THE COMMISSIONING PROCESS

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VÆRDISKABENDE BYGGEPROCES

SET UP REQUIREMENTS AND KEEP FOCUS WITH COMMISSIONING

Originally, the term commissioning comes from the shipping industry, where a ship is only launched for operation when it has been thoroughly tested and the crew have been trained to operate it. Commissioning in the construction sector is a proactive dialogue and Quality management process focusing on Life Cycle Costs, LCC and interactions between the installations. The method is now mainly used in complex construction projects and industrial Installations and Systems, but it can be adapted to the individual building project and sharpen the focus on the owner's technical requirements for the building.

The Participants in the construction process often lose sight of the fact that the building must meet the owner's requirements for future operation. The commissioning process ensures that this focus is maintained through all phases of the project. It focuses especially on the early phases, where the owner defines specific and measurable requirements.

By setting clear and measurable requirements, the commissioning process can ensure that the intentions of the project are supported. This creates confidence not only for the owner but also among consultants and contractors.

By constantly following up upon the owner's requirements, commissioning adds value to the building process, not least by preventing that the final testing of Installations and Systemss, installations and systems will expose serious errors just before handover. The commissioning process ensures the lowest possible energy consumption, a good indoor climate and a well-functioning building..

Commissioning also requires the owner to allocate resources and to be prepared to question the design and construction process along the way.

Commissioning is still new in Denmark, but it is indicating one of the ways of achieving better quality in construction and minimising the energy consumption of the building.

Værdiskabende Byggeproces (Værdibyg), 2013

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CONTENTS

SET REQUIREMENTS AND FOCUS ON COMMISSIONING **1**
ABOUT THE GUIDE **5**

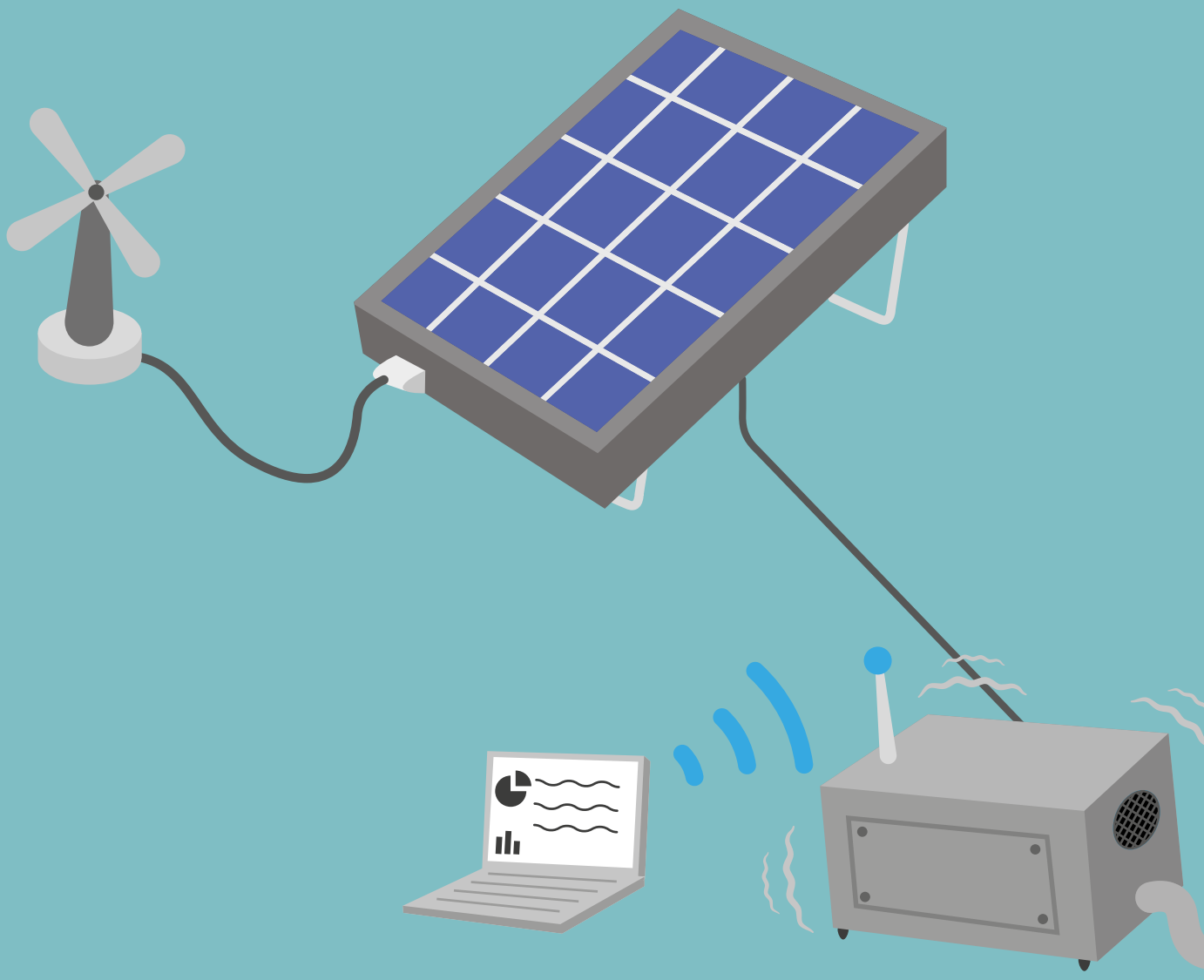
PART 1: COMMISSIONING

WHAT IS COMMISSIONING? **6**
BENEFITS AND PITFALLS **8**
COSTS **10**

PART 2: THE COMMISSIONING PROCESS

THE COMMISSIONING PROCESS **14**
1.0 PLANNING **17**
PROJECT DESIGN **20**
2.0 OUTLINE PROPOSAL 20
3.0 PROJECT PROPOSAL 20
4.0 MAIN PROJECT 21
5.0 EXECUTION **22**
6.0 START-UP **24**
7.0 OPERATION **24**

APPENDICES CAN BE DOWNLOADED FROM WWW.VAERDIBYG.DK



ABOUT THE GUIDE

The aim of this guide is to inspire the parties in the construction sector to use commissioning as a proactive tool to assure the quality of the building and an energy-efficient operation.

The guide is sectioned in two parts:

Part 1, which describes commissioning at a general level – based on benefits, drawbacks and costs.

Part 2 **contains a systematic presentation of** the activities in a commissioning process and is aimed at those directly involved. The individual phases provide the structure for a description of the most relevant activities.

The guide is thus aimed at owners (mainly Part 1), owner advisers, consultants and contractors.

This guide is published together with the guide to the 'Operations-based building process', which takes a more general approach to integrating operational considerations into the building process.

A Danish Standard for commissioning, conforming to this guide, was drawn up in 2014. Work is also in progress on European guidelines for the commissioning process.

PART 1: COMMISSIONING
WHAT IS COMMISSIONING?

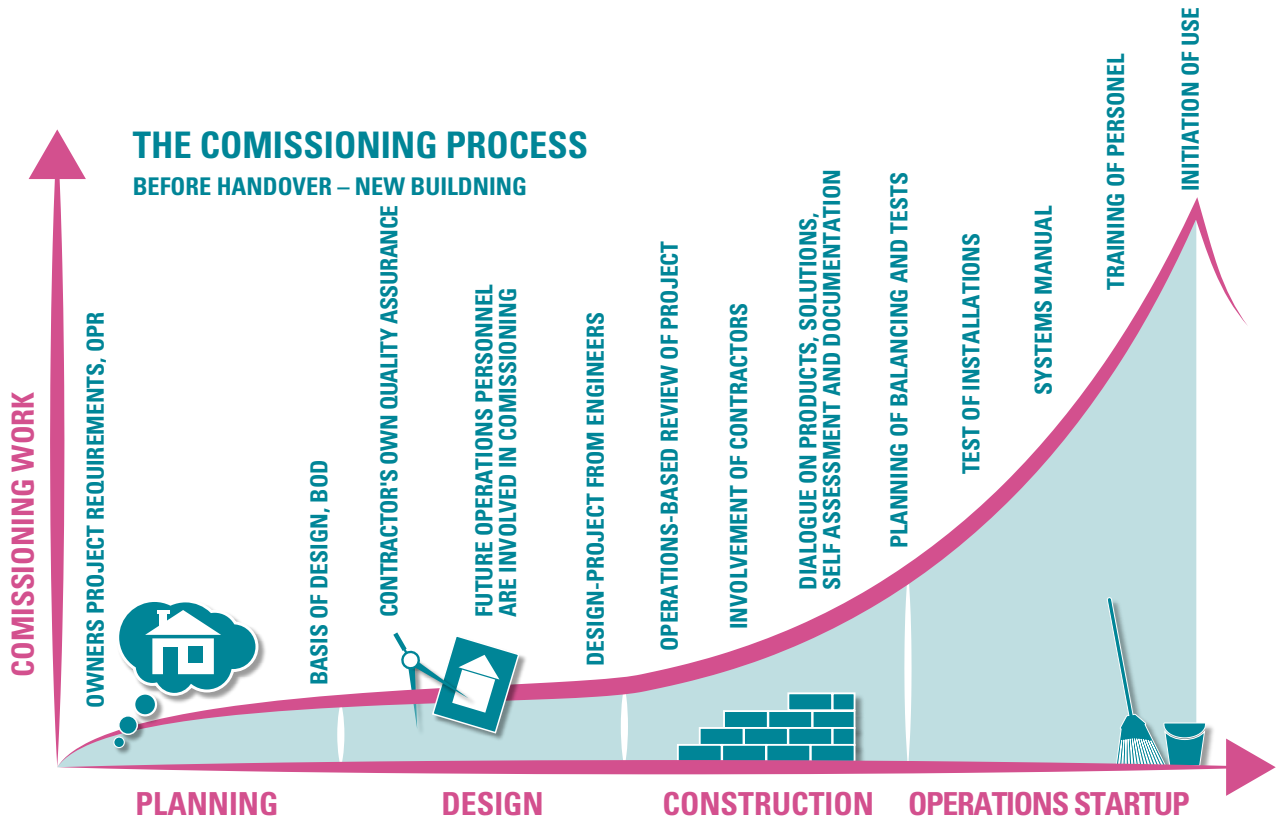
Commissioning is a proactive dialogue and Quality Management Process which focuses on Life Cycle Costs, LCC and on the interactions with the installations. The result is an energy-optimised and efficient building, with satisfied users and a more competent and motivated operating organisation.

The method is simple – but comprehensive. The owner starts by setting clear goals for the construction project, and an Issues Log is set up to track observations related to whether the goals are being met through all the phases of the project.

The commissioning process runs in parallel with a construction project and may proceed through the lifetime of the project. Commissioning is therefore much more than a 'test prior to handover' or a 'coordinated start-up', as it used to be conveyed in Denmark. The quality of a building project is managed according to the technical requirements of the owner and the user – not least including requirements to minimise energy consumption, which make the process especially well-suited for energy renovation jobs.

The construction sector traditionally thinks in terms of contracts and supplies, where the individual supplier ensures that his own systems work as they should. However, the installations are getting more and more specialised, and special skills are needed to ensure that the overall complex of ventilation, heating and cooling systems and building automation meets the requirements for the indoor climate, energy consumption etc.

The commissioning process interconnects the different contracts and suppliers by involving the operations organisation, users, consultants, contractors and suppliers – and utilises the resources already existing in the building process. Another key purpose is to manage the interfaces between the different suppliers and contracts.



ADDED VALUE OR OBSTRUCTION FOR PROGRESS?

The parties in the building process may feel that the commissioning process is so challenging that it constitutes an obstruction. Operational considerations, which are often disregarded in the building process, are brought into focus. The commissioning process requires resources, technical understanding of both project and operations and an overview across installations and systems. It also takes a holistic whole-life approach challenging those responsible for the construction costs.

THE COMMISSIONING ORGANISATION

A Commissioning team is established for the building project, to manage the commissioning process in parallel with the design- and construction process. The group is typically composed of a owner representative, an operations manager, a representative of the designers, a representative of the contractors and the commissioning manager.

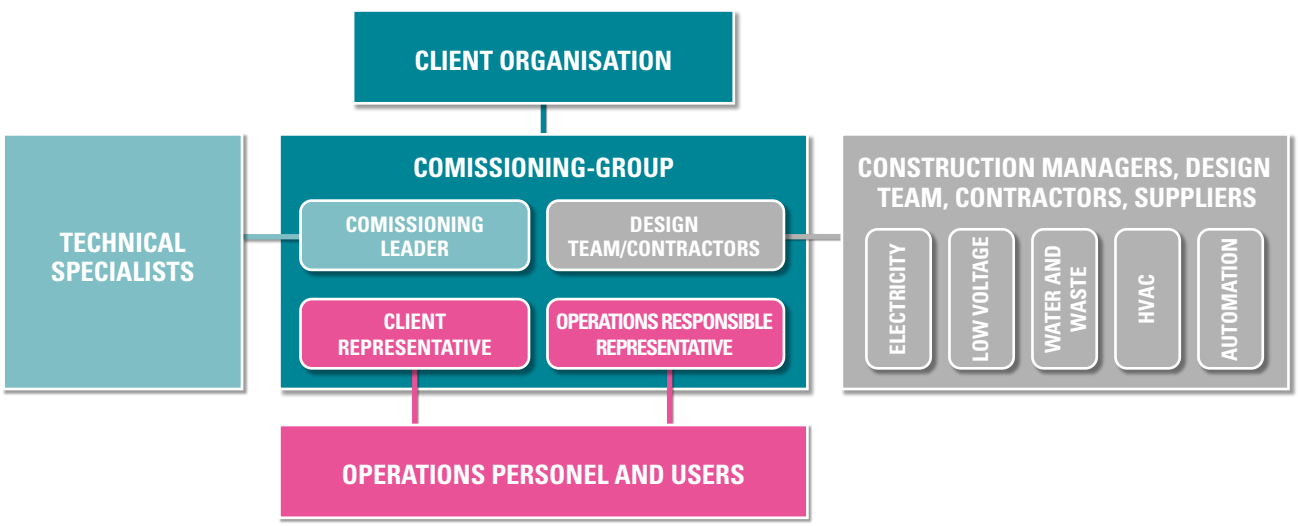
When necessary the Commissioning-team is supplemented with commissioning specialists, planners, contractors, suppliers, users and operations staff relevant to the particular task in hand.

COMMISSIONING SKILLS

The owner must appoint a commissioning manager. There is no template for the training required to manage the commissioning process. However, the following skills are needed:

- Broad technical understanding – building automation systems, HVAC (heating, ventilation, air conditioning), indoor climate etc.
- Experience with operating the relevant systems
- Experience of the building process
- Good at project management and communication

Depending on the systems to be tested and the complexity of the project, the commissioning manager may extend the commissioning organisation to take in specialists who can handle commissioning activities within their specific expertise.



BENEFITS AND PITFALLS

WHAT ARE THE ADVANTAGES OF THE COMMISSIONING PROCESS?

The commissioning process should create value. This value may take the form of reduced energy consumption, savings in operating costs and/or e.g. points in a sustainability certification.[1]

The advantages to the owner and the building manager could be that:

- The building is ready for use from day one
- The indoor climate meets expectations
- Operating costs are optimised, predictable and suitable for budgeting
- The building is flexible and robust
- The operations staff are able to operate the building in line with the Owners Project Requirements, OPR
- The documentation matches the tools used by the operations organisation
- An efficient building with satisfied users
- Documented services and consumption
- Best possible basis for increasing the value of the buildings (Asset Management)

Contractors are also showing an interest in the commissioning process, as it represents some benefits to them as well:

- The right building first time
- Delivery on time
- Documentation of services and quality
- Minimising defects
- Fewer warranty claims

PITFALLS?

The commissioning process requires resources and should be seen as an investment where the return only comes when the building starts to be used and managed.

When the Owners Project Requirements, OPR, are being constantly referred to, there will be discussions about solutions, methods and future performance at an earlier stage than normal. Subsequent to these discussions in the early phases of the project, however, the parties often welcome the fact that important requirements have not been overlooked – thereby avoiding unnecessary redesign and rework.

The focus of the commissioning process on Life Cycle Costs, LCCs can be a challenge, particularly during cutbacks and due to a narrow focus on production costs. At an early stage the owner can lay down requirements for the use of Life-Cycle calculations in consultant and construction contracts, in order to give whole-life calculations more impact on the project.

Time needs to be booked for commissioning activities in the project schedule, to ensure that the necessary reviews and tests are performed as planned. Users and operations staff are involved in the commissioning process, and this demands time and resources. The method is proactive and should prevent time pressures in the construction period through to handover.

Consistent involvement of all parties, including users and operations staff, may conflict with the culture on the site. The time spent on reviews, and not least the demands to finish individual supplies ahead of coordinated tests, can be problematical if it is not factored in from the outset.

1 See e.g. 'White Paper on Sustainability in the Construction sector' (2013)

LIFE CYCLE COSTS, LCC

The Life Cycle Costs, LCCs of a given solution cover the costs of establishing and operating the solution.

Life Cycle Costs, LCCing is a method of comparing two or more different solutions where the breakdown of acquisition costs and operating expenses is different. Whole-life calculations contribute to qualifying decisions in a building process when operation has to be included. It is essential to limit the scope of the calculations to the areas where they make most sense – such as facades, technical solutions or energy supply issues.

A requirement to use Life Cycle Costs, LCCing should be incorporated into the tender documentation and used actively in connection with the overall plan, the outline proposal and project proposal, and in the event of changes.

Most building processes are completed in one to three years, while the buildings may then be used for 30 to 100 years. Of the total costs, approx. 80% are accounted for by the operation of a building. It therefore makes sense to choose solutions on the basis of a whole-life approach.

LIFE CYCLE COSTS, LCC

There are a number of guides and tools for working with Life Cycle Costs, LCC

EXECUTIVE ORDER

Danish Building and Property Agency Order and associated guidelines on quality assurance, Life Cycle Costs, LCC and PPP.
www.bygst.dk

LCC AND LCA TOOLS

In 2015, the Danish Transport Authority developed tools for whole-life calculations (life-cycle cost and life-cycle assessment analysis)
www.trafikstyrelsen.dk

http://www.trafikstyrelsen.dk/DA/Byggeri/Baredygtigt-byggeri/Totalokonomi.aspx

GUIDE TO LIFE CYCLE COSTS, LCC IN TENDERING PROCEDURES

From Byggeri København/ Københavns Ejendomme, now part of the guide to 'Sustainability in building' (2015)
www.byk.kk.dk
https://byk.kk.dk/indhold/udbudsdokumenter

TOOL FOR WHOLE-LIFE ASSESSMENTS OF WINDOWS, FACADES AND ROOFS

Landsbyggefonden (2010)
https://totaloekonomi.lbf.dk/

BEST PRACTICE MANUAL ON LIFE CYCLE COSTS, LCC

Danish Business Authority (2009)
www.bygningsstyrelsen.dk

THIRTEEN GOOD TIPS ON LIFE CYCLE COSTS, LCC

Danish Business Authority/Danish Building Research Institute (2002)
http://www.sbi.dk/byggeprocessen/evaluering/totalokonomi/13-gode-rad-om-totalokonomi

COSTS

WHAT WILL IT COST?

The price is of course dependent on the scope, but typical indicators fall between 1 and 2% of the construction cost – depending on a number of crucial factors:

HOW MANY UNITS, INSTALLATIONS AND SYSTEMS IS THE COMMISSIONING PROCESS TO COVER?

The commissioning process can be scaled by adding and removing installations. Commissioning will typically deliver great value if it is used for water and waste, heating, ventilation, automation systems and cooling, and installations connected to these.

Things are often interdependent and it may not be possible to carry out commissioning on the heating system without also looking at the climate envelope.

WHEN DOES THE PROCESS START?

The sooner the better! Requirements for the project designers and the contractor to participate in the commissioning process should be in place before the tendering procedure, thus making the service part of the contract. Expectations should be aligned and sufficient resources assigned to the respective teams.

THE RESOURCES OF THE OWNER/BUILDING MANAGER AND THE PARTIES' EXPERIENCE OF COMMISSIONING

The more involvement from the owner and the more experienced the parties are, the fewer external resources will need to be brought in. It is recommended to engage an impartial commissioning manager for the building process, who can act as a constructive facilitator in close collaboration with the owner, his consultants (including any owner advisers and the project designers), contractors and suppliers.

EXPLOIT THE RESOURCES OF THE BUILDING PROJECT

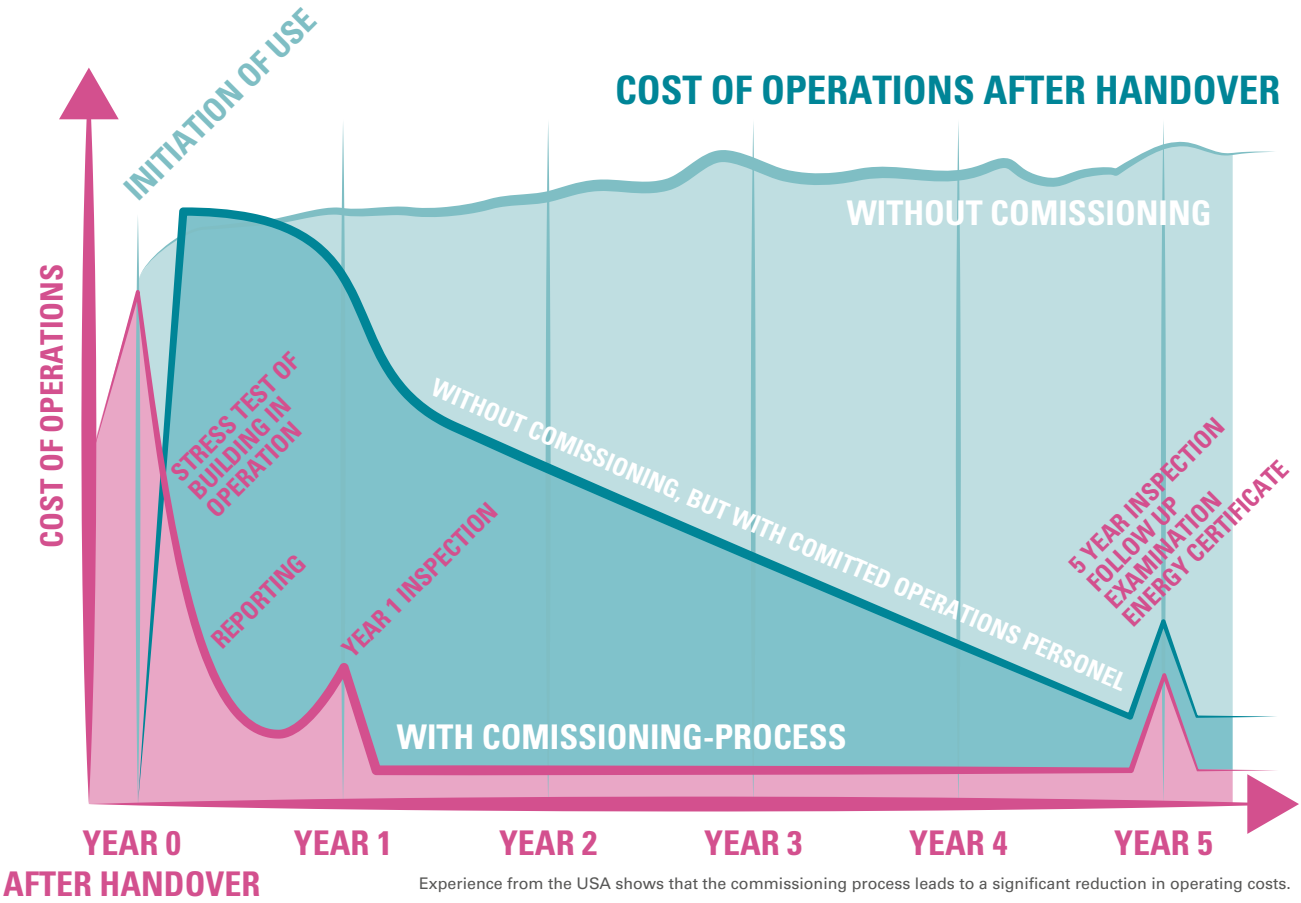
One way of keeping the costs down is to utilise the commissioning-related resources already present in the building organisation. Every contractor will already have included quality assurance, Contractor's own Quality Assurances, system calibration and tests in its own contract. Effective collaboration with the contractor and any sub-contractors to integrate the contractor-based tasks into the commissioning process could then save costs on tests run by the commissioning organisation.

WHAT IS IT WORTH?

Major studies in the USA point to energy savings averaging around 13% and an average ROI of 4.2 years.

A Danish study compared two Danish shopping centres[2] with a lot of features in common. The centre using commissioning as part of the construction process has 40% lower electricity consumption compared to the other centre. The electricity consumption alone results in a simple payback for the commissioning process of around 1 year.

2 Ágústsson, Rúnar Örn: Building commissioning, Advantages and disadvantages of the process and how it has been applied in Denmark. Dissertation project from Management Engineering, DTU, 2010.



Experience from the USA shows that the commissioning process leads to a significant reduction in operating costs.

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PART 2
THE COMMISSIONING PROCESS

Part 2 contains a systematic presentation of the activities in a commissioning process. A precondition for a successful commissioning process is that:

- All the parties to the project are thoroughly informed of the process
- All of them have agreed to carry out commissioning activities
- All are willing to follow up on the observations from the commissioning process

WHAT DO I DO?

Work should commence as early as possible. It will normally make the work easier if the commissioning organisation is in place before the design specification is complete in order to facilitate the definition of measurable Owners Project Requirements, OPR.

Outline of the elements of the commissioning process:

- Selecting focal areas
- Setting requirements for performance, functionality and effectiveness
- Establishment of an organisation
- Planning and coordination of the commissioning plan with the project schedules.
- Meetings of the commissioning organisation supplemented with relevant specialists
- Setup of a Issues Log, in which all observations are recorded and tracked
- Review of project documents focusing on operation and interactions between the installations
- Feedback from the designers on the fulfilment of the owner's requirements

PROGRAMMING PHASE

IDEA

- Communication, meetings and reports
- The owner's overall OPR outline requirements
- Budgeting

OUTLINE PLAN

- Organisation
- Planning
- Setting specific OPR requirements for performance and operation
- Requirements for the parties
- Setup of Issues Log
- Status report
- Owner acceptance of commissioning to date

DESIGN PHASE

OUTLINE PROPOSAL

- Verification that BOD requirements have been covered in the outline proposal
- Update log
- Status report
- Owner acceptance of commissioning to date

PROJECT PROPOSAL

- Review of design assumptions
- Update log
- Status report
- Owner acceptance of commissioning to date

MAIN PRO

- Requirement tractors and
- Review of main project
- Dialogue wit tractors and
- Writing test paradig
- Update log
- Status repor
- Owner accep

- Work should be targeted with specific activities in each phase of the construction project, including Contractor's own Quality Assurance, quality assurance, supervision, user training and documentation
- At the end of each phase, the owner accepts the commissioning activities and authorises the continuation of the process into the next phase
- Verification of the completed project and the building to comply with the requirements
- Reporting
- Planning of activities to sustain the commissioning process in the operational phase

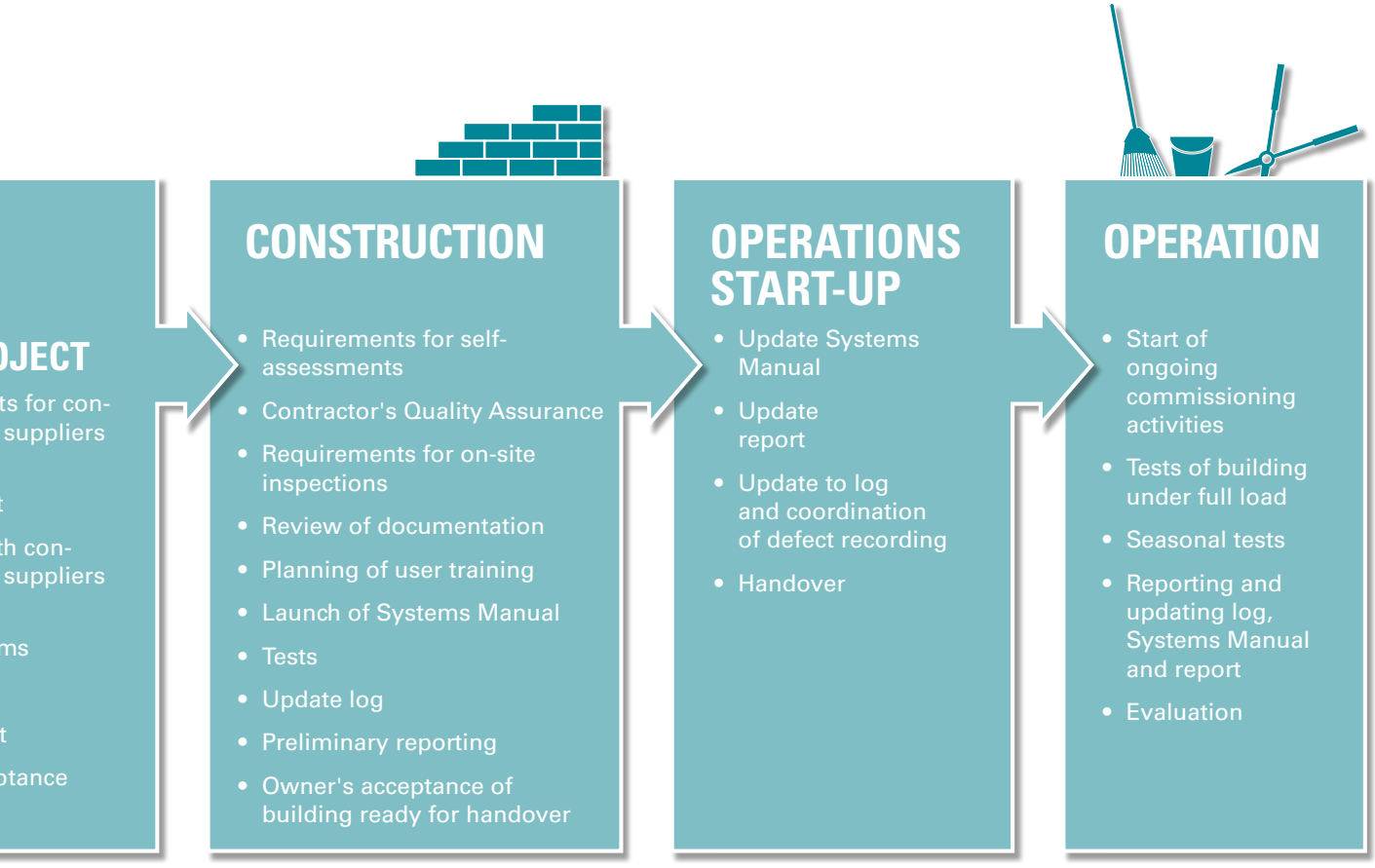
If initiated later than the early planning phase, some of the preceding activities will need to be picked up before proceeding with the activities relating to the current phase.

STATUS REPORTING AND ACCEPTANCE OF ACTIVITIES

An essential end-to-end feature of the commissioning process is status reporting and the owner's acceptance of the activities. The commissioning manager reports on the status to the owner at the end of each phase. Comparing the commissioning plan with the Issues Log highlights the progress of the commissioning activities.

It is a good idea to keep a complete log of all observations and to compare this log with a version showing only the unresolved observations.

After examining the status reports, the owner should indicate his acceptance for the work to continue into the next phase.



OVERVIEW OF ACTIVITIES AND DOCUMENTS

	ACTIVITY		DOCUMENT
PROGRAMMING	Start-up	⟷	Agreements, budget and organisation
	Workshop, requirements specification	⟷	Owners Project Requirements, OPR
	Planning	⟷	Commissioning plan
	Collecting observations	⟷	Issues Log
	Involvement of project designers	⟷	Appendices to contract documents
PROJECT DESIGN	Provision of Owners Project Requirements	⟷	Basis of Design, BOD
	Involvement of contractors	⟷	Appendices to contract documents
	Project review	⟷	Review results in Issues Log
	Review of sub-project	⟷	Review results in Issues Log
	Dialogue on QA and calibration	⟷	Impact on contractor paradigms
	Planning of tests	⟷	Test paradigms
EXECUTION	Supervision requirements	⟷	Impact on inspection plans
	Planning of user training	⟷	Training plan
	Execution of system tests	⟷	Test report/results in Issues Log
	Gathering documentation, QA and O&M	⟷	Systems Manual
START-UP AND OPERATION	Reporting	⟷	Commissioning report
	Stress tests	⟷	Test report/results in Issues Log
	Evaluation workshop	⟷	'Lessons learnt' report
	1- and 5-year inspections	⟷	Update of Issues Log

1.0 PLANNING

The owner is responsible for appointing a commissioning manager to plan and coordinate the forthcoming commissioning activities.

The commissioning manager should have a broad technical background and experience of project design, operations and project management. The commissioning manager may be someone from outside with specialised experience of the commissioning process, as impartiality is an important parameter when working with the parties to the building project.

Before outline planning or immediately after it, the commissioning manager should discuss the overall Owners Project Requirements, OPR (indoor climate, energy consumption etc.) with the owner, along with budgets for the commissioning activities.

Communication and meeting and reporting frequency are agreed on.

1.1 CLARIFYING THE OWNER'S OVERALL DEMANDS AND OBLIGATIONS

Here, it is the commissioning manager's job to help the owner to estimate the focal areas which yield most value for the commissioning resources invested.

Typical focal areas are:

- Water and waste
- Ventilation
- Cooling
- Electricity
- Low-voltage supply
- Security
- Climate envelope
- Building automation
- Heat supply

Verification of requirements from the building balancings is often part of the work of the commissioning organisation.

1.2 BUDGETING

The budget will inevitably be indicative, as the process is dynamic and resource needs can change if serious defects are found, for example.

The budget should include a statement on resource needs from the owner's operational organisation, from contractors and suppliers and from commissioning specialists.

1.3 ORGANISATION

A commissioning organisation should be established with a Commissioning Team reporting to the owner. The group will include a representative of the owner, an operations manager, a representative of the project designers (typically an engineer), a representative of the contractors (typically a contract manager for installation works), and the commissioning manager, who is responsible for heading the commissioning process.

This organisation is regularly supplemented with commissioning specialists, designers, contractors and suppliers who are relevant to the particular task in hand.

Commissioning specialists should have specific technical experience of both project design and operation of the installations concerned. The specialists will typically be external people with experience of the commissioning process. An organisation chart should be produced for the individual project.

An effective organisation shares the tasks among its members and draws upon the resources in the participants' respective teams. Subsequently, as this guide states that a task is carried out by the commissioning organisation, it reflects this division of labour.

1.4 COMMISSIONING REQUIREMENTS

Owners Project Requirements, OPR represent the owner's measurable requirements for performance, functionality and efficiency, which cannot be waived without the owner's consent. These requirements are the foundation on which the whole commissioning process rests.

The contents of a normal design specification are often not precise enough for tracking the requirements through the outline proposal, the project proposal, the main project, construction and operation. That is why the Owners Project Requirements, OPR are typically listed in a separate document, which is used when the commissioning organisation comes to verify the requirements through the subsequent phases. The requirements should be included in the tender documents, possibly as an appendix.

The commissioning organisation may run a workshop with all the relevant stakeholders, where Owners Project Requirements, OPR are laid down. A typical example of a commissioning requirement is shown in Appendix 2.

The Owners Project Requirements, OPR focus on Life Cycle Costs, LCCs, types of Installations and Systems and systems, verification, manuals, documentation, operation and maintenance, user training and reporting.

1.5 PLANNING

The Commissioning Team draws up a commissioning plan and a schedule. The plans describe the expected activities in the commissioning process in chronological order.

The commissioning plan is updated regularly whenever there are observations affecting the planned process.

The commissioning plan should be coordinated with the project schedule to ensure that dedicated periods are assigned for commissioning activities.

The commissioning organisation specifies the meeting frequency and expected time consumption for all players. This information should be included in the tender documents, so dedicated resources can be allocated to commissioning activities.

An example table of contents for a commissioning plan is shown in Appendix 3.

1.6 SETTING UP THE ISSUES LOG

The commissioning organisation sets up a Issues Log, in which all observations are recorded and tracked as the project develops. Appendix 4 provides an example of structuring a Issues Log.

The Issues Log accompanies the whole project and is carried forward into the operational phase.

It is recommended to have the owner's Owners Project Requirements, OPR clearly marked in the log, to prevent them being swamped by other observations later on.

Observations from user workshops etc. may also be documented in the log. Any conflicts between user requests, original requirements and other observations will then be clearly visible.

The Issues Log should be updated at the end of each phase and any items that have been covered should be closed before the next phase.

A copy of the log should be saved at the end of each phase, and the contents of the log should be used to decide whether to continue into the next phase.

1.7 REQUIREMENTS FOR PROJECT DESIGNERS/TURNKEY CONTRACTOR

Typically, the commissioning organisation will help to incorporate specifications of commissioning-related activities into the project designers' contract documents. The project designers should know beforehand that they have an active role to play in the commissioning process. They should design towards meeting specific requirements, and their project will be reviewed, typically in a workshop in which they participate. Furthermore, they should participate in supervision, testing and reporting.

If the project design is undertaken by a turnkey contractor, requirements should be laid down even at this point to ensure that contractors take part in the commissioning process along with the project designers.

1.8 REPORTING AND ACCEPTANCE

See section on page 17.

DESIGN PHASE

2.0 OUTLINE PROPOSAL

In relation to commissioning, this phase includes an initial assessment of whether the Owners Project Requirements, OPR are covered in the project.

2.1 MEETING SPECIFIC REQUIREMENTS

The project designers should clearly indicate in the outline proposal that each of the Owners Project Requirements, OPR has been covered.

The project designers document that the Owners Project Requirements, OPR have been complied with and the documentation is saved as the basis for the project; together with the requirements specification, this forms the baseline for the future commissioning activities. It may take the form of an appendix listing the Owners Project Requirements, OPR, with proposals for implementing them listed in parallel.

Appendices 2 and 4 show how adding extra columns to the document with the Owners Project Requirements, OPR provides an easy way to see whether the requirements have been covered.

2.2 REPORTING AND ACCEPTANCE

See section on page 15.

3.0 PROJECT PROPOSAL

The activities in this phase are based on the original Owners Project Requirements, OPR documented and covered in the previous phase. The commissioning organisation can profitably review the project proposal before it is used in an authority project to apply for a building permit.

3.1 REVIEW OF BOD AND CALCULATIONS

Design assumptions, indoor climate simulations etc. are reviewed to ensure that Owners Project Requirements, OPR have been covered.

The results of the review are documented in the Issues Log.

3.2 REPORTING AND ACCEPTANCE

See section on page 15.

PERFORMANCE TEST

The performance testing method is an element of the commissioning process, but can also be used on its own. The aim is to provide for a test-based handover process, thus taking a calibrated building into use and meeting the requirements that have been set.

You can obtain ideas for performance tests and test paradigms from the Danish Building and Property Agency, which developed documents to prepare invitations to tender in 2015.

http://www.bygst.dk/viden-om/performancetest/

4.0 MAIN PROJECT

This section describes the activities in the commissioning process to be carried out during completion of the project.

4.1 SPECIFICATIONS FOR CONTRACTORS/SUPPLIERS

Contractors and suppliers must be contractually obliged to participate in the commissioning process – as should suppliers of owner deliverables.

Contractors and suppliers must harmonise their paradigms for Contractor's own Quality Assurances, trials, balancing, tests, documentation and user training with the commissioning organisation. Their contract/deliverable will be tested by the commissioning organisation in cases where the contractor/supplier-based tests need to be supplemented. This will typically happen when multiple contracts and deliverables together constitute an overall system such as a cooling Installations and Systems. Contractors and suppliers should themselves participate in testing and reporting.

If the project design is undertaken by a turnkey contractor, requirements must be passed on to sub-contractors and suppliers.

The commissioning organisation can assist in this by drafting sections of supplier and contractor contracts obliging the stakeholders to participate in the commissioning process. Appendix 5 shows an example of an information letter to a supplier who is required to take part in the commissioning process.

4.2 REVIEW OF MAIN PROJECT

Together with technical specialists, the commissioning organisation carries out an operations-based review of the main project, the contractors' project design and owner deliverables to confirm compliance with Owners Project Requirements, OPR, interactions between the installations and future operation.

It is a big advantage for the future operations staff to be involved in the reviews, to enable them to acquire in-depth knowledge of the installations and systems they will later be responsible for.

The operations-based review does not replace the consultants' internal reviews. The results of the review are entered in the Issues Log.

4.3 DIALOGUE WITH CONTRACTORS AND SUPPLIERS

Contractors and suppliers must engage in discussions with the commissioning organisation on:

- Contractor's own Quality Assurances
- Start-up
- Balancing
- Testing
- Documentation
- User training

The dialogue covers contractors' and suppliers' own deliverables, except when these are a vital element of other deliverables, such as building automation systems.

Contractors' and suppliers' paradigms for Contractor's own Quality Assurance, start-up, balancing, testing and documentation are updated to reflect the procedures chosen for the verification to meet the owner's Owners Project Requirements, OPR.

4.4 CROSS-DISCIPLINARY TESTS OF SYSTEMS

The commissioning organisation writes out paradigms for testing systems that are expected to be tested under the auspices of the commissioning organisation. The paradigms should meet the requirements for verification included in the owner's Owners Project Requirements, OPR.

Function descriptions from the BMS project are suitable as inspiration when writing test paradigms. An example of this is shown in Appendix 6.

4.5 REPORTING AND ACCEPTANCE

See section on page 15.

5.0 CONSTRUCTION PHASE

The commissioning organisation ensures, together with contractors and suppliers, that the control paradigms are complied with on the building components, Installations and Systems and installations which are verified by Contractor's own Quality Assurance.

In the construction phase there should also be a dialogue with contractors and suppliers on user training.

Later in the construction phase, the workload in the commissioning organisation increases due to the testing and documentation up to handover and operational launch.

5.1 UPDATING THE ORGANISATION

In this phase, a contractor representative will often be added to the Commissioning Team, as the day-to-day activities are increasingly more related to construction than to design.

5.2 ON-SITE INSPECTIONS

The commissioning organisation itself does not necessarily handle supervision in the construction phase. It will typically collaborate with professional supervisors and contractors' supervision.

The commissioning organisation should specify the supervision aimed at contractors' and suppliers' Contractor's own Quality Assurances, start-up, balancing, testing and documentation.

A special effort should be made to exercise supervision of interfaces between contracts and deliverables.

The activity is reported by updating the Issues Log

5.3 PROVISION OF DOCUMENTATION

The commissioning organisation should check whether the documentation meets the Owners Project Requirements, OPR.

It may be profitable for the owner to provide resources to support contractors and suppliers in producing and handing over documentation and operational and maintenance material. It is a good investment to ensure that the documents go into the operational organisation's tools, whether electronically or in hard copy.

The results are reported by updating the Issues Log.

5.4 PLANNING OF TRAINING.

The commissioning organisation plans training of operations staff in specific operational procedures. Expected training results should be determined together with operations staff and contractors/ suppliers, to ensure that the operations organisation is able to operate the building in accordance with the Owners Project Requirements, OPR.

The planning is typically reported in a training plan.

5.5 LAUNCH OF SYSTEMS MANUAL

The Systems Manual is the library encompassing all of the information that the operations staff might need. Much of this information is part of the operations and maintenance (O&M) material in a traditional building process, but typically it is not held in one place.

Along with the structure, the commissioning process provides manuals for systems made up of several installations and/or deliverables. These Systems Manuals will probably only be produced at the instigation of the commissioning organisation, as the individual suppliers of installations constituting parts of more complex systems cannot be expected to have an overview of the whole.

A Systems Manual is made up of the following documents:

- The original Owners Project Requirements, OPR
- Documentation to show whether the BOD reflects the OPR
- Issues Log, in which all observations are recorded and tracked through the process
- Reference to as-built documentation
- Reference to quality assurance documents
- Reference to training plan
- Reference to operating instructions for all units and systems – both normal and emergency operation
- Instructions on how operation can be continuously optimised, e.g. by data logging in BMS systems
- Reference to plan for ongoing commissioning activities
- Formal requirements for future reporting of e.g. energy consumption and indoor climate parameters
- Reference to maintenance instructions for all Installations and Systems and installations
- Requirements for training future personnel, and maintenance training
- Commissioning process report
- Basis of Design, BOD
- Guide to maintaining the Systems Manual

Space should be allowed to insert the commissioning organisation's final report into the system manual.

5.6 TESTS

The commissioning organisation runs planned tests in line with the published test paradigms.

Tests of complicated systems involving multiple contracts and deliverables demand great expertise and will typically be managed by commissioning specialists in the systems concerned.

All affected stakeholders, project designers, contractors and suppliers of the relevant system and operations staff will participate in the testing.

Acceptance criteria for the test results are the original Owners Project Requirements, OPR specified earlier in the commissioning process, with the updates approved by the owner.
The results are reported with an update to the Issues Log and perhaps a link to a separate test report, depending on the number of observations during the testing.

5.7 PRELIMINARY REPORTING

The activities performed are gathered into a commissioning report, which can serve as a document for the handing-over meeting. Appendix 7 shows a typical table of contents for a commissioning report.

After examining the preliminary reports, the owner should accept that the building is ready to be handed over.

START-UP AND OPERATION

6.0 OPERATIONS START-UP

At this point, the commissioning organisation is expected to have the greatest collective knowledge of operational matters in the project, and may thus be expected to help in starting up systems.

Observations from this phase should be entered into the Issues Log.

The preliminary commissioning report is updated and the Issues Log appended to the handover documents by way of quality documentation.

The Systems Manual is updated and passed to the operations personnel, highlighting the operational activities that are required from day one. You can find out more about start-up in Værdibyg's guide on 'The operations-oriented construction process'

7.0 OPERATION

This phase includes tests of the building in use and other tests that could not feasibly be carried out in the construction period. The future commissioning activities to be carried out at the instigation of the users of the building are also outlined.

7.1 STRESS TEST OF BUILDING

A test of a building in operation with furnishings and users can give a more accurate result than a test during the construction period. Part of the test period for the BMS system will typically come now – not to verify the BMS system in isolation but to verify systems and indoor climate.

7.2 SEASONAL TESTS

Usually, it will not be possible to test heating systems before handover if the handover takes place in a warm period. Conversely, it is hard to verify the functioning of cooling systems in the winter. So it makes sense to defer one or other of these tests until after handover.

7.3 ONGOING COMMISSIONING ACTIVITIES

Most buildings have a dynamic life with alterations, refurbishments, changes of use etc.

The commissioning organisation can help by outlining the activities that the operations organisation needs to carry out in order to maintain the verified services and operating costs, such as:

- Maintenance and advanced training
- Optimisation processes
- Procedures for alterations
- Procedures for replacements
- Monitoring of the impact of variances
- Future use of the Issues Log in warranty inspections etc.

The effort should be reported in the Systems Manual and in the operations and maintenance documentation.

7.4 REPORTING

The Issues Log, the Systems Manual and the preliminary commissioning report are updated with observations from the operational phase, and the final versions are passed on to the owner.

7.5 LESSONS LEARNED

An evaluation workshop is held to gather feedback for use in the continuing operation of the building and for applying the commissioning process in future building projects.

THE VALUE-CREATING BUILDING PROCESS (VÆRDIBYG) IS A PARTNERSHIP BETWEEN SEVEN OF THE MOST INFLUENTIAL ORGANISATIONS IN THE BUILDING INDUSTRY. VÆRDIBYG IS DEVELOPING A NEW STANDARD PRACTICE FOR THE CONSTRUCTION PROCESS COVERING THE DIFFERENT STAKEHOLDERS IN THE INDUSTRY.

THIS GUIDE EXPLAINS HOW SUB-CONTRACTORS CAN BE ACTIVELY INVOLVED IN THE BUILDING PROCESS AND HOW PLANNING AND COORDINATION CAN SUPPORT COLLABORATION AMONG CONTRACTORS AT THE PRODUCTION STAGE, WHERE THE SKILLS OF THE SUB-CONTRACTORS MAKE AN ACTIVE CONTRIBUTION TO VALUE CREATION IN THE PROCESS.