

OPR, BOD, Systems Manual – Expensive, Useless Encumbrances or Valuable, Cost Effective Tools – It's Up to You

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Synopsis

Three commissioning-related documents – the Owner's Project Requirements (OPR), Basis of Design (BOD), and Systems Manual (SM) – can be cost effective keys to successfully commissioning and sustaining building functionality. The OPR, BOD and SM may be developed as a part of the overall project process with little to no additional project cost. As properly applied tools, the documents add to project efficiency by promoting project team collaboration, facilitating a common understanding of the project goals and requirements, and enhancing the exchange of knowledge. After the owner takes possession of the building, the OPR, BOD and SM continue to provide information regarding design intent, basis of design and functionality for the life-long operation and evolution of the building. Understanding this process is highly beneficial to owners, architects, engineers and commissioning agents.

Unfortunately, the fundamental purposes of the OPR, BOD and SM are frequently not understood. Inexperienced project teams may separate the development of these documents from overall project production, and may not apply them effectively to the progression of designing, building, and operating the building. As a result, they become burdensome, expensive and provide little value.

Understanding the OPR, BOD and SM has become more important as the commissioning processes mandated by various institutions and high performance building programs have begun requiring OPR, BOD and SM documentation. The US Green Buildings Council LEED program is a widely know example of such a program. The LEED Fundamental Commissioning Prerequisite requires the Owner to “document the Owner's Project Requirements (OPR),” and the design team to “develop the Basis of Design (BOD).” In order to obtain the LEED Enhanced Commissioning Credit, the commissioning team must “develop a systems manual.”

This paper describes a cost-effective approach for the development and long-term application of the OPR, BOD and SM. It explains that these documents provide a venue for efficiently documenting and effectively utilizing vital information upon which the systems are based; information that is often addressed at the time it's first needed, and later forgotten. The relationships between OPR, BOD and SM are explained, including the sequential manner in which each document forms the basis for the next. Perhaps most importantly, the paper

describes how these documents, when properly maintained, may be used to optimize systems operation throughout the life-long operation and evolution of the building.

About the Author

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Introduction

To quote ASHRAE Guideline 0, *“The Commissioning Process is a quality-oriented process for achieving, verifying and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.”* Three commissioning related documents – the Owner's Project Requirements (OPR), Basis of Design (BOD), and Systems Manual (SM) – have been promoted by ASHRAE, and other authorities on building commissioning, as valuable commissioning tools that not only facilitate effective commissioning but also provide valuable information to operators and designers throughout the life of the building. It therefore comes as no surprise to many commissioning experts that the OPR, BOD and SM are mandatory commissioning documents for high performance building programs such as the US Green Buildings Council Leadership in Energy and Environmental Design (LEED) program. The LEED Fundamental Commissioning Prerequisite requires the Owner to “document the Owner's Project Requirements (OPR,)” and the design team to “develop the Basis of Design (BOD).” In order to obtain the LEED Enhanced Commissioning Credit, the commissioning team must “develop a systems manual. Unfortunately, project teams that are unfamiliar with the fundamental purposes and interaction of these documents frequently find them burdensome, expensive and of little value. As a result the OPR, BOD and SM are widely misunderstood & underused.

Some of the confusion regarding the Owner's Project Requirements (OPR), Basis of Design (BOD), and Systems Manual (SM) results from the terms being used inconsistently by different organizations and publications. For the purposes of this discussion, the following definitions will be used:

- **Owner Project Requirements (OPR) document** – documents the owner's functional requirements and the criteria the owner will use to determine whether or not these requirements have been successfully fulfilled. Past ASHRAE and LEED publications used the title Owner's Design Intent Document to refer to this document.
- **Basis of Design (BOD) document** – documents the concepts on which systems are based, the methodology used to approach the design, and how the design satisfies the

OPR. It is not uncommon for the BOD to be called the AE or Engineer's Design Intent Document.

- **Systems Manual (SM)** – documents information to help understand and operate the systems as the owner and designers intended for them to operate. This systems oriented document goes beyond equipment oriented operating and maintenance manuals.

When the commissioning professional introduces the OPR, BOD and SM to the project team, the reactions vary depending on the experiences team members have had with these documents on past projects. Teams that haven't used the documents or have had bad experiences often push back. Typical and logical, reactions are: "that sounds like more work; who's going to do it, how are we going to find the time to do it, and who's going to pay for it?" Reactions like this are common among project teams that have been forced into developing OPRs, BODs, and SMs in order to comply with some program requirement. Negative experiences commonly result when the team proceeds without truly understanding the documents and their interaction. Project teams react differently when they are familiar with purposes of the documents, how to apply them and how to develop one document from the other. Teams with this experience welcome the OPR, BOD and SM as key documents that facilitate successful project design, construction and commissioning; cost effective tools that improve project efficiency; and documentation of the systems' functionality that provides value for operators and facility managers throughout the building's life.

In order to optimize the chance for successful commissioning, project teams new to the OPR, BOD and SM must answer the following question: "How can we use the OPR, BOD and SM as cost effective tools for our project?" The key to this question's answer is understanding the purposes of these documents and how they are related to one another. This paper will focus on these concepts. ASHRAE Guideline 0, the LEED Reference Guides and the Energy Design Resource website are good resources regarding potential specific content.

Understanding the OPR, BOD and SM

What the OPR, BOD and SM have in common

In order to fully understand the OPR, BOD and SM, it helps to understand what these documents have in common and how they build on one another. One of the most important things for project teams to understand is that all three of documents consist of work provided primarily by parties other than the Commissioning Authority (CxA) and are best developed by the team collaboratively. The previously cited LEED requirements underscore this. LEED for New Construction Version 2.2 (NC 2.2) requires the following regarding the OPR & BOD: *“The Owner shall document the Owner’s Project Requirements (OPR). The design team shall develop the Basis of Design (BOD). The CxA shall review these documents for clarity and completeness. The Owner and design team shall be responsible for updates to their respective documents.”* The Systems Manual, which is required for the LEED NC 2.2 Enhanced Commissioning Credit, is compiled by the CxA. As explained in the LEED Reference Manual, however, most of the document’s contents are provided by the Owner, design team and contractors.

Clearly then, the project team has to be prepared to share in the development and use of the OPR, BOD and SM. The contracts between the Owner and the project team members must support this effort, and the Owner’s staff has to be prepared for participation. With advanced preparation, however, this does not necessarily require a substantial increase in fees or project schedule. Much of the content of the OPR, BOD and SM must be known or created as a normal part of project development. A project team that understands the purpose and development of the documents can create them as a part of work already being done.

In order to efficiently develop and use the OPR, BOD and SM, the project team needs to understand how the documents support and build on one another. The OPR is the foundation on which the BOD is built, and the Systems Manual incorporates and builds on the OPR and BOD. It is important to keep this relationship in mind as the individual documents are considered.

More about the Owner’s Project Requirements document (OPR)

The OPR and BOD are first and foremost design tools; however, many commissioning experts consider the OPR to be the project’s commissioning bible. Consider the fundamental purpose of commissioning. Though many commissioning definitions and goals have been published, many commissioning experts believe they all boil down to this simple concept: the fundamental purpose of building commissioning is *to confirm that the systems being commissioned satisfy the owner’s functional requirements*. It stands to reason then, that the throughout the entire project the entire project team should have a common understanding of what those functional requirements are and how the success of their implementation will be judged. The purpose of the OPR is simply to document this.

Though the purpose of the OPR may be simple in concept, the value of documenting the Owner’s functional requirements cannot be overstated. As an example, consider the OPR’s

potential for minimizing conflicting owner directives. Most seasoned building consultants have gotten different messages regarding project priorities and expectations from different groups within a single owner's organization. The facility operations and maintenance staff may want to emphasize simplicity and reliability while the resource managers may want to concentrate on energy savings. The focus of the capital projects group may be constructability. Developing the OPR requires these groups to reach consensus on, or at least accept, common functional requirements. For owners that are new to construction, developing an OPR may facilitate awareness of critical performance issues early on, when they can be addressed by the basis of design. This minimizes the potential for becoming aware of these issues after occupancy when the product has already been delivered.

The value of the OPR is increased by, not only by describing the Owner's functional requirements, but also clarifying how the successful fulfillment of these requirements will be judged. In many cases, the very nature of these requirements may adequately communicate the success criteria. Take for example, stating the requirement that the temperature in interior office shall be $72\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$. The requirement alone clearly implies that the criterion for success is that the room temperature in interior offices must be maintained at $72\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$. On the other hand, it may be inadequate to simply state that the pressure of a lab shall be negative relative to the adjacent rooms. The project team needs to know how negative and how critical it is to ensure this relationship. Is this a critical functional requirement that must be maintained by using special fast-acting control systems? Or is it sufficient and more appropriate for the budget to simply balance the supply and return airflow systems with an offset and live with an occasional temporary pressure reversal.

An effective OPR provides this kind of clarification; however, it may need to be added to the original draft through collaboration during design development. An effective OPR is a living document. As functional performance questions arise during design, the team looks to the OPR for the answer. If the answer is not in the document a revision may be warranted to address the subject. Consider the lab pressurization example. The initial draft of the OPR might well have simply stated that "the pressure of a lab shall be negative relative to the adjacent rooms." The need for further clarification may not have been apparent until the engineer began to develop the BOD.

The question is often asked, "Who should develop and maintain the OPR?" This question is clearly answered for LEED project teams. Fundamental Commissioning Requirement 2, under LEED NC 2.2, clearly states, "*The Owner shall document the Owner's Project Requirements (OPR). The design team shall develop the Basis of Design (BOD). The CxA shall review these documents for clarity and completeness. The Owner and design team shall be responsible for updates to their respective documents.*" This requirement underscores how essential it is that the Owner be fully engaged in documenting their requirements. It seeks to avoid the unfortunate practice of the Owner delegating the creation of the OPR to the CxA or the design team without being fully involved and without taking final responsibility for the documents content. Experience has shown, however, that the most effective OPRs are typically the result of collaboration between the owner and their building consultants. ASHRAE Guideline 0 describes one approach to this kind of collaborative process. Participants include the design team, CxA,

and Construction Manager; as well as the Owner's project manager, building operators, resource manager and building user groups. Involving the design team in OPR development may also facilitate and expedite efficient development of the BOD.

More about the Basis of Design Document (BOD)

The BOD may be thought of as the design team's confirmation of the OPR. While the OPR describes the Owner's functional requirements, the BOD is the design team's opportunity to confirm that they understand what those requirements are and describe how they intend to achieve them with the design. For this reason, there is value in involving the design team in the development of the OPR as mentioned in the previous OPR discussion.

The BOD documents concepts, design assumptions, important calculations, decisions, product selections, rationale, and other applicable regulations, standards and guidelines the design incorporates in order to satisfy the OPR. It is possible to use the actual electronic OPR file to develop a BOD checklist, or even as an effective starting point for BOD document itself. These approaches automatically direct the design team to every item in the OPR. As the BOD takes form, the format may include narrative text, schematic zoning plans, one-line schematic systems diagrams, and data tables. The anticipated content of the plans, specs and Systems Manual may drive decisions regarding BOD format. As an example, consider the use of one-line schematic systems diagrams. The LEED NC 2.2 Reference Guide requires one-line schematic systems diagrams to be included in the Enhanced Commissioning Systems Manual. Knowing that the one-lines will be required for the Systems Manual at project closeout, it may be cost effective to begin developing them for the BOD. Schematic diagrams may save the BOD author a lot of narrative writing; and the fleshed out diagrams may also be included in the construction documents to add clarification. In the end, the foresighted leveraging of the one-lines saves work and adds value to the project at multiple phases.

As with the OPR, some design firms have for years used the BOD as a tool for communicating with the owner. Previously I mentioned working as a mechanical engineer in the 80s for a firm with the policy of not completing schematic design without an owner approved design intent document. That same firm had a policy of not proceeding with design development until the owner had accepted our basis of design document. As a commissioning professional I'm frequently involved in projects that utilize a design narrative of some kind even when an OPR or systems manual is not included in the project process.

Finally, it is worth noting that the concept of documenting the Owner's project requirements and AE's basis of design is not new. Some Owner's routinely do this as a part of project Programming, and some design firms have for years considered OPR and BOD documentation indispensable tools. In the 1980s I worked as a mechanical design engineer. The firm I worked for had a policy of documenting the owner's project requirements and our basis of design as one of the schematic design submittal deliverable. It was also the company's policy not to proceed with design development without the owner's signature of approval on this documentation.

More about the Systems Manual (SM)

The Systems Manual may be the least understood among the OPR, BOD and SM. Commissioning demonstrates that systems operate in accordance with the owner's functional requirements at the time of functional performance testing. The Systems Manual provides the facilities and operating staff, as well as the future designers of facility modifications, with information to help understand and optimally operate the systems throughout their lives. Without the SM much of this important information leaves the facility with the designers, contractors and commissioning authority. Because of this, some highly respected building experts believe that the SM is the most important document to come out of the commissioning process.

While the Operations & Maintenance (O&M) Manuals focus on equipment, the SM focuses on the operation of systems, particularly interactions between different equipment & systems. Like the OPR and BOD, the SM is a living document. The SM, however, lives and evolves throughout the life of the building. It is typically compiled by the CxA; however, it contains documentation developed by the Owner, design team, contractors and CxA as a part of their ongoing project work. The final document belongs to the Owner and is maintained by the building operators, and future consultants and contractors throughout the building's life. The objective of the SM is to provide the following information: 1) Document the functional intent and basis of design of the as-built systems; 2) Document the fundamental configuration, sequences of operation and operating characteristics of the as-built systems; 3) Provide guidelines for verifying that the systems continue to fulfill the facility's functional needs. Examples of typical contents include:

- Documentation of the owner's design intent and the AE basis of design (OPR & BOD), as provided by the owner and the design team.
- One-line schematic diagrams of fundamental systems configurations, interactions and flows. These are typically provided by the design team or the contractors, from the record drawings.
- Record sequences of operation including setpoints; provided by the control system contractor from the record controls submittal.
- Discussion of building systems interaction, the impact of changing setpoint and schedules, and special operating considerations. Much of this information may already exist in the BOD; however, valuable relevant information is often obtained during functional performance testing. Depending on the project, it may be appropriate for this section of the SM to be prepared by the AE, the CxA, or through a collaborative effort of both.
- Recommended schedule of recalibration for sensors and components; provided by the contractors and equipment manufacturers.
- Recommended re-commissioning schedule in the form of timelines and operating parameters; by the CxA.

- Re-commissioning FPTs; by CA.
- Date major equipment placed into continuous operation, date of most recent servicing, and manufacturer's recommended dates for next servicing. This is provided by contractors with assistance from manufactures.

In order to obtain optimal long-term value from the SM, the document must be diligently and thoughtfully maintained as the facility and systems evolve and more knowledge is gained.

Experienced building professionals will see from a review of this list that creating this document at the end of project without advanced planning could expensive and time. With foresight, however, experienced project teams can develop and execute specifications and work plans such that the SM can be compiled as the project progresses. When this is done, little effort is required at project closeout to complete the SM and present it to the owner's staff.

How do I make the OPR, BOD and SM work cost effectively for my project? Simple concepts and guidelines

Project teams begin to appreciate the OPR, BOD and SM, once the purposes and interconnection of the documents are understood. The question, however, may still remain, "How do I make the OPR, BOD and SM work cost effectively for my project?" Applying the following simple concepts and guidelines along with a good understanding of the documents has helped project teams answer this question.

Some fundamental concepts

In order to effectively utilize the OPR, BOD and SM, it is valuable to apply some fundamental concepts that apply to effective commissioning in general. I believe that the value of any commissioning approach, or any component of a commissioning process, can be maximized by remembering that the fundamental purpose of building commissioning. Though many commissioning definitions and goals have been published, I believe they all boil down to the fundamental purpose of building commissioning being to confirm that systems satisfy the owner's functional requirements. The primary reason for any commissioning process or procedure is to achieve this goal. Rigidly following any standard process or procedure because "this is the way we do it" may compromise that goal. A skilled commissioning professional can fine tune their commissioning process to address the unique characteristics of individual projects and project teams. Staying focused on the fundamental purpose of commissioning, rather than some standard format, results in more useful and efficiently developed OPRs, BODs and SMs.

Another concept that enhances any good process or document is the distinction between value and volume. To be of value, the OPR, BOD and SM must address the important issues pertaining to the project's functional requirements, basis of design and operating characteristics. On many projects, however, this can be done without lengthy or complex documents; and for all

projects, minimizing length and complexity to the extent possible, results in a more user-friendly, therefore valuable, document. Building professionals would do well to heed the words of aviation pioneer Antoine De Saint-Exupery: “*You know you've achieved perfection in design, not when you have nothing more to add, but when you have nothing more to take away.*” This concept can be well applied the OPR, BOD and SM. If something is required to achieve the fundamental purpose, we must be sure it is fully addressed. If it's not the users and owners of the documents may be better served by leaving it out.

As a commissioning professional I have developed and reviewed numerous OPRs, BODs, and Systems Manuals. Many of these experiences clearly underscored how common it is for project teams to loose site of these fundamentals. It is not uncommon to review documents that are difficult to follow, or contain confusion sections that add little value or make no sense at all. The value of some of these documents has been diminished by not including enough information, while others lack user-friendliness due to excessive length, irrelevant content and poor communication. In my experience, most of the time this occurs as the result of developing the documents in an inefficient manner; often trying to rigidly follow some template or guideline without asking the relevance of the format or the content of various sections to the particular project at hand. Focusing on the fundamental purpose of commissioning, heeding Saint-Exupery's principle, and applying the following simple guidelines for efficient document development can transform these unwieldy documents into the valuable user-friendly tools they should be.

Cost-effective OPR development guidelines

Start early. The primary key to a cost effectively developing the OPR, is to begin early. The greatest value for the least effort is obtained when OPR development begins with project programming. Remember, the purpose of the OPR is to document the owner's functional requirements. Creating the document after design is under way diminishes its value and may increase the cost of development. The project should be based on the OPR. The OPR shouldn't be based on the construction documents.

Don't confuse importance with length and complexity. Be concise and user-friendly, otherwise the document won't be used. Don't be strictly bound to following a template document. When using a template document consider the relevance of each section and ask more sections need to be added. If the subject is important to the owner it belongs in the OPR. On the other hand, if the owner doesn't have anything say regarding a section, consider leaving it out. The OPR is a designed document. Remember Saint-Exupery's principle - “*You know you've achieved perfection in design, not when you have nothing more to add, but when you have nothing more to take away.*”

Cost-effective BOD development guidelines

Develop the initial draft of the BOD at the onset of design, and use it as a design development tool. Use the BOD to obtain owner approval of concepts before designing specifics. Develop the document as the project evolves. The BOD can outline the direction the design team intends to take as they move from one design submittal toward the next. Using this approach the design team can obtain owner concurrence on the anticipated direction before investing time and money in design development. Like the OPR, creating the BOD after design is under way diminishes its value and may increase the cost of development. Base the design and construction documents on the BOD. Don't develop it after the project's been designed.

Don't confuse importance with length and complexity. As with the OPR, develop a concise and user-friendly document that the team will use. Pictures can be worth many words in this regard. Consider the use of schematic system diagrams and data tables. Many building professionals are more comfortable with pictures than prose. And as with any project document,

Leverage BOD efforts for maximum benefit. For example, replace tedious descriptive verbiage with system 1-line diagrams that will also be useful on the design development drawings, construction documents and in the Systems Manual. For descriptions of operation, describe the basic concepts early on and as soon as possible develop these into detailed sequences of operation. Developing sequences of operation early may optimize the selection of equipment and the layout of systems. Later, the sequences of operation will be needed anyway for the construction documents and the Systems Manual. Describing fundamental control logic in the BOD adds a level of confidence that the design satisfies the OPR and that the contractor and commissioning agent will receive the information necessary to program and test the systems in accordance with the designer's intent.

Cost-effective Systems Manual development guidelines

Develop the SM as the project evolves. Remember that the systems manual consists primarily of documentation that can be developed and used as the project progresses. These documents provide value to the project before the SM is compiled. The OPR, BOD and schematic diagrams are examples of this. The key to cost effective SM development is to develop and use these documents as they are intended, and begin compiling the SM as they are completed. Developing the documents just for the systems manual diminishes their value.

Some SMs also include systems performance metrics that should be tracked to indicate when the level of performance begins degrading. Defining these in the OPR & BOD early in the project provides great value in answering critical questions like what do we want to accomplish with this system, and what are the acceptance criteria.

Note operating information as it is discovered. CxAs should remember that most SMs include some discussion regarding information learned through commissioning. Examples include

building systems interaction and special operating requirements observed by the CxA. It's much easier and more cost effective to not these at the time they are observed.

Conclusion

The Owner's Project Requirements (OPR), Basis of Design (BOD), and Systems Manual (SM) are valuable systems commissioning and maintenance tools. The OPR describes the Owner's acceptance criteria for systems functionality and forms the basis of the BOD. The BOD is the design team's statement of how they interpret and how they intend to fulfill the OPR. The SM incorporates and builds on the OPR and BOD in order to provide systems operators and future designers of modifications with information necessary to maintain optimal performance. Fully understanding the use and interaction of these documents enables the project team to maximize their value. Applying the following fundamental commons-sense guidelines facilitates efficient development and optimized use:

- Start the documents early and use them as tools as the project progresses.
- Don't confuse importance with length and complexity.
- Leverage document contents for maximum benefit.