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Governor

ATTACHMENT #15
ASSESSMENT OF PROJECT BENEFITS AND FUTURE INITIATIVES

PIER FINAL PROJECT REPORT

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Prepared By:
Gas Technology Institute

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Assessment of Project Benefits and Future Initiatives

Task 5.5 Report

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Task 5.5– Assessment of Project Benefits and Future Initiatives

Background

The "Energy Efficient Mold-Resistant Materials and Construction Practices for New California Homes" project www.gastechnology.org/moldresearch was a 30 month research and demonstration project sponsored by the California Energy Commission, with significant co-funding provided by Gas Research Institute and non-contractual market participants. The goals of the project were to: 1) identify, evaluate, and recommend cost-effective residential construction practices and building assemblies that resist mold growth in the presence of moisture, 2) publish guidelines on building materials and construction practices that prevent or mitigate moisture migration from external or internal sources, 3) provide a relational database linking water damage claims incidences, construction details, and climatic conditions, and 4) provide technical data on mold-resistant building materials and design options for use in revisions to California Title 24 residential building energy standards.

Gas Technology Institute (GTI) led a research team that included two top California builders, authors of California Title 24 provisions and compliance manuals, building scientists with expertise in mold and moisture control, and market analysts. GTI led the project, performed the laboratory investigations, and coordinated information dissemination. The Energy Resources Center at University of Illinois at Chicago (UIC-ERC) had primary responsibility for the situation analysis. Architectural Energy Corporation, Douglas Beaman Associates, Indoor Environmental Engineering, Mason-Grant Consulting, and Magus Consulting Services provided expert consulting and training services as appropriate to meet project needs. John Laing Homes Inland Division and Clarum Homes provided builder input throughout the project and performed field demonstrations of innovative building construction on seven new production homes.

A Project Advisory Committee (PAC) guided the team and provided feedback to the Commission. Several non-contractual participating manufacturers served as PAC members, provided engineering support to the project team, and supplied materials and training for the laboratory evaluations and demonstration homes. A network of building scientists provided additional engineering support and task report reviews as well as permission to incorporate other guidance and resources into this project. Participating utilities coordinated builder training sessions conducted at their training facilities, provided linkages to participating builders, and offered continued assistance beyond the contract period of performance to ensure continued use of key project results. All products and support by these non-contractual participants were provided at no cost to the project.

Technical outcomes resulting from this work included:

- Literature Review Summary
- Relational Database of Water Damage Incidences in California
- List of Baseline and Innovative Building Materials and Construction Practices
- Laboratory Evaluation of Mold and Moisture Resistance of Targeted Building Assemblies
- Technical Report on Relevant Title 24 Issues
- Seven Demonstration Homes Containing Innovative Assemblies and Techniques
- Demonstration Homes Summary Report
- Builder Training Materials and Sessions
- Builder's Guide on Mold Risk Reduction Strategies for New California Homes
- Dedicated Web Site and Associated Content

Anticipated market outcomes resulting from this work include:

- Revisions to residential construction manuals used by building professionals (near term)
- Improved residential construction practices resulting in higher quality homes (near to medium term)

- Future revisions to Title 24, ASTM, and ASHRAE standards incorporating project technical data as the basis for the revisions (long term)
- Enhanced understanding of mold and moisture transport and prevention for future research and applications (near to long term)

Several of the recommendations from the 3 major technical tasks in this project are being adopted by participating builders and manufacturers. Research conducted during this project also identified continuing research needs in several areas.

Goal

The goal of Task 5 Information Product Dissemination was to disseminate the information products developed during the course of the project to the target customers, including builders, contractors, trade associations, government regulatory agencies, researchers, and consumers. Information products included:

- Builder's Guide
- Builder's Training Session Materials
- Title 24 Technical Data Report
- Presentations to Stakeholder Groups and at Technical Society Meetings

The goals of Task 5.5 were to assess the benefits provided by this research project, and to provide a list of future opportunities and research recommendations. Project benefits should be quantified when appropriate and feasible. Also, the assessment should include a realistic discussion of factors influencing market penetration for research products. Future opportunities and research needs should focus on initiatives with potential value to California electric ratepayers.

Scope

Benefits assessment and discussion of future initiatives under Task 5.5 included the following tasks:

1. Formally assess the benefits of the project relative to initial expectations;
2. Gather all pertinent information generated during this project related to future opportunities and research needs.; and
3. Identify from this list those opportunities and research needs with potential value to California electric ratepayers.

Approach

Benefits and recommendations for future research were listed as each major task of the project was completed. Each task report includes specific recommendations on future research associated with the focus of the work conducted under that task.

Most of the work in this project focused on improving quality in new home construction. Benefits identified in task reports were primarily qualitative and tangentially linked to energy efficiency. Where possible, energy benefits were identified and estimated. Other non-energy benefits were listed, but no attempt was made to quantify them for California ratepayers.

During the period of November 2005 through February 2006, Magus Consulting and Douglas Beaman Associates conducted supplemental literature search and telephone interviews to identify sources of research data or databases with statistically valid data on the relative frequency and severity of different moisture problems in new and existing houses. In addition, various online searches supplemented this work by following up on interview leads, and identifying new sources for interviews. The purpose of this

activity was to verify prior observations in the Task 2 Literature Surveys and Interviews and throughout the course of the project regarding the lack of empirical data on root causes of moisture problems and links to energy efficiency, and to provide updated information on the need and focus of future initiatives that would provide benefits to California ratepayers.

Benefits Assessment

Benefits to California electric ratepayers that may accrue as a result of this project include qualitative and quantitative benefits in three different categories:

1. Improved Indoor Environmental Conditions
2. Cost Savings
3. Energy Efficiency

Participating builders have begun to incorporate into their production homes several strategies to reduce the risk of mold formation and growth based at least in part on recommendations in this project. Specific changes cited in feedback forms include:

- Self-adhering flashing
- Sill pans under windows
- Concrete slab seats under doors
- High performance vapor retarder
- Thicker slab instead of interior grade beams
- Low noise energy efficient bath exhaust fan/lights
- Mold resistant coatings on OSB and studs in selected areas
- Quality inspection service

Each of these strategies will improve indoor environmental conditions and reduce risk of building failures. A synergistic benefit of this focus on quality will be improved energy efficiency. Envelope details, especially around windows, are critical for as-built construction to perform as designed. While it is difficult to quantify the energy impact of these quality improvements, they are real and may be quite significant.

The research results of the Title 24 investigation in this project have illustrated an opportunity to increase the market impact of energy efficient air retarding wraps through future revisions to the standard that provide appropriate builder incentives. Builders liked housewraps, but consider them too expensive. They prefer the convenience and familiarity of two-ply building paper. Each incremental home constructed with improved air barrier performance would reduce overall home energy consumption by 2 percent or more according to compliance software calculations. Further encouragement to use field verification instead of default credits would also increase market impact of this credit.

Future Initiatives

HUD Report on Moisture and Durability

Despite widespread attention to and concern about building energy consumption, indoor air quality, moisture, and building system interactions, much of what is known about moisture-related problems is qualitative, conceptual or anecdotal. A "very high priority" research need was identified in an October 2004 report sponsored by U.S. Department of Housing and Urban Development (HUD) entitled “Building Moisture and Durability, Past, Present, and Future Work” and summarized in a HUD Report to Congress in April 2005 as follows:

"Building improved knowledge about the nature, extent, and implications of moisture problems in the U.S. housing stock is among the top research needs within the industry. Current knowledge regarding the extent and severity of mold problems is based on many individual sets of disparate data, which prevents a valid analysis of mold problems throughout the housing industry" [HUD 2005].

This need is reflected in the following HUD goal:

- Compile statistically valid data on the relative frequency and severity of different moisture problems in new and existing houses.

According to the HUD report, this goal reflects the frustrating lack of quantitative data on how common different types of moisture problems in housing actually are, or how they relate to design and occupant variables, age of house and geographic location. Examples include prevalence of leaks through roofs and walls; wet basements; standing water in crawl spaces; plumbing fixture overflows; oversized cooling equipment; condensation in building cavities or on slabs, and so forth. While the prevalence of these types of problems is in itself of considerable interest, this information also needs to be supplemented with reliable estimates of the economic and non-economic impacts of moisture problems [Newport Partners, LLC, 2004].

Additional goals identified in the HUD report that would help address this research need include:

- Perform an in-depth analysis of existing American Housing Survey data on moisture problems.
- Characterize the moisture performance of existing homes through a field testing protocol.
- Assess the drying performance of typical wall systems in U.S. climates and disseminate results.
- Develop educational tools to enable certification programs that recognize good moisture control practices.
- Develop statistically validated procedures to assess internal moisture loads for use in hygrothermal analyses and related engineering studies.

A clear, authoritative, quantitative picture would serve several important purposes. It would help to attract funding from many sources for R&D, and to prioritize this problem relative to others. It would also help funding sources to allocate their resources across different areas of potential study under the overall moisture heading.

Stakeholder Interviews

Mortgage Banking and Mortgage Insurance Industry

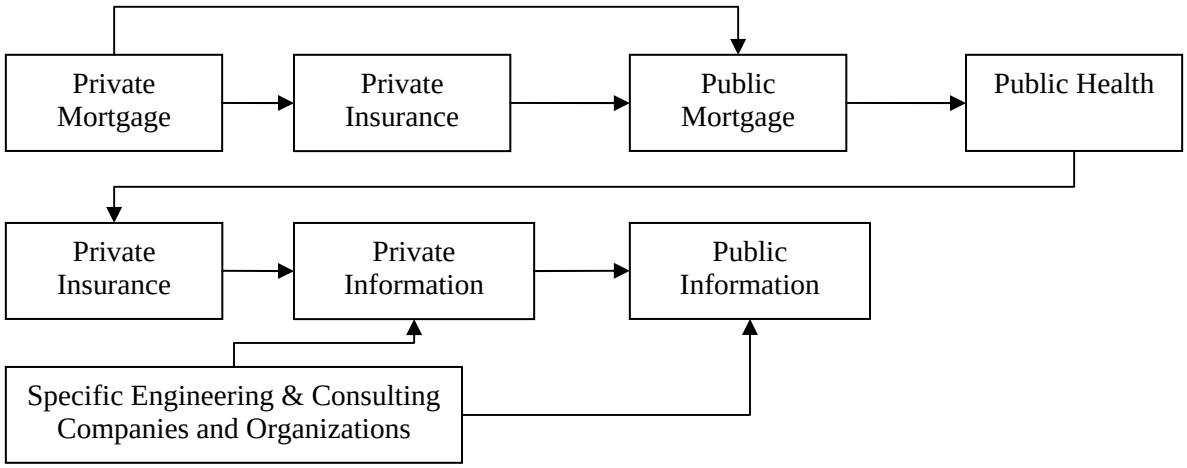
Initial inquires by Magus indicated possible databases with compiled field data related to mold and moisture. The interviews focused on financial stakeholders and private quality assurance organizations. Financial stakeholders interviewed included mortgage bankers, mortgage insurers, and regular insurance companies. Quality assurance organizations interviewed were West Coast Property Consultants, Pacific Properties/Quality Built, and Criterium Engineers.

The initial contacts made with these groups indicated a great deal of overlap in information presented. The inquiry approach was to contact one known or referred person and ask them for information about the existence of data on moisture/mold problems in residential housing. After gathering information—which for the most part was unsuccessful—contacts were then asked for a referral to someone who might have additional knowledge about this issue. Internet searches identified additional information about the existence of databases, as well as organization and agency contact information.

Common responses from the mortgage banking industry indicated a low level of concern with the issue. A lack of published data was noted in the mortgage insurance industry. One contact suggested looking in the public sector, i.e., Fannie Mae or Freddie Mac, since the likelihood of access to such information would be greater than it would be in the private sector.

Internet searches helped find contact information, which generally referred calls back to California state agencies for queries about California-specific research and databases. Despite a willingness to try to help by California state agencies like the Housing Finance Authority, Department of Housing and Community Development, Department of Health Services, Department of Public Health—with numerous internal and external referrals—the public trail also proved fruitless.

However, several of the contacts felt such information existed in the private insurance industry. This revealed a pattern of referral back and forth between private and public sectors, different types of organizations, and specific contacts. Overall, the information flow was as indicated below:



Private Insurance and Quality Assurance Organizations

Several contacts mentioned insurance data bases like "C.L.U.E" – the Comprehensive Loss Underwriting Exchange Property Database, developed by ChoicePoint (an information management company). Contact with insurance agents and ChoicePoint representatives lead to numerous other contacts in the field of information management (e.g., ISO, Acxiom Insights). Additionally, these sources provide leads for further internet searches.

ChoicePoint's C.L.U.E. database belongs to the insurance companies and individuals who supply the data, and information is not available to other entities. ISO also has a private database with mold-related information collected since 2003. The company representative noted that it does not contain the desired level of detail. Quality Assurance organizations noted that database information collected within their companies was proprietary and used for internal programs and services related to quality and training.

The findings of interviews—and online searches—essentially confirmed the inquiries and information gathered in Tasks 2 through 4 of this project:

Public domain databases on causes of mold problems in California residential construction do not exist.

This is true in terms of scope, accuracy, specificity, and availability to the public. There are proprietary sources of information in the insurance industry; small databases used for specific quality testing; and limited databases collected for brief periods by the information management industry. However, none of these fits the definition of the need identified by the HUD report.

California Energy Efficiency Program Linkages

Douglas Beaman Associates performed a data review and interviews with selected building scientists and Title 24 staff to identify available literature and reports that contained links between California residential energy consumption or building practices and moisture issues. This included a review of California building practices over time and any links between indoor air quality, energy standards, and moisture, as well as any unintended consequences of the Title 24 Residential Energy Standards on moisture issues within homes.

Predominant residential building practices over time in California are summarized below. The evolution in building practices from the 1940's to the present includes several changes in materials and construction practices related to installed cost, energy efficiency, location of construction, and composition of labor force. No published data linking any of these parameters to mold or moisture issues was identified.

California Residential Housing Stock Summary

Building Element	1940's	1950's	1960's	1970's	1980's	1990's	Current
Foundation	Raised Wood		Slab-on-Grade				
Exterior Siding	Mixed Wood & Stucco	Stucco					
Interior Wall Sheathing	Lath & Plaster / Button Board or Grip lath		1/2" Gyp Board				
Window Glazing	Single Pane				Dual Pane		Low-E
Window Frame	Wood		Aluminum			Vinyl	
Attic Insulation	None			R-19	R-30		R-38
Wall Insulation	None			R-11		R-13	
Floor/Slab Insulation	None			R-19/None			
Infiltration Control	None			Sealing required at plates, utility penetrations, around rough frame opening of doors & windows			
Location of Housing Starts	Urban	Homes are built in all areas of the state from the coast to the mountain, but the production homes typically are located on formerly agricultural land. Agricultural land ranges from former dairies, orchards, grazing land and other agriculture uses.					
Composition of Labor Force	Skilled/Union Workers			Slowly increasing use of immigrant labor force in many trades			

Notes: All dates are approximations due to varying rates of change in different geographic regions. The insulation values that are shown also vary by climatic region within the state. For instance dual pane glazing had much earlier market penetration in the mountain areas than the coastal areas.

First state-wide energy standards took effect in 1978 (16% single pane, R-19 attic, R-11 walls, R-19 floor)

State-wide energy standards increased significantly in 1983 (16% dual pane, R-30 attic, R-11 walls, R-19 floor)

The review identified a relatively small community of building scientists and engineers in California that perform detailed residential energy efficiency studies. Contacts interviewed were unaware of any published research that linked or correlated the Title 24 Standards with moisture intrusion problems. One project was identified that included measurement of the amount of moisture removed from inside a newly constructed house, but the data was not published. Data from that project suggested that the likely source of moisture in the unoccupied home was the building materials and the slab.

Contacts were asked if they felt that the California Energy Standards were driving home designs to be more "fragile" in terms of moisture intrusion issues. The most common response was that the California Energy Standards were driving insulation levels, limiting amounts of glazing, and encouraging construction practices to build more air tight homes. But the actual design of the homes is driven by market preferences, not by energy efficiency or the state energy standards. A common comment that these individuals hear from builders at conferences, meetings and in private is that the energy standards have made the homes so tight that moisture problems are being created by not allowing enough infiltration into the homes. While there does not seem to be any research to support this contention, builders continue to express this belief.

Thus, there is general agreement that the California Energy Standards have improved the energy efficiency of homes significantly. But there was no data identified that addressed the potential impact of the energy standards in reducing how robust the homes are to moisture intrusion. Home design has been driven by market preferences, not the energy standards.

For the 2008 revision of the Title 24 standards, Commission staff propose to adopt a mandatory requirement for mechanical ventilation in all new homes. This requirement is intended to replace the prior assumption that occupants operate their windows to maintain adequate IAQ [Wilcox 2006]. One likely outcome of the proposed requirement would be to change the moisture content profile of the indoor air. The impact, if any, on moisture problems is not known.

Research Recommendations

There is not a readily accessible database on the subjects of moisture intrusion and resulting mold growth in the housing industry. In order to conduct future research about this problem, it is necessary to compile such a database. This database should be comprehensive, searchable, available to the public, and include statistically valid data on the relative frequency and severity of different moisture problems in new and existing California homes.

Research recommendations based on cumulative project results focus on three major initiatives:

1. Expand field demonstration and monitoring of materials and methods with acknowledged energy efficiency, risk reduction, and performance benefits selected for full-scale implementation or further evaluation by builders under this project;
2. Develop and evaluate laboratory and field performance test methods for wall penetrations integrated with cladding and wall assemblies; and
3. Collect and analyze laboratory and field data on root causes and consequences of building envelope failures to identify and evaluate alternative mold risk reduction strategies for window/wall interfaces.

Recommended field demonstration and monitoring efforts include:

- Continue long term slab and moisture data acquisition initiated under this project.
- Expand field demonstration and monitoring of ACI 302.1R-04 concrete slab installation methods and materials throughout California.
    - Alternative interior grade beam designs
    - Exterior footing vapor retarder and waterproofing application solutions

    - Optimized concrete mix strategies
    - Additional climatic conditions
    - Additional soil conditions
- Collect comprehensive field data on window flashing and water resistive barrier performance and energy impact with stucco cladding throughout California.
    - Alternative water resistive barrier options and installation sequences
    - Sill pan flashing designs integrated with window installation methods and two-ply and two-layer water resistive barrier design options
        - window and stool compatibility
        - backdam designs
        - foam sealant air barrier effect
        - interior reveal designs to integrate air barrier with water resistive barrier
- Evaluate mold-resistant sealer and gypsum panel cost and efficacy over time as a part of a comprehensive mold risk reduction strategy.

The ASTM E 2112 standard committee recently formed a working group to explore options on fenestration installation performance test methods. Public and private stakeholder involvement in this process is strongly encouraged. Collaborative research efforts to evaluate candidate methods in laboratories and in the field are recommended.

The root cause field data collection and analysis program comprises a data collection effort involving laboratory experiments, laboratory house data collection and analysis, and targeted new homes representing a full cross section of California construction and climate zones. The overall goal is to link moisture parameters with appropriate home construction parameters to enable authoritative root cause analysis of moisture and mold problems. Only by understanding these relationships can the building community move from the current status of experience-based "building art" to data-based "building science" and provide robust solutions to important problems.

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