the most sophisticated such instrument in the world. Mr. Chris Judge, Head of Wind Engineering, showed me through the facility.

Two tunnels are the present mainstays of BRE testing. One is chiefly devoted to wind load testing, and the other to flow investigations -- the likely focus of our own work. While the general size and arrangement of both tunnels is like ours, they differ in significant ways. The general standards of permanency and precision are higher than those of our tunnel (the test sections are built of brick).

The traversing mechanism of the flow investigating tunnel (Figure 1) is a heavy steel structure and maintains locating tolerances of less than 1mm. Stepping motors are computer controlled and manually operable via joystick so that a probe can maintain a constant relative position -- as a model is rotated, for example. In many cases, Judge noted, manual probe placement is still simplest because of the complex model shapes.

A feature of interest in the flow visualization tunnel is the use of airfoil shaped slats as walls of the test section (Figure 2). These are meant to stabilize flows at the edge of the test section while relieving the blockage effects of the model itself, and were developed by Professor Jeff Parkinson of the University of British Columbia.

A test was underway during my visit. A shopping mall built in the 60's, typical of many such, included an open courtyard and a tower element at the north end, where it would not shade the mall. British winter winds tend like ours to be southerly; consequently

winds washing down the face of the tower scour the courtyard. Remedies usually comprise glass roofs or courtyard kiosks arranged to block these problem winds. A model of this arrangement under test is shown in Figure 1.

BRE flow visualization techniques include smoke, small helium-filled soap bubbles, ground walnut shells (of the sort used for grit blasting), or in some cases a spray of fluorescent-pigmented solvent. This mixture is sprayed onto the model and dries, leaving a colored trace which reveals surface flow patterns (Figure 3).

Two sources of probes and related equipment were mentioned: TSI Corporation of San Jose, CA (tel 408/452-0808) and Dantek, a Danish firm whose catalog I acquired. BRE's microcomputer system is PC based, linked to a network that permits researchers to engage the wind tunnels from their offices.

The new wind tunnel under construction is notable in several respects. It was designed from the inside out -- that is, the model support turntable (in fact, a pair of concentric turntables with massive anti-vibration foundations, Figure), the traversing mechanism (placement tolerances less than 0.1mm) and roughening element disposition (arrays of retractable aluminum blades which penetrate the floor of the tunnel, Figure) were designed before the tunnel itself. Also novel is the blow-down rather than draw-down fan arrangement which provides overpressure within the tunnel, making openings for roughening elements, etc., much less critical in their effect on tunnel flows.

The test section dimensions of this tunnel are 1.5m x 2.0m, about the same as ours. It will be roughly 25m long. Air speeds to about 40 mph will be possible, driven by a large standard air conditioning squirrel-cage blower unit.

In recent years political/economic pressures have encouraged BRE to engage in private consultancy more actively. This work is now quite substantial and their approach might serve as an example for us. I have copies of their promotional brochures.

Technical Consultancy

Wind Engineering

Building materials manufacturers, architects, services and structural engineers all have to take into account the effects of wind action on buildings. How do buildings respond to the wind?

We provide a complete wind engineering service, based on our long experience, which is backed by wind tunnel and other test facilities. The service provides construction industry

clients with data and advice for design, so that optimum performance is obtained while taking account of both safety and economic considerations

**Building Research
Establishment**

Department of the
Environment

The Service

We provide a whole building service, one of a wide range of services available from BRE. We give a comprehensive analysis of loads, wind environment, ventilation or other aspects of wind engineering. Our wind engineering expertise has been developed by investigations of design situations using analyses based on many model-scale and full-scale research studies.

The scope of the data and advice that we can provide covers:

- wind loads on structures and building claddings
- wind velocities at sites
- wind environment around buildings
- ventilation characteristics of buildings
- positioning of HVAC plant and smoke vents
- performance of roofing and cladding.

How we work

Model scale (wind tunnel testing)

We measure wind pressures and velocities on and around model-scale buildings and structures using our two boundary layer wind tunnels, with their dedicated on-line computers. This type of measurement has two main advantages over full-scale studies: the time-scale in wind tunnel measurements makes it possible to acquire data up to 200 times faster; and, unlike in full-scale conditions, the wind can always be relied upon to blow! (Additionally, of course, the building need not yet exist.)

The natural wind can be simulated for environments ranging from open country to city centre at scales from 1:1000 to 1:100. The full range of model tests that we can carry out includes:

- measurement of surface wind pressures on building

models using miniature pressure transducers and remote-controlled pressure scanning switches

base bending moments

shear forces

wind loading spectra

structural response spectra using a variety of strain gauge and piezo electric force balances

wind velocities and turbulence intensities using hot-wire anemometers

air flow patterns using flow visualisation with video/film recording.

Full-scale studies

Full-scale investigations – We have undertaken studies of the effects of wind action using a wide variety of real buildings. The wind tunnels provide results quickly and cheaply. Full-scale investigations, however, not only provide immediate information, for example, to guide remedial action. They also extend our experience base and

therefore increase our confidence in the model-scale studies.

We carry out full-scale investigations to measure:

wind pressures on real buildings using new servo-controlled pressure transducers developed at BRE

characteristics of the natural wind environment to a height of 500 metres using mast-mounted and kite anemometers

ventilation/infiltration characteristics of real buildings using tracer gas measurements and pressurisation techniques.

BRERWULF – This is a pneumatic, computer-controlled test rig capable of reproducing the fluctuations of surface pressure caused by wind on buildings and building components. It was developed by BRE, and the name means BRE Realtime Wind Uniform Load Follower.

No. 1 London Bridge development. Top Wind tunnel model. Below Completed development.

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BREWERWOLF is used to investigate the mechanisms and load paths by which surface pressures are transferred through to structural members. It is especially useful for assessing the resistance to the wind of modern forms of multi-layer cladding systems or roofing materials, since it can follow any input trace so that the pressures induced by major storms or hurricanes can be reproduced on the cladding or roofing material. It has been designed to apply pressure or suction in the range of plus or minus 8.5 kPa, and has been successfully used for realistic proof testing of prototype cladding and roofing systems. It can also be used for certification procedures and for 'forensic' investigation of wind-damaged buildings.

Mobile laboratory – A four-wheel-drive mobile laboratory is available for fieldwork in isolated terrain. It is completely self-contained, with an

independent power supply, and can log up to 36 channels of pressure or velocity data using on-board amplifiers, filters and a data-acquisition computer.

Nationwide wind damage survey

We back up our commercial work with an annual survey of wind damage in the UK. Wind damage statistics are compiled according to type and severity, class of building or structure damaged, geographical location, and occurrences of death or injury to people caused by direct or indirect wind action.

Ventilation (measurement and prediction)

In addition to measuring pressure coefficients in order to characterise building ventilation/infiltration performance, we undertake complementary ventilation/air movement studies using tracer gas analysis and pressurisation techniques. Predictive software tools are also

BREFAN large building pressurisation equipment.

used, which have been developed from our measurement experience.

A novel and impressive facility in this area is BREFAN, a 'pressurisation' rig that has been designed to carry out whole building envelope leakage tests on most office-type buildings. The rig consists of three large fans – each capable of delivering up to 5.5 cubic metres of air per second against a building envelope pressure difference of 50 Pa – the conventional target for test purposes. (The fans can be used in combination or singly to reach the target pressure.) Results from these tests can be used as a diagnostic tool for measuring the air-tightness in buildings.

Air flow visualisation in wind tunnels

The use of smoke and other visualisation techniques enables us to enhance quantitative air velocity data with visualised air flow patterns around buildings. Such techniques can be used, for example, to assess new high-rise development for induced wind problems, or to analyse the risk of inlet/outlet 'interference' of mechanical air handling plant.

Site wind speed and loading predictions

Many wind engineering problems can be solved by consulting BRE's extensive archive of data. We have a comprehensive archive of UK and Overseas Standards, Codes and meteorological data; we can make accurate predictions of design wind speeds using our own STRONGBLOW computer package; and we also have a program for assessing wind flow over complex topography.

BRE full-scale and model-scale studies have naturally amassed a vast amount of design loading data over the years, for a wide range of building shapes. We have collated all this information and supplemented it with data from other research establishments and published sources, so that we can now provide a unique resource on which to base our design advice.

Such a database enables us to make initial estimates quickly and cheaply at the conceptual design stage. This stage can be augmented by later model tests, but is often sufficient in itself to complete the design assessment.

BREWERWOLF dynamic wind loading test rig.

Recent projects

On the right is just a small selection of the many model- and full-scale investigations carried out at BRE.

Full-scale

Telecom Tower, London
Low-rise buildings, Aylesbury
Flow Over Hills Experiment, Askervein
Office buildings at TRRL & BRE
School building in Hampshire

Model-scale

River Hull Tidal Surge Barrier, Kingston upon Hull
Murrayfield Grandstands, Edinburgh
Ibrox Grandstands
Changi Aircraft Hangar, Singapore
No. 1 London Bridge, London

Princess of Wales Greenhouse and Palm House, Kew Gardens
Al-Shaheed Monument & Museum, Baghdad
Vauxhall Cross Office Development
British Library, Euston Road
Gloucester Road Office Development

Central Telegraphic Office.

Left Completed building.

Right Model undergoing wind environment tests.

Current projects

To develop our expertise even further, we are continuing research at model scale into surface wind pressures on buildings in scale simulations of the atmospheric boundary layer. The accurate measurements of wind loads and the environmental wind around buildings obtained from this work are being used to update and supplement our wind engineering advice, together with existing data in the BS Wind Loading Code of Practice, BS Ventilation Principles and Designing for Natural Ventilation Code of Practice and CIBSE Guide A4 (Air Infiltration).

We are also studying the dynamic response characteristics of high-rise structures and the associated wind loading and response spectra. Aero-elastic models tested in the wind tunnel will be

calibrated against theoretical models and prototype data from real structures. This work will result in a better understanding of the behaviour of actual structures and an improved basis for our advice on design.

We continue to improve existing techniques and develop new methods for measuring ventilation air flows in large and multi-celled buildings such as offices. We are also seeking to improve our prediction methods by drawing on the combination of wind tunnel model-scale studies and full-scale measurements, in order to develop and refine computer software tools.

And now ... your project

You could benefit from our experience by contacting us at the address and phone number given below. Our experts will be able to discuss your wind engineering problems with you, where necessary referring to design drawings. They can give you an early opinion on the likely structural or environmental implications, and suggest what investigations are necessary to provide specific data. Once you have agreed what testing you would like carried out, we will quickly produce a quotation.

Contact:
BRE Technical Consultancy
Building Research
Establishment
Garston
Watford
WD2 7JR
Telephone: (0923) 664800
Telex: 923220
Fax: (0923) 664010

The Building Research Establishment is the main organisation in the United Kingdom carrying out research into building and construction and the prevention and control of fire. With over 60 years of experience, it has built a worldwide reputation for independent, authoritative research and advice. Staffed by experts who are leaders in their fields, BRE has many specialised technical facilities, some indeed unique, and provides services to Government, the construction industry and its clients, and product suppliers. With its international links and breadth of experience, BRE is where construction professionals themselves turn for advice.

Technical Consultancy

Environmental Systems — Wind Environment, Ventilation and Infiltration

BRE environmental wind tunnel.

Ventilation is a key factor in the environmental performance of a building. Poor or inadequate ventilation may lead to stuffiness and overheating, lethargy of occupants or general discomfort. And poor ventilation has been mooted as one of the significant influences in the so-called sick building syndrome. But excessive ventilation or uncontrolled infiltration through, for example, poorly fitting

windows, can result in draughts, uncomfortably cold temperatures and significantly higher energy bills.

Difficulties in measuring ventilation and wind environment characteristics of large non-domestic buildings have meant that relatively little objective data exists to assist the designer or building owner/tenant. BRE has had considerable experience of studying the

mechanisms of natural ventilation and wind environment. It is well placed to provide design advice for new buildings, as well as to employ a range of measurement techniques to assess existing building performance and to provide guidance on remedial measures.

**Building Research
Establishment**

Department
of the Environment

BRE's Consultancy Service

Our service is tailored to solve individual problems at minimum cost:

Some problems can be dealt with by a simple telephone call or by giving a reference to a BRE publication.

Many more can be handled by a desk study using standard data for typical building types and weather.

More complex problems may require extensive laboratory wind tunnel or site measurements followed by analysis and recommendations.

Evaluations can be at the design stage (from sketch plan to final drawings) during commissioning or during the lifetime of the building when problems become apparent.

BRE's Technical Facilities

BRE has an extensive range of technical facilities to support its consultancy service.

The Environmental Boundary Layer Wind Tunnel is a major BRE facility used to study wind environment and ventilation characteristics. Utilising model scale buildings, wind pressures and velocities are measured using dedicated on-line computers. These control the various transducers and sensors and record the output. Analysis of the data provides information on the local wind climate for pedestrian comfort and safety, particularly in the vicinity of high-rise buildings. It also provides pressure coefficients, which are used in predicting ventilation rates.

Ventilation rates can also be predicted by using BRE computer software — BREEZE and BREVENT — developed from both our theoretical understanding of the physical processes involved with ventilation and infiltration, and feedback from our measurement experience.

Direct measurement of ventilation characteristics can be made in existing buildings using:

BREFAN — a facility unique to BRE, is used to 'pressurise' a large building to obtain a measure of the overall leakiness of its envelope.

Tracer gas methods including BRESIM — which enable more detailed analysis of air movement and ventilation mechanisms.

The results can be used in such cases as identifying refurbishment opportunities, or indicating the need for mechanical plant to ventilate complex inner spaces.

Making Contact

For further information on this, or any other matter, please contact:

BREFAN large building pressurisation equipment for measurement of ventilation characteristics.

Gas chromatograph, used to analyse tracer gas concentrations at very low levels, ie parts per billion.

BRE Technical Consultancy
Building Research
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Garston
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British Telecom building in central London. Design evaluated at BRE for wind environment and mechanical ventilation intake/exhaust locations.

**EEIH
Center for Housing Innovation
University of Oregon**

TRIP REPORT FORM [jf 90 - 1]

Date of Report: 3/5/90

Place Visited: TERRA VISTA, a developer project in Rancho Cucamonga, California developed by Ralph Lewis and Company of Upland, California. Side visits were made to a number of other projects in the immediate vicinity of Terra Vista.

Dates of Visit: 2/16/90

Attending: J. Finrow

Purpose of Visit: To investigate construction processes used by on site production builders in Southern California

Visit Report: Terra Vista is a new development that is being built by Ralph Lewis and company, a recent winner of the prestigious Builder of the Year award from the National Association of Home Builders. The project includes several hundred housing units and also has on site commercial and office facilities which apparently is the new trend in suburban Los Angeles development projects. Conventional stick frame construction techniques are used in building the houses. Apparently reasonably skilled and inexpensive labor is readily available in the area. There seems to be little incentive in developing any industrialization techniques given the labor situation. Upon inspection, the quality of construction is very mediocre. Lumber used in the project is "site dried" and a good deal of twisting and bending was observed. It was clear from this experience that until there is reason to market on consistent quality rather than quantity little improvement (and industrialization) will be forthcoming in this market.

Supporting Documentation: Slides and brochures of the project were compiled by J. Finrow.

TRIP REPORT

TITLE: Hooke Park College for Advanced Manufacturing in Wood

DATE: April 19, 1990

LOCATION: Beaminster, Dorset, England

ATTENDING: Rudy Berg

PURPOSE: Visit facilities, discuss research

SUPPORTING DOCUMENTS: Photos, brochures, *PA* article

"Hooke Park College opened in March 1989 to offer integrated training in Design, Product Manufacture and Enterprise Development in the context of the managed woodland. The College's objectives are:

- to generate new manufacturing businesses using indigenous timber in the production of quality products.
- to develop design and business talents, manufacturing systems and industries which benefit the natural environment.
- to co-ordinate research leading to improved ways of using timber, reducing waste and increasing value.
- to reduce pressure on the world's diminishing forests by demonstrating how improved management stimulates the growth of renewable resources."

Hooke Park College offers reasons for our interest besides these objectives. Its buildings, which reflect the aims outlined above, are innovative and architecturally interesting, and its circumstances -- responding to environmental issues and economic pressures of a changing timber resource -- are something like our own here at CHI.

The College was set up by the Parnham Trust, an entity established under the direction of British furniture maker John Makepeace to administer the Parnham House estate where he works and teaches, and which serves as a showcase of both skillful building restoration and world-class contemporary woodworking. In 1982 Makepeace was in effect "given a forest" of commercially useless small trees a few miles from Parnham. This forest now serves as campus, forestry experiment, and woodlot for the dozen full-time students who live and work for two years at Hooke Park.

Training there covers three basic areas: the first includes design, business skills, technology of materials and production, and marketing and promotion; the second covers development of new processes and product prototypes; and the third aims at bringing promising new ideas into production, and incorporates computer integrated

woodworking machinery and linked CAD/CAM operating stations. In addition Hooke Park offers short courses in related areas.

In the current start-up phase these courses are receiving economic support from national and regional governmental agencies. Understandably the prospect of creating a new set of industries based on an underused resource is appealing. The fact that this enterprise also aligns with the rising Green sentiment in Britain makes it doubly attractive.

The buildings at Hooke Park reflect the rustic/sophisticated duality of the College's approach. A large workshop/office is framed with arches made of spliced poles, roundwood purlins, and a high-tech insulated fabric skin. A second building, ultimately destined to become a dormitory, is a rather tentlike structure employing poles in tension and compression, specially detailed to permit use of green wood. Again, it uses a sophisticated fabric skin. These buildings were designed by the London firm of Ahrends Burton and Koralek, with Frei Otto as consulting architect and Buro Happold as structural and services engineer.

Equally high-tech is the joinery employed in some parts of these structures: steel fittings are glued into tapered holes in the green poles with an epoxy-sawdust mix. The environmental questions involved in the use of such toxic ingredients (as well as the plastic building skins) are glaring ones. Since these are experimental structures, however, it seems likely that subsequent refinements will have a "greener" aspect.

Certainly Hooke Park College offers an interesting experiment at several levels -- in student-developed wood products, in the innovative campus buildings, and in the pioneering approach of the College itself.

Who may apply:

Student intake on the main course is restricted to 12 per year. Applicants should possess a degree or practical training/experience relevant to the course. Selection is based on evaluation of education, experience, aptitude and a panel interview. Apart from assessing students' capabilities, they must have to be satisfied that applicants possess the necessary drive and initiative to so benefit from the course that they become entrepreneurs.

Presence of a high level of motivation is crucial.

Further Information

The Administrator
Hooke Park College
Breaminster
Dorset DT8 3PH
Telephone: 0908 863130

Directions

HOOKE PARK COLLEGE

Interior - Hooke Park College

Founded by the Pannhau Trust, the College offers an integrated training in Design, Product Manufacture & Enterprise Development. Graduates develop a combination of skills needed to run manufacturing businesses in rural areas using indigenous timber in the production of quality products ... The first group of students started their training at Easter 1989.

Objectives

- 1) generate new manufacturing business using indigenous timber, the production of quality products.
- 2) develop design and business talents manufacturing systems and industries which benefit the natural environment.
- 3) co-ordinate research leading to improved ways of using timber, reducing waste and increasing value.
- 4) reduce pressure on the forests in improving forests by demonstrating improved management.
- 5) imitates the growth of renewable sources.

Kiln-dried

Coppice chair

Courses

A two year full-time course offers an integrated programme of study of:

The Resource

- Design.
- Product Development
- Production.

Computer-Integrated Manufacture

- Enterprise Development.

Short courses of up to six weeks duration drawn from the main programme provide material for those wishing to strengthen personal resources in specific areas.

Grants & Fees

The next two-year course begins in January 1991. Fee details and application forms on request. Students may compete for Scholarship funding but are urged to seek their own Sponsorship.

The Training Centres

The main training facilities are housed in a three vaulted building of innovative design.

The Design & Business Centre
For the study of Design & Business Skills, the technology of materials and production, Business Management, Marketing & Promotion.

The Prototype Development Workshop
In this experimental workshop, new processes and products will be developed to the prototype stage.

The Production Workshop
A flexible manufacturing centre for training and production.

The training facilities include equipment for primary processing which will be shared by the manufacturing unit, computer integrated woodworking machinery & machine tools and linked CAD/CAM operating stations. The prototype 'house of trees' serves as a study centre.

1

HOOKE PARK COLLEGE - THE TRAINING CENTRE

You are now on the Visitors' Gallery of the unique Training Centre which has been constructed in three vaulted arches.

Take a Norwegian Spruce tree 16 metres high. Saw it down, debark and preservative treat it and here is a building component which is cheap, available and grown in the UK.

As a gardener would thin a vegetable patch and throw the thinnings onto the compost heap, so the forester thins woodlands.

QUESTION?: What does the forester do with thinnings?

ANSWER: The usual thing to do is to sell them to firewood merchants, having cut them into cordwood lengths, sell them for fencing posts or to a chipboard manufacturer - all low value outlets.

RESULT: This means that woodland management shows very poor returns for the capital and manpower investment which in turn means that little money is available to re-invest in order to improve the quality of woodlands and the final crop, mature timber.

ALTERNATIVE ANSWER: Use thinnings for other things such as building materials, furniture and woodware which sell at a higher price.

RESULT: Home-grown thinnings being made into articles instead of most of it being burnt, more income to the forester/owner, new businesses making home-grown products from home-grown timber.

So, why hasn't anything been done before about our vast supplies of forest thinnings? The usual answer is that it isn't worth the trouble, the technology is untried, British timber is rubbish, we've got plenty of timber in the world so let's do on importing 90% of our timber and timber products.

That does not make any economic or environmental sense. This is where THE PARNHAM TRUST comes in. Back in 1982 the Trust bought Hooke Park to establish Hooke Park College to train people how to use roundwood for profitable products as well as looking after the environment and providing a pleasant woodland in which to walk.

The Trust is proving the fundamental point that roundwood CAN BE USED AS A BUILDING MATERIAL and products are now being made by our budding student/entrepreneurs. Roundwood thinnings are easy to fix and work with, yet till now their structural potential has largely been neglected.

What better demonstration can we have that IDEAS and VISION are what we need to generate better woodlands, superior timber and new businesses and products.

Project: School for New Woodland Industries, Hooke Park, Dorset, England.

Architects: Ahrends Burton & Koralek with Frei Otto as consulting architect and Buro Happold as structural and services engineer. This building is the first of several structures for a School for New Woodland Industries, which will train people in the design, manufacture, and marketing of new products using an otherwise wasted resource: forest thinnings. Intended as a demonstration in the use of the round, unsawn timbers, this building will serve as a residence for the school.

The structure contains four timber A-frames that are supported by diagonal bracing and

that support tensioning ridge cables. These A-frames run through the center of the building, defining a corridor, and are connected by horizontal members to outwardly cantilevered timbers that frame the outside walls. All timber connections are made with steel rods adhered with epoxy.

The roof structure utilizes slender spruce timbers that bend under the dead and live loads. These unsawn rafters rest on curve timbers (with softwood packing used for leveling) and are clipped to the ridge cables that are hung between the A-frames. Sawn boards bridge between these timbers to support the rock fiber insulation and roof membrane.

The forest thinnings were used

green, so the design had to accommodate the shrinkage that would occur as the wood dried. The tension roof, for example, not only reduced the amount of timber necessary to carry the load, but easily adjusted to shrinkage of the rafters themselves. During construction, the rafters were pre-stressed to the ultimate curvature of the completed roof by being tied down to the floor structure.

In some ways, this project brings George Washington Snow's invention of the balloon frame full circle. While he developed stud construction because heavy timbers had become too costly and rare in Chicago in 1832, this project uses heavy timber construction because such material, left over

from the thinning of forests, is all too common and worth almost nothing on the market. Snow also changed our view of wood as an engineered material. Having been successfully applied to sawn lumber, that idea is here applied to the very material that prompted Snow's discovery in the first place.

FLORIDA SOLAR ENERGY CENTER

300 State Road 401, Cape Canaveral, Florida 32920-4099, Telephone: (407) 783-0300
Fax: (407) 783-2571

State University System of Florida

MEMORANDUM

Date: October 15, 1990

To: Dave Block
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From: Subrato Chandra *Subrato Chandra*

Subject: Trip Report : Future Buildings Forum (FBF) - 2025
Den Haag, Netherlands, October 3-4, 1990

This is a new International Energy Agency (IEA) activity initiated by Jim Smith when he was at DOE. The function of the FBF is to advise the IEA executive committee (exco) on energy conservation in buildings on pertinent long term issues facing 21st century buildings.

This first meeting of the FBF was attended by about 20 people. Canada - 2, Commission of European Communities - 1, Denmark - 3, Finland - 1, France - 2, Netherlands - 3, Sweden - 2, Switzerland - 1, United Kingdom - 3, USA - 4 (Ton Boorsboom, John Rivera, Jack Warner and myself). The meeting was chaired by Mark Zimmerman of Switzerland in Jim Smith's absence. John Rivera served as secretary.

The first day we talked about issues which were important to us. The next day we first voted on the 17 issues we had identified to narrow the list down to six. Next we broke up in four small groups to sharpen the issues and present action items. The final issues (also called subtasks) and subtask leaders were:

1. Interface protocols for advanced heating and cooling equipment - Mark Zimmerman
2. Innovative Cooling Techniques - Subrato Chandra
3. Building Envelopes as Energy Management Systems - ?

4. Buildings for sustainable built environment - Steve Irving UK
5. Efficient use of Electricity - Andre Regef, France
6. Interactive approach to low energy buildings - Ivar Moltke Denmark.
Note: This is very similar to our IH project.

Please see attached for a typical subtask write up.

At the end we talked about future plans. It was decided to create a FBF steering committee composed of the FBF chair, EC rep, AIVC center rep (as they have been already funded at a low level to create a database for FBF) and the subtask leaders. The next actions were for Ole Jensen of Sweden to present the results of this meeting to the IEA solar exco in october and for Mark Zimmerman to present it to the IEA energy conservation in buildings exco in November in Tokyo. If approved, then FBF activities are likely to continue. Funding is a big uncertainty. The FBF steering committee may want to meet again in March or April of 1991. I volunteered FSEC as a possible meeting place.

One of the best aspects of the meeting was to meet international colleagues with a similar interest. Of special note is Asko Sarja of Finland, Director of Structural Engineering Lab at VTT (their national lab). He has done some impressive work on industrialized building systems for multifamily/commercial buildings.

Please let me know if any of you would like any further information.

SUBTASK 2

TITLE - INNOVATIVE COOLING TECHNIQUES

AIM - Mitigate cooling needs in 21st century buildings through initiatives to develop innovative low energy techniques.

ISSUES:

1. Avoiding cooling loads
2. Integration with passive cooling (esp. in humid climates)
3. Developing building materials and machines to minimize the impact on peak electrical utility loads
4. developing higher COP air conditioners with increased comfort
 - Integrated CLG/HTG systems, possibly ground coupled
 - Heat pipe assisted systems
5. Developing solar passive/hybrid systems
 - Ground coupled
 - Solar regenerated desiccant
 - Night sky/evaporative cooling

FBF TASKS

Conduct workshop to:

- a) Present state-of-the-art
- b) Provide directions for developing new initiatives, e.g., new annex.

END

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