Commissioning: A Highly Cost-Effective Building Energy Management Strategy

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The emerging practice of building commissioning is a particularly potent means of increasing energy efficiency. Although commissioning has earned increased recognition in recent years—even a toehold in Wikipedia—it remains an enigmatic practice whose visibility considerably lags its potential.

Quality assurance and optimization are essential elements of any serious technological endeavor, including efforts to improve energy efficiency. Commissioning is an important tool in this respect. The aim of commissioning *new* buildings is to ensure that they deliver—if not exceed—the performance and energy savings promised by their design. When applied to *existing* buildings, one-time or repeated commissioning (often called retrocommissioning) identifies the almost inevitable drift in energy performance and puts the building back on course, often surpassing the original design intent. In both contexts, commissioning is a systematic, forensic approach to improving performance, rather than a discrete technology.

Specific deficiencies identified and corrected through the commissioning process include problems such as simultaneous heating and cooling, inefficient thermal distribution layout, miscalibrated or otherwise malfunctioning energy management controls and sensors, defeated efficiency features (e.g., variable speed drives locked at full speed), leaky air-distribution systems, inappropriate setpoints and control sequences, and oversized equipment. These kinds of problems collectively waste several tens of billions of dollars in energy each year in the U.S. alone, while compromising occupant comfort, health, and safety. In an ideal world, these issues would be caught during the original design or corrected by routine operations and maintenance, but that is all too rare in practice.

Energy-wasting deficiencies are often invisible to the casual observer, and unfortunately also to building designers, operators, owners, and all but the most attuned engineers. Commissioning can reduce the carbon footprint of unremarkable buildings, or ensure the success of ones deliberately designed to push the limits of efficiency.

Uncertainties about cost and cost-effectiveness are key barriers to the growth of the commissioning industry. Building owners understandably ask why they need to pay "extra" for remediation of less-than-best practices. Program designers, utility regulators, and other policymakers must all justify investments in commissioning.

In an effort to provide better information to all players, the Lawrence Berkeley National Laboratory (LBNL) has assembled the world's largest compilation and meta-analysis of commissioning experience in actual commercial buildings. The database has grown to 643 buildings (all located in the U.S., and spanning 26 states). Projects represent 100 million ft^2 (9 290 300 m^2) of floorspace, $43 million in commissioning expenditures, and

the work of 37 commissioning providers. The recorded cases of new-construction commissioning took place in buildings representing $2.2 billion in total construction costs. The costs include labor and materials for external commissioning agents, plus other trades and supporting in-house staff, and are limited to commissioning activities targeting energy savings, as distinct from other systems such as safety and security.

The results are compelling. The median cost to deliver commissioning was $0.30/ft^2 ($3/m^2) (in 2009 dollars) for existing buildings and $1.16/ft^2 ($12/m^2) for new construction (or 0.4% of the overall construction cost). More than 10,000 specific deficiencies were identified across the third of the sample for which data were available. Correcting these problems resulted in 16% median *whole-building* energy savings in existing buildings and 13% in new construction, with payback times of 1.1 years and 4.2 years, respectively. Median benefit-cost ratios of 4.5 and 1.1, and cash-on-cash returns (a common statistic used in the real estate industry) of 91% and 23% were achieved.

Projects with a relatively thorough approach to commissioning (e.g., incorporating benchmarking, design intent documentation, construction observation, functional testing, acceptance testing, operator training, and calibrated simulation) attained nearly twice the overall median level of savings and five-times the savings of the least-thorough projects. It is noteworthy that virtually all existing-building projects were cost-effective by each metric (e.g., paybacks of 0.4 years for the upper quartile and 2.4 years for the lower quartile), as were the majority of new-construction projects (1.5 years and 10.8 years, respectively). The LBNL review also found high cost-effectiveness for each individual commissioning measure for which data were available. High-tech buildings such as laboratories were particularly cost-effective, and saved greater amounts of energy due to their baseline energy-intensiveness. Cost-effectiveness is often achieved even in smaller buildings.

Thanks to energy savings that eclipse the cost of the commissioning process, associated reductions in greenhouse gas emissions come at a decidedly “negative” cost (meaning that it is cheaper to emit less emissions than to emit more). The median cost of conserved carbon is *negative:* –$110 per metric ton for existing buildings and –$25 per metric ton for new construction. This compares quite well with market prices for high-quality carbon offsets, currently on the order of +$20/metric ton.

The persistence of commissioning energy savings is still poorly understood. LBNL acquired data on post-commissioning energy savings over multi-year periods for 36 of the projects. Not all projects exhibit an erosion of savings over time. In fact, the tendency for the sample, as a whole, is for level or even slightly increasing savings over time. This perhaps counterintuitive outcome may be explained by the fact that comprehensive commissioning includes training, and, in some cases, installation of permanent metering and feedback systems (e.g., monitoring-based commissioning). These improvements “live on” after the commissioning providers leave the site, and, if properly used, can maintain and even help deepen savings over time. Many measures implemented in new-construction commissioning tend to be very durable, e.g., properly sizing HVAC equipment.

Non-energy benefits are often a more important driver in customers' initial motivation to perform commissioning and their perceived post-commissioning energy savings. These non-energy benefits surpass those of most other energy-management practices. In new construction, significant first-cost savings routinely offset some or all commissioning costs. For example, when accounting for these benefits, the net median commissioning cost was reduced by 49% on average, while in many cases the non-energy benefits fully exceeded the direct value of the energy savings. An example of this, when applied to new construction, is the capital cost savings resulting from "right-sizing" heating and cooling equipment. Commissioning is also routinely reported to avert premature equipment failures, avoid construction-defects litigation, improve worker comfort, mitigate indoor air quality problems, increase the competence of in-house staff, and reduce change orders, to name just some of the other non-energy benefits.

These findings demonstrate that commissioning is the single-most cost-effective strategy for reducing energy, costs, and greenhouse gas emissions in buildings today. Commissioning also optimizes and maximizes the quality and persistence of savings achieved through other energy-saving technologies and practices. The process ensures that building owners get what they pay for when constructing or retrofitting buildings, and it provides risk-management and " insurance" for policymakers and program managers enabling their initiatives to meet targets. It also detects and corrects problems that would eventually surface as far more costly maintenance or safety issues. As such, commissioning is more than "just another pretty energy-saving measure." It is a risk-management strategy that should be integral to any systematic effort to garner and maintain energy savings or emissions reductions.

Applying the median whole-building energy-savings (certainly far short of best practices) to the U.S. non-residential building stock corresponds to an annual energy-savings potential of $30 billion by 2030, which yields greenhouse gas emissions reductions of about 340 megatons of CO_2 each year.

How can society capture this potential?

The commissioning field is evolving rapidly. The fledgling existing-buildings commissioning industry is about $200 million per year in the United States. Based on a goal of treating each U.S. building every five years, the potential market size is about $4 billion per year in commissioning services, or 20-times the current number. To achieve the goal of keeping the U.S. building stock commissioned would require an increase in the workforce from about 1,500 to 25,000 full-time-equivalent workers, a realistic number when viewed in the context of the existing workforce of related trades.

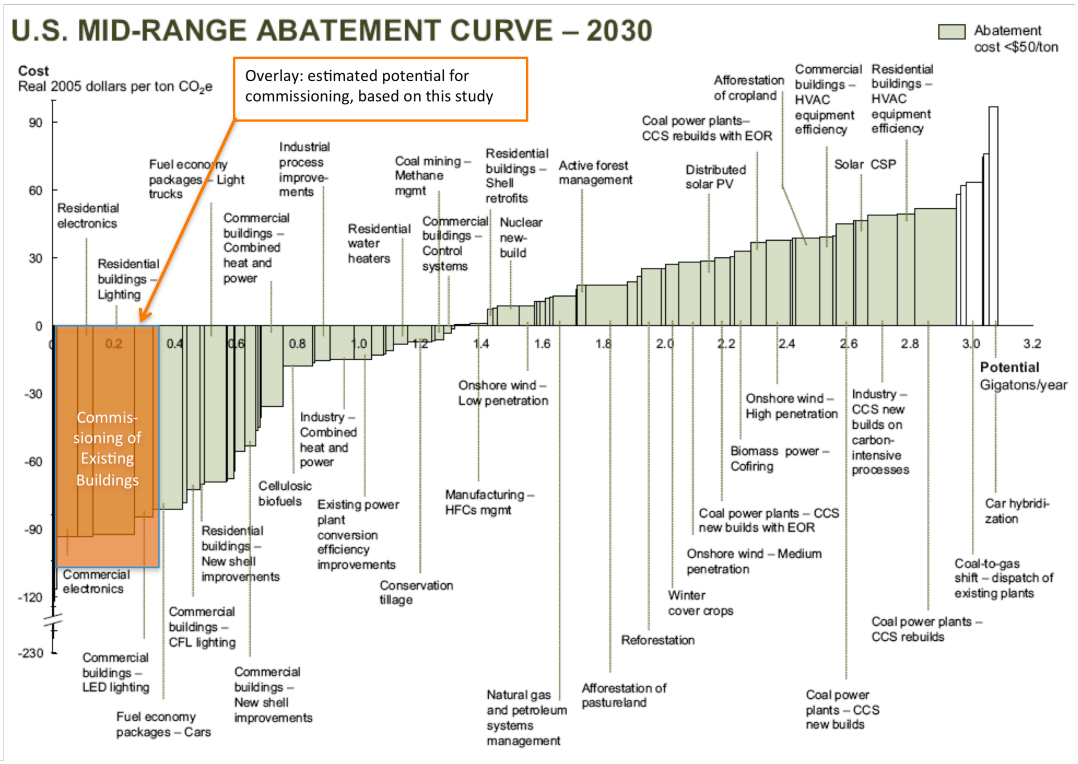
The delivery of commissioning services must be scaled up substantially. A California survey estimated that only 0.03% of existing buildings and 5% of new construction in that state have been commissioned. Reasons for this include a widespread lack of awareness of need and value on the part of prospective customers, insufficient professionalism within the trades, splintered activities, and competition among a growing

number of trade groups and certification programs. Numerous emerging technologies are entering the marketplace. Each will bring new risks along with opportunities for energy savings. It is critical that the practice of commissioning keep pace with technology innovation.

The energy policy community is also behind the curve. This is evidenced by the absence of commissioning-like requirements in most building codes, and omission or obfuscation of the strategy in most energy-efficiency potentials studies. The longest-standing effort to educate policymakers and others is the California Commissioning Collaborative, which brings together regulators, utilities, practitioners, and other stakeholders with a collective vision of defining and instituting best practices.

"Commissioning America" in a decade is an ambitious goal, but doable and consistent with this country's aspirations to simultaneously address pressing energy and environmental issues while creating jobs and stimulating economic activity.

The full study can be read at http://cx.lbl.gov



Notes. The overlaid orange "step" is derived from the analysis in the new LBNL report and superimposed for reference over the green carbon "abatement curve" published in 2007 by McKinsey & Company and the Conference Board. The full abatement curve indicates the potential emissions savings potential for a set of measures, ranked by the annualized net cost per ton of emissions reductions (y-axis), i.e., the cost of commissioning minus the value of the resulting energy savings over the measure life. The horizontal width of each step is the potential emissions reduction attributed to each measure. The mid-range scenario is described by McKinsey as one that "involves concerted action across the economy."

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