Building Commissioning: Maps, Gaps & Directions

Deborah Dodds, Carolyn Dasher, Marguerite Brenneke, PECI, Portland,OR

ABSTRACT

Building commissioning has made great strides since the early 1990s in gaining acceptance as a critical quality assurance component of building construction and operation. Public recognition of commissioning can be gauged by the growing and increasingly diversified attendance at national and regional commissioning conferences and seminars and more frequent mention of commissioning in trade journals. Though much momentum exists, commissioning remains an "outsider" to the traditional building industry. To integrate commissioning into the mainstream, the U.S. Department of Energy is developing a national strategy to promote commissioning. This strategy, developed through interviews with over 50 stakeholders and a process of public review and comment, attempts to overcome obstacles that have impeded commissioning from becoming "business as usual."

Introduction

Building commissioning performed in new construction and existing buildings helps to ensure that systems are installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.[1] The process is commonly defined as one of investigating and fixing building systems to ensure that a new building begins its life cycle at optimal productivity. Commissioning can also restore an existing building to high productivity. Further, when commissioning is repeated periodically throughout the life of a building, it improves the likelihood that the building will maintain a high level of performance (U.S. Department of Energy 1998).

Public recognition of commissioning can be gauged by the growing and increasingly diversified attendance at national and regional commissioning conferences and seminars and more frequent discussion of commissioning in trade journals and other publications. Despite much momentum, commissioning remains an "outsider" to the traditional construction industry.

To further integrate commissioning into the mainstream, the U.S. Department of Energy (DOE) is developing a national strategy to promote commissioning. The goals of this effort are to: 1) map the current state of commissioning activities in the United States; 2) identify gaps and needs for the commissioning market; and 3) develop recommendations for addressing these gaps and needs. The strategy is being developed through industry analysis, interviews with over 50 stakeholders, and a process of public review and comment. The process will result in an action plan for future initiatives needed to overcome obstacles that have impeded commissioning from becoming "business as usual."

[1] The term "commissioning" was originally used by the U.S. Navy to describe the process of ensuring that naval vessels (in particular submarines and battleships) performed properly and as intended before they were put to sea. Poor performance once a ship was at sea could have grave, even fatal, consequences.

Industry Background - The Map

Building Commissioning Services

The commissioning process, usually performed at a building owner's request, involves functional performance testing and other diagnostic methods.[2] Figures 1 and 2 outline the process of building commissioning for new construction/retrofit projects and existing buildings. These activities help determine how well the building systems are performing together. A thorough commissioning process will confirm that building systems and equipment are operating properly, allowing the owner to realize the benefits of:

- Improved building system control;
- Increased energy efficiency;
- Improved building equipment performance;
- Improved indoor air quality, occupant comfort, and productivity; and
- Decreased potential for owner liability; and
- Reduced operation and maintenance costs.

Private and Public Building Owners

Owners are the primary market and direct beneficiaries of commissioning services. Early adopters share the perspective that they operate and manage their buildings as long-term investments. They purchase the technical knowledge and facilitation skills of a commissioning authority to integrate quality assurance processes into standard construction and building operation practices.

Typically, owners who commission their projects seek energy savings as well as increased system performance. Commissioning services also are procured to provide quality assurance for performance contracts and for new construction and renovations. Some owners commission their facilities specifically for indoor air quality, others commission to make sure that systems come on-line with a minimum level of problems and/or callbacks. The majority of consumers who purchase commissioning services do so without utility financial incentive.

Institutional owners continue to lead the industry. Federal government agencies as property owners are required to develop a commissioning plan for their buildings under the U.S. Energy Policy Act of 1992 and Executive Order 12902 (1994). Together these directives mandate that energy consumption in federal buildings be reduced 30 percent by the year 2005 from 1985 levels (Haasl & Wilkinson 1998). Several state and local governments also have adopted the practice for their buildings. Early adopters in the private sector include such major corporations as Westin Hotels, Boeing, Kaiser Permanente, Disney Development Corporation, and Target, as well as numerous property owners who participated in utility-sponsored programs. Small commercial buildings appear to comprise only a minor portion of the commissioning market.

---

[2] As defined in American Society of Heating, Refrigerating, and Air-Conditioning Engineers. Guideline 1-1996: *The HVAC Commissioning Process* and in the *Proceedings of the National Conference on Building Commissioning* (1993-1998).

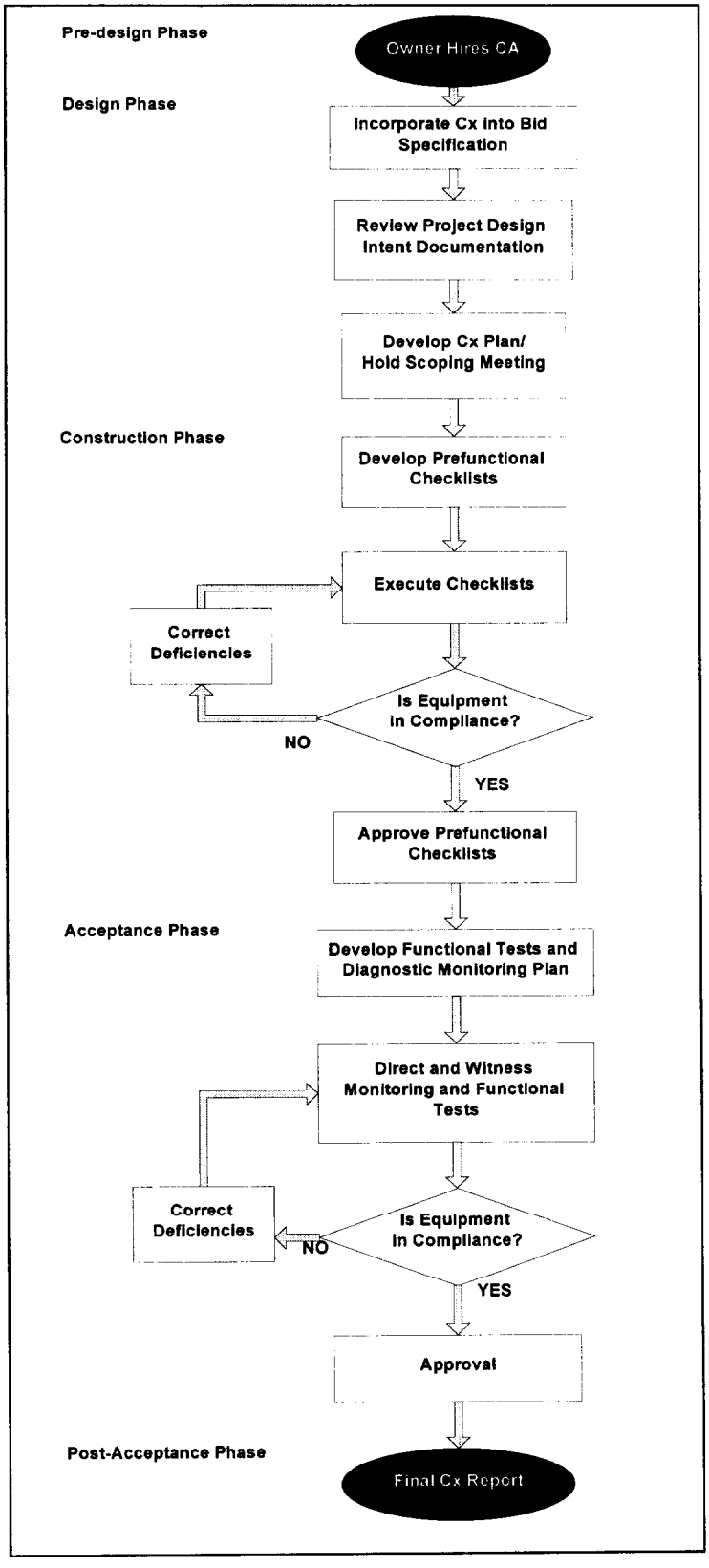

Figure 1. New Construction Commissioning Process

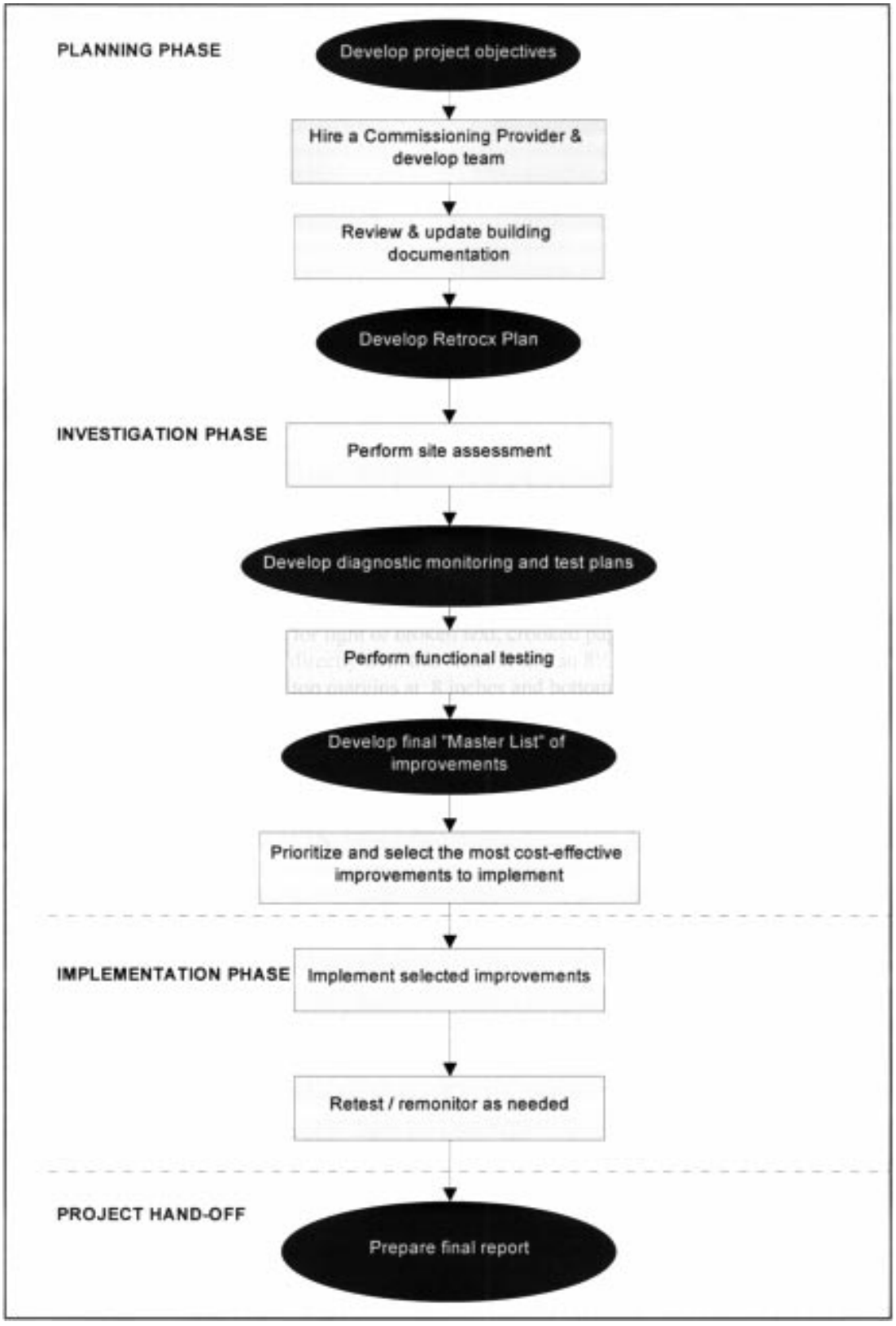

Figure 2. The Retrocommissioning Process

Commissioning Providers

Commissioning is not a typical component of the new construction and renovation processes. Selected findings from an industry survey conducted for the Electric Power Research Institute indicate the present infrastructure for providing these services is informal and developing (Portland Energy Conservation, Inc. 1996):

Nationally, firms providing these services span many different business types and sizes, and few firms provide commissioning as a primary business.

- The market for commissioning/diagnostic services is growing among all building types as owners learn more about the benefits available through early investigation and correction of building problems.
- Leading firms expect this growth to continue as owners experience the benefits of improved building quality control, complex system performance, indoor air quality, and operational efficiency.
- The service commonly falls under the umbrella of engineering, architecture, testing and balancing, or design-build services, with engineering firms predominating.
- Commissioning services are available to a limited extent in all regions of the United States and for various commercial building sectors (office and retail, schools, universities, hospitals and laboratories, government facilities, and others).
- Commissioning of existing buildings provides firms with an opportunity to work with their customers throughout the lifetime of their facilities.

Providers of Technical, Informational, and Training Services

Several national and regional organizations provide support services to the industry. These services can be grouped into the following categories:

Technical and Demonstration Services including research demonstration projects that involve on-site testing and diagnostics; development of tests and commissioning tools; documentation of case studies; and metering and data collection. Examples of organizations providing and/or funding these types of services include the California Institute for Energy Efficiency, the New York State Energy Research and Development Authority (NYSERDA), and U.S. national laboratories.

Information and Research Services including market research; identification of industry best practices; program design; and development and distribution of specifications, guidelines, informational materials, directories, and case studies. Examples of organizations supporting these services include professional associations such as American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), the Northwest Energy Efficiency Alliance (NEEA), the Florida Design Initiative (FDI), Portland Energy Conservation, Inc. (PECI), and numerous utilities.

Educational and Training Services including development of course curriculum and offering training workshops and seminars. Examples of organizations providing these services include workshops offered by the Association of Physical Plant Administrators, Association of State Energy Research and Technology Transfer Institutions (ASERTTI), FDI, PECI, National Environmental Balancing Bureau, NYSERDA, the University of Wisconsin, and Certified Energy Manager training.

The federal government also is quite active in developing these support services. DOE's Rebuild America Program, the Federal Energy Management Program (FEMP), and the U.S. General Services Administration have each developed a commissioning booklet targeted toward their owner

audiences. FEMP has also funded the development of comprehensive commissioning plans and guide specifications for construction documents and a number of commissioning demonstration projects. DOE in conjunction with the national laboratories has several projects underway. The U.S. Environmental Protection Agency's (EPA) ENERGY STAR® Buildings Program includes commissioning as a part of its tune-up component and EPA is considering a commissioning component for its building-labeling program. DOE and EPA have assisted in funding the national commissioning conferences. In addition, DOE is providing funding to ASERTTI to conduct commissioning training.

Market Potential

At present, it is estimated that less than 5% of all new construction and fewer than 0.03% of existing buildings are commissioned each year. These estimates are based on existing building and new construction data from the Commercial Buildings Energy Consumption Survey (Energy Information Administration 1995) and analysis of savings and cost data from 175 commissioning case studies.[3] A preliminary market estimate for commissioning is summarized as follows:

Existing Buildings. If 1% of all existing commercial buildings greater than 25,000 square feet are commissioned, the following could result:

- 285 million square feet per year of commissioned space
- $48.4 million cost ($0.17/square foot)
- 2730 billion Btu annual savings (12% of total bill)
- $46 million energy savings
- Payback in less than one year from energy alone
- Potential workload to sustain 570 full-time commissioning providers

New Construction. If 7% of all new buildings greater than 25,000 square feet are commissioned, the following would result:

- 43.8 million square feet per year of commissioned space
- $18.4 million cost ($0.42/square foot)
- 341 billion Btu annual savings (8% of total bill)
- $4.3 million energy savings
- Payback in four years from energy alone
- Potential workload to sustain 200 full-time commissioning providers

The large market potential for new and existing building commissioning services, coupled with the low number of experienced firms providing these services, results in a substantial opportunity for new entrants. An important aspect of this emerging industry from the owners' perspective will be the ability to qualify a firm and assess its capability to deliver the commissioning services as specified.

[3] As summarized in *What Can Commissioning Do for Your Building* (a brochure published by PECI), the buildings in the commissioning case study database range in size from 12,500 square feet to 2.2 million square feet, with a median size of just over 66,000 square feet. They include both new and existing facilities, ages 1 to 74 years old. The median building age is 6 years. Most of the buildings in the database were commissioned in 1994 or later.

Stakeholder Interviews

The next step in developing the national strategy was to conduct in-depth interviews with a diverse group of stakeholders to assess their current activities and their perspectives on the commissioning market. These interviews were designed to be exploratory rather than scientific in nature. The survey consisted of 19 open ended questions and took from ½ hour to 1 hour to complete. The design avoided using questions that would elicit merely "yes" or "no" answers. The majority of interviews were conducted via telephone. Some interviews were submitted in written form.

The survey was divided into four sections. Section 1, Interests and Perspectives, was designed to obtain information about the interviewee's role in the commissioning market (e.g., procurer of commissioning services, commissioning service provider, commissioning advocate). Section 2, Commissioning Initiatives/Programs/Services, was designed to map the current state of activity in the commissioning market. This section asked respondents to identify commissioning services that they currently provide or procure (including research and development). The next section, Commissioning Market Issues, asked questions to assess the respondent's perception of the current commissioning market, including market barriers and potential needs ("the gap"). Section 4, Commissioning Infrastructure Issues, was designed to obtain information about the specific process of commissioning. Interviewees were asked to provide their thoughts on training and certification of commissioning providers as well as how they envision various entities participating in the development of the commissioning market.

The interview list reflects the diversity of players in the commissioning market. Fifty interviews were conducted with individuals from the following categories:

- Commissioning Service Firms (6);
- State and Local Governments (6);
- Trade and Professional Organizations (5);
- Utilities (5);
- Architectural/Engineering Firms (4);
- Commercial/Industrial Building Owners (4);
- Consortia/Advocacy Groups (4);
- Federal Government (4);
- Universities (3);
- Energy Service Companies (3);
- National Laboratories (2);
- Contractors (1);
- Design/Build Contractors (1);
- Press Organizations (1); and
- Insurance Companies (1).

Barriers To Making Commissioning Business As Usual

Despite the benefits to owners mentioned above, commissioning has not reached the mainstream market. Interviewees cite three main obstacles to reaching owners of both new and existing facilities:

- A lack of awareness of commissioning by building owners, construction managers and design professionals;
- A perception that commissioning is an extra up-front cost that introduces an unnecessary layer into the normal construction process; and
- Insufficient cost/benefit data to substantiate the contributions of commissioning to building construction and operation.

After identifying these barriers, stakeholders were asked whether they perceive opportunities in the market and if so, what is needed to move the market forward. These ideas are discussed below.

Current Market Needs—"The Gap"—And Future Directions

Currently, the commissioning market is an informal one. Owners do not have mature, well-developed channels through which they can obtain commissioning services. This market, however, continues to increase and evolve. Future directions for the industry can be categorized into 1) ideas for transforming the commissioning market (demand-side approaches) and 2) ideas for building the commissioning infrastructure (supply-side approaches).

Transforming the Commissioning Market

Transforming the commissioning market involves understanding how the building construction market operates, identifying segments of the construction market that offer potential, and developing strategies to increase consumer demand for building commissioning.

Potential Markets. Early adopters of commissioning own buildings that can be characterized as having: 1) complex systems; 2) high-energy use; and 3) a high owner/occupant expectation for quality indoor environment. Specific types of buildings falling into these categories include government buildings and complexes, hospital and healthcare facilities, large commercial buildings, universities, and owners who are responsible for establishing ongoing building programs. While these building types are generally considered as offering the greatest opportunity for commissioning, commissioning services also are of potential benefit to smaller buildings and specific systems. Still, investigation into marketing and delivery of commissioning services to market segments other than early adopters remains incomplete.

Promotion/Information. Owners need information that illustrates how commissioning their buildings will result in a clear, positive financial outcome and enhanced building performance. To date, the cost/benefit analyses of available commissioning data have resulted in valuable case studies. However, there is a desire for information resulting from more rigorous cost/benefit analyses of additional projects. Interviewees registered a continuing need for informational materials targeted to the building owner. Specific suggestions included:

- Market the concept of commissioning in terms that owners can understand. Use financial, rather than technical language.
- Develop a standard definition of commissioning. Currently, commissioning is trying to be all things to all people, which makes the concept less meaningful.

- Conduct cost-benefit and potential studies to develop marketing materials that providers and advocates can distribute to owners.
- Obtain more information and analysis about non-energy benefits.
- Continue to promote commissioning through national and regional conferences and workshops.

Building the Commissioning Infrastructure. In addition to developing the demand for commissioning services, interviewees suggested that the supply of services ("the infrastructure") must be enhanced as well. The building commissioning infrastructure consists of the service providers and the tools and processes they use to perform commissioning. Assurance of quality and consistency is an increasingly important part of the commissioning infrastructure.

Supply of Providers. While several participants expressed a need to train more people to provide commissioning services, many cautioned that the pace of developing the infrastructure should not outstrip demand. Indeed, this question requires more research and may be regional in nature. A discussion of quality of service, however, applies to both scenarios, regardless of the number of providers.

Quality. Quality and consistency of commissioning services is critical to the success of commissioning. Professional certification and a professional association were both suggested as ways to assure customers that they are receiving quality and consistent service.

A slight majority of interviewees favor the idea of certification for commissioning providers. However, an almost equal number are opposed to the idea. Those who support certification note that it must be meaningful, that is, based on established criteria for education and experience and provided through a credible organization.

In addition to the merits of certification, participants assessed the need for a professional association of commissioning providers. Most supported the establishment of a professional commissioning providers' association. An organization open to different stakeholders holding different types of membership would offer a forum for sharing experience. While an association would facilitate a central focus for the commissioning niche, it should avoid creating additional fragmentation of the industry if it is to succeed. In early 1998, with start-up funding from NEEA, firms providing commissioning services in Washington, Oregon, Idaho, and Montana began organizing a regional association. Quality of commissioning service is addressed by the association through 1) membership application criteria, 2) adherence to a set of commissioning attributes, and 3) a peer review process that may be initiated by the recipient of commissioning services.

Training. There is a need to enhance the skills of current providers and to respond to growing demand by increasing the number of commissioning providers altogether. An on-the-job training program, favored by interviewees as the best method to develop commissioning skills, is not available. When asked to recommend specific training programs or models, participants repeatedly noted two concerns: 1) although some standards and training programs do exist, they provide little more than an introduction to commissioning; and 2) the industry lacks a standard source for hands-on training. At the same time, interviewees consistently identified ASHRAE professional development training seminars and the University of Wisconsin's commissioning courses as models for future training programs.

Interviewees contributed many ideas to develop effective training programs. These included:

- Designing an internship program to that provides commissioning experience to engineering students and recent graduates;
- Introducing commissioning into the standard curriculum for architecture and engineering programs; and
- Developing a one-day lesson plan with materials for commissioning to increase the likelihood that faculty would include commissioning in their coursework.

Once a training strategy has been established, participants must be recruited. Several participants expressed a need for a collaborative to coordinate training activities. This collaborative could establish relationships with professional organizations in order to recruit participants. Models cited included the Energy Center of Wisconsin and the Northwest Commissioning Collaborative. The Northwest Commissioning Collaborative is an ad hoc group of organizations and individuals analyzing regional barriers to the acceptance of building commissioning and advising NEEA on their commissioning projects.

Tools. Few participants in the survey noted the need for additional commissioning tools as many core tools are available (i.e., guide specifications, commissioning plans, guidelines, test procedures, and RFPs for commissioning providers). Of those who did see a need for additional tools, most focused on metering and monitoring equipment to document project baseline and commissioning savings. The development of an on-line database of commissioning forms for various types of equipment was thought to be beneficial. Such tools would reduce commissioning costs by decreasing the amount of time providers spend developing tests and checklists. A tracking tool would be useful from design through construction and into the life of the buildings, as information loss is the cause of many problems and reduced O&M efficiency. This development would also make commissioning information available to facilities staff that is unable to hire third-party commissioning providers. National lab activities are underway to address some of these needs.

Federal Role

When asked what role they envision for the Federal Government, participants responded with three general recommendations:

- Serve as an example by commissioning federal buildings. Track costs, savings, and benefits of these projects.
- Develop marketing/information materials to transfer commissioning information to the private sector.
- Provide funding for commissioning demonstration projects, cost-effectiveness studies, promoting building commissioning, and commissioning education.

Most stakeholders agree that the Federal Government should remain an advocate and should not engage in a regulatory role. A few interviewees, however, suggested that the success of commissioning would occur only if legislation (e.g., building codes) is enacted. Other stakeholder suggestions for government activity include:

- Develop a commissioning curriculum for engineering and architecture programs;

- Require commissioning as part of all government performance contracts, especially for military bases where a significant number of performance contracts have been proposed;
- Incorporate commissioning into current energy programs, such as EPA's ENERGY STAR® building labels program and Green Buildings program; and
- Develop metrics for measuring the benefits of commissioning as part of DOE's International Performance Measurement and Verification Protocol (IPMVP).

Recommendations for Leveraging Common Interests, Goals and Related Activities

Next steps for the national strategy process are:

1. Develop recommendations;
2. Distribute recommendations for public comment;
3. Review the recommendations at the National Conference on Building Commissioning in May 1998 and receive input from participants; and
4. Complete the final list of recommendations to be distributed by DOE in the summer of 1998.

References

American Society of Heating, Refrigerating, and Air-Conditioning Engineers. 1996. *Guideline 1-1996: The HVAC Commissioning Process.*

Energy Information Administration (EIA). 1995. *Commercial Buildings Energy Consumption and Expenditures 1992.* DOE/EIA-0318(92). Washington D.C.: U.S. Department of Energy.

Haasl, T., and R. Wilkinson. 1998. "Using Building Commissioning to Improve Performance in State Buildings." *In Proceedings of the 11th Symposium on Building Systems in Hot and Humid Climates.* Fort Worth, Tex.

Portland Energy Conservation, Inc. 1996. *Providers of Commercial Building Commissioning and Diagnostics: A Market Profile.* EPRI TR-107671. Palo Alto, Calif: Electric Power Research Institute.

Portland Energy Conservation, Inc. 1997. *What Can Commissioning Do for Your Building.* Portland, Ore.: Portland Energy Conservation, Inc.

Proceedings of the National Conference on Building Commissioning (1993-1997). Portland, Ore.: Portland Energy Conservation, Inc.

U.S. Department of Energy Rebuild America Program. 1998. *Building Commissioning: The Key to Quality Assurance.* Washington, D.C.: U.S. Department of Energy.