Project White Paper

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Critical National Need Idea Title:
Energy-Saving Smart Area Heating Concept

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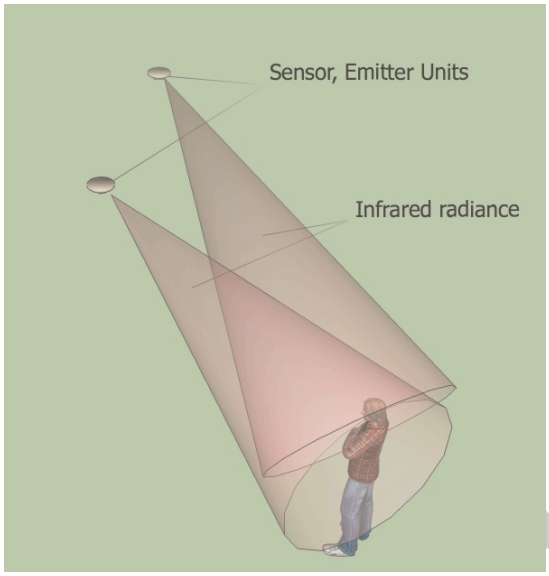
Critical National Need

Space heating accounts for 30-50% of the energy consumed by a typical home. Most of this energy is spent heating the air in a room, which, in turn, warms the enclosing walls, floor, and ceiling as well as solid objects in the room. Human occupants are warmed primarily by the warmed air and by contacting these heated structures, for example, when they sit in a chair. This traditional approach to room heating consumes great amounts of energy to maintain the whole environment at a temperature at which human occupants feel comfortably warm, regardless of whether or not anyone is present in the space!

According to the U.S. Department of Energy's Energy Information Administration data, of approximately 108 million homes using space heating, more than 54% have 1000 or more square feet of living space. Also, more than 64% of U.S. homes have only one or two occupants, and, of course, at any given time there may be no one at home. Heating this volume of space represents a staggering waste of (usually) non-renewable energy and money.

Although several of the technologies needed to successfully develop a smart area heating system already exist, they must be integrated and adapted to form an affordable solution for a typical homeowner or commercial building manager to implement. We propose an alternative approach embodying a *smart area heating concept* in which radiative infrared (IR) heating is directed selectively and dynamically toward building occupants by using a network of inexpensive sensors that are installed in the periphery of the room (see figure below). The sensor system will use a combination of pyroelectric infrared (PIR) motion detectors and digital camera modules to identify and locate the presence of human occupants using face recognition software. Radiative IR emitters will then direct heat to the occupants and the space around them. For outdoor use, the IR emitters could use a variety of energy sources including propane or other fossil fuels or biofuels.



The area of steerable IR emitters will require significant development. To be practical, the emitter technology must be affordable and safe to operate, and it should have a minimum of moving parts. Technologies exist for the controlled projection of visible light, but this program will require significantly more energy to be directed and at much longer wavelengths.

Societal Challenge

As we move to more renewable energy sources such as solar and wind, it will become critically obvious that we can no longer afford to waste energy as we could when fossil fuels were inexpensive to produce. In the past we have had movements to turn down thermostats to conserve energy, but these have been only marginally successful because many people simply do not want to be uncomfortable. The same problem extends to commercial building space. Other conservation strategies such as weatherizing and insulation are attempts to reduce waste while maintaining the same interior temperature levels. The proposed technology offers a new approach to maintaining individual comfort while significantly reducing building interior temperatures and energy waste.

Transformational Result

The smart area heating concept offers significant energy- and cost-savings and can enhance human comfort in multiple ways. Transformational benefits include:

- Use of energy only *when* needed. No directed heating is applied unless there is an occupant in the room. The system otherwise maintains the temperature of the room at a value that is lower than what would normally have to be maintained using a conventional heating system.
- Use of energy only *where* needed. Directed heating is not aimed at the entire room and its contents, only at the region in the immediate vicinity of the occupant. The sensing system detects the temperature difference between the occupant and the local area in which he/she is residing, for example, next to a cool window, to direct more energy to that area in order to maintain comfort.
- Fast, "personalized" heating. Room occupants immediately have a sensation of warmth, similar to that felt when stepping into sunlight. The "personalized" heating effect can be enhanced by wearing IR-absorbing fabrics to further increase efficiency, which can lead eventually to a high-value aftermarket for specialized clothing.
- Easy installation. The lightweight IR emitter arrays and sensor network present simple installation in comparison to traditional heating systems that rely on heavy ducts or piping that must be interconnected with the central heating unit. All required interconnections are electrical and easily routed. The sensor components can use wireless technology for communication. The radiant emitter arrays and associated reflector systems can be installed in the ceiling or other areas of the room behind decorative transmitting panels that harmonize with a room's décor. The proposed system architecture lends itself well to retrofitting applications as well as new construction.
- Indoor-outdoor use. This system could be deployed in homes and commercial buildings as well as in tents, aircraft hangars, and even outdoor

areas such as motor pools and other large areas typically considered un-heatable.

- Assembly from readily available components. Many of the required system components (motion detectors, cameras, solid-state temperature sensors) are already commercially available and can be readily assimilated into a heating system that is driven by a central computer. The central computer can serve an entire facility and manage other climate control systems such as A/C and ventilation.
- Additional benefits. The technology could easily be expanded to include management of room lighting and entertainment systems based on occupancy. With the addition of simple wirelessly controlled power-strip type devices, other devices could be automatically switched off when the room is empty. This occupancy count could also be interfaced to alarm systems so that in the event of an emergency such as a fire it would be possible to know which parts of a building were last occupied.

Proposed Solution

Successful space heating systems have historically been one of two types or a combination of the two. The earliest forms were simple open fires and later semi-enclosed fires in an open hearth. This form of heating is essentially an undirected form of IR radiant heating. Of course an open flame is not an energy-efficient way to create IR radiant heat, as the heated combustion products are generally wasted as exhaust. The development of the enclosed wood stove provided a leap in efficiency as more of the combustion heat could be converted to IR by the metal of the stove and exhaust piping. Efficiency is still weak, however, as the radiant heat is not directed, thus a large part of the available energy goes to heating the floor, walls, and ceiling of the space rather than being focused on the occupants.

Indirect heating of air is a relatively recent improvement but is limited by the difficulty of providing zoned temperature management and the overall waste of heating large, unoccupied volumes of space.

Previous attempts to use non-combustion-driven IR radiant heating have met with limited success. Ceiling mounted electric radiant heat systems developed in the 1950s were an attempt to heat the people rather than the room, but their undirected radiance was expensive to operate and was not adaptive to room occupancy. Interestingly, society seems to be trending toward a combination air–IR heating solution as evidenced by the increased popularity of plug-in heaters and wood stoves to augment traditional home heating systems.

Brewer Science proposes to design, build, and integrate available and custom-manufactured components to create a smart room heating demonstration unit and then evaluate the energy efficiencies and human comfort levels achieved under different operating conditions in comparison to a conventionally heated structure. Successful demonstration will be followed by implementation into residential and commercial test facilities as a means to disseminate the technology. We expect that commercial opportunities will eventually exist in component manufacturing (IR emitters, sensors, low-power wireless networks, computer controls, software) and sales, installation, and service of smart room heating systems.

Entities That May Be Interested in Funding the Proposed Solution(s)

Several U.S. Government agencies would benefit greatly from this new heating technology. The following agencies may be interested in funding the proposed solution(s):

- U.S. Department of Energy
- National Aeronautics and Space Administration

- U.S. Department of Defense
- Office of Naval Research
- DARPA

Reference

U.S. Department of Energy, *2005 Residential Energy Consumption Survey: Energy Consumption and Expenditures Tables*, Energy Information Administration, http://www.eia.doe.gov/emeu/recs/recs2005/c&e/spaceheating/pdf/tablesh6.pdf.