APPENDIX IV. PRODUCTION READINESS PLAN FOR RETROFITTING THERMAL DISTRIBUTION SYSTEMS IN COMMERCIAL BUILDINGS

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Production Readiness Plan for Retrofitting Thermal Distribution Systems in Large Commercial Buildings

The primary outcome from this project is the measured confirmation that duct leakage airflows can significantly increase fan energy consumption in large commercial buildings. In addition, we have defined a new metric for distribution system efficiency, demonstrated a reliable test for determining duct leakage, and developed new techniques for duct sealing. The parallel story in the residential and small commercial sector has shown that from the comparable stage in that research to maturity of technology adoption (e.g., commercialization and inclusion in standards) was approximately ten years. We conclude that a concerted effort will be necessary in order to make the same—or better—progress for the large commercial building sector.

Market transfer work to date:

- **Codes and Standards**. California's Title 24 currently has no performance criteria for thermal distribution systems in large commercial buildings. We have identified a metric for characterizing distribution system efficiency that the Title 24 compliance process should include for all new large commercial buildings. Once we have a good understanding of the range of distribution system efficiencies, we could then set guidelines for minimum acceptable levels.
- **CA Public Sector**. University of California staff is already asking for the development of duct tightness criteria for the new buildings at UC Merced. They are also interested in the measurement and verification procedures to ensure that these criteria have been met. These criteria could be adopted for new construction at University of California and California State University campuses throughout the state.
- **PIER-related activity**. Taylor Engineering, Eley Associates, and the Center for the Built Environment at UC Berkeley have all come on board this project as interested co-participants. The work at the test building in Sacramento has been a fertile testbed for several groups interested in sharing our monitoring capabilities to do unique measurements of HVAC systems in commercial buildings.
- **Synergistic funding with US DOE**. This project has benefited from over $400k of support from the Building Technologies office at the U.S. Department of Energy. DOE plans to continue supporting work in this area, including continued efforts at the test building in Sacramento to further assess duct leakage diagnostics, as well as measurements of duct leakage at different sites.
- **Work with the building services sector**. The engineering staff at the public building where we did the fieldwork for this study has been very interested and supportive of our work. They plan to use the findings from this study to better operate their showcase building.

In addition to the market transfer work identified above, there is one specific aspect of the study that has large commercialization potential: the aerosol sealing technology. We are currently negotiating a license agreement with a major commercial HVAC manufacturer for the use of the aerosol sealant in large commercial buildings. However, there are some development tasks that may be appropriate for the public sector to pursue, given the lack of R&D that is currently done in the building's sector. Once this work is done, we expect the private sector to fully commercialize this technology. The steps needed for its commercialization are as follows:

1. **Documentation of health and safety performance for the aerosol sealant**. UL has tested and approved the aerosol sealant for safety (e.g., fire, smoke) and there has been a

preliminary review of the literature for possible health effects from the sealant material. A more extensive health review is planned, but not currently funded. Without this documentation of the health impacts, there may be reluctance on the part of building owners and managers to use the aerosol technology. Our attempt to demonstrate aerosol-sealing technology developed in this project encountered such a barrier.

2. **Characterization of the energy savings potential of existing buildings**. Very few buildings have had their distribution systems fully characterized. We know the potential savings from computer simulations, but these models have been based on assumptions of leakage amount and distribution. There is a need for measuring a sample of large commercial buildings to determine the actual range of leakage distributions. The U.S. Department of Energy currently plans to fund this work in 2003.
3. **Demonstration of aerosol sealing in a sample of commercial buildings**. The aerosol sealant has been demonstrated in residential and small commercial buildings. This project has led to further development of the equipment suitable for testing in large commercial buildings. The next step is to demonstrate the performance in a sample of commercial buildings.
4. **Transfer to private sector**. The University of California currently holds the patents for the aerosol sealing technology. If private interests license the technology, they will then carry out the necessary training of contractors and production of equipment to reach the market.

Our recommendations for future work are as follows:

Recommendation #1: Further develop the test method for determining leakage airflows in large commercial duct systems and submit it for adoption to ASTM (e.g., "Test standard for determining duct leakage flow in large commercial building systems").

Recommendation #2: Work with California's Title 24 staff to introduce a requirement for quantifying and reporting the "overall efficiency of the distribution system" metric for new large commercial buildings. Once we have a good understanding of the range of duct system efficiencies from reported data, we could then use these data to set guidelines for minimum acceptable levels.

Recommendation #3: Develop specifications for maximum allowable duct leakage airflows and for duct sealing in new construction.

Recommendation #4: Continue collaborative work with the U.S. Department of Energy, University of California, private sector (e.g., Carrier, Eley Associates, Taylor Engineering) to transfer information to the building industry.

Recommendation #5: Evaluate the performance of the thermal distribution system at the demonstration building over a heating season, with and without the added duct leakage. The investment of time and equipment at the demonstration building makes it worthwhile to continue monitoring the system in order to look at energy savings over the year.

Recommendation #6: Survey additional sites to start a database of duct leakage characteristics in large commercial buildings. This work is currently planned with funding from the U.S. Department of Energy and would benefit from co-funding by the CEC.

The final Project Advisory Committee meeting in November 2002 also generated 11 recommendations for further work. These recommendations are in the form of desired outcomes

for improving thermal distribution systems in large commercial buildings, both new and existing, by 2010. Many of these outcomes reflect our recommendations, but they also represent a broader scope. The desired outcomes are as follows:

A. Stock Characterization and Energy Savings Potential

1. *Stock Characterization*. An assessment of thermal distribution systems in the large commercial building stock (e.g., magnitude and location of leakage airflows).
2. *Current Practice*. Characterization of existing practices for duct installation.
3. *Energy Impacts*. An expanded understanding of the energy impacts of thermal distribution system characteristics (e.g., impacts related to duct leakage and thermal conduction) and a ranking of the issues that warrant further study.

B. Design and Construction

1. *Design Guides*. Duct design and construction guidelines that focus on the most important issues in terms of their impacts on energy performance.
2. *Simulation Tools*. Mainstream simulation programs that can be used as design tools to predict distribution system performance.
3. *Technology Adoption*. Use of low-leakage duct components and joints, which will reduce or eliminate the need for widespread duct leakage testing.
4. *Specifications*. Specifications for achieving tight ducts within the normal building delivery process.
5. *Design Intent Linkage*. Improved communications between design intent, field construction, and operation.

C. Codes and Standards

1. *Metrics*. Further development of proposed metrics for system characterization (i.e., expanded definitions of what each metric includes, and how each is determined or measured).
2. *Standards*. Defined standards for distribution system installation.
3. *Test Procedures*. A standard test procedure for flow hoods.

D. Operations & Maintenance, Diagnostics, and Commissioning

1. *Commissioning Toolkit*. A toolkit for commissioning ducts.
2. *Real-Time Diagnostics*. A diagnostic method for measuring the energy use of distribution systems during operation, so that building operators can detect and rectify deficiencies in space conditioning energy delivery.
3. *Information Transfer*. Dissemination of our current knowledge to the critical players.